International Conference on Industry, Engineering, and Management Systems

March 20-22, 2017

Dear Conference Participants:

It is with pleasure that we present to you the Proceedings of the 2017 International Conference on Industry, Engineering and Management Systems (IEMS). The papers presented this year consistently represented high quality scholarship in the authors' respective fields. The papers covered a wide range of topics in the business and engineering disciplines, integrating concepts that further the mission of the IEMS Conference.

We present these Proceedings to you to enable your own thought leadership so that you may share your presentations and papers in the future at our IEMS conference.

These proceedings would not have been made possible without the valuable contributions of our Track Chairs and reviewers for the time and effort they spent reviewing the papers and coordinating our conference sessions. Thank-you also to our Administrative Coordinator, Elki Issa, whose work behind the scenes helps make our Conference a success.

We look forward to seeing you at IEMS 2018!

Warmest Regards,

Sandy Furterer, Ph.D., MBA
IEMS Publications Editor

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AN EXPERT SYSTEM OF SHERYL SANDBERG'S KNOWLEDGE (COO OF FACEBOOK)

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Abstract

This paper describes the conceptual development of an expert system to advise those considering the top-level position in a firm in the very competitive computer industry based on the expertise of Sheryl Sandberg who has been the COO of Facebook for the past few years. She had joined Facebook as their first female software engineer in 1999. She has become a role model for female computer science and MIS students that it is possible to reach the top-level position in an industry formerly dominated by males. She qualifies for the model developed by the authors to recognize heroes of the computer industry as potential experts for a computerized expert system having achieved wealth, power, and respect for her efforts.

1. Introduction

Since the early 1980s expert systems have been developed for the purpose of passing expertise from those with the knowledge to those who need the knowledge in a convenient and easily accessed manner. The idea is to tap the mind of the expert such that a person of less expertise can solve problems normally handled by the expert without the expert having to be present. In the early 1980s, expert systems were crude, self developed by only a few firms that saw value in them. By the late 1980s, special languages such as VP-Expert and CLIPS emerged and software shells developed to increase the ease of development of these systems. The first decades of the 21st century have witnessed the emergence of intelligent expert systems which provide access to multiple experts within a narrow field of interest.

In the 1990s with the focus on downsizing and the need to cut costs in all area, many managers of large corporations had turned to expert systems to provide advice when the cost of hiring an expert (consultant) or access to a previous expert employee who has been downsized was gone. The recent interest in the first decade of the 21st century on knowledge management has caused a renewed interest in expert systems as a way to manage knowledge for easier and wider distribution. The software industry has matured to build "intelligence" into software, sometimes known as "learning systems" which can adapt themselves based on how they are used. Expert Systems continue to become more complex but require constant upkeep.

This paper captures the knowledge of a single expert in a limited domain in the computer industry. It is developed for student use to recognize heroes in the computer industry who have made significant contributions. It is a jointly written paper by two MIS professors as a continuing series of expert systems for a senior elective course in expert systems taught at Southern Connecticut State University. This model has been useful in the classroom for the "Expert System" course for students to select their own expert and design such a system for that expert to better understand the nature of these complex

systems. One student, Dana Mares, continued with an independent study course where she coded her work in CLIPS to demonstrate that the model be used to build an actual system if an appropriate language is used.

2. Additional Background to Paper

Since the early 1990s, an elective course in the MIS program at SCSU titled "Expert Systems" has been taught periodically. In MIS work, expert systems have long been considered the most difficult and complex of all information system types. They are included in the family of applications known as "artificial intelligence". They represent an application attempting to mimic the human brain. These applications capture the experience of an "expert" in a narrow area of expertise in computer form such that this vast "knowledge base" can be used to produce advice for a non-expert to solve a problem to which they have not gained appropriate experience as if they were equal to the expert. This is quite a challenge. Students were having difficulty understanding the nature of these systems and how they differ from traditional information systems from a design standpoint. Figure 1 outlines the components of an expert system.

COMPONENTS OF AN EXPERT SYSTEM

- Dialog Screen – Determine Nature of Problem
- Knowledge Base – A collection of "If ...Then" statements From Experts
- Inference Engine – Software to search knowledge base
- Presentation – Determine how to display advice to system user

Figure 1

For several years in the 1990s, expert systems had fallen out of favor in business because they had been incorrectly applied to the elimination of experts, who were usually the highest paid workers in an organization outside of the managers. However, with the downsizing of the early part of the 21st century, expert systems have reappeared as a training tool for such businesses.

In support of this course, which was the most challenging MIS course to teach, Dr. Mullen developed a model of an expert system to demonstrate to the students how such a system is developed using a language, CLIPS. The model involved picking two individuals a year who were experts in their field and who were living at the time so theoretically they could have been interviewed personally to capture their expertise. However, these chosen individuals were well known enough in their field to have had books and later Internet articles published about them. This was the source of information for these systems. Dr. Mullen began presenting his work at various conferences for peer comments to improve the process. A list of organizations where these papers have been presented and published is shown as figure 2 below. Since 2003, the focus of presentations has been the IEMS Conference held each March in beautiful Cocoa Beach, Florida when the weather in Connecticut has reached its peak of winter cold and snow.

CONFERENCES WHERE EXPERT SYSTEM PAPERS WERE PRESENTED

Association of Management
Decision Science Institute
Industry, Engineering, and Management Systems
Info Resource Mgmt Association

Figure 2

Dr. Mullen also began to utilize the model to recognize the many contributors to the advancement of computer application usage who may be seen as heroes or role models to my MIS students. Such individuals who have had prior models developed of the expertise in the computer field include Bill Gates (Microsoft); Paul Allen (Microsoft); Steven Jobs (Apple Computers); Michael Dell (Dell Computers); Lawrence Ellison (Oracle); Scott McNealy (Sun Microsystems) and in 2011 Mark Zuckerberg, founder of Facebook, Steve Wozniak (co-founder of Apple computers). A co-author, Ms. Kramer, was added last year as a co-author to assure the model did not die off with the retirement of Dr. Mullen for future presentations at IEMS conferences.

3. Background of Sheryl Sandberg Featured In This Paper

Sheryl Sandberg was born in Washington D.C. on August 28, 1969. She graduated from Harvard University with a Bachelor of Science in Economics in 1991. Later, in 1995, she earned a Master of Business Administration degree from the same University. The focus of this paper is to recognize Sheryl Sandberg's contribution to the computer industry. Sheryl Sandberg began her work career with the World Bank from 1991-1993. She worked as a management consultant from 1995 to 1996 and Chief of Staff of the Treasury Department 1997-2001. Her involvement in the computer industry began when she became VP of Global Sales for Google 2001-2004. She joined Facebook as COO in 2008.

For this paper, Figure 3 summarizes the management philosophy of Sheryl Sandberg. This will be used to design the expert system of this paper.

MANAGEMENT PHILOSOPHY OF SHERYL SANDBERG
1. She acknowledges that her success stems from hiring incredibly smart people and leading them with a hard work ethic. 2. She works hard and celebrates never getting to the bottom of her "to-do" list. 3. She believes employees should not consider anything in business to be someone else's problem. 4. She believes in open communication and the value of teamwork. 5. She believes that fortune favors the bold.

Figure 3

4. Specific Development of This Paper

During the Fall 2010 semester, Dr. Mullen offered the course in Expert Systems that had not been taught for five years. It was then an elective for both MIS and management students. Students were asked to select an expert in a field of interest to them and design an expert system based on public information. Most chose sports figures or well-known managers. One student selected Mark Zuckerberg with an interest toward developing the social network system into a target marketing tool. Dr. Mullen had planned to do a paper on Mark Zuckerberg for the 2011 IEMS conference that year so combined this work into a single paper for the IEMS March 2011 conference. This also stimulated Dr. Mullen to return to his original model of using these papers to recognize contributors to the computer industry. At the 2012 IEMS conference, the subject was Paul Allen as co-founder of Microsoft. At the 2013 IEMS conference, featured Steve Wozniak, co-founder of Apple. Dr. Mullen retired in 2013 but continues to teach as an adjunct. The business school of Southern Connecticut State University is progressing toward AACSB accreditation which now requires adjuncts to continue to do research and present results at conferences with peer review.

Ms. Ellen Kramer co-authored this paper and provided the basic research regarding Sheryl Sandberg for use in the expert system model's focus for the 2017 IEMS conference.

In developing an expert system, a knowledge engineer asks questions of an expert in order to build a knowledge base. Figure 4 contains some example questions that would be appropriate to ask of Sheryl Sandberg to simulate the collecting of her knowledge in the form of advice for anyone interested in managing in the fast paced computer industry. Of course, we did not have an opportunity to actually meet with Sheryl Sandberg herself. With appropriate funding, cooperation, and time, it would have been possible to do so for the conceptual model development. But, we could uncover such situations from publicly published material via the Internet.

The language of an expert system is usually rule-based so that advice is shown as the answer to an "IF" question that the expert system user might have as a problem. Most of the advice from Sheryl Sandberg deals with her managerial philosophy.

SHERYL SANDBERG'S ADVICE ON MANAGING IN THE COMPUTER INDUSTRY
• IF your goal is to work alone, THEN your attitude toward being a team player does not fit the computer industry. • IF you are not willing to work hard, THEN the computer industry is NOT the right choice for you. • IF you are not willing to focus on detail, THEN the computer industry is NOT the right choice for you. • IF you are not an extremely smart person, THEN the computer industry is NOT the right choice for you.

Figure 4

This paper describes the conceptual development of an expert system to capture the knowledge of Sheryl Sandberg. Figure 5 depicts the conclusions reached from the writing of this paper. In the reference section at the end of this paper are other similar papers written and presented at earlier conferences in the series of expert systems on computer professionals known to be experts in their field.

CONCLUSIONS
• IT IS POSSIBLE TO CREATE AN EXPERT SYSTEM FOCUSED ON AN EXPERT IN MANAGEMENT IN THE COMPUTER INDUSTRY. • CERTAINLY, SHERYL SANDBERG HAS HAD A SUCCESSFUL CAREER. • SHE CAN SERVE AS A ROLE MODEL IN THE COMPETITVE COMPUTER INDUSTRY.

Figure 5

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Sandberg, S. (2013): "Lean In: Women, Work, and the Will to Lead" (page 217).

AN EXPERT SYSTEM OF TIM COOK'S KNOWLEDGE (CEO OF APPLE COMPUTERS)

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Abstract

This paper describes the conceptual development of an expert system to advise those considering the top level position in a firm based on the expertise of Tim Cook. Tim Cook was promoted to the CEO position in 2011 during a very difficult time when the firm had lost their founder Steve Jobs to cancer. He faced the challenge head-on having worked closely with Steve Jobs since being hired in 1998. His success qualifies him for the model developed by the authors to recognize computer industry managers as potential experts for a computerized expert system.

1. Introduction

Since the early 1980s expert systems have been developed for the purpose of passing expertise from those with the knowledge to those who need the knowledge in a convenient and easily accessed manner. The idea is to tap the mind of the expert such that a less expertise person can solve problems normally handled by the expert without the expert having to be present. In the early 1980s, expert systems were crude, self developed by only a few firms that saw value in them. By the late 1980s, special languages such as VP-Expert and CLIPS emerged and software shells developed to increase the ease of development of these systems. The first decades of the 21st century has witnessed the emergence of intelligent expert systems which provide access to multiple experts within a narrow field of interest.

In the 1990s with the focus on downsizing and need to cut costs in all area, many managers of large corporations had turned to expert systems to provide advice when the cost of hiring an expert (consultant) or access to a previous expert employee who has been downsized was gone. The recent interest in the first decade of the 21st century on knowledge management has caused a renewed interest in expert systems as a way to manage knowledge for easier and wider distribution. The software industry has matured to build "intelligence" into software, sometimes known as "learning systems" which can adapt themselves based on how they are used. Expert Systems continue to become more complex but require constant upkeep.

This paper returns to the original concept of capturing the knowledge of a single expert in management. It is developed for student use to recognize heroes who have made significant contributions. It is a jointly written paper by two MIS professors as a continuing series of expert systems for a course in expert systems taught at SCSU.

This model has been useful in the classroom for the "Expert System" course for students to select their own expert and design such a system for that expert to better understand the nature of these complex systems. One student, Dana Mares, continued her project into an independent study course where she coded her work in CLIPS to demonstrate that the model be used to build an actual system if an appropriate language is used.

2. Additional Background to Paper

Since early 1990s, an elective course in the MIS program at SCSU titled "Expert Systems" has been taught periodically. In MIS work, expert systems have long been considered the most difficult and complex of all information system types. They are included in the family of applications known as "artificial intelligence". They represent an application attempting to mimic the human brain. These applications capture the experience of an "expert" in a narrow area of expertise in computer form such that this vast "knowledge base" can be used to produce advice for a non-expert to solve a problem to which they have not gained appropriate experience as if they were equal to the expert. This is quite a challenge. Students were having difficulty understanding the nature of these systems and how they differ from traditional information systems from a design standpoint. Figure 1 outlines the components of an expert system.

COMPONENTS OF AN EXPERT SYSTEM

- Dialog Screen – Determine Nature of Problem
  - Knowledge Base – A collection of "If ...Then" statements From Experts
    - Inference Engine – Software to search knowledge base
  - Presentation – Determine how to display advice to system user

Figure 1

For several years in the 1990s, expert systems had fallen out of favor in business because they had been incorrectly applied to the elimination of experts, who were usually the highest paid workers in an organization outside of the managers. However, with the downsizing of the early part of the 21st century, expert systems have reappeared as a training tool for such businesses.

In support of this course, which was the most challenging MIS course to teach, Dr. Mullen developed a model of an expert system to demonstrate to the students how such a system is developed using a language, CLIPS. The model involved picking two individuals a year who were experts in their field and who were living at the time so theoretically they could have been interviewed personally to capture their expertise. However, these chosen individuals were well known enough in their field to have had books and later Internet articles published about them. This was the source of information for these systems. Dr. Mullen began presenting his work at various conferences for peer comments to improve the process. A list of organizations where these papers have been presented and published is shown as figure 2 below. Since 2003, the focus of presentations has been the IEMS Conference held each March in beautiful Cocoa Beach, Florida when the weather in Connecticut has reached its peak of winter cold and snow.

3. Background of Tim Cook Featured in This Paper

Tim Cook was born on November 1, 1960. He graduated with a Bachelor of Science in Industrial Engineering. Later, he earned a Master of Business Administration degree from Fuqua School of Business. The focus of this paper is to recognize Tim Cook's contribution to the field of management. Tim Cook began his work career as an industrial engineer but soon moved into various managerial positions culminating with his hire in 2008 as VP of World Wide Operations at Apple. Prior management positions as COO for Intelligent Electronics and VP of Corporate Materials for Compaq.

For this paper, Figure 2 below summarizes the management philosophy of Tim Cook.

MANAGEMENT PHILOSOPHY
OF TIM COOK

1. Considered a hands-on manager known to be directly involved with new product development.
2. He is focused on the company delivering what Apple believes are customer "wants".
3. He encourages employees to live each day as if it were their last to focus on what is important to spend time that last day.
4. He is not concerned for gaining personal wealth which drives most CEOs.
5. He believes in worker balance in their lives to enjoy their families and leisure time and to care for social issues.

Figure 2

4. Specific Development of Paper

During the Fall 2010 semester at Southern Connecticut State University, Dr. Mullen offered the course in Expert Systems that had not been taught for five years due to lack of support from the students. It had now been advertised as an elective for both MIS and management students. Students were asked to work on a term project that required selecting an expert in a field of interest to them. Most chose sports figures or well-known managers. One student selected Mark Zuckerberg with an interest toward developing the social network system into a target marketing tool. Dr. Mullen had planned to do a paper on Mark Zuckerberg for the 2011 IEMS conference that year so got permission to combine their work into a single paper for the IEMS March 2011 conference. This also stimulated Dr. Mullen to return to his original model of using these papers to recognize the many contributors to the highly successful computer industry such that future students of the course may continue that effort rather than focus on well-known sport's millionaires. At the 2012 IEMS conference, the subject was Paul Allen as co-founder of Microsoft. At the 2013 IEMS conference, featured Steve Wozniak, co-founder of Apple. Dr. Mullen did retire in 2013 but continues to teach as an adjunct, mostly on-line courses. The business school of Southern Connecticut State University is progressing toward AACSB accreditation which requires adjuncts to continue to do research and present results at conferences with peer review. This generated a new focus of female executives as previously unrecognized contributors to the computer industry in particular or managerial ranks in other industries. Dr. Richard Bassett co-authored this paper regarding Tim Cook as an expert system model's focus for 2017 IEMS conference.

In developing an expert system, a knowledge engineer asks questions of an expert in order to build a knowledge base. Figure 3 contains some example questions that would be appropriate to ask of Tim Cook to simulate the collection of those interested in managing in the fast paced computer industry. Of course, we did not have an opportunity to actually meet with Tim Cook himself. With appropriate funding, cooperation, and time, it would have been possible to do so for the conceptual model development. But, we were able to uncover such knowledge from publicly published material via the Internet. This is the same form of research that is suggested for students.

The language of an expert system is usually rule-based so that advice is shown as the answer to an "IF" question that the expert system user might have as a problem. Most of the advice from Tim Cook deals with his managerial philosophy that was shown in Figure 2. The philosophy must be shown in rule-based format. The statements are formed in terms of working for Apple but they apply to any firm in the computer industry.

TIM COOK'S ADVICE ON MANAGING
• IF you are not willing to work smart, THEN Apple is NOT the right choice for you. • IF you are not interested in working for change and consumer "wants", THEN Apple is NOT the right choice for you. • IF you do not take pride in the work you do or the products you produce quality products, THEN Apple is not the place for you. • IF you do not believe in living every day as if it were your last, THEN Apple is not the place for you.

Figure 3

This paper describes the conceptual development of an expert system to capture the knowledge of Tim Cook. Figure 4 depicts the conclusions reached from the writing of this paper. In the reference section at the end of this paper are other similar papers in the series of expert systems on computer or management professionals known to be experts in their field. Although Dr. Mullen retired in 2013 and does not expect to teach the Expert System course at Southern Connecticut University, there is value to continue this series of papers for IEMS. Dr. Mullen will develop future papers involving other faculty at SCSU so they may carry on the model for the Expert Systems course. He also plans to continue to honor individuals who have demonstrated managerial leadership or a significant contribution to the computer industry so that MIS and Management student majors may have their heroes.

CONCLUSIONS
• IT IS POSSIBLE TO CREATE AN EXPERT SYSTEM FOCUSED ON AN EXPERT IN MANAGEMENT IN THE COMPUTER INDUSTRY. • TIM COOK HAS INDEED HAD A SUCCESSFUL CAREER AND SO QUALIFIES TO SERVE AS AN EXPERT IN HIS FIELD. • HE CAN SERVE AS A ROLE MODEL IN THE COMPETITVE COMPUTER INDUSTRY FOR MIS OR COMPUTER SCIENCE STUDENTS.

Figure 4

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REVIEW ON SECURITY ISSUES AND CRYPTOGRAPHIC APPROACHES IN WIRELESS SENSOR NETWORKS

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Abstract

Sensor nodes collect data from the physical world then exchange it until it reaches the intended destination, this information can be sensitive information, such as battlefield surveillance. Therefore, providing secure and continuous data transmission between sensor nodes in wireless network environments are very important. Wireless sensor networks (WSN) have limited resources, limited computation capabilities, exchange data through the air and are deployed in accessible areas making the energy, security and routing major concerns in WSN. In this review paper, we are looking at Security issues for the above reasons, WSN is susceptible to malicious activity such as hacking and physical attack. In general security threats classified depending on the layers into the following five layers: Physical, Data link, Network, Transport and the Application layer.

1. Introduction

Gathering information from the surrounding environment makes wireless sensor networks applied in major areas in our life. Due to the continuous low cost of developing sensors and the ease of deploying and building networks of sensors, WSN becomes more commonly used in wide areas of technology applications. Sensor networks are important in various applications, mainly in applications dealing with monitoring real time data such as battlefield surveillance for the military, geo-fencing of gas, oil pipelines and child location ("wireless sensor networks", 2014). The subject of “Sensor networks” can be illustrated from its title which is composed of two broad subjects of interest. Meaning sensors in any establishment, and the communicating network among them, in other words wireless sensor networks connect sensor nodes through a wireless network. The functionality term used for describing such systems is ‘Process Control.’ In process control, sensors are coupled with actuators. The sensors are responsible for capturing physical readings in a specific medium, while the actuators are responsible for changing the magnitude of the physical property. For example, in an air conditioning system, thermometers are used to capture the temperature of a room. If the room temperature decreases below a certain value, a mini-chip processor sends a signal to the actuator (ac engine) to reduce burning of the Freon.

