Proceedings of International Conference on Technology Management (ICTM 2016)

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Proceedings of International Conference on Technology Management (ICTM 2016)

Chicago, USA August 10- 12, 2016

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Science and Engineering Publishing Company

Published by
Science and Engineering Publishing Company
6815 E Manor Drive, Terre Haute, IN 47802, USA

Proceedings of International Conference on Technology Management (ICTM 2016)

ISBN: 978-0-9853540-9-1

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Keynote Address

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Good afternoon everyone, thank you for coming. It is my distinct pleasure to be here for our first international conference on technology management. Several months ago, Dr. Shahhosseini, Dean English, and I were having a meeting about the PhD program. During that meeting, I noted that in the last 18 years, since its approval, the program has grown into a significant community of professionals. I expressed the opinion that the program needed a means of bringing together the faculty and students involved in the program. Currently, we have over 90 faculty who are connected to the program in some way, over 140 graduates from the program, and more than 100 students currently enrolled; this constitutes a strong community. However, in the last 18 years, the full faculty has only come together one time, I believe it was either the summer of 1999 or 2000. It was a very beneficial three-day gathering during which faculty got to know one another better and worked out many of the existing curriculum and procedural issues. We have never attempted such a meeting again. I believe this is to our distinct disadvantage. There are many important issues that the faculty need to discuss and agree upon, but so far it has only been possible for sub-sets of faculty to meet, typically electronically, and by serving together on committees. And while this conference may be just a simple and small start; it is a positive and worthwhile event.

I first became involved with the PhD program while serving as a department chair at Central Connecticut State University. I received a phone call one day from the original Director, Dr. Lowell Anderson, during which he asked for a copy of my vita. He told me one of the other universities in Indiana had lodged an objection to our application for a new degree on the basis that we did not have an adequate number of PhD faculty. Obviously we successfully addressed the concerns before the Indiana Commission of Higher Education as the degree program was approved in 1998.

Shortly after the approval of the program, Dean Clois Kicklighter decided that it was time to retire. Unknown to me, a couple of my colleagues nominated me for the position. I was not looking for a new position, but decided to consider the opportunity, and to my surprise I was offered the position.

When I became dean in 1998, I inherited a new building, a new

bachelor's degree completion program using distance education, and a new PhD program. To say the least, those were challenging times as we were also dealing with growing our enrollments and several pending faculty retirements.

During the first two years, I identified a set of informal benchmarks that I thought would help me to understand how well we were doing with the new program. The first benchmark was whether or not anyone was going to enroll in the program. When we applied to the commission of higher education for the new degree, we were obligated to provide them a five-year projection of enrollments. We achieved our fifth year enrollment projection about three years into the program; a clear indication that we had a degree that people wanted. The second benchmark was whether any of our graduates did in fact get jobs. And I was particularly interested in those who would be getting jobs in higher education as faculty. I don't have exact data, but I believe that every graduate of our program that wanted to be in higher education successfully became a professor somewhere (it turned out that many were faculty already). So, we were attracting quality candidates, those candidates were completing the program, and they were getting jobs, even jobs at research extensive institutions. I then turned my attention to whether or not they were getting tenure at these universities; and they were. Again, I don't have exact data, but I do not know of a graduate of the program, who has not earned tenure. Finally, I wanted to know if any of these graduates were being promoted to full professor, and this spring I learned that at least one has. I believe this is exactly the kind of data we need to demonstrate to our university administrations, future students, government agencies, and the like that this is a quality program. In short, we need data. In addition, data about such things as publications, research, grants, citations, and other accomplishments are needed to demonstrate that our faculty, our students, and our graduates are making valuable contributions to their respective fields. This year, the graduate programs offered by Indiana State University's (ISU) College of Technology will be reviewed by Graduate Council. It is an internal review done every five years, and hopefully when this review is over we will have a much stronger database of our accomplishments.

I will now turn my attention to the challenges that we faced at the outset; in some ways continue to be challenged by these issues. First as I noted earlier, one of the universities in Indiana (I believe it was their dean of graduate studies) objected to our application for a PhD program. This individual did not object to us having a doctorate. He argued that it shouldn't be a Doctor of Philosophy degree program; that it should be a specialist doctorate, such as a Doctor of Technology degree. While the argument did not sway the Commission on Higher Education, the argument struck me as a reasonable inquiry. Consequently, I spent a

couple of years at the start of my term studying applied research. I wanted to explore the nature of the research being done at the doctoral level in such fields as mechanical engineering, chemical engineering, computer science, business administration and others. I found that there was indeed a great deal of applied research, and a clear “niche” for applied researchers from a technology perspective. For the last 50 years, faculty and colleges of technology around the country have brought their unique practical perspective to a wide variety of questions/issues, and have helped to lead business and industry. I believe this practical perspective makes this faculty uniquely qualified to apply existing knowledge and skill to address the problems we are facing. Further, there is a great deal of basic research that that one could say is still “sitting on the shelves”. There is clearly a strong need for applied researchers in technology and innovation. However, I believe that we have yet to adequately address the question of how the PhD in Technology Management is in fact a philosophy degree; additional work is needed.

Second, we have been challenged by the way people understand and use the term technology management. By and large, when someone uses the word technology today they are typically referring to some aspect of digital communications or information technology. In other words, it is computers, the Internet, cell phones, and the like. However, this is not what we mean when we say technology management. To understand my point, please think about the word biology. Its origins are Greek. It is made up of two words, which are translated loosely as the study of life. Now, if a biologist discovers something that would say, for example, cure cancer, would the result be called biology? Probably, not. The result would be called medicine or a surgical procedure or something else. When I take a pill I don’t say that I’m taking or using biology, I’m taking medicine. This is not the case with the word technology. In fact, almost 30 years ago, I read an article that summarized that there were over 100 definitions of technology. Think about the problems we would have if the same we’re true about temperature or gravity or some other physical characteristic.

My colleagues and I at the University of Illinois in the 1980s, defined technology as a “noumenon that occurs through the synergistic interaction of knowledge, thinking skills, and physical processes and results in the extension of human capability”. In other words, it is part of human thinking and innovation. However, I am sure that many scholars would not agree with our definition. The issue is compounded when we say technology management. When an engineering college offers a master’s degree, it is often called engineering management. This makes sense because you can find engineering firms and engineering departments in companies. And, if you get a promotion within an

engineering department, you would be managing engineers. If you are in retail, and you choose a degree in retail management, it makes sense because you would be managing within a retail environment. But, in the case of technology, it is clearly different. There are no departments of technology in business and industry, other than information technology. Consequently, it behooves our faculty, students, and graduates to do more work to develop a clear definition of technology and technology management. To that end, I would call your attention to the website www.dictionary.com, as it is obvious that at least one group has a popular understanding that is similar to ours.

Third, we are clearly challenged by the consortium model that we have chosen to use. The five partners that currently make up the consortium are very good universities, with outstanding faculty who have agreed working together. There is clearly a desire to make this program work! But we cannot say that we are a consortium, a single entity. We are five loosely connected partners. For example, at the outset of the degree program, we tried to find a way to create a single admissions process, tuition rate, transcript tracking, point of contact for registration and other information, and the like. We entered into meaningful dialogue with officials at the other universities, and it was clear from the outset that state rules and state autonomy were not going to allow us to create a single entity. We even went so far as to consider creating our own nonprofit corporation. We still have not figured out how to make it work; and I know that most of you are very aware that still have not achieved the goal of a single point of contact. This is clearly a major challenge to us as we try to delivering this degree program efficiently and cost effectively.

Fourth, we were and are clearly challenged by the nature of the universities in the consortium. For the most part, the universities that agreed to help deliver this program were at one time a teacher's college. They had a single mission to prepare educators for the primary and secondary schools of the country. Historically, there were multiple tracks of university development. In public education, the land grant legislation signed by President Lincoln created a set of universities dedicated to agriculture and mechanics. Today, we call these institutions research extensive universities. The faculty at these institutions tend to have research as their primary concern, not teaching. However, the universities that make up the consortium have teaching as the faculty's primary responsibility and this reality conflicts heavily with the needs of a robust PhD program. A PhD program is mostly about research, but for the faculty at the consortium campuses 60-70% of their time is dedicated to teaching. Consequently, the majority of the faculty in the consortium view PhD work as "above and beyond" their normal duties. It also means that the culture and the expectations of the faculty and the university's administration tend to be undergraduate in nature. Our PhD program is

one of the larger graduate programs on campus, but it is difficult to get faculty and the administration to make it a priority.

Finally, we are clearly challenged by the delivery of distance education and the various realities of working with doctoral students at a distance. For my purposes here, I'm going to ignore the logistical realities of delivering courses online. I would like to focus my attention simply on working with individuals who do not have face-to-face contact with their faculty, and especially their advisor. Most of our students are employed and are trying to make time to take courses in the degree program. Life often gets in the way, and many of our students find it difficult to complete the degree requirements in a timely fashion. However, becoming a doctor isn't just about taking courses; it is about becoming a scholar, a responsible autonomous professional. This isn't easy and doesn't necessarily occur simply because one takes a bunch of distance courses, passes an examination, and completes a dissertation. We are challenged to find a ways that will support deeper levels of interaction so that our candidates can be successful in thinking and acting as scholars. And again this conference is an effort in that direction.

When I became dean, the very first person to come to my office for a meeting was a senior faculty member close to retirement. He sat down, looked at me and asked, "Why should I care about graduate education and research? " He really took me by surprise, and I responded that I didn't understand the question. As I listened, I came to realize that what he was really saying was that his job had nothing to do with graduate education and research. He viewed his work as teaching classes and serving on committees. It turned out that he was one of the faculty members who once tenured had eliminated research from his agenda. I told him that I stayed involved in graduate education because I need to surround myself with quality students who could help me do my work, as I in turn helped them become what they were trying to become. In other words research and graduate education has always been central to my perspective of being a scholar, but it is not the perspective of most of my colleagues. We cannot have a robust PhD program, if we do not have robust faculty who have an area of current expertise, and who have the time to engage in personal research so that they can involve graduate students in that agenda; and perhaps even generate a little grant money to actually support graduate students with tuition and fee waivers.

Recently, I suggested to our dean that we have reached a point in our development as a college and as a program that we can afford to have a few faculty members at each of the consortium campuses who are given a PhD teaching load (i.e., two classes or less per semester) and who have research as their main priority. We will see what the future holds.

I will conclude my presentation with a few suggestions that I believe would enhance our program directly and lead to growth in our recognition

and reputation. As I noted earlier, I believe that we need a great deal of dialogue, with student and faculty input, regarding the essential experiences of the PhD program. Since returning to faculty, I have re-eneergized my research agenda. I am trying to develop a team of researchers by focusing my advisees' attention on research questions, in which I am interested and able to participate. It is often the case that doctoral candidates have not adequately mastered the literature to be able to identify an appropriage research topic. The faculty have typically immersed themselves in the literature for many years and are in a key position to guide future research. I am not talking about abusing graduate students for personal gains. In my opinion that is unethical. What faculty provide students far exceeds a return on investment for the tuition paid. It works best when it is a mutually beneficial relationship.

Another issue worth immediate attention is expanding our revenue stream for the program. To my knowledge only Indiana State University and one other in the consortium received funding directly for the program. At the outset, Indiana State University requested an increase of $400,000 in annual appropriations from the state. Our request was denied. However, the university administration provided an infusion of internal funds. The amount was reduced annually to a low of $12,500. Currently, the funding at Indiana State University is about $22,500. This amount is barely sufficient to operate the PhD director's office with nothing available for faculty stipends, travel, conferences. A more robust revenue stream is clearly needed.

Finally, significant effort is needed to continue to develop the program's reputation as a quality doctoral experience. There are a number of ways this can be accomplished. At the very least, effort is needed to collect and communicate the accomplishments of the faculty and students. There is definitely no value in being "the best kept secret."

I thank you for the opportunity to address this fine group of scholars and will be glad to answer your questions.

Contents

The design of Intelligent parking lock system based on Android phone

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This paper is mainly about the design of intelligent parking lock system based on Android phone. The system includes parking lock hardware and "intelligent parking lock" App. The hardware communicate with the App through Bluetooth. The system realizes the operation of register, connect, lock, unlock, share and so on. Intelligent parking lock system has characteristic of simple operation, low cost. So it has a great potential for future application.

Keywords: Intelligent parking lock; Android phone; App; Bluetooth.

1. Introduces

With the development of economy, car is one of the most popular way of transport for people. However, many cities have problems with not enough parking. People search various methods to avoid this problem. Intelligent parking system is one of the best methods. We designed an intelligent parking system which allows the driver to find and reserve empty spaces using their phone without having to drive around and waste time. The entire intelligent parking system involves several components. In this paper, we introduce the design and function of the intelligent parking lock system based on Android phone.

2. Structure of intelligent parking lock

The intelligent parking lock based on Android phone contains two parts: parking lock hardware and Android App which named "intelligent parking

lock". The Android App communicate with the parking lock hardware through Bluetooth. The block diagram of intelligent parking lock is shown in figure1.

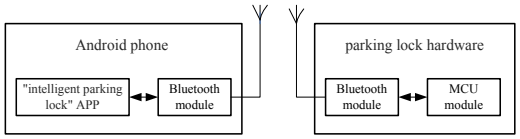

Fig. 1. The block diagram of intelligent parking lock

This intelligent parking lock system can only be used in Android mobile phone. It is short-range wireless communication, and it also can be used without Internet.

3. The design of parking lock hardware

The parking lock hardware contains Bluetooth module, MCU, reset circuit, clock circuit, power circuit, indicator circuit, relays and electromagnetic locks. Figure2 shows the block diagram of parking lock hardware.

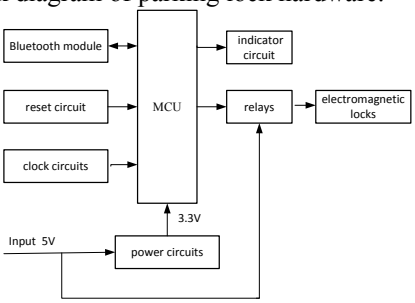

Fig. 2. The block diagram of parking lock hardware

The main task of power circuit is to convert 5V input voltage into 3.3V output voltage through ASM1117. 3.3V voltage is necessary to MCU. The reset circuit is to restore the MCU to its original state. The MCU can reset not only by reset circuit but also by a high level signal when it power up. The indicator circuit is to indicate whether the system is working properly. It use timer to check whether it is working per 2 seconds. If the system works well, the led will flashing. If it is not work, the led will not flashing. In the proper operating condition, the Bluetooth module of parking lock hardware receive the command from the "intelligent parking lock" App. The MCU read it and then control relays to realize the operation of register, connect, locking, unlock, share and so on.

The MCU of the parking lock hardware is STC12LE5A60S2, STC12C5A60S2 is a single-chip microcontroller based on a high performance 1T architecture 80C51 CPU. The flow of working shows figure 3.

(1) The system power on, it will operate initialization process, including setting timer working mode and initial value, setting serial port working mode and baud rate;

(2) It will check whether the system works well, if it is not, the system will be reset;

(3) It will check whether the MCU receiver the command from App. If not, it will return to (2);

(4) It will check whether the password is correct. If it is incorrect, the system will check whether the user is registered. If it is, it will return to (2). Otherwise, the system will request to reregister;

(5) The MCU read the command, and realize the operation of locking, unlock, share and so on.

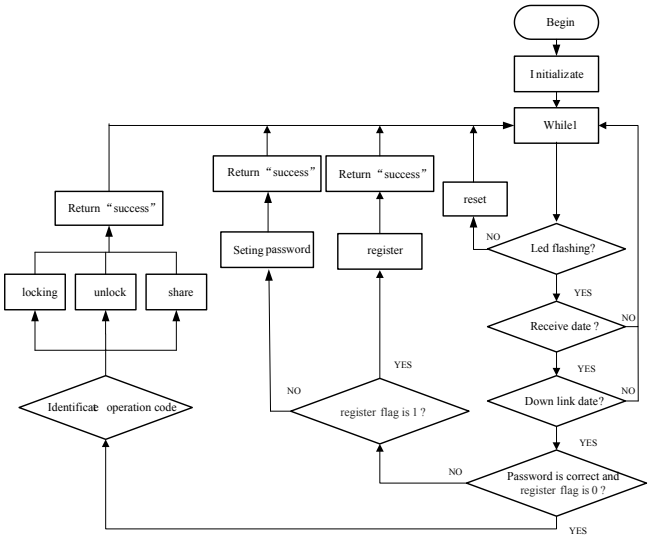

Fig. 3. The flow of MCU working

4. The design of "intelligent parking lock" APP

Android is an open smart phone platform based on Linux with strong portability and maneuverability. Android is a completely open system, anyone and any department can download the free source code to design the phone system. Bluetooth, have been integrated into Android as way of mobile communication, provide wireless connection communication between mobile

devices and their accessories with low power and cost. The design of "intelligent parking lock" APP based on Android platform. The "intelligent parking lock" APP can communicate with the parking lock hardware through Bluetooth. It can realize operation of register, connect, locking, unlock, share. Figure 4 shows functions of "intelligent parking lock" APP.

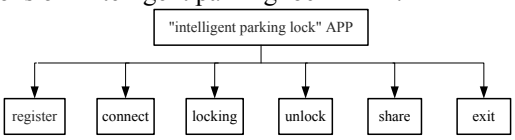

Fig. 4. Functions of "intelligent parking lock" APP

The "intelligent parking lock" APP adopts a three-tiered architecture, consisting of startActivity, Service, Bluetooth. The user-interface is startActivity. The back end is Bluetooth integrated into Android phone, which is apply to communication with parking lock hardware. The user-interface connect to Bluetooth using Service, which is one of the major components of Android. Figure 5 shows software architecture of "intelligent parking lock" APP.

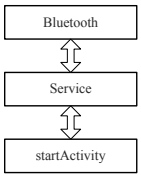

Fig. 5. Software architecture of "intelligent parking lock" APP

4.1. *The design of user-interface*

The design of user-interface adopts a linear layout. The layout will occupy the entire screen area, and the direction is vertical. It use <Textview/> to add text “welcome to use “intelligent parking lock" APP”. It use <Button/> to add six buttons, which named register, connect, locking, unlock, share, exit. It use <EditText/> to add text box, the aim of the text box is to fill in the new password. Figure 6 shows user-interface.

Fig. 6. User-interface

4.2. *Bluetooth communication*

Android phone communicate to parking lock hardware through Bluetooth module. Bluetooth communication depend on Bluetooth API in Android SDK, including BluetoothAdapter class、BluetoothDevice class、BluetoothServerSocket class, and so on. Bluetooth communication includes search, connection. Bluetooth module use Bluetooth adapter search Bluetooth device, then use socket to pair and connect Bluetooth devices. Figure 7 shows search and connection of Bluetooth.

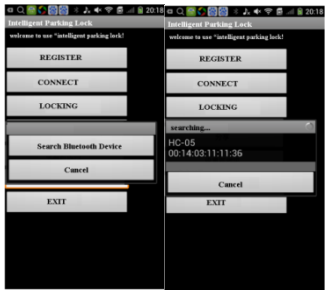

Fig. 7. Search and connection of Bluetooth

In development of Android APP, it needs to apply for authority when we use Bluetooth. It needs to write the following code in the AndroidManifest.xml file.

```
< uses – permission android : name = "android.permission.BLUETOOTH_ADMIN" / >
< uses – permission  android : name = "android.permission.BLUETOOTH" / >
```

Before search, it needs to get local BluetoothAdapter, which is the Bluetooth in Android phone. It gets BluetoothAdapter through getDefaultAdapter() in BluetoothAdapter class. It needs to create BluetoothAdapter member variable in BTClient.java:

```
private BluetoothAdapter_bluetooth = BluetoothAdapter.getDefaultAdapter();
```

When it begins to search, if it found Bluetooth device, the system will sent Broadcast command, and save the name and MAC address. The main code of searching Bluetooth device as the following codes:

```
private final BroadcastReceiver mReceiver = new BroadcastReceiver() {
        @Override
        public void onReceive(Context context, Intent intent) {
            String action = intent.getAction();
            if (BluetoothDevice.ACTION_FOUND.equals(action)) {
                BluetoothDevice device =
intent.getParcelableExtra(BluetoothDevice.EXTRA_DEVICE);
                if (device.getBondState() != BluetoothDevice.BOND_BONDED) {
                    mNewDevicesArrayAdapter.add(device.getName() + "\n" +
device.getAddress());
                }else ...
```

Bluetooth devices connection requires a unified UUID (Unique Identifier Universally), which used to Bluetooth pairing. UUID setting as the following:

```
private final static String MY_UUID = "00001101-0000-1000-8000-00805F9B34FB";
```

The connection of Bluetooth devices requires to distinguish master device or slave device. In this system, Bluetooth of Android phone is master device, Bluetooth of parking lock hardware is slave device. It needs to add "OnItemClickListener" event in device list. It realizes devices connection through choice the device in device list. The main code of connection Bluetooth devices as the following:

```
private OnItemClickListener mDeviceClickListener = new OnItemClickListener() {
    public void onItemClick(AdapterView<?> av, View v, int arg2, long arg3) {
        mBtAdapter.cancelDiscovery();
        String info = ((TextView) v).getText().toString();
        String address = info.substring(info.length() - 17);
        Intent intent = new Intent();
        intent.putExtra(EXTRA_DEVICE_ADDRESS, address);
        setResult(Activity.RESULT_OK, intent);
        finish();
    }
};
```

4.3. *The realization of locking and unlock*

The realization of locking and unlock depend on Bluetooth communication. Data format of Bluetooth communication shows table 1. One frame is 10 bytes. Table 2 shows description of Bluetooth data.

Table 1. Format of Bluetooth data

Frame head	Flag	Data flow	Operation code	password	Frame trail
1 byte	1 byte	1 byte	1 byte	4 byte	2 byte

Table 2. Description of Bluetooth data

Name	description
Frame head	0X7F
Flag	0X60:success，0X06:default
Data flow	0X15: date from APP to parking lock hardware; 0X16 date from parking lock hardware to APP
Operation code	0X31:locking;0X32;unlock;0X33:register
password	4 bits only for data
Frame trail	0X0D 0X0A

The way of obtaining output and input data stream of Bluetooth communication depend on "BluetoothSocket "class. It use the code of "InputStream in=_socket.getInputStream ()" to get input data. And it use the code of "OutputStream out=_soket. getOutputStream ()" to get output data. When it unlock, the Bluetooth module of Android phone will transmit "0X7F

0X60 0X15 0X32 0X31 0X32 0X33 0X34 0X0D 0X0A" to Bluetooth module of parking lock hardware through command of "write()" in "OutputStream". Bluetooth module of parking lock hardware receive the data of "0X7F 0X60 0X15 0X32 0X31 0X32 0X33 0X34 0X0D 0X0A", and then put the data to MCU. The MCU will know the meaning of the data, and then unlock the mechanical lock . After unlock, the MCU will return "success" command. It will be encapsulated the data of "0X7F 0x60 0X16 0X32 0X31 0X32 0X33 0X34 0X0D 0X0A", and transmit to Bluetooth module of Android phone. It will read and analysis of data through command of "read()" in "IutputStream". "success unlock " display in the user-interface. In addition to data, the processes of locking is mainly same to unlock. Bluetooth module of Android phone will transmit "0X7F 0X60 0X15 0X31 0X31 0X32 0X33 0X34 0X0D 0X0A" and receive "0X7F 0X60 0X16 0X31 0X31 0X32 0X33 0X34 0X0D 0x0A" when it is locked. Figure 8 shows user-interface of lock and unlock.

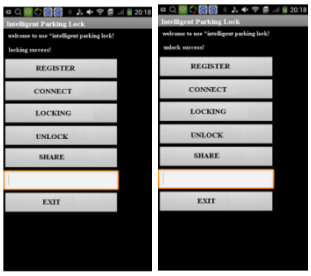

Fig. 8. Lock interface and unlock interface

5. Conclusion

This paper presents the design of intelligent parking lock system based on Android phone. Intelligent parking lock system includes parking lock hardware and "intelligent parking lock" App. The APP communicates with parking lock hardware through Bluetooth. The Intelligent parking lock system can realize to register, connect, lock, unlock, share, exit. Intelligent parking lock system has characteristic of simple operation, low cost. So it has a great potential for future application.

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Performance Analysis of a Forensics Distributed Processing Array on Different Evidence Image Sizes[i]

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As drive sizes increase at a relentless rate in desktop systems it has become far more time consuming to process the data sets for the forensic examiner (Marziale, 2007). The advent of cloud computing and the significant size of data queries in e-discovery litigation has also significantly impacted the processing times for cases in the digital forensics field (Reilly, Wren, & Berry, 2010). Distributed processing (Thompson, 2007) will likely become the primary method to process evidence in digital forensics due to these increasingly problematic conditions. Regional forensics labs are also growing more dependent on internal SANs to meet data storage and retention requirements. Distributed processing forensics environments are extremely demanding in input/output (I/O) requirements for evidence servers. This experiment seeks to determine if a Distributed Processing Array in a SAN based evidence server configuration can provide the expected categorized performance gains in typical regional laboratory environments.

Keywords: Digital Forensics; Distributed Processing; Cloud Forensics.

1. Introduction

1.1. *Overview*

The research conducted in this study is primarily focused on arrays that use a SAN for evidence storage rather than a local evidence drive. Regional lab managers are generally open to distributed processing but the gains for large cases need to justify the effort while smaller cases should not receive a performance penalty. Those familiar with distributed processing environments in forensics are aware that small cases less than 30,000 artifacts (typically from mobile devices or flash drives) are often perceived as slower or equal in processing times to that experienced on a stand-alone machine. However, since the processing time is very short typically there are still several reasons distributed processing or SAN evidence storage is preferred by some labs. One reason is that security of the

evidence image is maintained in one place and usually done by infrastructure specialists, freeing the examiner from this task. Security in this case is not merely referring to ensuring authorized access but also long term availability. The original evidence often goes into an evidence room, the analysis image stays on the SAN for long term storage with functional backups occurring. For medium and larger cases the availability of the SAN and the distributed processing model should not only provide security and availability advantages but also show a decrease in processing times. This research attempts to validate and quantify this assumption.

Because it is recognized that image size has varying results with distributed processing arrays the drive images tested were divided into three categories based on input from an advisory board based upon their relative size and artifact count. Image files in the 1 MB to 4 GB size will be considered "small" images. Images greater than 4GB and up to 100 GB will be considered medium images. Images over 100 GB up to 1TB will be considered large images.

1.2. *Research Questions*

There were three primary research questions in this experiment.

(1) Would the SAN based Distributed Processing array process small drive images (1MB to 4GB) slower than typical stand-alone forensics system?

Ho1: Ptime DPA ≤ Ptime Stand-Alone. The Processing Time for the Distributed Processing Array is less than or equal to processing time for small images on a stand-alone machine. (Ptime is processing time)

Ha1: Ptime DPA > Ptime Stand-Alone. The Processing Time for the Distributed Processing array is greater than a stand-alone machine for small images.

(2)Would the SAN based Distributed Processing array process medium size images (over 4 GB to 100 GB) consistently faster than a typical stand-alone forensics system?

Ho2: Ptime DPA ≥ Ptime Stand-Alone. The processing time for medium sized images is greater than or equal to when SAN based distributed processing arrays are compared to stand-alone systems.

Ha2: Ptime DPA < Ptime Stand-Alone. The processing time for medium sized images is less when SAN based distributed processing arrays are compared to stand-alone systems.

(3)Would the SAN based Distributed Processing array process large size images (over 100GB) at least two times faster than a typical stand-alone forensics system?

Ho3: Ptime DPA ≥ .5 x Ptime Stand-Alone. The processing time for large sized images is not at least 2 times lower when SAN based distributed processing arrays are compared to stand-alone systems.

Ha3: Ptime DPA < .5 x times Ptime Stand Alone. The processing time for larger sized images are at least 2 times lower when SAN based distributed processing arrays are compared to stand-alone systems.

2. Experimental Design

The experimental design for this study consists of single prototypical stand-alone machine described below and a prototypical distributed processing array also described below. A variety of case sizes/images were processed by each method respectively and the results were compared. The methodology for this study uses a fixed base hardware configuration (processor, RAM and chipset) for each machine and a variety of evidence images taken from suspect drives. The first phase of the experiment tested a variety of evidence drive images in terms of processing times. The stand-alone machine was a former front line forensics examination machine with a P7 processor, X58 chip-set, 8GB RAM and a 7200 RPM velociraptor hard drive measured at 600 IOPS (4K block, 50% read/write, 20GB file size). The software used for case processing was Forensic Tool Kit (FTK) 5.5. (processing options in FTK were “MD5 Hashing”, “no KFF”, expansion of compound files, flag bad extensions, create thumbnails for graphics, include deleted files and full indexing). Each of the test images were processed and the results of this processing can seen in Tables 1, 2 and 3. An important note to reiterate here is that the SAN involved in this project does not use RAID 5 arrays. Fault tolerance must be achieved through RAID 10 or similar concepts. Striping performance is critical to distributed processing and RAID 5 parity calculations limit drive I/O to unacceptable levels.

The second phase performed processing on same image drives using a distributed processing array which added three additional worker machines, a database server, a case server, and moved the evidence file to SAN based storage. All machines in the distributed processing array were identical to the stand-alone machines. The SAN used for evidence storage is configured as a 6 drive stripe array with measured performance (IOMETER) of 1945 IOPS (4K block, 50% read/write, 20GB file size). The SAN is logically connected to processing machines through an iSCSI connection scheme to allow block level I/O access. Each of the test images (same images as the stand alone test) were processed and the results of this processing can seen in Tables 1, 2 and 3.

The evidence images used are identical for both the stand-alone and distributed array to allow a more exact comparison (Levine, Stephan, Krehbiel, & Berenson, 2011). As this was a single factor experiment each of the three hypothesis could be tested by a paired t-test. As long as the sample size is not unduly small and there is not a significant skew in the differences the paired t-test method is acceptable. As will be discussed later the results of all comparative runs were approximately normally distributed with less than moderate skew. The level of significance is set at α=.05 for all processes. All paired t-tests were performed as lower tail tests.

3. Results

The first processing runs performed were those with small images. The results of the small image experiment box plot show (see Figure 1) no significant departure from normality for either method. The difference between each case (stand alone time – DPA time) is also normally distributed (a paired t-test assumption) as assessed by Shapiro-Wilk's test (p =.494).

Processing time was not significantly different for small images between the DPA array (M = 105.6s, SD = 55.19s) and a stand-alone machine (M = 106.79s, SD = 60.6s) a non-significant mean decrease of 1.14 seconds, $t(13) = .605$, p=.556.

This result indicates the null hypothesis should not be rejected. This is advantageous from the DPA perspective as it is desired that the DPA would not show statistical evidence of being slower than a stand-alone machine when small images are processed which was a concern due to the overhead imposed by the DPA.

The medium sized images were investigated next using a similar methodology (units for processing time in medium and large images are in minutes). The results of the medium image experiment box plot show (see Figure 2) no significant departure from normality for either method. The difference

between each case (stand alone time – DPA time) is also normally distributed (a paired t-test assumption) as assessed by Shapiro-Wilk's test (p =.152).

Processing time was significantly different for medium images between the DPA array (M = 66.91m, SD = 33.22m) and a stand-alone machine (M = 108.70m, SD = 71.7m) a significant mean decrease of 41.78 minutes, $t(12) = 2.887$, p=.014.

This result indicates the null hypothesis should be rejected and the alternate hypothesis (the DPA is faster) accepted.

The large images were investigated next using a similar methodology (units for medium and large images was taken in minutes). The results of the large image experiment box plot show (see Figure 3) no significant departure from normality for either method. The processing time of the stand-alone array were each divided by two for comparison as it was desired to test to see if the DPA was at least twice as fast stand alone machines for large images. This was a study objective. The difference between each case (stand alone time/2 – DPA time) is also normally distributed (a paired t-test assumption) as assessed by Shapiro-Wilk's test (p =.703).

Processing time was significantly different for large images between the DPA array (M = 501.27m, SD = 189.32m) and .5*stand-alone machine (M = 948.33m, SD = 464.13m) a significant mean decrease of 447.067 minutes, $t(14) = 5.86$, p<.001. This result indicates the null hypothesis should be rejected and the alternate hypothesis (the DPA is at least 2x faster) accepted.

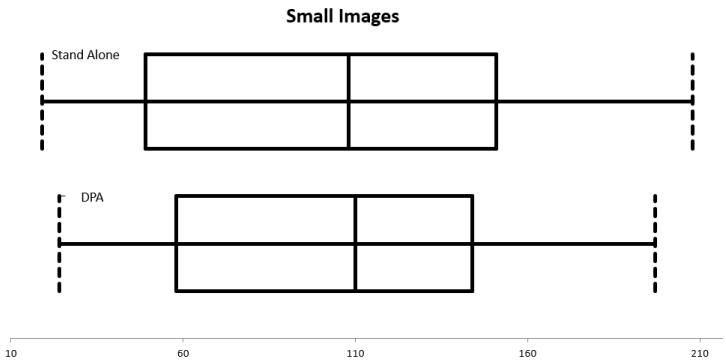

Figure 1: Small Images Processing Times Box Plots

□

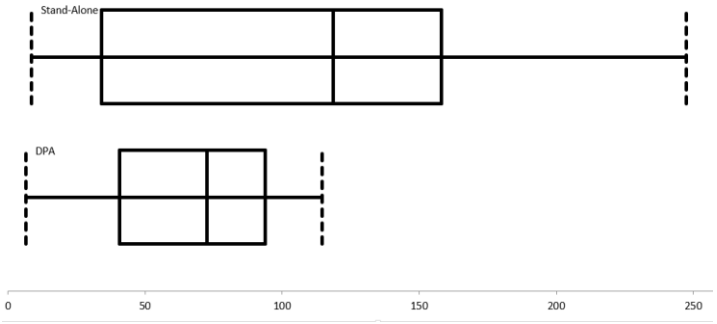

Figure 2: Medium Image Processing Times Box Plots

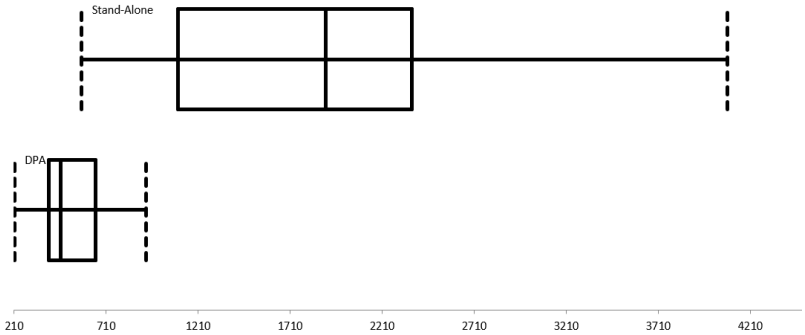

Figure 3: Large Image Processing Times Box Plots

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Spectrum sensing algorithm using double eigenvalue and energy distribution

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In accordance with that the threshold of the spectrum sensing algorithm(DMM) of difference between maximum eigenvalue and minimum eigenvalue is related to noise energy, a spectrum sensing algorithm(DED) using double eigenvalues and energy distribution is proposed. The ratio of the difference between maximum and minimum eigenvalue and the energy of received signal is used as decision statistics. The decision threshold is obtained by utilizing energy distribution and limited values of the maximum eigenvalue and minimum eigenvalue. Theory analysis and simulation results in the additive Gaussian channel show that, the threshold of DED algorithm is not related to noise energy, but its performances have regard to cooperation users numbers and sample numbers. And DED algorithm is better than DMM and DEL, and it can obtain high detection probability under low false probability.

Keywords: Spectrum Sensing, Random Matrix Theories (RMT), Maximum Eigenvalue, Minimum Eigenvalue, Energy.

1. Introduction

Spectrum sensing is one of the key technologies of cognitive radio (CR) [1], which has been extensively researched. There have been several narrow band sensing algorithms including the energy detection, the matched filtering and cyclostationary detection. However, they all have shortcomings. For example, energy detection can be influenced by the uncertainty of noise power [2], and the detection capability to weak signal is undesirable. On the other hand, both cyclostationary detection and matched filtering require the prior information of primary users (PU) [3,4]. To overcome those shortcomings, the spectrum sensing

technology based on random matrix theories (RMT) has attracted people's attention [5]. Researchers have proposed many spectrum sensing algorithms based on RMT, like maximum eigenvalue detection(MED) algorithm[6], maximum-minimum eigenvalue algorithm(MME)[5], difference between maximum eigenvalue and minimum eigenvalue (DMM) algorithm[7] and cooperative spectrum sensing based on double eigenvalue limitation distribution (DEL) algorithm[8]. The performance of DMM is better than MME and MED. DMM takes the difference of maximum eigenvalue and minimum eigenvalue of sample covariance function as decision statistics. The decision threshold is obtained by using the maximum eigenvalue probability distribution and the limit of minimum eigenvalue. The decision threshold of DMM is related to noise power. The decision statistics of DEL is the same as DMM. DEL uses double eigenvalue limitation distribution to get the decision threshold, and can perform better than DMM. Furthermore, in order to reduce the influence of noise to DMM and DEL, in this paper, a spectrum sensing algorithm of using double eigenvalue and energy distribution (DED) is proposed. This algorithm takes the ratio of the difference between maximum eigenvalue and minimum eigenvalue and the energy of received signals as decision statistics, and decision threshold is obtained by using the averaged energy distribution feature and the limitation of maximum-minimum eigenvalue, which has no relations with noise.

2. DED algorithm analysis

2.1. *Signal model*

Assuming in a cognitive radio system, M cognitive users (CU) enter sensing process. Let $x_i(k)$ be the received signal, $s_i(k)$ be the signal transmitted by PU and $w_i(k)$ be the noise of the ith CU in time k. The received signal vector、noise vector and signal vector of PU sampled by the ith CU are $\boldsymbol{x}_i = [x_i(1) \quad x_i(2) \cdots x_i(N)]^H$ 、 $\boldsymbol{w}_i (i = 1,2,\cdots,M)$ and $\boldsymbol{s}_i$, respectively, N represents the number of sampling points. Define the above signals as following:

$$\boldsymbol{X} = [\boldsymbol{x}_1 \quad \boldsymbol{x}_2 \ldots \quad \boldsymbol{x}_M]^{\mathrm{H}} \tag{1}$$

$$\boldsymbol{W} = [\boldsymbol{w}_1 \quad \boldsymbol{w}_2 \ldots \quad \boldsymbol{w}_M]^{\mathrm{H}} \tag{2}$$

$$\boldsymbol{S} = [\boldsymbol{s}_1 \quad \boldsymbol{s}_2 \ldots \quad \boldsymbol{s}_M]^{\mathrm{H}} \tag{3}$$

where, $[.]^H$ represents matrix conjugate transposition; $\boldsymbol{X}$ represents received signal matrix of M CUs, $\boldsymbol{W}$ represents noise vector matrix, $\boldsymbol{S}$ represents signal

matrix of PUs. So, received signal $\boldsymbol{X}$ [9] can be depicted as following form:

$$\boldsymbol{X} = \boldsymbol{S} + \boldsymbol{W} \tag{4}$$

where, $\boldsymbol{W}$ is Gaussian White Noise (GWN) with mean zero and variance σ_n^2.

