UNIVERSITY OF GOTHENBURG

ASSESSING THE IMPORTANCE OF QUALITY ATTRIBUTES AND METRICS IN MOBILE GEOGRAPHICAL INFORMATION SYSTEMS (GIS) APPLICATIONS.

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Abstract

The need for quality software that satisfies both customers and software developers is very essential. Quality attributes and metrics play an essential role in assuring the quality of software during the software development process. This thesis was done with an industrial partner and its aim was to access the importance of quality attributes and metrics in mobile geographical information systems (GIS) applications. As a case study, this thesis used an existing mobile device called the GuardTools which is an operational support system specially adapted to the security branch and also a kind of geographical information system. One of the main objectives of this thesis was to investigate the effects of introducing GPS and maps as a feature to the GuardTools and also to find out the effects of the proposed feature in supporting the daily work practice of security guard companies and their security guard. Studying work practice and literature reviews were used as research methods for this thesis. Data collected for the thesis was done through a survey and interviews. The findings from the data collected give evidence that introducing GPS and maps as a feature in the GuardTools will have more positive effect as compared to the negative effects. The outcome of this thesis is a quality model which will assist the intended audience for this thesis that is the quality assurance manager and the tester to efficiently assess the quality of the proposed feature. The aim of this quality model is also to help in bringing to light the importance of quality attributes and metrics.

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1 Introduction

1.1 Background

Information provided by geographical information systems (GIS) are used by many applications such as emergency management, environmental analysis, and national infrastructure protection, for various kinds of analyses. For instance, during emergency situations, it is critical to provide the first responders quick access to geographical information system data to do damage assessment and make critical decisions, so that resources can be dispatched to save lives and properties (R. Hariharan et al). Information provided by these geographical information systems should be accessible regardless of the mobility or location of these applications and users that access them.

Global positioning system (GPS) provides important real-time and accurate spatial data acquisition method through a satellite positioning method and this serves as an important GIS data source. GPS provide an extension of the application areas and application of GIS methods. For GPS, GIS is an important spatial data processing, integration, and application tool. The two work closely together to create and deepen a broader range of space applications. Relative to GIS, the satellite positioning system, specifically GPS has been a satellite position system that has gained popularity with more and more people in their production and daily life, in areas such as mapping, field data collection, vehicle navigation and tourism. This is due to the popularity of GPS with most mobile devices.

Mobile devices with positioning capabilities, specifically GPS allow users to participate in a variety of useful and exciting location-based applications. Mobile devices with positioning capabilities for example enable users to request for information about important landmarks such as police stations, restaurants etc within their proximity. Users of these mobile devices which have positioning capabilities are also able to track the whereabouts of their acquaintances in location-aware social networking applications, e.g., Google Latitude (Ghinita .G et al).

Most design-oriented research on mobility deals with the access of information while on the move. It is based on the recognition that mobile workers often find themselves missing a document or some information which is left back in the office, and therefore need to access this document remotely (Lamming, 2000; Churchill and Wakeford, 2001). The need for readily accessible information for the mobile work force is essential. In the security industry for example, the need for quality, readily accessible location relevant information about resources is essential.

1.2 Purpose

The purpose of this research is to assess the importance of quality attributes and metrics in mobile GIS applications. This research also investigated the importance of geographical information systems, specifically, GPS and maps for supporting a security guard company's daily work practice.

As a case study, this research used an existing mobile device called the GuardTools. The GuardTools is an operational support system specially adapted to the security branch and is based on research and many years of professional experience within the security sector. It consists of three software applications; one for security guards in the field – GuardTools Mobile, one for office-based operative personnel - GuardTools Office and one for the security company's customers - GuardTools Web. In other words, the GuardTools has three categories of users. This research was done with an industrial partner and it also aimed at finding out the effects of introducing GPS and maps as a proposed feature to the existing mobile device (GuardTools).

This research also provides further studies into the daily work practice of users of the existing mobile device, especially the security guard company and their security guards. The research aims not only at providing more insight about the design and functionality of the proposed feature but also to observe the nature of work of the users of the existing mobile device in order to be able to come to a valid conclusion about the effects of introducing the proposed feature.

The outcome of this research is a quality model which will assist the intended audience for this research that is the quality assurance manager and also the tester to efficiently assess the quality of the proposed feature with all its functionalities. This report is also a compilation, which contains a detailed description of all activities carried out during the research.

1.3 Scope

This research focused mainly on the security guard companies and their security guards. All problem domain analysis for the research was done while focusing on the security guard companies and their security guards. To assist in a better understanding the daily work practice of users and also how beneficial the proposed feature going to be to users, a survey and interviews has been conducted among the security guard companies and their employees.

1.4 Research objectives

This research seeks to answer the following research questions:

1. How can we measure and assess the quality of the proposed feature?

2. What are the effects of the proposed feature in supporting the daily work practice of security guard companies and their security guards?

In answering the above questions, the importance of quality attributes and metrics can be fully realized and assessed.

2 Method

The research methods used for this research were chosen based on the type of data that was needed for the research. The sample population was also a major factor that was considered while choosing both a data collection method and a research method for this research.

2.1 Literature study

Literature study is one of the main research methods that were used during this research. A thorough study of previous research that had been done with regards to GIS, specifically GPS and maps, was done to provide more insight into GPS and maps and also to be abreast with the current state of the art, when it comes to GPS and maps. A study of literature surrounding quality models and international standards was also done in order to have a standard for the purpose of comparison and conformance. A study of various articles gathered for the literature study also assisted in providing an interesting area for research and subsequently appropriate research questions.

2.2 Interview

Interviewing as a design tool is becoming more and more important since designing information technology services and products demands great knowledge about users, their practices and world views (Bergquist .M, 2009).

Interviewing provided a means of gathering information from the sample population. It also served as a means of seeking “insider accounts” in order to have a feel and an idea about the interviewee’s world from the interviewee’s perspective. Interviewing was used in this research in order to obtain valuable information about the interviewee’s values, experiences, local knowledge, practices, and ways of understanding their world. It also provided a means of observing some of the interviewees while they went about their daily work practice.