In more complicated applications like monitoring physical properties of radioactive materials, there are bigger structures of networks. What is known as wireless sensor networks can be illustrated using Figure 1. In this figure, the triangles represent the sensors that are accompanied with a particular location. Each set of sensors are responsible for monitoring one physical property in one room. The figure shows two sets of three triangles, therefore two different rooms. The two rectangles of the second branch of the tree is the mother node of the network. There are two mother nodes in the

network that receive readings from the two sets of sensors, and ultimately convey the reading to the root node. This tree structure is the most common sensor network topology according to Mayank Saraogi (Saraogi, 2004), (Schmid, Gädeke, Bross, Mairbäurl, Stork, 2011).

In any application depending on sensors, the data transferred from sensors to nodes to other nodes, and then to ultimately the root nodes, the data has to be secured. Failure to secure the data can cause failure to stabilize the actuators coupled with the sensors and eventually a problem with the medium under control. The majority of the security algorithms provide a good limit of security but none of them provide a full security level. Most security systems disregard the effect of physical attacks. It is therefore important to emphasize security measures that can be joined with robust algorithms to prevent such a problem.

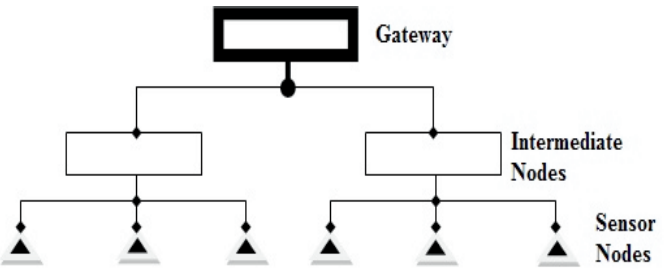

Figure 1: Common wireless sensor network topology

WSN, can be divided according to the nodes capabilities and localization as follows:

Capabilities:

- Homogenous sensor networks: where all nodes are identical and have the same specifications within the network. (Shang, Ruml, Zhang, Fromherz, 2004).
- Heterogeneous sensor networks: Within the same network there are more than one type of sensor with different specifications (Tahmasbi, Javadi, Shiri, Allahyari, 2013).
- Localization: Static wireless sensor networks: in static WSN, all nodes once deployed will not move from their position. (Ji, Huang, Wang, 2013).
- Dynamic wireless sensor network: in dynamic WSN, the nodes can be reorganized and have the ability to self reorganize after they have been deployed.

2. Security Threats

The following are common attacks on WSNs

2.1 Jamming and tampering:

Jamming and tampering are the most common types of denial of service(DoS) attacks on the physical layer. The adversary at this layer attacks the radio frequencies of the wireless sensor network by using the same radio waves between the network nodes. In some cases the adversary uses a strong radio wave which can affect the whole network or most of it. (Bhatt, Patel, Rathod, 2009). (He, Niedermeier, Meer, 2013) In some cases the radio waves are weak which can affect a small part of the network. This attack is called jamming. A tampering attack is a direct physical attack at nodes which may cause damage, replaced with a compromised node or extracting sensitive information.

2.2 Collision Attack:

A collision occurs when more than one node tries to send data using the same radio frequency at the same time. As a result of too many collisions the network resources will be exhausted. However, the attacker keeps retransmitting corrupted packets to exhaust the resources. (Gaubatz , Kaps , Ozturk Sunar, 2005).

2.3 Spoofed, altered, or replayed routing information:

At the network layer, adversaries can spoof routing information and change it by targeting the routing protocols between nodes during the exchange of data to create a false loop. This could cause error messages, latency and may attract the traffic to false nodes instead of the right one.

2.4 Selective Forwarding:

In a selective forwarding attack, attackers create a malicious node to act like a black hole. It listens to the other nodes in the network and convinces the target node that it has the shortest path. Once the malicious node gets the data packets, it drops part of it and sends the rest to the next node or drops all of it. This causes huge losses in data.

2.5 Sink Hole Attack:

A sink hole attack is a selective forwarding attack but in a complex form. The adversary creates a malicious node with the ability to attract surrounding nodes to route all data packets through it, then the adversary has complete control over the data. In some cases if the malicious node gets closer to the base station (BS) it may appear to the other nodes as the base station.

2.6 Sybil Attack:

Each node in a WSN should have a unique identity. When a compromised node simulates multiple nodes and fake multiple identities to attack routing protocols then this attack is called a Sybil attack.

2.7 Wormhole Attack:

To create a wormhole attack the attacker needs to create two powerful malicious nodes or more compared to the other normal nodes. These malicious nodes have the ability to establish faster communication tunnels between them comparing to the other normal nodes. The attacker uses these compromised nodes to confuse the other nodes and make the long paths appears to them as a short paths, which would interrupt the routing scheme and sends replayed packets to other nodes, which may cause a sink hole.

2.8 Flooding Attack:

A Flooding Attack, also known as a hello flooding attack. In common protocols, nodes get to start communicating between each other by sending an hello message. An attacker can use fake hello messages by malicious nodes with the capability of powerful transmission to illusion the BS and the other nodes by making them think that it's their own neighbour. This causes useless traffic on the network. This type of attack is considered as one of a DoS attack.

3. Security Requirements in WSNs

Following are the general security requirements in a WSN

3.1 Data Confidentiality:

Data confidentiality aims to keep the data secure from adversaries. This is the main aspect in securing any network. Data confidentiality aims to provide privacy for communication channels all over the network so the content of the network communications remain secret from eavesdropping operations.

3.2 Authentication:

A WSN can be compromised by different ways such as, injecting additional nodes or injecting additional packets into it. So it's very important for the receiver to make sure that the data originates from the intended source.

3.3 Integrity and Freshness:

The integrity requirement ensures that nothing has been altered during the network communications. Freshness aims to prevent attacks such as replay attacks by ensuring that the messages are recent and not old ones. Although authentication and data confidentiality can be guaranteed, we also have to guarantee the freshness of every single message.

3.4 Availability and Reliability:

Availability and reliability are two requirements that ensure the ability to have available and reliable service all over the WSN. It includes any part of the WSN, even a single node within the network, in different states of continuous changing in the network structure and data transmission.

3.5 Authorization:

Authorization is simply intended to ensure all WSN entities involved in any specific operation are authorized.

3.6 Time Synchronization:

Time Synchronization is very important to a WSN since sensor nodes have limited resources. Power consumption and energy efficiency become an important concern for a WSN. Using time synchronization conserves power (e.g. for data fusion , individual sensor's synchronize sleep periods by turning the radio off, etc.). Also, it can be a great benefit for performing operations during data transmission among the network, like calculating packets' delay time. (B. K, E. D, S. O, 2012).

4. Basic cryptographic key algorithms

The following are the basic cryptographic algorithms for the common recent cryptographic algorithms.

4.1 RSA Algorithms:

The RSA cryptosystem is one of the most widely-used public key cryptography algorithms in the world. It can be used to encrypt a message without the need to exchange a secret key separately. RSA was first developed by Ron Rivest, Adi Shamir, and Leonard Adleman in 1977 (Rivest, Shamir and Adleman, 1978). The RSA algorithm can be used for both public key encryption and digital signatures. The security of the RSA algorithm is based on the point that the factorization of large integers is very difficult and in some cases it is not possible to do so.

The RSA uses two keys (a public key and a private key), one for encryption of data at the sender side and another one for decryption of encrypted data at the receiver side. So that data transmitted securely over the network without being attacked by any attacker. This algorithm implemented by selecting two large prime numbers (p, q), calculating their product (N), and producing the public key and private key based on some modulus operations. Then by using these keys, the sender and receiver communicate very securely over any network medium.

Working with a public-key encryption system has mainly three phases:

1) Key Generation: Every person who wants to send or receive secret messages should have a public key and a private key. The process of developing keys in such a way that it will be difficult for others to find the private key by using their public key.
2) Encryption: A process of encrypting a secret message by using their public key.
3) Decryption: A process of decrypting the secret message by using the private key of the person who is being addressed.

RSA works as follows:

If X and Y are two persons who want to communicate over the network, then simply X sends the message to Y by encrypting it with Y's public key and Y can see the original message by decrypting it with his/her own private key, which Y knows only. RSA implementation is very simple to understand but calculations take more time for a simple computer (Boneh, 1999).

Implementation of RSA:

The RSA algorithm generates a public key and a private key by using the following steps:

- Select the two prime numbers (p , q) which should be large, over 154 digits long.
- Find the product of the prime numbers N=p*q.
- Calculate the Ø = (p-1)(q-1).
- Select the integer E which does not divide the Ø evenly (E is a relative prime of Ø) .
- Find the number D which satisfies the following operation E*D=1mod Ø.
- The pair (E, N) is a public key to encrypt the plaintext and convert to cipher text.
- The pair (D, N) is a private key to decrypt the cipher text (Unknown format text).

Given a text T , the encrypted text C called cipher text is created by
C = T^E mod N. (1)
Given an cipher text C, the original text T is recovered by
T = C^D mod N. (2)

X uses the equation 1 to encrypt the message and Y uses Equation 2 to decrypt the message. Here (E,N) is available in a public key directory but (D,N) is a unique key for everyone.

4.2 Strength of RSA:

The difficulty involved in breaking the RSA algorithm is factoring the N value i.e. finding the two large prime numbers for a given N value. Brute force attack can do it but it takes thousands of years. The number digits of prime numbers increased, then the difficulty to find them also increased. So we can derive a relationship between the number of digits and the strength of the RSA as proportionality. (B. K, E. D, S. O, 2012). Adding to that, secret-key algorithms need less computing power to be created when compared to equivalent private keys in public-key cryptography. The advantage of RSA is that it is used for encryption of a message without having a need to exchange the secret key separately. Since complexity arises in factoring the large integers its security depends on it. Both digital signatures and public key encryption can be done by using the RSA algorithm.

4.3 Elliptical curve cryptography:

In the year 1985, Victor Miller and Neil Koblitz had discovered an alternative mechanism for the implementation of the public key cryptography and they named this alternative mechanism Elliptic Curve Cryptography (ECC). Elliptic Curve Cryptography (ECC) is an alternative mechanism for the public key cryptography and it is based on the elliptic curves of algebra. These elliptic curves are defined over finite fields. The advantages of the Elliptic Curve Cryptography (ECC) over other public key cryptography algorithms is that the ECC can process digital signatures and it also provides fast decryption.

The power of the 163-bit public key in the Elliptic Curve Cryptography (ECC) is the same as that of a 1024-bit RSA key. The public key in the ECC algorithm is created by taking a point on the elliptic curve and then multiplying it by a random number. The random number is the private key. The strength of the ECC algorithm is that it is very difficult for anyone to know the private key even if they come to know the public key. The public key in the ECC can be used in various ways to encrypt and decrypt. The functionality of the Elliptic Curve Cryptography (ECC) is similar to that of the RSA algorithm. The computing power of the Elliptic Curve Cryptography (ECC) is less when compared to that of the RSA algorithm. So, it is a good idea to implement the ECC instead of the RSA in smaller devices like PDA's or cell phones because both are similar. The ECC uses less computational power (B. K., E. D., S. O., 2012).

The elliptic curves in the Elliptic Curve Cryptography (ECC) can be defined by using a small equation and these curves can be defined over any field of numbers. An elliptic curve usually consists of the set of real numbers (x,y) and the equation for the Elliptic Curve Cryptography (ECC) is as follows:

$y2 = x3 + ax + b$

By changing the values of a and b we can change the shape of the elliptic curve and if we make some small changes in the parameters, there will be a huge difference in the set of (x,y) solutions.

TEXT MESSAGE ENCRYPTION AND DECRYPTION BY ECC (Saravanabava, Gandhi , 2013):

Algorithm: elliptic curve encryption Input:

Parameters field of elliptic curve (p, E, P, n), Public key Q, K random integer Plain text m

Output: Cipher text (C1, C2)

Begin

1. Represent the message m as a point M in E (F p)
2. Select $k \in R$ [1,n−1].

3. Compute C1 = k P
4. Compute C2 = M+ k Q.
5. Return (C1, C2)
End

Algorithm: elliptic curve decryption
Input: Parameters field of elliptic curve (p ,E, P, n), Private key d,
Cipher text (C1, C2)
Output: Plain text m
Begin
1. Compute M = C2 − dC1, and m from M.
2. Return (m).
End

The previous algorithm gives the clear picture of encryption and decryption of a text message over an insecure communication.

Strength of ECC:

The Elliptic Curve Cryptography uses smaller keys and operates faster than RSA providing the same level of security. The important thing is that ECC is based on an elliptic curve discrete log problem so that it becomes harder for the middle man or the third party to crack which is harder than the factoring integers. Above all of these advantages, we can say that ECC is more secure than any other public key scheme.

5. Comparison of WSN algorithms

Recent studies (Shukla, Kumari, 2013) show that by using the right selection of algorithms and associated parameters it is feasible to apply public key cryptography to a WSN. The searched public key algorithms include RSA, ECC and diffie-helman key exchange. Data and code size, power consumption and processing time make it difficult for public key algorithm techniques such as the diffie-hellman key exchange to put to use in Wireless Sensor Networks. The advantage of ECC is that it provides equal security for a smaller key size, so it reduces the processing and communication overhead.

ECC with 224 bit key takes 2.19 seconds where as RSA public key operation with 2048 bit key takes 1.94 seconds, while private key operation takes 83.26 seconds. So the RSA private key operations are too slow while ECC is faster which makes ECC preferred for a WSN. In the client/server model, the client initiates the communication and the server responds to the client. It calls by verifying the client signature with the help of RSA or ECC signature algorithms. In this RSA with 1024 bit key, it consumes 304 mj for sign and 11.9 mj for verifying the signature. The ECC with 160 bit key consumes 22.82 mj for sign and 45.09 mj for verifying the signature. For key exchanging between the client and server, RSA consumes 15.4 mj at the client side and 304 mj at the server side. ECC consumes equal energy, 22.3 mj on both ends. So compared with RSA cryptography at the same security level, ECC signatures are significantly cheaper than RSA signatures. Certicom software and hardware solutions (Certicom software and hardware solutions, Founded in 1985), compared the ECC with the RSA algorithm in the matter of encryption key size and the result is displayed in the following table.

The public key algorithm efficiency of a microprocessor is mainly determined by the total number of clock cycles that are needed to perform a multiplication command. Public key algorithms such as RSA are computationally rigorous and usually execute hundreds and thousands of multiplication instructions to perform a single cryptographic operation. Conversely, symmetric key cryptographic algorithms and hash functions utilize much less computational energy when compared to public key

algorithms. The public key algorithms compared here include RSA, diffe-hellman key exchange and Elliptic Curve Cryptography (ECC). (Sastry, Sulthana, Vagdevi, 2013).

The main advantage of ECC is that it offers equal security for a smaller key size, which reduces processing and communication overhead.

6. Conclusions

WSNs suffer from many security threats due to the fact that sensor nodes have limited capabilities. This literature review on wireless sensor networks discuss requirements, threats and the general basic cryptographic key algorithms for WSNs. Wireless Sensor Networks, like any other network system, is susceptible to malicious activity such as hacking or physical attacks. Therefore, with the existence of a sensor network system, it is crucial to couple it with a robust security plan that enables the sensors to communicate and exchange data securely.

6.1 List of Recommendations

Following is a list of possible security recommendations (Table 1).

Table 1: List of recommendations

First	To select the right cryptographic encryption /decryption protocol you should consider comparing between more than one reliable secure routing protocol.
Second	Testing the security protocol in both environments: simulation environments and real-life environments.
Third	Create an access control matrix for all participants in the WSN before starting communications.

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EVALUATION OF INDIVIDUAL STUDENT PERFORMANCE ON A CAPSTONE TEAM PROJECT IN ELECTRICAL ENGINEERING TECHNOLOGY PROGRAM

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Abstract

Teamwork is encouraged in many Engineering Technology senior projects or capstone projects, and each member of the group or team often receives the same grade without evaluating individual student's ability and performance on the project. This paper will discuss how each student on the team is evaluated on a portion of the project through oral presentations and knowledge of material, and how this course also satisfies ABET criterion 3 (d, f, and i).

1. Introduction

Teamwork is encouraged in many Engineering Technology senior projects or capstone projects, and each member of the group or team often receives the same grade without evaluating individual student's ability and performance on the project. When each member of the team receives the same grade, does it mean they all performed the same level of responsibility and participation?

This paper will discuss how each student in a team is evaluated on their knowledge and performance during presentation of the project. Each student in a team of two or three is given equal time (10 minutes) to present a section of the project which is decided by the team members, and the PowerPoint presentation is evaluated by five faculty members from the Electrical Engineering Technology & Engineering Science department.

2. Discussion

Within the Electrical Engineering Technology & Engineering Science department, we have the following programs:

- Electrical Engineering Technology (B. Tech)
- Electrical Engineering Technology (A.A.S)
- Engineering Science (A.S)
- General Technology (AAS)

Final grade evaluation of the senior project is based on the following:

(1) Project Proposal > 5%
(2) Project Research and Design > 15%
(3) Weekly Updates > 5%
(4) PowerPoint Presentation > 25%
(5) Project Demonstration > 25%
(6) Final Project Paper > 25%

Members of the team receive the same grade at each level of the project except for the PowerPoint Presentation.

Evaluation of the project presentation by five team faculty members is based on the following: Communication Skills, PowerPoint Quality, Knowledge of Material, Construction Quality, and Project Demonstration. Project demonstration is evaluated by the five team faculty members where the evaluation is based on project quality, and project performance (Did it work as expected?). All other evaluations of the course including thefinal grade is determined by the course instructor.

This course satisfies ABET Criterion 3 (d, f, i):

(d) An ability to function effectively as a member of a technical team

(f) An ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature

(i) A commitment to quality, timeliness, and continuous improvement

Table 1 is an indicator of individual student performance for PowerPoint presentation base on communication skills, and knowledge of the project.

Table 1 – PowerPoint presentation communication skills evaluated for individual students in a team

	Communication Skills 100%				
Faculty Evaluator	Faculty #1	Faculty #2	Faculty #3	Faculty #4	Faculty #5
Group & Student Number	Grades (Each student in group)				
A/2	98/86	85/80	85/80	90/85	80/78
(B)/1	82	82	70	85	86
C/2	95/90	90/83	88/78	90/87	87/82
D/2	95/83	80/77	95/80	80/76	88/78
E/2	90/92	80/80	85/76	88/80	87/85
F/2	90/85	85/76	90/84	90/87	88/74
G/2	80/87	65/70	70/70	72/80	80/87
H/2	80/76	85/80	75/70	80/75	80/80
I/2	87/89 /90	80/88 /90	82/90 /95	88/89 /87	85/87 /88
(B) Individual student working by himself					

Table 2 is an indicator for each team evaluation for the quality of PowerPoint design.

Table 2 – PowerPoint quality evaluated as a group

	PowerPoint Quality 100%				
Faculty Evaluator	Faculty #1	Faculty #2	Faculty #3	Faculty #4	Faculty #5
Student Groups	Grades				
A	100	80	85	78	80
B	80	85	85	80	80
C	95	85	85	90	85
D	90	65	95	80	88
E	95	75	85	85	90
F	90	80	90	90	90
G	85	70	85	88	86
H	85	85	85	80	80
I	90	85	75	85	90

Table 3 – Project construction quality evaluated as a group

	Construction Quality 100%				
Faculty Evaluator	Faculty #1	Faculty #2	Faculty #3	Faculty #4	Faculty #5
Student Groups					
A	90	90	85	95	80
B	80	90	95	95	90
C	100	85	95	95	90
D	95	70	85	75	88
E	90	65	85	95	85
F	100	85	90	100	90
G	100	70	90	95	80
H	95	80	90	100	80
I	90	70	80	95	85

Table 4 – Project demonstration evaluated as group

	Demonstration 100%				
Faculty Evaluator	Faculty #1	Faculty #2	Faculty #3	Faculty #4	Faculty #5
Student Groups					
A	90	70	80	80	80
B	80	90	90	90	90
C	100	90	95	95	90
D	90	70	90	90	85
E	90	65	90	80	88
F	100	90	90	100	90
G	90	50	85	60	85
H	100	80	90	95	85
I	60	70	75	80	70

Table 5 –Final breakdown of course grades

Student Group	Project proposal graded as a group 5%	Project design and research graded as a group 15%	Monthly updates grades as group 5%	Project Final paper graded as group 25%	PowerPoint presentation individually graded 25%	Project demonstration grades as group 25%
A	5	15	5	20	22/20.4	24
B	5	10	5	20	20	21
C	5	10	5	20	22.5/21	21
D	5	15	5	25	22/20	24
E	5	15	5	20	21.5/20.6	23
F	5	15	5	25	22.2/20.3	23
G	5	15	5	25	18.4/19.7	20
H	5	12	5	25	20/19	20
I	5	15	5	20	21/22/22.5	22

Table 6 – Final grade for each student

	Total Score	Final Grade	Grading Policy
Student Group	%		%
A	91/89.4	B+/B+	95-100 = A 89-94 = B+ 83-88 = B 77-82 = C+ 71-76 = C 65–70 = D+ 59-64 = D
B	81	C+	
C	83.5/82	B/C+	
D	96/94	A/B+	
E	89.5/85.6	B+/B	
F	95.2/93.3	A/B+	
G	88.4/89.7	B+/B+	
H	87/86	B/B	
I	88/89/89.5	B/B+/B+	

There was a significant difference in the final grades of the following groups due to individual student performance on a portion of the project: Group (C), (D), (E), (F), and (I).