Hypothesis H_1 represents the presence of PU, hypothesis H_0 represents the absence of PU, and then the narrow-band spectrum sensing problems can be depicted as a binary hypothesis test problem.

$$\boldsymbol{X} = \begin{cases} \boldsymbol{W} & H_0 \\ \boldsymbol{W} + \boldsymbol{S} & H_1 \end{cases} \tag{5}$$

Assuming PU signals are statistically independent of noise, the covariance matrix of received signals is

$$\boldsymbol{R}_{\mathrm{x}} = E\left(\boldsymbol{X}\boldsymbol{X}^H\right) = \boldsymbol{R}_{\mathrm{s}} + \boldsymbol{R}_{\mathrm{w}} = \boldsymbol{R}_{\mathrm{s}} + \sigma_{\mathrm{n}}^2 \boldsymbol{I}_M \tag{6}$$

where, $\boldsymbol{R}_{\mathrm{s}} = E\left(\boldsymbol{S}\boldsymbol{S}^H\right)$, $\boldsymbol{R}_{\mathrm{w}} = E\left(\boldsymbol{W}\boldsymbol{W}^H\right)$, $\boldsymbol{I}_M$ is unit matrix. Define sampling covariance matrix of $\boldsymbol{X}$ as follow:

$$\hat{\boldsymbol{R}}_{\mathrm{x}}(N) = \boldsymbol{X}\boldsymbol{X}^H / N \tag{7}$$

Assuming signal and noise are stable ergodic, so when $N \to \infty$, the statistic average of signal covariance matrix equals sampling average, that is $\boldsymbol{R}_x = \hat{\boldsymbol{R}}_{\mathrm{x}}(N)$, $\boldsymbol{R}_{\mathrm{s}} = \hat{\boldsymbol{R}}_{\mathrm{s}}(N)$, $\boldsymbol{R}_w = \hat{\boldsymbol{R}}_w(N)$。

2.2. *Rules of detection*

Let $\lambda_{\mathbf{max}}$ and $\lambda_{\mathbf{min}}$ respectively represent the maximum eigenvalue and minimum eigenvalue of matrix $\hat{\boldsymbol{R}}_{\mathrm{x}}(N)$, $\rho_{\mathbf{max}}$ and $\rho_{\mathbf{min}}$ respectively represent the maximum eigenvalue and minimum eigenvalue of matrix $\hat{\boldsymbol{R}}_{\mathrm{s}}(N)$. So, the binary hypothesis test of Eq. (5) can be depicted as:

$$\lambda_{\max} - \lambda_{\min} = \begin{cases} 0 & H_0 \\ \rho_{\max} - \rho_{\min} & H_1 \end{cases} \tag{8}$$

In order to reduce the influence of noise to threshold, and improve the performance of spectrum sensing, a decision statistics is proposed in this paper, which is a ratio of the difference between maximum eigenvalue and minimum eigenvalue and the energy:

$$\mathrm{T}_{\mathrm{DED}} = \frac{\lambda_{\max} - \lambda_{\min}}{E_x(N)} \tag{9}$$

When $\mathrm{T}_{\mathrm{DED}} = 0$, hypothesis H_0 is true; when $\mathrm{T}_{\mathrm{DED}} > 0$, hypothesis H_1 is true. Due to the influence caused by noise and eigenvalue estimation error, the detection threshold cannot be 0. As a result, the decision rule of DED algorithm is:

$$T_{DED} \underset{H_0}{\overset{H_1}{\gtrless}} \gamma \tag{10}$$

2.3. *Detection threshold*

The threshold is determined when a false alarm probability is fixed. At hypothesis H_0 , when sampling number N is very large, average energy $E_x(N) = \frac{1}{M}\sum_{i=1}^{M}[\frac{1}{N}\sum_{n=1}^{N}|x_i(n)|^2]$ obeys Gaussian distribution whose mean is σ_n^2 , variance is $\frac{2\sigma_n^4}{NM}$. As follows:

$$\mathrm{E_x(N)} \sim \mathrm{N}\left(\sigma_n^2, 2\sigma_n^4 / NM\right) \tag{11}$$

When the threshold is γ , false alarm probability $\mathrm{P_f}$ may be obtained as follows:

$$\begin{aligned} \mathrm{P}_f &= \Pr\left(T_{DED} > \gamma \,|H_0\right) = \Pr\left(\frac{\lambda_{\max} - \lambda_{\min}}{E_{\mathbf{x}}(N)} > \gamma \,|H_0\right) \\ &= \Pr\left(\frac{E_{\mathbf{x}}(N) - \sigma_n^{\,2}}{\sqrt{\frac{2}{MN}}\sigma_n^{\,2}} < \frac{\lambda_{\max} - \lambda_{\min} - \sigma_n^{\,2}\gamma}{\sqrt{\frac{2}{MN}}\sigma_n^{\,2}\gamma}\right) \end{aligned} \tag{12}$$

When PU signal is absent, sampling covariance matrix is Wishart random matrix and the joint probability density function equation of Wishart random matrix is very complicated. Using the asymptotic theory, the limitation of maximum eigenvalue and minimum eigenvalue of Wishart[10] random matrix can be depicted as:

Theorem 1: *According to M-P law, when* $\lim_{N\to\infty}\frac{M}{N} = c(0 < c < 1)$

$$\lim_{N\to\infty}\lambda_{\min} \approx \sigma_n^2\left(1-\sqrt{c}\right)^2 = \frac{\sigma_n^2}{N}\left(\sqrt{N}-\sqrt{M}\right)^2 \tag{13}$$

$$\lim_{N\to\infty}\lambda_{\max} \approx \sigma_n^2\left(1+\sqrt{c}\right)^2 = \frac{\sigma_n^2}{N}\left(\sqrt{N}+\sqrt{M}\right)^2 \tag{14}$$

Where, $\Phi(x) = \int_{-\infty}^{x}\frac{1}{\sqrt{2\pi}}exp\left(-\frac{t^2}{2}\right)dt$, $erfc(x) = \int_{x}^{\infty}\frac{2}{\sqrt{\pi}}e^{-t^2}dt$.

According to theorem 1,

$$P_f = \Pr\left(\frac{E_x(N) - \sigma_n^2}{\sqrt{\frac{2}{MN}} \cdot \sigma_n^2} < \frac{\frac{4\sqrt{MN}}{N} - \gamma}{\sqrt{\frac{2}{MN}} \cdot \gamma} \right)$$
$$= \Phi\left(\frac{\sqrt{8}M - \gamma\sqrt{\frac{MN}{2}}}{\gamma} \right) = 1 - \frac{1}{2}\operatorname{erfc}\left(\frac{\sqrt{8}M - \gamma\sqrt{\frac{MN}{2}}}{\sqrt{2}\gamma} \right) \quad (15)$$

Given the false alarm probability P_f, the decision threshold of DED can be obtained from the Eq. (16):

$$\gamma_{DED} = \frac{4M}{2\operatorname{erfc}^{-1}\left(2\left(1-P_f\right)\right) + \sqrt{MN}} \quad (16)$$

Summarily, the main steps of proposed DED algorithm are as follows:

(1) According to the given false alarm probability、M and N, decision threshold γ_{DED} is gotten from Eq. (16) ;

(2) According to the N received samples of M sensing users, the sampling covariance matrix $\hat{\boldsymbol{R}}_x(N)$ is obtained;

(3) Applying eigenvalue decomposition to $\hat{\boldsymbol{R}}_x(N)$, maximum eigenvalue λ_{max}, minimum eigenvalue λ_{min} and average energy $E(N)$ are obtained;

(4) The decision statistics T_{DED} is computed from Eq. (9);

(5)When $T_{DED} < \gamma_{DED}$, hypothesis H_0 is true, which means, PU is not existed. Otherwise, H_1 is true, that is to say, PU is existed.

3. Simulations and Performance Analysis

The spectrum sensing performance of DED algorithm, DMM algorithm [7] and DEL algorithm [8] is analyzed and compared in this section. In the simulation experiment, QPSK modulation signal is taken as PU.

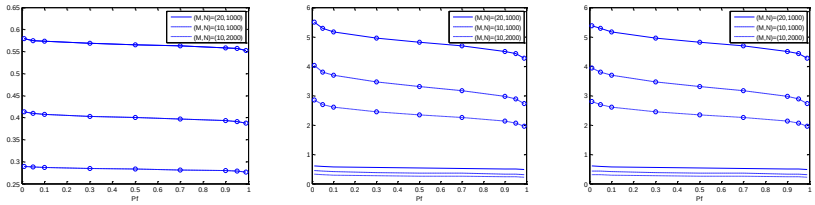
The number of CU is M and sampling number is N, denoted (M,N). When (M,N) is respectively (20,1000), (10,1000), and (10,2000) and noise variance is 1 and 9, the relation curves of threshold and false alarm probability of DED algorithm、DMM algorithm and DEL algorithm is shown in Fig. 1. The solid curve, dotted curve and dashed curve represents the result, respectively, when (M,N) is (20,1000), (10,1000), and (10,2000). The curve with cycle represents the result when noise variance is 9, and the curve without cycle represents the result when noise variance is 1. When P_f varies from 0.01 to 0.1, and (M,N) is respectively (10,1000), (10,2000) and (20,1000), the thresholds ranges of DED、

DMM and DEL are shown in table1. From Fig.1 and table 1 we can see that the threshold of DED is not related to noise variance, the threshold of DMM and DEL is largely influenced by noise variance. When false alarm probability P_f increases, DED threshold decreases slowly, the threshold decreasing rate of DMM and DEL is coherent with noise variance. When N increases or M decreases, the threshold of DED、DMM and DEL decreases.

When false alarm probability $P_f = 0.01$, sampling number N is 1000, M=10、20 and 30, the detection probabilities of three algorithms are shown in Fig. 2, where solid curve、dotted curve and dashed curve represents the result when M is 30、20 and 10，respectively. From the figure we can see that, when N=1000, with the increase of M, the detection probabilities of three algorithms are improved. The performance of DED algorithm is the best, DMM is the worst.

Table 1 Thresholds ranges of three algorithms when P_f varies from 0.01 to 0.1

（M，N）	（10,1000）		（10，2000）		（20,1000）	
σ_n^2	1	9	1	9	1	9
γ_{DED}	(0.407，0.414)	(0.407，0.414)	（0.287，0.290）	（0.287，0.290）	（0.573，0.579）	（0.573，0.579）
γ_{DEL}	(0.410，0.437)	（3.689，3.977）	（0.290，0.314）	（2.608，2.824）	（0.575，0.599）	（5.174，5.395）
γ_{DMM}	(0.410，0.448)	（3.689，4.035）	（0.290，0.316）	（2.608，2.844）	（0.575，0.611）	（5.174，5.497）



(a) DED (b) DMM (c) DEL

Fig. 1 the relation curves of three algorithms thresholds and false alarm P_f

When $P_f = 0.01$、M=20 and sampling number N is 500、1000 and 2000, respectively, the detection probabilities of three algorithms are shown in Fig.3, where solid curve、dotted curve and dashed curve represents the result when N is 2000、1000 and 500, respectively. We find that, when N=1000 and 2000, the performance of DED is the best, DMM is the worst. When N=500, DEL is slightly

better than DED, DMM is the worst. When M is certain, with the increase of N, the detection probabilities of three algorithms are enhanced.

When sampling number N is 1000 and user number M is 20, and false alarm probability P_f is 0.1, 0.01, 0.001 and 0.0001, detection probability curves of DED algorithm are shown in Fig. 4(a), when false alarm probability P_f is respectively 0.1, 0.01 and 0.05, detection probability curves of DMM algorithm and DEL algorithm are shown in Fig.4(b) and Fig.4(c), respectively. From figure 4 we can see that, when the false alarm probability decreases from 10^{-1} to 10^{-4}, the detection probability of DED algorithm reduces within 15%.

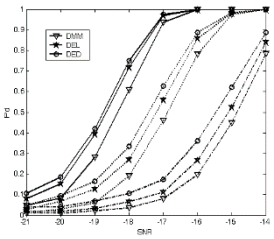


Fig. 2 performance of algorithms: M=20

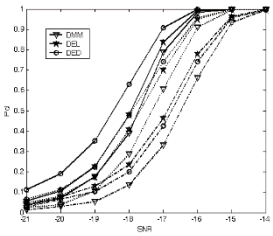
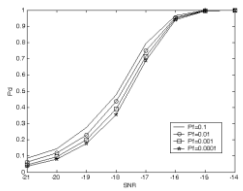


Fig. 3 performance of algorithms: N=1000

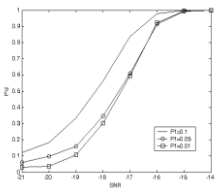
When false alarm probability decreases from 10^{-1} to 10^{-2}, the decreasing of detection probability of DMM and DEL is beyond 25%. So DED algorithm can achieve high detection probability while keeping a low false alarm probability.

4. Conclusion

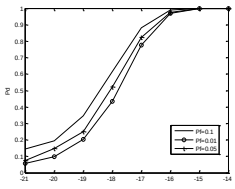
The ratio of the difference between maximum eigenvalue and minimum eigenvalue and the energy is taken as detection statistics of the proposed spectrum sensing algorithm (DED), and the decision threshold is obtained by using double eigenvalues and energy distribution in this paper. The decision threshold is not related to noise. The result of simulation shows that, the performance of this algorithm is better than DMM algorithm and DEL algorithm. When false alarm probability decreases from 10^{-1} to 10^{-4}, detection probability of DED decreases within 15%, which means, DED algorithm can achieve high detection probability while keeping low false alarm probability.



(a) DED algorithm



(b) DMM algorithm



(c) DEL algorithm

Fig.4 the variance of three algorithms detection probability along with false alarm

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Network Security and Next-Generation Firewalls

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As security becomes a more critical aspect of any organization's Information Technology (IT) strategy, a major step is the move away from traditional network firewalls to next-generation firewalls (NGFW). Traditional firewalls control traffic at an entry or exit point within a network using either stateless or stateful methods. The defining characteristic of a next-generation firewall is the ability to identify and control traffic at the application layer. Whereas traditional firewalls monitor specific applications running on specific ports, NGFWs monitor traffic on all network layers and make determinations as to what type of traffic is being sent and received. This paper will cover some of the basic differences between traditional firewalls and NGFW technology.

Keywords: Next-Generation Firewall; Stateful Packet Inspection; Application Aware; Cloud Computing.

1. Introduction

Cloud computing is emerging as a commercial infrastructure that eliminates much of the overhead of maintaining traditional computing hardware and assets. In recent years, cloud computing has revolutionized how information is processed by providing a scalable, cost-effective and efficient technology platform. From a technology management standpoint, cloud computing offers additional computing power and more storage at a low cost. A study by Market Research Media states that the global cloud computing market is expected to grow at a 30% Compound Annual Growth Rate (CAGR) reaching $270 billion in 2020 [1]. However, the characteristics that make cloud computing so powerful also make cloud-based crimes and attacks on clouds and their users more difficult to prevent and investigate [2]. While cloud technology provides a distinct competitive advantage to many organizations, a recent report found that 52 percent of large companies and one-third of small and medium businesses are not moving to the cloud because of security concerns [3].

2. Traditional Firewalls

One of the most important tools for network protection is the firewall. As shown in Figure 1, a firewall is a combination of hardware and software that is placed between the organization's private internal networks and distrusted external networks such as the Internet, and controls the flow of incoming and outgoing network traffic.

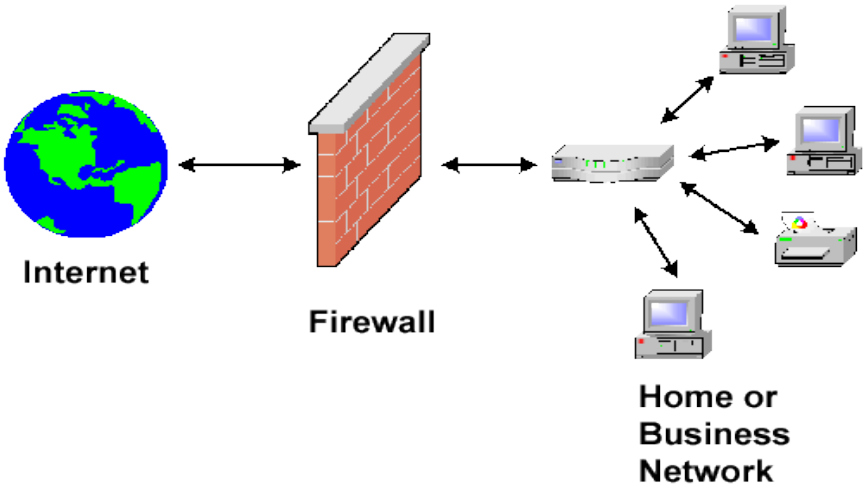

Fig. 1. Firewall Architecture

Firewalls can be divided into four major processing-mode categories: First Generation, which looks at the source and destination addresses, ports and services requested; Second Generation, which looks at the state and context of packets; Third Generation, which acts as a middleman between communicating systems by breaking the session and re-establishing a new session to each system; and Fourth Generation, which looks deep into packets and makes granular access control decisions based on packet header and payload [4]. There are many firewall screening technologies including packet filtering, stateful inspection, application proxy filtering, deep packet inspection (DPI), and intrusion detection systems. Whereas the traditional firewall architecture focused on blocking ports and IP addresses, the growth of Internet usage and increased accessibility to account information, names, passwords and proprietary data has necessitated a firewall architecture that can not only

perform deep packet inspection but can also evaluate the data coming into the network at the application layer of the OSI model [5]. Figure 2 shows a comparison between some of the major firewall manufacturers.

Fig. 2. Comparison of Firewall Manufacturers

3. Next-Generation Firewalls

3.1. *Next-Generation firewall architecture*

A next-generation firewall (NGFW) is a new generation of firewalls that integrate intrusion prevention, malware filtering, and other security functions to

allow more advanced control over the data flow. The defining characteristic of a next-generation firewall is the ability to identify and control traffic at the application layer. These new firewalls look deep into the packet's payload before making a decision on whether to allow or deny the traffic flow [4]. While traditional firewalls have tended to focus on network ports and protocols, NGFWs focus more heavily on the applications and data. Application Intelligence, or awareness, is a foundational component of a NGFW that enables the identification of individual applications within network traffic, ideally irrespective or port, protocol or evasive tactic [6].

3.2. *Threat evolution*

Threat evolution has made a significant shift from attacks directed onto the operating systems or network protocols to attacks of vulnerabilities in the application layer. Currently, over 70% of all attacks are targeted toward the application layer [7]. As attack vectors have begun to focus more heavily on applications versus the network, it is necessary to implement a deeper level of protection in this area. Traditionally, each type of application – web pages, email and FTP transfers went through a specific TCP port. If an organization wanted to stop a certain type of communication from happening within the network, it could simply block the corresponding port. As more applications have been written to function over HTTP (port 80), it has become increasingly infeasible to block HTTP communications through the firewall. There are too many legitimate uses for HTTP to universally restrict access [8]. The growth of service-oriented architectures and Web communication has led to more data going through fewer ports with fewer protocols, meaning port/protocol-based policy has become less effective. While deep packet inspection intrusion prevention systems inspect for known attack methods against operating systems and software, they cannot effectively identify and block the misuse of specific features within applications. Gartner has long supported the concept of NGFWs as the next stage of evolution in dealing with these issues [9].

3.3. *Application threat landscape*

Significant changes have occurred recently to both the application and threat landscapes. As personal applications have become more pervasive they have become more difficult to distinguish from legitimate business applications. This implies that much of the traffic looks the same and so it is more important to identify the applications being used and which users are using them and for what purpose [10]. Applications such as instant messaging, personal communication,

file sharing, web mail and a host of social networking applications have become a primary target for access into the enterprise network. Even "pure" business applications have been designed to use the same evasive techniques such as use of non-standard ports, tunneling within commonly used services, and hiding within SSL encryption so that they can be accessible and functional for legitimate business use in every network, for every user, regardless of the security infrastructure in place [11].

Additionally, the threat landscape itself has changed as the motivation for hacking has changed from building notoriety to making money. To this end threat vectors have shifted to building threats that operate on, and through applications. Applications give attackers access to many options to avoid detection such as tunneling, encryption, compression and port evasion. This method of attack passes through many enterprise defenses because they are designed mostly for protection at the network layer and not the application layer. Today's hackers are focusing more heavily on the growing popularity of user-centric applications such as those seen in social networking which provide a good platform for worms and trojans. Worms and botnets also target P2P file sharing networks; not only as a means to spread but also as a platform for command and control communication [11].

In addition to applications, threats have evolved to avoid detection by traditional IPS solutions by using encryption and compression. Although security researchers have warned that encryption would be used by various threats, encrypted attacks still need a conduit which is available through user-centric applications. Through phishing and other attacks, users are easily tricked into clicking on encrypted links which can then send encrypted threats through the enterprise network. In order to detect these type of threats it is necessary to decrypt SSL and unzip content to look more deeply into the possibility of threats. This functionality is generally far beyond the capabilities of the traditional IDS. The "find it and kill it" model of the traditional IDS doesn't work well with the types of control necessary to deal with the new generation of threats that move across the enterprise network through applications [11].

3.4. *Additional threat vectors*

In addition to identifying the actual threats it is necessary to look for the hidden transmission vectors that traditional IDS is not able to detect. Within the business environment there is always the tension between security and functionality. The most secure device is one that's unplugged. While applications can be threats or enable threats, it may not be practical to

completely block the application if it has legitimate business value. The NGFW provides for more granular controls that allow the control of applications such as regulating users, controlling bandwidth usage, disabling certain application features, and analyzing data traffic to and from the application [11]. For example a Web application such as Facebook can be seen as both bad and good to a company – as a productivity threat, a security threat, and a valuable marketing tool. A NGFW has the granularity of control to enable the marketing department in a company to have prioritized bandwidth to use Facebook, but at the same time to prevent other departments from using it during working hours and ALL users from accessing Farmville or Mafia Wars [11]. This can allow for legitimate use of applications for business functions while providing a satisfactory level of protection for the enterprise network as well. NGFWs provide classification of traffic based not only on signatures, but an ongoing process of application analysis, decryption and decoding in order to analyze the layers of a traffic stream to determine its true identity.

4. Conclusion

Next-generation firewalls are the next step of improvement over the traditional firewall and intrusion detection system. Traditional firewalls generally perform packet forwarding and blocking and often incorporate packet inspection techniques. The IDS adds the ability to detect and dismantle attacks but these functions typically fail to be tightly integrated with network access and WAN connectivity capabilities of enterprise-class firewalls. To protect networks in the presence of social media and other Web-based applications, a NGFW infrastructure intelligently combines network security, content security, application control and network access to detect application-specific attacks, enforce application-aware access policies, and perform traffic routing and prioritization for application-aware traffic across the WAN. Although NGFWs are available through many different companies with pros and cons for each system, the concept of integrating the functionality of a traditional firewall with IDS and the ability to manage traffic at the application layer will characterize the future standard for enterprise network protection.

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Exploring the Centralized Safety Management to Mitigate the Threats and Risks of Aircraft Maintenance

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The International Air Transport Association (IATA) Safety Report found that in 26 percent of accidents, a maintenance-caused event started the accident chain. Boeing has estimated that around 30 percent of engine in-flight shutdowns and 50 percent of engine related flight delays and cancellations are caused by maintenance error. The complex working environment of aircraft maintenance may reduce maintenance technicians' effectiveness, increase operational risks, and generate threats for technicians' occupational safety. A concept of a centralized safety management is proposed in this paper. The system is expected to mitigate the threats and risks in the process of aircraft maintenance with the functionalities of supervising tasks progress, tracking maintenance technicians' position, intercepting maintenance process by threats warning. To achieve the primary functionalities, several open source techniques were incorporated, such as Online Analytical Processing (OLAP), and positioning and mapping techniques. With the Hangar of the Future at Purdue University Airport (KLAF) as the testbed, exploratory system modules were developed.

Keywords: Safety Management; Aircraft Maintenance; Threat and Risk Control; Management System

1. Introduction

Aircraft maintenance is an essential part of MRO – maintenance, repair and overhaul, which covers the tasks of overhaul, repair, inspection or modification of an aircraft or aircraft component to maintain airworthiness and mission readiness. Aircraft owners/operators are required to maintain the aircraft in an airworthy state prior to each use of the aircraft.[1] Aviation maintenance is divided into four check types, which are carried out at predetermined periods based on the number of flight cycles or flight time. Three common areas where aircraft maintenance is performed are: flight line maintenance which occurs at or near the gate or terminal; hangar maintenance which could be any level of maintenance performed inside a hangar; and the heavy maintenance, the highest level of maintenance in a certified repair station under part 145, Title 14 of the Code of Federal Regulations.[2]

Risk management is the overall process of identifying, evaluating, controlling, reducing or mitigating risks.[3,4,5,6] Risk management encompasses conserving assets and minimizing exposure to losses; it means looking ahead to

detect hazards before they lead to mishaps and "taking appropriate action when these risks cannot be eliminated".[5] Accidents and incidents may be preventable through effective management.[6,7]

Maintenance hazards and risks are not only threatening the safety of pilots and heavy duty mechanics, but also others working near the aircraft in the busy hangars, ramps and aprons. Based on the data from the International Air Transport Association (IATA), the Flight Safety Foundation (FSF) reported that approximately 27,000 ramp accidents and incidents occur annually worldwide injured around 243,000 people. FSF also estimates that ramp accidents are costing major airlines worldwide over $10 billion US a year.[8] Similar conditions and safety issues also exist in the hangars.

2. Methodology

With the goal of reducing ground accident and unsafe incident, the purpose of this study is to explore a solution to potentially mitigate the threats and risks of aircraft maintenance. The following methods were used to achieve the study purpose:

- Examine and review previous studies on the ground damage incidents (GDIs) prevention, human factors in aviation maintenance, and hangar/ramp risk management to identify the most common latent failures and hazardous patterns;
- Based on the latent failures and the hazardous patterns, a centralized safety management concept is proposed by analogizing the centralized operations management technique used in airlines' operations centers;
- Several open source techniques, such as Online Analytical Processing (OLAP), and positioning and mapping techniques, were incorporated into the development of a centralized safety management supporting system;
- The Hangar of the Future at Purdue University Airport (KLAF) is used as the testbed for exploratory system modules.

3. Literature Review

The three most frequently reported latent failures that have led to ground damage incidents (GDIs) are problems with equipment, use of an improper number of personnel, and lack of awareness of risks and hazards.[9] In order to identify and optimize the factors that affect human performance in maintenance and inspection, the Federal Aviation Administration (FAA) invested in studying human factors in aviation maintenance with industry partners, and resulted in a series of solutions to affect efficiency and safety of maintenance.[10] The Fatigue Risk Assessment Tool and the Line Operations Safety Assessment (LOSA) are

examples of outcomes.[10] In 2003, the FSF launched the Ground Accident Prevention (GAP) program with the purpose of eliminating accidents and incidents on airport ramps and adjacent taxiways, as well as during the movement of aircraft into and out of hangars.[11] The Ground Accident Prevention Cost Model, the Ground Accident Prevention Leadership Tip Sheets, and the Ground Accident Prevention Ramp Operational Safety Procedures are examples of the outcomes of the GAP program.[8] The IATA has initiated the Safety Audit for Ground Operations (ISAGO) trying to reduce the risk in ground operations, lessen damages and injuries, and support to implementation of Safety Management System by the providers.[12] Other safety initiatives are also under study to improve the safety of ground operations.

Generally, according Wenner and Drury (2000),[13] Drury's (2001),[14] and Hobbs's (2004),[15] the prominent latent failures could be categorized as: 1. Poor equipment, 2. Inadequate space, 3. Lack of awareness of risks/hazards, and 4. Poor communication.

4. Centralized Safety Management System

This study explores a concept of centralized safety management for aircraft maintenance. The architecture of centralized safety management is created with the purpose of mitigating the latent failures contributing to GDIs. The architecture of centralized safety management system for aircraft maintenance is shown in figure 1. The overall architecture consists of two parts: the ramp/hangar end and the maintenance operations center end. Working with this supporting system, the maintenance managers would be able to: 1) Distributing tasks, tracking current task progress; 2) Tracking the real-time positions of mechanics; 3) Evaluate the risk level of tasks; and 4) Update or intervene in the risky operation.

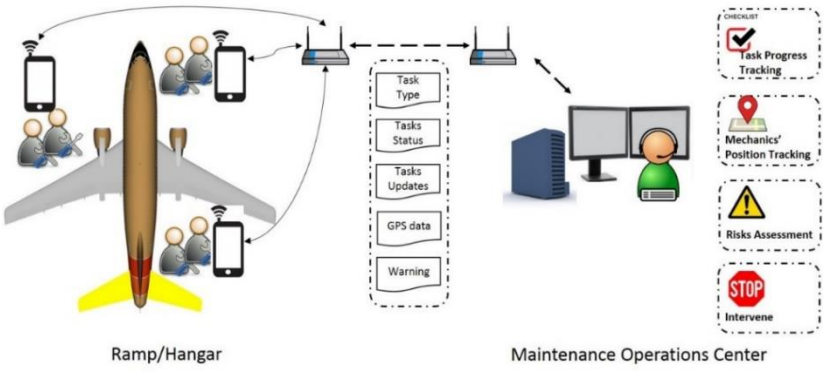

Fig. 1. Overall architecture of centralized safety management system

Tracking the real-time positions of mechanics is believed to be able to enhance the situational awareness of risks/hazards, and help avoid risks from concurrent maintenance tasks. For example, activities in the cockpit might create unsafe issues for mechanics working around the engine or the wing unit. In this study, GPS capable mobile device is used as the platform on the ramp/hangar end to yield GPS data for tracking mechanics' position. Other local positioning techniques might provide more accurate location data for the working scenario in the hangar. The Online Analytic Processing (OLAP) is adopted for the function of distributing tasks and monitoring task progress. By accessing the internet, the mobile device can receive the task information distributed by supervisor, and also feed back task progress to multidimensional database where supervisor can access the real-time task progress. This module is shown in figure 3. Each mechanic's position is mapped on the digital map of ramp/hangar, and visualized on the supervisor side. In this system, we adopted the ICAO safety risk assessment matrix to evaluate the risk level of maintenance activities.

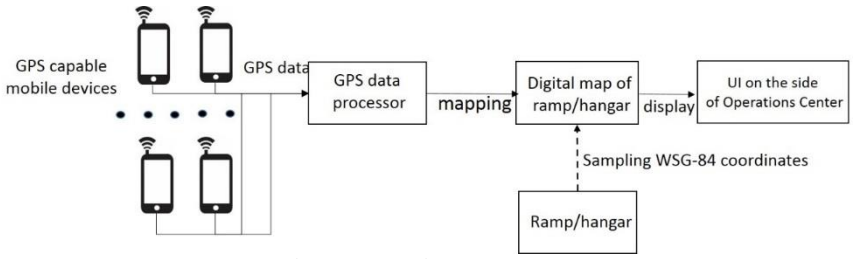

Figure 2. The positioning module of centralized safety management system

Figure 3. Flowchart of risks assessment of centralized safety management system

A centralized safety management tool will provide maintenance mechanics, ramp/hangar ground support personnel, and their supervisors a more accurate risk assessment instrument related to immediate maintenance tasks. This architecture with its supporting system is expected to increase the perception of "environmental elements" that can affect safety for front line maintenance mechanics, such as risky tasks or activities which might jeopardize the safety of others, weather condition, task progress, and other anomalies. Potentially, a 'green cell' in the safety risks assessment matrix could move to yellow or red depending on other environmental elements. By providing real time alerts and task updates

to intervene unsafe actions, engaged personnel are believed to have better awareness of risks associated with job tasks and environment.

5. Testing in the Hangar of the Future

Based on the system architecture in figure 1, the initial prototype was developed and tested at the Purdue Hangar of the Future. The system capabilities are: 1) Assigning maintenance tasks to specific mechanics by creating a Job Card with relevant assignments; 2) Monitoring task progress and risk level for each mechanic; 3) Communicate with front-line mechanics, update and intervene in-progress tasks; and 4) Tracking the real-time positions of mechanics. However, the positioning module has not been tested at the ramp due to resource limitations and safety concerns. The system was tested to verify that it worked as planned. Additional testing is needed to validate and understand its effective functions and safety.

Figure 4. Interface of task progress, risk level, intervening

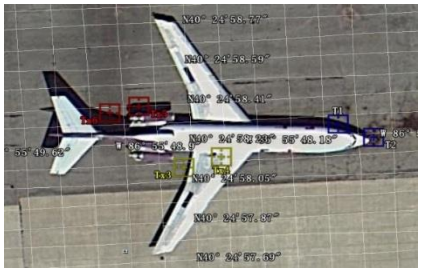

Figure 5. Screenshot of simulation of the and positioning module (decommissioned B-727)

Tasks In Progress

ID	Title	Area	Started	By	Step	Status	Possible Actions
13	Windshield Inspection	1	15:46:08		1		Approve Halt Resume
15	Main Landing Gear Inspection	3	23:48:23	Bruce, Lucky	1		Approve Halt Resume
16	Aircraft Towing	3	23:48:34	Bruce, Lucky, Nathan, Lara	1		Approve Halt Resume
17	Windshield Inspection	1	23:49:06	Bruce	1		Approve Halt Resume

Figure 6. Interface of tasks status

6. Discussion and Follow-ups

This study developed a centralized safety management concept to address threats and risks incurred by the prominent latent failures and hazardous patterns in aircraft maintenance. The architecture of the system was designed and developed with a testbed at Purdue University Airport. With the anticipated functionalities

of online maintenance task distribution, monitoring, and update, automated maintenance task risk assessment, real-time mechanics' positions tracking, and risk alert, this solution can be tested to estimate its effectiveness on improving situational awareness about the risk factors likely to be present in the maintenance tasks performed by technicians, and prompt intervention of motion risk control measures before exposing the personnel and the aircraft to potential risk factors. Limitations in current phase of study include: 1) The architecture is based on historical GDI records; 2) Resources constraints limited the development and integration of full-featured system.

Usually not considered as "aviation incidents", most GDIs are not investigated.[9] So, it is difficult to get the types, frequencies, and causal or contributing factors. More reliable contributing factors and latent failures may be included in updating the architecture of centralized safety management, the implementation of risk control strategies, and the enhancement of aircraft maintenance safety as a whole. Continuous development of system, and on-site verification are anticipated with further financial support.

Acknowledgements

This research is a part of the Smart Ramp/Hangar project initiated by Professor Timothy D. Ropp, who leads the Hangar of the Future. We are thankful to Professor David L Stanley who provided important consultancy.

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Mobile Cloud Computing Adoption and Wireless Network infrastructure Issues in Saudi Arabia

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The Cloud Computing shift provides users with elastic computing resources by virtualization technology. Mobile users require wireless network capabilities in order to reach and consume the cloud virtualized resources [1]. In this paper, we present a case study by conducting real- world experiments in order to test the current performance of wireless network capacity in Saudi Arabia. The test will provide a clear understanding on how the wireless network infrastructure is ready in Saudi Arabia. Distinct results were produced by our test that give an overall assessment on the future of mobile cloud computing adoption in Saudi Arabia.

Keywords: Mobile Computing; Network Performance; 4G; SLA; Mobile Users.

1. Introduction

Cloud computing is an evolving ICT service paradigm, which provides an elastic access to large pool of online resources such as processing, storage and network with nearly no capital investment and with modest operating costs proportional to the actual use (pay-as-you use model) [2]. Basically, cloud computing is TCP/IP

based technology and high development as well as integrations of computer technologies (e.g. fast microprocessor, huge memory, high speed network and reliable system architecture) [3]. Cloud service types can be abstracted into three layers: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) [2]. Hardware and software services form the basis for delivering IaaS and PaaS. The top layer focuses on application services (SaaS) by making use of services provided by the lower layers. PaaS/SaaS services are often developed and provided by third party service providers who are different from the IaaS providers. Cloud services layers SaaS, PaaS, and IaaS provide us the concept of cloud virtualization that we consider throughout our paper.

For its flexibility in delivering IT services based on Internet protocols, there is a notable increase in the number of companies adopting this new economic model offered by cloud computing [4]. For instance, in a Mckinsey Quarterly survey conducted in 2010 on 332 companies, 75% believe that the use of cloud computing can motivate a value at their companies [4]. Among these companies, 68% state they are now adopting the cloud to set up electronic collaboration and 82% are intending to do it in the 18 coming months [4].

Practical means for connecting to consume cloud services are diverse and not limited to any specific method of connecting. Nowadays, wireless connection to the Interne is becoming one of the most methods people rely on. Until recent days, wireless/mobile users are mostly familiar with third-generation (3G) standards, since most smartphones support such a communication standard [5].

In addition, The Long Term Evolution (LTE) of Universal Mobile Telecommunications System (UMTS) is the latest wireless cellular standard invented by the Third Group Partnership Project (3GPP) in order to meet the fourth Generation (4G) requirements specified by the International Telecommunication Union (ITU) [6]. Moreover, 4G is currently deployed and used worldwide [7-10].

4G is described as a packet based system that has less network elements. This enhances the connection performance, capacity and coverage of the system which results in providing high data rates with low latency and stability in bandwidth [11]. Authors in [1], present an estimation of the mobile data traffic showing that the mobile data traffic is doubling each year; leading to have 1,000 x increase of mobile data traffic in 2020 with respect to 2010. Furthermore, they state that this exceptional growth demands a substantial increase of wireless network capacity; even though the LTE standardization process foresees a significant capacity improvement with respect to 3G systems.

