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2009

An ontology-driven topic mapping approach to multi-level management of e-learning resources

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Recommended Citation
Helfert, Markus; Foley, Owen; and Cappiello, Cinzia, "An ontology-driven topic mapping approach to multi-level management of e-learning resources" (2009). *ECIS 2009 Proceedings*. 59.
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ANALYSING THE EFFECT OF SECURITY ON INFORMATION QUALITY DIMENSIONS

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Abstract

Information quality (IQ) has become a critical concern in today's organisations. Although recent studies of information systems indicate an increasing importance of IQ, foremost research is still limited. Indeed, little is known about the impact of various design decisions on IQ. Recent research shows that security measures are increasingly important for any information system; however security measures are often introduced without considering the effect on IQ. At the same time, literature provides us with indications that trade-offs between various IQ dimensions exist. In this article we aim to investigate how security measures impact on different IQ dimensions. We carried out an experiment, which indicates that security measures have a significant effect on timeliness, whereas other dimensions are not particularly influenced. This observation led us to the proposal of cost-benefit considerations, an important aspect for IQ management. The study is valuable for both research and practitioners. Further research studies can build on our observations and extend the research. Practitioners are provided with arguments for considering IQ trade-offs in relation to security measures.

Keywords: Information Quality, Trade-offs, Security, Cost-Benefit model

1 INTRODUCTION

Over the last two decades researchers have addressed data quality (DQ) and information quality (IQ) from various view points. Researchers have developed many frameworks, criteria lists and approaches for assessing and measuring IQ. Also, literature provides us with numerous case studies, investigating IQ in practice. However, despite the increasing interest in this topic, little is known about the effects and relations between different criteria of IQ. Knight and Burn (2005) point out that despite the sizeable body of literature available relatively few researchers have tackled quantifying some of the conceptual definitions such as security and accessibility. We aim to address this limitation of foremost research and intend to provide insight into associations of different IQ criteria.

Due to the increasing importance of security and accessibility we focus on these aspects and their implications on other IQ dimensions. In our previous research (Fehrenbacher and Helfert, 2008) we show that the importance of security and accessibility as IQ criteria has increased. This is accompanied with an increase in security requirements and complexity of information systems. Due to the increasing complexity and variety of access methods, question about its impact arises. What are implications of security measures on other IQ criteria? Does architecture have a significant (moderating) effect on the relationship between IQ criteria? What is the difference in the impact of accessibility from a workstation compared to a mobile device?

In order to address current limitations, this research focuses on the security and accessibility dimension of IQ. Review of related research shows that most IQ frameworks consider accessibility and security; however researchers classify or consider these IQ dimensions diversely among various IQ frameworks. Furthermore, our research indicates an impact of security and accessibility on other IQ dimensions. An experiment is conducted to evaluate the effect on IQ dimensions of varying levels of security to an Information System (IS). It allows for a thorough analysis of accessibility as a dimension of IQ. We propose a research model and illustrate results of an experiment, which support our research hypothesizes.

The paper is structured as follows. Section 2 reviews related work and provides indications for IQ assessments and trade-offs. Section 3 centers on selected IQ dimensions and proposes a research model and the underlying assumptions. Section 4 presents an experimental research and illustrates the key results. Section 5 discusses the implications of our research and proposes some considerations concerning cost-benefit considerations. We conclude our paper in section 6, in which we discuss some limitations of our research and summarize further research directions.

2 RELATED WORK

Many studies have confirmed that IQ is a multi-dimensional concept (Ballou and Pazer 1985, (Redman 1996, Wand and Wang 1996, Wang and Strong 1996, Huang et al. 1999). Over the last two decades, different sets of IQ dimensions have been identified from both the database and management perspectives. Often IQ and DQ alike has been defined as ”fitness for use”, in that way that data or information of high quality “meets or exceeds users’ requirements.” (Wang and Strong, 1996). Most researchers consider IQ by a set of dimensions that are able to describe different characteristics of data or information. Following many other research, we do not distinguish explicitly between DQ and IQ since our findings are general and suitable for both concepts. Therefore, both terms are used in this article interchangeably.