Students in group (A), (G), and (H) received the same final grades which show that they were equally involved in their projects, knew the material, and were well prepared for the PowerPoint presentation. Their final scores were approximately the same.

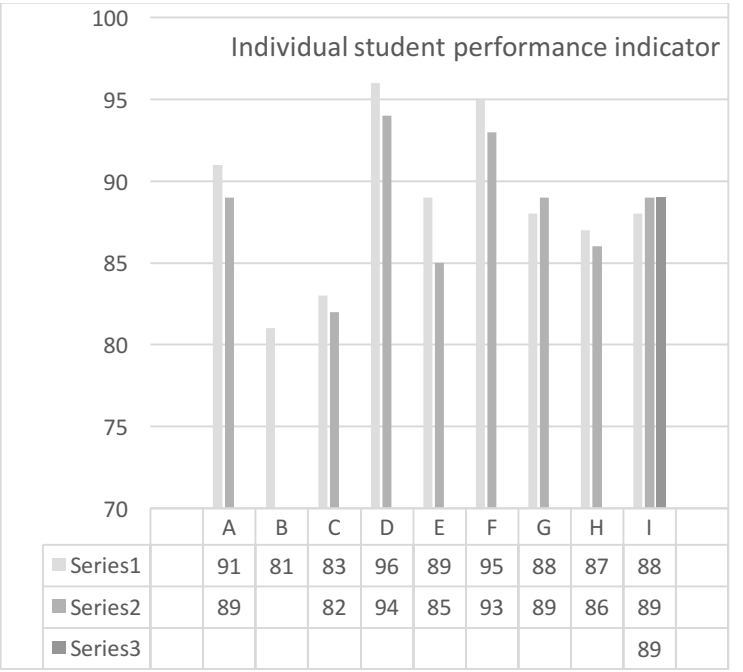
3. Conclusion

This paper has demonstrated that each student in a team project receiving the same final grade does not necessarily determine the knowledge and performance of each student. However, giving each student the opportunity to demonstrate his or her knowledge about the project through a PowerPoint presentation will encourage all students to be fully involved in a team project, and to differentiate final grades among students in a team. This paper also demonstrated how a senior/capstone project can be used to meet ABET student outcomes.

Table 7: How ABET- Criterion are satisfied by this project course

How ABET-Criterion 3(d, f and i) are satisfied by this project course	
d) An ability to function effectively as a member of a technical team;	Individual student is evaluated for the presentation section of the project. As such, all students must be fully involved in all aspects of the project, and share responsibilities.
f) An ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature;	Students conduct research on the project, submit written 10 pages minimum paper, and each student is given 10 minutes to do PowerPoint presentation, and respond to questions and answers.
i)A commitment to quality, timeliness, and continuous improvement;	Students have to complete the project within 14 weeks, and they are evaluated on the quality of the project, and performed continuous improvement at various stages of the project.

Figure 1: Individual Student Performance Indicator



	A	B	C	D	E	F	G	H	I
Series1	91	81	83	96	89	95	88	87	88
Series2	89		82	94	85	93	89	86	89
Series3									89

ONLINE USERNAME PREFERENCES AND SELECTION STRATEGIES

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Abstract

Software today often requires users to create a unique user or account name to access all of the system's features. As the number of software users grow, more usernames are taken making it difficult for users to find an available name. If a username is unavailable, users may add extraneous numbers, letters, or words to their desired name, or they may choose an entirely different name in search of one that is unique. The scarcity of usernames has led to a phenomenon referred to as land rushing. Users will flock to a service when it launches to secure an account name that they were unable to obtain elsewhere. The researchers conducted a survey and message board analysis. The survey findings indicate that it was common practice for users to add extra characters to usernames while seeking a familiar name. The survey findings also suggest that users were more likely to use a service if they could register their preferred username. However, they would not sign up for a service solely to prevent others from using their preferred name. The message board analysis consisted of scraping usernames from two web message boards with different username requirements. The message board analysis suggests that when users could choose any username, names were typically shorter and did not contain numbers when compared to the system that required all usernames to be unique.

1. Introduction

Computer users today are overloaded with the number of logins, specifically usernames and passwords, in which they must recall (Carstens, 2008). Due to the overwhelming number of usernames and passwords, users try to choose similar usernames and passwords for multiple accounts, making the "human factor" the biggest threat to information security (Clark & Carstens, 2016). The present study builds upon Clark's and Carstens' (2016) initial research that explored username trends in single and multiple namespaces.

Users are often required to create a unique username to access all of the features of computer-based systems. While requiring usernames results in a more secure system, it may negatively impact the user's experience. As more users use the software, more usernames are taken and it can become difficult to find an available name. If a username is unavailable, users may add extraneous numbers, letters, or words to their desired name, or they may choose an entirely different name in search of one that is unique.

The scarceness of usernames has led to a trend referred to as land rushing. Users will hurry to a website or application when it opens to obtain an account name that they were unable to acquire on other services. The researchers conducted a survey and message board analysis to understand username preferences and make recommendations for future software design.

2. Literature Review

Organizations can mitigate and minimize security risks by having best practices for passwords which include password syntax, password policy, and overall password security (Walters & Matulich, 2011). Research by Castelluccio (2012) suggests making passwords memorable and strong by including numbers, upper and lower case letters as well as symbols. The passwords strength can be estimated by the time it takes to hack or randomly guess the password.

Passwords are only one part of organizational information security. Systems may require users to memorize usernames as well. To strengthen a credential system further, Florêncio, D., Herley, C., & Coskun (2007) also recommend enforcing username requirements. These extra requirements can reduce usability, however.

Moallem (2004) found user's experience inconsistencies and differences among commercial and public web sites when logging into pages involving usernames and passwords due to the different security requirements of each site.

Facebook allowed users to uniquely identify their accounts with usernames beginning in 2009 (Narayanan, 2009). This created a "land rush" for names. Fifty million users signed up for a username on Facebook within two months of the system launching. A land rush also occurred when Microsoft started a new email service, Outlook.com, in 2012 (Dvorak, 2012). The launch of Outlook.com opened a new set of account names that were previously unavailable on Microsoft's other email domains.

Like Microsoft, Yahoo opened two additional email domains to drive more users to their email service in 2008 (Shankland, 2008). Yahoo even created a waitlist for usernames (Yahoo, n.d.). For $1.99, users can reserve a username in the event it becomes available due to inactivity and deletion.

Usernames are not only used for identification, but they are frequently used in combination with passwords for authentication. When usernames are used as the method of identification and authentication (such as with email services), it can result in a shortage of names. It is possible in some cases, though, to design a system that does not require unique usernames and allows users to share aliases.

In these instances, the username does not uniquely identify a person. Another piece of information such as a phone number or email address can be used in combination with a password to authenticate the user.

Enabling users to choose any name can improve the user experience of a website or application as usernames can be personal. Kokkinakis, et al. (2016) discovered that usernames could be reflective of a person's traits. Rau (2000) also conducted a survey regarding usernames in Taiwan. Fifty-five percent of the survey respondents preferred meaningful usernames with names over randomly chosen usernames.

Crenshaw and Nardi (2007) found that users' preferred usernames that they can change as they age. Gross and Churchill (2007) came to the same conclusion as well as users desire to change their identity as they mature or life events such as marriage occur. These studies suggest that systems should allow users to change their username at will as preferences change over time. The social media website, Twitter, allows users to change their username at any time. While this can create problems in communication continuity, Jain and Kumaraguru (2016) showed that 10% of Twitter users took advantage of this feature over a two-month period.

Usernames can also be used as a means of remaining anonymous. Deggs, Grover, and Kacirek (2010) used web messages to conduct online focus groups. The researchers allowed users to generate their own usernames and passwords, but also implemented name pattern rules to prevent participants from being identifiable via their username.

3. Methodology

The methodology for this study consisted of two research methods. The first method was a voluntary response survey consisting of twenty questions. The survey was sent via email to the Florida Institute of Technology students, faculty, and staff. The survey contained demographic questions and username questions relating to behavior and preferences. The focus of the survey was to determine the respondents experience with usernames on websites and in applications.

Usernames on two web message boards were analyzed in the second part of the research. Username data was collected from the official Diablo III message boards hosted by Blizzard Entertainment and the official Assassin's Creed message boards hosted by Ubisoft. Usernames were scraped from the two message boards from year 2012 through 2015. These two forums were chosen as they represent a similar population (video game players), but the systems use two different methods of handling username registrations. The Diablo III message board employs multiple namespaces and the Assassin's Creed message board uses a single namespace. As such, the Diablo III message boards do not require users to have unique names, and the official Assassin's Creed message board requires all usernames to be unique.

4. Results

4.1 Username Preference Survey

There were 89 complete survey responses. The results are discussed from descriptive statistics and a two proportion Z statistical test was used to determine significance. The significance level was set to 0.05 ($p < .05$). Fifty-five percent of the respondents were female and 45% were male. The age range of the survey respondents can be found in table 1.

Table 1. Age Range of Survey Respondents

Age Range	Count
18-24	34
25-34	24
35-44	10
45-54	10
55-64	10
65-74	1

Eighty-seven percent of the survey respondents use or try to use the same username for every website or application. When their preferred username is taken, typically 72% add numbers or words to make their username unique, 26% try an entirely different username, and 2% give up or quit the registration process.

Even though only 2% *typically* refuse to use an application if their preferred username is taken, 28% of the survey respondents indicated they refused to use an application at least once in the past due to their ideal username being taken. Furthermore, 73% claimed they were more likely to use a website or application if they could use the system with their preferred name. Survey respondents were also asked to rate the degree to which they were more likely to use the system and the result can be found in figure 1.

Figure 1. How much more likely are you to use a website or application if you can use it with your preferred username?

Forgetting a username was common among the users surveyed. Ninety percent of the survey respondents had used the "forgot username" feature on an application. Email addresses on the other hand were more memorable. Only 40% of the respondents forgot which email address they needed to use to sign into an application. Eighty-two percent of the users who completed the survey reported they preferred using their email address to log into a system when given the option between using an email address or a username.

When asked about privacy, 35% of the survey respondents preferred to always be anonymous online. The majority (61%), however, said their privacy concerns vary depending on the website or application. Four percent of the users did not mind being uniquely identified online.

The survey also explored video game players' connection to their username. Sixty-five percent of the survey respondents reported playing a video game within the last week. However, recent video game players were not significantly more likely to use a website or application if they could use their favorite username when compared to people who had not played video games within the last week, $z = 0.32$, $p = .75$. Seventy-four percent of recent video game players and 71% of those who had not played video games in the last week said they were more likely to use a system if they could use their preferred username.

The researchers asked users if they had active Facebook or Twitter accounts. Most (87%) of the respondents said they used Facebook or Twitter. No significant difference was detected between those who used Facebook or Twitter and those who did not use either, $z = 1.13$, $p = .26$. Seventy-four percent (56 of 76) of Facebook, 77% (30 of 39) of Twitter, 69% (9 of 13) of non-Facebook and 70% (35 of 50) of non-Twitter users said they were more likely to use a system if they could use their preferred username.

The survey findings indicate that there is a significant difference among Battle.net and Steam (video game services) users, $z = 3.53$, $p < .001$. The survey respondents that used these services were more likely to employ a different username selection strategy than people who did not use Battle.net or Steam. Fifty percent (14 of 28) of the Battle.net and Steam users said they typically choose a completely different name when their preferred username is taken. However, among other respondents, only 15% (nine of 61) reported using the same strategy.

Another significant difference was found among male and female users, $z = 2.25$, $p = .02$. Females respondents were more likely to use the same name on every website or application. Seventy-eight percent of males and 94% of females reported using the same name everywhere.

Only 10% of users reported registering for a website or application solely to get a username they were unable to get elsewhere or to prevent others from obtaining their desired name.

4.2 Web Message Board Analysis

Username trends were observed on two web message boards: the official Diablo III message boards and the official Assassin's Creed message boards. On average, 1,893 usernames were recorded each year on the Diablo III forum, and 1,136 were recorded each year on the Assassin's Creed forum from 2012 through 2015.

Usernames are used to identify posters on the Diablo III message board. However, an email address

and password are used for logging in and authentication. When users choose a name, a pound sign and a randomly generated number are appended to the name. The pound sign and number are normally only exposed when multiple users with the same name exist on a page. This system allows multiple users to share the same username.

Users log into the Assassin's Creed message board using an email address and password like the Diablo III message board. However, the Assassin's Creed message board requires all users to choose a globally unique username as well. No two users can have the same name on the Assassin's Creed forum.

4.2.1 Average name length:

The average length of the usernames on the Diablo III message boards fluctuated between 7.53 and 7.59 over the four-year period observed. On the Assassin's Creed message board, the average length of the usernames increased each year. In 2012, the average name was 9.36 characters. By 2015, the average username was 10 characters long, shown in Figure 2.

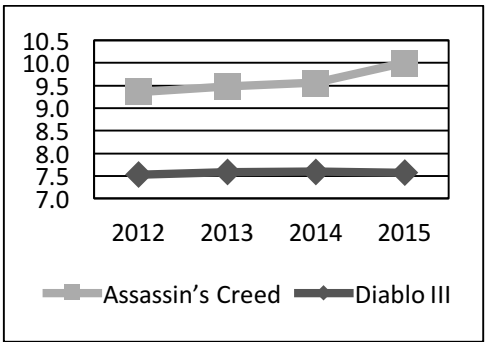

Figure 2. Average length of usernames from 2012 to 2015.

4.2.2 Names containing digits:

The number of names containing digits (0-9) decreased each year on the Diablo III message board. In 2012, 9.27% of the usernames contained digits while in 2015, 7.45% of the usernames contained digits.

The opposite was observed on the Assassin's Creed message board. Each year the number of names containing digits grew on the Assassin's Creed forum. In 2012, 41.25% of the usernames contained digits while in 2015, 44.37% of the usernames contained digits, shown in Figure 3.

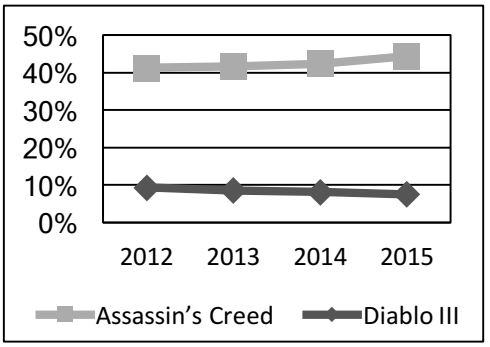

Figure 3. Usernames containing digits from 2012 to 2015.

4.2.3 Number of characters:

The trends in the number of characters (i.e., letters and numbers) between 2012 and 2015 on the two forums can be seen in figure 4 and figure 5. On the Assassin's Creed message board, shorter names become less common as time went on and longer names became more common.

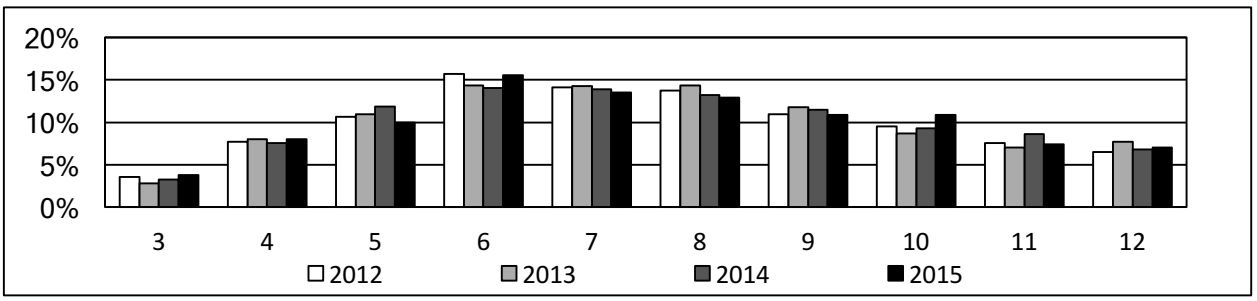

Figure 4. Number of characters in usernames on the Diablo III message board from 2012 to 2015.

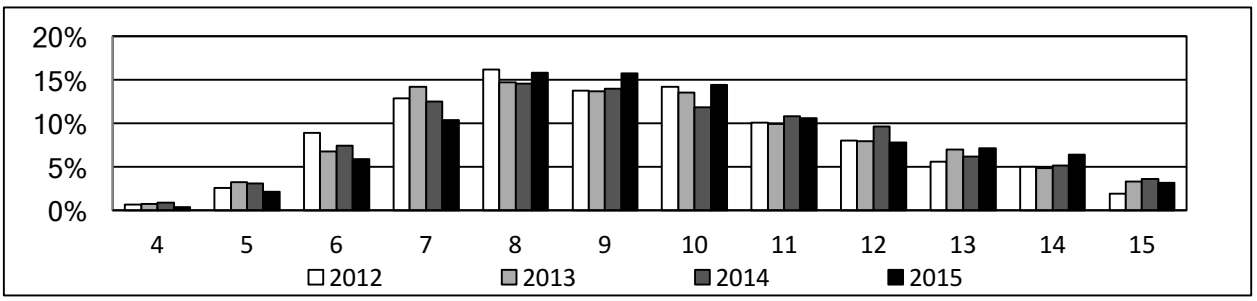

Figure 5. Number of characters in usernames on the Assassin's Creed message board from 2012 to 2015.

5. Discussion

The survey data suggests that most users prefer to remain anonymous online. Yet, perhaps contradictorily, users also reported using or trying to use the same name on every website or application. This behavior could put their privacy at risk as fragments of information could be gathered from multiple sources via their username. The fragmented information could then be combined to create a uniquely identifiable profile of the user.

Since some applications require users to log in with an email address and password and others require users to log in with a username and password, the researchers asked survey respondents if they had ever forgotten their username or email address. Additionally, users were asked which log in method they preferred most. The survey results indicate logging into a system with an email address is the preferred method of authentication even though this may reduce the security of a credential system.

Land rushing was not a common behavior among survey respondents. Few survey respondents said they would sign up for a service solely to prevent others from using their preferred name or to obtain a name they were unable to attain elsewhere. This suggests that a service may need to add other benefits besides enabling users to register a username they could not to obtain on a different service.

The researchers began to identify different username preferences among different user groups (i.e., video game players and social media users). Gamers and users of Twitter and Facebook did not report significantly different behavior compared to other respondents. However, the researchers did find that users of Battle.net and Steam specifically may have adopted different username selection strategies than other users.

Battle.net and Steam are video game services that do not currently require unique usernames. Users may share the same name. Battle.net and Steam users appear to be more likely to choose a completely different username when their preferred name is taken. Other users are more likely to add number or letters to their username.

Trends observed on the Diablo III message boards seem to support the findings of the survey. Diablo III is played through Battle.net and the users on the Diablo III message board contain less numbers than the Assassin's Creed message board, which requires all usernames to be unique.

The number of usernames containing numbers declined every year on the Diablo III message board which may suggest that users may be modifying their name as they learn that they do not need to include numbers to make it unique.

The usernames on the Diablo III message board are also shorter than the Assassin's Creed message board. This, however, could be due to different length requirements as the maximum length is 12 for Diablo III users and 15 for Assassin's Creed users. Still, as time passed on the Assassin's Creed forum, usernames grew longer each year unlike the usernames on the Diablo III forum. The researchers found that when users could choose any username, names were typically shorter and did not contain numbers when compared to the system that required all usernames to be unique.