Two interviews were conducted during this research. The first interview was conducted with an employee of the security guard company at their office premises, whiles the second interview,

which involved an end-customer that is the customer of the security guard company, was conducted at the offices of the industrial partner.

2.2.1 Conducting interview

An interview guide containing a total of twelve questions was prepared for the two interviews. The first five questions of the interview guide were general and more open type of questions. These five questions related to interviewee's roles and responsibilities, daily work practice, constraints of their work and also in the use of the existing mobile device. These questions also sought the interviewee's opinion and ideas about future modifications of features in the existing mobile device. The last seven questions of the interview guide basically introduced the theme of the research and also areas of the security industry where this research sought to emphasis and address, such as emergency response, safety of security guards and improving quality of the existing mobile device and work practice. The last seven questions were specifically related to the proposed feature and the effects of its introduction in the specific areas of the interviewee's work.

The semi standardized form of interviewing was used in this research where the interviews were conducted in an interactive manner using an interview guide which contained questions focusing around the theme of the research (Berg B. L, 2007). Some of the answers given by the interviewee during the interview were used as cue for further probing or for new questions. Questions prepared for the interview were often asked in the exact order in which they were documented. At certain points of the interview sessions, some of the questions were rephrased depending on the situation, to provide more explanation to the interviewee and also to provide further clarification of answers initially given by the interviewee. Questions that were not contained in the interview guide were also asked during the interview. These new questions lead to answers which provided new knowledge that were essential for this research. The interview sessions lasted between thirty to sixty minutes.

2.2.2 Studying work practice

Studying work practice provides an effective means of observing participants while they carried out their daily work practice (G. Button and R. Harper). Studying and observing the work practice provided essential knowledge about users and their way of practice. For the purpose of this research and to have a better understanding of the daily work practice, one of the interviews was conducted at the work premises of the interviewee. This provided a means of not only studying and observing their work practice, in order to be able to come to a valid conclusion about the effects of introducing the proposed feature but also provided an insight about the design of the proposed feature. Using a combination of interview as a design tool and studying work practice provided to an extent, a rich picture of their daily work practice and the effects that the proposed feature might have.

2.3 Survey

In order to enable effective capturing of the target population, a survey was conducted as part of the data collection method during this research. This method was chosen while considering the various geographical locations of the target population and also due to the fact that it provided a means of quicker and effective means of data collection. The internet survey method was specifically chosen for this research since the target population for this research consisted entirely of internet users.

2.3.1 Survey development

One of the main aims of this research was to find out the benefits that the proposed feature would offer to the users of the existing mobile device, especially the security guard company and their security guards. The sample population for this survey consisted of individuals who had experience in utilizing the existing mobile device for their daily work practice. The survey questions were developed based on three major themes, namely emergency response, safety of security guards, quality of work and of the existing mobile device. These themes were chosen based on a review of literature surrounding the use of positioning systems, especially in other security industry such as the police and also in other social networks. The themes were also chosen based on the study of the work practice of a security guard companies and their security guards. The first part (questions 1 to 5) of the survey consisted of questions which asked for additional information and individual characteristics in relation to organizational characteristics, such as job title, roles and responsibilities in the organization, constraints of using the existing mobile device and also of daily work and ideas for future modifications of the existing mobile device. The second part of the survey consisted of GPS and maps usage questions mapped directly to onto the three themes mentioned earlier on in this section. The estimated burden time for participating in the survey was ten minutes.

2.3.2 Survey Administration

The target population for the survey was obtained from a database of e-mail address of security guard companies provided by the industrial partner. Direct e-mails containing a brief introduction about the purpose of the survey and also containing a link to the questionnaire for the survey were sent to participants requesting them to volunteer and participate in the survey. The e-mail also requested that they forward the link to their employees. A total of 12 emails were sent to twelve security guard companies, who are direct customers of the industrial partner. These 12 companies varied in sizes ranging from big, medium and small. For the big companies, the e-mail containing the link to the survey was sent to the project manager, for the medium sized companies, the e-mail was sent to the operations manager and for the small sized companies, the e-mail was sent to the team leader. Out of these 12 companies, one was a big company with about 20 local branches or offices, whiles the rest were local with no branches. From these details, it can be estimated that a total of 40 of e-mails were sent out and

out of these 40 e-mails, a total of 18 complete responses was received. The total response rate for the survey was 45%, which was considered to be good considering the fact that no incentive, especially monetary, was offered to entice respondent to participate in this survey.

2.4 Constraints of method used

Even though there was a question guide it was sometimes difficult to control the interview as interviewees were keen and much eager to express their views on other aspects of the existing mobile device which did not match the context or the theme of the research.

In order for participants to understand the questionnaire for the survey and also clearly express themselves, the survey was conducted in Swedish. The results of the survey were later translated into English and this posed a threat to the exact meaning to some of the technical terms that were used by participants. During the survey, only interested parties could be solicited to participate and this introduced a certain level of inherent biasness.

Much as studying work practice was important for the purposes of this research, it was only possible to observe and interview the security guards whiles they went about their daily work practice in the office. Following and observing the security guards in the field, while they were guarding an object or responded to alarm was not possible. As a result of this, work practice was not effectively studied.

3 Theory

The *quasi-statistics* theory according to (Becker .H et al) refers to the use of descriptive statistics that can be extracted from qualitative data. (Becker .H et al) also contended that one of the greatest faults in most observational case studies has been their failure to make explicit the quasi-statistical basis of their conclusions. The *grounded theory* is accurately described as a research method in which the theory is developed from the data. This theory was chosen since it is based on the process of constant comparison (Ratcliff .D).

The quasi-statistics and the grounded theory were used as the bases for all data analysis that was done during this research. The grounded theory was used in order to identify certain characteristic or essential indicators that were evident in the data collected whiles the quasi-statistics theory was used to count and assess the amount of evidence in the data collected that bears on a particular conclusion or threat for this research. Data analysis, comparison and categorization were based on existing theories, standards and also on previous research that has been done in areas relevant to this research. Consistencies and differences that were

identified between the various data that was collected were subsequently used as basis for conclusions for the research.