The literature provides numerous definitions and classifications of IQ dimensions analyzing the problem in different contexts and from different perspectives. Common examples of IQ dimensions are accuracy, completeness, consistency, timeliness, interpretability, and availability. Many researchers have proposed several measures and approaches for each IQ dimension. Some suggestions

include aggregation functions (e.g. weighted sum, ratio, max, and min) in order to provide a unique IQ index. Considering different measurement values of the same dimensions or different measures associated with heterogeneous dimensions is challenging and the subject of current research in IQ.

A variety of IQ assessment methodologies have been proposed over the last decade. We select five popular methodologies (Redman 1996, Huang et al. 1999, Lee et al. 2002, Pipino et al. 2002, and Stvilia et al. 2007) and evaluate these by following criteria: definition of IQ dimensions, classification of IQ dimensions, model, tool, and case study. Definition of IQ dimensions describes which IQ dimensions and perspectives are defined. Classifications of IQ dimensions are used to compare the classification of dimensions in each methodology. The theoretical basis of the methodology is described in the category model. Tool expresses how the methodology is implemented. Case study concentrates on the empirical feasibility of these methodologies.

If the methodology is only applied to a specific domain, it is considered as a specific methodology. If the methodology can be applied to multiple domains, it is regarded as a generic methodology. If the case study is provided in the literature, we classify the methodology as a practical study otherwise it is theoretical. We summarize our evaluation of the five methodologies and their characteristics in table 1.

	Redman (1996)	**Huang et al. (1999)**	**Lee et al. (2002)**	**Pipino et al. (2002)**	**Stvilia et al. (2006)**
Definition	12 IQ dimensions are defined from the database community	16 IQ dimensions are defined from management community	15 IQ dimensions are defined from both communities	16 IQ dimensions are defined from both communities	22 IQ dimensions are defined from both communities
Classificati on	Conceptual view, data value and representation	Classification of Wang and Strong (1996)	Classification of Kahn et al. (2002)	Without classifications	Classification of Wang and Strong (1996)
Model	A step by step procedure adapted from statistical process control	Adopt Deficiency model of Wand and Wang (1996)	Adopt PSP/IQ model of Kahn et al. (2002)	The model combines subjective and objective assessment	The model consists of activity types, IQ Problems, and IQ taxonomy
Tool	DCI system	IQ assessment survey	IQ assessment survey	IQ assessment software	IQ assessment survey
Case Study	Telstra Co. Ltd.	Appliance Company		1, Global Consumer Goods, Inc., 2, Data Product Manufacturing, Inc.	1, Simple Dublin Core 2, English Wikipedia
Conclusion	Specific, practical	Specific, practical	Generic, Theoretical	Generic, practical	Generic, practical

Table 1. Comparison of IQ assessment methodologies

Pipino et al. (2002) categorizes IQ assessment into objective and subjective assessment. Objective IQ assessments reveal IQ problems in databases while subjective IQ assessments reflect the needs and experiences of data consumers. In order to discuss IQ assessments from objective and subjective perspectives, we follow this general classification.

Objective IQ assessment measures the extent to which information conforms to quality specifications and references. We distinguish objective IQ assessments into two categories: intrinsic and real-world IQ assessment. Intrinsic IQ assessment follows a data perspective and uses data specifications to assess the quality of the data in the database. For example, Savchenko (2003) develops item frequency

rules and regular expression patterns to facilitate an automated intrinsic IQ assessment. Real-world assessment follows the ontological perspective and compares real-world facts to discover IQ deficiencies. For example, Wand and Wang (1996) identify data mapping deficiencies between real world states and its representation in information systems. Overall, objective IQ assessment can be considered as the procedure of comparing current data value with an ideal data value of high quality.

