

Proceedings of the 7th Israel Association for Information Systems (ILAIS) Conference July 1, 2013

**Ruppin Academic Center
Emek Hefer, Israel**

**Editors: Dizza Beimel, Rina Zviel-Girshin, Shirly Barlev
Assistant: Omri Mugzach**

The Israel Association for Information Systems (ILAIS) was founded in 2005 as the Israeli chapter of the Association for Information Systems (AIS). The goal of ILAIS is to promote the exchange of ideas, experiences and knowledge among IS scholars and professionals engaged in IS development, management and use.

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

Conference Program

09:00-09:30 **Welcome and greetings:**
 Dov Te'eni, Past President of AIS and Phillip Ein-Dor, President of ILAIS
 Engineering Hall, Engineering Building

Co-Chairs: Dizza Beimel, Rina Zviel-Girshin, Shirly Bar-Lev, Ruppin Academic Center

09:30-10:15 **Keynote speaker: Professor Shimon Schocken, IDC Herzliya,**
 Developing Educational Apps for Mobile Platforms: Problems and Solutions

10:15-10:30 **Coffee Break**

10:30-11:45 **Parallel sessions A-D**

Session A – Room 13

Session Chair: Nitza Geri

Oshrat Ayalon (Tel-Aviv University), **Eran Toch** (Tel-Aviv University)
Understanding the Temporal Aspects of Information Sharing in Online Social Networks

Amit Rechavi (Ruppin Academic Center), **Sheizaf Rafaeli** (University of Haifa)
Major Players' Network in Yahoo! Answer

Benny Bornfeld (Ruppin Academic Center), **Sheizaf Rafaeli** (University of Haifa), **Daphne Raban**
(University of Haifa)
Electronic word-of-mouth spread in Twitter as a function of the message sentiment

Ofer Arazy (University of Alberta), **Oded Nov** (Polytechnic Institute of NYU)
Wiki DNA: Uncovering the Patterns of Online Collaboration

Session B – Room 14

Session Chair: Yoram Kalman

Omri Mugzach (University of Haifa), **Mor Peleg** (University of Haifa), **Steven C. Bagley** (Stanford
University), **Russ B. Altman** (Stanford University)
Modeling DSM-IV Criteria in the Autism Ontology

Sharone Lev (Ben-Gurion University of the Negev), **Tsipi Heart** (Ben-Gurion University of the Negev)
Physician's Perceived EMR-Communication Fit: Towards Developing a Measurement Instrument

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

Liran Politi (Ben-Gurion University of the Negev), **Lior Fink** (Ben-Gurion University of the Negev), **Iftach Sagy** (Soroka Medical Center), **Victor Novack** (Soroka Medical Center), **Shlomi Codish** (Soroka Medical Center)

Usage Patterns of OFEK Health Information Exchange System at the Soroka Emergency Department:
Research-in-Progress

Adi Fux (University of Haifa), **Mor Peleg** (University of Haifa), **Pnina Soffer** (University of Haifa), **Sagit Zolotov** (Technion – Israel Institute of Technology), **Eddy Karnieli** (Technion – Israel Institute of Technology)

Personal Context Profile for Personalizing Clinical Guidelines

Session C – Room 8

Session Chair: Adir Even

Barak Aviad (Bar-Ilan University), **Gelbard Roy** (Bar-Ilan University)

Determining Clustering Segmentation via Feature's Saliency

Michael Feldman (Ben-Gurion University of the Negev), **Adir Even** (Ben-Gurion University of the Negev)
The Effect of Missing Data on Classification Quality

Arie Jacobi (Ono Academic College), **Ofir Ben-Assuli** (Ono Academic College)

Improving Correctness of Scale-free Networks to Message Distortion

Eli Rohn (Ben-Gurion University of the Negev), **Kobi Palachi** (Ben-Gurion University of the Negev), **Omri Chen** (Ben-Gurion University of the Negev)

Cellphone Induced Distracted Driving: Research-in-Progress

*Session D - Room 7
Round Table – 21st Century School*

Session Chair: Rina Zvi-Girshin

11:45-12:00 *Coffee Break*

12:00-13:15 *Parallel sessions E-G*

Session E – Room 14

Session Chair: Eran Toch

Iris Reinhartz Berger (University of Haifa), **Yair Wand** (University of British Columbia)

Software Variability: Where Stakeholders Requirements Meet Software Engineering

Michel Benaroch (Syracuse University)