Based on the discussion above, it is obvious that adopting cloud solutions in SA lacks a definite knowledge of the network capacity, especially the wireless technology; for both cloud services providers who have future market plans in SA as well as the cloud services consumers (mobile users). In addition, to the best of our knowledge, there is no published papers nor reachable test data of the wireless network infrastructure in SA. Therefore, this paper investigates the wireless network performance in SA, namely the LTE, which is highly required as a vastly utilized method for connecting to cloud services. This paper contributes by providing experimental outcomes through benchmarking the performance of LTE technology data traffic provided by the three dominant LTE operators in two different geographic locations in SA and USA.

The rest of the paper is organized as follows. Section II presents the related work. Section III presents a motivation of our research. Section IV presents our experiment setup and implementation. Section V presents our experiment results and discussion. Finally, section VI concludes the paper.

2. Related Work

In [5], a performance test of the LTE coverage in Abha city in SA was presented. Tests were made using the LTE services of Mobily*, Saudi Telecom Company† (STC), and Zain‡. Resulted tests revealed quite good Download/Upload bit rate for all the three LTE service providers. Authors in [12], compared indoor and outdoor LTE network performance. For experimentation, their work was based on collecting data using a commercial tool. Typically, their method was comparing throughput and common LTE key performance indicators. This way, they could estimate the value of throughput performance in Abha city. Further, they presented a study for the relation of such indicators and the throughput performance. They concluded that indoor throughput has a large variation than outdoor.

3. Research Motivation

Corresponding with this unparalleled growth of network data traffic, everyday life experience shows an increasing habit to run an excess of applications specifically developed for mobile devices, (e.g. smartphones, tablets, laptops) for (e.g. entertainment, health care, business, social networking, traveling, news, etc.) [1]. Moreover, recently a strong motive to computation offloading

* http://www.mobily.com.sa/

† http://www.stc.com.sa/

‡ https://www.sa.zain.com

has come through cloud computing rapid availability, which enables the users to consume resources on demand [1]. Typically, mobile cloud computing is a scenario where a cloud consumer acquires access through mobile handset to cloud resources [13]. But, it is not trivial to manage latency over a WAN. In fact, authors in [14-16] indicated that resources' consumers are critical to delay and jitter while interacting over networks; as latency increases, the response time will be affected. Therefore, in current cellular networks, network latency is considered to be a main bottleneck for the development of an effective mobile cloud computing resource interacting. Meeting this constraint requires a deep rethinking of the overall service chain, specifically the devices which by cloud users reach and consume cloud resources on demand.

Late in 2011, Saudi Arabia's LTE operators started to provide this wireless network service. STC, which provided LTE service starting from September 14, 2011 covering almost 38 cities in SA [5]. Mobily, which equates to 40%+ market share of the mobile subscriptions in SA [17]. Furthermore, Mobily launched their LTE service on September 14, 2011 [5]; and Zain which started to provide commercial LTE service in major cities (e.g. Riyadh, Jeddah, and Dammam) on September 14, 2011 [5].

Benchmarking the wireless network infrastructure, which is in our case the LTE technology is an essence phase that both cloud service provider and cloud service consumer need to gain a solid knowledge about. In addition, there is no accessible data, which can help to assess or gain a clear understanding about the wireless network performance provided by the aforementioned ISPs in SA. For cloud computing providers, it is a high priority to have experimental evaluation, which might be required for decision making towards agreements with LTE providers and adopting their LTE services. Furthermore, for Service Level Agreements (SLA), such benchmarking data is a substantial element, which needs to be fine-grained.

4. Experiment Setup and Implementation

4.1. *Network Throughput Performance*

Network throughput represents the performance of a network which is the average number of data packets delivered to the destination successfully over a specific interval of time [18, 19]. Maximum network throughput determines the maximum flow of data packets [20]. However, the network throughput can be affected by different factors. These factors reside in analog, hardware and user behavior limitations. Electrical signals transmitted over wires are represented as analog signals. Moreover, the same issue exists for hardware

such as processor power of network devices. The user behavior is concerned about sharing the communication links with multiple users that sometimes cause network congestion over these links. Hence, these factors can highly influence the network performance [21].

4.2. *QCheck Benchmarking Tool*

QCheck is a software benchmarking tool that can be used to measure network performance. It depends on endpoints while measuring performance of trace-route, streaming, response time and throughput [22]. QCheck has the ability to test link quality and to make simple measurements of the network efficiency. Most network performance tools rely on Ping, which uses Internet Control Management Protocol (**ICMP**). In contrast, QCheck relies on protocols used for data transmission such as Transmission Control Protocol (**TCP**), User Datagram Protocol (**UDP**), Sequenced Packet Exchange (**SPX**), or Internetwork Packet Exchange (**IPX**). Moreover, QCheck tests the network performance with more real sizes of packets. This achieves efficiency in estimation with typical network existing conditions. Furthermore, QCheck is able to measure network performance with its distributed architecture [23]. In addition, it uses endpoints in order to test performance in an active way. A control console of QCheck sends instructions for test-setup to a pair of endpoints which sends back results after a test is executed [22]. This control console can be located on either endpoints or on a separate machine. Authors in [23] exploited QCheck functionalities in a typical operation environment to measure network performance. Furthermore, they demonstrated how QCheck is able to send real data packets with sizes in the range of 1 to 1000 kilobytes [23].

For throughput calculation, QCheck tests how fast a block of data that can be sent and received. The resulted measurements depend on the link bandwidth between two endpoints where the test takes a place. In the following, we demonstrate an equation, which QCheck uses to calculate network throughput [25]:

$$T = (S + R) / m \quad (1)$$

Where:
T = throughput rate, in bytes/sec.
S = bytes sent by Endpoint 1.
R = bytes received by Endpoint 1 (always 1 byte).
m = measured time, which is end time – start time.

4.3. *Experiment Test-bed Locations*

In this experiment we have two main scenarios, which include two major cities in SA and the aforementioned three LTE providers. Riyadh, which is the capital city and it is known to be a busy city. Moreover, the Head Quarters of all LTE providers are located in Riyadh. Furthermore, government ministries, organization, private sector major companies are mainly based on Riyadh. The second city is, Hail, which is relatively smaller city comparing to Riyadh, but it represents the centre of the northern region of SA. We believe that our experiment can show if the wireless network infrastructure in SA, namely, the LTE technology is ready in terms of capacity for any future growth to use the cloud services.

4.4. *Experiment Time Window*

The experiment is done in two different time windows. On-peak hours (12.00-2.00 PM) and off-peak hours (12.00-2.00 AM). Considering the social life of people in SA, we assume these two time windows are the ideal representing on-peak and off- peak hours during the weekdays.

4.5. *Experiment Configuration*

During the experiment, we use one LTE portable 4G router and three different SIM cards providing us the LTE service from STC, Mobily and Zain.

Furthermore, throughout the experiment we intended to run the benchmarking test at central location of each city where we can assure to gain a strong signal. Moreover, we configured the LTE portable router to make it only working whenever there is LTE service signal only in order to guarantee that the LTE service is the only used service through all the experiment.

The other side of this experiment is located in Northern Virginia, USA where we have a running VM hosted in Amazon N. Virginia datacenter. Our VM is operating using Windows Server 2008 accepting the remote requests from the other side, which is based in SA. In our experiment, we tested the network performance in terms of throughput using QCheck. Figure 1 presents the network topology of our experiment. For each LTE operator, we retrieve the throughput readings based on intervals each of 10 minutes. Throughput readings are presented in tables 1-4.

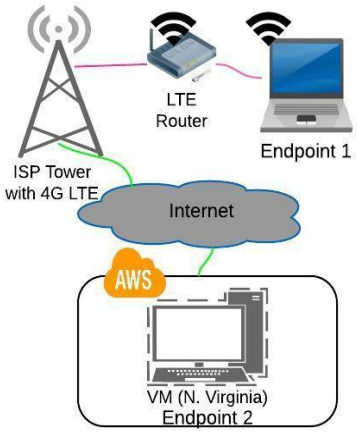


Fig. 1. Experiment network topology.

4.6. *Experiment Throughput Measurements*

Ideally, QCheck is intended to generate small, brief data flows. Furthermore, QCheck is limited to a single connection and the data to be sent in each connection event does not exceed more than 1,000,000 bytes. As mentioned earlier, while throughput benchmarking, QCheck sends real data packets that are not an image type of data.

Table 1. On-peak throughput readings in Riyadh.

STC	Mobily-KSA	Zain-KSA
988.876 Kbps	251.257 Kbps	147.368 Kbps
1.088 Mbps	473.625 Kbps	263.548 Kbps
1.138 Mbps	424.584 Kbps	368.936 Kbps
1.151 Mbps	446.429 Kbps	311.236 Kbps
1.068 Mbps	458.112 Kbps	202.606 Kbps
1.085 Mbps	420.876 Kbps	272.109 Kbps
1.120 Mbps	474.975 Kbps	273.374 Kbps
954.769 Kbps	402.759 Kbps	332.862 Kbps
812.592 Kbps	378.699 Kbps	220.093 Kbps
1.263 Mbps	424.697 Kbps	264.157 Kbps

Table 2. Off-peak throughput readings in Riyadh.

STC	Mobily-KSA	Zain-KSA
1.093 Mbps	436.443 Kbps	361.256 Kbps
1.353 Mbps	436.443 Kbps	270.042 Kbps
1.566 Mbps	423.909 Kbps	237.431 Kbps
1.367 Mbps	467.755 Kbps	297.752 Kbps
1.230 Mbps	456.961 Kbps	338.395 Kbps
1.171 Mbps	462.295 Kbps	339.617 Kbps
1.321 Mbps	456.830 Kbps	295.618 Kbps
1.566 Mbps	464.982 Kbps	268.358 Kbps
1.498 Mbps	436.443 Kbps	360.621 Kbps
1.124 Mbps	459.533 Kbps	319.069 Kbps

Table 3. On-peak throughput readings in Hail.

STC	Mobily-KSA	Zain-KSA
3.322 Mbps	2.809 Mbps	1.747 Mbps
2.988 Mbps	2.830 Mbps	1.682 Mbps
2.947 Mbps	2.757 Mbps	1.653 Mbps
3.156 Mbps	2.931 Mbps	1.580 Mbps
3.291 Mbps	2.721 Mbps	1.616 Mbps
2.743 Mbps	2.676 Mbps	1.697 Mbps
3.045 Mbps	2.646 Mbps	1.617 Mbps
2.857 Mbps	2.953 Mbps	1.686 Mbps
943.620 Kbps	2.708 Mbps	1.631 Mbps
3.512 Mbps	2.629 Mbps	1.695 Mbps

Table 4. Off-peak throughput readings in Hail.

STC	Mobily-KSA	Zain-KSA
2.750 Mbps	2.540 Mbps	1.727 Mbps
3.448 Mbps	2.797 Mbps	1.751 Mbps
3.118 Mbps	2.904 Mbps	1.685 Mbps
145.767 Kbps	2.519 Mbps	1.685 Mbps
3.426 Mbps	2.616 Mbps	1.641 Mbps
2.819 Mbps	3.135 Mbps	1.540 Mbps
3.089 Mbps	2.683 Mbps	1.677 Mbps
3.526 Mbps	2.582 Mbps	1.654 Mbps
3.043 Mbps	2.444 Mbps	1.603 Mbps
2.935 Mbps	2.496 Mbps	1.603 Mbps

Table 1 shows throughput readings of Riyadh on-peak hours (12.00 PM - 02.00 PM). We expect this time window to be the highest utilization of wireless networks during week days according to the social life style and working hours in SA.

Table 2 shows throughput readings of Riyadh off-peak hours (12.00 AM - 02.00 AM). Correspondingly, this time window is ideally the off-peak during the week days in Riyadh.

Similarly, as we perform our throughput readings experiment in Riyadh, in Hail we sat the on-peak time window to be (12.00 PM - 02.00 PM), as shown in table 3. For off-peak time window, we also sat it to be (12.00 AM - 02.00 AM) to retrieve the throughput readings as shown in table 4.

5. Results and Discussion

In essence, we are motivated by the fact that there is a need for high performance wireless network infrastructure to adopt mobile cloud computing services in SA. Adoption and utilizing in our context are not limited for only cloud providers but, also cloud consumers acquire the best reachable knowledge in order to make a decision of which LTE service provider has better network performance to fully utilize resources located at any cloud provider datacentre, worldwide. Figure 2 shows the average throughput of the readings for Riyadh during on-peak hours. Likewise, the average throughput in Riyadh during off-peak hours is presented in figure 3. Moreover, figures 2, and 3 show that STC outperforms Mobily and Zain by almost factors of 2 and 4 in Riyadh, respectively. Analysing these figures 2 and 3, we assume that STC outperforms Mobily and Zain due to its temporal properties of network hardware devices. Moreover, studies [26] show that geographic location and coverage can significantly affect the network performance; hence, this factor may give advantage to STC over Mobily and Zain providing that STC is the largest and major player of cellular networks in SA. On the other side, Figures 4 and 5 demonstrate that both STC and Mobily networks show comparable performance, which outperforms Zain by a factor of 2 in Hail. Overall, results show that wireless network performance is better in Hail than in Riyadh.

In addition, we observe that wireless network throughput readings have almost the same average value during on-peak or off-peak hours in both cities. Since wireless network throughput is influenced by some factors as mentioned previously such as network congestion [21], it can be predicted that networks of the three ISPs STC, Mobily and Zain are not congested during time of benchmarking in both cities. All ISPs wireless networks outperform better in

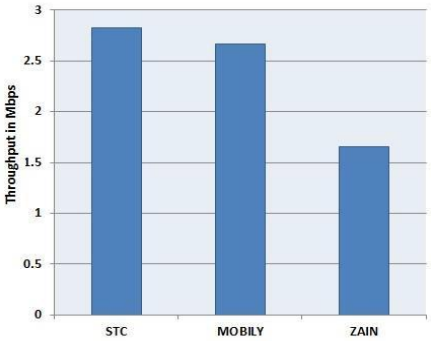
Hail comparing to Riyadh. This may be due to other factors that need to be discussed further. Possibly, among these factors, network devices and signals strength of the LTE service may have impact on network performance. For example, LTE signals strength may be weaker in Riyadh comparing to Hail. Moreover, network design and number of traversed hops differences can be a cause of the variation in the average wireless network throughput in both cities [24]. Additionally, carriers experience different relative variations in wireless network throughput performance during busy hours. Studies in [26] show that a significant network performance differences can arise across carriers, access technologies, and geographic region. However, authors in [26] also highlight that such variations themselves are not uniform. Furthermore, they emphasize that stability of network performance diverges substantially among LTE carriers.

Fig. 2. On-peak average throughput in Riyadh.

Fig. 3. Off- peak average throughput in Riyadh.

Fig. 4. On-peak average throughput in Hail.

Fig. 5. Off-peak average throughput in Hail.



6. Conclusion and future work

This paper presented an evaluation for the LTE technology using real-world experimentation in different endpoints between SA and USA. We benchmarked the LTE network throughput performance of the dominant ISPs in two major cities in SA. Our benchmarking results shown notable indications on how these ISPs could vary in providing the LTE service in SA. Overall, experimentation outcome reflect how this would impact the adoption of mobile computing. Moreover, the results provide a clear assessment of wireless network performance during both on-peak hours and off-peak hours. The results can provide the mobile users as well as the cloud providers a basic knowledge about the wireless network performance in SA. Furthermore, the variations of the results provide a basic element for any future decision that cloud providers and/or mobile users will make when adopting LTE service in order to consume cloud services SA.

As future work, we intend to make further investigation assessing the network infrastructure from different aspects in SA and what are the possible impacts on datacenters and cloud computing virtualized resources. Our future study will have a wider scope and contributions using different approaches for assessment.

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Biometric Applications for Credit Card Fraud Prevention

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Credit card fraud has continued to grow despite efforts to secure financial data from data breaches of financial institutions. Data breaches of financial transactional records over the past decade have impacted millions of U.S. consumers, resulting in decreased consumer confidence in the security of financial data. Credit card companies continue to focus on methods for identifying fraudulent transactions as they occur and validating account owners. Financial institutions utilize various models to alert consumers of potential fraud on a real-time basis; however, the authorization models to validate identity of the account holders during the transaction is limited or nonexistent. Many consumers are not required to provide any form of identification or signature proving identity for minimal purchase amount. For purchases requiring a validation, consumers are able to validate a transaction with a simple, unverified signature mark at a merchant terminal.

This research seeks to provide an analysis of various fraud detection models and the use of biometrics for user authentication as a means for fraud prevention in the financial credit card sector. A general summary of selected fraud detection models is introduced, including biometric applications and concerns. A dual mode system of combining non-biometric data with biometric data for user authentication is proposed in effort to increase the level of credit card transaction security and reduce the occurrences of fraud. The proposed method targets the user authentication process at the point of sale to provide a real-time validation of the user as the credit card account owner using the biometric fingerprint as identity proof and signature.

Keywords: Biometrics; Fraud Prevention; User Authentication; Fingerprint Authorization

1. Introduction

Credit card fraud is a crime that surpasses physical and geographical boundaries and requires companies to remain steps ahead of criminals in order to prevent significant losses from impacting the companies as well as the card holders. Most credit card companies provide fraud protection in order to minimize losses to both card holders and credit card institutions. When a fraudulent transaction

occurs, the credit card institution is often the initial entity on the receiving end of the financial loss, losses which are then passed on to the institution's customers. Numerous fraud detection and prevention methods exist in order to detect fraudulent transactions before they occur. Fraud detection models are generally considered company proprietary information, making the analysis of the various methods more challenging.

Current credit card terminals require a physical card to be swiped and a PIN number or physical signature for validation purposes. The introduction of the CHIP card added the additional element of security but can be combined with additional user authentication. Stolen cards can be swiped at a merchant terminal and used with nothing more than a forged signature. In this case, user authentication is simply the signature, which is not analyzed systematically to compare a valid versus an invalid signature.

Physical credit cards make up the majority of credit card purchases, but mobile credit card processing is gaining in popularity. Identity verification of mobile devices can be realized through biometrics, most commonly, a fingerprint. The use of biometrics for credit card purchase authorization validations can be achieved through the use of merchant touch screen credit card terminals and mobile purchasing applications to provide a more secure financial transaction. This paper will investigate the effectiveness and concerns of biometric identity verification for purposes of credit card user authentication, combined with the traditional PIN number and in conjunction with existing mag stripe, CHIP card processing, or mobile validations to create a dual-mode transaction authorization.

2. Sources of Credit Card Fraud

Before fraud detection models are created, understanding the sources of credit card fraud and their corresponding frequencies can help in determining the type of model that should be developed. The Federal Trade Commission describes methods that thieves use to commit fraud to include: low tech dumpster diving, high tech account hacking, dishonest clerks copying credit card information, disguised telemarketers seeking account information [2]. Regardless of the method used, once the thief has a customer's information, the role in detecting fraud becomes a responsibility of the credit card institution.

The United States accounts for the highest number of data breaches worldwide, 72 percent in 2014. Approximately 31.8 million U.S. consumers had their credit cards breached in 2014, which is more than three times the number affected in 2013. The majority of fraud experts believe that the slow

pace and lack of EMV adoption, CHIP cards, by merchants in the U.S. has caused a disproportionately high amount of fraud. EMV represents a global standard for authenticating credit card transactions. Each credit card carries a computer chip inside the card, which aims to reduce counterfeiting by dynamically authenticating card transactions. Counterfeit cards represented 37 percent of U.S. credit card fraud in 2014 [7].

Mobile transactions are exceptionally at risk for fraud. Mobile transactions accounted for 14 percent of transaction volume in 2014 and 21 percent of overall fraudulent transactions, showing the high level of risk when utilizing mobile devices for purchasing transactions. Merchants who sell through mobile channels lost 70 percent more revenue due to fraud in 2014 than in 2013 [5]. Mobile transactions will continue to rise as smart phones introduce more purchase-friendly apps, such as Amazon and eBay's purchasing apps. However, physical cards are expected to continue to remain a dominant source of fraud.

A Verizon risk team conducted a study in cooperation with the United States Security Service to analyze the sources of fraud impacting their company. The results of their study recorded approximately 900 million data breaches in financial institutions from 2008 to 2010. Hacker and malware attacks accounted for 35 percent of the overall attacks [3]. Fraudulent credit card transactions can present themselves as stolen cards, copied cards, identity theft, theft of mobile devices, and online theft of credit card information. Each source presents an opportunity for fraud and the possibility for a different detection model to be developed.

3. Fraud Detection Models

Banking institutions losing money due to fraud are forced to raise interest rates and increase fees to their cardholders. These costs from fraud are passed on to the banking institution's customers to offset the losses. The need to detect and eliminate fraud before it occurs is mutually beneficial to both the banking institution and cardholders. Detection models vary from organization to organization and incorporate a variety of methods, creating dynamic models that track and evaluate customer behaviors to data mining techniques and alert messaging. The exploration of biometrics for verifying a user's identity provides an opportunity for an additional layer of credit card security.

The importance of the analysis of detection models increases as additional variables are introduced from technological advancements in the devices used to make and receive credit card transactions, i.e. mobile devices, enhanced CHIP credit card terminals. Millions of credit card transactions are processed on a

daily basis, requiring complex detection models to be able to identify fraudulent transactions. Detection models must filter through billions of lines of data to determine which transactions are legitimate. A variety of methods are used for identifying illegitimate transactions. Most fraud detection models analyze the transactional data during the transaction processing or afterward.

3.1. *Dempster-Shafer Behavior –Based Model*

A large number of detection models are behavior-based, using algorithms to analyze spending behaviors. The Dempster-Shafer theory described by Raj and Portia uses a fusion approach, combining evidences of past and current shopping behavior [10]. When a purchase in progress falls out of acceptable deviation of spending patterns, the transaction can be denied, and the customer can be alerted of the potential fraud. Alerts can be in the form of a phone call from the company, an email, or a text message. In such cases, the customer has the opportunity to provide personal information to validate their identity with a customer service agent and proceed with the purchase.

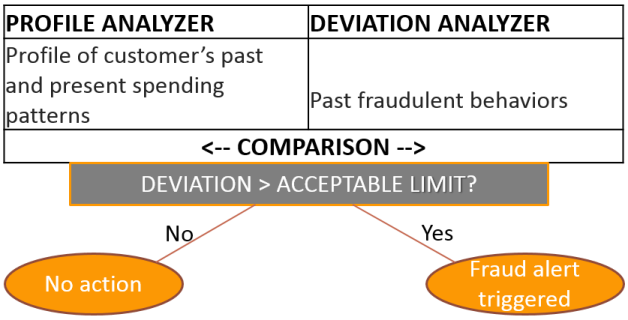

Fig. 1. Dempster-Shafter Theory.

In the Dempster-Shafter theory, the BLAH-FDS is a hybrid of BLAST and SSAHA algorithms, using a two-stage sequence alignment to analyze past spending behaviors [10]. The profile analyzer establishes a profile of the consumer based on past and present spending patterns. An additional deviation analyzer looks for past fraudulent behaviors, and a comparison of the two analyzers is performed. If the comparison yields a potential fraud, alerts can be triggered (Figure 1).

3.2. *Patterson's Universal ID and Biometrics*

Patterson proposes a method using a universal identification number (UID) and biometric data for validating receipts on a payment processing network [9]. Patterson's model uses three identifiers that must match in order to authenticate a user. The first identifier can be an account ID or bank identification number, coupled with the second identifier as biometric data. The two identifiers are then sent to an identification system to detect predetermined correlation, such that the data received matches stored data. This process of predetermined correlation describes the identification system that receives the authentication request message and compares the UID and biometric data to a second set of data to determine if a match exists [9].

In Patterson's model, the user inputs a card into a Micro-ATM terminal and uses biometric data to authenticate that the data matches the system ID for payment processing. While Patterson's model thoroughly depicts a relationship between a UID and biometric data, the model can be further extended beyond payment processing and micro-ATMs to credit card purchasing transactions. Patterson's usage of a UID for associating biometric data requires a separate identification system, external to the customer data in the source of record, for matching the biometric data provided by the user to the data associated with a customer. The use of biometrics at the entry point of the transaction allows for detection of fraud before the transaction is executed.

3.3. *Moganeshwaran's et al. Fingerprint-Fingervein Multimodal Biometric Authentication*

Moganeshwaran proposes a multimodal authentication using more than one biometric input for verifying user identity [6]. Their model suggests an increase in probability of user authenticity when two or more biometric data are provided. The data could be more than one fingerprint, a fingervein plus fingerprint, hand vein, or multiple snapshots of the same biometric data (e.g. three templates of right index fingerprint). Moganeshwaran states several advantages of the multiple biometric authentication system, such as the following: it can overcome the non-universality, is less affected by noise, provides a stronger security environment, and improves matching accuracy [6].

Fig. 2. Captured fingerprint smudges.

Fig. 3. Fingerprint quality comparison.

The fingerprint authentication system has high authentication rate, but the captured images are susceptible to noise [6]. Additionally, the fingerprints can be smudged, damaged, or forged, as noted in Figure 2. The quality of fingerprints (Figure 3) can vary and create the potential for a denial or rejected authentication, resulting in a false negative. False negative results of a biometric match, when being used for a credit card transaction authorization, can cause erroneous transaction denials.

Moganeshwaran suggests fingerveins for higher authenticity, as the vein is located underneath the finger and is difficult to forge or steal. The error rate must be considered as a factor for measuring the need for multimodal, further validated by the measured rate of .33 percent error in contrast to 2.21 percent error with fingerprints alone [6]. Using the multimodal biometric model requires more than one biometric input by the customer. Capturing multiple modes of biometric data when making a credit card purchase is not a cost-effective method. Merchants may be unwilling to participate in capturing the information. Customers may be resistant to provide personal information for a simple purchase.

3.4. *Proposed Biometric and PIN Dual Mode User Authentication*

Rather than focusing on purchasing behavior and detecting fraud after it has occurred, stronger user authorization before the transaction occurs can reduce the possibility of a thief completing a fraudulent purchase. Combining existing

processes of PIN numbers / signatures with a fingerprint should be considered (Figure 4).

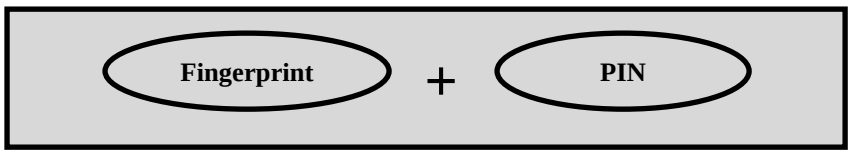

Fig. 4. Credit card terminal input.

The authorization process can prevent the transaction from occurring before the fraud detection models are initiated. An authorization request message sent for verification can include information about the customer/user, such as name, account ID, customer ID, and user biometric data (e.g. fingerprints).

The advancement of touch screen functionality creates the potential for biometric ID verification, e.g. fingerprints, in financial transactions, thereby eliminating the ability for a thief to use a stolen credit card. A person attempting to make a purchase on a card that is unauthorized would receive an error during the authentication process. The authorization process must be established to include biometrics as part of the user authorization at the point of sale. Changes to current merchant credit card terminals must be made to support biometric information input.

Combining Patterson's and Moganeshwaran's methods for a bimodal authentication system can reduce the fraud occurring with physical cards and mobile device purchases. The proposed authorization system includes a biometric input (fingerprint) coupled with a required PIN entry, in place of a signature on a magstripe or CHIP card machine. Using this method reduces the probability of a thief obtaining both sets of data in the event of a forged fingerprint.

Keys, tokens, PIN numbers, secret codes, and passwords can be forgotten, compromised, shared or observed; however, biometrics is not susceptible to these problems [11]. Biometrics allows for greater individual security and control over access to credit card accounts and satisfies the question of "Who are you?" The first step in credit card fraud prevention is ensuring authorization at the moment of the transaction initiation and before behavioral or detection models need to be triggered.

4. Biometric Concerns

4.1. *Biometric Validation Accuracy*

An analysis of biometrics verification was performed by Ruiz-Mezcue (1999) in a real environment for teleservices cash dispensers to measure the effectiveness of voice and facial recognition in user identification for ATM transactions using different hardware architecture. The verification included imposter's claims and positive matches. The facial and voice recognition method provides a variation of using multimodal biometric user authentication, but the practicality of multimodal biometrics is far less valuable for merchant credit card transaction terminals.

The ability to validate the fingerprint with high level of accuracy is crucial to the success of biometric authorization. If the fingerprint is not aligned correctly, a different finger is used, or the image is rotated, this will lead to a declined credit card transaction. Back-up processes would need to be in place to ensure identity verification can be established via alternative means.

"Minutia-based (fingerprint ridge discontinuities: ridge endings and ridge bifurcations) is the most widely used technique due to its good performance with less computational costs (processing time and memory needs) than other techniques; matching two fingerprints in minutia-based representations becomes a point pattern-matching problem, and it consists of finding the alignment and correspondences between pairs of minutiae points in both sets", [3]. Distortions in fingerprints can be caused by a cut, bruise, or laceration to the finger as well as dirt. Areas with significant distortion where a large area of the fingerprint has been compromised can lead to the creation of spurious minutiae, resulting in a large area to be ignored and a large error in localization [4]. Compared to a single biometric system, the extraction of multiple biometric features reduces the error rate and leads to improved performance of an authentication system [1].

4.2. *Biometric Data – Identity Theft & Privacy Risks*

While biometric data is considered to produce the highest level of accuracy in identity verification, forging biometric data is not without possibility. Systems using the raw biometric data can create comparable signatures or hack into the system and capture the stored image without detection. The risk of biometric data falling into the wrong hands is far greater than credit card fraud. If a thief is able to obtain this data, the potential exists to use the biometric information to steal identities, which could impact law enforcement, passport information, and

any other database that stores biometric data for identification and matching purposes.

In addition to the risk of theft is also the consideration of personal privacy. The use of personal information to deter fraud has increased over the past two decades as technology has increased the methods for making purchases and the use of direct cash has declined. Privacy advocates fear an organization's inability to properly secure the biometric data and prevent improper access and abuse of biometric information. If left to a financial institution's control, the biometric data becomes customer confidential information and is subject to the control and protection methods used by the institution. Poor security controls lends opportunities for personal data to be obtained by hackers and misused. Once this data is breached, the damage often cannot be reversed, as the personal data is so uniquely related to one individual.

Woodward emphasizes the invasive secondary market effects, noting that once a biometric identifier is captured from an individual in the primary market, the biometric identifier can be replicated, copied, and shared among public and private sector databases [11]. The ability for the data to be shared without the knowledge or consent of the customer can have potentially damaging effects if the information falls into the wrong hands.

Ownership of such personal information as biometric data by a non-governmental institution carries additional risks due to the freedom of action from government interference, with few legal limits on the use of biometric information held by private businesses [11]. Once personal biometric information is provided to a private institution, there are no constitutionally based grounds for privacy. In the event of a data breach, the biometric data could be used outside of the parameters of financial information, e.g. bioinformatics. Companies seeking to utilize biometric data must ensure proper security of the data and may need to consider legal implications of customer proprietary information.

5. Future of Fraud

As the United States transitions to EMV, POS fraud will grow less lucrative. Higher-security cards will make counterfeiting substantially more difficult, if not impossible. Additionally, any encrypted or tokenized payment information will make data gained from compromised terminals useless for future POS transactions. Criminals will focus on other areas, including card-not-present (CNP) fraud, vulnerable merchants that have been slow to transition to EMV

terminals, and businesses that store Social Security Numbers that will be of significant value in committing new account and account takeover fraud [8].

The use of biometrics for tracking memberships is now occurring at amusement parks in effort to prevent membership cards from being stolen or shared with others. Specific studies of companies currently using biometrics for membership tracking could be conducted to determine the level of savings from stolen or shared entrances and to measure the effectiveness of biometric user authentication.

Questions remain over the impact on customers and their willingness to provide such personal information as biometrics for a simple credit card purchase. The prevention of fraud may not be of higher value than customer privacy, and the credit card industry could receive significant resistance. However, the use of the fingerprint as a password for mobile devices suggests some adaptation and acceptance to the use of biometrics and its potential adoption for protecting one's identity and financial information.

6. Conclusion

The use of biometrics for identity verification alone may not offer enough security to prevent fraudulent transactions from occurring, since the likelihood of biometric data distortion must be considered and alternative measures provided. Combining the biometric fingerprint identification system with the commonly used PIN code adds a layer of identity protection and creates a dual mode means of user authentication, one biometric component and one non-biometric component. The capability for a hacker to retrieve both the fingerprint and the PIN are significantly reduced when both sets of data are required. Future research and testing is necessary to quantify the increased level of security and potential reduction in fraud as a result of a dual mode option. Future studies should include combining the PIN and biometric fingerprint data for each credit card transaction in conjunction with existing mag strip, CHIP card processing, or mobile validations.

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A Study of the Impact of Globalization on Indiana's Manufacturing Industry

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The decline in employment in the manufacturing industry has had severe consequences not only for the workers employed in this sector, but also for the economy of the country in general. This study sought to explore whether or not globalization was responsible for the loss of jobs in the gas engine manufacturing and parts industry in Indiana during the period 1998 – 2008. Despite its relevance, this industry has experienced a tremendous decline in employment and has almost lost its presence in Indiana. While many companies have offshored, others have closed their doors for good. This study covered five different discrete areas: technology, education, globalization, competition and employment. These areas were investigated separately since the researcher looked to identify which (if any) of the areas studied could be responsible for the decline in employment. The areas of study are also presented independently, thus, education is the only area presented in this report. The area of globalization and competition was presented at the International Society of Agile Manufacturing in Agra, India in 2011, and is not discussed here. To assess the impact of education in the loss of manufacturing jobs, an anonymous online survey was conducted. Individuals associated with this industry and holding positions in the areas of engineering and/or management were surveyed. The results found in this study contradict the common perception that offshoring is the main factor for the dislocation of workers in the manufacturing sector.

Keywords: Globalization, outsourcing, offshoring, global competition, education, competitiveness, manufacturing, production

1. Introduction

1.1. *Globalization, outsourcing, and offshoring*

There is strong discrepancy whether or not globalization and outsourcing are actually good for the economy of the country. Globalization, defined as the free movement of labor, capital and goods, has encountered both strong opposition as well as equally strong support, among scholars and the general public. Globalization has been the enabler of open markets and consequently global competition conducted through outsourcing and offshoring. The term globalization is extensively used, but despite its frequent use there is no general consensus about its true meaning. Jovanovic posits that "globalization is defined in business schools as the production and distribution of products and services of

a homogeneous type and quality on a worldwide basis" (Jovanovic, 2006). For some, globalization is connected strictly to the area of economics where it first was conceived. Over the last fifteen years globalization has become one of the most studied areas in social sciences, separating to some extent from its economic roots, and now embracing political and cultural aspects of human life. Some scholars even relate globalization to political science and in particular to the field of sociology (Caseli, 2008) .

According to Venkatesan (1992), Quinn (1999) and (2000) and Quinn and Hilmer (1994) outsourcing has a more commonly accepted and established definition; it is referred to as allowing the performance of tasks by outside partners, that otherwise would be performed in-house as cited by Zhao and Calantone (2003). Similarly they define outsourcing as the means that allow firms to concentrate on a few tasks in order to provide unique and superior value to customers, protect and strengthen its core competencies, and retain or win competitive advantage in the marketplace. It gives the firm access to resources and capabilities that are not available or not easily developed internally. For Corbett (2003) outsourcing is "nothing more and nothing less than a management tool". In the early 80's outsourcing was referred to as the purchasing of manufactured goods from an outside firm, but in recent years outsourcing also comprises international trade in services bought abroad (Bhagwati, Panagariya, & Srinivasan, 2004).

Despite outsourcing's multiple definitions, it is believed that outsourcing improves the performance of business in areas that do not represent a core competency for the company, liberating capital and resources for investments in areas that do (Corbett, 2003). Heshmati (2003) notes that outsourcing is the firm's response to import competition from low wage countries by moving non-skilled labor intensive activities abroad . Thus, outsourcing from the U.S. economy is generally for low-value jobs (Bhagwati, et al., 2004). A report published by Forrester Research and authored by John C. McCarthy (2004) states that the number of jobs lost to outsourcing would amount to 3.4 million by 2015; such a report can only increment the misconception of outsourcing, explains Bhagwati et al. (2004). Bhagwati argues the accuracy of such reports, since they fail to reveal that the U.S. economy lost around 30 million jobs in 2003, but created approximately as many as manifested by the Business Employment Dynamics survey of the Bureau of Labor statistics. Therefore they also exhort the American people to remember that any job losses in the country must be set against job gains obtained through outsourcing from other nations into the U.S. Through Foreign Direct Investment (FDI), foreign multinational's investment in the U.S. has created more than 5.4 million jobs by 2002, paying on average 31 percent higher wages than American companies (Slaughter, 2004).

The Commission of the European Communities (1993) as cited by Krugman and Venables, (1995) issued a White Paper stating that "the rise of Third World manufacturing nations has already had serious adverse impacts" for

developed nations. According to Krugman (2000) if China continues to grow at 7 percent per year while the U. S. is growing at only 3 percent a year, China will have the world's largest economy by 2025. He also notes that developing countries, as a group, will eventually overtake the economic superiority of developed nations. This, he explains, is not that "America is doing something wrong, but because many other countries are also doing something right" (pg. 175). Hagel (2004) is concerned that the U.S. is not producing as many engineers as other countries which, he says, could have devastating consequences for the competitiveness of the country. China is producing yearly 350,000 graduate engineers, compared to 90,000 in the U.S.; however, the level of education may not be outright comparable.

During the decades of 1960's and 1970's Americans feared that the rise of Japan as an economic superpower would become a threat to the American economy. Craig Barret, CEO of Intel (as cited in Bhagwati, et al., 2004), expressed his concerns about India and China soon having 300 million high-skilled workers and the consequences this might have for the skilled worker within the American economy. Although the main outsourcing destinations for the U.S. continue to be China, India and Mexico, multinational corporations are seeking production opportunities in other Asian and Latin American countries. Bronfenbrenner and Luce's 2004 report to the U.S.-China Economic and Security Review Commission revealed that there has been a major increment in the shift of production to the above mentioned countries. Hilsenrath (2004) argues that technology, and not trade, could have played the most important role in the loss of manufacturing jobs worldwide. Adbela and Segal (2007) predict that "the technological revolution that has driven the current wave of globalization will continue. Communication will become cheaper and easier, allowing corporations to spread their operations… around the planet" (pg 104). There are several factors mentioned as the motivators for the increasing trend in manufacturing mobility: cost reduction, cheaper labor, skills, market expansion, better technology and better systems.