Subjective IQ assessment measures the extent to which information is fitness for use by information consumers. Information consumers assess IQ according to their demands and expectations. Subjective IQ assessment follows the user perspective and focuses on discrepancy between the current quality of information and the user's expectation. In order to indicate the differences between objective and subjective IQ assessment, we provide a comparison in table 2.

Method / Feature	**Objective assessment**	**Subjective assessment**
Tool	Software	Survey
Measuring Object	Data	Information
Standard	Rules, Patterns	User Satisfaction
Process	Automated	User Involved
Result	Single	Multiple

Table 2. Comparison of objective and subjective IQ assessment

Objective IQ assessment uses mostly software applications to evaluate the data in a database by a set of quality rules. This can often been carried out automatically. Subjective IQ assessment uses typically a survey or interview approach to measure the contextual information by data consumers. The advantage of objective IQ assessment is that it allows one to automatically process large data sets. Subsequently to the assessment, the objective approach obtains a single or aggregated assessment result. Subjective IQ assessment normally involves data users' opinion or evaluations on data samples. Although subjective assessment may contain different assessment results due to the different opinions and roles of information consumers (Strong et al. 1997), the advantage of subjective IQ assessment is the measurement of a comprehensive set of IQ dimensions. Furthermore, certain IQ dimensions such as believability and reputation are only suitable for subjective IQ assessment. Recognizing the advantages of both objective and subjective assessment, researchers (Pipino et al. 2002, Kahn et al.2002) have combined objective and subjective IQ assessment.

A number of literatures have analyzed dependencies of IQ dimensions. Ballou and Pazer (1995) propose a framework to investigate tradeoffs between accuracy and timeliness in the context of decision making. Redman (1996) points out that timeliness has an impact on accuracy. Ballou and Pazer (2003) model the utility and tradeoffs between completeness and consistency. Olson (2003) implies the relationship between accuracy and completeness and states that consistency is a part of accuracy. Cappiello et al. (2004) analyze the time-related accuracy and time-related completeness in multi-channel information systems. Amicis et al. (2006) propose a data-driven approach to analyze the dependency between syntactic accuracy and timeliness as well as the dependency of completeness and timeliness.

Observing the literatures above, we divide relationships of IQ dimensions into two categories: negative correlated and positive correlated dependencies. Negative correlation refers to the improvement of one IQ dimension that may lead to a decreasing value in another dimension (often also referred as IQ tradeoffs). For example, by introducing new information to improve completeness, the new introduced information may be inconsistent with the existing information. In this manner, completeness and consistence are negatively correlated. Positive correlation means two IQ dimensions are mutually contributing to a shared set of IQ problems. For example, when timeliness and accuracy are sharing outdated data as their mutual IQ problem, the improvement of timeliness may lead to an increasing value in accuracy. In this way, timeliness and accuracy are positively correlated. According to the discussion above, we summarize correlations of IQ dimensions in table 3.

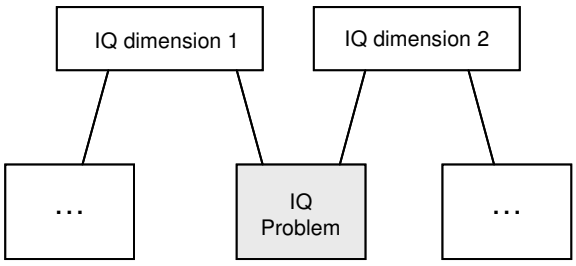
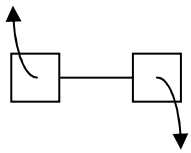
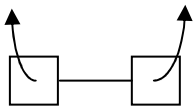
Negative Correlation	Positive Correlation
Improvement of certain information quality dimensions, may lead to a decreasing value in other dimensions: tradeoffs between completeness and other dimensions, accessibility and other dimensions, security and other dimensions, relevancy and other dimensions.	 When we improve IQ dimension 1, IQ dimension 2 may be improved or remain at the same quality value. The quality values depend on the mutual IQ problem.
Negative Correlation Model	**Positive Correlation Model**
	