6. Conclusion

Based on the research findings, recommendations for future software design were identified. The researchers suggest that systems should be designed to allow users to use the same usernames when possible. Users often forget their usernames and prefer to use email addresses when logging into websites and applications. As such, email addresses should be used instead of usernames when logging into a system. Users may also be more likely to use a service if their preferred username can be used to identify them. Nevertheless, providing users with their preferred name alone may not be enough to drive them to use a service. Other benefits may be needed as well.

Observations based on two video game message boards suggest that users may prefer primarily alphabetic usernames. Also, when usernames are scarce, users add numbers to their names and the usernames become longer over time as more users use the system. The observed trends seem to support the findings of the survey conducted where most respondents reported adding extra characters to their username when they are unable to obtain their first-choice username.

In this study, the researchers attempted to identify differences in username preferences among different communities. The researchers did not find any differences among Facebook and Twitter users. The researchers did find that Battle.net and Steam users employ different strategies when registering usernames. Female respondents were also more likely than males to use the same name on various services.

This research addressed the human factor in information security through the examination of user behavior and preferences. Overall, usernames are important to secure and operate a system. However, the use of usernames and the difficulty in users being able to secure their username on online accounts may negatively impact the user experience. With the growing number of usernames being used for creating online accounts, future research is needed to further explore the human factor in information security specifically as it relates to enhancing the user experience.

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USE OF LEAN SIX SIGMA TOOLS TO IMPROVE THE CUSTOMER SATISFACTION AT A CAMPUS DINER: A CASE STUDY

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Abstract

The service quality characteristics of the Towers Café Cafeteria (breakfast, lunch and dinner) were studied using the Six Sigma methodology, to improve customer satisfaction and generate more profits. The diner has several customers however often fails to provide a good service to them, sometimes making its clients frustrated. As one of those customers to the Cafeteria, the initiative was taken to create a Six Sigma project trying to improve one key aspect of the diner that the clients judged as the most inefficient but essential to every restaurant. The data were collected by observing the process and talking to some of the diner's employees. Minitab was used to create some analysis graphs, and Microsoft Excel was utilized to document data and results and to create tables. The project utilized the DMAIC methodology (Define, Measure, Analyze, Improve, and Control) to find the main sources of one major problem and by analyzing it and brainstorming, a new methodology was developed that would solve the organization problem of the diner. Process improvement is achieved by raising the sigma level of the process from 0.9 to 2.1, as it can be observed from the simulation done in the Control Phase.

1. Introduction

The research took place at the Towers Café, a Campus Restaurant at Wayne State University, Detroit, Michigan. Towers Café serves three main meals per day (breakfast, lunch and dinner), opting to serve a more limited menu between those three meals, to up to five hundred customers, mainly students enrolled on the meal plan. The restaurant facility counts with seven different "food stations", each one specialized on serving a specific type of food and therefore, giving different food options for the customers in every meal except breakfast, when most of the stations are usually closed. The students who conducted this study were frequent customers at Towers Café for eight months and evaluated the service provided as poor, but they needed to know if that was a general evaluation. Checking the Google reviews, they concluded that most customers felt the same way about the Diner, since the facility's average is 1.5 out of 5.

With that in mind, the student team decided to start a project at the Towers Café to understand better the desires of the customers, how the poor service was affecting customer satisfaction and also which processes most affected it. The Six Sigma methodology fits perfectly on that kind of situation since it is mainly focused on customer satisfaction and brings results based on data. Also, the team members had already learned about Six Sigma, two of them being certificated as Green Belts, and it is a research area all of the members are interested in.

To start the project the team performed three simultaneous activities, aiming to collect data and map the processes:

- Online Survey to understand exactly how the customers feel about the services provided, quantitatively;
- Observations by the members at the Cafeteria during peak times, for three consecutive days;
- Meeting with the Towers Café supervisor to understand the processes/company better.

2. Background Research

The research started at the spring semester, during a Six Sigma course offered at Wayne State University, in which two of the three students were enrolled. The team had contact with the Six Sigma methodology for the whole semester, and learned how to deal with the main tools used in the DMAIC cycle. A class project was proposed, in which the team conducted a Survey to understand the customers' desires, applied the Kano Model theory to separate the costumers' needs into categories and also mapped the processes and collected data in order to have data driven decision making. Based on that background, the team continued the project during summer semester at Mercer University.

Lean has been marketed as a new organizational change and improvement method, particularly as a cost reduction mechanism (Bicheno, 2004; Achanga, 2006). Similarly, Six Sigma has been promoted as a new organizational change and improvement method (Hoerl *et al*., 2004; Arnheiter and Maleyeff, 2005). The purpose of Six Sigma is to reduce costs by reducing the variability in the processes that leads to decreased defects. Six Sigma is a method to improve process capability and enhance process throughput (Nave, 2002). Six Sigma is also hailed as a method to reduce waste, increase customer satisfaction, and improve financial results (Revere *et al*., 2004). By using statistical methods, organizations are able to understand fluctuations in a process, which will allow them to pinpoint the cause of the problem. Improving the process by eliminating root causes, and controlling the process to make sure defects do not reappear (Pojasek, 2003) should ideally provide long-term benefits to the firm (Bisgaard and Freiesleben, 2004).

Separately, Lean Production and Six Sigma have changed the face of the manufacturing business. Together, they have become an unprecedented tool for improving product and process quality, production efficiency, and across-the-board profitability. Lean Six Sigma introduces you to today's most dynamic program for streamlining the performance of both your production department and your back office, and providing you with the cost reduction and quality improvements you need to stay one step ahead of your competitors (George, 2002).

When multi-billion dollars, Fortune 50 Company implemented its Six Sigma strategy a few years ago, it was optimistic. Sold on the success of General Electric (GE) and others, their leaders simply expected the results to start flowing in, and to some extent they did. They measured their Six Sigma system in terms of "deployment" - how many people they had trained, how many projects they had started, etc. They thought that they were doing really well. And one day, they realized that their "deployment" metrics were missing something; they weren't measuring "efficiency" or "effectiveness" of their Six Sigma system. When they did that, they soon realized (1) how inefficiently and ineffectively they were managing their Six Sigma "process" and (2) how much opportunity there was to make even more money and achieve even greater results. So, they chartered a DMAIC project to "improve the efficiency and effectiveness" of Six Sigma (Starbird, 2002).

3. Methodology: DMAIC

3.1 Define

Surveys are used to obtain the voice of the customer. Surveys create a clear, unbiased, and complete data to get relevant feedback without being difficult for the respondent to complete and return (Six-sigma-material.com, 2016). The Kano model is a framework for categorizing and prioritizing the different performance features of a product or service (Brook, 2014).

To help the Define phase review, a Project Charter (also known as a summary/mandate/project description) is used. It is a one-page document that enables all the stakeholders to review the project and commit to its support.

3.2 Measure

It can be meaningful to present data in a form that visually illustrates the frequency of occurrence of values (Breyfogle III, 2003). Bar charts are a type of graph that are used to display and compare the number, frequency or other measure (e.g. mean) for different discrete categories of data (University of Leicester, 2016).

In order to know how much time it takes to replace the silverware in the cafeteria, several measurements of the time between two consecutive repositions were done. To test the validity of those data, a Probability Plot was utilized.

Process capability is the assessment of how the process delivers what the customer wants. It refers to a range of KPIs (metrics) that measure the ability of a process to deliver the customer's requirements.

3.3 Analyze

Fishbone diagrams are usually used during brainstorming, to identify root causes. However, they can also be used throughout the Analysis phase as a great tool for structuring a team's thoughts (Brook, 2014).

Failure Mode and Effect Analysis can be used during Analyze, Improve or Control, to highlight the aspects of a product or process that should be targeted for improvement (without any failures having actually occurred) (Brook, 2014).

3.4 Improve

The team created a new process map with the new methodology of the operation gradually and to assist on the training of the employees that are not familiar with the improvements proposed (Brussee, 2010).

3.5 Control

To control the improvements suggested, several control plans must be developed to manage the project and the control plans must be implemented (Goh, 2002).

4. Results and Discussions

4.1 Define

Results from the Survey

The survey was conducted with the regular customers of the Cafeteria using the Google Forms platform. The online link to the survey was distributed in the University's group on the website Face book. Then, random customers from the Cafeteria were volunteers to fill the Survey. A total of 128 customers answered the survey. Table 1 shows 30 of 128 answers collected with a Likert scale of 1-5 (1 corresponds to "poor" and 5 corresponds to "excellent"). The data were analyzed in the Measure Phase.

Table 1. 30 of 128 answers collected from survey to cafeteria's customer

How do you evaluate the following Cafeteria services?						How important these services are in a Cafeteria?				
A	**B**	**C**	**D**	**E**	**F**	**A**	**B**	**C**	**D**	**E**
4	3	4	2	5	4	4	5	3	5	5
3	2	4	4	4	3	5	5	2	4	5
2	2	3	4	4	3	4	4	5	4	5
3	2	4	2	3	2	4	5	3	5	4
4	1	3	2	3	2	5	5	3	5	4
2	2	4	2	2	2	4	5	4	5	5
4	2	4	2	3	2	4	4	4	5	5
3	3	3	3	5	2	5	5	4	5	4
3	2	5	3	4	3	5	5	3	2	5
3	3	3	3	4	3	4	5	5	4	5
3	2	4	3	3	2	4	5	3	4	5
1	1	3	2	4	3	5	5	5	5	5
3	2	4	4	3	4	5	5	5	5	4
3	4	4	4	4	2	5	5	3	4	5
3	1	4	4	4	3	5	3	5	5	5
1	2	4	3	4	3	5	5	3	5	5
3	3	4	5	4	4	3	5	3	5	4
3	2	5	2	3	2	4	3	4	4	5
4	2	4	4	4	3	4	5	5	3	5
3	2	4	3	4	3	4	3	3	5	5
4	1	4	2	4	2	5	5	3	5	5
3	2	3	3	5	3	5	5	3	4	5
3	2	4	1	4	2	5	5	5	5	4
3	3	3	3	3	2	5	5	5	3	5
3	2	4	2	4	3	5	5	3	4	5
3	3	3	3	4	2	5	5	5	4	5
3	2	4	2	5	2	5	5	5	5	4
5	1	4	2	5	2	3	4	3	4	5
3	2	4	1	3	2	4	5	4	5	4
3	4	4	3	4	3	5	4	5	5	4

How do you evaluate the following Cafeteria services?
A = Quality; B = Taste; C = Friendly Service; D = Organization; E = Cleanliness; and F = Overall.
How important these services are in a Cafeteria?
A = Quality; B = Taste; C = Friendly Service; D. Organization; and E = Cleanliness.

Kano Model

The Kano Model was created based on the data analyzed on the survey with quantitative answers to the questions, which allowed the calculation of the average and standard deviation of the data generated by the survey and concluded what is really necessary in a business and what is just an attractive need. It shows clearly, what aspects are the most important for a cafeteria to obtain high customer satisfaction. The team classified the aspects Food Taste, Organization (Silverware and Porcelains disposal), Cleanliness (Cleanliness of the Cafeteria and access to restrooms) as the Must Have

Needs of Towers Café Cafeteria. The Kano Model developed by the team is shown in Figure 1.

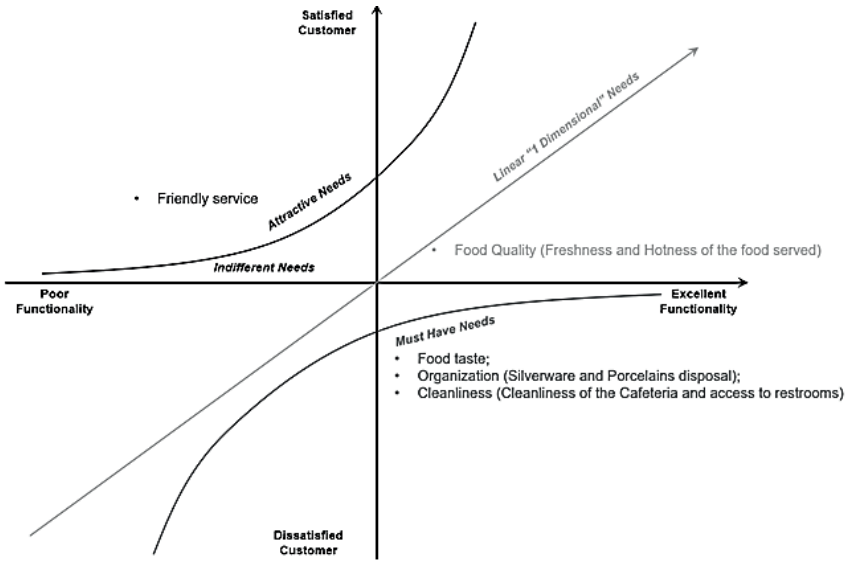

Figure 1. Kano model of Towers Café Cafeteria

Project Charter

The Project Charter developed by the team is shown in Table 2. It contains the Business Case, Problem Statement, Goal Statement, and the Scope of the project.

Cutlery Availability Process

The Cutlery Clearing Process is shown in flowchart in Figure 2. The Process starts with the dirty cutlery in the clearing belt and ends with the reposition of the last replacement station. The process is divided into 3 parts: 1. Cleaning belt; 2. Cleaning Sector; and 3. Cutlery Reposition. Knowing the Process, the Measure Phase is responsible to gather technical information about it, such as time for each part of the process and quantity of cutlery. The flowchart was created by observing the process and talking to some employees.

Table 2. Project charter of the team for applying six sigma in towers cafe cafeteria

Project Charter	
Project Title: Applying Six Sigma in Tower Cafe Cafeteria	
Business Case	**Problem/Opportunity Statement**
The cafeteria is having issues with the overall quality of its services. Customers are unsatisfied with food quality (Taste, Freshness and Hotness) and service provided (Friendly Service, Cleanliness, and Organization). A study through Six Sigma methodology is carried out to overcome the factors that had the lowest rates on survey, which was filled at the month of March with 128 students that eat daily at the cafeteria.	Tower Café Cafeteria has problems with silverware flow and availability. This problem is causing dissatisfaction with the organization of the cafeteria, one key factor in customer satisfaction. By analyzing and improving the organization of silverware, the team seeks to improve the quality of organization in the cafeteria and the customer satisfaction.
Goal Statement	**Scope**
Increase the customer satisfaction of the worst factor to at least 80% which is average customer satisfaction of US.	Improve the disposal and availability of silverware in the cafeteria in order to provide better organization for customers. In Scope Processes: disposal and availability of silverware. Out of Scope Processes: disposal and availability of cups and dishes.

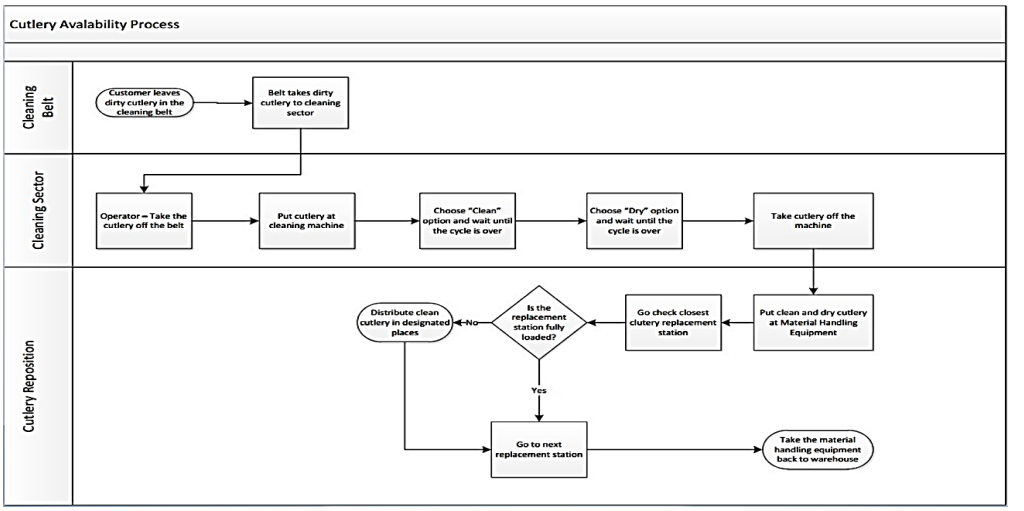

Figure 2. Cutlery availability process in Towers Café Cafeteria

4.2 Measure

Survey's Analysis

Figure 3 shows the overall importance of the Cafeteria services based on the data collected from the Survey. The team calculated the average and the standard deviation of each topic and displayed in a table (Table 3). Comparing Figures 3 and 4, it is seen that the Cafeteria has worst results in Taste and Organization. Since the food management is out of limits for the students, they focused on Organization problems which are also a serious problem. Some observations were taken in the cafeteria during 3 days.

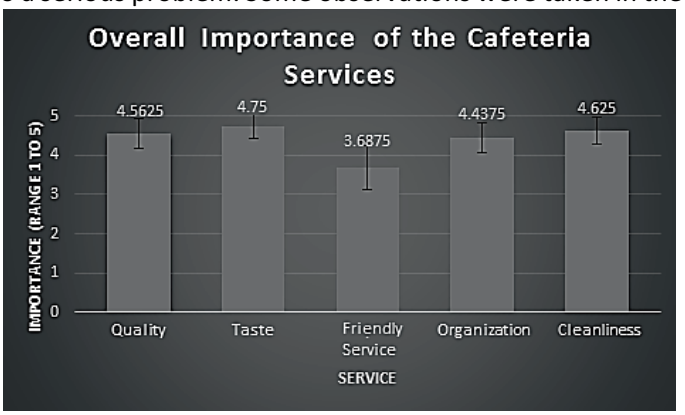

Figure 3. Overall importance of the cafeteria services

Table 3. Average and standard deviation of results from the survey

Topic	Overall Importance of the Cafeteria Services	Overall Evaluation of the Cafeteria Services
Quality	4.56 ± 0.30	3.06 ± 0.45
Taste	4.75 ± 0.28	2.12 ± 0.39
Friendly Service	3.69 ± 0.46	3.81 ± 0.32
Organization	4.44 ± 0.43	2.75 ± 0.54
Cleanliness	4.62 ± 0.24	3.69 ± 0.38
Overall	---	2.69 ±0.34

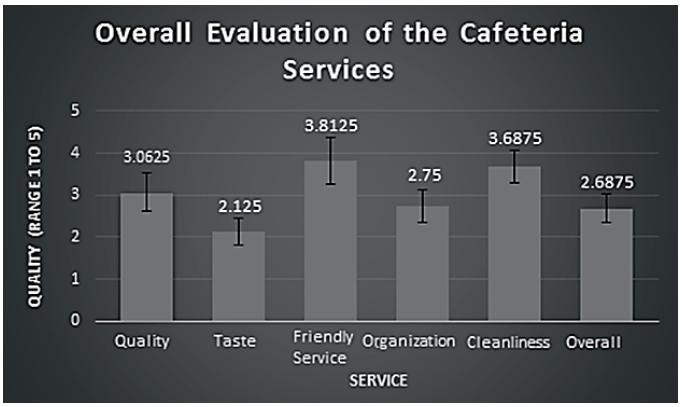

Figure 4. Overall evaluation of the cafeteria services

Table 4 shows the number and average of silverware utilized in those periods, and it is seen the average number of silverware represented in a column chart in Figure 5. In Figure 5, it is seen that the highest demand is in lunch time. Also, the number of each type of silverware carried were the same on the reposition method but one can observe that the spoons are not a problem for the Cafeteria just by watching its low daily use, the spoons would not produce a high number of defects in the method and that's why the team is more focused on forks and knives.

Table 4. Number of silverwares used by customers in 3 different meals during 3 days (20 min duration)

NUMBER OF SILVERWARE USED BY CUSTOMERS				
Day	**Meal**	**FORKS**	**KNIVES**	**SPOONS**
1	Breakfast	27	27	6
1	Lunch	44	44	6
1	Dinner	37	37	4
2	Breakfast	24	24	5
2	Lunch	42	42	4
2	Dinner	34	34	5
3	Breakfast	25	25	5
3	Lunch	45	45	4
3	Dinner	36	36	4
BREAKFAST AVERAGE		**25.33**	**25.33**	**5.33**
LUNCH AVERAGE		**43.67**	**43.67**	**4.67**
DINNER AVERAGE		**35.67**	**35.67**	**4.33**

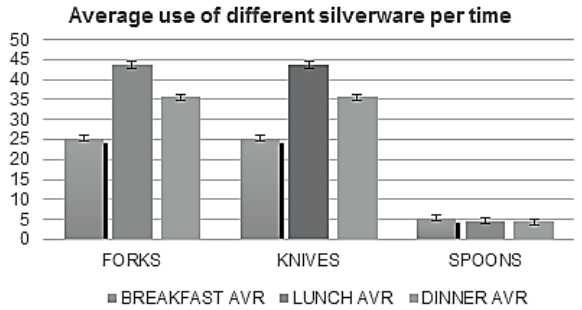

Figure 5. Average use of different silverware during 3 different meal times (20 min duration)

Reposition Time

Usually the researcher rejects the assumption of normality if P < 0.05 (Pyzdek and Keller, 2014). The Normality Test for reposition time (Figure 6) achieved a P-value of 0.864, a value much higher than 0.05. The test fails to reject the assumption of normality and the mean reposition time is 93.6.