3.1 Quality

The need for quality software that satisfies both customers and developers has become very essential. Previous research that has been done has mainly focused on the importance of quality with regards to product quality and customer satisfaction. These researches have brought into a common acceptance and definition of software quality which centers on conformance to requirements or specification and also meeting customers' needs. For software product to conform to requirements or specifications there must be certain measurable characteristics which satisfies the specification or requirement (Hoyer, R. W. and Hoyer, B. B. Y., 2001). These measurable characteristics, known as quality attributes, can be effectively measured using software metrics. Software metrics are essential when it comes to software quality and also during the software development process (Jeff Winter et al) since they provide a means of quantifying and comparing states, there by assisting in improvement processes.

Various quality models and standards that access both the quality of product with regards to customer satisfaction using various kinds of measurements and quality attributes has become very popular in recent times. Most popular amongst these quality models and standards are the McCall's and Boehm's quality models and the ISO/IEC 9126. The McCall's and the Boehm's quality model form the basics and foundation of most present day quality models.

The McCall's quality model created by (Jim McCall et al) is organized around three types of quality characteristics. The three types of quality characteristics are categorized under three major heading that the model uses for addressing and defining quality. The three headings are: product revision (ability to undergo changes), product transition (adaptability to new environments) and product operations (its operation characteristics). The model uses a hierarchy of metrics, criteria and quality attributes to describe, measure and provide details for selected quality characteristics that are categorized under the three headings. The Boehm's quality model presented by Barry W. Boehm on the other hand focuses on qualitatively defining software quality based on a given set of quality attributes and metrics (Boehm et al).

There are certain similarities between the McCall's and Boehm's quality models and one of these similarity is that both models use a hierarchical presentation of high-level characteristics, intermediate level characteristics and primitive characteristics for the overall quality level. These high, intermediate and primitive level characteristics basically represents requirements of actual use to which evaluation of the software quality could be put, quality factors that describe qualities expected from a software system (e.g. usability and testability) and a foundation for defining metrics for these qualities respectively. Much as there are similarities between these models, there are also slight differences. The differences lies in the fact that the

McCall's model (McCall et al) primarily focuses on the precise measurement of the high-level characteristics "As-is utility" (how well or easily, reliably, efficiently, can I use it as-is?) whereas Boehm's quality model (Boehm et al) is based on a wider range of characteristics with an extended and detailed focus primarily on maintainability.

The ISO 9126 standard which basically provides: Software Product Evaluation: Quality Characteristics and Guidelines for their Use-standard was also another international quality standard that was followed for conformance and comparison during the research. The ISO 9126 standard is also based on the McCall's and Boehm's quality models.

3.1.1 Common focus

After comparing these quality models and standard, one major similarity that was identified was the use of quality attributes and metrics, which provided a means of measurements for these attributes. Further comparison also revealed a set of quality characteristics and attributes that were common to the McCall's, Boehm's and the ISO 9126 standard. This evidently shows the importance of these attributes and metrics when it comes to assessing and measuring software quality. Table 1 shows a set of quality characteristics that are common to the two quality models and standard and which were also used for the purpose of this research.

Quality characteristics	**McCall's, 1977**	**Boehm's, 1978**	**ISO 9126, 1993**	**Model for the proposed feature**
Usability	✓	✓	✓	✓
Correctness	✓	✓	maintainability	✓
Reliability	✓	✓	✓	✓
Maintainability	✓	✓	✓	✓

Figure 1: a comparison of quality characteristics between the McCall's, Boehm's, the ISO 9126 and the quality model for the proposed feature.

4 Security industry and positioning systems

Services provided by security guard companies through their employees, specifically the security guards are very specific as compared to services provided by other branches of the security industry, for example the police. The service of a security guard is an example of a service that can be bought in the security industry, by individuals. The uniqueness of this

service is that the individual can purchase this service, which is not available with other branches that fall under the security industry, e.g. the police.

There are several methods for locating a user via a mobile device. The most popular amongst these methods is GPS. Users enjoy a variety of location-aware benefits from this system if their mobile device contains the GPS module. In the security industries, GPS and maps have been found to be very essential since the play a vital role. (Streefkerk .J et al, 2008) discussed the need for location relevant information to be made available to mobile police whiles on surveillance in order for them to be aware of locations of incidents and colleagues, crime hotspots and police focal points so they can act on this information when they are in that vicinity or location. (Streefkerk .J et al, 2008) also referenced the success story of the Dutch police, in developing and implementing a location-based notification system (LBNS) mobile services that notified police officers proactively to warrants, agreements and police focal points in their current vicinity. The results of an evaluation test to access the efficiency of the LBNS system showed that using the LBNS, police officers were better informed of relevant information in their environment and this led to positive operational results. (Kjeldskov J et al, 2004).

Much research based on context-aware systems, specifically location based notification systems have been done in a variety of domains, such as first response, military, tourism and firefighting (Jiang, X. et al, 2004). These research have thrown more light on the effects of context-aware systems, specifically location based notification systems. Other researches have also focused on addressing security issues that come with such systems. (Ghinita .G et al) discussed a typical approach to preserving location privacy by generating cloaking region (CR) that encloses the user position. These researches have in one way or the other addressed the benefits and success stories of context- aware and location-aware systems not only in social network applications but also in some branches of the security industry.

5 Result and analysis of data

Data for this research was collected through a survey and two interviews. In all a total of 18 complete responses were received out of an estimated total of 40 e-mails containing a link to the survey that was sent out. This represented 45% response rate for the whole survey.

5.1 Findings

Data collected for this research was analyzed in subsections 5.1.1 to 5.1.3. According to the data collected from both the survey and interviews, it can be concluded that introducing the proposed feature would have more positive effects compared to its negative effects.

The survey was focused on the security guard companies and their employees, specifically the security guards. During the data collection, one question that was asked was the participant's job title and also the roles and responsibility that came with it. The aim of this question was to find out if the target population had been effectively captured. Capturing the target population was essential as it meant that the effects of the proposed feature on the target population could be easily identified and addressed. This also meant that the various functions required of the proposed feature by the target population could also be easily identified. See figure 2.

Job Title	**Response rate**
Chief of operations	4
Team leaders	4
Security guards	6
Project managers	1
Foremen/Overseers	2
Customer service representative	1
Total number of response	**18**

Figure 2: a description of the various job titles of respondents of the survey.