Table 3. Dependency of IQ dimensions

Many researchers have indicated various relations between IQ criteria, such as timeliness and availability. In table 4 we combined a list of common IQ criteria and relations described in literature (Fehrenbacher and Helfert, 2008). We indicate a potential negative (N) or positive correlation (P). As the list indicates, various trade-offs of IQ dimensions can be assumed. However, most researchers merely propose some form of relations but do not further investigate the strength or direction of the relation.

Item 1	Item 2	N	P	Source
Timeliness	Accuracy	•		Eppler (2001) adapted, Ballou and Tayi (1999), Ballou and Pazer (2003), Scannapieco and Batini (2006)
Timeliness	Believability		•	Eppler (2001) adapted
Timeliness	Consistent representation	•		Scannapieco and Batini (2006) adapted
Timeliness	Completeness	•		Scannapieco and Batini (2006)
Completeness	Accuracy			Ballou and Tayi (1999),Cappiello Francalanci and Pernici (2003), Fisher et al. (2006)
Completeness	Consistent representation	•		Ballou and Pazer (2003), Scannapieco and Batini (2006) adapted
Completeness	Conciseness	•		Eppler (2001) adapted, Fisher (2006) adapted
Accessibility	Security		•	Huang, Lee and Wang (1999), Eppler (2001), Fisher et al. (2006)
Accessibility	Accuracy	•		Missier et al. (2003)

Table 4. Selected relationships of IQ criteria

Based on a framework proposed by Wang and Strong in 1996, we evaluated in a recent empirical research the importance of IQ dimensions (Fehrenbacher and Helfert, 2008). Comparing the item rankings our research showed a similar ranking pattern, however accessibility and security among

others received increasing importance. Due to its increased importance but limited attention in foremost literature, we decided to focus our research on security and accessibility. To illustrate the effects and implications of trade-offs among IQ dimensions, we analyse particular effects of security and accessibility on timeliness.

3 INFORMATION QUALITY DIMENSIONS AND RESEARCH MODEL

3.1 Security and Accessibility as IQ dimensions

The literature has put forward a number of frameworks and classified the dimensions associated with each of these frameworks. In addition to the variety of IQ frameworks, most provide their own definitions for security and accessibility associated with particular IQ frameworks. Generally it can be assumed, that an increased level of security impacts on the accessibility to an information system. The relationship between security and accessibility allows for examination of the attributes of accessibility. Thus, accessibility in essence is a function of security. An examination of the accessibility dimension directly relates to the accessibility dimension. Loshin (2001) describes it as the degree of ease of access to information as well as the breadth of access. Wang and Strong (1996) consider that access security is also an important concept that must be taken into account when considering the dimension. Batini and Scannapieco (2006) describe accessibility in terms of the ability of the user to access the data from his / her own culture, physical status / functions and technologies available. In summary, the definition of accessibility is framework dependent. Nonetheless, there is also an ongoing debate about the relation of accessibility to IQ and some frameworks do not even consider it as a dimension of IQ.

With a view to analyzing in more detail the frameworks that are of specific interest to the accessibility dimension, we examined selected IQ frameworks. Table 2 summarizes these frameworks outlining the dimensions associated with each framework. We selected most prominent frameworks in the field of IS and IQ research. The examination allows this research to focus in more detail on the frameworks that pertain to accessibility as noted in column three of table 2.