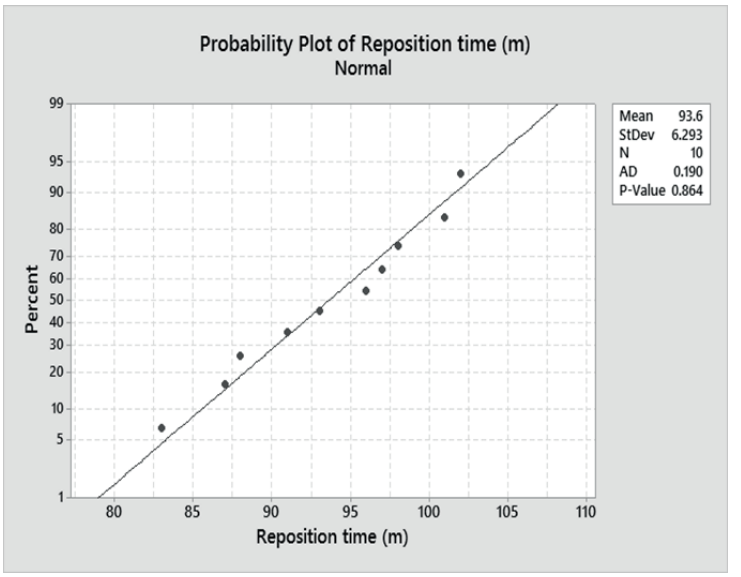

Figure 6. Normality test (P-Value: 0.864)

Process Capability

The C_{pk} values are obtained from http://www.six-sigma-material.com. On the process capability test (Figure 7), the time taken to reposition the silverware (Table 5) is utilized and the minimum and maximum time limit to this process to happen without generating defects are noted. One can observe that the process has a large variability problem, it is not within the limits, what generates defects and it has C_p and C_{pk} is very low (0.34; 0.30) and the sigma level of 0.9.

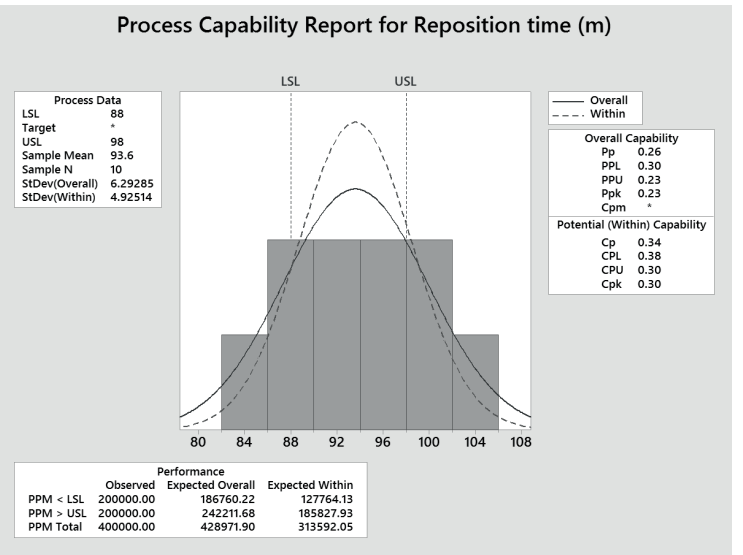

Figure 7. Process capability test (C_p: 0.34; C_{pk}: 0.30)

Table 5. Reposition time data collected in the cafeteria

n	Reposition time (min)
1	83.1
2	87.0
3	87.5
4	91.1
5	93.2
6	96.1
7	97.1
8	98.3
9	101.2
10	102.1

4.3 Analyze

Fishbone Diagram

A fishbone diagram (Figure 8) was created to understand every problem that could be generating problems in all stations that lead to customer dissatisfaction. The team brainstormed several possible causes to the defects and focusing on cutlery availability, it was noticed that the main aspects that cause more defects are the method efficiency and staff availability and the other aspects are not relevant to this project because it seems to work well.

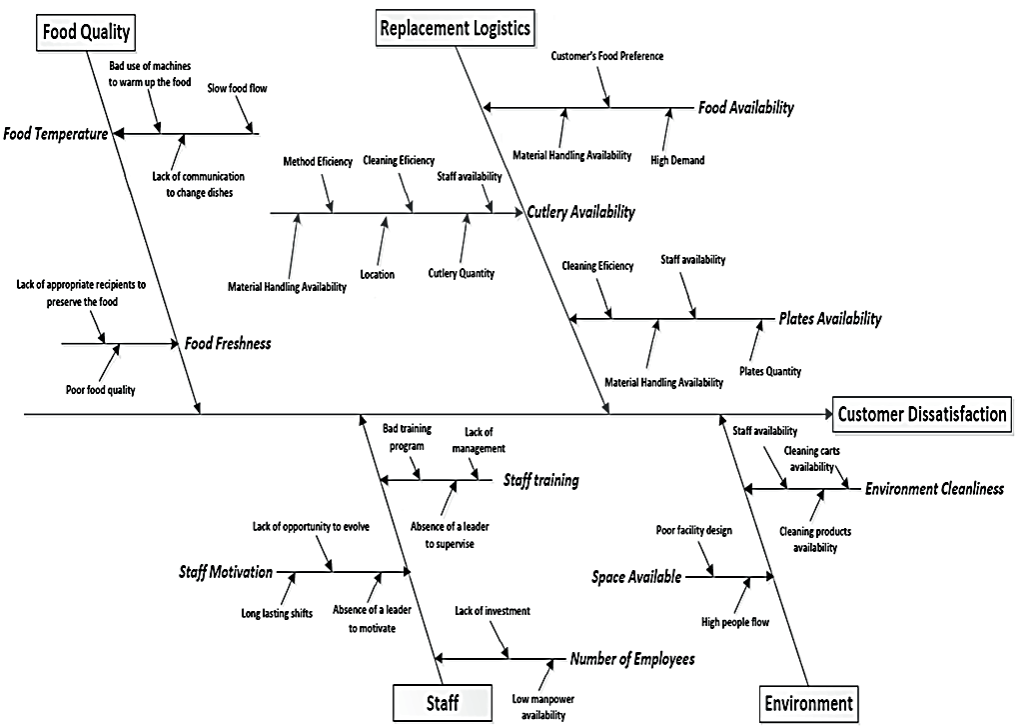

Figure 8. Fishbone diagram of towers cafe cafeteria

FMEA

At this stage of the project, the team was already focused on the cutlery availability problem. To understand how the operation happens, a FMEA was created and the team tried to identify what part of the process was not efficient and crucial at the same time so it could be improved. Observing Table 6, the FMEA showed that the first, second and third process functions are the ones that have the highest Risk Priority Number (RPN), which means that those actions influence a lot in the efficiency of the whole process if they are not working perfectly.

Table 6. Failure mode and effect analysis of the cutlery availability process

Process Function	Potential Failure Modes	Potential Failure Effects (Y's)	SEV	Class	Potential Causes of Failure (X's)	OCC	Current Process Controls	DET	RPN	Recommend Actions	Responsible Person & Target Date	Taken Action	SEV	OCC	DET	RPN
Take the cutlery off the belt	No cutlery on the belt	Delay on the cutlery's replacement	7	P	Broken Machine	6	Detection after Failure	4	168	Fix the belt	Dishes' responsible	Use the loading cart to get the dirty dishes	3	6	3	54
Put cutlery at cleaning machine	Cleaning machine is not working	Delay on the cutlery's replacement	9	P	Broken Machine	3	Detection after Failure	3	81	Fix the cleaning machine	Dishes' responsible or supervisor must call for maintance	Wash by hands; at least 2 employees will be required	4	5	3	60
Choose "Clean" Option and wait until the cycle is over	Cleaning machine is not working	Delay on the cutlery's replacement	9	P	Broken Machine	3	Detection after Failure	3	81		Dishes' responsible or supervisor must call for maintance	Wash by hands; at least 1 employee will be required	4	5	3	60
Choose "Dry" option and wait until the cycle is over	Cleaning machine is not working	Cutlery wet	7	P	Broken Machine	3	Detection after Failure	2	42				3	5	3	45
Put clean and dry cutlery at Material Handling Equipment	No Material Handling available	Delay on the cutlery's replacement	5	C	Missing material handling	2	SPC	3	30	Check if the material availability is enough	Supervisor	Transport the cutlery by hands	2	5	2	20
Go check closest clutery replacement station	Not an optimized replacement	Delay in replacement	3	C	Lack of employee organization	4	SPC	2	24	Instruct employees	Supervisor	Employees followed the Supervisor's instructions	1	1	3	3
Distribute clean cutlery in designated places	Distribute in any place	Poor organization	5	C	Lack of employee organization	2	SPC	2	20				2	1	2	4
Go to next replacement station	Don't go to next station	Poor organization	4	C	Lack of employee organization	2	SPC	2	16				2	1	2	4
Take the material handling equipment back to warehouse	Not taking the material handling back to warehouse	Delay the next replaement and poor organization	6	C	Lack of employee organization	2	SPC	2	24				3	1	2	6

4.4 Improve

Redesign of the Cutlery Availability Process Map (Figure 9) and Standardization of the Process:

1. Will bring two new inspection steps, in order to guarantee that someone will be responsible for making sure that there is clean cutlery available to replace the dirty ones and that there is no replacement stations with empty cutlery carriers.
2. The “cutlery distinguishing” steps of the process will now take place at the cleaning belt and will be performed by the customer, instead of in the replacement stations like it was before. That will reduce total time and bring a better time usage for the company’s employees.
3. Standardization of the process and better definition of the role played by each of the employees.
4. Will bring less variation to the process, when both C_p and C_{pk} values increase.

Besides redesigning the Process Map, the team will suggest and develop improvements discussed in the control phase.

New Cutlery Availability Process

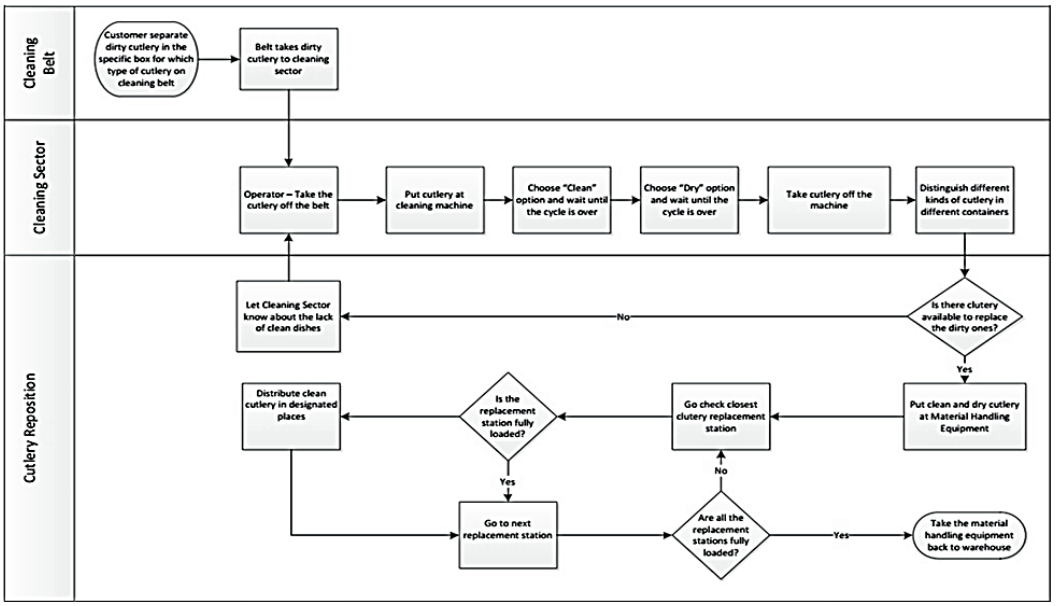

Figure 9. Suggested cutlery availability process

4.5 Control

Process Capability Report (Figure 10)

During the Control Phase, the team seeks to make sure that the recommendations developed in the Improvement Phase will be applied to the company's processes. With that in mind, the team will develop the following:

1. Work instructions for all the employees involved on the Cutlery Availability Process, in order to make sure that they have a guide to perform the job perfectly.
2. Print and attach the Redesigned Process Map to the work station's walls, specifically in the Cleaning Sector and Cleaning Belt areas;
3. Development of Maintenance Plan for both the cleaning belt and the dishwasher, in order to reduce the frequency in which machines break.

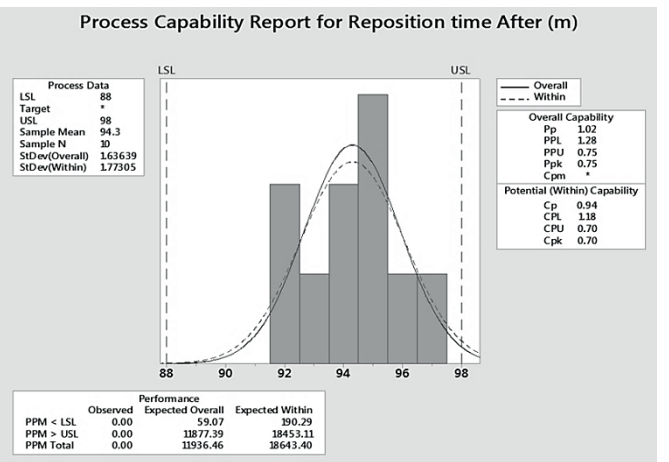

Figure 10. Process capability report for reposition time after (min)

4. Development of basic trainings, focusing on standardizing the process and documenting

results.

5. Time control collection to make sure that the operation is working as simulated previously.

As the methodology was not implanted, the team realized a simulation considering the new methodology to check if the methodology improved the process. One can observe that C_p and C_{pk} values increased to 0.94 and 0.70. The process is not capable yet, however, the sigma level improved from 0.9 to 2.1 which is a good sigma level for a campus diner.

5. Conclusions and Recommendations

The project's main objective, since its beginning, is to increase the customer's satisfaction of Towers Café by analyzing, and if necessary, changing the processes of the company using Six Sigma Tools and, most important, the DMAIC improvement cycle. In order to achieve that, the team performed both a survey with the customers, and the company's Kano Model, to understand the needs of the customers and quantitatively analyze the data. The team concluded, with those that the organization was the main problem, according to the customers. Using the diverse Six Sigma tools showed above, such as Ishikawa Diagram and Process Mapping, the team could see that the Silverware Disposition was not working accordingly, which is a huge problem for the company, since that is a "Must Have" requirement according to the Kano Model.

Following the DMAIC cycle and using its tools, the team could understand the process as well as find changes and recommendations to make the "Cutlery Disposal Process" more efficient and fulfill the "Must Have Requirement", Organization – Silverware Disposal. The recommendations are listed below:

- Redesign of the Cutlery Availability Process Map and Standardization of the Process.
- Development of Maintenance Plan for both the cleaning belt and the dishwasher, in order to reduce the frequency in which machines break.
- Development of documents and basic trainings, focusing on standardizing the process and documenting results.

After implementing the recommendations listed, it is suggested that Towers Café performs a new Survey, similar to the previous one, to see how the customers react to the changes and instruct the manager to observe how the changes impact both the customers and the employees.

6. Acknowledgments

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MANAGING A MULTI-CULTURAL WORKFORCE

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Abstract

This paper will examine the many factors that come into play when managing a multi-cultural workforce. The first thing that will be discussed is a brief introduction as to how our workplace is changing and how diversity must be included in our modern workforce. The next topic will explore the importance of workplace diversity, and then going into the benefits and challenges managers have to face with workforce diversity. After going over these topics, we will discuss the manager's role in maintaining a diverse workforce, and then further explore modern companies that have effective diversity management practices. To conclude the paper, we will discuss the future of diversity in the workplace and wrap up everything else that has been mentioned in the paper.

1. Introduction

Diversity in the workplace has been an increasing demand among our planet's top employers since the 1970s, and it is only going to keep increasing as our world starts to globalize more and more each year. These companies as well as many others know that keeping a diverse workforce is very important due to the increase in diverse populations and the increase of globalization. As we move forward in time we see that all kinds of different people are moving to different countries, this is probably the most profound in America. In addition to this the number of employees that have to travel for work outside of their home country is increasing. Other factors that come into play with workplace diversity include immigration, racism, sexism, and the acceptance of cultural differences (Cox, Taylor and Blake, 1991). Aside from these there are really an endless amount of things that affect a diverse workforce. Top companies realize the importance of keeping their workplace diversified, and as such it has given bosses and managers the task of how to effectively manage it. The strategies used by different businesses to manage this will be discussed later in the paper. Businesses in today's world must recognize the role of diversity in the workplace if they are to thrive as a company.

2. Importance of Workplace Diversity

The importance of a diversified workforce is greater now than it ever has been in the past. More and more companies today are branching out internationally, and this requires people of different cultures/ethnic backgrounds to work with each other to accomplish the many tasks a multinational business will face. When you are a manager of such a team, there are certain things that you must look out for in your staff. Some of the major things include learning about the cultures of your staff, looking for dismay among them, and developing sensitivity to the certain cultures you are not accustomed to. This is very crucial when managing a diverse workforce because there are so many differences between all of the cultures that are out there. It is also key to remember that no one culture is better than the other, only different. According to Vincent Seglior, who was the World Trade Institute's director of international training for over 10 years, it isn't as difficult as it may seem, you just have to take a little bit of time to learn about your employee's background and how to make them feel the most comfortable

in the workplace. “It’s a give and take, you’ll find out about their culture and they’ll discover more about ours,” he says (The Guardian, 2016).

The most important aspect of managing a diverse workforce and recruiting employees of different cultures is the expansion of business. As the staff becomes more diversified, so do your customers. This specific reason explains why having a multi-cultural staff is so important in today’s economy/workforce. If a company branches out to hiring people from all around the globe they have increased their chances of hiring the best possible candidate for the job. By having a group of employees that come from a multitude of backgrounds, you have allowed your company to branch out to an entire new breed of customers. Employees who come from the same background as their customers gives the customer a feeling that they have something in common with the company. It also tells the customer that your company cares about all kinds of people and shows no prejudice towards any group of people. The modern marketplace is super competitive and it is only going to become more competitive. Which is why many of today’s top corporations have implemented a diversity policy and require their employees to know it. Having a workplace where each individual feels comfortable gives the employees more motivation and will make them want to stick with that company. This also gives the company a whole new set of perspectives that can be put to use when working with people from a different region of the world. The value of diversity in the workplace has drastically increased over the past 30 years, so the importance of keeping diverse employees in your company is crucial for your success.

In addition to a diverse workforce leading to the expansion of business, there are several other factors that demonstrate the importance of having a diversified workforce. For example, companies with a diversified workforce tend to experience more organizational productivity than other companies who aren’t as diverse. By having a large group of people with different skillsets and different specializations a company will see improvement and more creativity in being more productive. Studies also show that these companies are better organized than other companies who are not as diverse (Cox, Taylor and Blake, 1991). Another key role in the diverse workplace is the increase in hiring the most talented person for the company. Access to a larger number of individuals to hire is a huge advantage for a company to have. As well as this, employees who work for diversified companies typically feel like they are valued as an employee. This is also a huge benefactor to a company because it makes the employee feel like they are worth something and that their actions directly impact the company. There are so many important aspects to maintaining a diverse workforce in today’s business world. As we globalize more and more each year with our increase in technology, it only makes sense that people of all kinds will have to work together in order to get things done.

2.1 Benefits of a Diverse Workplace

As previously discussed, a company’s success in the modern world can be determined as to how well it embraces diversity and sees the benefits it has to offer. Diversity in business is only going to get bigger and bigger, so it is important for businesses to value diversity. Just a few of the potential benefits a diverse workplace have already been mentioned, such as organizational productivity and employee value. However these are just some of the positive effects of a diverse workforce, there is still much more diversity can do for a company/business. When a company implements a solution for workplace diversity, they will experience a very wide range of benefits affecting everyone in the company for the better.