Development of a Phase-Level Software Maintenance Effort Estimation Model

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

Ron Hirschprung (Tel-Aviv University), **Eran Toch** (Tel-Aviv University), **Oded Maimon** (Tel-Aviv University)
Simplifying Configuration Options of Data Agent in Cloud Computing Environment

Eli Rohn (Ben-Gurion University of the Negev), **Gilad Sabari** (Ben-Gurion University of the Negev)
Israeli Small Business Information Security Posture

Session F – Room 7

Session Chair: Aharon Yadin

Ilana Lavy (The Max Stern Yezreel Valley College), **Aharon Yadin** (The Max Stern Yezreel Valley College)
Do Industry requirements and academic qualifications meet in the case of soft skills?

Aharon Yadin (The Max Stern Yezreel Valley College)
Virtual Learning Environments and Peer Assessments for Enhancing Students' Decision Making Processes

Nitza Geri (The Open University of Israel), **Ruti Gafni** (The Academic College of Tel Aviv Yaffo), **Amir Winer** (The Open University of Israel)
Mobile Video: Opportunities and Challenges for Learning

Rina Zviel-Girshin (Ruppin Academic Center)
Exploring User Choices in Game-based Educational Software for Kindergarten Children: Research-in-Progress

Session G – Room 8

Session Chair: Pnina Soffer

Naomi Unkelos-Shpigel (University of Haifa), **Irit Hadar** (University of Haifa)
Using Distributed Cognition Theory for Analyzing the Deployment Architecture Process

Lihi Raichelson (University of Haifa), **Pnina Soffer** (University of Haifa)
Unifying Event Logs to Enable End-to-End Process Mining

Alex Blekman (Technion, Israel Institute of Technology), **Dov Dori** (Technion, Israel Institute of Technology)
Model-Based Documents Authoring with Object-Process Methodology (OPM)

Inbal Mechrez (University of Haifa), **Iris Reinhartz-Berger** (University of Haifa)
Variability Modeling in Business Processes: Existing Support and Deficiencies

13:15-14:15 *Lunch*

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

14:15-15:15 *Parallel student projects sessions H-J*

Session H - Practical Session - Room 14

Session Chair: Benny Bornfeld

Shahar Mintz, Einav Cohen, Eldad Cohen , Nir Rozenbaum, Ron Ben-Ishay (Technion, Israel Institute of Technology)

Supervisors: Dov Dori, Alex Blekhman

ART building articles

Michael Assraf, Yossi Halevi, Roi Cohen (Azrieli College of Engineering)

Supervisor: Gabi Pinto

Information System development – Polling and presenting environmental data

Cohen Adir, Badichi Niran, Barda Yoni (Ruppin Academic Center)

Supervisor: Benny Bornfeld

Web and mobile application for the management of human resources, logistics and finances in NGOs

Oryan Rokeah, Suzy Salman (Haifa University)

Supervisors: Tsvi Kuflik, Ofra Rimon

Interactive "Treasure Hunt" game application and an information system for the Hecht Museum

Session I - Practical Session – Room 8

Session Chair: Amit Rechavi

Roy Timor, Itamar Snir, Shani Chaushu, Yael Friedmann (Ben-Gurion University of the Negev)

Supervisors: Lior Rokach, Adir Even

A System for Clinical-Data Monitoring at the Intensive Care Unit

Gabi Magen, Yoav Ben-Shitrit (Sapir College)

Supervisor: Moshe Zofi

Building an application for choosing assault positions and for analyzing the threats over a given path of a military ground force

Roi Rozenblat (SCE - Shamoon College of Engineering)

Supervisor: Ronit Shmallo

Analysis, specification and design of an information system for "ZAZ-Delet" company

Erez Shalom (Ben-Gurion University of the Negev), **Yuval Shahar** (Ben-Gurion University of the Negev),

Eitan Lunenfeld (Soroka Medical Center, Ben-Gurion University of the Negev)

Clinical decision support through the automated application of clinical guidelines

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

Session J - Theoretical Session – Room 7

Session Chair: Gilad Ravid

Nitzan Gazit, Ohad Gan Raveh (Ben Gurion University)

Supervisor: Eli Rohn

Detection of Irregular Sentences in Text

Yana Konstantinovsky (Tel Aviv Academic College)

Supervisor: Esti Peshin

Does Information Gathered by Patients On the Internet Influence IVF Treatments?