Although companies are somewhat reluctant to publish numbers regarding their offshoring efforts, some estimate that by moving their operations to Asian countries, productivity has tripled (Hagel, 2004). Other reports show that the cost of moving manufacturing operations to China or India involve an increment of tangible and intangible cost that could be as high as 24 percent of the total product cost (Hogan, 2004). According to a survey conducted by the Nirupam Bajpai of the Earth Institute at Columbia University, 70 percent of the respondents stated that cost saving was the main reason for outsourcing followed by increased capacity, affordable labor and access to better technology (Smith, 2006). Trefler, as cited in Cheung, Rossiter, Yi, (2008) expands the list of motives for outsourcing by including access to a skilled workforce, expansion into growing markets and closer proximity to customers as principal motivators.

2. Need for the Study

There is great discrepancy among scholars and the general public as to what the effects of globalization, outsourcing and offshoring, have had for Americans, American businesses, and especially for the American worker. The manufacturing industry is often touted as the most negatively affected industry, but even here there is no consensus. Reports show indecisively that Americans benefit from globalization through affordable products manufactured abroad, while on the other hand, millions of jobs are outsourced and offshored to low wage countries, leaving workers without job opportunities. Both sides present evidence supporting their stances, but there is no general consensus. The Bureau of Labor Statistics (BLS) does not keep records of outsourced jobs, thus their positions cannot be confirmed or denied. Indiana has always been a manufacturing hub for the U.S. economy and the Midwest, and consequently it has also experienced the loss of manufacturing jobs in the region (Miller, 2005). Lack of evidence on the actual effects of globalization in the manufacturing industry leaves many questions unanswered. The purpose of this study is to assess the impact of globalization on the Gas Engine Manufacturing and Parts (GEM&P) industry during the time period 1998 – 2008 in order to determine whether globalization or technological improvements have caused the decline of employment opportunities in this industry. The industry selected for this research experiences strong global competition both from high-wage and low-wage countries and is thus considered appropriate for this study.

3. The Review of Literature

There are two types of outsourcing, one that relates to labor intensive processes from which jobs are frequently outsourced to developing countries as a result of labor arbitrage; and outsourcing to industrialized countries in which the outsourcing nation benefits from advanced technologies or economies of scale. Despite the type, organizations that outsource enhance their profits in their home country (Cheung, et al., 2008). However, most of the turmoil around globalization is related to the outsourcing of labor-intensive tasks performed by low skilled workers to developing countries. The outsourcing of jobs to industrialized nations is a topic scarcely discussed by the media and unnoticed by the general public.

In 1995 the Bureau of Labor Statistics created a program called the Mass Layoff Statistics (MLS) with the purpose of tracking the reasons behind layoffs that affected large numbers of employees and also to assess the need for employment and training for the displaced workers. Since June 2004 the data collected nationally and by State has been published and for the first time it included questions about domestically and/or internationally "movement of work". The MLS program asks for reasons behind the "movement of work" which targets directly the question whether or not the work was moved (or

outsourced) out of, or within the United States. Outsourcing information is collected through employer interviews and identifies the economic reasons for the layoff, the affected workers, and possible reemployment opportunities. The relocation destinations mentioned frequently in the interviews were China and Mexico. Permanent closures were recorded for the following manufacturing industries: food, transportation equipment, electronic and computer products; these closures were due to reorganization. Company restructuring accounted for 20 percent of layoffs displacing almost 200,000 workers in the same year (Brown & Siegel, 2005).

Smith (2006) posits that offshoring has four substantial economic benefits for the outsourcing nation; first, it reduces costs (organizations save approximately 20 to 30 percent by moving their operations overseas) and through the flow of jobs abroad, inflation can be kept at lower levels. Second, and in direct contrast to popular belief, there is a substantial gain in real income (approximately 70 to 80 percent) in the form of lower prices enjoyed by the outsourcing nation. Third, countries having high unemployment usually have a shortage of labor in particular areas that can be covered with outsourcing. And finally, workers displaced by outsourcing can be moved up the value chain to higher value-added/higher productivity jobs. However, Smith recognizes that there is no perfect mobility of labor and that frictions are likely to arise (Smith, 2006). According to Cheung et al. (2008) the gains of offshoring receive much less publicity due to the fact that they do not occur immediately and are difficult to associate with offshoring. Solomon deems that searching worldwide for personnel and production capability is not a new phenomenon, the only difference is that is happening at a much faster pace in an increasingly borderless marketplace (Solomon, 1999).

4. Education and Employment

In 2008, when unemployment was at 5.6 percent, there were 3 million jobs vacant for over six months. These jobs were related to Science, Technology, Engineering and Mathematics (STEM) and required higher education skills. By 2009, unemployment rose to 9.4percent and still there were over 3 million jobs available in the same areas. According to an analysis based on unemployment related to education, it was found that unemployment rates are negatively correlated with educational levels. Unemployment is higher among individuals lacking a high-school diploma (15 percent) compared to individuals with a bachelor's degree or further advanced education (4.8 percent). Edward E. Gordon (2009) states that recent school dropout rates at 30 percent levels is a serious deficiency in the American education system, and that "the picture of the U.S. economy that emerges is of abundance and poverty: abundance of labor, poverty of talent…"(p.35). Gordon also cites a survey conducted in 2005 in which American manufacturers expressed that holders of high-school diplomas are poorly prepared even for entry level positions Thomas

Friedman writes that: "…finally we are developing an education gap. Here is the dirty little secret that no C.E.O. wants to tell you: they are not just outsourcing to save on salary. They are doing it because they can often get better-skilled and more productive people than their American workers" (Friedman, 2005) . On the other hand, Vivek Wadhwa an adjunct professor with the Pratt School of Engineering at Duke University wrote in a testimony to the U.S. House of Representatives in 2005 that the notion that the U.S. is producing fewer engineering graduates than China and India is erroneous. Wadhwa distinguishes between transactional and dynamic engineers and contends that dynamic engineers, those capable of abstract thinking and high level problem solving, globally rounded and having strong interpersonal skills will be in demand; transactional engineers, defined as those that possess engineering fundamentals and perform repetitive tasks will experience a decline in demand. Wadhwa suggests that engineers should also possess business education in order to address technical and business complex issues and that they should learn to think as entrepreneurs and innovators (Wadhwa, Rissing, & Gereffi, 2006).

In a report conducted in 2005, Wadhwa found that the statistics frequently cited regarding engineering graduates in India and China are inaccurate, despite the fact that these numbers are provided by the Chinese Ministry of Education and from reports provided by the National Association of Software and Service Companies in India. Wadhwa states that the statistics presented contain not only four-year degrees, but also sub-baccalaureate degrees and certificate and diploma holders. According to this report, the U.S. awarded 134,406 bachelor degrees, India 112,000 and China 351,537 in 2004. Thus, there is no direct comparison with the accredited four-year engineering degrees statistics provided by the U.S. Another important factor is the quality of education, Wadhwa states that the quality of Chinese graduates is not close to the standards of U.S. graduates. Wadhwa sees a negative correlation between quality and quantity, with quality suffering at the expense of quantity. Barry Myers, a professor of Biomedical Engineering at Duke University states that" the quality of the students from the renowned Indian Institute of Technology (ITT) is as good as the average American student he teaches at Duke University" (Wadhwa, et al., 2006).

Thus, Wadhwa et al. (2006) foresee a shortage of dynamic engineers in China and India but foresees an abundance of transactional engineers. He warns that producing engineers without first studying the types of engineers that will be needed in the U.S. may have an adverse effect on the job market and lead to further unemployment. According to the Indiana Department of Education (IDE) and the Outreach Committee Presentation prepared in February of 2010, the United States loses a high school student every 26 seconds, leading to more than 1.2 million high school dropouts every year (Indiana Department of Education, 2010). The Indiana Department of Education states that school dropouts affect the country's economy directly by lowering tax revenues in all states and by increasing the cost of social programs; it is estimated that over 25 to 30 years a

dropout student can cost a community as much as $500,000 in public assistance, health care and incarceration costs. Harlow (2003) states that it is noteworthy that state and federal prisons inmates represent an overwhelmingly high population of school dropouts. In a study conducted by the Bureau of Justice Statistics in 2003 it was found that 75 percent of the country's state prison inmates are high school dropouts while federal prison inmates represent 59 percent of high school dropouts. In another study it was found that high school dropouts are 3.5 times more likely to be arrested than their counterparts that completed their school education. An increase of only 1 percent in graduation rates would save approximately $1.4 billion in incarceration costs (Alliance for Excellent Education, 2006). Alli et al. (2007) posit that the modern industry is knowledge intensive and jobs will be created for the highly educated; although, it is unlikely that jobs will be generated for the uneducated. Thus, "technology comes from but one place- education. The primary way to accept (or fight it) globalization is through knowledge*"* (Alli, et al., 2007). Fisher (2004) states that the primary cause of decline in employment in manufacturing is due to technological advances. Miller supports Fisher's position, stating that the primary driver of the decline in manufacturing employment is increased productivity, which allows manufacturers to increase an additional unit of output with fewer workers; this he says, is the "cause and the cure" for the decline in manufacturing employment (Miller, 2005).

Manufacturing jobs have been especially important for those without education or formal training beyond high school (Miller, 2005). In a report prepared for the Indiana Chamber of Commerce Foundation, it was found that the U.S. has serious workplace skills problems; in the nation approximately 50 percent of adults have low literacy (Futureworks, 2005). In the 21st century, 60 percent of all jobs will require skills that are possessed only by 20 percent of the current workforce (Futureworks, 2005).

Walter explains that John Howard, Director of the National Institute for Occupational Safety and Health sees a shift in the pattern of employment and that college education might not be the key to future employment. He states that from 2010 to 2020 around 30 percent of Americans in their 20s will work towards a college degree, but only 60 percent of future jobs will require a degree (Walter, 2010). Alli (Alli, et al., 2007) states that the most fundamental lesson from the globalization of markets is that the education and skills of the work force and managers are the dominant firm's competitive weapons (pg. 94). Wadhwa posits that competitiveness is a function of the graduation rates of engineers and scientist; … "Reality: It is all about age, workforce education and skills" (Wadhwa, 2011)

The disappearance of manufacturing jobs in the US is leaving manufacturing workers unemployed, and the media usually contends this as the result of globalization. The educational level of manufacturing workers in the area seems to be another factor contributing to their unemployability in an economy that seeks to implement technology in order to remain competitive in

the global market. However, there is still discrepancy whether globalization, technological improvements or education are causing the decline in employment in this industry.

5. The study

To uncover the effects of globalization an online survey was conducted targeting the industry selected and the Indiana Chamber of Commerce, the Engine Manufacturers Association and the Society of Manufacturing Engineers. The selected companies were operating under NAICS 336312. The requirement to be considered as a potential participant in the survey consisted of having at least 2 years of working experience in the industry or 3 years for all non-industry specific positions. It must be noted that since the industry under study was disappearing, there were very few companies still operating and willing to participate during the time the study was conducted. The survey was sent to 22 participants, and 18 responses where recorded. The participants were asked to assess the effects of globalization as experienced by them in their respective organizations and within their industry. The participants were also asked to give insight about the broad skills set required from future manufacturing workers to secure the stability and subsistence of this industry in the U.S.

Internal validity, the extent to which the design and the data yields allow the researcher to draw accurate conclusions about the cause-and-effect and other relationships within the data (Leedy & Ormrod, 2010) was achieved by approaching four professors at different universities and one PhD Candidate at Indiana State University. These individuals were considered knowledgeable and with substantial expertise in the area of research. For the validation process the survey questionnaire was sent electronically to this group of experts who were expedient in providing feedback and improvements to the questionnaire.

5.1. *The Results of the Study*

The results of this research sought to understand or explain how globalization had affected the industry under study. The repeatability of the study suggest that if the same questions were asked to a similar set of respondents then similar answers would be gathered. The requirement to be considered as participant in this study was that the interviewee must have at least 2 years of industry working experience or 3 years for all non-industry specific positions. The participants were requested to share their knowledge and experience in the area of globalization and employment by providing their views about the present and future of this industry. They also were asked to give insight about potential factors that could help manufacturing workers to compete in a globalized world as well as their opinion about the broad skills set that future manufacturing workers may possess to secure their work in this globally challenged industry.

The knowledge gained from this study can help identify any negative factors affecting this industry in order to ameliorate these factors and allow this manufacturing sector some insight toward a possible improvement. As also found in the review of literature, there is a correlation between educational achievement and job security palpable in this industry as well. The higher the educational level of the individual the less affected they are by the introduction of i.e. new technology. Half of the respondents agree that automated manufacturing processes will replace less skilled workers. Thus, based on these results and in the review of literature it can be concluded that new technology will continue to dislocate primarily low-skilled and unskilled workers, while holders of higher degrees will not be as affected in the same proportion.

The survey inquired further whether or not the skill set of the workforce at the time of the implementation was sufficient to deal with the new technology. Half of the respondents were unsure about this fact while 29 percent considered that the skill set of the workers at the time of the implementation was not sufficient to deal with the new technology. Only 21 percent considered that their current workforce could manage the new technology without further changes on employment rates. The respondents state that the lack of skills encountered resulted on the other hand, in the positive fact of hiring new skilled workers. From the answers gathered it could be deduced that automation is equally destroying as well as creating employment opportunities. Less skilled workers are being replaced by technology and automation. These machines require knowledge and expertise that can be provided by high-skilled workers only, who were not previously present on the manufacturing floor. Thus, it can be concluded that the face of the manufacturing industry is changing from labor-intensive production processes to knowledge-intensive and high-tech. Fewer workers will be needed on the production floor while productivity will continue to increase. The respondents agreed unanimously that in the future there will be a shortage of a qualified workforce and that this will lead to other nations surpassing and even coming to dominate manufacturing areas in which the U.S. used to lead. Half of the respondents glimpse a seemingly difficult future for the U.S. manufacturing industry and believe that the American manufacturing industry may even disappear to the benefit of foreign competitors.

The survey explored the area of education as a competitive factor in the global arena. Eighty seven percent of the respondents consider that education in the areas of mathematics and science are extremely important to withstand competition and technological advances from foreign competition. Eighty percent of the respondents consider that current manufacturing workers need to improve their skills in primarily technical areas. Seventy three percent of the respondents consider interpersonal skills as an important factor while 47 percent deemed business knowledge an important area that needs improvement. Technical competitiveness is undoubtedly the major competitive factor in the area of education. The shortage of a qualified workforce was often mentioned in the review of literature as a major problem in the manufacturing industry. Thus,

the survey investigated further where this industry finds currently the workforce they need. The respondents state that manufacturing workers are mostly found at: 2-year technical colleges and Universities

- Unemployed experienced workers
- Hands-on experienced workers
- Engineering departments
- Current workers working for competitors
- Workers must be trained on site

The survey questionnaire explored whether higher education was relevant for technical competency and global competitiveness. The results show that 75 percent of the respondents agree that certifications provided by industrial organizations and 2 year technical colleges provide the necessary skills and knowledge required for this industry.

Sixty percent of respondents state that university studies at the Bachelor's level provide the technical education required. Advanced degrees at Master's and Doctoral levels are deemed less relevant for this industry. The review of literature discussed the fact that in the 21st century, most of the jobs will require skills that are possessed only by 20 percent of the current workforce and that many of those jobs are in areas still unknown to us. Certainly, technological improvements are also requiring more sophisticated skills that may have not been created yet.

The educational level of the manufacturing workforce in the area is considered scarce. Employees with low or no formal education seem to be mostly affected by the introduction of new technology in the manufacturing floor. The introduction of technology in the manufacturing process is displacing low-skilled workers. However, the respondents deemed globalization as the main responsible for any negative impact suffered on employment rates in this industry and not educational achievements by the domestic workforce.

6. Conclusion

This study sought primarily to understand the effects of globalization on the gas engine manufacturing and parts industry in Indiana as experienced by those individuals working in this industry. In that context, the researcher feels the objective of the research was achieved by the responses obtained through the survey. Although, the responses obtained in the survey showed divergence of experience in some areas while others seemed to have more commonality. However, the results gathered in this study were valuable in bringing some understanding to how globalization and technology have impacted this industry in Indiana. The results show that employees with no formal education or scarce education were mostly affected by the introduction of new technology. Low-skilled and unskilled workers seemed to be the first employee category to be replaced by equipment when automation was brought into the manufacturing floor. The majority of respondents considered increased competition as one of

the major drawbacks of globalization. They also stated that globalization was, according to their knowledge and experience, the main responsible for the decline in employment opportunities in this industry. The results of the survey showed that employment security and education are correlated; a workforce that possesses higher education and technological skills is less at risk of being replaced with automation.

There was consensus among the respondents about the fact that, in the future, the U.S. will experience a shortage of a qualified workforce. This situation may give other nations a dominating manufacturing position in areas where the U.S. used to excel. The majority of respondents affirmed that the increasing number of student dropouts from the school system and the scarce availability of a knowledgeable workforce are creating substantial problems for this industry. The respondents stated that education in the areas of science and mathematics was extremely important to withstand competition, and also that the current school system was not providing the basic skills required to secure a job in this industry. The vast majority stated that the workers in this industry needed to improve their technical skills, followed closely by interpersonal skills. At this time business knowledge and entrepreneurial thinking were not considered relevant. Technical knowledge was considered by far the number one competitive tool for this industry. The respondents stated that certifications provided by industrial organizations and 2- year colleges bestowed future manufacturing workers with the skills and competencies deemed necessary in this industry.

Despite the theories that anticipate the U.S. manufacturing industry will succumb to the advantage of developing nations, this industry can still constitute one of the main pillars of the nation's economy. The results of this exploratory research demonstrate that the perception of the manufacturing industry under study is similar to that of the opinion of the general public. The fact that globalization enhances competition should be regarded as a means to further development and discovery and raise the bar by which U.S. companies need to perform in order to compete globally. Indiana and U.S manufacturers alike are, as a result, pushed to continuously improve their production processes and become more efficient in order to remain competitive in a globalized world.

Globalization is certainly putting Indiana's manufacturing to the test. This industry is facing real challenges with competition and workforce related issues. This competition is not exclusively associated with foreign competitors and products manufactured abroad; it is the daily struggle of trying to attract future workers to an industry that is tainted by the old image of Henry Ford's assembly line. Oftentimes manufacturing jobs are portrayed by layoffs, the offshoring of jobs to developing countries and unsanitary working conditions. The manufacturing industry' image has been regarded by many as its own worst enemy. If the manufacturing industry is to survive, great effort should be dedicated to depart from this dated image and promote manufacturing as the exciting industry it actually is; an industry that has certainly reinvented itself as

high-tech in the 21st century. The industry itself, but also trade schools and universities, have the responsibility to make this "face lift" possible and make it known. Future manufacturing workers must first be reassured that there is job security and potential for growth in this industry. The United States Department of Labor provides a countrywide and state specific apprenticeship sponsor programs that could be utilize to spark the interest of potential students in technical related areas necessary in this industry. On-the-job apprenticeships provide hands-on experience and successful students are usually employed by the sponsoring company.

However, the scarcity of a qualified workforce deters investment in capital goods since current manufacturing workers lack the technical skills required to deal with new technology. In order to overcome this obstacle and mitigate the effects of globalization, education in technical areas is necessary. It is the accessibility of a knowledgeable workforce that will decide the future of the manufacturing industry in general, and this industry in particular. The lack of a knowledgeable workforce will continue to push the manufacturing industry to become more automated and to increasingly rescind from their need of labor, or it will force them to offshore when qualified domestic labor becomes unavailable. The only way to withstand competition is through education. Without an educated workforce no industry will be able to survive, and our world will become with or without us "One World Ready Or Not" as Greider (1997) once stated.

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A Model of Flight Slot Utilization and its Effect on Training Completion

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Flight students enrolled in collegiate bachelor's degree programs seek to log as many hours as possible, earn as many certificates as possible, and do this in the shortest amount of time. Collegiate flight programs share these goals, but typically have a fixed number of aircraft, university scheduling policies, aircraft maintenance, and weather minimums that affect the number of flights to be scheduled in a slot. . The number of hours each pilot logs is directly related to the number of flights in a flight slot, the number they are able to fly and the number of slots they have missed. Quality measures such as pilot training performance and completion rate are related to the number of hours flown. In this paper, an exploratory model of pilot behavior, weather events and maintenance events is developed and an initial set of quality metrics are proposed. The quality metrics may be used to better understand pilot training completion and to explore process and quality improvements in relation to the flight slot utilization due to pilot behavior, weather events and maintenance events.

Keywords: collegiate pilot training, quality measures, simulation, flight slot utilization.

1. Introduction

Human factors, weather events and maintenance downtime are a few significant obstacles to pilot training. It is imperative for flight students in the college who have the desire to become a business, corporate or airline pilot to log as many hours as possible in the shortest amount of time. On the other hand, collegiate flight programs have similar goals but have limitations on fleet size, scheduling policies, aircraft maintenance, and weather minimums which can possibly affect the number of flights in a slot.

Flight training and slot utilization are effected by weather minimums; for instance Visual Flight Rules, dual local or pattern training flights are only allowed if the ceiling is over 1500 ft. above ground level and visibility is over 3 nautical miles[1]. Complying with the safety rules ensures student safety but also affects

flight slot utilization negatively, especially during special weather events. There is also the safety grounding due to maintenance downtime or pilot readiness.

2. Methodology

According to the Advanced Aviation Analytics Institute for Research[2] plane tracking website created at Purdue, for most of the school year, there are six two-hour slots available daily between 7:30am– 5:30am. There is an average of 10 flights allocated for each slot is, and every slot has a stand-by student scheduled.

This paper focuses on slot utilization, not fleet utilization, by modeling training slots and exploring quality measures. The quality measures provide insight into flight slot utilization lost due to pilot behavior, weather events and maintenance events. A process model created through observation and interview methods was developed and modeled using discrete event stochastic simulation software. The researchers interviewed pilots and dispatchers to better understand pilot behaviors and how those behaviors may result in negative impact on flight slot utilization. The model estimates quality measures using flight slot utilization, and the number of flights slots lost due to maintenance, weather, or pilot behavior.

The number of flights allocated in each slot depends on the number of aircraft available; the number of aircraft available is closely related to maintenance events. Dispatchers can dispatch all available aircraft during a permissible weather day. On average, there are 10 Cirrus SR-20 aircraft dispatched per slot.

The most frequent reasons that pilots miss their slots are illness and weather. Pilots are responsible for calling-in before their scheduled time to inform dispatchers that they cancelling their slot. If they do not call-in to cancel, there is a grade penalty. On average, there is a 90% show-up rate during a normal school day and 60% show-up rate during the week before Spring Break. Reasons for cancellation are not explored in this paper, but may also be related to the level of motivation, perceived course workload, or other extracurricular workloads. Absences due to cancellation happen more frequently early in the fall semester as some students are adapting to collegiate demands. Another pilot behavior modeled is lateness. If a pilot is more than 15 minutes late in being ready to fly with keys and tablet, then the pilot loses the slot.

3. Literature Review

A literature review was conducted to explore the impact of weather minimums, flight cancellations, maintenance on flight slot utilization for flight training. According to Mott and Bullock[3] in a fleet utilization and fleet sizing study, the total weather downtime per week from August 30th, 2014 to December 13^{th,} 2014

was 101.25 hours and total Maintenance downtime per week from the same period was 399.38 hours for the 16 Cirrus SR-20s in the Purdue training fleet. Modeling of uncertainties in flight training operations is not common, but it is more common in commercial airline operations[4, 5].

4. Model Development

A simulation software package Arena (a Rockwell Automation, Inc. commercially available software product) was used to create a process model and collect data for quality measures. Observations and interviews were conducted to develop the process model and to collect quantitative inputs for the model parameters. Inputs include process steps and decisions, and the following data:

- Verify Certificates (license, ID and medical) time,
- Obtain CFI approval time,
- Check out the pilot, keys, flight tablet time,
- Preflight inspection time,
- Aircraft available per slot,
- Grounded pilots per slot,
- Solo flights per slot,
- Pilots approved by CFI per slot,
- Pilots arriving late per slot,
- Aircraft with discrepancies after preflight inspection per slot.

In the model, entities move around, change status, and are affected by other entities and the state of the system. The entities for the model are the pilots because they are the dynamic objects studied in the simulation and move through the processes. The next step was to define the "Resources" needed to fulfill the needs of the "Entities" in processes. A process seizes a resource when available and releases it when finished. In the model, pilots need to be verified and checked out by dispatchers before they can do their preflight inspection and fly; therefore, dispatchers are resources. With the "Entities" and "Resources" defined, a Process Flowchart Module was created to show the process. The process begins with the pilots checking the weather and schedule and ends with the pilot either beginning their flight or losing the slot due to Weather, Maintenance or Pilot's Behavior in Figure 1. Following the completion of the Process Flowchart Module, process parameters and rules were added. In the processes, the resources are seized, delayed then released as entities pass through the process. A number of units of a "Resource" are seized, delayed during the processing time, and then released back to the pool of resources available for the next entity or for other processes. In this

model, triangular distribution were used in the model because the processing times are rough estimates of the minimum value, maximum value and the peak value. For the "Decide" modules, percentage true was entered.

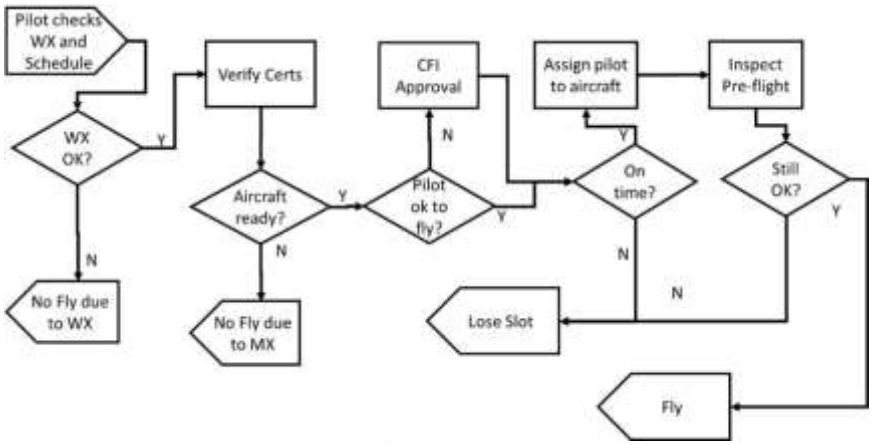

Figure 1. High level model for pilot training flight check-in process.

5. Analysis

During model analysis, graphs were created to visualize the number of pilots released over time and the number of pilots that managed to fly at the end of the process so that the researchers could verify the model set up and validate the model when compared to the real process. In this exploratory model, the number of pilots that lose their slots due to Weather, Maintenance and Behavior was collected. The number of pilots who lose their slot due to pilots behavior averages 10 per day, the number pilots who lose their slots due to Weather and Maintenance are only 1 and 4, respectively. Therefore, the main reason in this exploratory model that a pilot loses the slot on a day to day basis and affects the quality of flight training is their behavior, and not weather or maintenance. Further comparisons of the model outputs to real system behavior is necessary to increase the validity of this model. Potential quality metrics for this process were identified:

- Number of slots scheduled versus total slots,
- Number of slots flown versus scheduled slots,
- Number of flight slots cancelled and the associated reasons,
- Number of slots not scheduled and the associated reasons.

If these metrics are collected daily in the simulation or in real life, then these metrics could be then analyzed by using quality tools such as a Pareto chart for summative analysis, or the np-chart for temporal analysis of system behavior. If the np-chart is established, then systemic variation versus special cause variation may be identified. Combining the Pareto chart with a fish-bone chart may be used to increase the depth of understanding of why cancellations occur.

6. Future Model Improvements

This model was built to explore a technique to estimate the number of slots missed due to Weather, Maintenance or Pilot's Behavior. Much further development is needed to verify the model and validate the model. While the results are reasonably presented, there are certainly many areas that can be improved on to ensure more accurate results. Building a more complex model is essential to accomplish this. For example in figure 1, the “Weather OK?” decide module may be replaced with separate decisions for IFR and VFR flights, and the “Aircraft ready?” decide module may be replaced with model processes to show the effect of different types of maintenance downtime, not just discrepancies.

In addition, a separate process for the standby pilot could be modeled to better reflect the situation when a pilot did not fly their scheduled slot for any reason, so the pilot waiting standby for the slot will be able to fly. Developing a dashboard for the model and quality charts may be used to explore options for improving the flight slot utilization and time to completion for students. In improved models, the main reason that a pilot loses the slot might change and the quality measures for flight training may be expanded or more specific to understand process behavior.

7. Conclusion

In conclusion, the analysis of the model output provides an understanding of the pilot training process in terms of a quality measure, flight slot utilization. The flight slot utilization is negatively affected by Pilots' Behavior, Weather Minimum and Maintenance Events. As indicated in the results, the losing a slot negatively affects slot utilization. However, there are limitations to the current process model such as the level of detail in the model, the accuracy of the estimated times, and the accuracy of estimated slot loss rates. The results might change and would be more accurate if future improvements are done. This paper lays a foundation to explore the prominent factors affecting slot utilization in pilots’ training.

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A study of the relationship of certain measures of success on the technology readiness index score for small manufacturing organizations in the Mexico City metropolitan area

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Mexico's economic success has been consistently attributed to the entrepreneurial and hardworking characteristics of small manufacturing organizations. These firms usually rely on the owner's and manager's knowledge to make technological decisions. The role of technology management is to understand the value of technology and be able to argue when to invest in or withdraw from on technology. A review of current publications indicates an urgent need for scholarly inquiry on technology issues such as, how ready are small manufacturing organizations to embrace and effectively use new technologies? If they are, does this mean, they will be successful and competitive? It is with these questions in mind, that the purpose of this study was to determine if a relationship exists between certain measures of success of small manufacturing organizations located in the Mexico City metropolitan area, and organizations technology readiness index score.

Keywords: Technology Management; Technology Readiness; Manufacturing; Small Organizations; Success.

1. Introduction

The effective management of technology is what creates wealth for organizations by having the ability to effectively manage resources and technological assets [1]. According to Peterson [2] the keys to success in manufacturing industries are skilled worker supply, technology integration, quality and outsourcing. Combining these elements will create a strong and competitive forum for every level of manufacturing. The nature of manufacturing is unpredictable and its' perceived decline are driving people away from manufacturing as a career choice [3]. There is in fact, given this perception, a critical shortage of skilled manufacturing workers. However, in recent years, the business environment in Mexico has been highly favorable to open new manufacturing organizations.

There is no evidence of existing research on how an organization technology readiness index score affects certain measures of success in Mexico. The changing demographics of small manufacturing organizations workforce, such as educational preparation and position in the company can influence and affect the measures of success. This study intends to expand the body of knowledge in technology management and technology readiness in small manufacturing organization's in Mexico City, Mexico.

2. Literature Review

In business, the concept of success is often referred to a firm's financial performance in terms of an increase in the number of employees and in turnover. Startup businesses create an average of 3 million new jobs annually according to the Kauffman Foundation [4]. According to Reynolds and White up to one-half of all adults are engaged in self-employment or the creation of a business at some point in their work career [5]. These micro and small organizations do not have the same resources as others, and usually are run day-by-day operations. A great example is a study made by Qureshil, Kamal & Wolcott, where a set of micro organizations in North Omaha were analyzed [6]. Many entrepreneurs who had received state-of-the-art technology to assist them with their organization had not opened the packaging six months after they had received it. A different study made among micro organizations showed that only 27 percent use e-mail and 22 percent use Web sites to interact with clients and suppliers [7]. Small organizations have unique features that could be shared with micro organizations but not others. In 2009 micro organizations where defined as having one to nine employees with annual sales less than 2 million pesos and small organizations ran from 10 to 49 employees with no more than 10 million pesos annual sales [8].

Many manufacturing firms have moved their operations throughout the past decade, to Mexico and China because of the attractiveness of low-cost sites available. Technology is driving changes, providing major opportunities and challenges in product and production innovation, which enables manufacturing industry to respond positively if used properly. Technology readiness refers to "people's propensity to embrace and use new technologies for accomplishing goals in home life or work" according to Parasuraman [9]. A combination of positive and negative feelings regarding technology exist that can impact a person's willing to embrace a new technology [10].

Small manufacturing organizations are increasing in number and helping the economy without much knowledge of technology management and or technology readiness concepts. For the purpose of this study, certain measures of success were identified from the review of literature and selected by the researcher as: business survival, annual revenues, number of employees and technology consumption.

3. Methodology

The problem of this study was to determine if a relationship exists between certain measures of success (business survival, annual revenues, number of employees, and technology consumption) of small manufacturing organizations located in the Mexico City metropolitan area and organizations's technology readiness index score. Because of the uniqueness of the study, a questionnaire was developed and administered via interview consisting of four sections: demographic data, organization information, technology consumption and technology readiness index 2.0 (TRI). The technology readiness index score 2.0 is a 16-item measurement scale assessing four dimensions of technology belief that impact an employee's level of technology readiness. According to Parasuraman [9], two of the technology readiness index dimensions are contributors (optimism and innovativeness) and two are inhibitors of technology adoption (discomfort and insecurity).

The researcher presented the notion that the greater the technology readiness index score of small manufacturing organizations the more aggressive an organization manages and implements certain measures of success. In essence, the more ready the small manufacturing organization's are to embrace technology, the better their chances are of being successful.

The Mexican System of Entrepreneur Information [10] database was used to determine the sample frame. The researcher used manufacturing organizations that had 49 or fewer employees and had been in business for more than 5 years located in the Mexico City Metropolitan area selected counties. An invitation to participate in the study was sent to fifty viable participants. The response rate for the study was of 32%.

4. Analysis and Results

Descriptive statistics, compared means and spearman rho correlation were made to address each research question, since most of the data was ordinal.

Hypothesis:

$Ho_{(1,6)}$: There is no statistically significant relationship

$Ha_{(1,6)}$: There is a statistically significant relationship

Table 1. Nonparametric Correlations – Spearman's rho

Correlations

			BS	AR_Mode	NE_Mode	TC_ModeYear	TEC_Mode	TR
Spearman's rho	BS	Correlation Coefficient	1.000	-.021	.401	-.179	.021	-.115
		Sig. (2-tailed)	.	.942	.124	.508	.940	.671
		N	16	15	16	16	16	16
	AR_Mode	Correlation Coefficient	-.021	1.000	.598*	.109	-.335	.117
		Sig. (2-tailed)	.942	.	.019	.700	.222	.679
		N	15	15	15	15	15	15
	NE_Mode	Correlation Coefficient	.401	.598*	1.000	.042	-.440	.213
		Sig. (2-tailed)	.124	.019	.	.877	.088	.429
		N	16	15	16	16	16	16
	TC_ModeYear	Correlation Coefficient	-.179	.109	.042	1.000	-.660**	.286
		Sig. (2-tailed)	.508	.700	.877	.	.005	.284
		N	16	15	16	16	16	16
	TEC_Mode	Correlation Coefficient	.021	-.335	-.440	-.660**	1.000	-.380
		Sig. (2-tailed)	.940	.222	.088	.005	.	.147
		N	16	15	16	16	16	16
	TR	Correlation Coefficient	-.115	.117	.213	.286	-.380	1.000
		Sig. (2-tailed)	.671	.679	.429	.284	.147	.
		N	16	15	16	16	16	16

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

RQ1: Technology Readiness Index Score and Business Survival - The Spearman's rho coefficient was a negative correlation that was not significant with a value of -0.115 (as shown in Table 1). The researcher failed to reject the Ho_1 of no statistical significance in favor of the alternate.

RQ2: Technology Readiness Index Score and Annual Revenues - The Spearman's rho correlation coefficient was a weak correlation that was not significant with a value of 0.117 (as shown in Table 1). The researcher failed to reject the Ho_2 of no statistical difference and favors the alternate.

RQ3: Technology Readiness Index Score and Number of Employees - The Spearman's rho correlation coefficient was a weak correlation that was not significant with a value of 0.213 (as shown in Table 1). The researcher failed to reject the Ho_3 of no statistical significance in favor of the alternate.

RQ4: Technology Readiness Index Score and Technology Consumption -The Spearman's rho correlation coefficient for TRI and TC per year was a weak correlation that was not significant with a value of 0.286 (as shown in Table 1). The Spearman's rho correlation coefficient for TRI and TC perception was a weak negative correlation that was not significant with a value of -0.380 (as shown in Table 1). The researcher failed to reject the Ho_4 of no statistical significance in favor of the alternate.

RQ5: Technology Readiness Index Score and the Combined Measures of Success - A multiple linear regression was calculated but not significant with a value of 0.936 and an R^2 of 0.107. Technology readiness index score

cannot be predicted by the combined measures of success. The researcher failed to reject the Ho_5 of no statistical significance and favors the alternate. The regression analysis, supports the Spearman's rho correlation that none of the IV are significant related to the DV.

RQ6: Technology Readiness and Size of the Organization - A regression equation was calculated but not significant with a value of 0.895 and an R^2 of 0.001. Technology readiness index score cannot be predicted by size of the organization. The researcher failed to reject the Ho_6 of no statistical significance and favors the alternate.

5. Conclusions

Although results showed no statistical relationship between technology readiness index score and the selected measures of success, it is not prudent to assume that results are equally applicable across Mexico City. A large replication of the current study incorporating all counties in Mexico City metropolitan area would provide more generalizable information from which to draw inferences. This study has built research in the field of technology management in Mexico City, Mexico.

6. Future Research

A comparison of this study between small, medium and large manufacturing organizations can be made and see if technology readiness has actually an impact in success in any of the groups mentioned while using the Mexican System of Entrepreneur Information database. Using more than one database could also broaden the sample size, improve response rate, and create a greater and better picture of how technology readiness affects success in manufacturing organizations.

Further research could be an investigation of the relationship of demographic information (age, gender and experience) and how these variables influence technology readiness index score.

Many of the participants of this study provided voluntary feedback and expressed the desired to complete the instrument at the moment of the call (via telephone) or via Internet (online), no need for an actual visit. A potential area of study identified by the researcher was to run the same study with different types of delivery, phone call, online and/or interview. Then compare the data among the three groups, this will create a larger sample from which to draw inferences.