An organization that employs a wide variety of people of different ethnicities are able to bring forth a broad range of solutions to any problem that might come up within the company. Some of these problems may include improving service, reducing costs, and the allocation of resources (Rice, 2016). Some companies actually hire people of different races/ethnic backgrounds for this reason alone. When working with a group of people all from different backgrounds everyone has something to bring to the

table, this is because all of the employees have had different life experiences which has shaped the way they view the world. This multitude of perspectives is something that can take an organization to the next level, leading to innovation and ingenuity within it.

Moreover, another more obvious benefit of being a diversified company is having a larger range of service. Employing people from different backgrounds who know their country's language and understand their culture allows the company to branch out to a whole new breed of customers. The customer will likely then choose that company over its competitor because they will feel that the company cares about them and values their business. Reaching out to new customers when running a business is very important, many of today's top corporations like Apple, Verizon, and Samsung have made diversity an utmost priority for this reason. Companies that are this big in size would not have been able to branch out to other countries without having diverse employees (*Black Enterprise, 2001)*.

Probably the most crucial benefit of workplace diversity is the increase in productivity. Many companies that choose to invest a broader diverse workforce see itself pay off in the end by showing an increase in productivity (Bourne, 2016). This is a direct result of cooperation among employees, and a willingness to work together in order to effectively solve problems within the business. In a diverse company employees tend to be satisfied with their role in the company and thus are much more motivated to work harder and get along with their colleagues. A company with this asset has a massive advantage from its competitors, because they will attract the most talented people in their profession. Efficient productivity and having a staff who all get along with each other are two very important aspects of running a business, but is more important when managing large workforces of different backgrounds. This can be quite challenging for some managers to handle, which leads us to discuss the challenges associated in a diverse workforce.

2.2 Challenges of a Diverse Workplace

Despite the numerous advantages of having a diverse workplace, establishing a diverse staff that gets along with each other does not come easily. The manager of the staff must implement an effective strategy to accomplish this. Diversity includes respect for any person and respecting the differences among them. These differences can be race, ethnicity, gender, age, religious practices, sexual orientation, and many more (Ryan, 2016). With all of these differences among people in a workplace it is only logical that not everyone is going to get along with each other.

Communication among employees can be a challenge among workers in a diverse environment. Language and cultural differences must be overcome in order for the organization to thrive. In order to overcome this employees must be willing to take some time to learn about different cultures that their coworkers may practice. Additionally workers will not be encouraged to work as hard when they cannot effectively communicate with their colleagues. Poor communication in a company leads to low employee morale, inefficient teamwork, and confusion among workers (Ryan, 2016). Whenever this happens in a company they will see a decrease in productivity and dissatisfaction in their workers.

In addition to poor communication among workers, a resistance among employees to change is also a challenge in managing a diverse workforce (Ryan, 2016). If someone has worked for a certain company for over twenty years and they start to see a drastic change of pace in the company, they might be a little hard-headed about it and not be willing to change with the company. There are always going to be people that will not accept the fact that the diversity of their workplace is changing. These people typically have the attitude that things within the company have been done this way for so long so nothing should have to change.

Moreover, similar to employees resisting to change with the company, certain employees may hold certain prejudices towards some kinds of people. There is no doubt that racism is still an issue in our time and that managers in top companies with a diverse workplace must implement an effective

strategy to prevent this from occurring. Employees who hold prejudices towards others usually don't last too long in a multicultural workforce, but those that are willing to change can last longer in the company and change the way they view people of different backgrounds for the better. In order to accomplish this the manager has to do something to allow the employee to change (Ryan, 2016). Certain strategies can be holding seminars on diversity, meeting with employees and discussing whatever issue they may have, and (if the employee succeeds) rewarding them for their willingness and accomplishment of changing their view on certain cultures and backgrounds.

By far the most challenging aspect in managing a diverse workplace is assuring successful management within the organization. Diversity training is just not enough to assure success in the company's plan in diversity management (Rice, 2016). Something that a manager can do to ensure the success of diversity management is to assess the diversity of the workplace. Many international companies today have made this a top priority in their management system. One way to assess the effectiveness of diversity among employees is to have the employees complete an employee satisfaction survey. This will tell the manager how happy each employee is within the company and they will see if a worker has any problems within the company. Another strategy that managers can use to implement diversity in the workplace is to include every possible employee in the decision of diversity policies in the company. When a manager does this they have allowed themselves to get a very broad set of ideas from people in the company, this will provide the company with the best set of feedback and will enable the company to put in the most effective diversity policies that will keep everyone happy. Managers are given a difficult task with accomplishing this, so it is important that they reach out to each individual employee in order to maximize their results.

3. How to Manage a Multi-Cultural Workforce

We have already discussed the importance, benefits, and challenges with managing a diverse business, but how do managers effectively accomplish establishing a diverse workplace? Some examples have already been given like assessing the diversity of the workplace and reaching out to each individual employee to see how they are doing with their job, but there is still much more to cover in managing a multi-cultural workforce.

The first step in managing diversity is to recognize that all people have differences, whether they are physical, mental, generational, or cultural (Cox, Taylor and Blake, 1991). All people are going to have differences and that is something that we have to deal with in our modern workplace, let alone our lives. When managing a diverse staff it is crucial to let your employees know that they shouldn't be afraid to show their differences and let their individuality shine in the workplace. Also as a manager, you should ask your employees of a different culture than your own about their mannerisms, what's offensive to them, what holidays do they celebrate, and anything else worth discussing. A manager that takes the time to talk to their employees about how they feel and what they would like to see in the future shows the employee that the company cares about them and values their work. This will encourage the employee to work harder for the company, a factor that plays into increasing the productivity of the organization. Without recognizing the differences among your workers, you will never be able to move forward in managing your workforce (Revzani, 2016).

As well as recognizing the differences among your workers, managing a diverse workforce requires treating your employees with an equal amount of respect. If you show favoritism towards one type of person than the next, your employees will eventually start to catch on and they won't respect you as much. This will lead to a decrease in employee morale and in productivity, no one is going to want to work for a boss that shows prejudice towards a group of people. It is very important that you treat your employees fairly, another aspect that is important to remember is to realize the holidays that different employees may celebrate, and to give them the appropriate time off if they would like it. This is why it is

key to talk to your employees about their feelings in the workplace, and make accommodations for them as such (Bourne, 2016).

Additionally, you the manager must also look and observe your own behavior when it comes to diversity in your establishment. For example, say you are conducting a job interview, and someone of a different ethnicity comes in, it is of utmost importance that you do not make any assumptions about that person and judge them like you would any other applicant. You must also be aware of your behavior when conducting an interview, pay attention to your tone and the way you ask questions. It's also important that you respond appropriately to the different types of communication that you will face in an interview. Giving your employees respect and paying attention to your own mannerisms are key in progressing an organizations diversity.

After you, the manager, have gotten to know your employees relatively well and know the cultures and backgrounds that they come from, the manager must now establish a good strategy for the employees to learn about their coworkers as you have. When employees learn about the different backgrounds of their coworkers they will most likely get along better with them and work better as a team (*Black Enterprise, 2001)*.. One good strategy to allow the employees to do this is to encourage them to work in diverse groups. This will allow the workers to get to know each other a little better and learn about the different backgrounds that they come from. Working in diverse groups lets the employees see the value in one another and can change their perspective on solving problems as they play off of the strengths and weaknesses of others. Working in diverse groups presents a great image for the company and shows that the organization not only tolerates diversity, but also encourages it.

4. Real Companies and Their Strategies for Management

As already discussed, today's top corporations have to make diversity a top priority if their business is going to succeed. Our world is becoming more and more globalized each year and is changing the way everyone looks at our world. Global diversity is increasing at a rapid rate, and the number of companies who are wishing to expand their business internationally is also increasing. Therefore, it is very important that they firmly establish diversity policies and effective methods of managing it within their organization. The companies that will be examined are Ernst & Young, Verizon, and Apple. These companies have been renowned internationally for decades and provide a great model for other companies looking to be more diversified.

4.1 Ernst & Young

Ernst & Young (abbreviated EY) is a multi-professional services firm located in London, United Kingdom. The firm has history all the way back to the mid-1800s, and it is considered one of the 'big four' auditing firms, ranked number three behind PwC and Deloitte (*Black Enterprise, 2001)*. The firm has locations in every continent expect Antarctica, so as one could imagine diversity management is crucial in the success of their business.

EY was the first company of its kind to make workplace diversity a priority. In 1994 they established the Office of Minority Recruiting and Retention, an organization that would oversee the recruitment of individuals that are minorities. In addition to establishing this organization, the firm has had very strong bonds between different African-American organizations such as the National Black MBA Association, National Society of Black Engineers, and the National Association of Black Accountants. The firm has always targeted African-Americans from a recruiting standpoint, and they provide professional services to many African-American owned business (*Black Enterprise, 2001)*.

Diversity is fundamental to how EY does business. With so many locations around the world and long-lasting relationships with different ethnic organizations, it makes sense as to how EY is one of the

top companies in its game. Diversity management, effective communication, and a high rate of productivity are the primary reasons for the success of EY. You can reference figure 1.1 to view EY's employment diversity.

Figure 1.1 EY Employee Diversity

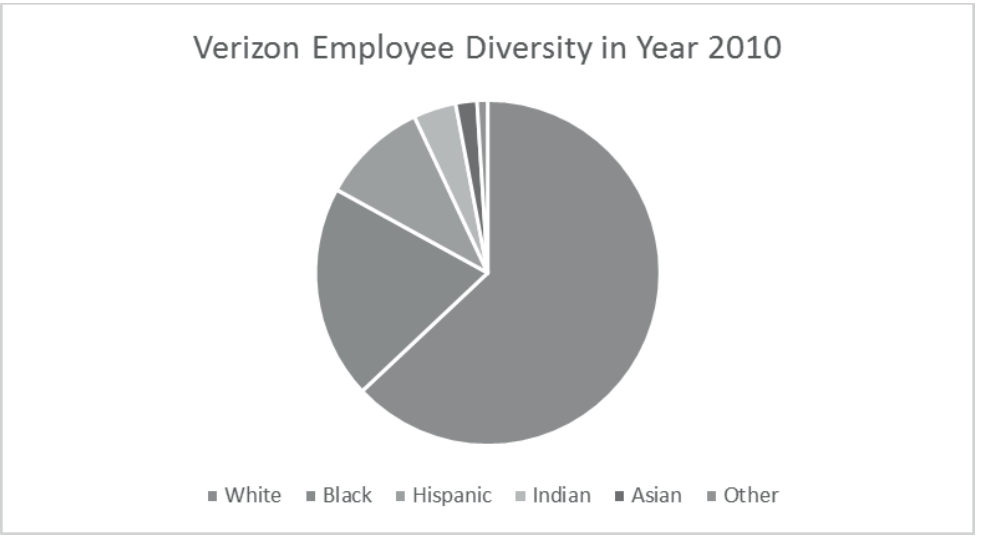
Race/Year	White	Black	Hispanic	Indian	Other
2010	120,500	55,800	25,800	28,220	19,680
2011	119,300	56,430	24,500	27,070	18,200
2012	118,900	56,930	25,150	27,590	18,970
2014	119,400	57,120	25,670	27,710	19,600

4.2 Verizon

Verizon is currently the largest telecommunications company in the world. According to modern data, Verizon employs over 300,000 people and brings in an average revenue of $125 billion per year (The Guardian, 2016). The company has always believed that diversity has played a huge role in their success. They have always been committed to hiring the best individuals for the job, and similar to Ernst & Young they've branched out their services across the globe. Being a company that employs this many people, diversity management has been a huge part of their business for decades.

Verizon's immensely large customer base requires a large and diversified workforce. Employees traveling to different countries must know the culture and at least some of the language before they travel there. Additionally the company realizes that they need to hire people who can effectively communicate with people from different cultures. The company needs employees that can speak multiples languages and act appropriately in societies that are different from their own. This is important to Verizon because they need to properly maintain customer relations with a lot of various companies in different parts of the world. Verizon likes to present a very good image and employees that can really connect with their customers is key to have in their line of business. Verizon manages their workplace diversity by connecting different kinds of people to other kinds of people across the world. Verizon also supports several diverse employee resource groups. This has been an effective strategy for them, and years of working with various ethnic groups for decades Verizon has made a name for itself when it comes to workplace diversity. View figure 1.2 for Verizon's employment diversity.

Figure 1.2: Verizon Employee Diversity in Year 2010



Especially in today's world where we have been able to connect our entire planet through computers and telephones, Verizon has a huge market for customers, and being a worldwide company makes including people of all kinds a must. On Verizon's website they make a statement that everyone can benefit from accepting diversity. Some facts about diversity in Verizon's workforce include that 7 of their 13 board directors are women or people of color, and they have spent over $25 billion dollars on working with diverse companies since 2011 (*Black Enterprise, 2001)*. Verizon continues to be the best telecommunications company in the world, and their excellence in diversity management made their success possible.

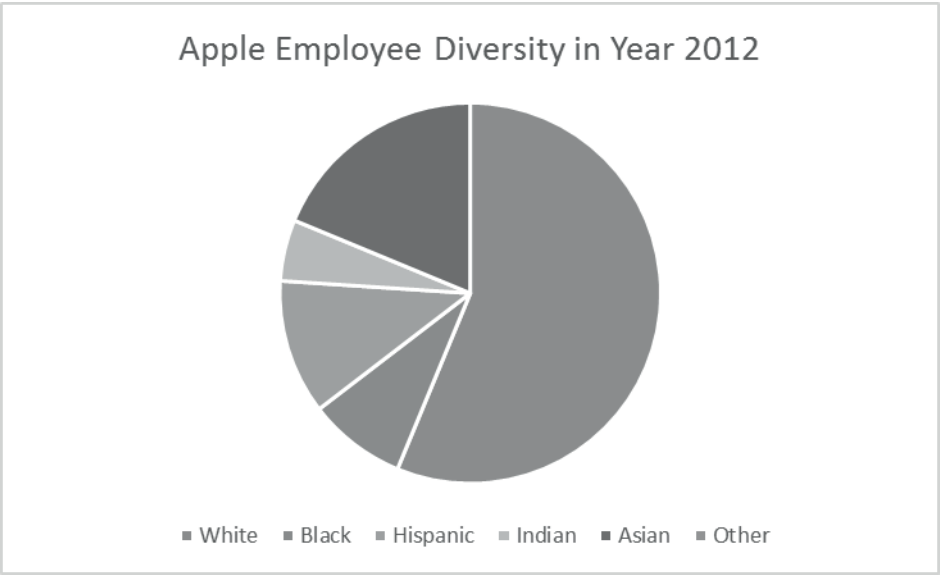
4.3 Apple

Apple is the most innovative and diverse company to date. They employ roughly 160,000 people and they earned a revenue of $215.6 billion in their last fiscal year. With numbers like that there workforce has to be very productive and work together to solve business problems that may occur. Apple's diverse workforce has led to many technological breakthroughs in various different areas. Apple products affect billions of people every day in so many different areas in the world that it would have been literally impossible for Apple to get where it is today without having diversity in their workplace (The Guardian, 2016).

Apple backs up there claim of being the most diverse company. On their website they claim that "the most innovative company must be the most diverse". In addition they state that they take a view of diversity that goes beyond that of other companies. Apple's view on diversity is one that includes the different perspectives people have to offer from every aspect of the company. With the amount of capital Apple deals with, it is important that every employee is competent enough to behave in areas unfamiliar to them. Apple holds diversity seminars that teach their employees the proper etiquette of diversity and gives them a basic background of some of the major countries Apple is involved in, such as China, United Kingdom, and the United States. Apple also efficiently manages diversity with the placement of diversity policies for every employee and holding high employee morale throughout the workplace. Apple workers are very well trained with their products and are excellent at providing service with all kinds of people.

What really stands out about Apples statement of diversity is they include real life workers who have made great breakthroughs using technology and have brought their talents to Apple. One of these workers is Divya Nag, a young Indian women. Divya founded two very successful medical companies before she was twenty years old. She then took her talents to Apple to start exploring how their products could give personal healthcare and improve research. She and the rest of her team developed an app called CareKit that allows medical patients to view their records and keep track of their symptoms. Another one of these workers is Edith Arnold, with a PhD is neuromuscular biomechanics she is an expert in the movement of the human body. She is also a mechanical engineer, which gives her the talent of accomplishing many things with technology. Her most recent accomplishment was the development of sensors in the Apple Watch that measure how many calories a person has burned when exercising. When a company tells personal stories like these it presents the company with a very good image. This reaches out to customers of all kinds which has really played a role in Apple's success (The Guardian, 2016). View figure 1.3 for Apple's employment diversity.

Figure 1.3: Apply Employee Diversity in Year 2012



5. The Future of Workplace Diversity

There is no question that the future of workplace diversity is going to have to be part of a business that wishes to thrive internationally. More and more companies are implementing diversity policies and are trying to include all kinds of people from different racial backgrounds in their organization. Globalization is definitely one of the major reasons that workplace diversity has become a hot buzz issue among major businesses. As our world becomes more and more interconnected each individual human feels more legitimate. When this happens people start to become happier and when they are happy at their company they will want to work harder. So one strategy businesses will want to keep for the future is making sure their employees feel good about their job.

In addition to globalization being a factor in the future of workplace diversity, another thing businesses are starting to do is associate diversity with innovation. More and more companies are coming to the realization that the more variety of people you have working for your company the better chance you have of creating a breakthrough in something. A lot of big modern corporations have directors and presidents for diversity. For example, in America the Corporation of Public Broadcasting employs a Senior Vice President for Diversity and Innovation. Many other companies have hired people for similar positions. Such as Genentech's Senior President for Innovation, Diversity & Inclusion (Revzani, 2016).

The biggest change that diversity has undergone is that the term itself has changed. It's not just about race, gender, or sexual orientation anymore. Corporations today are experimenting with a concept known as diversity of thought. In a nutshell, it is basically measuring the way a person goes about solving problems and the way they think about things. The primary companies that are experimenting with this are technology companies. This is because in our world technology is progressing at an astronomically quick rate, and requires many different talented individuals who think in a different way. The future of workplace diversity lies in the hands in the modern employers for large corporations. They will set the stone for how companies will manage workplace diversity in the future (Revzani, 2016).

6. Conclusion

In conclusion, managing a multi-cultural workforce is a growing demand in today's workplace. So many companies have branched out internationally with the use of technology to market their product, and the numbers are only increasing. More and more companies are realizing the importance of diversity in their work environment and are making it an increasing priority as we move forward in time. Diversity in the workplace has never been more important as it is now, we have been globalizing quicker and quicker each year, and large businesses will have to learn to how to effectively manage diversity in order to be successful as a company.

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*Data for charts and graphs taken from google

EFFICIENT JUNIOR SOFTWARE DEVELOPERS USE EVOLUTIONARY COMPUTATION

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Abstract

We investigate the cost- and time-efficient use of evolutionary computation (EC) in software engineering; in particular, its use in developing the optimization module of software systems. Using two example problems we analyzed the software solutions created by upper-level computer science majors (typically juniors and seniors) and by recent computer science graduates during upper-level undergraduate computer science classes, during independent research classes, and during internships. The main result of our study is that software developers with limited development experience have a higher rate of success when they pick a (metaheuristic) evolutionary algorithm approach to solve the problem, rather than picking more traditional approaches such as e.g., backtracking, integer linear programming, or a bipartite matching algorithm based on algorithms for the network flow problem. Also, often the development time was shortened when an evolutionary algorithm was used.

1. Introduction

Many proponents of evolutionary computation argue that it can find solutions to certain problems where other algorithms fail. Or, they argue that an evolutionary computation approach is more efficient than other traditional methods for certain problems. We will take a different perspective here to argue in favor of evolutionary computation. This paper argues that, for certain problems, it is easier to train software developers to implement solutions using evolutionary computation. Furthermore, the solutions produced with evolutionary computation are more likely to be correct, the risk of failure is smaller when evolutionary computation is used wisely for certain problems, and the development time is often shorter than when traditional approaches are used.

We investigate the cost- and time-efficient use of evolutionary computation in software engineering; in particular, its use in developing the optimization module of software systems.