Adi Ben Ivri, Regina Vogman (Ben-Gurion University of the Negev)

Supervisor: Gilad Ravid

Twitter based prediction models for The Oscars Awards

15:15-15:30 ***Coffee Break***

15:30-16:45 ***Parallel sessions K-L***

Session K – Room 8

Session Chair: Esther Brainin

Ofir Ben-Assuli (Ono Academic College), **Itamar Shabtai** (College of Management Academic Studies),

Moshe Leshno (Tel-Aviv University)

Characteristics Related to Accessing Health IT

Esther Brainin (Ruppin Academic Center), **Efrat Neter** (Ruppin Academic Center)

The societal effect of health websites affordances: Is it a utopian lens of exploration?

Adi Katz (Shamoon College of Engineering)

User Preferences: Applying a Cost-Benefit Approach to Human Computer Interaction

Dizza Beimal (Ruppin Academic Center), **Efrat Kedmi-Shahar** (Ruppin Academic Center)

Integrating HCI elements into the waterfall methodology to ease novice developers to define system requirement: Research-in-Progress

Session L – Room 14

Session Chair: Daphne Raban

Peretz Shoval (Ben-Gurion University of the Negev)

Ranking Suppliers of Multi-Alternative Proposals of IT Projects – the GCB Method

David Zvilichovsky (Tel Aviv University), **Ohad Barzilay** (Tel Aviv University), **Yael Inbar** (Tel Aviv University) Success and Reciprocity in Crowd funding Networks

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center, Emek Hefer, Israel

Ronen Bar Lev (University of Haifa), **Nitza Geri** (The Open University of Israel), **Daphne R. Raban** (University of Haifa)

The contribution of interorganizational systems to inventory management: A financial statement analysis perspective: Research-in-Progress

Rafi Cohen (Ruppin Academic Center)

Factors that impact the outcome of acquisitions of Israeli high tech companies

16:45-17:30 *ILAIS meeting - Engineering Hall*
Chair: Dov Te'eni

ILAIS Program committee

Michel Avital	Copenhagen Business School, Denmark
Mira Balaban	Ben-Gurion University of the Negev, Israel
Dizza Beimel	Ruppin Academic Center, Israel
Adir Even	Ben-Gurion University of the Negev, Israel
Lior Fink	Ben-Gurion University of the Negev, Israel
Nitza Geri	The Open University of Israel
Tsipi Heart	Ben-Gurion University of the Negev, Israel
Yoram Kalman	The Open University of Israel
Igor Kanovsky	Yezreel Valley College
Adi Katz	SCE - Sami Shamoon College of Engineering, Israel
Tsvi Kuflik	University of Haifa, Israel
Yair Levy	Nova Southeastern University, USA
Yossi Lichtenstein	The College of Management Academic Studies, Israel
Gal Oestreicher-Singer	Tel-Aviv University, Israel
Daphne Raban	University of Haifa, Israel
Gilad Ravid	Ben-Gurion University of the Negev, Israel
Amit Rechavi	Ruppin Academic Center, Israel
Iris Reinhartz-Berger	University of Haifa, Israel
Aviv Shachak	University of Toronto
Pnina Soffer	University of Haifa, Israel
Arnon Sturm	Ben-Gurion University of the Negev, Israel
Eran Toch	Tel-Aviv University, Israel