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Quality Assessment in Higher Education: A Comprehensive View of the Data

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Abstract

Public and private organizations in every sector have used The Malcolm Baldrige National Quality Award criteria and process to assess organizational performance. This comprehensive approach to performance assessment has helped these organizations to address major challenges. Yet relatively few higher education institutions have embraced this approach, in spite of major persistent challenges. Although The Malcolm Baldrige Quality Award criteria and process have been used in higher education for at least 25 years, its application has been sparse, and research on its effectiveness consists primarily of a few case studies. This makes it difficult to evaluate the efficacy of this approach in higher education. In their analysis of the Baldrige Education Criteria, Badri et al.[4] suggested that future research evaluate other samples and different educational organizations, so that results may be generalized to a greater degree. This exploratory study utilizes twenty years of data from the Integrated Postsecondary Education Data System (IPEDS) to analyze the performance of state and national quality award recipients from higher education compared with similar non-recipient institutions. Two different comparisons are made. Institutional performance of award recipients in the award year is compared with that of non-recipients. Also, changes in award recipient performance across an implementation time line is compared to that of non-recipients. The study explores performance on multiple measures related to important issues in higher education including value for students, institutional outcomes, student accessibility, and student centeredness. An implementation timeline for a Baldrige type assessment in higher education is also analyzed. This study may help to inform both administrators and policy makers regarding the efficacy of quality assessments such as the Malcolm Baldrige National Quality Award process.

Key Words: Malcolm Baldrige, MBNQA, Quality Awards, Higher Education, Quality Assessment

1. Introduction

When faced with significant challenges, many U.S. manufacturing companies implemented Total Quality Management (TQM) with mixed results. Nonetheless, this implementation spread to other sectors including service, non-profits, healthcare, and education. Just as American manufacturing has faced an end to its global dominance, unprecedented challenges face public higher education institutions (HEIs) in the U.S. today.

A significant number of higher education institutions at least toyed with TQM in the 1990s.[1,2]. Many declared failure and moved on. Others are still trying.[3,5,8,12] One difficulty in assessing TQM efforts is that definitions of TQM, while aligned in principle, differ in specifics. Like many quality improvement efforts, successful implementation may be difficult to define clearly. One approach to this assessment of TQM implementation is to use the Malcolm Baldrige National Quality Award (MBNQA) process. This process aligns well with the principles of TQM. It has been argued[9] that receiving quality awards is an appropriate measure of successful implementation of TQM. The receipt of quality recognition based on the MBNQA process and criteria was used in this study as an indicator of successful TQM implementation. This study examined the efficacy of public higher education institutions that have received quality awards in addressing important challenges for undergraduate education.

2. Background

The Malcolm Baldrige National Quality Award has been in existence for well over 20 years. Cost, accountability, and access have been major challenges for public higher education for even longer. Although the Baldrige process has been used in a limited way in higher education since the early 1990s evidence of its efficacy, particularly related to these challenges, is anecdotal at best. Previous research studies on results from the Baldrige process have focused mostly on manufacturing organizations and more recently on healthcare.

The purpose of this study was to begin to establish a body of research that tests the efficacy of the Baldrige approach in various types of organizations. This study was to a degree exploratory. This author hopes that this line of research will be continued to establish the benefits and limitations of the Baldrige process in various types of organizations.

A review of the literature identified major challenges that have persisted for 30 years. These challenges were cost, accountability, and access. A theoretical

framework based on these challenges was constructed. Twelve dependent variables were identified related to those challenges. This model was then tested at three levels. Smaller groups of these variables were used to test each of the three constructs. There is ample room for improvement and refinement of these research elements.

3. Research Questions and Hypotheses

Below are the fundamental research questions and associated performance hypotheses for this study.

RQ1. Do public HEIs which are award recipients perform differently from similar institutions on key measures of cost, accountability, and access in the performance year?

$H_0$1. There is no statistically significant difference between award recipients and non-recipients in institutional performance on key measures of cost, accountability, and access in the performance year.

H_a1. There is a statistically significant difference between award recipients and non-recipients in institutional performance on key measures of cost, accountability, and access in the performance year.

RQ2. Do performance changes on key measures of cost, accountability and access in the period preceding a quality award differ between award recipients and non-recipients?

$H_0$2. There is no statistically significant difference between award recipients and non-recipients in changes to institutional performance on key measures of cost, accountability, and access from the base year to the performance year.

H_a2. There is a statistically significant difference between award recipients and non-recipients in changes to institutional performance on key measures of cost, accountability, and access from the base year to the performance year.

The performance year is the year the award is based on and is the year before quality recognition is granted. The base year, is five years before the performance year. This is used to compare performance over time, and is based on the five year implementation period suggested by previous studies[9] (Hendricks & Singhal, 1997).

4. Methodology

The population for this study was all public undergraduate institutions of higher education in the U.S. that received federal funding and were therefore required to report data to the Integrated Postsecondary Education Data System (IPEDS). HEIs

that have received quality awards were identified through the state and national quality award websites and compared with those that have not received quality awards. For this study, the population was divided into two groups for comparison; those which had been awarded recognition from state or national quality awards and those which had not.

From the quality award website data, 107 recognition awards were identified for higher education institutions between 1993 and 2008. For profit institutions were removed. Where institutions were recognized in multiple years, the first recognition was used. After consolidating the cases of multiple recipients, there were 61 distinct institutions that had received recognition at the state or national level. Three cases were removed because of missing data. The study then compared 58 award recipients and 58 matched non-recipients.

The key challenges facing public HEIs were identified through a comprehensive review of the literature. Measures of organizational performance related to those challenges were identified, selected, and defined in further literature review. Five dependent variables were identified related to cost, five related to accountability, and two related to access. Comparison of organizational performance of quality award recipients before and after implementation of the Baldrige process utilized repeated measures MANOVA. The comparison of the organizational performance of quality award recipients with non-recipients in the performance year utilized MANOVA.

Award status was the primary independent variable of interest. Other variables were included to control for differences in size, institutional type, locale and geographic area. Size was entered as a covariate, and award recipients were matched with non-recipients for type, locale and geographic area. The dependent variables with definitions and related constructs are shown in table1.

Table 1 Dependent Variables with Definitions and Related Constructs

Measure	Definition	Cost	Accountability	Access
Tuition & Fees	Total of Tuition & Fees for the lesser of in-district students or in-state students.	X		
Graduation Rate	Total undergraduate completions per 100 FTE. (completions /FTE)*100		X	
General & Educational Spending	General & Educational Spending per FTE. (instruction, academic support, student services, institutional support, operational support, scholarships and fellowships) / FTE	X		

Measure	Definition	Cost	Accountability	Access
Direct Spending	Direct Spending per FTE. (instruction + student services + Scholarship & Fellowship Spending) / FTE	X		
Federal Grants	Total federal aid per FTE (Pell grants + other Federal Grants / FTE)			X
Scholarship & Fellowship Spending	Total Scholarship & Fellowship Spending / FTE	X		
Tuition Funding	Total Scholarship & Fellowship Spending / Tuition & Fees	X		
Minority Completions	Minority Completions / total completions		X	
Minority Success	Minority Completions / minority undergraduate enrollment.		X	
Retention	The number of undergraduates in the previous year minus the number of completions divided by the number of undergraduates in the current year minus freshmen.		X	
Minority Enrollment	Minority undergraduate enrollment / total undergraduate enrollment			X
Completions	Certificates and diplomas awarded / total undergraduate enrollment		X	

4.1 *Significance level*

Alpha of .1 was chosen. Protection against Type I error is desirable, as there may be some risk to capital, disruptions, and the well being of people that could occur as a result of policy changes. However, given the nature of the Baldrige process, it was thought that the effects of Type I error would be neutral rather than negative. These risks are moderate; and any policy changes are not likely to be catastrophic or irreversible. Additionally, the risks described above must be balanced against the risks of no action if the researcher failed to detect a difference because alpha was set too low. A more liberal alpha of .1 would give more power to detect real differences. Previous research[11,13] contends that researchers may have erred too much in favor of avoiding type I error at the expense of power. Cohen[7] suggested that exploratory studies such as this one use an alpha of .1.

5. Results

Multivariate analyses for the model, and for the constructs of accountability and access for research questions one (performance year), and two (performance change over the implementation period) revealed no significant differences at alpha = .1, and in each case, we failed to reject the null hypothesis. For the construct of cost, the p-value associated with award status for research question one was .060, therefore the null hypothesis was rejected. For research question two, the p-value was .158, which did not meet our significance threshold of alpha = .1. We failed to reject the null hypothesis for the cost construct for research question two. However, the univariate analyses revealed some interesting differences.

5.1 *Results: research questions one*

The cost construct was composed of five of the twelve dependent variables related to the cost to students, or the benefits of spending that was directed at students. These measures were Tuition & Fees, General & Educational Spending, Direct Spending, Scholarship & Fellowship Spending, and scholarship funding. Three of the five cost variables demonstrated statistically significant performance differences between award recipients and non-recipients. Within the cost construct, the dependent variable general and education spending had a p-value of .123, Slightly beyond our significance threshold of alpha = .1. The dependent variable Direct Spending is a subset of General & Educational Spending, and represents spending that most directly affect students. This dependent variable had a p-value of .051. The dependent variable Scholarship & Fellowship Spending had a p-value of .037, and the dependent variable Tuition Funding had a p-value of .081.

The accountability construct was composed of five of the twelve dependent variables which reflect outcomes from the educational process. These variables were Graduation Rates, Retention, Minority Completions, Minority Success and completions. Differences between award recipients and non-recipients were not statistically significant for the accountability construct, but two of the dependent variables within that construct showed interesting results. The dependent variable Graduation Rates yielded a p-value of .148. This is beyond our threshold of significance. However, there was an interesting interaction between Graduation Rates and institution type. At four year institutions, the difference in Graduation Rates based on award status was not significant, and award recipients had slightly lower rates. At two year institutions, the Graduation Rate was significantly different

between award recipients and non-recipients, which may call into question the accuracy of the five year implementation period as applied to higher education.

The effect size for each of these differences is also notable. Pair-wise comparisons revealed that, on average, award recipients Direct Spending was approximately 30% more than non-recipients. Scholarships and fellowships awarded were 37% more per student at award recipient institutions, and award recipients funded the tuition of their students at a rate of 72% compared to 50% for non-recipients. The mean Graduation Rate for award recipients was approximately nine percentage points higher than non-recipients for two-year institutions.

5.2 *Results: research question two*

Within the cost construct for research question two (performance change over the implementation period), the results of interest were the interactions between the dependent variables from research question and the dependent variable years, which represents performance change over the implementation period. This interaction between years and general and education spending produced a p-value of .107, again, slightly beyond our significance threshold of alpha = .1. However, it is worth noting the difficulty in finding significant results when analyzing interactions. The interaction between years and the dependent variables Direct Spending, Scholarship & Fellowship Spending and Tuition Funding yielded p-values of .036, .031 and .065 respectively. In these three cases, the null hypothesis was rejected.

Within the accountability construct, the interaction of years and award status success yielded a p-value of .07 for the dependent variable Minority Success. The three-way interaction of years, award status and type yielded a p-value of .098 for Graduation Rate. This suggests that there was a difference in the Graduation Rate change between recipients and non-recipients by type of institution over the implementation period.

When using repeated measured to estimate the performance change from over the implementation period, the effect sizes for the differences was again notable. Direct Spending increased approximately 25% at recipient institutions, while it increased 18% at non-recipients. Scholarship & Fellowship Spending institutions increased 26% at recipient institutions; while during the same period it decreased by about 1% at non-recipients. Tuition Funding increased by about 4 percentage points at recipient institutions, while it decreased by 19 percentage points at non-recipients. Minority Success increased from base year to performance year at award recipients, while declining at non-recipients. Perhaps the most surprising finding was for

Graduation Rates. At four year institutions, the Graduation Rates for both groups declined slightly, with a slightly greater decline at award recipient institutions. Meanwhile, at two year institutions, the Graduation Rate for non-recipients increased by less than a percentage point, while the Graduation Rate for recipients increased six percentage points.

6. Conclusions and Discussion

6.1 *Cost*

The dependent variable Tuition & Fees did not demonstrate any statistically significant difference between award recipients and non-recipients on either research question. Given the funding structure of most public higher education institutions, management approaches may have had little effect in restraining these increases. This finding lends support to statements by previous researchers[6,10,13,14] which suggest that institutions have limited control over Tuition & Fees. However, award recipients appear to do a better job of helping students fund the cost of education, and on institutional spending that directly benefits students. This suggests that successful implementation of the award criteria and process may lead these institutions to make different decisions regarding how they spend their money.

6.2 *Accountability*

As outcomes of the educational process, it was thought that these variables would be indirectly influenced by management actions. Differences in Graduation Rates between two and four year institutions were found in both research questions one and two. Performance differences between two and four year institution on Graduation Rates suggests that the five year implementation used for this study may not be appropriate for higher education.

6.3 *Access*

The access construct utilized only two of the 12 dependent variables. These were the variables that might be indicators of the ability of disadvantaged students to attend public higher education institutions. The review of the literature strongly suggested that access is primarily a function of social policy and political decisions, not decisions made by institutions. There is nothing in the result of this study that contradicts that assertion.

6.4 *Discussion*

Award recipients appear to spend more money directly on students (on a per student basis), than non-recipients. Award recipients were found to spend more on students through Direct Spending, and Scholarship & Fellowship Spending, than non-

recipients. Changes in spending from the base year to the performance year also indicated better performance on the part of award recipients. The effect of new management approaches on accountability measures was less clear. Administrators have some direct control over spending which is an input into the process. Accountability, which is a process outcome can only be influenced rather than controlled. Administrative policies and decisions can clearly influence these outcomes, but the effect is not direct. Since these effects are indirect, it may take more time for them to develop. Accountability results may be confounded by the personal situations and decisions of students, by changes in the job market, and by public policy decisions. It may also be of interest to community college administrators that two-year institutions which were award recipients outperformed the comparison group on Graduation Rates, while four-year institutions did not.

This researcher concludes that MBNQA recipients perform better than the comparison group of non-recipients on some measures related to cost; notably Direct Spending on students, and the ability to help students pay for tuition. It was noted that this represents inputs into the system rather than outcomes. Outcomes were represented by measures of accountability. The results for accountability were mixed. Minority students who attend award recipient institutions succeeded at a higher rate than those at non-recipient institutions. Graduation Rates were higher at two-year institutions for award recipients, but not at four-year institutions. For other accountability measures, such as Retention and completions, this study found no significant differences.

This study was a first attempt to construct a theoretical framework reflecting the three major challenges facing higher education. Having learned something about the performance against the selected measures, it might be useful to refine this framework. The framework examined in the study was purposely expansive. Three constructs and 12 dependent variables were tested for effects of award status. Based on the results of this analysis, a model can be proposed which might reflect performance differences between award recipients and non-recipients resulting from changes in management actions. The proposed model contains only two constructs; value (formerly cost) and accountability. Two to four dependent variables aligned with each construct might be included. This would create a much simpler model than the framework tested in this study.

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Development of a Six Sigma framework minimizing quality defects in 3D Printing Process

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A framework based on Six Sigma methodology consists of five stages - Define, Measure, Analyze, Improve, and Control (DMAIC) - was developed and successfully demonstrated in this paper to minimize quality defects in 3D printing processes. During the Improve stage, an orthogonal array (OA) L9 Taguchi experiment design was implemented with four controllable factors, each with three levels, and one non-controllable factor investigated, a total of 18 experiments were conducted and analyzed. The Six Sigma based framework leads the researchers to define optimal combinations of 3D printing process with Infill% of 35%, Extruder Speed of 150 mm/sec, Extruder Temperature of 235°C, and number of Shells of 4 to be able to produce 3D printing products with minima defect rate. This optimal parameter setting was verified through a confirmation run with 9-sample size which successfully improved the process capability index Cp and Cpk. This developed framework is well documented and could be used as a systematic reference to reduce defect per millions in many other industrial processes.

Keywords: Framework; Six Sigma ; 3D printing.

1. Introduction

3D printing, an additive manufacturing method, is becoming a hot topic in the modern manufacturing world. In its recent report on disruptive technologies, the McKinsey Global Institute (MGI) identified 3D printing as one of the top 12 technology areas with the potential for massive impact on how people live and work, and on industries and economies. It is well known for its rapid

prototyping, customizing ability and unlimited possibilities of making relatively complex parts. In the meanwhile, 3D printing is a good way to provide affordable and efficient design parts, which requires less assembly and fewer raw materials. However, even though 3D printing is a relatively new area, major companies are facing an increasing amount of pressure from customers about the quality issues which causes more intense competition and, as a result the margin shrinks. In order to meet the expectations of customers and to increase the profit of the company, the parts quality needs to be improved with stable manufacturing processes and a standardized worksheet. There are a variety of methods to enhance the quality of the products, and one of the outstanding methods introduced, in this paper, is the Six Sigma methodology. Six Sigma seeks to improve the quality characteristics of a process output by optimizing key input parameters, by identifying and removing the causes of defects. Plus it minimizes variability in the manufacturing process for a desired part to meet the needs and requirements of each specific customer. Taguchi based Six Sigma methodology with a hands-on lab-based case study, has been proven to be successful in both improving the process and reducing costs in the 3D printing process. That is why this framework has been developed to help many other facilities reduce defects per millions in their manufacturing processes.

2. Methodology

Six Sigma is a disciplined, data-driven approach, and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limits) in any process – from manufacturing to transactional and from the product to the service. It consists of five stages - Define, Measure, Analyze, Improve, and Control (DMAIC). This paper introduces the application of DMAIC Six Sigma methodologies to optimize the quality characteristics of the 3D printing parts. The flowchart (Fig. 1**)** defines the specific steps, starting with the identification of the problem and concluding with the implementation of long-lasting solutions.

3. Case Study

The case study is based on one key quality characteristic of a 3D printing part that was required by a customer, the Part Modulus. Makerbot Replicator 2x 3D printer (Fused Deposition Modeling or FDM) is used to print the parts. ABS plastic is used as the feed material. The goal is to make plastic parts in the 3D printer with the desired Part Modulus by using an optimal setting of the parameters achieved through DMAIC process.

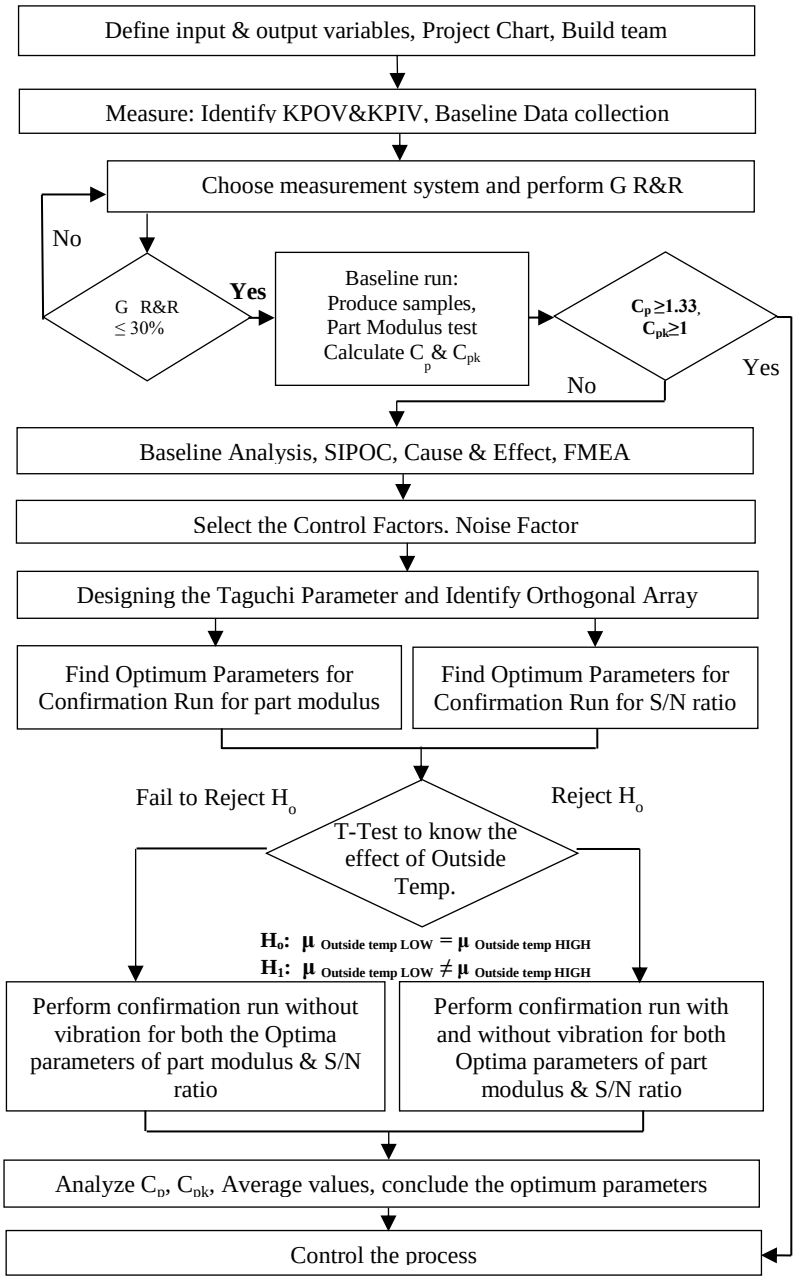

Figure 1. 6Sigma Flow Chart for 3D Printing Process

3.1. *Define & Measure phase*

Define and Measure are the first two phases in the DMAIC process, the main objectives are defining critical customer requirements, identifying the improvement opportunity and forming an effective project team. The technical tools such as Project Charter, the CTC/ CTQ vs. CTP matrix, SIPOC and Gage R&R can be used in the case study.

3.1.1. *Project Charter*

The Project Charter is a statement of a business problem encountered by the Project Sponsor. It is a key deliverable document that helps in defining an issue a team needs to solve. The charter includes information such as, the objective statement of the problem the team will tackle, the project scope which summarizes all the deliverables that add value, the business case which is the justification as to why a project has value to the sponsoring organization, and the benefit to the internal and external customers. The objective of this project is to improve the process capability and reduce costs in the 3D printing process.

3.1.2. *CTQ&CTP(Critical to Quality versus Critical to Process)*

CTC/ CTQ vs. CTP matrix tools are used to identify the customer's needs and process improvement opportunities. The basic function of the CTQ/CTC vs. CTP matrix is to take the newly defined Y, or the part Modulus, and evaluate all of the X's or process parameters which most significantly affect the output of the part Modulus.

Table 1. CTQ & CTP

NEEDS	*DRIVER*	*CTQS/CTCS*	*CTP*
VOC: I want the good Part Modulus	Product Quality	Good Part Modulus	Type of Material - ABS plastic
		Accurate dimensions	Infill density (%)
		Surface finish	Nozzle Speed(mm/sec)
			Temp of Build plate (°C)
			Temp of Extruder head (°C)
			Level of Build plate (180°)
			Order delivery time
		Cycle time	Nozzle Speed(mm/sec)
	Cost	Selling price	Material cost ($)
			Packing cost($)
			Shipping cost ($)

3.1.3. *Baseline Results*

In the measurement phase, baseline data is defined and an initial idea about the process capability is formed. With the current process parameters (infill=30%; No. of shells= 2; Extruder Speed=150m/sec & Extruder Temp=230°C) a baseline study has been conducted and a small sample size of 9 parts are produced and tested. The required Part Modulus that needs to be achieved is 2930±150Mpa. The baseline data demonstrated a low value of process capability with a Cp of 0.62 & Cpk of 0.21 which indicates the improvement opportunities of the current manufacturing process. In order to improve the value of Cp & Cpk, the project team needs to review and analyze the root causes and identify the optimal solution.

3.2. ***Analysis Phase***

Analysis is the third stage of the DMAIC process, the main objective of the analysis phase is to stratify and analyze the opportunity, in order to identify a specific problem. It is the beginning of the statistical analysis of the problem. It statistically reviews the inputs of variation to determine which significant contributors affect the output. Cause and Effect Diagrams, Fishbone diagram are used for the root cause analysis. The Taguchi experiment and hypothesis testing are used to identify the optimal parameters of the robust design for 3D printer.

3.2.1. *Taguchi Experiment*

L9 Taguchi experiment design is used in this case study which helps to understand the effect of 4 independent factors with each having 3 factor level values. Taguchi parameter design uses orthogonal (fractional factorial) arrays which can reduce treatments, but sacrifices the interaction information. This array assumes that there is no interaction between any two factors. From analyze phase, the 4 key controllable input parameters are identified as A(infill %,) B(extruder speed),C(Extrude temperature) and D(no. of shells). 3 levels are set for each parameter. Ambient temperature has been identified as a key non controllable factor. The three levels of input data have to be tested in low (10-13) °C & high (18-21) °C temperatures to identify optimal conditions. 18 experiments are conducted in a randomized fashion and each experiment is the combination of different factor levels. The results of Taguchi L9 Design Experiment are shown in Table2 .

Table 2. Taguchi L9 Design

Run	A (Infill) %	B (Extruder Speed) mm/sec	C (Extruder Temp)°C	D (No Of Shells)	Part Modulus (MPa)		Y-bar	S/N(η) Ratio
					Temp (10-13) °C	Temp (18-21) °C		
1	1(35)	1(100)	1(225)	1(2)	2705.5	2927.8	2816.7	25.07
2	1(35)	2(125)	2(235)	2(3)	2873.73	3043.34	2958.5	27.84
3	1(35)	3(150)	3(245)	3(4)	2998.58	2988.87	2993.7	52.79
4	2(40)	1(100)	2(235)	3(4)	2782.84	2986.12	2884.5	26.05
5	2(40)	2(125)	3(245)	1(2)	2717.91	3063.34	2890.6	21.46
6	2(40)	3(150)	1(225)	2(3)	2772.38	2852.2	2812.3	33.95
7	3(45)	1(100)	3(245)	2(3)	2748.25	3084.71	2916.5	21.77
8	3(45)	2(125)	1(225)	3(4)	2942.68	3190	3066.3	24.88
9	3(45)	3(150)	2(235)	1(2)	2818.95	2835.12	2827	47.86

S/N ratio approach is used to analyze the results which make it faster to arrive at the conclusion. There are three categories of quality characteristics in the analysis of the S/N ratio, i.e. the lower the better, the higher the better, and the nominal the better. As we look at the target value of the part Modulus 2930Mpa, we use Nominal-the-Better Equation η = 10log(y-bar2/s2); where η is signal-to-noise (S/N) ratio, y-bar is the average of part Modulus and 's2' is the variance between them. The S/N ratios are calculated for all responses and presented in Table 3.

Table 3. Response table

	Level	A (Infill) %	B (Extruder Speed) m/sec	C (Extruder Temp) °C	D (No Of Shells)
Part Modulus (Raw Data)	1	2922.97	2872.54	2917.39	2844.77
	2	2862.47	2971.83	2890.02	2895.77
	3	2936.62	2877.68	2933.61	2981.52
S/N Ratio	Level	**A(Infill) %**	**B(Extruder Speed) m/sec**	**C (Extruder Temp) °C**	**D (No Of Shells)**
	1	35.23	24.29	27.96	31.46
	2	27.15	24.73	33.92	27.85
	3	31.50	44.87	32.01	34.57

The predicted Values using the formula $Y_{predicted} = (\overline{Y}_{A1} + \overline{Y}_{B2} + \overline{Y}_{C3} + \overline{Y}_{D2}) - 3\overline{Y}_{all}$ is calculated for raw data with the nominal optimal combination-$A_1B_2C_3D_2$ and obtains a result of 3083.13Mpa. The predicted value for the S/N ratio's optimal combination-$A_1B_3C_2D_3$ obtains a result of 2945.39Mpa. Since, the predicted value using S/N ratio combination is closer to the required value (2930 Mpa),

we use $A_1B_3C_2D_3$ as optimal parameter setting: A1: Infill %=35%, B3: Extruder Speed =150 mm/s, C2: Extruder Temp=235 ^{o}C; D3: No. of shell=4;

To draw a conclusion, if the noise factor- the outside temperature really affect the Part Modulus, we conduct T test.

H_o: $\mu_{LOW10\text{-}13} = \mu_{HIGH18\text{-}21}$

H_1: $\mu_{LOW10\text{-}13} \neq \mu_{HIGH18\text{-}21}$

With alpha level 0.05 and degrees of freedom being 16, $T_{crit.}$ is 2.12 and the calculated T-test statistic is 3.52. Since T-test statistic is larger than T-Critical value, we reject the null hypothesis. The observed data has proven that the Part Modulus is impacted by the environment temperature. The part Modulus printed in high temperature is 2997MP; and the value printed in low temperatures is 2817 Mpa. Since the value printed in high temperature is closer to the required value(2930 Mpa), we set the high temperature (18-21) °C as the printed ambient temperature.

3.3. *Improvement Phase*

Improvement is the fourth stage of the DMAIC process; the main objectives are to identify, evaluate and select the right improvement solutions achieved by Taguchi design experiments.

In this phase, the confirmation run is performed to make 9 parts with the obtained $A_1B_3C_2D_3$ optima settings. The obtained average of the mean of the Part Modulus is 2920.65 Mpa which lies between the specification limits. The C_p has been improved from 0.62 to 1.56 and The C_{pk} has been improved from 0.21 to 1.47.

3.4. *Control Phase*

Control is the final stage of the DMAIC process. The improved process needs to be monitored by doing sampling inspection of parts at regular intervals. SPC is designed to monitor the process. The control limits are calculated for the concluded optimal setting and formulated in Table 4.

Table 4. Control-limits of improved 3D printing process

Control Limits				Optimal Setting	
UCL -X bar	2965 Mpa	UCL - R	137 Mpa	Infill Rate	35%
CL-X bar	2921Mpa	CL - R	60 Mpa	Extruder Speed	150 mm/s
LCL-X bar	2877Mpa	LCL - R	0 Mpa	Extruder Temp	235 ^{o}C
Process Capability: Cp=1.56,Cpk=1.47				No of shells	4

4. Conclusion

The framework has been well developed based on this case study. There were 18 experiments - conducted using the L9 orthogonal array in a 3D printing machine. The Optimal combination of 3D printing process with Infill% of 35%, Extruder Speed of 150 mm/sec, Extruder Temperature of 235°C, and number of Shells of 4 have been identified to be able to produce 3D printing products with minima defect rate based on the S/N ratio calculation and T statistic test. This optimal parameter setting was verified through a confirmation run with 9-sample sizes which successfully improved the process capability index (Cp) from 0.62 to 1.56, and (Cpk) from 0.21 to 1.47. The framework developed in this case study can help many other facilities reduce defect per millions in their manufacturing processes. Further research could be carried out by comparing different Nozzle speeds or Platform temperature, taking different parameters and noise factors into account or considering different printing materials.

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Suspension Stroke Reconstruction From Acceleration

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Semi-active suspension control needs relative velocity of wheels respect to the vehicle body to regulate damping forces versus roughness of the road surface and riding style. Linear potentiometers are the most used in racing for linearity and simplicity, but they are expensive for mass market and unreliable in the long run. Couples of accelerometers can be a good alternative, but signal integration problems arise when velocity has to be calculated from acceleration. In this paper a novel solution to classical problems of drift and delay in signal integration thought for real time application to suspension control is presented and described with simulation and experimental results.

Keywords: digital signal processing, integration of acceleration to velocity, semi-active suspension, embedded systems.

1. Introduction

Both vehicle handling and passenger comfort depend on the suspension system. It guarantees contact among vehicle tires and road, and contemporary isolates vehicle body from road roughness [1]. Passive (hydraulic type) suspension characteristics are always the result of a trade-off between these two needs. The problem is even more evident for motorcycles, since they are much more sensitive than other vehicles, to both load variations and shocks caused by the road asperities [2]-[4]. Semi-active suspensions look like being a solution, if a suitable control strategy is available [5] to adjust the damping force versus vehicle dynamics and riding style. Parameters to be measured to this aim come out from a sensor set usually composed by accelerometers and/or stroke sensors. Thus, research activities look toward the development of adjustable dampers (linear solenoid valves, rheological dampers), performant control strategies [6]-[8] and new sensors. This last topic is strategic because stroke sensors, which must be external to the embedded system controller, are crucial as for both

reliability and cost [9]-[10]. Linear potentiometers are the most used in racing for linearity and simplicity, but they are expensive for mass market and unreliable in the long run. Rotative inductive sensors, widespread in automotive, would be not suitable to front forks without unaesthetic fittings. From both the position sensors, the velocity comes out from the derivative of the suitably filtered signal.

Velocity can be obtained also from the direct numeric integration of acceleration signals and accelerators are cheaper than potentiometers. Numerical integrators can be designed both in time-domain and in frequency-domain [11-15]: in the case of on-line application the former is often the only choice. Main processing problems affecting time–domain direct integration of the accelerometer signal are two: i) drifts caused by offset and unknown initial conditions of accelerometers; ii) signals to be integrated are usually affected by noise at lower and higher frequencies. In some papers like in [12], the drift problem in numerical integration is solved by a pass band filter, partially implemented in an analog filter, followed by a feedback stabilization method to eliminate drift. Even if its estimation error seems to converge to zero exponentially, the time response and phase shift could be still too high for real time applications, due to the use of big time constants to avoid the drift. Some authors propose the use of the baseline correction as alternative method to avoid drift during integration. The polynomial curve applied in [16] to correct the offset is fitted by the least-square method, but the low frequency components in the accelerometer were estimated and removed off-line. The problem of drift in position reconstruction through double integration of the acceleration can be faced with calibration techniques [13], that cannot be used in real time single integrations. Fourth-order polynomial filters and weighted residual parabolic integration formulas are proposed in [14], but these baseline correction integrators do not solve the difficulty generated in real time applications by the time response of high order filters designed to remove low frequency noise [16].

Starting from previous works in the field [17]-[19], in this paper the authors present an further solution to the problem of real time velocity calculation by digital processing of acceleration. The proposed procedure can be suitable for signals acquired by accelerometers installed on body and wheels of a motorcycle. The solution has been searched with these goals: i) reduced processing burden; ii) negligible delay respect to velocity obtained by the derivative of the position signal. A good estimation of the velocity amplitude has to be considered as a positive effect, but it is not mandatory for the real time application. At first, details about the mathematical model are given together with the first simulation results. Then, experimental results concerning with the

application of the method to actual signals provided by a sensor set installed on a motorcycle are presented and compared with simulation.

2. Experimental test bed

A Ducati motorcycle was used as experimental test bed. A suitable measurement system was installed on board and several tens of km have been run to acquire data necessary to the experimental validation of the method.

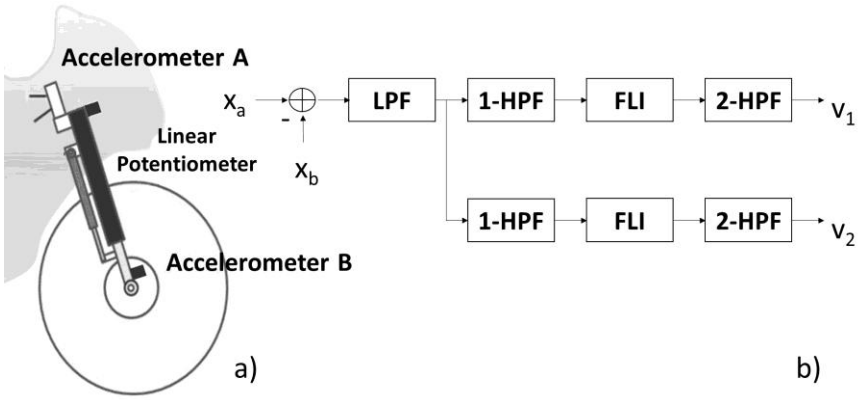

Fig. 1 a) On board installation of the sensors: linear potentiometer and accelerometers; b) Proposed scheme for signal integration

The installed measurement system (see Fig.1a) was made of the following elements:

- linear potentiometer;
- accelerometer A, fixed to the motorcycle body;
- accelerometer B, fixed to the wheel;
- data logger.

While the linear potentiometer output voltage (0-5 V) is acquired by the Data Logger via an analog input channel (sampling frequency =1 kHz), the two accelerometers are nodes of a CAN BUS network working at 1Mbit/s. Each accelerometer node is made of a microcontroller, a triaxial accelerometer ST LIS331H and a transceiver CAN. The LIS331H is a triaxial linear accelerometer with SPI serial interface, it allows the user to dynamically select the full scale among the values: ± 6 g / ± 12g / ± 24g and is capable of measuring the accelerations with data transfer speed of 0.5 Hz to 1 kHz output. For this experimental tests it was decided to select the ±24 g input range and

1kHz output data rate. The LP filter integrated in the LIS331H, having a cut-off frequency of 780Hz has been enabled.

3. Signal filtering and integration procedure

The proposed procedure is depicted in the scheme of Fig 1.b where a second order low pass filter (LPF) , two first order high pass filters (HPF), a filter like integrator (FLI) are included to solve integration drift caused by offset and noise at lower and high frequencies. The cut-off frequencies have been chosen by taking into account both the signal frequency range and the delay introduced in the original signals by the filters.

More in details, the cut-off frequency f_{LP} for LPF should be designed with the aim of preserving the frequency band of the physical phenomena of interest, but limiting the phase delay. The frequency range of the vibration experimented by the motorcycle damper is typically 1-10 Hz, thus, f_{LP}=25Hz demonstrated to allow: *i)* the noise at high frequencies to be reduced; and *ii)* a slight phase delay to be added in the band of interest.

The first stage HPF is introduced to reduce the noise at low frequencies which should be emphasized by the next FLI. On the other hand, the corresponding cut-off frequency $f_{1\text{-}HP}$ should be designed by also taking into account the combined effects of the filters (1-HPF and FLI) roll-out within the lower band of interest. For example, about a motorcycle damper, $f_{1\text{-}HP}$ should be considered in the range 2-20Hz. In Figure 2 are reported the details of the filtered suspension velocity when the suspension stroke (from linear potentiometer) and the trapezoid approximation of the FLI are considered.