Framework	**Dimensions / Quality Category**	**Accessibility**
Wang and Strong (1996) (A Conceptual Framework for Information quality)	Believability, Accuracy, Objectivity, Reputation, Value-added, Relevancy, Timeliness, Completeness, Appropriate Amount of Data, Interpretability, Ease of understanding, Representational consistency, Concise Representation, Accessibility, Access Security.	Accessibility, Access Security.
Zeist and Hendricks (1996) (Extended ISO Model)	Functionality, Reliability, Efficiency, Usability, Maintainability, Portability	
Alexander and Tate (1999) (Applying a quality framework in a Web environment)	Authority, Accuracy, Objectivity, Currency, Orientation, Navigation.	
Katerattanakul et al.(1999) (IQ of individual web sites)	Intrinsic, Contextual, Representational, Accessibility.	Navigational Tools Provided.

Shanks and Corbitt (1999) (Semiotic-based framework for IQ)	Well defined / formal syntax, comprehensive, unambiguous, meaningful, correct, timely, concise, easily accessed, reputable, understood, awareness of bias.	Easily Accessed.
Dedeke (2000) (Conceptual framework for measuring IS quality)	Ergonomic Quality, Accessibility Quality, Transactional Quality, Contextual Quality, Representational Quality	Technical access, System availability, technical security, data accessibility, data sharing, data convertibility
Naumann & Rolker (2000) (Classification of IQ Metadata Criteria)	Believability, Concise Representation, Interpretability, Relevancy, Reputation, Understandability, Value Added, Completeness, Customer Support, Documentation, Objectivity, Price, Reliability, Security, Timeliness, Verifiable, Accuracy, Amount of data, Availability, Consistent Representation, Latency, Response time	
Zhu & Gauch (2000) (Quality Metrics for Information retrieval on www)	Currency, availability, information to noise ratio, authority, popularity, cohesiveness	
Leung (2001) (Adapted extended ISO model for Intranets)	Functionality, Reliability, Usability, Efficiency, Maintainability, Portability.	
Kahn et al.(2002) (Mapping IQ dimensions into the PSP/IQ Model)	*Product Quality:* Free-of-Error, Concise, Representation, Completeness, Consistent Representation, Appropriate Amount, Relevancy, Understandability, Interpretability, Objectivity *Service Quality*: Timeliness, Security, Believability, Accessibility, Ease of Manipulation, Reputation, Value Added	Accessibility & Service Quality
Eppler & Muenzenmayer (2002) (Conceptual work for IQ in the Web Site Context)	Comprehensive, Accurate, Clear, Applicable, Concise, Consistent, Correct, Current, Convenient, Timely, Traceable, Interactive, Accessible, Secure, Maintainable, Fast.	Accessible, Secure, Maintainable, Fast.

Table 5. IQ Frameworks and Dimensions

The examination of the IQ frameworks in table 5 demonstrates that accessibility does feature as a dimension to varying degrees across many frameworks. Reviewing these selected frameworks resulted in a list of drawbacks, which current frameworks do not address. We identified the following five key research challenges related to the accessibility and security dimensions of IQ:

- What are the impacts of accessibility / security on the overall IQ?
- How do accessibility / security impact on other dimensions in an IQ framework?
- Do current IQ frameworks provide valid and reliable measures?
- Is the impact of accessibility / security consistent across IQ frameworks?
- What impact do multiple access / security methods have upon IQ?

Answering these questions would allow for providing an insight or even quantifying the impact of accessibility and security on other IQ dimensions and thus on IQ.

3.2 Hypothesis and Assumptions

As discussed above, research has indicated many relationships between IQ dimensions. Several studies aimed to investigate the relationship between selected dimensions, however regarding its importance

accessibility and security related trade-offs are often not considered. We centre our research on these important dimensions, and investigate their effect on other IQ dimensions. From the related literature above, we can hypothesis a general relation between the dimensions. However, little is know of which dimensions are affected or their significance.

In our article we centre on process oriented IQ dimensions such as timeliness and availability. Other intrinsic IQ dimensions, such as consistency, completeness and accuracy are less affected. Considering Security measures, we assume following indicative relationship. *As security measures are increased, timeliness and availability decrease. Other dimensions are not affected.* Security measures act as independent variable, whereas other IQ dimensions act as dependent variables. We assume that this effect can be perceived by information users, and thus result in a lower perceived IQ. There are many suggestions for discrete measures for IQ values, and thus we can assume such measure. For security we assume a categorical measure, consisting of advanced, intermediate and basic security measures.