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

Table of Contents

Understanding the Temporal Aspects of Information Sharing in Online Social Networks Oshrat Ayalon , Eran Toch	10-13
Major Players' Network in Yahoo! Answer Amit Rechavi , Sheizaf Rafaeli	14-17
Electronic Word-of-mouth Spread in Twitter as a Function of the Message Sentiment Benny Bornfeld, Sheizaf Rafaeli, Daphne Raban	18-20
Wiki DNA: Uncovering the Patterns of Online Collaboration Ofar Arazy, Oded Nov	21-25
Modeling DSM-IV Criteria in the Autism Ontology Omri Mugzach, Mor Peleg, Steven C. Bagley, Russ B. Altman	26-29
Physician's Perceived EMR-Communication Fit: Towards Developing a Measurement Instrument Sharone Lev, Tsipi Heart	30-33
Usage Patterns of OFEK Health Information Exchange System at the Soroka Emergency Department: Research-in-Progress Liran Politi, Lior Fink, Iftach Sagy, Victor Novack, Shlomi Codish	34-37
Personal Context Profile for Personalizing Clinical Guidelines Adi Fux, Mor Peleg, Pnina Soffer, Sagit Zolotov, Eddy Karnieli	38-42
Determining Clustering Segmentation via Feature's Saliency Barak Aviad, Gelbard Roy	43-45
The Effect of Missing Data on Classification Quality Michael Feldman, Adir Even	46-50
Improving Correctness of Scale-free Networks to Message Distortion Arie Jacobi, Ofir Ben-Assuli	51-56
Cellphone Induced Distracted Driving: Research-in-Progress Eli Rohn, Kobi Palachi, Omri Chen	57-60
Software Variability: Where Stakeholders Requirements Meet Software Engineering Iris Reinhartz Berger , Yair Wand	61-64
Development of a Phase-Level Software Maintenance Effort Estimation Model Michel Benaroch	65-68
Simplifying Configuration Options of Data Agent in Cloud Computing Environment Ron Hirschprung, Eran Toch, Oded Maimon	69-74
Israeli Small Business Information Security Posture Eli Rohn, Gilad Sabari	75-78
Do Industry Requirements and Academic Qualifications Meet in the Case of Soft Skills? Ilana Lavy, Aharon Yadin	79-82
Virtual Learning Environments and Peer Assessments for Enhancing Students' Decision Making Processes Aharon Yadin	83-87
Mobile Video: Opportunities and Challenges for Learning Nitza Geri, Ruti Gafni, Amir Winer	88-90
Exploring User Choices in Game-based Educational Software for Kindergarten Children: Research-in-Progress Rina Zviell-Girshin	91-96

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

Using Distributed Cognition Theory for Analyzing the Deployment Architecture Process Naomi Unkelos-Shpigel, Irit Hadar	97-100
Unifying Event Logs to Enable End-to-End Process Mining Lihi Raichelson, Pnina Soffer	101-106
Model-Based Documents Authoring with Object-Process Methodology (OPM) Alex Blekhman, Dov Dori	107-110
Variability Modeling in Business Processes: Existing Support and Deficiencies Inbal Mechrez, Iris Reinhartz-Berger	111-114
Characteristics Related to Accessing Health IT Ofir Ben-Assuli, Itamar Shabtai, Moshe Leshno	115-118
The Societal Effect of health Websites Affordances: Is it a Utopian Lens of Exploration? Esther Brainin, Efrat Neter	119-122
User Preferences: Applying a Cost-Benefit Approach to Human Computer Interaction Adi Katz	123-127
Integrating HCI Elements into the Waterfall Methodology to Ease Novice Developers to Define System Requirement: Research-in-Progress Dizza Beimal, Efrat Kedmi-Shahar	128-133
Ranking Suppliers of Multi-Alternative Proposals of IT Projects – the GCB Method Peretz Shoval	134-138
Success and Reciprocity in Crowd funding Networks David Zvilichovsky, Ohad Barzilay, Yael Inbar	139-142
The Contribution of Interorganizational Systems to Inventory Management: A Financial Statement Analysis Perspective: Research-in-Progress Ronen Bar Lev, Nitza Geri, Daphne R. Raban	143-146
Factors that Impact the Outcome of Acquisitions of Israeli High Tech Companies Rafi Cohen	147-152
Clinical Decision Support Through the Automated Application of Clinical Guidelines Erez Shalom, Yuval Shahar, Eitan Lunenfeld	153-158

UNDERSTANDING THE TEMPORAL ASPECTS OF INFORMATION SHARING IN ONLINE SOCIAL NETWORKS

Oshrat Ayalon

Department of Industrial Engineering
Tel Aviv University
oshratra@post.tau.ac.il

Eran Toch

Department of Industrial Engineering
Tel Aviv University
erant@post.tau.ac.il

Keywords: Online social networks, privacy, information aging.

INTRODUCTION

Online social network forget nothing as some scholars note (Mayer-Schönberger, 2009). Personal information shared and stored by users in online social networks (OSNs) is not deleted by default. New and powerful mechanisms, such as Facebook Timeline and Google social website indexing, are making historical information on Facebook and other OSNs readily available to the user's social network. The pervasiveness of OSNs is raising crucial questions with regard to the impact of accessibility of historical OSN information on people's social lives.