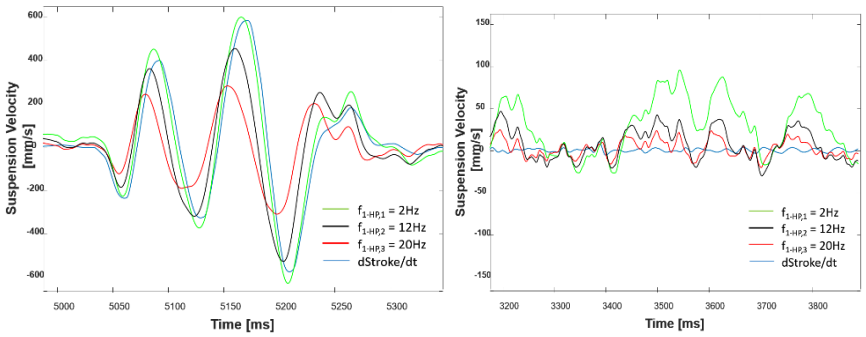

Fig. 2 Integration of acceleration signal according to proposed scheme (details about simulated data)

The suspension velocity (achieved from the stroke through LPF filter and numerical differentiation), represents the reference for the output of the proposed scheme when different cut-off frequency $f_{1\text{-}HP}$ are applied (2, 12, and 20 Hz). As expected, the adoption of lower cut-off frequency allows to better estimate the relative velocity when the suspension is solicited by fast transients (for example the motorcycle passing over a hole, see Fig. 2.a) because the components of interest at lower frequencies are put into FLI. On the other hand, an HPF with lower cut-off frequency is not able to filter adequately all the noise components before the FLI when the suspension stroke is in steady-state condition (see Fig.2.b). The second stage HPF is finally adopted to remove the offset emphasized by the integrator and limit the drift caused by the unknown initial condition of accelerometers.

4. Experimental results

The proposed scheme for signal filtering and integration has been adopted to measure the suspension velocity from accelerometers and to use it as control signal for controllable dampers of a motorcycle semi-active suspension system. According to the control strategy introduced in [18], damper force is augmented when a significant suspension velocity is observed (out of an hysteresis gap equal to ± 50mm/s).

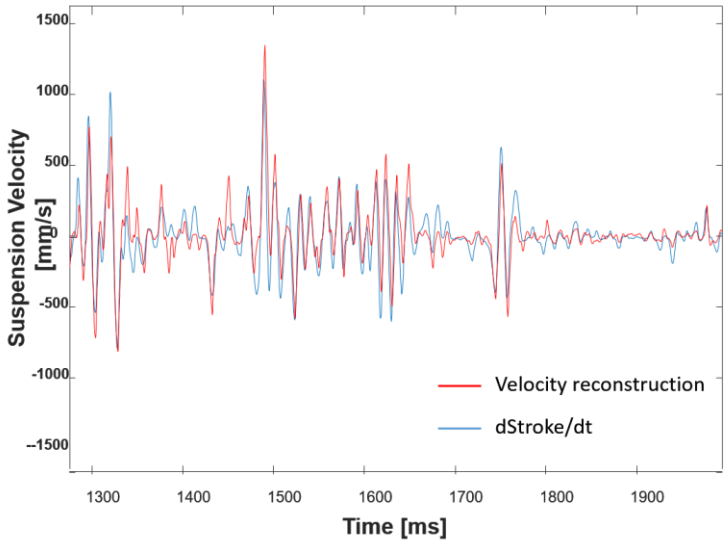

Fig. 3 Estimation of the front suspension velocity resulting from the integration of measured acceleration signals

Pursuing this goal, the previous scheme has been implemented by adopting two paths for the cascade 1-HPF, FLI and 2-HPF, differentiated about the $f_{1\text{-}HP}$ (cut-off frequencies equal respectively to 2 Hz and 16 Hz). More in details, the suspension velocity estimated by adopting $f_{1\text{-}HP,1}$ =16 Hz allows to identify the non-steady-state conditions. Correspondingly, the output from the second path ($f_{1\text{-}HP,2}$ =2 Hz) is adopted as close estimation of the suspension velocity. An example of velocity reconstruction from the acceleration data measured during a motorcycle riding is reported in Fig. 3.

5. Conclusions

A signal processing procedure has been proposed to measure the velocity of not suspended mass in a motorcycle from acceleration. A high pass filter has been added to the typical signal integration process before of the integration step. The output signal compared with a reference has shown some differences in the time domain, depending on the filter cut off frequency. The adopted solution to this problem, as described in the paper, can be suitable for the needs of a semi-active suspension control system in order to both reduce the negative effects of low frequencies and to follow with precision the widest oscillations of the signal. Experimental results are good and future developments will concern the on-line implementation of the integration procedure.

Acknowledgments
Authors want to thank Vincenzo Paciello and Alfonso Attianese for the useful suggestions.

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Industrial Design Science & Technology: Art-to-Part

Applied Art/Design Engineering Design Graphics Technology

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Paper introduces modern Industrial Design (ID) pedagogy and professional trade practices relevant to integrated product-oriented design based interdisciplinary education. ID design/model phases include artistic conception, product design, technical surface modeling, and solid model part design. University programs in electronic media, engineering, engineering technology, interior design, may include computer aided industrial design to additive manufacturing 3D Printing investigative studies. ID Design Thinking System categorizes Industrial Design model/design Major Phases discussed as paper topic for relevance to interdisciplinary education topics. As ID model/design phases transpire from artistic to mechanical design engineering, advancement of ID model/design phases challenges initial artistic concept design intents.

Keywords: Industrial Design, Model Phases, Engineering Design Technology

Industrial Design Thinking System

The Industrial Design Society of America (IDSA) verbally connotes/visually illustrates "32 ID" asset classes/subtypes relative to ID project idea conception, product design to development. Categorized here as ID Design Thinking computer aided industrial design to product design management system includes: four Major ID Design Phases: O) Discover, I) Define, II) Design, III) Develop that may be written as O) Idea Discovery, I) Project Definition, II) Product Design, III) Part Development.

Industrial Design Phases

Phase O: Discover Ideas: initial idea generation phase initiates as visual design thinking: concept art sketches, perspective illustration, and visual mind maps.

Phase I: Define Project includes project objectives, problem statements, and storyboard use case scenarios,. Define phase includes: orthographic, multi-view investigative engineering drawings of design project and schedule list of project parameters, parts to physical material/manufacture constraints.

Phase II: Design Product engages traditional ID industrial illustration, concept appearance surface modeling "surface styling" in addition to preliminary ID technical surface modeling via vector based B-spline technology application.

Phase III: Develop Surface employs three-dimensional, solid volumetric modeling and/or "Class A" technical surface modeling methods demonstrative of *curvature continuity* (cc). Curvature continuity governs "*accuracy"* as to ID "*curvature degree*" constraints for curve network curvatures to define surface patch model exterior surface interfaces with adjoined product parts.

Phases III/IV: *Part Design* for surface/solid modeling incorporates polymer part mechanical design engineering guidelines for part features ie: "snap: fit "latch joints", "flexible/living hinge", fastener "inserts", surface support: "bosses/ribs".

Paper premises Industrial Design (ID) modeling/design pedagogy and professional practices are relevant to contemporary virtual-to-physical *product-oriented*, vocational applied "*ID Art/Design-to-Part*" engineering technology accredit-able by both: NASAD/ABET (Computing Commission (CC)). Interdisciplinary, integrated ID design education best includes recent industrial revolutions topics in: 1st Generation: Industrial Arts, 2nd Gen: Electronic Media, 3rd Gen: Digital Additive Manufacturing: 3D Printing.

Historic, *current*, and *future* applied ID model/design education as 1st - 3rd Gen: Industrial Arts/Design Science & Technology include design/model domains relative to ID: I): *concept artifacts,* II) *digital designs*, and III) *physical models IV) parts* as ID *outcomes*.

Industrial Design Technology

Applied industrial design/model phases of paper centric focus includes artistic-to-technical application of computer aided art, drafting, design-to-digital surface sculpting, technical surface modeling, and solid volumetric modeling for mechanical engineering part design. Paper surveys ID technology trade skills; ID software practices relevant to three-dimensional applied manufacturing branded also as three-dimensional printing. ID is not limited to product styling.

Computer aided industrial design (CAID) technology is tri-part: 2D/3D pixel art to (CAD), NURBS curves/surfaces (CAID), and pre-engineering volumetric, solid modeling (CAM). ID includes 2D/3D raster pixel art to 2D/3D vector math 2D Orthographic Drafting, *artistic-to-technical* surface 3D Surface Modeling, and *true-to-life*: 3D Solid Modeling. ID design/model types correlate to: a) concept art/design, b) industrial design technical surface modeling, and c) mechanical engineering solid part design. ID model/design phases are pertinent to modern three-dimensional printing industries.

ID design/model major phases include: a) concept *styling* appearance models as 2D/3D "art" to polygon/surface meshes b) concept *shaping* "design" via freeform surface *patches*, and c) prototype: part/product technical surface/solid *modeling* for additive/reductive applied manufacture. ID design/model phases a-d) provide service/solutions to: a) electronic advertising, b) multi-media telecommunications c) product marketing d) mechanical part design engineering. Relevant ID outputs include: *precise* vector based graphical design product brand identity signage to diverse outcomes: a) electronic print b) entertainment media: games/video c) digital visualization: industrial design d) additive manufacturing: 3D printing. Industrial Design Technology is diverse, interdisciplinary, integrated design education relevant to university majors.

ID Design Model Phases / Additive Manufacture: 3D Printing

ID's latter computer aided design/model phases III/IV include: a) additive manufacture: 3D *printing* b) reductive manufacture mechanical CNC *routing*. Printing and routing include: pre-engineer, mechanical design, & part design surface/solid modeling methods relative to fabrication, physical part assembly, visual/tactile design, and usability.

ID's III-IV Design/Model Phases: ID's 3-4 Model/Design Prototypes

A-D) A) Stylized Art: B) ID Concept Design C) Technical Surface Model D) Part Design

Artistry to *accuracy* defines ID design/model phases listed as AI-DIV. Advanced topics are CIII: B-Spline technical surface modeling, DIV mechanical design pre-engineering.

AI) ID Stylist: Computer Artist (CA): artistic illustration to rough cage polygon mesh sculpt techniques to fashion rough art as ID "visual appearance" concept models/renders. Polygon art concept sculptures may appear as refined ID B-Spline surface meshes.

BII) ID Designer: Computer Accurate Designer (CAD) applies drafting/design via NURBS (Non Uniform Rationale B-Spines) to form refined surface shapes (ID Patch Models). Accurate CAD vector-based B-Spline curves are employed.

CIII) ID Surface Modeler: Computer Aided Industrial Design (CAID) Technologist: intelligently apply precise freeform surface "Class A" (G2: curvature continuous) technical surface modeling methods for mass manufacture.

DIV) ID Solid Modeler / Pre-Engineer: Computer Accurate Drafting/Design (CADD), Industrial Design (CAID) and/or Computer Aided Modeling (CAM: Solid Volumetric) true-to life solid modeling may include a) mechanical part engineering design guidelines, b) material polymer sciences relevant to additive manufacture. Multi-material 3D printer technology may integrate/intermix material properties as time based fabrication procedures to create material compound substrates inter-woven for stability/strength.

Solid modeling is true-to real life 3D modeling that applies ID model/design engineering technology to encompass actual 3D "part" design. 3rd phase ID technical surface model data is extended to include *multi-depth/dimension* to comprise part thickness, fastening system surface customization, and internal mechanisms/support structures (bosses/rims). Solid ID model/design may include mechanical system design innovation as pre-engineer part design guidelines/methods such as: snap: fit latch, living hinge, inserts, ribs, and bosses. Solid modeling is accurate, *detailed* 3D modeling for real physical solutions.

ID stylist, designer, and surface modeler phases as *letter/roman numeral* denote ranked exponential increase in design factors and constraint complexity. As example: a) ID surface/solid modeler may *co-design* cell phone exterior surface shape design with engineered constraints; b) ID stylists/ designers may design "third party" protective cell phone cases independently. Lettered/numerated phases AI-DIV: steadily compromise artistic sketches and desired artistic surface curvatures due to multiplied design factors, mechanical design pre-engineering constraints. ID may co-configure mechanical systems such as often-included, integrated engineered mechanism design parameters.

In Phase III/IV ID design/model, ID professionals *collaborate* with engineering professionals. *Cooperative* model/design includes ID's mission to house product features/functions in aesthetic, easy-to-use/understand physical, human-safety inclined vessels. ID is diverse, integrated art/design science and applied engineering technology interdisciplinary studies that include: behavior psychology, cognitive design, geometric aesthetics, and human centered factors such as: anthropometrics, ergonomics, intuitive shape affordances, usability scenarios, and safety. Modern ID programs include integrated computer aided manufacturing tool path simulations and pre-engineering part stress/strain analysis. ID specialisms may be 1st - 3rd GEN interdisciplinary, integrated design education that includes STEM disciplines.

ID STEAMS: Inter-Disciplinary ID Design Science Education Model

ID STEM studies are integrated ID design education as applied: physical sciences, technical art, engineering graphics, and math. Introduction to Industrial Design investigative topics may include applied a) industrial arts b) design science c) design/model technology as topical investigations. Design science is interdisciplinary, integrated design based STEAMS educational model that includes geometric construction principles in art, architecture, and design. "Connections: The Geometric Bridge between Arts & Sciences" (Kappraff, 1991) presents design science as theory/practice of architecture and applied geometric mathematics. ID studies in human evolution to society apply three major transformations: 1st Gen) *Homo Faber*: human "maker of things", 2nd Gen) Industrial Machine Technology to post-industrial society 3rd Gen) Information Age: "Electronic Media" *telecommunications* and other intellectual technology. 3rd Gen: *Home Gubernator* illustrates human as "designer/steersperson of large, complex interactive systems" (Banathy, 1996). ID Systems include technical surface models to solid models.

Design philosophy, design theory, and design methodology are functional contexts as design becomes fourth domain of design inquiry (Banathy, 1996). Generic design inquiry derives from observations that regardless of what "artifact" is being designed, common archetypal domains as creative stages of labor are applied that transpierce all design disciplines. Universal problem solving design process domains and systematic thinking compose Design Science. IDEAS A+ Design Thinking System (Wronecki, 2004) illustrates way to Teach Visual Design Thinking (Wronecki, 2007) as graphical representation of universal design science phases, domains, and stages to provide context for structuring integrated design education to industrial design major/minor studies.

ID STEAMS synergizes as intellectual design science to incorporate both art & design science methods/process thinking systems. Industrial Design Science & Technology best comprises ID design/model investigations and comprehensive design science topics.

Design Science founder, (Buckminster Fuller) textbooks: “Synergistics I/II: Explorations in Geometry of Thinking” include topics: diagrams, blueprints, and patents as textbook topics for applied ID design/model class project studies. Projects provide concrete, practical examples of integrated, interdisciplinary design science. ID minor studies as investigative topics may apply modern CAID technology to recreate Fuller’s patented prototypes/systems as practical case study of topical ID design science: product design-to-development technology. Fuller’s patents include: energetic geometric synergetic systems, Dymaxion aerial automobile, 4D Sea Dwelling, 4D airship home, as well as interior furniture designs to tensegrity structures.

ID curriculums provides relevant general introductory industrial design to ID design science & technology minor education topics to interdisciplinary majors: electronic media: visualization, engineering, engineering technology: industrial technology: additive manufacturing, product development, and interior design.

Modern CAID studies are applied computer aided art/drafting/industrial design. Industrial design *surface/solid* modeling technology outcomes include ID *virtual visualizations* and traditional to industrial design physical *printed* ID *prototypes*. Product *design*-to-*development* includes: art/design surface/solid modeling and 3D Printer material sciences technology as means/methods of applied, additive rapid manufacturing of product parts-to-prototypes. Phases III/IV Surface Design / Part Development applies mechanical engineering part design “guidelines” paired with solid modeling to fabricate “synthetic” materials as 3D printed, ID model as physical product prototype.

ID design/model for multi-material *additive* manufacture via emergent three-dimensional printers includes additional design considerations for evolving physical material science properties relative to specialized 3D printer chemical polymers. Advanced printers include integrated assembly substrate timed combinations as “compounded resins” that may be layered or “intermixed” to manifest material characteristics / physical properties for real/physical solutions. Compound materials are defined as engineered materials.

Conclusions

ID design/model education includes additive manufacturing: 3D printing research studies to include traditional engineering design graphics fundamentals as practical, modern applied design technology investigations in: 1) Computer Art/Drafting (CAD), 2) Computer Aided Industrial Design (CAID), and 3) mechanical solid model / part design engineering (CAM/CAE). Industrial Design Technologist models demonstrate phase III: Technical Surface Models to feature: "Class A technical surface modeling". CAID design/model visual/physical outcomes feature artistic, accurate, aesthetic visual/tactile curvature continuity "surface integrity" via NURBS B-Spline vector geometry. Emerging (CAID) technology solutions strive to simplify complex, but not complicated, ID product surface design to part design/model workflow scenarios.

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Temperature Monitoring on Reciprocating Compressor Connecting Rods

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Condition monitoring of critical rotating machinery is broadly accepted. But condition monitoring of reciprocating machinery such as compressors and internal combustion engines has not received the same degree of acceptance. This paper analyzes the reliability impact as a result of upgrading the temperature monitoring devices on the connecting rods of electric driven reciprocating compressors. A cost analysis is also presented to establish that the upgrade in hardware and software eventually yields a saving in the operating cost.

Keywords: Reciprocating Compressor, Temperature Monitoring, Reliability, Cost Analysis.

1. Introduction

Reciprocating compressors are the dominant style of compressor utilized due to their capacity control which allows them to adapt to changes in flow and pressure easily. Reciprocating compressors are flexible and able to handle wide capacity and condition swings, offer an efficient method of compressing almost any gas composition in a wide range of pressures and have numerous applications and wide power ratings. This makes them a vital component in various industrial facilities. Condition monitoring of critical rotating machinery is widely accepted by operators of centrifugal compressors. However, condition monitoring of reciprocating machinery; such as compressors and internal combustion engines, has not received the same degree of acceptance. This paper examines the reliability impact as a result of upgrading the temperature monitoring devices on the connecting rods of electric driven reciprocating compressors.

The movement between the connecting rod and compressor frame makes it challenging to make a temperature measurement on the crosshead pin bearing [4]. Eutectic probes are characterized as an offline solution that is unable to provide any quantitative information about the bearing temperature. They provide only an alarm or shutdown indication with no temperature data to support corrective action or indicate false alarm. Radar-wireless measurement of bearing temperatures uses a sensor in direct contact with the bearing shell to provide fast accurate, real-time continuous temperature monitoring. It provides a constant indication of a potential issue and justification for an emergency shutdown [3].

2. Discussion of the Project

The compressors currently utilize eutectic temperature sensors in the connecting rods. Often compressors have been saved by shutdowns due to eutectic or "turkey popper" temperature devices in connecting rod bearings [8]. The sensors use a fusible eutectic material that is designed to fail at a designated temperature, in this case 200° F. The fuse rod threads into a thermowell in the connecting rod parallel to the bore of the sleeve bearing in the connecting rod. When the fuse rod fails under spring tension it trips a pneumatic switch and the compressor is shutdown, see figure 1. Due to the design, the devices cannot be recalibrated and even testing requires replacing the fuse rod. For this reason, the fuse rods are replaced annually [2]. The operators have no advance warning of an issue; detection occurs only at the point the unit shuts down from a fuse rod failure/trip.

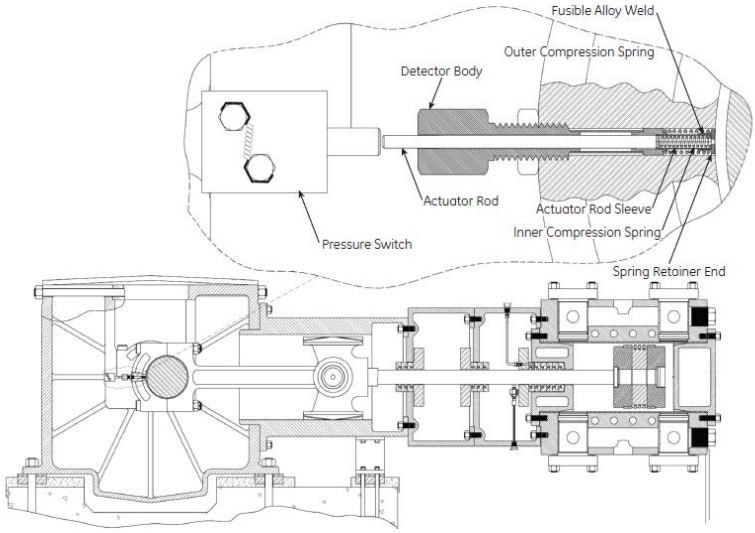
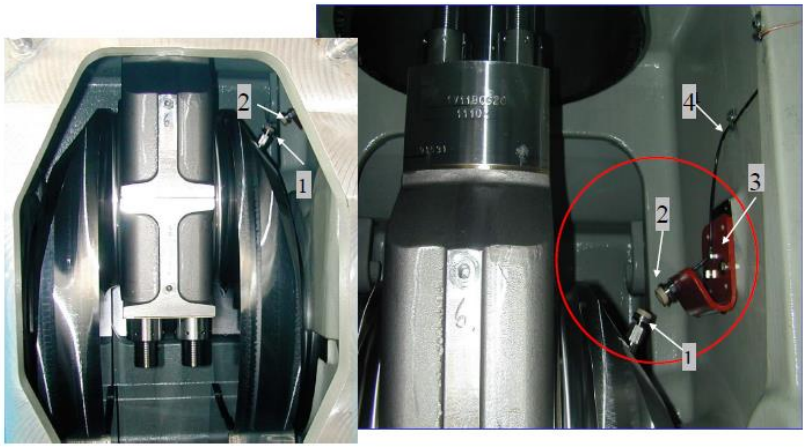


Figure 1. Cross Section Diagram.

The upgraded temperature sensors utilized in this project consist of a wireless measurement system based on wireless radar technology without the need of an external power source. A wireless sensor replaces the eutectic device in the connecting rod's thermowell. An antenna replaces the pneumatic switch and receives a signal from the wireless sensor every time it passes, once per revolution, see figure 2. The processing unit software calculates the temperature and transmits it to the supervisory control and data acquisition (SCADA) system [6]. The SCADA system can trend the temperatures in real time with low level, high level and differential alarms created to provide operations an early warning. This affords operations critical information needed to make the decision to shutdown or remain running until maintenance personnel are on-site.



1.Wireless temp sensor; 2. Antenna; 3. Bracket; 4.Antenna Cable

Figure 2. Wireless Configuration.

After the initial installation of the wireless temperature monitoring system, the eutectic device shutdown point of 200° F will be used as the high level alarm. The low level alarm will be determined after baseline temperature data is collected and trended over time. Temperature differential alarms will be determined once baseline deviations can be established and analyzed. After the accumulation of connecting rod temperature data, additional SCADA values already being collected can potentially be utilized to normalize the connecting rod temperature data.

A design, cost estimate and reliability analysis were completed to determine the impact of updating the temperature monitoring on the connecting rods of the reciprocating compressors. The fourteen compressors included in the project are located throughout six compressor stations. The upgrade includes temperature modules capable of taking readings from installed transmitters mounted on each connecting rod. In this project the total quantity of temperature measurements upgraded will be 56. Each of the existing eutectic temperature

sensors on each connecting rod will be replaced on all compressors. The temperature module will provide a wide variety of critical process data for monitoring, trending, and alarming. At completion, the system will increase the operability and reliability of the units. The cost for the upgrade of all compressors including installation, commissioning and training is approximately $276,200. The expected improvement in reliability is estimated to add thirteen production hours per year.

3. Reliability

The RBD (Reliability Block Diagram) used for reliability analysis of this complex system is shown in Figure 3 below. Although each unit has been given its own reference designator, all eutectic devices are identical and have the same reliability. Compressors and Compressor Stations also have unique reference designators. Compressor Stations at the six locations are denoted CS, Compressors as C, and eutectic devices as E. The eutectic devices are in series within each compressor and multiple compressors are in parallel at any given station that has more than one compressor. The dashed lines between compressor stations attempts to indicate that each location operates independently. A failure in any given eutectic device results in a failure in the compressor; however, redundancy is designed in at each compressor station location having more than one compressor, being that the compressors are in parallel.

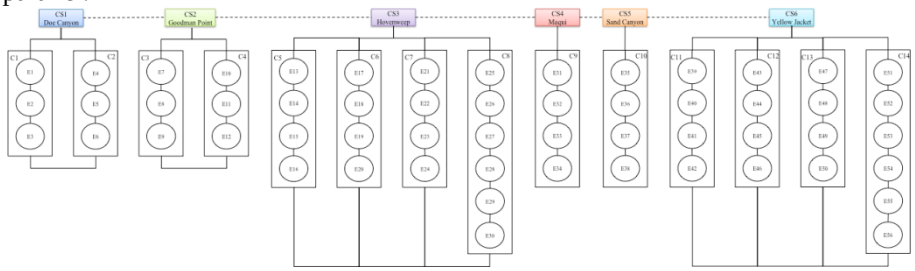


Figure 3. Reliability Block Diagram.

The eutectic devices are at the component level, and must perform continuously for 1 year, according to the planned rod replacement. The devices are non-repairable and the system is a time dependent based system. A best estimate of the eutectic device failure rate was obtained from data consisting of all failures over a designated time period.

The time for all eutectic devices to fail was 4,597 days. There were a total of 26 failures and an average of 1.48 downtime hours per failure. It should be noted that eutectic devices operate continuously for one year and are replaced annually. If a eutectic device fails prior to completing one year, it's replaced. The best estimate of MTTF (Mean Time To Failure) being that the eutectic devices are non-repairable items, was calculated as explained in [5]. Failure here

refers to the failure which causes downtime. Annual replacement of the devices due to preventive maintenance was not considered causing downtime. MTTF, failure rate, and system reliability have been computed in [9]. Results of the reliability estimates at the system level are provided in table 1.

Table 1. System Level Reliability Estimate (taken from [9])

Device Type	System Reliability
Eutectic	6.84957E-19
Wireless	0.999992

The wireless devices are estimated to have much better reliability than the eutectic devices at the system level; the decision for performance purposes is clear.

4. Cost Factor Estimates

The project costs will consist of drawing updates, hardware, software, field machining, installation, SCADA modifications and training. The installation will be completed in conjunction with an annual PM so lost production will not be a consideration. The total project is estimated to be $276,200. The estimated compressor downtime cost per hour is $20,625.

The Infor EAM system was utilized to query the maintenance history for unplanned downtime by failure codes that indicate eutectic device failures. The annual average downtime that is expected to be eliminated is thirteen hours and considered a conservative estimate as improper failure coding cannot be captured. Based on the current economic estimates, the annual operating cost savings as a result of increased run time are $268,125. The return on investment (ROI) or payback period [7] is estimated as follows:

ROI = Project cost ÷ Annual operating cost saving = 12.36 months

5. Recommendations and Conclusions

After the system has been in service for one full year, a follow-up reliability study and economic analysis must be performed. The study will examine the same fault codes to determine the actual reliability improvements versus the projected improvements as well as the actual operating costs saved versus the projected savings. In addition, the operators must be consulted to assess the benefits of remote access to real-time compressor data and calculated parameters.

Maintenance costs of reciprocating compressors are approximately three and a half times greater than centrifugal compressors. The worldwide operating horsepower of reciprocating compressors is three times the horsepower of centrifugal compressors [1]. Reciprocating compressor operators

must achieve the level of condition monitoring that centrifugal users have implemented for decades. Only after economic analysis proves the benefit of reciprocating compressor and engine online condition monitoring, will operators begin to take advantage of the technology that is becoming available. After the demand for the technology increases, the reciprocating compressor users will learn to benefit from the data the same way centrifugal users have for years.

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Cost Analysis of Open Source versus Proprietary Learning Management Systems

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The selection of an LMS is a complex decision because of the fact that there are numerous different alternatives, and each LMS differs in terms of its pedagogical design, andragogical design, usability, compatibility, accessibility, and various other factors. There are studies in the literature that provide frameworks for evaluating the usability of LMS for easier decision making. Moreover, various research work has been conducted on evaluating the pedagogical design perspective. However, there has been limited research on the costs associated with implementing an LMS.

The objective of this paper is to initiate a long-term research project to explore the cost aspect of learning management systems from the perspective of higher education institutions. This paper is the first step of the research to get an overall idea of cost types associated with LMS types by consulting subject matter experts. Thus, this study is the initial step of the process of addressing the research question: "What cost types should educational institutions expect in cases of the use of open source vs. proprietary LMS?" Interview results showed potential cost types that can be accrued as a result of selecting open source versus proprietary LMS. These results will be used in succeeding stages of the research project.

Keywords: Open Source LMS costs; Proprietary LMS costs; Hidden costs of LMS; Cost analysis of LMS, Moodle, E-College

1. Introduction

E-learning provides education by eliminating the location and time constraints [6]. It is facilitated via software applications that are commonly called learning management systems (LMS). An LMS is designed for the purpose of assisting instructors [5] creating, storing, assembling, and delivering learning content to students [1]. There are over 552 companies that develop an LMS [7]. These LMS can be divided into two major categories; open source versus proprietary.

Open source software refers to software programs that are released with the source code [4]. The open source LMS license provides the freedom to execute and modify the program, and to freely redistribute copies of the original or modified versions [4]. On the contrary, proprietary software programs are closed source, hence all rights are retained by the developer. Proprietary licenses are given to end users under specific terms defined by the developer. The developer restricts the usage, distribution, and modification of the software [3]. Open source and proprietary software have been compared comprehensively with respect to instructional design, accessibility, usability, and many other various factors in the literature, yet there is a lack of evaluation and comparison in terms of the cost types. There is no scholarly research detected in the literature that differentiates costs types for open source LMS investments against proprietary LMS investments for higher education institutions. Existing body of knowledge is restricted to blog posts and similar online discussions.

The purpose of this study is to initiate a longitudinal research exploring the hidden costs of LMS investments for higher education institutions. The primary steps of the research can be listed as: consulting experts to identify possible cost types with regards to LMS type, confirming these cost types by contacting multiple higher education institutions, exploring the potential cost amounts and benefits, and finally conducting a cost-benefit analysis for LMS investments. This particular study is the first step on this list, which is 'subject-matter expert consultation'. This study is not intended to draw conclusions or statistically test any hypothesis, rather it is gathering preliminary information by consulting two subject matter experts of open source and proprietary LMS. The method used is explained in the next section.

2. Methodology

The method used in preparation for this study is interviews. There are total two subject matter experts participated in the interview. One subject is an expert of an open source LMS; Moodle, whereas the second subject is an expert of a proprietary LMS, E-College. Both participants have been involved in proposal writing, purchasing, set up, installment, and maintenance of the respected LMS in higher education institutions. The interview questions mainly explored the cost types accrued as a result of the LMS selection. The interviewers discussed several types of costs under the categories of direct, indirect, variable, and fixed costs. The terminology used for cost types are provided in Table 1.

Table 1. Terminology used for Cost Types [2]

Type	Explanation
Direct Cost	Directly incurred with the production of the product, including direct materials and direct labor costs
Indirect Cost	Indirectly related to production
Fixed Cost	Remain fixed regardless of output
Variable Cost	Presumed to increase directly with increases in output

The responses of the participants are discussed in the next section.

3. Interview Responses

The responses of the subject matter expert of Moodle are listed in Table 2.

Table 2. Responses of Moodle Subject Matter Expert

Type	Explanation
Direct Cost	Hosting cost of MoodleRooms (yearly) SSL Certificate cost (yearly) Personalization cost MoodleTrain subscription costs Upgrade costs
Indirect Cost	Logo copyright costs Costs associated with Administrative Support Personnel Utility costs
Fixed Cost	Hosting cost of MoodleRooms (yearly) SSL Certificate cost (yearly)
Variable Cost	Training costs Server upgrade costs Hardware upgrade costs Personalization costs Security costs User threshold exceeding costs

According to the subject matter expert, the hidden costs fall mostly under the variable cost category. The cost of Moodle Training depends on the training packages purchased. The number of individuals to be trained is also a key factor

in the determination of this cost. Another hidden cost is that server upgrades might be needed considering the amount of users that will be online concurrently. If a pre-determined threshold value is exceeded, the license fee will rise. In addition, hardware upgrades will be needed to cope with the user threshold, which could be significantly high. Moreover, the expert explained that Moodle releases upgrades often, and in case of a significant upgrade, additional personalization and training costs are incurred. Personalizing the MoodleRooms for a higher education institution might lead to extra costs such as copyrights of logos. Furthermore, security cost is another hidden cost type according to the expert as possible Cyber-attacks can cause enormous costs and other nonfinancial but serious issues such as leak of confidential data. The higher education institution is under liability in these situations. Next, the responses of the subject matter expert of e-College is provided in Table 3.

Table 3. Responses of E-College Subject Matter Expert

Type	Explanation
Direct Cost	E-College Contract Third Party Contracts
Indirect Cost	Support Personnel Utility costs
Fixed Cost	E-College Contract Third Party Contracts
Variable Cost	Training costs

According to the subject matter expert, there is no hidden cost in proprietary LMS investments. All costs are negotiated initially to avoid unexpected significant hidden costs later. These negotiations involve determining which third party applications or modules will be implemented in the contract. For instance, a higher education institution would prefer the option of having live chat module in the LMS interface. These applications are added to the initial contract cost. Only variable cost that the expert mentioned is the training costs which depends on the number of users to be trained.

4. Conclusions

This study is a preliminary part of a future research project. In this part, subject matter experts were consulted to have an overall understanding of the potential cost types associated with open source and proprietary LMS. From the interviews with these experts, it was observed that open source LMS investments might cause unexpected costs, in other terms, hidden costs. These hidden costs of open source LMS investments can be summarized as training costs, server upgrade costs, hardware upgrade costs, personalization costs, security costs, and user threshold exceeding costs. To clarify, the method used in this study and the number of participants involved is not sufficient to make judgments that compares LMS types. However, further research will involve communicating with experts from a random sample of higher education institutions and assess the cost types they have incurred to have a solid basis to compare the LMS types.

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Framework for Developing Undergraduate Student Diagnostic Skills*

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Integrating case-based learning in an interactive multimedia program to assist undergraduate engineering and technology students to develop diagnostic skills holds great promise. Cases revealing symptoms of technical problems were developed for the electrical power grid and a complex manufacturing system. Learners (subjects) used knowledge gained by reviewing the cases and studying a diagnostic process to create a visual map of a possible diagnostic strategy. Expert diagnostic maps were validated by specialists from industry partners. An intelligent engine using a similarity flooding algorithm provided automatic feedback about the comparison of the learner and expert map. The percentage of match was provided to the subject in order to assist the subject to improve their diagnostic strategy.

The data indicate that many learners showed obvious improvement in mapping their diagnosis strategies. Learners also reported that the training was meaningful and useful to anyone in a technical career. It is believed that mapping strategies will help learners develop a more agile habit of mind when considering solutions to problems in complex technical systems.

Keywords: Diagnostic Skills; Conceptual Mapping; Similarity Flooding Algorithm; Technical Systems; Case-Based Learning.

1. Introduction

1.1. *Understanding complex technical systems*

A technical system is a collection of human-made elements (hard, firm or soft). These artifacts function together, following a specific architecture (a typical hierarchy structure from large to small is: system, sub-system, component)

* This work is supported partially by the National Science Foundation's Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES) program under Award No. 114067.

within a specified boundary, to accomplish a goal(s).[1] A system as such is a construct defined by individuals. For example, the boundaries of the simple technical system that makes up a refrigerator could be specified by the metal cabinet that encloses the components. The electrical power from a wall outlet, although primary to the function of the unit, can be excluded. If the entire refrigerator is considered to be a system, then the control components would be a sub-system as would the compressor elements, and so on. Because the main goal of the refrigerator as a technical system is to subtract heat from items placed inside, any ancillary components, such as a digital clock on the door which does not contribute to the main goal of the technical system, are not considered to be part of the refrigerator system. Boundaries could be identified around the technical components of a natural gas transmission system, an electrical power grid, a rail transportation system, or an information technology system thereby creating complex technical systems. There are no natural technical systems. Boundaries must be identified to envelop a system. The behavior of a technical system (simple or complex) is based on a machine logic whereas all components perform within their design parameters and all interactions among components perform within their design parameters.

This investigation focuses on strategies that advance the diagnostic skills of future engineers or technical workers who possess limited content expertise who are performing an analysis on problems in complex technical systems. A problem in a complex technical system exists when the performance of the system, subsystem, assembly or component is outside of the acceptable (specified) range of performance of that system, subsystem, assembly or component in the pursuit of the primary goal(s) of the system, and results in failure or substandard performance. Such problems are "hard" problems which can be identified within the context of the efficiency of means toward a defined end.[2] Most performance issues are defined as a problem if a ready solution is not available; not all issues are perceived as problems.

1.2. *Diagnosing technical problems*

Engineers and technicians have long used decision-trees or trouble-shooting guides to assist the diagnostic process while identifying problems in technical systems. Some contemporary technical systems have built-in aids to monitor and ensure performance or to identify problems in the system, its components and/or the interaction among the components. Typically these embedded control tools sense performance and make adjustments. Some tools identify issues such as low oil pressure, increased bearing temperature, or slow data transfer speeds.

However there are times when the condition of unspecified problems, cascading problems, or root-causes can remain undetected. Embedded performance control/problem identification elements may also experience difficulty in recognizing performance trends to anticipate problems. A common belief is that the best diagnostic process for complex technical systems involves using embedded performance reporting tools as well as human diagnosticians who possess both content expertise and diagnostic skills.

Technical system problems are analytical problems that require a specific solution.[3] Creative problems, designing a bridge for example, usually have multiple solutions. It is the ability of technical workers to create a somewhat agile diagnostic strategy that has good potential to identify problems in technical systems so that these problems can be solved correctly and with efficiency. Jumping directly to problem-solving can lead to inefficient trial and error or large-scale parts/component replacement.

1.3. *Instructional design and visual mapping*

This research focused on the development of interactive computer-based training modules that required learners to create a diagnostic plan to address a problem in a complex technical system. Learners created and submitted a process map (concept map) to illustrate his/her diagnostic plan using VUE concept mapping software (an open source project based at Tufts University; http://vue.tufts.edu) within an instructional shell created in Lectora. Concept mapping was selected as the main way to communicate diagnostic strategies because of its flexibility in creation and use, and that it forced learners to think in agile ways not typically practiced in the performance of technical work. These factors also provide a means for learners to consider alternative causes of problems they know little about but have observed small indications. In this case, these observational cues can lead to a diagnostic conclusion.[4]

Cognitive development theory associated with higher-order thinking skills and problem-solving was integrated into a hierarchical thinking strategy used to assist learners to understand abstract and process concepts. Feedback was applied to the instructional design so that learners had the opportunity to receive feedback from experts, rubrics and through iterative feedback messaging.[5]

This investigation creates situations within a case that require learners to discover and organize knowledge about the performance of a technical system to create a diagnostic strategy to identify problems. This approach is primarily based on Bruner's[6,7] concept of discovery learning and his connection of cognition to a theory of instruction which leads to concept attainment. The three

simultaneous processes employed were, (1) the acquisition of new information about the technical system and the diagnostic practice, (2) applying this new knowledge to the case, and (3) checking their results (learner created diagnostic visual map) with a map form an expert and other feedback cues. The concept attained is actually the process concept, diagnosing.