5.1.1 Quality of work and of the existing mobile device

Identifying constraints of daily work practice and also in the use of the existing mobile device was essential. This was because eliminating or mitigating these constraints would go a long way not only to improve upon the quality of respondents daily work practice, but also improve the quality of the existing mobile device. During the survey and interviews, participants were asked if they had any constraints during their daily work practice. The aim of this question was to identify constraints which could be mitigated or solved with the introduction of the proposed feature.

A total of 17 responded to this question during the survey. 7/17 of respondents answered no, when asked if the had any constraints during their daily work practice. Some these respondents explained that constraints were a normal part of their work and for that reason they always found way of dealing with their constraints. 10/17 of respondents who responded yes to this question identified constraints ranging from time, slow nature of system (existing mobile device) which needed to become faster, difficulties in finding correct locations, incompetence on the part of their managers, clumsiness of existing mobile device, slow nature of work due to limited resources, customers been registered under different names at the dispatch center to health related issues, as their major constraints. During the two interviews, one interviewee identified time as a major constraint while the other interviewee also explained that not being able to follow the security guards around in order to find out what the have not done well was a constraint for him since most of his security guards worked at night.

In order to find from respondents' point of view if they thought the introduction of the proposed feature could help eliminate or mitigate some of their constraints, one question that was asked during the survey and the interview was, if participants would like to have the proposed feature introduced into the existing mobile device. 16/18 of respondents responded in affirmative while 2/18 answered no. One respondents who answered no to this question explained and raised concerns about the fact that introducing an additional feature would only make the existing mobile device slower; he/she conditionally stated that he/she will like to have the proposed feature only if its introduction would not affect the speed of the existing mobile device and could also afford them privileges such as a fast and easy to use system. The other respondent who answered no also explained that, they already have GPS-navigators in their vehicles and that the proposed feature would be completely unnecessary for him/her if it is not a navigator that will help the dispatch center to find his/her location when being assaulted.

The functions to be provided by the proposed feature were a major concern for the respondents. Constraints at work and in using the existing mobile device could only be eliminated or mitigated based on the functions that the proposed feature would be designed to provide. When asked if they thought the introduction of the proposed feature could help improve the quality of their work and also of the existing mobile device, respondents identified certain areas in their work and also in the existing mobile device, where they thought could be improved thorough the introduction of the proposed feature.

Majority, that is 7/18 of the respondents identified the area of quickly locating objects through the quickest, shortest and smoothest route, 3/18 of the respondents identified the area of having support from the alarm center and 2/18 identified the area of being able to prove to clients if the security guard was actually at post as areas where there could be improvement with regard to quality of their work and of the existing mobile device. 5/18 of respondents also identified the following areas: being able to trace units incase of robbery, being able to see affected areas in case of damage, being able follow up the work of the security guard and reporting to the customer, the area of providing support during dispatch and also when assisting co-workers and the area of reducing the number of gadgets in the patrol vehicle.

An interviewee and a respondent from the survey also suggested that much improvement in the quality of their daily work practice and also the existing mobile device could be seen if all the features of the existing mobile device has been fully developed and all users were effectively using it .

In order to have quality software that satisfies both developer and customers/users, one area that needs to be carefully address is requirement specification. Requirements form the back bone or the main platform for all software development projects. According to (Loconsole .A,

1999), requirements of a software project should be complete, documented, unambiguous, and controlled, in order to design a software product, which satisfies the customer's needs. The data collected based on respondents response to question 6 of the survey provides a rich source of customer/users requirement which when carefully documented and followed would assist in providing a software system that will be beneficial not only to the security guard companies and their security guards but also to their customers.

The response collected form both survey and interview gave a clear indication that, the functions to be provided by the proposed feature were a major concern for the respondents. Satisfying respondents' request about the proposed feature based on the requirement identified through their response will go a long way not only to improve the quality of their work but also the quality of the existing mobile device in general. This will also help mitigate some of the constraints that respondents identified.

5.1.2 Safety of security guard

16/18 of respondent responded in affirmative when ask if they thought the proposed feature could be use to ensure the safety of the security guard whiles 2/18 of the respondents answered no. Respondents explained giving reasons that in the case of assault on the security guards for example during a robbery, if the proposed feature could provide the exact location of the security guard who is being assaulted or the exact location where the robbery is taking place to the dispatch center so that nearest back up or support could be sent to that location, then the safety of the security guard could be ensured. Respondents also explained that they believed that the safety of the security guard could be ensured if the proposed system could track each security guard in real time. Respondents also suggested that if the proposed feature could be directly connected to the alarm center, then the safety of the security guard could be effectively ensured. Respondents who answered no to this question explained that they already had a unit that can distribute assault alarm to the dispatch center and that it would be more practical to have that unit combined or built in the existing mobile device.

Much as some respondents were happy about the prospects of being able to easily locate their resources, for example the security guards at every point in time whiles the were at post and ensuring the safety of their safety and also for easy dispatching, the idea of the security guards not been comfortable with the knowledge of been watched all the time was also an issue of concern. One issue of concern which was raised by the second interviewee was that it is different issue when the security guard is in trouble (being assaulted) and need help and another issue when they are not at post whiles they are supposed to be and did not want to be found out.

5.1.3 Emergency response

16/18 of respondent responded yes when ask if they thought the proposed feature could be used to improve emergency response in their daily work practice, while 2/18 of the respondents answered no. Respondents identified specific areas in emergency response which could be improved with regards to their work. Time is of great essence during emergency; respondents explained that with the introduction of the proposed feature, it would be faster and easy to find the exact location of objects so that the nearest operator can send assistance. They also went on to further explain that not only will the proposed feature help them to have a better picture of how a dispatch was conducted but it would also give them access to pre-stored locations of customer's sites that are immediately available for the field worker during a dispatch, thereby saving time. For the purposes of emergency response, respondents explain that if the proposed feature could offer them affordances such as finding other units with help from the GPS and map, that would go a long way in assisting incase of emergency situations e.g. assault of a co-worker. Respondent also explain that it would be beneficial to them if the proposed feature could enable them review the work of a security guard then they could choose which one they could send on extra rounds to cover up shifts for other security guards in minor emergency cases such as a security guard calling in sick.