Almost all research in the field of privacy in social networks is focused on present implications of privacy. However, as information ages, the privacy preferences that relate to the information can change. It is unclear what is going to be the effect of time on sharing preferences and whether there is any temporal dimension to sharing preferences at all. In this study, we wish to narrow this crucial gap by investigating **retrospective privacy**: how sharing preferences are influenced by the time passed since publishing the information.

RELATED WORK

The relation between time and privacy is discussed in two main domains: digital memory theories and privacy issues theories. Mayer-Schönberger (2009) discusses the impact of digital memory, claiming that it negates time and threatens humans' ability to make decisions, in both the individual and the societal level. Palen and Dourish (2003) are describing the relation between time and privacy, focusing on the individual identity. Since the user has a little control over how the information would be accessed in the future, temporal aspects are becoming part of any action people carry out.

Acknowledging the challenges in managing historical data, several studies suggested technical solutions for the information permanence on the web. Geambasu et al. (2009) developed Vanish, software that using a self-destructing mechanism aiming to help users to control the lifetime of their Web objects such as emails.

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

METHODOLOGY AND RESEARCH QUESTIONS

Our study relies on a broad observation: We expect that people, who regularly publish information on an OSN, would have different sharing preferences for old and new content. This observation leads us to introduce the following hypotheses concerning the impact of information age on sharing preferences:

H1. Willingness to share decreases with time.

H2. Willingness to alter the Facebook post (delete, change or block) increases with time.

H3. Major life changes increase the decline in willingness to share.

In order to test the hypotheses we designed and ran two experiments: (1) a within-subjects user study ($n = 193$); (2) a between-subjects user study ($n = 168$). Both studies were executed using Amazon's Mechanical Turk crowdsourcing service.

The experiments were constructed as surveys and included questions about posts which were published by the participants in different time points. In the first survey the participants chose the posts, following our instructions of how to choose them. In the second experiment we used a custom-built Website application, randomly choosing the posts for the participants. Each participant was asked about five randomized post. The posts were randomized from a certain epoch, differing at the post's "age": 0-1 years, 1-2 years and 2+ years.

RESULTS

In our first set of results we look at the relation between the participants' approach regarding their published posts and the time passed since first publishing the posts. We look at the participants' *willingness to share*: the willingness to show the post on the timeline. Figure 1 depicts the relation between time and willingness to share the post, as we find in the first experiment. The results show that willingness to share decrease with time. We find significant negative correlation between time and willingness to share ($\rho = -0.24$, $p < 0.0001$, using Spearman correlation test). In the second experiment we compare groups, which differ in the posts' epoch of publication date. Figure 2 displays the difference between the groups. It can be seen that the willingness to share score is the highest for the earliest epoch group. A Kruskal-Wallis test shows that the difference between the groups is significant ($p < 0.0001$).

In our second set of results, we look at the effect of time on the manifested behavior of the participants, their indication to alter the post: to delete the status, change its content or hide it from their Facebook friends. We find significant positive correlation between time and likelihood to hide the post in the second experiment results ($\rho = 0.06$, $p = 0.052$, using Spearman correlation test). We also asked the participants what would be the reason to hide the post in case they considered to do so. We find that irrelevancy is the major reason with 60% of those who were considering hiding the post chose irrelevancy as the reason.

Lastly, we tested the impact of life changes on willingness to share. We divided the second experiment's results into two groups: the occurrence or mis-occurrence of major life changes since publishing the post. A Kruskal-Wallis test shows a significant difference between the groups ($H = 34.46$, 2 df, $p < 0.00001$) with higher willingness to share score for the group with no changes occurrence.

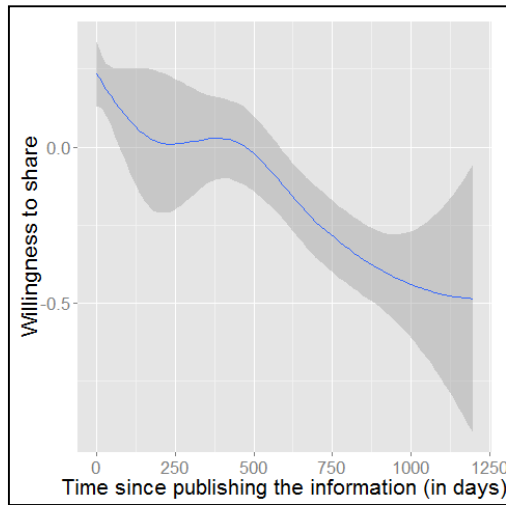


Figure 1. Standardized result: time since publishing the information in terms of days versus willingness to share