Another connection to the theory of cognition and instruction employed in this investigation is Butcher and Sumner's work[8] on self-directed learning and sensemaking. In this case, learners use a self-paced computer-based training program to acquire a content overview of technical systems and diagnostic strategies. These learners then engage in deep-thinking to process and apply this new knowledge to create a diagnostic strategy.

A generic rubric was presented to learners to assist them in the creation of their own diagnostic rubric for the cases presented. A simple problem was presented during the instruction provided, then two cases were used, the first was a technical problem in an electrical power grid, and second, was a technical problem in a manufacturing system.

2. Intelligent feedback to learners and concept mapping comparison

In the past 2-3 decades, researchers have been interested in using concept maps as a strategy for instruction and assessment[9] in variety of subjects, such as psychology courses[10] computer programming,[11] and problem-based medical curriculum.[12] Results from this research show that concept maps are a valid means of instruction, planning, and assessment. However, inefficient manual evaluation of concept maps is an obstacle for the application of concept maps in computer-based instructional situations.

Because concept maps include nodes and links, both the relationships and the content of the nodes are important. Kuo-En, Yao-Ting, Rey-Bin, and Shui-Cheng[13] proposed a weighted concept, whose propositions are given a weight value from 0 to 1. The higher weighted value a proposition is assigned, the more important the proposition. By comparing a student's map with a teacher's (expert's) map, each node in both maps gets a closeness index. Then based on the closeness index and weighted value of each node, a score of similarity index is calculated for each node. Using the similarity index, learner's comprehension of the node can be ranked into learned, partially learned, or misconception.[13] The limitation in this method is that the nodes in the concept maps are predefined. Students use predefined concepts and links to construct their maps, so the content of the nodes and links are not considered as a factor in comparison. The maps in this research are open – ended, so the algorithms of

closeness index and similarity index are not applicable. However, the weighting mechanism is helpful to identify the importance of nodes in expert's map.

Melnik & Rahm[14] presented a method called Similarity Flooding Algorithm (SFA). SFA takes two graphs as input, and matches the nodes in both maps. The similarity relies on the intuition that nodes from two maps are similar when their neighbor nodes are similar. The output is a list of corresponding nodes with a similarity value. After a filter selection, the most optimized pairs are considered as the best matched nodes. SFA works on many types of graphs, such as data schemas, catalogs, xml ontologies, and concept maps. Particularly, SFA support open-ended nodes, which are required for this research. This algorithm works for directed labeled graphs, like a process map, which has arrows on links between nodes to indicate the order of the steps of a diagnosis strategy. The authors evaluated the accuracy of SFA and conclude that overall labor saving are above 50%, and actual savings might be higher.[14]

Simpson and Dao[15] present an approach of string comparison with the meaning of the words – semantic similarity. The approach uses WordNet®[16]-based Semantic Similarity Measurement (WSSM) as the database for synonyms. WordNet® is a database of English, an open source project based at Princeton University. The authors use five steps to compute a semantic similarity for two sentences. The steps are (a) separating sentence into a list of tokens, (b) disambiguating part-of-speech, (c) stemming words, (d) finding the most appropriate sense, and (e) computing the similarity. Although Simpson and Dao[15] note there might be many limitations in the method, their method worked fine for this research, because the target learners in this investigation are trained to use terms in their process maps.

Based on the weighting mechanism, SFA, and semantic similarity of two strings, a combination of these three approaches is adopted in this research.

2.1. *Process of comparison*

A process map contains nodes and links between nodes. To compare two process maps, the comparison needs to consider both the relations (links) between nodes and the content of the nodes. The researchers used a SFA (Open source java code developed by Melnik ae al.[14] and converted the java code to C#) to match the nodes based on their relationships.

A prototype computer program of process map matching program was created. The process for comparing process maps is shown in Fig. 1. The first step in the prototype program was to generate a base similarity that is calculated based on the result of comparing an expert's map with the expert's map itself

(saee). The base similarity includes absolute similarity for each paired nodes, according to their links and content. The second step is to compare a student's map with the expert's map (sase). The results of comparison include absolute similarity for each node, which is considered as a matched pair with one node in the expert's map. The third step is to calculate the relative similarity (srse) for each paired nodes by the percentage of saee and sase. And, the overall similarity of the map is calculated based on the relative similarity of each pair. In this step, weighting (w) of each pair can be considered. Important nodes can have more weighting in overall similarity.

The fourth step is to generate feedback. The feedback includes two parts. One part is a summary that shows the overall similarity, number of nodes in expert's map, number of nodes in learner's map, percentage of matched nodes, and the similarity range of matched nodes; the other part is a color-coded similarity, darker color stands for higher similarity and lighter color stands for lower similarity. A new map is generated based on the learner's map. Sometimes, the learner's map does not have a high overall similarity because the learner's map has fewer nodes than the expert's, but the feedback still could be positive because the similarities of matched pairs are strong.

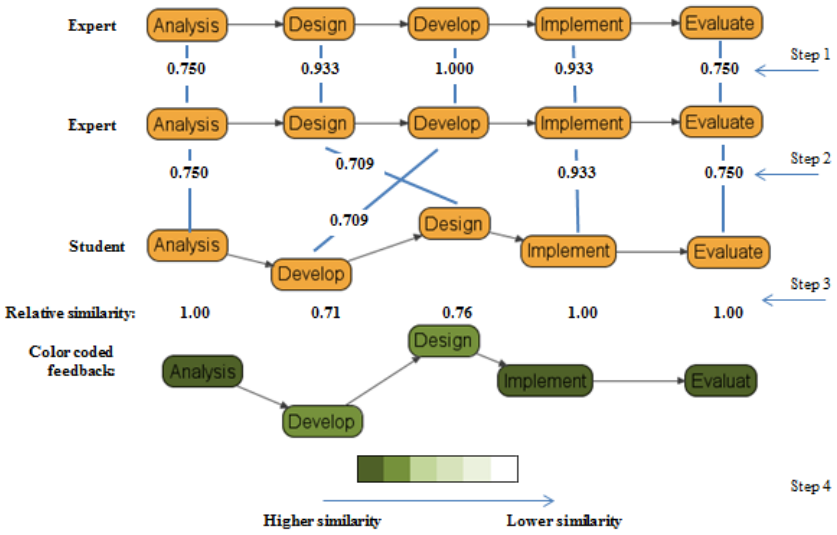

Fig. 1. The process of comparison for process maps.

Fig. 2 is an example of a summary feedback. When learners see the feedback, they can review and analyze which part of their map might need to be adjusted.

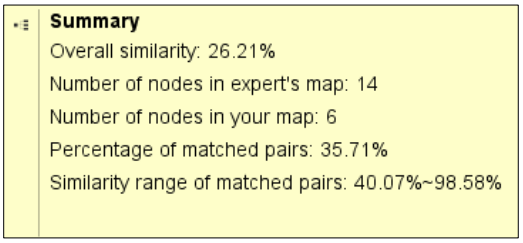

Fig. 2. The summary feedback

2.2. *Feedback for learners*

The feedback used in the formative evaluation includes a similarity summary and a color-coded indicator, but similarity is not enough to help students improve their diagnosis skills. There are two possible improvements for the feedback. The first one is to provide information on the reason of the lower similarity. The similarity of a node contains two scores, the relationship with other nodes and the content of the node. Lower similarity might be due to lower relationship score or content score. Given these two scores separately, learners could have better directions to improve their strategies. The second possible improvement is to provide information on the weighting of nodes. Important nodes have larger weighting value. If those important nodes are not presented in learners' maps, it is very possible to have a lower overall similarity. Given information on what important nodes are missed in learners' maps could help learners reconsider their approaches.

3. Discussion

The development of a self-contained computer-based training program that enables learners to develop introductory (limited) content knowledge about a complex technical system, and diagnostic skills, so that these learners can develop visual maps of a diagnostic strategy to identify a technical problem comparable to an expert, was accomplished by using several software packages and one unique program module. This solution was considered important to create a training package of approximately two hours in length that could engage learners in interactive instruction by using text and illustrative information without an instructor. This was accomplished by using Lectora as the primary

authoring platform. In addition, VUE was incorporated into the instruction by enabling learners to, in essence, leave Lectora and use VUE to create visual maps. A unique program was developed in C# and added to our SFA code to take the learner's VUE map and compare it to a map developed by an expert. This comparison was accomplished by an enhanced similarity flooding algorithm. This program returned the comparison feedback to the learner and then returned the learner to the Lectora package. The ability of this computer-based training package to function as an interactive, stand-alone training package was found to be high.

The primary feedback provided to learners was a comparison of their visual map describing a diagnostic strategy to identify a technical problem in a complex technical system to an expert's map. Upon the submission of a revised visual map submitted by learners, after they received expert comparison feedback, learners increased the percentage of their comparison. The highest similarity score was increased by 19%.

The diagnostic skills training software is undergoing field testing at multiple universities. Data collection is still in process to increase the validity and reliability of the data. Preliminary indications show discriminating differences among the treatment group that does not get expert feedback and those who do. In addition, there is an overall positive result for the computer-based diagnostic skills training software.

4. Conclusions

Diagnostic training focusing on the identification of technical problems in complex technical systems has been dominated by the belief that expert system content knowledge and a trouble-shooting guide will be adequate. The implications here are that an organization has the time to develop system experts and that the application of a trouble-shooting guide will be useful in diagnosing technical problems in complex technical systems. To provide alternative methods to develop diagnostic skills among technical workers, this research investigated the potential of using interactive computer-based training. This innovative approach expands the scope of traditional diagnostic skill training as well as provides critical technical detail necessary to accomplishing computer-based visual map comparison.

The method to provide feedback to learners was created by integrating an enhanced similarity flooding algorithm into the training software so that learner developed visual maps could be compared to expert maps. Although fairly high associations between the two maps were achieved, additional research needs to

be done to assess the full potential of the techniques used in this investigation. In addition, this work establishes a stepping-off position for those offering training in technical system analysis and trouble-shooting.

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Effects of climb and conventional milling methods on surface quality during machining of carbon-fiber reinforced polymer composite

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Widespread application of carbon-fiber reinforced polymer (CFRP) composites in automobile, structural and aerospace engineering leads to vital concern for attaining usable shapes with reasonable accuracy through machining and moulding processes. During machining of such heterogeneous materials, damage to the surface and sub-surface structure can be induced as the machining properties of fibers and matrix differ significantly. Machining of CFRP composites needs careful planning and estimation of adequate process parameters as it is substantially different from conventional machining of metallic materials. In the study, climb and conventional end-milling processes of woven CFRP were investigated. Different cutting parameters such as feed, cutting speed and flute number have been chosen to determine the surface quality. However, the comparison of climb and conventional milling of CFRP has been presented.

Keywords: Machining, CFRP, surface quality, cutting parameters, end-milling

1.Introduction

The use of components made of carbon-fiber reinforced polymer (CFRP) composite material has risen sharply in recent years. Because of their excellent weight-specific properties fiber reinforced plastics count among the most highperformance materials in the field of light-weight design. The high specific strength and stiffness make them particularly interesting for structural components in the aircraft and space industry [1]. Fiber reinforced plastics are also increasingly used in the sector of automotive, medical and general engineering where they allow for new opportunities regarding construction and design of products [2,3].

Delamination is a major production error when machining fibre-reinforced plastics. In connection with the milling of CFRPs, delamination is generally recognised as the damaging of laminate top layers. Chipping and protruding fibers are signs of this type of delamination. Delaminated components make the assembly process more difficult and their mechanical properties are impaired [4,5]. Delamination causes reworking, which costs both time and money or even leads to scrap. An overall understanding of the delamination process helps to specifically avoid delamination. While delamination during drilling is the subject of numerous scientific studies and diverse model approaches have been developed

to describe it [5-7], the subject of contour milling has to date received less literary interest [8-10]. However we do know that delamination depends decisively on the tool wear and the alignment of the fibre to the cutting direction of the tool – here in after referred to as the fiber cutting angle - and that under standard conditions, even in the case of polycrystalline diamond tools, the cutting edge radius increases very rapidly due to wear [9,11]. The mechanisms for the development and propagation of delamination have been described by the authors in [10,12]. The cause of the development of delamination is the stress in the cutting area due to the cutting force induced by the acting tool. The stress load can be calculated using Lekhnitskii's theory of elasticity for anisotropic elastic bodies [9,13-14]. Puck formulated inter fibre fracture criteria for the breakdown of fibre composites depending on stress conditions [15]. Schornik and etc. focused on milling of composite materials, specifically fiber reinforced plastics produced by filament winding, in terms of cutting conditions which could be used for good surface quality [16].

The aim of the study is to schematically describe the deformation during end milling using different cutting parameters. Optimum cutting parameters have been determined to obtain good surface quality.

2. Material and Method

2.1 *Material*

In the experiments, double-hopping (twill) carbon-fiber oriented mesh-reinforced composite materials produced by Politek Co. were used. 95% epoxy resin fiber composite material mixing ratio of 5%, 10 mm thickness (30 layers) and 0/90° fiber orientation were prepared in the form of plates. The CFRP plates have been prepared at 200x100x10 mm. dimensions. The mechanical properties of CFRP material are indicated in Table 1.

Table 1. The mechanical properties of the CFRP material

Properties	Values
Resin Type	Epoxy E201
Laminate İntensity	1.55 g/cm^3
Fiber Rate	55–60 %
Tensile Strength	760 MPa
Elasticity Module	70 GPa
Bending Strength	780 MPa
Shear Module	55 GPa
Transition Temperature of Resin	140 ˚C
Thickness of Laminate Floor	0.63 mm

2.2. *Cutting tools and equipment*

For milling CFRP composites it is recommended to choose the rake angle in the range of 0-7°. Then the recommended wedge angle is 75°. Greater rake angle leads to smaller cutting forces during machining and less smearing of matrix on the surface. Overall, it is recommended to choose a more positive rake angle for better surface quality. The flank of the cutting tool is scratched by the material which has been compressed and due to elastic deformation returns to the initial position. Therefore it is recommended to choose a greater clearance angle for a moderate improvement of surface quality. The edge radius should be minimized in a ratio to the depth of cut. A greater radius leads to a larger elastic deformation and to larger flank wear [17].

During the experiments, TiN coated cemented carbide end-mills have been used 8 mm diameter of the tool was chosen for the experiments (Fig. 2).

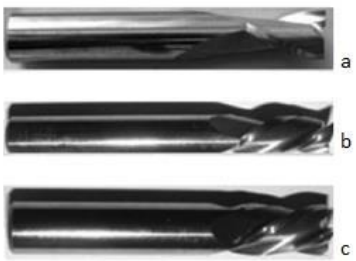

Fig. 2. The cemented carbide end-mills (a) 2 flute tool (b) 3 flute tool (c) 4 flute tool

A CNC milling machine (TAKSAN TMC 500V) was used for the experiments. The machine performed 5 kW of engine power and 12000 rpm of maximum speed. The experimental setup is given in Fig. 3.

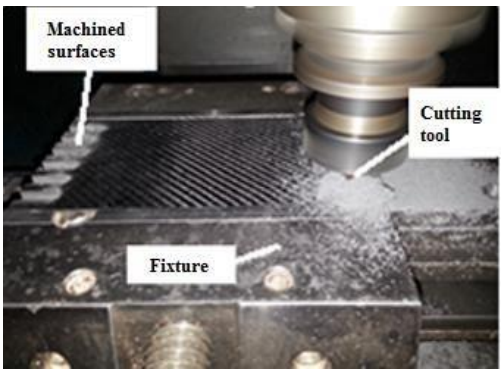

Fig. 3. The experimental setup

2.3. *Cutting Conditions*

Various types of polymers exhibit a transition from ductile to brittle fracture due to different strain rates. This factor affects the quality of the machined surface. Therefore cutting conditions must be selected according to the construction and composition of the FRP composite. In most cases high cutting speed and less feed per tooth are used. Increasing the feed rate causes very large thermal stresses and deterioration in the quality of the machined surface [18]. Higher cutting speed causes failure of the material under less stress and brittle fracture. On the other hand, increasing the cutting speed increases the cutting temperature [19]. In the experiments, cutting speed, feed and flute number have been used as cutting parameters given in Table 2.

Table 2. The Cutting parameters

Cutting speed, Vc [m/min]	Feed, f [mm/min]	Flute number
60	100	2
80	200	3
100	300	4

After the experiments, maximum width on deformation area on both sides has been observed by using a stereo microscope (Nikkon SMZ06150). The maximum deformation width named "dw" has been measured as given in Fig. 4.

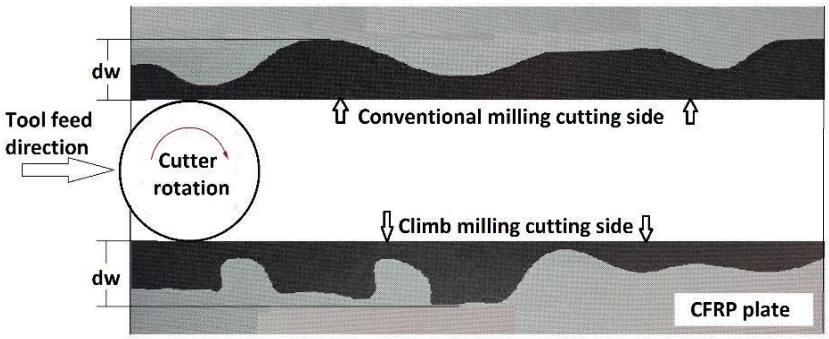

Fig. 4. Definition of the deformation width

3. Experimental results

The comparison graphs are given in Figures 5 and 6 according to the experimental results. It is clearly seen that increasing cutting speed and flute number decreases deformation width both on cutting sides. Unlike that increasing feed increases

deformation width both on cutting sides. The deformation width results of climb milling are bigger than conventional milling results. Especially bigger flute number s have better surface results.

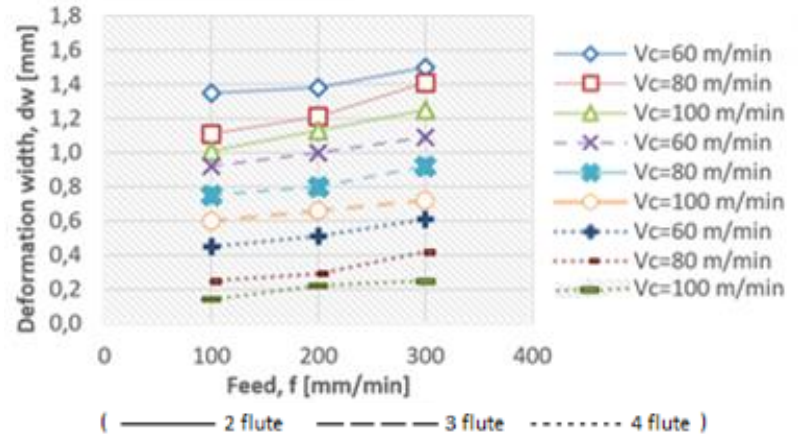

Fig. 5. The comparison of dw and feed when conventional milling

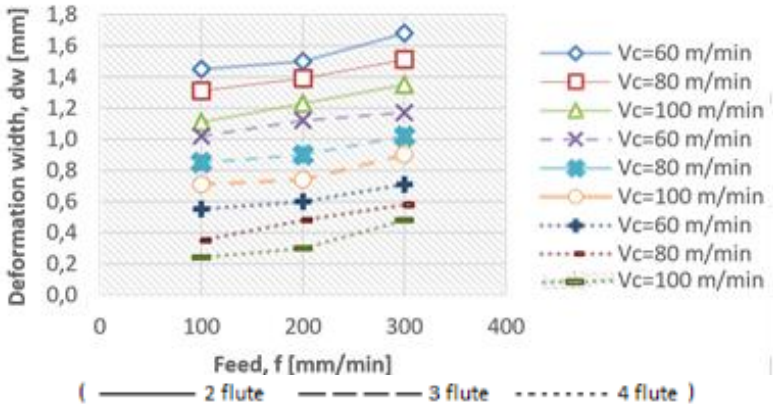

Fig. 6. The comparison of dw and feed when climb milling

4. Conclusion

The main task of this paper is finding of the usable cutting conditions for milling in terms of the machined surface quality. The usable cutting conditions were determined by the experiments. According to the experimental results, to obtain better surface quality less feed, higher cutting speed and higher flute number must

be chosen. Conventional milling is recommended, because it generates horizontal cracks. Climb milling generates vertical cracks, which are formed in the machined surfaces. Number of flutes has significant influences on cutting process and deformation width.Since the angle between cutting edges of four flute end-mill is 90°, they cut four times a revolution. Similarly, since the angles between cutting edges of two and three flute end-mills are also 120° and 180° respectively, they cut twice a revolution. However in conventional milling, the direction of cutting speed of the edge in contact with the workpiece is opposite to direction of feed. In climb milling, the direction of the cutting speed is the same as that of the feed. The resulting chip area in both cases has a "comma" shape and the length of the chip is described by a torchoid that results from the superposition of peripheral motion and feed motion. In conventional milling, the cuttin edge begins engaging the chip at the thin section of the comma shape. This results in low engagement forces and in lifting up of the workpiece.

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Technology Forecasting Using a Dynamic Multivariate Time Series Similarity Measure

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In almost any dynamic multivariate system, there is great value and insight that can be obtained from identifying the most influential components. Moreover, when examining more than one multivariate system, there is an even greater importance to identify similar variable interactions from not just one group, but across all the dynamic assortments. It is the belief of this research that the benefits from using such an approach are essential in establishing a technology forecasting model. This paper will introduce a new method for assessing the similarity of multiple variables between two different Multivariate Time Series (MTS) systems. This approach will use a modified Extended Frobenius norm, Approximate Entropy, and subspace projections to develop a semi-metric measure of association between two MTS groups. An improvement on previous methods, this approach will allow for the comparison of an unequal number of variables in each compared MTS group. The similarity measure produced in the example used in this paper will help identify how changes in multiple technology categories compare to employment changes that have occurred at the same time in multiple job sectors.

Keywords: Time Series; Multivariate Analysis;, Technology; Econometric Modeling

1. Introduction

The objective of most, if not all, types of predictive analysis models is to provide some measure of association. The level of this relationship varies by the type of application, methods, and eventual goal of the analytic problem. However, at the root of the process, the overall goal is usually focused on demonstrating some level of similarity. In most cases this takes the form of causality. When one considers a technology forecasting (TF) model, the desired outcome is the same. Any given predictive model needs to be capable of demonstrating that prior, historical data can be used to project future values.

These models are all predicated on the assumption that there is a strong similarity between the input and output variable(s) of a system.

As an example consider the growth in cellular devices. Over the past fifteen years the mobile phone industry has undergone nothing short of a complete transformation. In 2001 some cell phones had the ability to access the internet or take photos, but not all of them. At that time the majority of them were just used as telephones (albeit portable ones). The evolution of these devices in the decade to follow was a massive impact on technology, society, and the economy. It's difficult to know if anyone could truly have predicted the explosion of computing power that would occur. However, for the sake of this paper, what if it was possible to assess the current and past states of technology, and use it to predict what type of growth an industry could expect. This is all possible if a reasonable technology forecasting model can be created.

While a TF model can take many forms and provide a breadth of prognostications, there is at the root of these models a need to establish some measure of correlation/association to determine causality. This paper introduces the Extended Frobenius Entropy Measurement (EFrEM) as one of these key building blocks. The goal of this technique is to assess the similarity between two dynamic multivariate systems. Where each system is a group of similar time series trends. There are many models available for assessing the similarity of two time series trends. However, very little work has been done in comparing one TS set comprised of multiple variables to another similarly structured set. Figures 1 and 2 illustrate this scenario. The it is easy to observe that the two trends in Figure 1 perform in a very similar manner. However, the plots in Figure 2, where there are multiple trends in each group, it is much more challenging to determine if each set performs similarly.

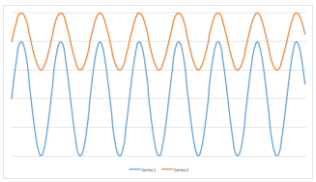

Fig. 1. MTS Example 1

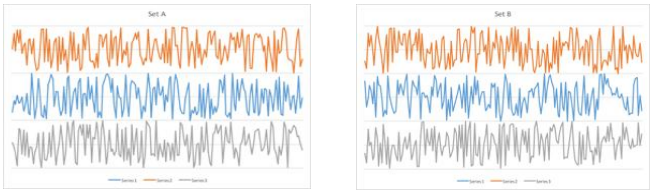

Fig. 2. MTS Example 2

An important distinction that needs to be made is that the EFrEM approach is not intended to create an exact one mapping between each MTS group. Instead, the technique looks to find the similarity in the interactions that exist between all TS in one group to the interactions present in the second. How do the holistic changes in one system compare to the changes in the other. This way the influence of all variable are taken into account. Furthermore, the EFrEM algorithm will loop through all possible variable combinations to measure the effects of all combinations of variables. This way any obfuscated associations embedded within each MTS group will not be missed. At the root of all of this is the running theme of this paper and research, how do two dynamic MTS systems compare to one another.

This paper introduces a new technique that can be used in the construction of a TF model. The benefits of an effective model are numerous and certainly present different opportunities to each person/organization. The specific area that will be demonstrated in this research will be that of employment. Using the EFrEM technique, fluctuations in technology patents will be compared to changes in employment opportunities. This research intends to demonstrate that over a ten-year time frame, similarities exist between quantities of USPTO patent classes and the number of job opportunities in various employment sectors.

2. Background

It is certainly no secret that there has been a plethora of technological advancements over the last 30 years. While some people such as Moore [1] have prognosticated that technological growth would occur, few expected the growth to be at such an unprecedented rate for such a long period of time. Also, while in a very general sense, Moore's Law does a great job of predicting that growth will occur, it does not provide any insight into what exactly the results of that growth will yield. However, there has been research done that demonstrates the economic and industrial benefits of TF models [3][4][5]. It is also worth noting that these works also use patent mining as a foundation of their TF models. Research has shown that patent data can be modeled and forecasted using various time series methodologies [6]. Smith & Agrawal [7] have also shown that patents contain analytic trends that can be mined and clustered into similar groups.

Various attempts and techniques have been used to create TF models. According to Yoon & Park [2], there are two main philosophical approaches to TF are exploratory forecasting and normative forecasting. The exploratory approach projects the present state of technology into the future by treating technological change as being subject to an internal, opportunity-oriented law of development. By contrast, the normative approach focuses on the creation of

alternative technological paths to a desired, predefined end state. Some of the Technology Forecasting methods attempted have been Morphology and Conjoint Analysis [2], Matrix Mapping and Support Vector Clustering [3], Bibliometric Analysis and the Bass Diffusion Model [8], and Brownian Agents [9]. Mori et. al [10] proposed a very unique approach for automatically determining a measure selection to cluster time series data sets in a database. While their work is similar to what is proposed here, it still does not account for the total behavior of each MTS cluster.

The lack of a method for comparing MTS groups was a driving factor for this paper and research. In addition to the Eros method mentioned earlier there has also been similar work done by Tapinos and Mendes [12] in which Dynamic Time Warping and discretization of time series trends produced a semi-metric measure of similarity. The use of entropy as a weight on the Frobenius Norm give a unique perspective to the issue in question. Heuristically, Approximate Entropy measures the (logarithmic) likelihood that runs of patterns that are close remain close on next incremental comparisons [13].

3. Methodology

To create a measure of association, the EFrEM function modifies part of the Extended Frobenius Norm (Eros) technique proposed by Yang & Shahabi [11]. The Frobenius Norm (also known as the Euclidean Norm or the Hilbert-Schmidt Norm) can be computed as follows [14]:

For an $m \times n$ matrix:

$$\|A\|_F \equiv \sqrt{\sum_{i=1}^{m} \sum_{j=1}^{n} |a_{ij}|^2} \qquad (1)$$

Yang & Shahabi expand on that principle as follows:

$$\|A\|_F = trace(A^T A) = \sum_{i=1}^{n} \langle x_i, x_i \rangle \qquad (2)$$

From this extension they are then able to propose their Eros approach:

Let A and B be two Multivariate Time Series (MTS) items of size $m_A \times n$ and $m_B \times n$, respectively. Let V_A and V_B be two right eigenvector matrices by applying Singular Value Decomposition (SVD) to the covariance matrices, M_A and M_B, respectively. Let $V_A = [a_1, \cdots, a_n]$ and $V_B = [b_1, \cdots, b_n]$, where a_i and b_i are column orthonormal vectors of size n.

The Eros similarity of A and B is then defined as

$$Eros(A, B, w) = \sum_{i-1}^{n} w_i |\langle a_i, b_i \rangle| \qquad (3)$$

where $\langle a_i, b_i \rangle$ is the inner product of a and b. w represents a weighted vector and w_i is the specific value of that vector that correspond to the variable iteration of $\langle a_i, b_i \rangle$. In the Eros approach, this weighted vector is found by placing the eigenvalues of each respective covariance matrix into a temporary $M \times n$ matrix, where M is the number of MTS and n is the number of eigenvalues. Each row in this weighted matrix now represents a pair of values that represent the variance of each variable to all other variables in each respective MTS. The average of this pair is taken for all rows of the temp matrix and is then normalized. The resulting Eros score is a value between zero and one, with zero indicating no association and one implying extremely similar systems.

Intuitively, Eros measures the similarity between two MTS items by comparing how far the principal components are apart using the aggregated eigenvalues as weights taking into account the variance for each principal component. Moreover, the covariance matrix represents how scattered the data generated by one variable are in relation to the other variables by computing the covariances with all the other variables. The reasoning behind this logic is that the scatteredness would be similar for the data with the same label [11]. One potential drawback to this approach is that the eigenvalue based weight component works well when trends are easily observed in the data. However, this assumption starts to break down when the trends become less predictable and the eigenvalues are very small.

In early testing, it was discovered that the eigenvalue weight used in Eros produced an abnormally high number of Eros values that were very close to one. While it is possible that in any given dynamic system, if you explore all combinations of variables, then it is not a stretch to think that some of those combinations will show a high level of similarity. However, this frequency of these tremendously high values did not seem to justify and encapsulate the effects of each MTS. Therefore, a weight that uses Approximate Entropy is applied in the EFrEM technique.

Another issue with the original Eros approach is that it only works when the initial MTS groups have an equal number of variables. This is due to some of the linear algebraic operations that are performed in the algorithm. The proposed EFrEM method improves on this technique by allowing for the computation and comparison of MTS sets that have an unequal number of columns. This is accomplished by appending columns of zeroes to the smaller MTS group until the two have an equal number of columns. While it may seem to be a trivial addition, this modification allows for equal covariance matrices to be constructed. Furthermore, it is no different than projecting any lower

dimension system to a higher one. In simplest terms it would be analogous to projecting a two dimensional circle into three dimensions. If other aspects of the system remain constant then the expanding dimension would remain the same, and the circle would transform into a cylinder.

To create the EFrEM algorithm three different functions were created. The first function (aevector) is one that is capable of creating an Approximate Entropy vector for each MTS set. Approximate Entropy can be computed for any time series, chaotic or otherwise. The intuition motivating Approximate Entropy is that if joint probability measures (for these "constructed" m-vectors) that describe each of two systems are different, then their marginal distributions on a fixed partition are likely different [13]. To implement this in R the approx_entropy function from the pracma package was used. This initial function returns the approximate entropy for each column in the MTS group and returns the value to a vector for future calculations. Each approximate entropy calculation is bound between zero and one so that unreasonable values do not distort the eventual EFrEM output.

The aevector function is then used in a modified Eros (MEros) function where, as mentioned above, acts as a weight to the Frobenius Norm product. The Approximate Entropy vectors for both MTS groups are combined into a two column matrix and the max value in each row is taken to create the initial weight vector. It should be noted that the original eigenvector weight proposed by Yang & Shahabi is still used as a final normalizing iteration of the MEros function. The resulting function can be represented as follows:

$$EFrEM(A, B, w, aev) = \sum_{i-1}^{n} w_i aev_i |\langle a_i, b_i \rangle| \qquad (4)$$

where *aev* represents the aevector weight vector mention above.

4. Experimentation

The implications of this research are intended to go beyond just a new MTS algorithm. It is the intention of this paper to show how this method can be applied to real life data. Exploring information and data in patents has and will continue to be a source of intrigue for TF professionals everywhere. Hopefully, the results of the experimentation related to the EFrEM approach will provide a building block for more meaningful in-depth analysis.

4.1. *Results*

To demonstrate the usefulness of the EFrEM method as related to Technology Forecasting, two different TS data sets were explored. The first data set is a collection of USPTO patent data. The data set includes the number of patents

that were granted for six patent classes from January of 2001 to March of 2013. The second data set used was employment data obtained from the Bureau of Labor Statistics. This data set contains the number of job opportunities in various employment sectors from January of 2003 to March of 2013. The categories included are: Manufacturing, Wholesale Trade; Transportation; Warehousing; and Utilities; Information; Professional and Business Services; Education and Health Services

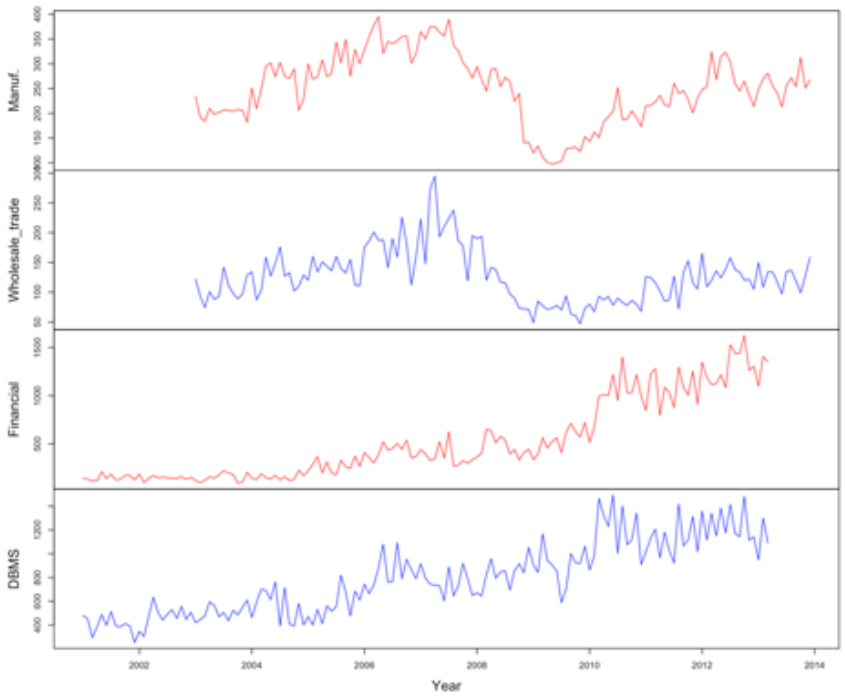

Fig. 3 All four TS with same time scale

To conduct the initial analysis in this paper it was necessary to limit the number of variables in both the patent and employment data sets. In future research it would be more beneficial to expand both of these data sets to gain a more comprehensive examination of the data similarities. From this initial experimentation, the MTS groups that showed the highest levels of similarity were financial, database patents and Manufacturing and Wholesale Trade employment trends with an EFrEM value of 0.7207. What this implies is that the behavior of the two patents mentioned performs similarly to how the two employment categories interact in the same time period. Figure 3 shows each MTS group in this example. The implication of these results suggest that

observing changes in both financial and database patents might be a good indicator changes in Manufacturing and Wholesale Trade employment.

4.2. *Discussion*

Probably the immediate takeaway from Figure 3 would be that the two groups appear to be completely different. However, it is important to keep in perspective that the EFrEM score for this comparison was 0.7207. While there are some similarities, it is not as strong as a score of 0.95 would be. Additionally, in dealing with higher dimensions and secondary layers of measurement/comparison, the similarities might not be as apparent.

Some other points to be considered are that there may be an inherent lag in the two MTS that should be included. Especially when one starts to think about the practicality of these specific variable comparisons. Changes in patents are unlikely to immediately have an impact on the changes in employment opportunities. The length and span of that lag is something to be determined in future research. However, for the purposes of this paper, the establishment of a comparison mechanism in EFrEM is the important point. Additionally, it's important to remember that the EFrEM method is not intended to show causality. Instead it should be used to identify similar MTS groups and serve as a starting point for more analysis. In this instance, it cannot be stated that changes in Database Management and Financial Patents cause changes in employment in the Warehousing Transportation and Manufacturing sectors. However, what can be gained is a starting point for more analysis by knowing that these variable groups perform similarly.

5. Conclusion

This paper and research has proposed a method for determining the similarity of two MTS groups through the use of the EFrEM technique. The primary need to create and test this method is so that more robust Technology Forecasting models can be constructed. More specifically, TF models that utilize time series analysis. As demonstrated by the experimentation documented in this paper, it may be possible to create better predictive models if the most similar components of the systems are first defined.

Future research in this area will focus on creating a TF model that incorporates the EFrEM method. For example, one proposed model would use Natural Language Processing, and Support Vector Clustering to discover patent trends from the entire USPTO database. Using the date of grant for each patent, the newly formed patent time series trends could be compared to other economic indicators using the EFrEM approach. Similar to the research carried out here, employment trends might be a good candidate. As an indicator of technology

growth the patent trends could be measured against themselves. Those showing similar performance could potentially be modeled and ultimately provide an additional utility for assessing technological growth.

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Pragmatic Suggestions for improving the Practice of Strategic Human Resource Management: Perceptions from Top Management of Sri Lankan Listed Companies

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Practice of Strategic Human Resource Management (SHRM) is critical for the achievement of organizational objectives. There are several internal and external factors influencing the practice of SHRM. The purpose of this study is to present some suggestions for improving the practice of SHRM as per the perception of Chief Executive Officers (CEOs) and Heads of Human Resource (HR) of Sri Lankan Listed Companies. The CEOs and Heads of HR for this study were drawn from a sample of 20 listed companies which were selected in order to represent each industry from a population of 288 listed companies of Sri Lanka across various industry sectors. Qualitative data was collected through semi - structured interviews and data analysis was done through thematic analysis. The results of the thematic analysis reveal that there are several factors to improve the practice of SHRM in Sri Lanka. Four clusters of themes have been emerged in the analysis, namely, competency of Head of HR, positive top management attitude and support, support from the external parties, and positive internal system. These findings help to enhance the understanding of SHRM

and can be applied to strengthen the practice of SHRM in Sri Lanka. These are original contributions to the Sri Lankan SHRM literature. The findings of the study support to fill the existing gap identified and provide some practical implications to professionals regarding practice of SHRM in the Sri Lankan context. Hence, this research may help policy makers of Listed Companies as well as other companies in Sri Lanka to identify ways in which they can improve the practice of SHRM.