"Yes, as I said earlier on, the better the information, the better the response. The fire services or the ambulance service, the better information they have, the more exact geographical information (exactly where), the better". This was the exact response given by one of the interviewees when asked if he thought the proposed feature could improve emergency response. The quality of information available during emergency response is very essential, for example exact location given in coordinates will provide easy location, especially for surveillance object that can not be found in the normal address system and also reduce the probability of driving in the wrong direction and there by saving time.

Respondents who answered no to question 8, which was to find out if the proposed feature could help in improving emergency response explained that they felt it was better for them to have a standard navigator that is mounted in their vehicle since they did not like the idea of having any extra work with the existing mobile device.

6 Defining quality for positioning

The need for quality of positioning systems and the information they provide is very essential. The quality of the proposed feature will be defined for the purposes of this research as conformance to requirements and meeting customers' needs. The quality model developed, will be used to assess how well the goals and requirement set for the development of the

proposed feature has been achieved and also how well the evaluation criteria set for the proposed feature can contribute to the achievement of the set goals and also meeting specified requirements. Quality will be measured and assessed using selected quality attributes and metrics. The metrics used will also provide a means of comparison and improvement of the proposed feature and its functions in the future.

The quality attributes selected for the quality model can be described as non-functional requirements which define the requirements specification criteria that will be used to judge or assess the operation of the proposed feature and all its functionalities. These quality attributes would be contrasted and compared with the functional requirements that specify specific behavior or functions of the proposed feature. Generally, functional requirements will define what the system is supposed to do whereas non-functional requirements define how the system is supposed to be. The following quality attributes and metrics, discussed in section 6.1 and 6.2, have been identified as important in developing and assessing the proposed feature according to the system goals and user needs. These quality attributes have also been categorized under the following headings, feature operation and feature revision.

6.1 Feature operation

The operation characteristics of the proposed feature and all its functions will be used to describe the extent to which the proposed feature fulfils its specifications and requirements. The quality of feature operations depends on its usability, correctness and reliability.

6.1.1 Usability

“Hand unit is too clumsy; it’s mostly in the way of other things. Must become faster to use and work with the program “. This is a direct quote some of the respondents gave as a constraint they face whiles using the existing mobile device. Other respondents also named time as a major constraint during their daily work practice. The second interviewee also brought to light the increasing number of damage or destruction cause by security guards to the existing mobile device. This destruction he said was the result of frustration on the part of the security guard caused by the unfriendly user interface of some features of the existing mobile device. The usability of the proposed feature with regards to the existing mobile device will be described and accessed by the following quality attributes; responsiveness and ease of use. Selected metrics will also be used to effectively measure these quality attributes.

- **Ease of use** – the proposed feature should be easy to understand and use with little effort. In other words, the proposed feature and all its functions should be user friendly. User-friendliness of the proposed feature is essential since it will play a major role in the over all success of the proposed feature. The user-friendliness of the proposed feature will be tested through a usability test. Usability test will be done among users of the existing mobile device and this test will be done over a period of time. The usability test

will be use to assess how easy the proposed feature is to use and also the general overview of the proposed feature. The ease-of-use of the proposed feature will be measured by the metrics described below. Number of satisfied users after usability test should be at least 80%.

Metrics:

- *Number of satisfied users after the usability test*.
  The unit of measurement for this metric will be calculated in percentage.

- *Percentage of satisfied customers with number 5 rating.*
  A scale for rating, ranging from 1 to 5 will be provided for used by customers to rate their satisfaction after using the proposed feature. In ascending order, 1 will be the lowest and 5 will be the highest on the customer satisfaction rating scale.

- **Responsiveness** – this quality attribute describes the over all responsiveness of all functions of the proposed feature. This quality attribute is essential since it will provide a means of assessing how fast the proposed feature with all its functions is in responding to users' request. The metrics that will be used to measure this quality attribute are described below. Response time metrics for example will be used to measure the time taken for the proposed feature to provide search results requested by user. The response time is essential as it will assist in providing respondent with a feature that is not only easy to use but fast as well.

  Metrics:

  - *Response time.*
    (For example time taken for the system to provide search results should be a maximum of 10 seconds and also number of clicks (time taken) for maps, overview, location etc to be shown should also be considered).
    The unit of measurement for this metric will be seconds.

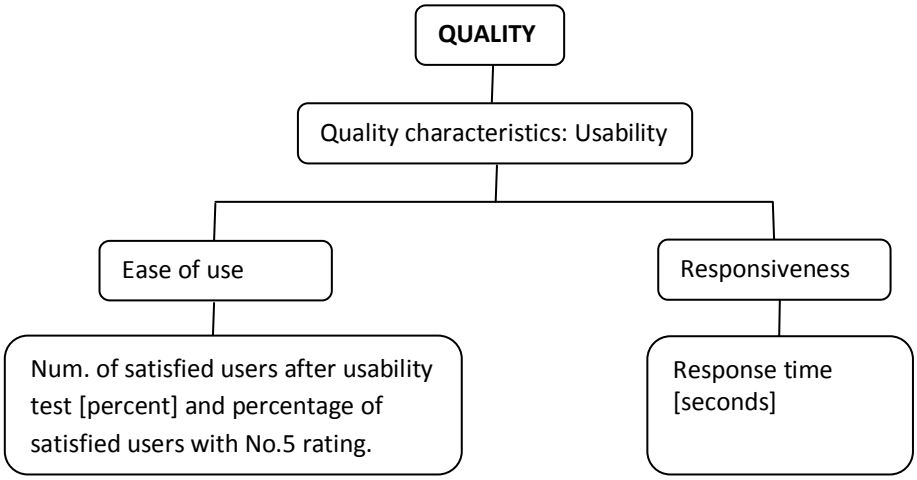

Figure 3: model for quality characteristic: usability.

6.1.2 Correctness

Quality of information provided by the proposed feature will also be assessed based on its correctness. Correctness of information provided by the proposed feature is essential for all emergency response cases, especially for the purposes of locating security guards and objects in times of emergency and also in addressing all concerns raised in section 5.1.3. The correctness of the proposed feature will be measured and assessed according to the following quality attributes and metrics.