4 AN EXPERIMENT TO SUPPORT THE RESEARCH MODEL

In order to support our research model, we conducted an experiment. In contrast to other research methods, experimental research is particularly suitable for the identification and study of relationships between a small number of variables. Experimental research is found to be effective in addressing the cause and effect relationship (Campbell and Stanley 1963, Jarvenpaa et al. 1985). Although our experiment represents a simplified real world scenario, it assists us to understand fundamental relationships between IQ criteria. However, one of the challenges is the isolation of and control of exogenous factors, such as decision complexity and experience.

Data can be collected in a number of ways in order to answer research questions. It can be gathered by direct observation or reported by the individual. Fisher et al. (2001) indicate that systematically collecting data to measure and analyze the variation of one or more processes forms the foundation of statistical process control. In the case of an experiment a variable is manipulated and the corresponding effect on the other variables is noted. Fisher et al. (2001) also point out that a statistical experiment is a planned activity where variables that have the potential to affect response variables are under the control of the researcher.

In order to examine the impact of accessibility dimension as an IQ dimension, we examine four IQ dimensions across three architectures and two IS domains. The aim of this experiment is to demonstrate what trade offs if any are associated with varying levels of security.

- *IQ Dimensions:* As IQ is a multidimensional concept the impact on individual dimensions is examined in the experiment. For our research, we selected four dimensions that are common across IQ frameworks free-of-error, completeness, consistency and timeliness. In order to measure IQ, a subset of the questions from the AIMQ (Lee et al. 2002) methodology are employed. The specific survey questions with respect to free-of-error, completeness, consistency and timeliness were used.
- *Architectures:* Web, Client Server, Work Station
- *Domains:* The two IS domains are a library system and a student exam result system. The major areas of functionality of both systems were employed during the experiment. Three different access methods were used namely workstation, client server and web. These are used on day to day operation of both systems. All users were also day to day operators of the systems.

The experiment sets different levels of security and measures the corresponding effects on the four dimensions. Three levels of security are manipulated in the experiment basic, intermediate and advanced. Basic security has no restrictions set while the advanced level is stringent. There were twenty seven participants for the library system and eighteen for the student exam result system. The results recorded are the average scores for the twenty seven participants of the Library IS and eighteen participants of the student exam system IS. The experiment was conducted over a two day period in March 2008. The results of our experiment are illustrated descriptively and set out in a number of tables below (tables 6 – 11). Subsequently we describe and interpret the results.

Security Level	Architecture	Free-of-Error	Completeness	Consistency	Timeliness
Advanced	Web	79%	84%	73%	46%
	Client Server	83%	88%	77%	48%
	Work Station	81%	85%	76%	56%

Table 6. Library IS Domain – Security Level Advanced

Security Level	Architecture	Free-of-Error	Completeness	Consistency	Timeliness
Intermediate	Web	74%	71%	71%	60%
	Client Server	82%	78%	77%	61%
	Work Station	84%	81%	79%	64%

Table 7. Library IS Domain – Security Level Intermediate

Security Level	Architecture	Free-of-Error	Completeness	Consistency	Timeliness
Basic	Web	78%	79%	74%	81%
	Client Server	85%	81%	75%	87%
	Work Station	82%	84%	77%	89%

Table 8. Library IS Domain – Security Level Basic

Security Level	Architecture	Free-of-Error	Completeness	Consistency	Timeliness
Advanced	Web	74%	81%	74%	49%
	Client Server	77%	83%	77%	53%
	Work Station	79%	88%	80%	62%

Table 9. Student Exam IS Domain –Security Level Advanced

Security Level	Architecture	Free-of-Error	Completeness	Consistency	Timeliness
Intermediate	Web	77%	77%	75%	64%
	Client Server	81%	84%	78%	69%
	Work Station	79%	85%	72%	71%