Key Words: Suggestions, Practice of SHRM, Top Management, Sri Lanka, Listed Companies

1. Introduction

Jain (2005) has mentioned that SHRM includes comprehensive concerns about structures, values, cultures, quality commitment of the human resource through whom the goals of an organization are accomplished. Not only Jain but also many other researchers like Karami, Analoui and Cusworth, (2004) have emphasized that HR must not only focus on business level outcomes rather than HR level inputs but also it must become a strategic core competency rather than a market follower. Having identified several definitions, it can be explained that the SHRM perspective considers employees as strategic resources and implies that people are a critical investment in a firm's performance. In essence SHRM requires a holistic approach, with not only an internal integration between personnel systems (recruitment, selection, reward mechanisms, appraisal performance management), but also an integration between those systems-summarized in an HR strategy and the organization's strategy overall. According to the findings of Sajeevanie and Opatha's (2007) study "relationship between HRM- related factors and Practice of SHRM in Sri Lankan Listed firms" competency, education, experience and hierarchical level of the Head of HRM of a firm positively and significantly related to the practice of SHRM of the firm. Also they have found, in the Sri Lankan context there are less number of organizations practicing SHRM.

Unfortunately, little attention has been paid to studying SHRM practices in Sri Lanka, even though a number of scholars had studied SHRM in other developing countries. The research gap identified here is the intellectual puzzle on "how to improve the Practice of SHRM in Sri Lanka". Hence, this study aims at investigating SHRM practice within Sri Lanka and to present some pragmatic suggestions for improving the Practice of Strategic Human Resource Management as per the perception of CEOs and Heads of HR of Sri Lankan Listed Companies.

2. Methodology

In order to achieve the objective of the present study, i.e. to derive some pragmatic suggestions for improving Practice of Strategic Human Resource Management as per the perception of CEOs and Heads of HR of Sri Lankan Listed Companies, a qualitative approach was used.

2.1. Population and sample

The researcher approached the Sri Lankan Listed Companies as the targeted population. These companies are the top performing companies in Sri Lanka. Since, industry sectors represented by these organizations were 20 it ensured a broad spectrum of industries. For the collection of data for this study 20 CEOs and Heads of HR were selected conveniently representing at least one from each industry.

2.2 Data collection and analysis

Qualitative data and in particular semi structured interviews were conducted to explore existing uncovered realities. Except 5 members all others were interviewed using a tape recorder for responses. Their comments were identified as SLCR1 to SLCR20 respondent wise without any sequence.

There are different methods to analyze the research findings in qualitative research. Thematic analysis is a commonly used approach in data analysis of qualitative research. Thematic analysis was chosen because it is a flexible, uncomplicated technique that allowed for the study to be informed and to generate new insights. Thematic analysis is a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set (Braun & Clarke, 2013).

3. Findings

The question related to how to improve the practice of SHRM in Sri Lanka, one Head of HR explained; "I think the most important part is to hire the right people for the right place. Specially Head of the HR should be a correct person having required skills. Also top managers should value Human Resources and Human Resource Management. And they need to allocate sufficient resources then only the HR department can think beyond its day today administrative works".

Another CEO from Sri Lankan Listed Companies expressed his views on how to improve practice of SHRM in Sri Lanka as ;

"I am so much happy to know, about conducting SHRM research in Sri Lanka. Because some people still think about personnel management. But now we

should think beyond even from traditional HRM. I can't say there is up to 100% level practice of SHRM in our company. We would like to encourage other organizations by showing the benefits of SHRM for our organization".
One of the Sri Lankan Listed companies' Head of HR explained as; "Since we are a medium sized organization we can't practice SHRM as large organizations".

From the interview data, the study has identified four themes under the research question of "How to improve Strategic Human Resource Management Practice in Sri Lanka". They are; Improve competency of Head of HR, Positive top management attitude and support, Support from the external parties, and Create a positive internal system.

The objective of this study is to present some pragmatic suggestions for improving Practice of Strategic Human Resource Management as per the perception of CEOs and Heads of HR of Sri Lankan Listed Companies. As explained above there are several factors to improve the practice of SHRM in Sri Lanka. According to the answers from the Heads of HR and CEOs of the Sri Lankan Listed companies , those factors can be categorized under four themes; competency of Head of HR, Positive top management attitude and support, Support from the external parties, and positive internal system. Thus, improving competency of Head of HR was found as one of the main factors to improve practice of SHRM in Sri Lanka. Furthermore, positive top management attitude and support is vital for this. Similarly, a positive internal system helps to improve the practice of SHRM in an organization. Moreover, the study found that support from some external parties also was critical in order to improve the practice of SHRM in the Sri Lankan context.

4. Discussion and Conclusion

This finding is aligned with the previous literature, as such HR managers need to improve their knowledge of core markets, competitors, cost, products and stakeholders in order to integrate SHRM with corporate strategy (Ayanda & Sani, 2010). Dharmasiri (2009) has explained that to be a strategic partner; the Head of HR has to acquire business mastery, and a path that would lead him/her to greater interactions with the top team. Furthermore, these results are well supported by the results of the survey done by Ayanda et al. (2010). They explained that government should consider the practice of SHRM and reduce the unfavorable influence on HR matters. Thus, this finding is aligned with the previous literature, and they are confirmed in the Sri Lankan context.

Qualitative analysis was done by using thematic analysis. The Qualitative analysis revealed pragmatic suggestions for improving the practice of SHRM in Sri Lanka as per the perception of CEOs and Heads of the HR from Sri Lankan Listed companies. Thus, improving competency of Head of HR, positive top management attitude, positive internal system, support from some external parties were their suggestions to improve practice of SHRM in the Sri Lankan context. These findings are original contributions to this area. Human resources are the most important resources in an organization. As resource base theory explains HR can be used as sources of competitive advantage. Hence practice of SHRM is critical for the achievement of organizational objectives.

5. Implications

The findings of the study support to fill the existing gap identified and provide significant implications to HR professionals and Top Management in Sri Lankan Listed companies and policy makers and the government of Sri Lanka. Hence, the study suggests several ways to increase the practice of SHRM in the Sri Lankan context. Another important implication of the findings of the study are that a firm, that wants to establish a serious Practice of SHRM, should hire and retain a person as the Head of HRM who should process a high competence of HRM, higher formal education on HRM and more experiences in HRM. Further, Sri Lankan organizations need to improve competencies of their Head of HR, develop positive top management attitudes and support. And it is very critical to create a positive internal system towards practice of SHRM within the organization. As a country policy makers and government can support to improve the practice of SHRM in Sri Lanka. The practice of SHRM should be further popularized in Sri Lanka. It is possible for the relevant academics of government universities and other educational institutions to engage in empirical studies in order to explore specific cultural, economic and other barriers for the practice of SHRM and to find specific solutions to establish and enhance the practice of SHRM. Also it is possible for them to publish learning materials useful for Training and Development of practitioners. Hence, this research may helps policy makers in Sri Lankan Listed companies and other companies in Sri Lanka to identify ways in which they can improve the practice of SHRM.

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Informal Learning: Using a puzzle to communicate technical instructions

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It is a significant challenge for higher education to prepare technology professionals with the appropriate technical communication skills, especially with writing technical instructions directed to specific end-users. Writing in the engineering and technology classroom allows students to think comprehensively, deepen their understanding of technical topics, and enhance cooperative learning. The purpose of this study was to provide the results of a case study, using informal learning through a puzzle activity, to teach written instructions in a technical communication course. The participants were students enrolled in 3 sections of a Technical Communication course in the Department of Polytechnic Studies at a Midwestern university. Two (18%) of the eleven teams solved the puzzle from the written instructions. The successful teams seemed to be able to focus on the needed details, while still remaining concise with their instructions. Reasons for the low solve rate included students struggling with writing written instructions, implementing the instructions, and being unprepared to apply course knowledge. The researchers felt that the informal activity, followed by the video presentation, helped students to improve writing technical instructions. Students commented that the activity assisted them on improving written instructions.

Keywords: informal learning; learning organization; group effectiveness; communication.

1. Introduction

With changes in organizational structures and innovation, universities are tasked with teaching students to learn how to communicate technical information to compete in the global complex work environment. This learning can be formal or informal. Denson, Stallworth, Hailey and Householder (2015) found that students

in STEM-based learning may benefit from informal learning. This informal learning can lead to success in the learning environment and to the ability to recruit and retain students. Additionally, benefits of informal learning, include students feeling a sense of accomplishment, time management skills and the ability to solve problems. Informal learning also makes learning fun. Problem solving in teams, often through informal learning, is critical to success of organizations (Ranieri, 2004). Students need soft skills beyond technical training, including working in teams, communicating, paying attention to detail and solving problems (Jozwiak. 2004). All of these skills can be accomplished through informal learning environments. Garet et al., (2001) found that three core aspects of learning are focused on content knowledge, active learning activities, and other learning opportunities, including informal learning. Teacher supported informal collaboration can lead to productive learning (Jones & Dexter, 2014).

2. Problem

It is a significant challenge for higher education to prepare technology professionals with the appropriate technical communication skills. Technologists are expected to bridge the communication gap between the subject matter expert and the end-user, especially with writing instructions directed to specific end-users. Additionally, these technologists are sometimes criticized for being poor communicators and writers. Wheeler and McDonald (2000) proclaimed that students need to be proficient in writing instructions and the ability to work in teams. Providing informal learning, through a fun activity may help students to learn how to create written instructions. There is minimal research available on the use of informal learning in the classroom to communicate technical instructions.

3. Significance of the Problem and Review of Literature

Writing is a powerful tool inside and outside of the classroom. Wheeler and McDonald (2000) concede that writing in the engineering and technology classroom allows students to think comprehensively, deepen their understanding of technical topics, and enhance cooperative learning. Many students struggle with creating written instructions. Faculty members who teach technical communication courses are not impressed with the pedagogy of written instructions. Students should understand how to write instructions that are clear, concise and most importantly easy to apply. To achieve this challenge, informal learning may hold the key. Informal learning can take place in the classroom by having an activity that teach students without using traditional formal assessment.

Faculty members who teach technical communication courses are challenged to instill in students the importance of being able to communicate technical information, including written instructions. Cantanio & Cantanio (2010) found that because there is a necessity for students to be proficient in technical communication, informal learning can help them keep their skills up-to-date. This study uses informal learning through a puzzle activity in the classroom to provide an avenue for students to learn how to create written instructions.

4. Purpose

The purpose of this paper is to provide the results of a case study using informal learning through a puzzle activity designed to teach written instructions, in a technical communication course. The following question was asked: Does using informal learning through a puzzle activity teach students to communicate written instructions?

5. Methodology

This study involved a case study using a puzzle, as an informal activity, to teach students written instructions. The participants were students enrolled in 3 sections of a Technical Communication course in the Department of Polytechnic Studies at a Midwestern university in the fall of 2015.

5.1 Instrument

The instrument used was a Hollow Square Puzzle (Pfeiffer & Jones, 1974, 32-40). The puzzle was used as the informal learning activity. The puzzle contained sixteen pieces that were assembled on a square with a hollow center. The puzzle pieces were inserted into an envelope with a key.

5.2 Procedure

Phase 1: Participating in the informal activity. Students were introduced to the objective of the study and asked to sign a consent form to participate. Next, students were divided into teams of six. Within each team of six, students were randomly divided into sub-teams of three that consisted of writers and implementers. The sub-teams of writers and implementers were separated into two classrooms. The writers were given the envelope with the puzzle pieces and the key. They had 25 minutes to draft written instructions from the key. During this time frame, the implementers were asked to discuss their reactions and expectations to waiting for the written instructions. After the 25 minute timeframe

expired, the writers entered the room where the implementers were located. The writing sub-team members gave their implementing sub-team members the blank puzzle and the envelope with the puzzle pieces. The implementers had 20 minutes to solve the puzzle from the written instructions only. The writing and implementing sub-teams were not allowed to communicate, verbally or non-verbally, during the 20 minute time frame. The team was considered successful if they completed the puzzle in the timeframe.

Phase 2: Videotaping of written instructions from informal activity. The faculty member teaching the technical communication course identified the best of the written instructions from a previous semester. This set of written instructions, along with the blank puzzle and puzzle pieces, was given to a faculty member in the Department who agreed to participate. The faculty member was instructed to describe out loud the process he was performing in order to solve the puzzle, while being video-taped. The faculty member did solve the puzzle.

Phase 3: Watching the video of the informal activity. In a subsequent class, after the informal puzzle activity, students watched a 19-minute video of the faculty member trying to complete the puzzle of written instructions from a previous semester. The goal of the video was to allow the students to watch an individual struggle with trying to solve the puzzle from written instructions. During the video, the faculty member verbally described his process, as he tried to complete the puzzle. While the students were watching the video, the instructor of the course paused the video to make key points and discuss usability issues with the students.

Phase 4: Revising the written instructions. After the video presentation, the class discussed how the teams could improve their written instructions, based on the information from the video. The teams were then allowed to improve their written instructions.

6. Results and Discussion

The research question was: Does using informal learning through a puzzle activity teach students to communicate written instructions? The focus of the study was not on solving the puzzle, but on the success of the informal activity in learning written instructions. Students struggling with written instructions is not a new revelation. It was not a surprise that very few teams actually solved the puzzle in the time frame. Of the eleven teams involved in this case study, only two (18%)

solved the puzzle from the written instructions. The successful teams seemed to be able to focus on the needed details, while still remaining concise with their instructions. Reasons for the low solve rate included students struggling with writing written instructions, implementing the instructions, and being unprepared to apply course knowledge. Students struggled with articulating each step in the written instructions and describing each puzzle piece accurately. Some teams approached this task by focusing on just writing something down on paper, while others scrutinized each word of every step. The teams that focused on just writing something down on the paper, seemed to rush through the process and missed important details. The teams that scrutinized each word, had more detail in each step, but frequently were not able to complete the entire set of instructions. A second reason was the frustration in implementing the written instructions. The implementing sub-team member's became frustrated because they did not understand the written instructions that were given. The writing sub-team members who believed they drafted clear written instructions, also became frustrated with the implementing sub-team not understanding the written instructions. The final reason for the low success rate was students not being able to apply the principles learned in the course content on writing technical instructions. As the students completed the informal activity of solving the puzzle, they did not make the connection of clear, specific, and comprehensive instructions. The follow-up video and discussion, helped students to see the connection through watching an individual struggle. Students were very eager to discuss the issues found in the instructions from the video. In the discussion of the video, students made valid suggestions on ways to improve certain parts of the instructions. Students were urged to consider the issues within their team's set of instructions.

7. Summary and Conclusions

The goal of the informal activity was to help students write technical instructions. A low percentage (18%) of the teams were able to successfully communicate technical instructions through the informal learning activity of the Hollow Square puzzle. The researchers felt that the informal activity, followed by the video presentation, helped students to improve writing technical instructions. Students also commented that the activity assisted them on improving written instructions. For example, the writing sub-team members liked being able to observe the implementing sub-team complete the puzzle. It was helpful for them in making the instructions clear, concise, and easy to implement in the re-write of the instructions. Moreover, students enjoyed being given time to discuss the pros and

cons of their instruction sets as an entire group. Students consistently mentioned that time was an issue that they believed hampered them in solving the puzzle. Future researchers should consider adding additional time for the writers to draft the written instructions. This research has implications for educators. They can use informal learning activities that can help students to learn technical information, including written instructions. Although this study was performed in an educational setting, the researchers expect similar behaviors in industry.

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The Role of Diversity and Inclusive Policies on Firm Performance

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This research aimed at analyzing the relationship if any between organizational diversity and Inclusive policies on the performance of 100 Best Companies to Work List. This paper adopted an ex-post facto design for its data analyses, as due to the subject sensitivity, ex-post facto design was the only option for the analyses at this time. The study found that the relationship between both diversity and inclusive policies must be looked at more comprehensively and closely in order to draw solid conclusions as to how companies' with diverse employees and inclusive policies would be able to improve their financial and nonfinancial performance.

Keywords: Diversity; Inclusion; Organizational Change, Performance

1. Introduction

Prior to the diversity management movement, many organizations managed their diversity in terms of Equal Employment Opportunity and Affirmative Action. Equal opportunity and affirmative action initiatives were in line with legal compliance and not geared towards utilizing diversity for better performance. Diversity Management is different to Equal Opportunity in that diversity management values the differences between individuals and supports while Equal Opportunity focuses on sameness of individuals. Diversity management is a strategic response to labor market and differentiated from equal opportunity by focusing on individuals rather than groups. Possessing diverse organizational workforce does not automatically result in inclusive organizations. Leadership support and organizational culture are key components in transitioning organizations diversity into inclusivity. According to the literature, inclusive organizations are better posed to deal with the external environment and changes compared to less than inclusive organizations (Robinson and Dechant, 1997;

Kelly & Dobbin, 1998; Boxenbaum, 2006; Hanappi-Egger, 2012; Kumra & Manfredi, 2012).

1.1. *Research Problem*

Scholars stress firm level conditions that allow for identification of organizations resources and capabilities such as diversity in attaining competitive advantage. However, possession of valuable resource in of itself is not sufficient in improving organizations' performance or attainment of competitive advantage. Scholars have further argued the importance of organizational culture and leadership support in creating inclusive organizations, whereby, all members' talents are realized, and utilized in achieving organizations' goals. Many studies have analyzed the relationship of diversity to organizations' performance. However, based on these studies, it is still unclear what the relationship of diversity to performance if any is. Furthermore, based on the literature the role of organizational context such as culture and leadership is very important to how resources such as diversity are utilized and subsequently impact performance. Therefore, it is still unclear what is the relationship of diversity to performance in 100 Best Companies to Work List which are selected through anonymous surveys from their employees as having great organizational cultures in the United States (Cox & Blake,1991; Tomervik, 1995; Anderson & Cavanagh, 2000; Engardio, Bernstein, & Kripalani, 2003; Hubbard, 2004; Lockwood, 2005; Carrell, Mann, & Tracey, 2006; Chang, 2009; Hassan, 2009; Bezrukova & Jehn, 2012; Obina, 2012; Sabharwal, 2014).

1.2. *Research Purpose*

The focus of this study is on the 100 Best Companies to Work list, published annually by the Fortune Magazine-based on the research and analyses of the Great Place to Work Institute. The Great Place to Work Institute annually conducts an anonymous survey and cultural audit from the applicant companies' employees and managers in regards to workplace practices and policies in addition to questions regarding employee demographics. The companies are then categorized and ranked based on the score they receive from the surveys. The purpose of this research is therefore, to study the relationship between organizational diversity as well as organizational culture, which in the context of this study includes organizations' policies and programs pertaining to work-life balance, benefits and compensation and training and development and the impact of this relationship on organizational performance. This study is therefore, an ex post facto analysis of the 100 Best Companies named by Fortune Magazine to be the best places to work for in the United States in 2014.

1.3. *Theoretical Framework*

As evidenced based on the research, creating inclusive organizations conducive to better performance requires systematic change efforts supported by organizations' leaders. Causal Performance and Change Model is an appropriate theoretical framework for this study as it underscores various bi-directional variables which enable organizations to deal with the external environment and through various activities support changes within organization and improve organizations' performance (Burke & Litwin, 1992). This study therefore, fits into the Causal Performance and Change Model in its direction.

1.4. *Research Questions*

This research was guided by the following questions:

- Is there a statistically significant relationship between organizations' percentage of female executives, female employees, minority employees and organizations' annual revenue?

- Is there a statistically significant relationship between organizations' percentage of female executives, female employee, minority employees and organizations' employee productivity?

- Is there a statistically significant relationship between organizations' Work-Life Balance Programs score (telecommuting, work sharing, compressed workweek, and onsite childcare), Compensation Programs score (percentages of company-paid health coverage for employee, percentage of company-paid health coverage for dependents, 401K, pretax savings account, and deferred profit sharing plan), Employee Training and Development score (college tuition reimbursement, average annual training for fulltime employees, average annual training for part-time employees) and organizations' annual revenue?

- Is there a statistically significant relationship between organizations' Work-Life Balance Programs score (telecommuting, work sharing, compressed workweek, and onsite childcare), Compensation Programs

score (percentages of company-paid health coverage for employee, percentage of company-paid health coverage for dependents, 401K, pre-tax savings account, and deferred profit sharing plan), Employee Training and Development score (college tuition reimbursement, average annual training for fulltime employees, average annual training for part-time employees) and organizations' employee productivity?

2. Methodology

This research is a quantitative, ex post facto analysis of the relationship between diversity and firm performance in the 100 Best Companies to Work For in the United States in 2014. The framework of the study is the Causal Performance and Change Model's transformational components.

2.1. *Population and Sample*

The population of this study was comprised of 100 Best Companies to Work For list, in 2014, based on the annual ratings of the Great Place to Work Institute. 92 of these companies were used in the study's analysis due to missing data in the other 8 companies on the list.

2.2. *Data Collection*

The data for this study, has exclusively been collected from the Great Place to Work Institute's website. The Great Place to Work Institute, rates companies based on anonymous employee and management surveys and cultural audits which includes data in regards to organizations' work-life balance programs, benefits and compensation policies and training and development policies. Applicant companies are required to submit other informational data in their application for being considered a Great Place to Work list. This study, uses the data provided by the companies, in regards to their demographic composition, and the demographic composition of the senior management. Furthermore, the study utilizes the data from Great Place to Work's cultural audit of the companies in order to create a cultural score for each company for the purpose of this study's analyses based on companies' work-life balance programs, benefits and compensation policies, , as well as training and development opportunities.

2.3. *Addressing Research Questions*

Research questions one and two were addressed directly through the demographic data as well as data regarding the organizations' annual revenue, in addition to data for employee productivity which was obtained by dividing the firms' revenue to its number of employees. Research questions three and four required the development of three cultural scores for each company (i.e., work-life balance programs, benefits and compensation programs, and training and development programs) and were addressed based on the abovementioned scores and data related to organizations' annual revenue and employee productivity.

3. Results

The research found divergent results between the relationship of the percentage of female executives, female employees and minority employees and organizations' revenue and revenue per employee. In other words, the data indicate that organizations with higher percentages of female employees and executives tended to have lower performance levels and organizations with higher percentages of minority employees tended to perform somewhat higher ($r = .15$). However, based on the limitations of the data, any conclusions must be tentative. The data did not indicate a statistically significant relationship between organizations' cultural score, which in this study was calculated based on a score given to companies for having certain work-life balance, benefits and compensation and training and development policies.

4. Conclusion and Discussion

As the review of literature suggests, the issue of diversity and inclusion, and its relationship to companies' performance is of great importance. This paper thus contributes to the current literature by shedding light on a divergent result between the relationship of female employees and minority employees to organizations' performance, highlighting future research opportunities as to why this difference exists. Furthermore, this research emphasizes the importance of creating clear benchmarks for measuring organizations' cultural components such as work-life balance policies, benefits and compensation policies and training and development policies that are aimed at creating inclusive organizations and how such initiatives could be related to organizations' performance. Cox and Blake (1991) and Sabharwal (2014) suggest that organizations which create inclusive work cultures are set to see greater financial benefits and employee productivity. However, as evidenced in this research, such inclusive measures should be

defined in a more concrete measurable manner in order to assess their relationship and contribution to organizations' financial and non-financial performance more accurately. Furthermore, as evidenced in the literature, organizations' leadership play an integral role in setting company policies and in moving the organizations from EEO compliance to fully inclusive organizations. There are many studies that numerate the impact of diversity training on companies, the impact of diversity on firms, the impact of culture on firms, the impact of culture on employees, and the importance of inclusion in the company. It is also granted based on the literature that diverse employees possess diverse and unique skill sets which can help the advance and attain competitive advantage. However, in order to truly understand the phenomenon of diversity, it is not enough to solely analyze diversity's impact on organizations' performance, rather it is better to study diversity in a manner that helps both researchers and academics to understand how better to include everyone so that they can positively contribute, and tie such theoretical findings to concrete and measurable organization training initiatives, leadership practices, company culture, and then analyze if such measures of including everyone yielded positive performance outcomes for the organization.

This study is another effort to define factors that impact organizational success that was unable to confirm significant relationships. Recently, Dean (2014) compared leadership style and organizational success in commercial banks; (Blake, 2014) looked at the impact of sustainability efforts in aerospace manufacturing, and (Bell, 2014) compared integration of strategy to performance in Oklahoma manufacturing companies. However, in each study, the data did not indicate significant correlations. The most that could be said is that the innovation/activity was obviously not harmful. In other words, the organization did or is doing a particular activity/innovation and their bottom line demonstrates they are not being harmed financially and are probably gaining in other, less obvious, ways (e.g., politically, reputation, employee satisfaction, and the like).

It is clear that additional work on the possibility that diversity efforts result in increased organizational performance is needed; it is also clear that cross-sectional, "snapshot" designs will probably not be effective. Future research must be conducted in ways (e.g., comprehensive longitudinal designs) that will clear "map" the impact of any management effort to improve working conditions and performance. It is clear that the relationships and impacts are complex in nature and require more in-depth designs.

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A framework for the comprehensive management of LEED project documents: Lessons from construction professionals

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Leadership in Energy and Environmental Design (LEED) certified buildings must meet additional green building requirements that are typically not required for non-LEED buildings. Despite progress made by the LEED program, there are still persistent challenges that reduce project success. In particular, serious concerns are raised regarding the complex documentation processes for obtaining the LEED credits for timely certification. The purpose of this paper was to examine the document management strategies that minimize LEED project challenges.

Adopting a mixed-methods approach involving a case study and structured surveys, LEED document management practices being implemented by selected construction professionals in North Carolina are examined. Data analysis revealed that subcontractors posed the greatest challenge. The four key components of the comprehensive LEED document management strategy that emerged from data analysis were: Tracking of LEED data (37%); Allocation of LEED resources (23%); Assignment of LEED tasks (23%); and Mentoring of LEED subcontractors (17%). Sixty-seven percent of respondents concurred that subcontractor development programs should be offered by contractors at no cost to subcontractors. An effective strategy should minimize challenges associated with the processing and submission of LEED documentation. In effect, organizations should be better equipped to achieve targeted LEED credits in a more timely and cost-effective manner, leading to overall LEED project success.

Key words: LEED, credits, documentation, buildings, construction management

1. Introduction

1.1 *Overview of LEED projects*

The Leadership in Energy and Environmental Design (LEED) program is a green building rating system that certifies buildings after the submission of accurate documentation by the LEED project team. Traditional project management strategies are inadequate and cannot ensure LEED project success due to the additional challenges associated with managing LEED projects (Ofori-Boadu, 2012). Challenges have included but not been limited to high cost, lack of communication and interest, lack of management and time, lack of credible research and complex codes and green building regulation. In particular, construction teams are burdened with the LEED project documentation process, which is necessary for the attainment of LEED credits and eventually LEED certification. LEED project documentation has been a major barrier that delays and burdens the project certification process; discourages project teams from applying for LEED certifications; prevents projects from obtaining the targeted certification; and increases the LEED certification failure rate. Eight of the 43 registered LEED projects (18.6%) were unable to attain LEED certification (Johnson, 2005).

The required LEED documentation usually includes calculations, narratives, specifications, drawings, and other related documents. According to France (2007), the basic data and documentation that would be required for LEED registered projects included occupant count, definition of site area, and project site area breakout (vegetated, impervious, shaded and pervious). The capacity of any organization to attain its targeted LEED certification, is largely dependent but not limited to the project team and their document management strategies.

Project stakeholders cannot expect to maximize LEED project success by implementing traditional document management practices. The main purpose of this paper is to examine the current LEED document management practices being implemented by selected construction professionals in North Carolina.

2. Review of Literature

2.1 Management studies on green building projects

LEED project challenges include high costs, technical difficulty, contractual risks, lengthy planning, unfamiliarity with LEED process, need for greater communication and interest, as well as the need for more time to implement green practices (Hwang and Ng, 2013; Zhang, Shen, and Wu, 2011; Tagaza and Wilson, 2004; Hwang and Tan, 2010). Hwang and Ng (2013) classified challenges as related to planning, project, client, project team, material and equipment, labor, and external (government). The LEED documentation process for project certification is evolving and burdensome as has been documented in several research studies (Duckles, 2009; Hanby, 2004). While Ofori-Boadu, Owusu-Manu, Edwards and Holt (2012) explored quality management strategies that are critical for LEED projects, there was no specific focus on management strategies necessary for LEED project documentation .

3. Research Methodology

3.1 *Development and Administration of Survey Questionnaire*

A mixed methods approach was adopted for this study. A survey questionnaire was designed to explore the strategies to enhance LEED project success. This questionnaire had 55 items which were classified into three major sections. This present paper reports on the findings for Section 1 (Demographics of respondents) and Section 3 (LEED project challenges and management strategies). Open-ended questions required respondents to describe the technical and managerial challenges faced on LEED projects, as well as management strategies that minimize those challenges. The questionnaire was emailed to 50 building professionals whose organizations were engaged in LEED projects in North Carolina. These professionals were selected due to their knowledge of current construction management practices used on commercial and industrial projects in North Carolina.

3.2 *Case Study*

Using the case study approach, the management strategies being implemented on an elementary school project are discussed in this paper. This ongoing project was selected because it is pursuing the LEED

certification. Further, the lead General Contractor is listed on the top 100 Green Building Contractors List as published by the Engineering News and Record (ENR). Interviews and document reviews were used to collect project data and information.

4. Results and Discussions

4.1 *Description of Respondents*

A 48% response rate was obtained as 24 out of the 50 professionals returned completed surveys back to the research team. Over 75% of the respondents worked with organizations that had been operating in the U. S. for at least 30 years, had over 51 employees, were classified as either General Contractors or Construction Managers, had annual revenues in excess of $500 million, and had completed over 21 LEED projects. The position titles of the respondents included Project Engineers, Estimators, Project Managers, Vice-Presidents and Presidents. Eighty-three percent of respondents had at least a bachelor's degree, and 17% had a master's degree. LEED Accredited Professionals (LEED-AP) made up 50% of the respondents. On the average, respondents had 14 years of working experience and had worked on 4 LEED projects.

4.2 *Description of LEED Case Study Project*

The pseudonym for the LEED Case Study project is EDULEED. This $15 million new 2-story, 39-classroom elementary school building has over 80,000 sf which includes a kitchen, multipurpose dining / gymnasium, media center and administrative wing. LEED features included public transportation access, low-emitting and fuel efficient vehicles, water efficient landscaping, water use reduction, optimizing energy performance, construction waste management, recycled/regional materials, low-emitting materials and LEED AP.

One of the core values of the lead contractor (pseudonym CONLEED), is sustainability. Its corporate office building is a LEED-GOLD building, which recycled and diverted 95% of its construction waste from landfills, materials with recycled content and used energy alternatives to reduce gas usage. This building has an irrigation system which collects rainwater and uses gray water, thereby utilizing 40% less water than required by the minimum standards of the EPA..

4.3 *Challenges associated with LEED projects*

Almost 63% of respondents expressed some level of difficulty with managing subcontractors on LEED projects. Respondents used terms such as subcontractors, suppliers, manufacturers, vendors, products and services to describe the challenges associated with subcontractors. Almost 80% of the respondents indicated that the key issues were associated with LEED project documentation. In particular, understanding the LEED requirements and collecting accurate data necessary for earning LEED credits was burdensome to General Contractors and cluttered with several issues. There seems to be a general struggle in obtaining data from subcontractors, completing calculations, tracking and storing LEED data.

4.4 *A framework for the comprehensive management of LEED project documents*

Drawing from the results from data analysis, a framework for LEED document management is proposed. Frequently occurring words and themes were clustered and analyzed. Seventy-five percent of the LEED management strategies recommended were related to LEED documentation. Terms used included LEED requirements, standards, submittals, data, submissions, credits, and information. Figure 1 shows the four key themes that were identified after analyzing the LEED document related strategies recommended by respondents.

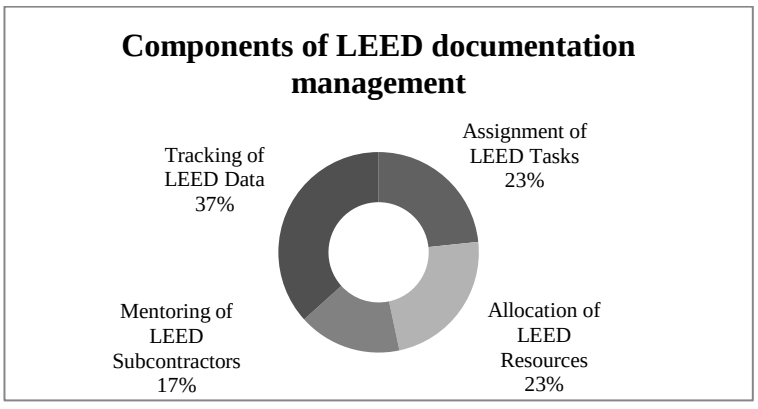

Fig. 1. Key components of the LEED document management strategy

4.4.1 *Tracking of LEED data*

An internal tracking system for LEED data is a critical component of any comprehensive LEED documentation process, as demonstrated by 37% of the responses. Employees of the General Contractor should understand the processes for documenting and tracking LEED data and requirements. Templates, checklists, forms and standard processes should be established and communicated to all team members. Early in the construction process, General Contractors should require subcontractors to provide all LEED submittals. The submittals should be reviewed early and carefully to ensure adequate time for revisions when there is non-compliance.

The EDULEED project engineer responsible for tracking LEED data noted that subcontractors' challenges with tracking LEED data were usually associated with keeping logs, collecting proper data, regional material calculations, and post/pre consumer documentation. Periodic meetings are held to provide updates and notify subcontractors of outstanding LEED documentation. A few subcontractors have to be contacted multiple times to coerce them to submit LEED data and documentation. While the project engineer was not a LEED Accredited Professional (LEED-AP), his supervisors, the Project Manager and Vice-President are LEED-APs. Also, the EDULEED Vice-President is actively engaged in the U.S. Green Building Council (USGBC) and provides LEED related training to professionals and K-12 students. Her regular participation in LEED professional development activities keeps her very well informed about changes in the LEED rating system. It is critical that these changes are well-noted and assessed to determine their impact on the data tracking process for LEED projects. In order to increase the efficiency of its tracking system, CONLEED includes LEED documentation as a part of the closeout documents and retainage is held until compliance is attained.

4.4.2 *Allocation of LEED resources*

Approximately 23% of the responses concurred that LEED resources have to be efficiently allocated to all LEED project team members to enhance a successful LEED documentation management process. These resources should be provided by LEED project supervisors. Resources are varied and include access to LEED data bases, LEED core concepts guide, and USGBC membership. In particular, subcontractors have to be provided with the resources that they need in order to submit LEED documentation in a timely manner. An invaluable resource for LEED projects is a project

supervisor who is a LEED-AP and is available to provide guidance and support to subcontractors and other field workers.

All project team members on the EDULEED project are provided with standard checklists and templates to minimize duplication and errors in the tracking of LEED data. Further, the contractor shares its internal LEED database with its external partners. In order to improve their capacity to make critical decisions on LEED projects, the contractor reimburses employees who pass LEED tests and participate in LEED conferences.

4.4.3 *Assignment of LEED tasks*

The assignment of LEED project documentation tasks plays an important role in the document management strategy as indicated by 23% of the respondents. A comprehensive submittal plan should be developed very early to outline the specific role and responsibility of each subcontractor in the LEED documentation process. Specific responsibilities for specific categories have to be accurately defined. Installation meetings should be held very early in the project to communicate assignments, responsible parties and guidelines for compliance.

In order to emphasize the importance of LEED requirements, EDULEED specifications were color coded so they were easily identified. The project utilized LEED checklists and contract language to clearly assign LEED project tasks. Contract language emphasized that subcontractors would be responsible for all losses associated with their failure to complete LEED assignments in a cost and time effective manner. Also, the project manager believed that subcontractors should be rewarded for completing their LEED documentation assignments in a timely manner.

4.4.4 *Mentoring of LEED subcontractors*

Mentoring of LEED subcontractors was considered an important strategy and was identified by 17% of all the respondents. It is very essential, especially for subcontractors who are new to the LEED process. Mentoring programs have to be implemented by contractors and owners. Considering that mentoring requires the commitment of funds, one GC signaled the prequalification of subcontractors for mentoring programs. Subcontractors enrolled in the mentoring program would be trained, supervised, monitored and rewarded for their success on LEED projects. Further, subcontractors would be rewarded for their sustainability efforts, even if they were not directly related to earning LEED credits on a specific LEED project.

Contrary to expectations, 67% of the respondents were of the opinion

that subcontractor development programs have to be offered at no cost to the subcontractor. Majority of the respondents also concurred that a fee for a development program would be a disincentive to subcontractors. Since owners would benefit from subcontractor development, some respondents suggested that it would be best if subcontractor development costs were transferred to the owner, instead of requiring the subcontractor to pay for the program. On the other hand, a few respondents believed that requiring subcontractors to pay program fees would increase their commitment to self-development.

On the EDULEED project, subcontractors were educated, trained and supervised to ensure acceptable performance on the LEED project. Although it does not have a formalized LEED mentoring program, CONLEED has mentoring programs for minority contractors.

4.5 Communication

An effective communication strategy is critical for connecting the four key components of any LEED document management strategy. Twenty-one percent of the respondents highlighted effective communication in their responses. Clear instructions should be reviewed very early and thereafter regularly with subcontractors on an individual basis and also during monthly team meetings. Further, communication between leaders and implementers had to be clear and regular to ensure smooth transitions from planning to implementation of LEED requirements.

5. Conclusion

Despite the fact that LEED has been in existence for many years, building professionals are still burdened with its complex documentation process for earning LEED credits. A comprehensive document management strategy should have a strong communication strategy that connects its four key components: assignment of LEED tasks, allocation of LEED resources, tracking of LEED data, and mentoring of LEED subcontractors. Unlike the manufacturing industry, general contractors do not seem to be strongly committed to the mentoring and development of its subcontractors and suppliers. Additional research should be conducted into the implementation of subcontractor development programs as they could improve the LEED project documentation process and eventually enhance LEED project success.

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