- **GPS coordinates correctness –** the GPS coordinates for a particular location created for an object will be compared to coordinates of that same object but on more precise or accurate GPS system in order to effectively compare its correctness. The more precise or accurate device would be a device that uses assisted GPS (AGPS) or differential GPS (DGPS). The DGPS is more effective at broadcasting the difference between the positions indicated by the satellite systems and the known fixed positions of objects while the AGPS uses an assistant server which assists in providing correct and more precise location of objects. The GPS coordinate correctness quality attribute will be measured using the mean deviation between coordinates metric, which will be mean difference between coordinates of an object recorded from the more accurate (standard) GPS device and the coordinates of that same object recorded from the proposed feature. An alternative means of ensuring the correctness of the GPS coordinates will be to equip the existing mobile device with an AGPS receiver. Even though this alternative could be more expensive, it would enhance the performance and increase the reliability of the proposed feature.

Metrics:

- *Mean deviation between coordinates*.
  This software metric will measure the average deviation or degree of deviation between the position of an object in coordinates, recorded by the proposed feature and that of the actual position of the object. The unit of measurement for this metric will be yards or meters.

- **Timeliness –** the frequency of updated in formation, in terms of current/recent maps updates and real time location of security guards in terms of coordinates are very essential. Current and recent updates in terms of streets maps, etc should be readily available to the proposed feature. Timeliness of proposed feature will be measured with regards to the real time mobility of the security guard since this is essential during emergency response and also to help in assuring customers of the presence of the security guard on their property as they requested. The location of the security guard in real time should be available in coordinates at least every 3 minutes. Updated location in coordinates of the security guard should also be sent periodically from the existing mobile device to the back office.

Metrics:

- *Number of updates per hour*.
  The unit of measurement for this metric will be updates/hour.

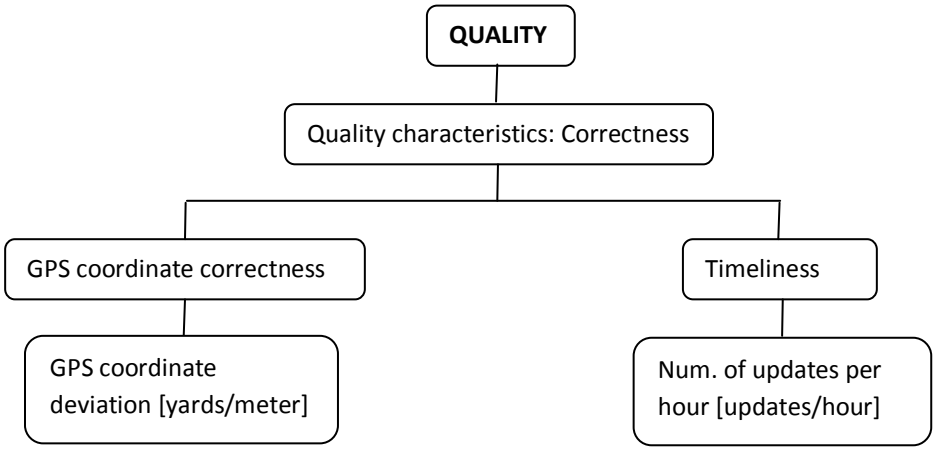

Figure 4: model for quality characteristic: correctness.

6.1.3 Reliability

The need for a reliable failure-free system is essential. Coverage for GPS indoor buildings and in tall buildings are usually poor, inaccurate and sometimes unavailable. These factors reduce reliability, performance and also cause failures. The issue of poor coverage or reception from satellite could be solved with the introduction of assisted GPS (AGPS) or Differential GPS (DGPS) for the proposed feature. The AGPS provides assistance to GPS devices though data available from a network. This data is made available to the GPS receiver when there is little or no signal from the satellite, while the DGPS provides enhancement to GPS devices through a fixed ground based reference station which transmits the difference between the positions indicated by the satellite and the known fixed positions. The AGPS and DGPS methods can be used to obtain much higher accuracy and reliability for the proposed feature.

Reliability of the proposed feature will be measured and assessed by the following quality attribute and metrics.

- **Recoverability -** the proposed feature should be capable of quickly and effectively re-establish its level of performance and recover affected data in case of a failure within the shortest possible time and also with less effort. Recoverability of the proposed feature is essential especially in the area of emergency response. The recoverability quality attribute will be measured by the metrics described below.

  Metrics:

  - *Time to restore.*
    E.g. time take for the system to recover after a failure has occurred. The unit of measurement for this metrics will be seconds, minutes or hours.

- **Availability –** the proposed feature should be up and running twenty four hours each day. The proposed feature and all its functions should be accessible and available at all times as these factors are essential to the success of the proposed feature. Availability of the proposed feature will be measured by the mean time between failure metric described below.

  Metrics:

  - *Mean time between failures*.
    Mean time between failures should not be less than 1week. The unit of measurement for this metric will be hours.

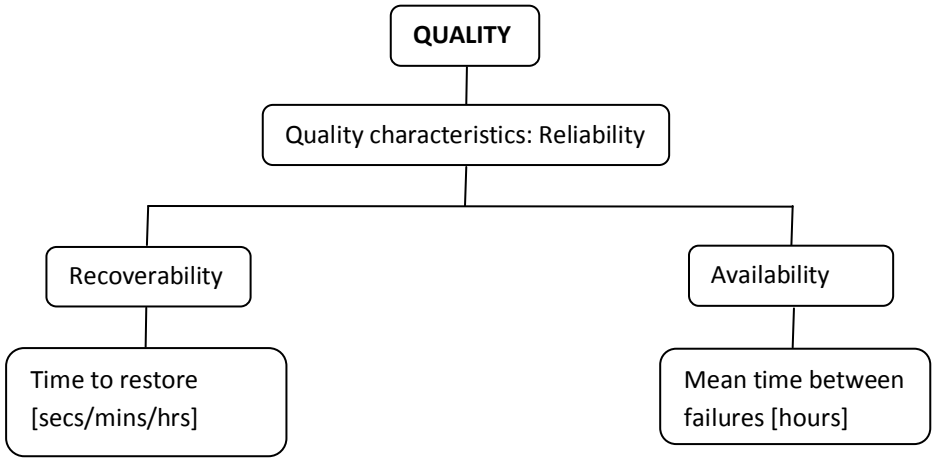

Figure 5: model for quality characteristic: reliability.