Table 10. Student Exam IS Domain –Security Level Intermediate

Security Level	Architecture	Free-of-Error	Completeness	Consistency	Timeliness
Basic	Web	80%	75%	71%	81%
	Client Server	82%	78%	72%	82%
	Work Station	88%	79%	76%	86%

Table 11. Student Exam IS Domain – Security Level Basic

The results are based on a subset of the AIMQ survey instrument (Lee et al. 2002). This questionnaire has been used in many studies. Appendix one lists the questions that were employed in the survey. The key findings of the experiment indicate that as security levels are manipulated the other IQ dimensions are affected. Fisher et al. (2001) point out that if data is not accessible then quality will decrease because information can not be accessed in a timely fashion. There is a trade-off between security and timeliness. Our result show timeliness is significantly affected. As the level of security became more advanced the users survey results with respect to the timeliness dimension were less and less satisfactory. This research indicates that security as a dimension of IQ can have different levels and the more access is restricted the greater the dissatisfaction with the timeliness dimension. It is not merely two states of accessible and inaccessible.

A closer examination of the timeliness dimension is warranted. For example in table 6, table 7, table 8 which reflect results with respect to the library IS there is an increase in satisfaction in the survey results with respect to timeliness as the level of security is lessened. At a high level of security the satisfaction with timeliness is 46% for web access, 48% for client server and 56% for work-station. This is an average satisfaction of 50% with the timeliness dimension. As can be seen from the results the average increases to 61.6% for intermediate and 85.6% for a basic level of security. The results for the student exam system IS domain display a similar pattern with an average of 55% satisfaction with the timeliness dimension when there is an advanced level of security where as at a basic level of security the satisfaction was at 83%.

The other dimensions surveyed; free-of-error, completeness and consistency did not radically change across IS domain. Another interesting finding was the users' satisfaction with the IQ dimensions when web architecture was employed. It compared less favourably with client server or workstation architectures. This was the case for both domains examined.

5 IMPLICATIONS – TOWARDS A COST/BENEFIT MODEL

As our research above indicates, there is an interesting relationship between timeliness and security. In the following section we analyse the implications of these observations, and examine the impact of IQ level from a cost and benefit perspective.

The trade-off between security and timeliness is often analyzed in real-time applications. In fact, these applications have clear timeliness constraints but sometimes they can also have security issues in addition to timing constraints. The timing constraints of real-time applications are typically specified in the form of rules that require that an operation has to be completed in a specified time. Failures of such rules can cause critical situations since the provided results may be useless if not timely. Real-time systems are often adopted in particular environments such as defence systems, air traffic control or stock trading where data security is a fundamental aspect. These scenarios require access restrictions in order to differentiate the data accessibility on the basis of the users that require some information. Security and timeliness requirements conflict with each other since the implementation of methods to guarantee data security may introduce some delays in the application execution. Whether to maintain timeliness or security is dependent upon the system.

Let us consider a system A in which security is preferred to timeliness and a system B in which timeliness is preferred to security. Considering the level of security (SL), we can assume that timeliness is inversely proportional to the security level along a general exponential decay trend. On the contrary, increasing the security level the quality costs increase exponentially. In fact, large investments are needed for a secure system and thus for the adoption of complex protocols. We make the assumption that the economical benefits deriving from IQ are proportional to the value assessed for the IQ dimensions. Along these considerations, it is possible to compare costs and benefits related to the different security levels and evaluate the total profit in the two considered scenarios. Cost and benefit analysis show (see Figure 1) that it is possible to define the most suitable security level by

calculating, the maximum value of profit, resulting from the subtraction of the security costs from the IQ benefits.