Our hypothesis is that the concept of evolution, which is central to the metaheuristic technique of evolutionary computation (see the next section for a more detailed introduction), is relatively easy to understand; with very little training it is possible to model a problem in such a way that the design of the envisioned software system follows the concept of evolutionary computation, and furthermore such a design is relatively easy to implement. A similar claim has been stated previously as "[evolutionary computation] has a clear advantage in marketing the technology to potential users. The scientific principles are easy to explain to almost any audience" (Kordon 2006, p.6.)

In this prior work, Kordon emphasizes the competitive advantages of evolutionary computation in industry: "We have shown that the models generated by [evolutionary computation] are a low-cost alternative to both high fidelity models and expensive hardware analyzers" (Kordon 2006, p.4). Among the specific advantages are ease of modeling, and low total cost of development, deployment and maintenance. It is concluded that "[evolutionary computation] created significant value [...] by improving the manufacturing process and accelerating product discovery."

There are numerous pieces of prior work that describe how evolutionary computation is used for specific software engineering subtasks. Catal conducts a systematic literature review to investigate the effectiveness of genetic algorithms for test case prioritization (Catal, 2012.) Successes in automated software repair using evolutionary computation have been reported (Forrest et al., 2009; Weimer et al., 2010.)

But to this point no studies seem to exist that specifically answer the question whether using evolutionary computation for the optimization module of a program could be cheaper to develop, or faster to develop, or whether by using evolutionary computation it could be cheaper to train the software developers. In this paper, we take the first steps towards answering this question.

2. Evolutionary Computation

Evolutionary Computation encompasses methods of simulating evolution on a computer (Bäck 2000, p.xxv.) Subsets of the field are known under the names of evolution strategies, evolutionary programming, and genetic algorithms. While there are differences in detail, all evolutionary algorithms mimic the Darwinian evolution process. For example, genetic algorithms (Holland, 1975; Goldberg, 1989) tend to make more copies of individuals (fixed-length character strings), which exhibit higher fitness, as measured by a suitable fitness function. Over time individuals in the population evolve because of natural selection and because genetic operations (mutation, recombination) modify individuals. After the random generation of an initial population, evolutionary algorithms enter an evaluation - selection - alteration - cycle until the termination criterion (e.g., maximum number of generations, perfect individual sighted, etc.) is satisfied. Evolutionary algorithms are a robust search technique and they are widely used in optimization (Goldberg, 1989; Liu, 2011.)

3. Methods

Our study is based on the software implementations of two example problems, one an academic one, one a real-world problem: (1) Find the solution to a Sudoku puzzle and (2) find the optimal assignment of students to classes under certain load and preference constraints.

For both of these problems there exist traditional solution methods that in theory are superior to the evolutionary computation approach: e.g. a backtracking solution for the Sudoku puzzle, and e.g. a polynomial-time bipartite matching approach based on a network-flow algorithm for the optimal assignment problem.

We analyzed software products created by undergraduate students (upper-level computer science majors classified as juniors and seniors) and by recent (less than one year since graduation) computer science graduates. The software solutions were created during upper-level undergraduate computer science classes, during independent research classes, and during internships. All software developers of this study were trained in an object-oriented high-level programming language for at least one year, in a 14-week course (42 contact hours) in data structures and algorithms, and in a 14-week course (42 contact hours) in evolutionary computation. (Some students started solving the two sample problems as early as seven weeks into the evolutionary computation class.) To the best of our knowledge none of the developers had received any specific training in college-level biology. All developers were mentored by a chief developer, who gave milestones to achieve, but would not help with implementation specific details or provide source code.

4. Problem 1: Sudoku

This well-known problem consists of a 9x9 square grid, which is subdivided into nine 3x3 squares grids. The solution of a Sudoku puzzle fills the complete 9x9 grid with values from the set {1,2,...,9} such that each row, column, and 3x3 grid contain each of the numbers {1,2,...,9} exactly once. In its initial state the instance of a Sudoku problem contains a certain amount of fixed numbers (called "givens") on the grid. A puzzle is considered well-posed if there is a unique solution that respects the givens. We chose problem instances from newspapers that had between 27 and 32 givens as test cases to evaluate the software products (see Fig.1 for an example.)

8			4		6			7
						4		
	1					6	5	
5		9		3		7	8	
				7				
	4	8		2		1		3
	5	2					9	
		1						
3			9		2			5

Figure 1. A Sudoku Puzzle

The software product is rated as success, if the following conditions are met: (1) Correctness: the computed solution solves the Sudoku puzzle. (2) Runtime efficiency: the solution can be computed within 48 hours on a personal computer with average specifications.

The typical traditional, most efficient approach to solve this problem is by a variation of backtracking. To solve this problem by evolutionary computation, one popular way is to use a genetic algorithm that encodes a solution candidate by an array of integers of length 81, representing all the integers of the 9x9 grid (Mantere, 2007.)

5. Problem 2: Assignment of Students to Classes

In this real-world problem the task is to assign *n* students into *m* classes such that the students' preferences are respected as much as possible. Every student is assigned to exactly one class. Every student can express up to *p* (unordered) preferences for classes. Because of classroom constraints and faculty load concerns, there is the hard constraint that class sizes can differ by at most one. Furthermore, there is the soft constraint that the gender ratio in a class should reflect the gender ratio of the total student pool. The goal of this optimization problem is to maximize the number of students getting into one of their *p* preferred classes. (As a real-world problem, slightly suboptimal results were deemed fine.)

Table 1 shows an abbreviated sample input set for *n=500, m=25,* and *p=5*. These are typical parameters for the problem instances used as test cases.

Table 1. Sample input to assignment problem

ID	Sex	Pref1	Pref2	Pref3	Pref4	Pref5	
1	M	12	23	4	21	15	
2	F	3	11	7	17	19	
3	F	18	24	19	3	4	
4	M	25	18	22	5	24	
...							
499	M	1	3	24	21	4	
500	F	12	23	8	3	13	

Table 2 shows a sample output for the above instance in the last column (labeled "Ass."), which indicates which student was assigned into what class. Due to the constraints, in this case it was not possible to assign the student with ID 3 into one of her preferred classes. It is these types of "disappointing" assignments that we want to minimize.

Table 2. Sample output of assignment problem

ID	Sex	Pr1	Pr2	Pr3	Pr4	Pr5	*Ass.*
1	M	12	23	4	21	15	*23*
2	F	3	11	7	17	19	*7*
3	F	18	24	19	3	4	***14***
4	M	25	18	22	5	24	*25*
...							
499	M	1	3	24	21	4	*4*
500	F	12	23	8	3	13	*23*

The software product is rated a success, if the following conditions are met: (1) Correctness: the computed solution found a number of students getting into one of their preferred classes that lies within 1% of the theoretically achievable maximum. (2) Runtime efficiency: the solution can be computed within 48 hours on a personal computer with average specifications.

One traditional way to solve this problem is by using a modified bipartite matching algorithm, which takes into consideration the various constraints. To solve this problem by evolutionary computation, one way is to use a genetic algorithm that encodes a solution candidate by an array of length *n*, representing the classes assigned to each of the *n* students.

Note that it is a considerable challenge to solve this problem correctly; naive greedy heuristics such as filling up the least preferred class first lead to very poor, suboptimal results.

6. Results and Analysis

We stay away from the measure of an individual developer's productivity in lines of code per day, since we are dealing with software modules that deal with complex algorithmic problems that we try to solve; the focus is on quality, accuracy, and correctness, not on quantity, which might be more useful for other software components.

Basic ways to measure progress such as Budgeted Cost of Work (BCW) are difficult to estimate when we hunt for traditional algorithmic solutions in the literature – maybe a solution does not even exist, or is difficult to understand and implement. For the same reason estimating function points for function point analysis is challenging, because it is difficult to estimate the effort needed to develop the most

difficult modules.

In our following results we measure actual effort in programmer-days or hours. We provide a qualitative assessment of estimated completion date versus actual completion date and indicate when a project was completed late. We define the quality of the software as whether it does what it is supposed to do: correctness and low error rates are key.

We evaluated a total of 19 software products. The results are shown in Table 3.

Since at this point we have a rather small sample size both in terms of number of developers and number of problems to be solved we provide only a brief qualitative analysis of the 19 data points here. The evolutionary computation approach always resulted in a successful, or at least partially successful outcome. (We declare a "partial success" when the approach met the correctness requirements on some, but not all test runs; or when the efficiency requirements are met on some, but not all test runs.) The success rate when solving a problem with a traditional algorithm was 11%. This is in contrast to the 80% success rate obtained by evolutionary computation (where the remaining 20% still were rated "partially successful".)

Using the traditional approach, the time spent until success: was N/A for Sudoku (all failures), and 300 man hours for the Assignment Problem. Using evolutionary computation, the time spent until success was 73.3 man hours for Sudoku, and only 34.4 man hours for the Assignment Problem.

Table 3. Results

Developer ID	**Problem ID**	**Traditional Approaches**	**Evolutionary Computation Approach**
d01	Sudoku	*failure*; did not have the background to comprehend backtracking literature, did not make a serious attempt	*success* after 80 man hours; project completed late
d02	Sudoku	*failure*; unsuccessfully attempted backtracking approach (solution looked correct theoretically, but too inefficient, the run did not terminate within 48 hours)	*success* after 60 man hours
d03	Sudoku	*failure*; did not attempt; lack of understanding of specific variations of backtracking approach	*success* after 80 man hours; the difficult problem instance took ten times longer to solve than the easier ones; project completed late
d07	Sudoku	*failure* after 5 man hours*;* tried to model the problem as an integer linear program, but did not have adequate operations research skills and gave up	*partial success* after 50 man hours, could solve easier problem instances, but timed out on harder problem instances
d04	Assign	*success* after 300 man hours; required extensive literature review, casted the problem as a bipartite matching problem by using an adaptation of the network flow algorithm; project completed late	*success* after 24 man hours

d05	Assign	*failure* after 20 man hours; attempted to solve by modeling as an integer linear program (ILP), but was unable to arrive at a correct set of constraints	*success* after 40 man hours
d06	Assign	*failure* after 30 man hours; the ILP model attempted was not elegant, required a very large amount of binary decision variables, which was too many for the solver module in its standard configuration	*success* after 48 man hours
d07	Assign	[no data available]	*success* after 20 man hours; but solution was 1% off the theoretical global optimum
d08	Assign	*failure* after 5 man hours, did not have the background to understand network flow algorithm literature	*success* after 40 man hours
d09	Assign	*failure* after 50 man hours, unable to debug bipartite matching algorithm due to overly complex data structure used for implementation	*partial success after 40 man hours*, genetic operator used was rather unsuitable, but genetic algorithm sometimes got "lucky" and found solutions despite this.

7. Future Research

We plan to expand this study by increasing both the number of observed software developers and by adding additional problems to be solved, so that we have additional data points for statistical analysis. To increase confidence that our results generalize to a variety of problems we have and will pick types of problems that are not obvious textbook candidates for evolutionary computation, but problems for which there exists a traditional solution method that in theory is superior to the evolutionary computation approach.

8. Conclusion

One of the main results of our study is that software developers with limited development experience (defined as practitioners having less than four years of programming experience, or new computer science graduates with a bachelor's degree) have a higher rate of success when they pick a (metaheuristic) evolutionary algorithm approach to solve the problem, rather than picking more traditional approaches such as e.g., backtracking, integer linear programming, or a bipartite matching algorithm based on algorithms for the network flow problem. Also, often the development time was shortened when an evolutionary algorithm was used.

Therefore, if the development resources are constrained in terms of time or amount of experience of the developers, the use of a metaheuristic approach such as evolutionary computation frequently turns out to be the preferable solution in practice. This is particularly true when a near-optimal solution "close enough" to the optimal solution of a real-world problem is sufficient.

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MODELING AND SIMULATION OF A COFFEE SHOP TO IMPROVE CUSTOMER SERVICE QUALITY

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Abstract

In this paper, how to plan and approach a simulation study for a small business and how to do it using proper mathematical models and software tools have been presented and discussed. A simulation model was developed using the system characteristics of a coffee shop such as employee's schedules, business hours, and available resources. The system was simulated through data collection, modified to other possible scenarios, such as the decrease of one employee, two registers, and those modifications combined. Data were analyzed using the theory of queues, and programs such as Excel, Input Analyzer and Arena. Based on the analysis of the simulation results, it can be concluded that two registers is the best scenario for the current arrival and service pattern of the coffee shop for minimizing the waiting time of the customers in the queue.

1. Introduction

The study is on a small business coffee shop located in the downtown of the city of Macon, GA. The research objective is to find the most appropriate way to use the coffee shop resources so that it benefits the owner and customers.

The data collected from the coffee shop is analyzed using the Queuing Theory and probability laws to predict the behavior of a system. The programs used to create the system simulation were Microsoft Excel, Arena Simulation Software and one of its tools called Input Analyzer. Microsoft Excel was used for the data collection at the establishment and the data analysis; Input Analyzer generated the probability distributions; and the Arena Simulation Software was used to create the realistic simulation model and create other possible scenarios for the system.

To create a simulation, despite all collected data, the characteristics of the establishment need to be known, such as the working hours, number of employees, and schedules. The coffee shop is open from Monday through Saturday between 7:00AM and 10:00PM and count with 115 available sits, including balcony sits, sofas, regular tables and a meeting room, which is a place where people can call and schedule a time to have conferences. The coffee shop has art paintings available for the customers to appreciate or buy.

There are two work shifts: the first is from 6:30AM to 2:30PM and the second is from 2:30PM to 11:00PM. During the first shift, one manager and three baristas work and on the second shift, one manager and two baristas work. They start and finish their shifts earlier or later than the local business hours because they need to prepare the area for the customers and leave everything clean at the end of the day. All employees have the right of two breaks of fifteen minutes and one lunch break of thirty minutes per shift, however only one employee can be on a break at a given time. A barista earns US$ 8.25 per hour plus tips and a manager earns US$ 10.25 per hour plus tips.

Based on all parameters obtained about the coffee shop during the search, the realistic model of the system was simulated. The model shows the system information, such as average number of customers during a week, how many of them ask for just drink, just food, or both, average waiting time in the queue, and average number of people in the queue. After this process, the model was manipulated to observe the differences that some modifications can cause in the results, and to compare which scenario is the best option for the coffee shop.

2. Background Research

There are more than 50,000 coffee shops in the US. According to Statista (2015), that number will jump by about 5,000 within two years. In order to build a solid business, in this case a coffee shop, people should follow four major concepts. According to Lisa Furgison (2014) the first one is related to planning that includes creating a solid business plan. This document spells out exactly what the business is, how it will be profitable, defines the customer base, explores competitors, plans for growth, and provides strategies that should be done for achieving the goals. Andrea Testi (2015) explains that the first step to determine what business growth means, more customers, more sales revenue, more profitability, more employees or some combination of them.

The second step is associated with funding. To find startup funds for a coffee shop cannot be easy. Marc Renson, owner of Ambition Bistro in Schenectady, New York (2015) suggests talking with friends and family about investing in your coffee shop first. An idea is to show the solid business plan for them as an attempt to receive their investments. If that is not possible other options can be found, a bank loan is an example. In addition, any business including a coffee shop spends at least 6 months to become profitable, so save money for your own expenses is needed.

The third concept is marketing. The theme is the image of the business owners, they need to network to maintain a connection to the area, and how to attract more customers if they can. Some examples are to join the local chamber of commerce, as a business association and charity. Also, start marketing before opening the business.

According to Lisa Furgison (2014) managing is the last and not least important concept to achieve an ideal coffee shop. Owners need help manning the register, waiting on customers, and making drinks, but don't hire too many people too fast. Sometimes owners have to change employees who are hurting the business for other ones more qualified to set higher standards for the business.

A coffee shop is seen as a general business that cannot survive without management because management is what supports it. According to Chandra Bose (2012) management is defined as acquiring the maximum prosperity with minimum possible efforts. This project is included in this part of the process in building a successful coffee shop.

According to Carter McNamara (2003) a business is basically a group of different activities and management has an important role in improving the quality and efficiency of these activities. These improvements depend on studies and techniques the management conducts such as reducing the waiting time of the customers in the queue and improving the quality of the products offered to the customers.

The Investopedia Website (2011) says that this can be a mathematical method of analyzing the congestions and delays of waiting in line. In addition, queuing theory examines every component of waiting in line to be served, including the arrival process, service process, number of servers and the number of customers in line, which might be anything and not just people. In addition, Arnold Allen (1997) stated that queues involve waiting, to be sure, but, one's attitudes toward queues may be influenced by other factors.

This project has a real simulation of a coffee shop that uses applications of the queuing theory. According to the Investopedia Website (2011), the theory can provide faster customer service, improve

traffic flow, ship orders efficiently from a warehouse and design telecommunications systems, and other important information about the processes.

The central theme of this project is to create simulation models, using an Arena Simulation Tool. According to the Arena Simulation Website (2015), this software can be used to analyze the performance of systems and show important data used to improve the processes in the coffee shop that have been the base of studies for the project. Also, according to Rossetti (2010) and Kelton et al (2015) Arena is used as the vehicle for explaining important simulation concepts.

The Arena Simulation Website (2015) explains how the simulation model is developed and presented through the use of animation, showing a sequence performed of waiting in line in different parts of the process. Additional details on simulation modeling and analysis and discrete event system simulation are respectively discussed by Law (2015) and Banks et al (2013).

Riley et al (2016) determined customer frequencies, interarrival times, service times, and other variables that allow for development of an accurate representative simulation of a restaurant in Tallahassee, Florida using ProModel software. Acquah et al (2015) used Minitab statistical analysis software to analyze the data from both Starbucks and Dunkin' Donuts and obtained probability distributions and descriptive statistics. The results were then used to create simulations of the queuing process using Arena Simulation Software to reduce the waiting time of the customers in the queue. Also, Das et al (2015) presented a case study explaining how to brew a sustainable Starbucks blend for Indian market.

3. Methodology

First, a spreadsheet was created to facilitate the data collection, which was made during 2 mornings approximately for three and a half hours each (between 8:30AM and 12:00PM). The following information were noted: time between client arrivals, order time, what was ordered (beverage, food or both), pick-up time, if the client used the self-service station, if the client ordered to go or dine-in, if the client reordered, and leave time. Based on this information, the following information were obtained: intervals between arrivals, time between arrival and order, time between order and pick-up, time between pick-up and leave from those who dine-in, time between pick-up and leave from those who ordered to go, time between arrival and leave from those with no order, the order percentages, self-service station percentages, and reorder percentages.

Besides the data collected in those two visits at the coffee shop, other data available from a previous research done in the same place was used, that resulted in a more realistic distribution. Some data are distributed around a mean value according to a statistical distribution. These statistics are generally related to the time variable, which is the focus of the work.

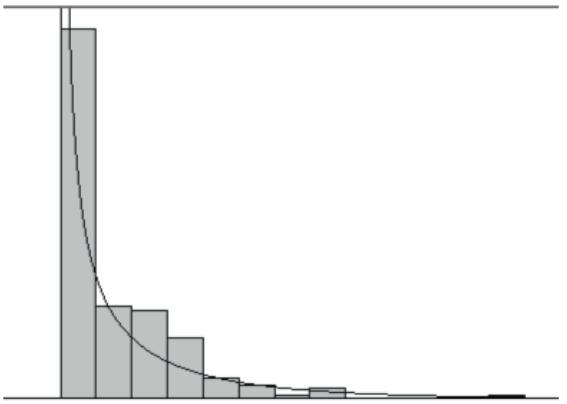
After obtaining the necessary information of the coffee shop, like for example, time between customer arrivals, the data were introduced into the Input Analyzer to determine the best function that adjusts and to get statistical distributions/expressions to use in the ARENA software.

To choose the best distribution statistics, the P-Value of each case was observed. The Input Analyzer program shows two types of P-Value, which are made through two different tests. The first one is the Chi-Square test, which is the sum of the squared difference between observed and the expected data, divided by the expected data in all possible categories. In this test the results tend to be null, which states that there is no significant difference between the expected and observed result. The other is the Kolmogorov-Smirnov Test, which tries to determine if two datasets differ significantly. The authors decided to use the second test, where the P-Value should be less than or equal to 5%.

Another important coefficient that was observed is the Square Error. The Square Error is a mathematical optimization technique that seeks to find the best fit for a set of data trying to minimize the sum of squares of differences between the estimated and the observed data. It consists of an

estimator that minimizes the sum of squares of residuals of the regression in order to maximize the degree of model fit to the observed data.