6.2 Feature revision

The ability of the proposed feature to undergo smooth revision or changes is essential. Extension and modification of the proposed feature and its functions should be easy to carry out so as to improve the quality of the proposed feature in the future. The maintainability quality characteristic is described using the modifiability and the testability quality attributes.

6.2.1 Maintainability

The proposed feature should be maintainable after its development that is it should support all future modifications. Maintainability of the proposed feature will be describe and assessed using the modifiability and the testability quality attribute.

- **Modifiability –** this quality attribute will describe the degree to which the proposed feature supports adding new functions after release without recompilation. In order to have an easy modification process, there should be more API functions since each of these API functions would provide a means for a future extension. The modifiability quality attribute will be measured using the metrics below.

  Metrics:

  - *Number of API functions available via .NET interface or components.*

- **Testability -** this quality attribute will be used to test and validate the proposed feature. The performance standard for the proposed feature and all its future modification must

be zero defects, as advocated by (Crosby P. B). Zero defects should be the target for the proposed feature. The testability quality attribute will be measured using the metrics below.

Metrics:

- Number of test classes per a method. The unit of measurement for this metrics will be test class/method.
- Number of test classes per a function. The unit of measurement for this metric will be test class/function.

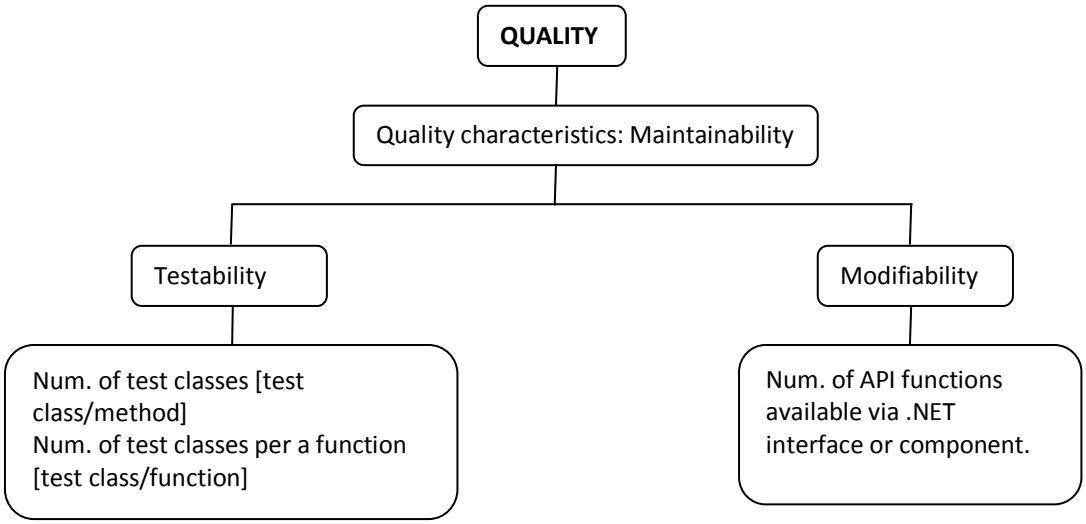

Figure 6: model for quality characteristics: maintainability.

7 Quality model (QM)

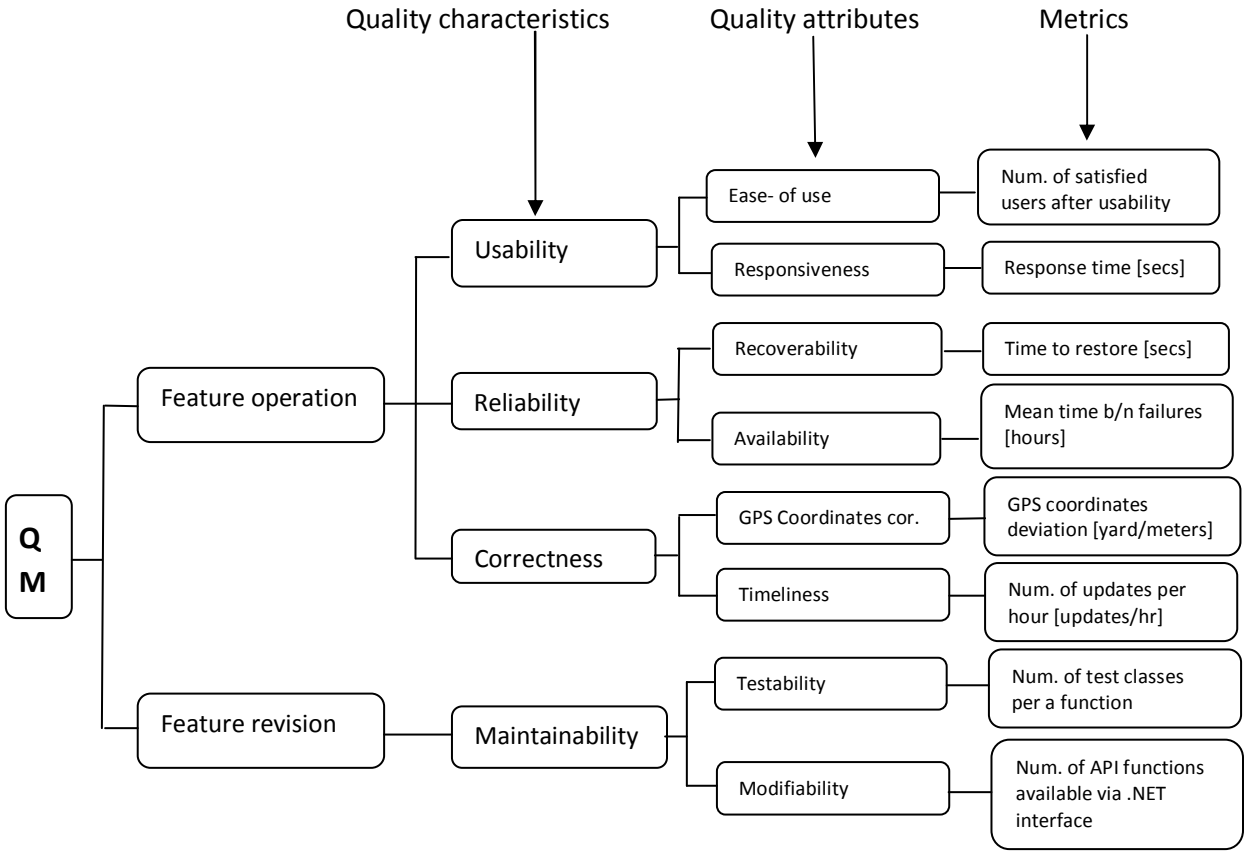

Figure 7: quality model for the proposed feature.