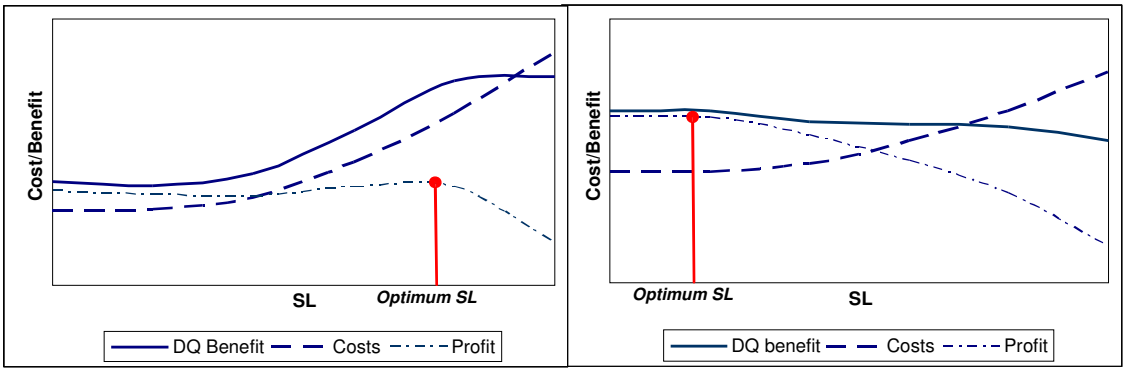


Figure 1. Cost/benefit analysis – (a) Security is considered more important than timelines, (b) timeliness is considered more important than security

6 CONCLUSIONS

In literature as well as in practice, it is often assumed that in order to reach the maximum IQ and the best satisfaction of user requirements maximum IQ is required. However, this disregards the existence of trade-offs among IQ dimensions. Our research indicated that there are significant effects between information system decisions, such as security measures, and IQ. Applying three distinct security levels, advanced, intermediate and basic, we found that timeliness is significantly affected. Other dimensions are not significantly affected in our experiment. The research led us to the proposal of some cost-benefit considerations. As discussed, the perception of IQ is important in order to evaluate an optimal security level.

Although we provided an experimental research design, which provided some insights into the relationship between security and IQ as well as IQ trade-offs, our research is still rather conceptual. Due to the relatively low number of participants, the analysis is descriptive. In future research we intend to extend the number of participants and apply suitable quantitative analyses techniques. We also plan to investigate further IQ trade-offs, which subsequently assist us to understand cost-benefit considerations. However, although our research has some limitations, we believe that the results are beneficial for researchers and practitioners. Further research studies can build on our observations and extent the research with experimental or empirical research approaches. A number of the IQ frameworks examined in table two do not consider security. As a result of the initial findings of this research especially with respect to the key finding of security levels and the timeliness dimension it is suggested IQ frameworks need to take the levels of security into account. This it is argued will lead to a more comprehensive view of IQ. Practitioners are provided with arguments for considering IQ trade-offs in relation to security measures. This research suggests that the factors with respect to the architecture employed need consideration when IQ policies are being designed and implemented. Furthermore, in contrast to many empirical researches, this article applies an experimental research approach. The authors believe that this more rigorous approach can complement and enhance the IQ research area, in which case studies are dominating. The authors strongly believe that more experimental research is needed in order to complement the important but often practical oriented research in this particular domain.

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APPENDIX 1

The user is surveyed for their opinion with respect to the following questions, summarized in Table 12.

Dimension	**Question**
Timeliness	This information is sufficiently current for our work. This information is not sufficiently timely. This information is not sufficiently current for our work. This information is sufficiently timely. This information is sufficiently up-to-date for our work.
Accuracy	This information is correct. This information is incorrect. This information is accurate. This information is reliable.
Completeness	This information includes all necessary values. This information is incomplete. This information is complete. This information is sufficiently complete for our needs. This information covers the needs of our tasks. This information has sufficient breadth and depth for our task.
Consistency	This information is consistently presented in the same format. This information is not presented consistently. This information is presented consistently. This information is represented in a consistent format.

Table 12: User Survey