The first set of data that was analyzed is the inter-arrival time of costumers. The gamma distribution was chosen for this case, because the model results indicated better P-Values in both tests, and the Square Error was good too, as can be seen in Figure 1. The same process was made in all the collected set of data, always choosing the best P-Value and the smaller Square Error.



```
       Distribution Summary

Distribution:   Gamma
Expression:     -0.001 + GAMM(12.8, 0.338)
Square Error:   0.015873

Chi Square Test
  Number of intervals   = 5
  Degrees of freedom    = 2
  Test Statistic        = 21.6
  Corresponding p-value < 0.005

Kolmogorov-Smirnov Test
  Test Statistic        = 0.175
  Corresponding p-value < 0.01
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Figure 1. Time between arrivals distribution

After finding the statistical expressions, the simulation model was created according to the flowchart shown in Figure 2 and system characteristics, such as employees' schedules, business hours, and available resources.

After creating the realistic model, three other scenarios were designed for the coffee shop: less one employee, two registers, and both changes. For the first change, the schedule of the system was modified to run with one less worker, and for the second change, the order and pickup process was doubled, so when the client entered the coffee shop, he/she could choose either queue, and for the last change, the modifications were combined. Simulation runs were made for these alterations and the results obtained were analyzed to identify the best scenario.

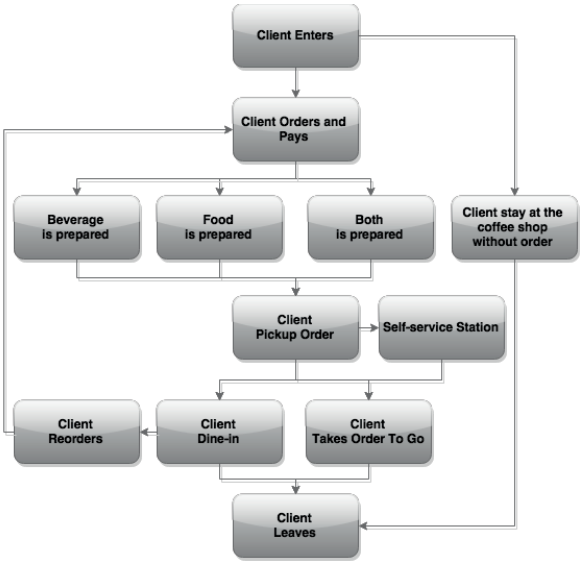

Figure 2. Flowchart

4. Results and Discussions

Table 1 shows the statistical distribution expressions for different variables of the queuing model. The realistic simulation model is shown in Figure 3. From all the customers, 4.37% consume nothing, only stay to participate in meetings or to use their computers. From the 95.63% left, 65.14% ask for beverages only, 2.29% ask for food only and 32.57% ask for both. Once they pick up their orders, 41.14% use the self-service station, 62.86% eat in the place, and 7.27% of these reorder something.

For the scenario modifications, the changes occurred in the schedule of the resource "barista" from the model, and the process order and pickup was doubled. For the analysis, each model was run three times, and then the average of these values for each model was taken, resulting in Table 2.

Table 1. Distribution Expressions

Time between arrivals	-0.001 + GAMM (12.8, 0.338)
Time between arrival and order	-0.001 + WEIB (2.18, 0.564)
Time between order and pickup	-0.001 + WEIB (5.23, 1.29)
Time between pickup and leave (dine-in)	-0.001 + EXPO (46.9)
Time between pickup and leave (to go)	-0.001 + EXPO (0.79)
Time between arrival and leave (no order)	TRIA (5, 67.1, 74)

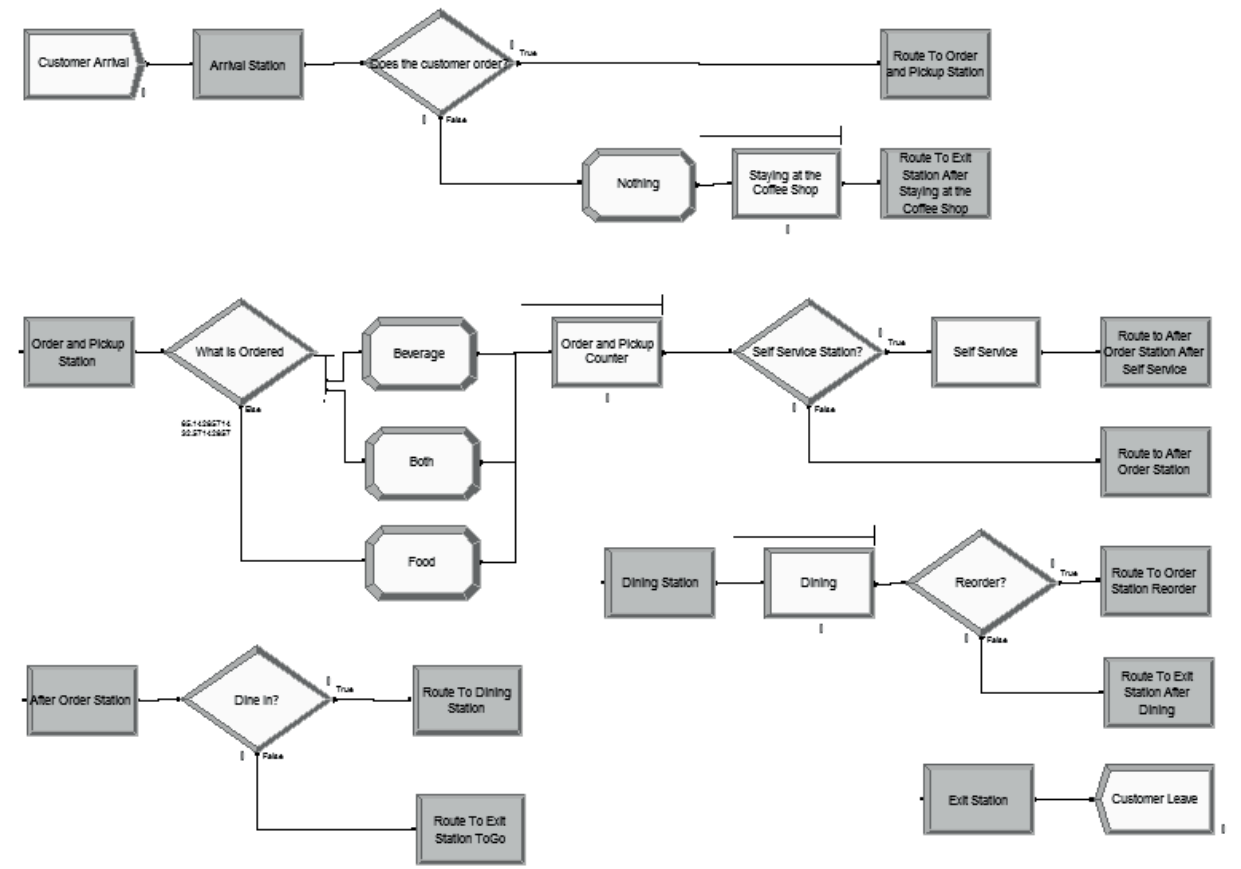

Figure 3. Simulation model

Table 2. Reports results

	A	B	C	D
1	1221.33	1210.67	1221.67	1189.67
2	27.12	27.70	26.61	25.97
3	45.67	48.67	47.67	44.00
4	0.39	0.49	0.41	0.58
5	0.31	1.97	0.16 and 0.17	0.82 and 0.83
6	11.33	19.67	5.67 and 6	9.33 (both)
7	1.33	8.52	1.39 and 1.42	7.21 and 7.34
8	25.78	65.92	24.59 and 25.49	58.59 and 61.79

Labels:

A = No modifications; B = Less one employee; C = Two registers; and D = Both changes (two registers and less one employee).

1 = Number of customers in the system per week; 2 = Average number of occupied seats; 3 = Maximum number of occupied seats; 4 = Barista performance; 5 = Average number of customers in order and pickup queue; 6 = Maximum number of customers in order and pickup queue; 7 = Average time in the order and pickup queue; and 8 = Maximum time in order and pickup queue.

The numbers of customers in the system from all scenarios are similar, presenting a maximum variation of 32 people, which equals to less than 3%. The average numbers of occupied seats also are similar between all scenarios. It is observed that the maximum number of occupied seats between all of the scenarios is 48.67, approximately 50 seats; it means that 115 seats currently available can be reduced to 75 seats considering a 50% increase of customers in the future. The remaining 40 seats of space can be used for display of additional art work. The option that makes the barista work from more to less order is: both changes, less one employee, two registers and no modifications. Regarding the average number of customers, the maximum number of customers and the maximum time in order and pickup queue, the best option for the coffee shop is the two registers modification. For the average time in order and pickup queue, the best option for the coffee shop is the no modifications scenario.

5. Conclusions and Recommendations

The best option is two registers modification, because it is the scenario that shows more benefits for the coffee shop: lower average number of customers, lower maximum number of customers, and lower maximum time in order and pickup queue. Another suggestion to the establishment is to reduce the number of seats available, because in all of the simulations done, the maximum number of occupied seats does not reach 115 seats. In the two registers modification, the maximum number of occupied seats is about 50, so the number of seats available could change from 115 to 75 that allow a 50% increase of customers in the future. Therefore, the coffee shop could use the remaining 40 seats vacant space to expose more art objects for the public.

The biggest difficulty of the research was the data collection, because it was not possible to follow all of the customers full time, in other words, from the arrival to the leave time. This problem could have affected in some way the simulation results.

The future work at the coffee shop could be done with a large data collection and an expansion objective as well as increasing the number of simulation runs based on sample size calculations. This could involve other parts of the business beyond the queue system, such as the marketing, cost and investments studies.

6. Acknowledgments

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A MODIFIED CONSTRAINED APPROACH FOR MAX COVERING PMU PLACEMENT PROBLEM IN POWER SYSTEMS

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Abstract

The broad advancement of power systems has amplified the necessities for reliable monitoring and control techniques based on the concept of Wide Area Measurement System (WAMS). WAMS has a crucial role in the safe operation of Power Systems. Phasor Measurement Units (PMUs) deliver Global Positioning system (GPS) centered time synchronized measurement. This capability to estimate synchronized phasors make the PMUs one the most important measurement devices in power systems and highlights the role of PMUs as key components of WAMS. Most algorithms consider power system observability aiming for minimum cost assuming resource availability. In this paper we incorporated the modified constraint for Zero Injection Buses (ZIB) and compared it with the existing models. The problem formulated as a Nonlinear programming (NLP) model and solved for IEEE 14 and 30 bus systems. The model targets to find the best placement in order to reach the maximum coverage constrained to the restricted number of PMUs. The reliability of the network has been assessed for results reaching full power system observability.

1. Introduction

Power system reliability, security and efficiency must be improved in order to survive contingencies (U.S. Department of Energy, 2014). Modern study in smart grid is concentrating on innovative monitoring techniques centered on the concept of Wide Area Measurement System (WAMS) (Phadke and de Moraes, 2008). The WAMS is designed to integrate measurement information in order to improve power grid security, operation, and control. Phasor Measurement Units (PMUs) are WAMS primary source for collecting and integrating synchronized measurements of voltage and current phasors (Phadke, 1993). WAMS structure consists of PMUs placed in various sites around the smart grid connected to Phasor Data Collector (PDC) through a regional network (Liu et al., 2009). Figure 1. illustrates the WAMS structure.

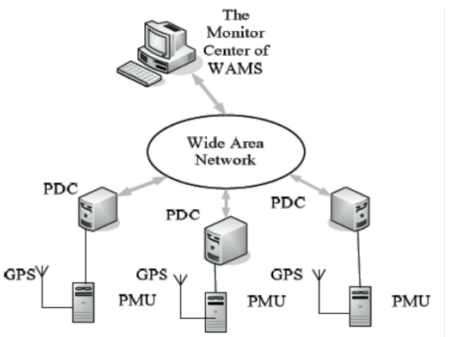

Figure 1. WAMS structure (Liu et al., 2009)

The power system is called observable if the measurements of all of the buses are adequate for obtaining the system state. Dongjie et al (2004) explain how the placement of the PMU on the strategic buses makes those buses and all neighborhood buses observable utilizing the Ohm's law. Consequently the system observability can be obtained with fewer PMUs. Hence, the goal of the PMU placement problem is to reach overall system observability consuming the least number of PMUs. Therefore intensive research has been done for optimal PMU placement recently. Xu and Abur (2004) developed an integer linear programming (ILP) model to solve PMU placement problems. Dua et al (2008) proposed a systematic ILP approach for PMU placement considering zero-injection buses. Khiabani et al. (2012) proposed a reliability estimation and optimization model for PMU placement problem.

The traditional PMU placement models study the power network observability aiming for minimizing the number of PMUs. Instead, reliability-based models aiming for full system observability maintaining a desired reliability level. However in most circumstances the decision maker needs to allocate the limited number of PMUs in order to maximize the coverage.

In this paper, we incorporated the modified constraint for Zero Injection Buses (ZIB) and assessed the reliability of the resulting placement. The Nonlinear programming (NLP) model targets maximal coverage constrained to the restricted number of PMUs. To demonstrate the application of the proposed max covering model, it is solved for IEEE 14, and 30 test systems and compared with the model presented in (Khiabani et al, 2012).

2. Problem Formulation

The proposed model incorporates the nonlinear constraint for zero injection buses. The primary goal is maximization of the system coverage with the existing number of PMUs. Obviously, lack of availability of a sufficient number of PMUs will result in the partial system observability. The optimization model is formulated as follows:

$$\begin{aligned} &Max \sum_{i=1}^{n} f_i \\ &s.t \\ &\sum_{i=1}^{n} x_i \le c \\ &x_i \in \{0, 1, 2\} \;\; i \in 1, 2, 3, \ldots n \end{aligned} \tag{1}$$

In which x_i is a binary decision variable, and will obtain a value one if a PMU is installed on the ith bus and zero otherwise. The variable c is the number of existing PMUs. The variable f_i denotes the total number of PMUs covering ith bus and is defined as:

$$f_i = \sum_{j \in N(i)} x_j \tag{2}$$

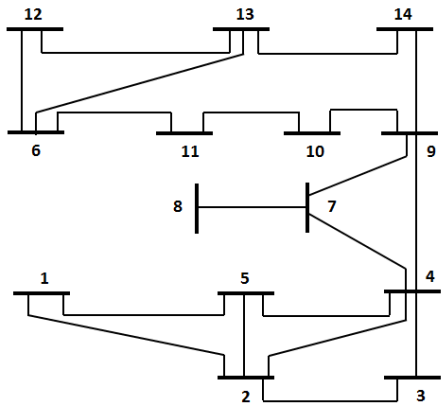

Figure 2. IEEE 14 bus system

Where $N(i)$ is the set of PMUs placed on buses j that are adjacent to ith bus. Consider the IEEE 14 standard system shown in Figure 2 then the total number of buses covering bus I, are defined as:

$$f_1 = x_1 + x_2 + x_5$$
$$f_2 = x_1 + x_2 + x_3 + x_4 + x_5$$
$$f_3 = x_2 + x_3 + x_4$$
$$f_4 = x_2 + x_3 + x_4 + x_5 + x_7 + x_9$$
$$f_5 = x_1 + x_2 + x_4 + x_5$$
$$f_6 = x_6 + x_{11} + x_{12} + x_{13}$$
$$f_7 = x_4 + x_7 + x_8 + x_9$$
$$f_8 = x_7 + x_8$$
$$f_9 = x_4 + x_7 + x_9 + x_{10} + x_{14}$$
$$f_{10} = x_9 + x_{10} + x_{11}$$
$$f_{11} = x_6 + x_{10} + x_{11}$$
$$f_{12} = x_6 + x_{12} + x_{13}$$
$$f_{13} = x_6 + x_{12} + x_{13} + x_{14}$$
$$f_{14} = x_9 + x_{13} + x_{14}$$

The model can be modified to incorporate zero-injection buses (Dua et al., 2008). The nonlinear constraint method been modified for the proposed model to incorporate zero-injection buses in the system. Considering bus 7 as a zero-injection bus in an IEEE 14 bus system. If the phasor voltages at any three out of the four buses 4, 7, 8 and 9 are known, then the fourth one can be calculated using the Kirchhoff's Current Law applied at bus 7 where the net injected current is known (Korkali and Abur, 2009). The Nonlinear constraint method can be applied to the model by eliminating f7 and the following updates:

$$f_4 = x_2 + x_3 + x_4 + x_5 + x_7 + x_9 + f_7.f_8.f_9 \quad (3)$$
$$f_8 = x_7 + x_8 + f_4.f_7.f_9 \quad (4)$$
$$f_9 = x_4 + x_7 + x_9 + x_{10} + x_{14} + f_4.f_7.f_8 \quad (5)$$

Applying logical AND & OR properties:

$$A \subset B \rightarrow A + B = B \;\; \& \;\; A.B = A \tag{6}$$

The equations (3), (4) and (5) will be simplified as follows:

$$f_4 = x_2 + x_3 + x_4 + x_5 + x_7 + x_9 + x_8.x_{10} + x_8.x_{14} \tag{7}$$

$$f_8 = x_4 + x_7 + x_8 + x_9 \tag{8}$$

$$f_9 = x_4 + x_7 + x_9 + x_{10} + x_{14} + x_2.x_8 + x_3.x_8 + x_5.x_8 \tag{9}$$

3. Discussions and Computational Results

The proposed maximum covering placement model is solved for the IEEE 14 and 30 test systems. The zero-injection buses for the IEEE standard bus systems are as follows:

14 bus :{ 7}

30 bus :{ 6, 9, 11, 25, 28}

The summary of results for all cases assuming PMU reliabilities of 0.99 for both with and without zero-injection buses are shown in Tables 1-4. The 0.99 level of PMU reliability used since PMUs are highly reliable and their reliabilities are around 98%. These tables show the number of PMUs and overall system reliability of observability assessed. The model presented in Khiabani et al. (2012) is used to evaluate overall system reliability of observability of the system.

The results for IEEE 14 and 30 standard bus systems without considering the zero-injection buses are shown in Tables 1-2 for the number of PMUs as input, the total coverage, and overall system reliability of observability achieved.

Table 1. IEEE-14 placement results

#PMU	Cover	R
1	6	0
2	11	0
3	16	0
4	18	0.89
5	24	0.92

Table 2. IEEE-30 placement results

#PMU	Cover	R
1	8	0
2	15	0
3	21	0
4	26	0
5	31	0
6	36	0
7	41	0
8	45	0
9	49	0
10	52	0.83
11	56	0.84
12	60	0.86
13	64	0.87
14	67	0.87
15	70	0.89
16	73	0.89
17	76	0.91

The results for IEEE 14 and 30 standard bus systems with the zero-injection buses are shown in Tables 3 and 4 for the given number of PMUs, the total coverage, and overall system reliability of observability achieved.

Table 3. IEEE-14 placement results with zero-injection buses

#PMU	Cover	R
1	7	0
2	13	0
3	15	0.88
4	22	0.93

Table 4. IEEE-30 placement results with zero-injection buses

#PMU	Cover	R
1	13	0
2	23	0
3	33	0
4	43	0
5	52	0
6	61	0
7	57	0.86
8	70	0.89
9	80	0.89
10	90	0.89
11	100	0.90

In Tables 5 and 6, we compared the results with the reliability-based placement in Khiabani et al. (2012) in order to investigate the effectiveness of the proposed model. Since PMU reliabilities of 0.95 were considered for the Khiabani et al (2012), we run the max covering model again with PMU reliabilities of 0.95 and the goal of reaching minimum overall power system reliability (R) of 0.90. As can be observed, max cover model results in more coverage compared to the reliability-based placement model. In the referenced work, the model reaches a higher reliability level (R) than the proposed model.

Table 5. Comparison of obtained results with R=0.90

IEEE	Proposed model			Khiabani et al (2012)		
System	#PMU	Cover	R	#PMU	Cover	R
14	9	56	0.98	9	37	0.98
30	24	208	0.93	21	85	0.95

Table 6. Comparison of obtained results with same number of PMUs

IEEE	Proposed model			Khiabani et al (2012)		
System	#PMU	Cover	R	#PMU	Cover	R
14	9	56	0.98	9	37	0.98
30	21	191	0.72	21	85	0.95

4. Conclusions

The Nonlinear modified constraint Zero Injection Bus method for max covering model is solved in this paper. The key idea is in the consideration of the modified constraint for Zero Injection Buses in order to determine Max coverage. The proposed modified constraint Max covering model is solved for IEEE 14 and 30 test systems with the restricted number of PMUs as input and compared to the reliability based model in the literature. Results obtained shows the competence with other methods for the goal of maximum coverage. However the software calculation time increased substantially for the model because of inclusion of the nonlinear constraint.

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