8 Discussion and conclusion

The ever growing need of quality information flow between all three categories of GuardTools users, specifically the security guards, security guard companies and their customers is evidently essential. Introducing a positioning feature to the existing mobile device with the right functions, with regards to customer needs and requirements would be very beneficial, not only to users but also to the industrial partner. This will be because information sharing between security guards, security guard company, security guard company's customers, emergency agencies and also other security agencies would be improved. Introducing a positioning feature to the existing mobile device would also lead to positive operational results as seen in the success story of the location based notification system (LBNS) implemented by the Dutch police since it will provide ready access to essential location relevant information.

The positioning functionalities that were focused on during this research were mainly tracking and navigation. This was because both security guard companies and the security guards focused more on safety and also in locating resources and objects, and less on the end-user customer. The tracking and navigational functionalities were found out to be essential and beneficial in the areas of emergency response, safety of the security guard and also a means of quality improvement in daily work practice and also of the existing mobile device. The evident benefits from the tracking and navigational functionalities were limited solely to the security guard companies and the security guard since they were the main focus group for this research.

Introducing a positioning feature can serve as an effective means of collecting data for GIS used by the security companies. For GuardTools Office, introducing a positioning feature, would not only mean an effective means of tracking or locating resources but also data collected through the positioning feature can be used for effective data analysis, which will in turn help in effective planning, scheduling, dispatching and reporting analysis by the office-based operative personnel (back office). For GuardTools Mobile a positioning feature would not only mean an effective means of locating resources, but will also mean an improvement or an increase in the level of assurance of the safety of the security guard.

In conclusion, introducing a positioning feature with selected functions would not only improve the quality of the GuardTools but also go a long way to improve the quality of daily work practice. This improvement in terms of quality can only be achieved through relevant quality attributes and metrics embedded in the proposed quality model. These quality attributes and metrics must be applied at the various stages during the software development process for the proposed feature since they are essential in measuring, controlling and assuring the quality of the proposed feature and most importantly the overall quality of GuardTools. These quality attributes and metrics will not only provide a means of assessing or measuring quality now but will assist in ameliorating quality by providing an effective and efficient means of comparing previous states to current states in order to attain a much higher quality throughout subsequent future modifications of the proposed feature.

8.1 Future Work

Future research could be carried out to effectively study the work practice of all three categories of users in order to come up with more valid conclusions about the effects of positioning on GuardTools and daily work practice and there by discover more positioning functionalities that will be beneficial to all three categories of users. This research focused on mainly on the security guard companies and their security guards. Future research could be done to focus extensively on the end user customers, specifically on GuardTools Web and also the area of improving or enhancing the quality of reporting not only for the security guard company and their security guards but also for the end user customer. An improvement in the

quality of reporting, through a positioning functionality would not only improve the overall quality of the GuardTools and of daily work practice, but would also go a long way in assisting to maximize profits for the industrial partner.

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10 Appendix

10.1 Focus Group

The focused group consisted of 3 companies and two interviewees.

10.2 Companies

Company 1 – is a company that offers an IT-based operational support system that addresses the companies' competitiveness, efficiency and quality for security guard companies. The operational support system connects a work-flow between operational stationary personnel, personnel on the field and the customers of the security guard company. Company 1 is an industrial partner for this research.

Company 2 – is a comprehensive and nation wide security company that provides skilled guard services for businesses and the public sector in Sweden.

Company 3 - is an insurance company for the city of Gothenburg and an end-customer.

10.2.1 Interviewees

Informant 1 – is the CEO at company 1 and also my contact at the industrial partner.

Informant 2 - is an operations manager at company 2 and is responsible for all the security guards at his department. Informant 1 is also a user of the GuardTools office.

Informant 3 - is a risk engineer at company 3, an end user customer and also a user of GuardTools web.

10.2.2 Questionnaire for interview

1. What is your role or responsibility in your company?
2. Please describe a typical day at work.
3. What are some of the constraints you have during your work? For example limitations, problems and set backs?
4. What are some of the constraints you have while using the GuardTools?
5. If you had to choose new features to be added to the GuardTools, what would it be?
6. Would you like to have GPS and maps in the GuardTools? Please give reason for your answer if No.
   Note: If yes continue with question
7. How or in what way will GPS and maps affect or help your work? (Benefits)
8. Do you think GPS and maps can be used to improve the quality of your work and also the quality of the GuardTools in general? Please give reasons for your answer.
9. Do you think GPS and maps can be used to ensure the safety of security personnel?
10. Do you think GPS and maps can be used to improve emergency response in your work?
11. Which areas of your work do you think GPS and maps introduction will improve greatly?
12. If you had the chance to prioritize GPS and map feature to other feature that u mentioned in question 5 how that priority list be?

10.2.3 Questionnaire for survey

1. What is your role or responsibility in your company?
2. What are some of the constraints you have during your work? For example limitations, problems and set backs?
3. What are some of the constraints you have while using the GuardTools?
4. If you had to choose new features to be added to the GuardTools, what would it be? Please list features in order of your preference.
5. Would you like to have GPS and maps in the GuardTools? Please give reason for your answer if No.

6. Do you think GPS and maps can be used to improve the quality of your work and also the quality of the GuardTools in general? Please give reasons for your answer.
7. Do you think GPS and maps can be used to ensure the safety of security personnel?
8. Do you think GPS and maps can be used to improve emergency response in your work?
9. Which areas of your work do you think GPS and maps introduction will improve greatly?
10. If you had the chance to prioritize GPS and map feature to other feature(s) that you mentioned in question 4 how would that priority list be?