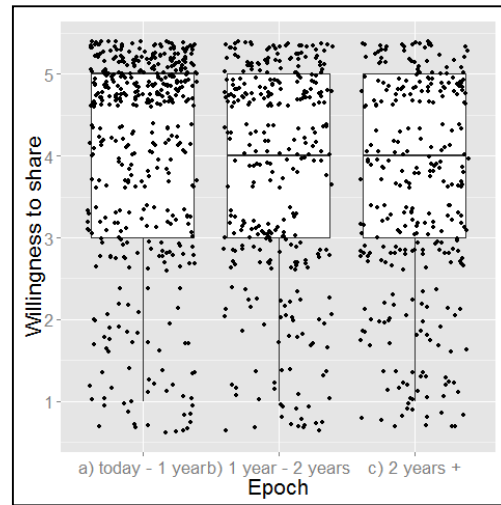


Figure 2. Time since publishing the information in terms of epochs versus willingness to share.

DISCUSSION AND CONCLUSIONS

Our research analyzes retrospective privacy, contextualizing the temporal dimension of privacy approaches. Our findings confirm hypotheses 1 and 3. Hypothesis 2 is confirmed only partially, showing temporal effect on hiding but not on content changing. Why do participants change their sharing preferences? The analysis points to two possible explanations: *staleness* and *anachronism*. We witness staleness with the majority of participants who considered hiding a post due to irrelevancy. Anachronism is expressed in the negative impact that life changes have on sharing approaches. We explain this result by the relation between life changes and publication context. We also witness a gap between users' manifested approaches towards sharing the information and their manifested actions. This result is consistent with the well-known gap between privacy preferences and actual privacy-related behavior on SNSs (Gross & Acquisti, 2005).

Above results lead us to propose the insertion of expiration date into OSNs. This idea was previously suggested by Mayer-Schönberger (2009) and our results can be used to characterize its properties, while also highlighting the challenges in implementing it. Using a regression, we see that two years after the publication time, more than 50% of the users find the post as irrelevant. This 50% threshold point makes it as an interesting candidate for a default expiration date. Our study is subject to several limitations such as recruiting all the participants from MTurk and basing our analysis on the participants' self-reported answers.

REFERENCES

Geambasu, R., Kohno, T., Levy, A., & Levy, H. M. (2009, August). Vanish: Increasing data privacy with self-destructing data. In Proc. of the 18th USENIX Security Symposium, (p. Vol. 41).

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

- Gross, R., & Acquisti, A. (2005, November). Information revelation and privacy in online social networks. In Proceedings of the 2005 ACM workshop on Privacy in the electronic society (pp. 71-80). ACM.
- Mayer-Schönberger, V. (2011). Delete: The Virtue of Forgetting in the Digital Age (New in Paper). Princeton University Press.
- Palen, L., & Dourish, P. (2003, April). Unpacking privacy for a networked world. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 129-136). ACM.

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center,
Emek Hefer, Israel**

MAJOR PLAYERS' NETWORK IN Yahoo! ANSWERS

Amit Rechavi
Sagy Center for Internet Research
Graduate School of Management, Univ. of Haifa
Haifa, Israel
Amit.rechavi@gmail.com

Sheizaf Rafaeli
Sagy Center for Internet Research
Graduate School of Management, Univ. of Haifa
Haifa, Israel
Sheizaf@rafaeli.net

Keywords: “Major Player”, Social Questions and Answers (SQA), topology, Yahoo! Answers, huge social networks, SNA.

INTRODUCTION

A social network is a “*set of actors (individuals or social groups) and relationships of different kinds (friendship, kinship, status, sexual, business or political) among them*” (Wasserman and Faust, 1994). Social Question and Answers sites (SQA) are Web-based information-seeking services in which questions are asked and answers provided by the users. These sites are a platform for synthetic, collaborative work. They attract active and consistent users (Shah et al., 2008) and the answers from these sites have a higher quality than those of specialists (Harper, et al, 2008). These online groups are most successful when a leader sets the agenda and the quality of the answer (Kerr, 1986) and in these sites a “minority of individuals influence an exceptional number of their peers” (Watts and Dodds, 2007). *Yahoo! Answers*, the world’s largest question-answer system, acts as a community site and as a social network (Agichtein et al., 2007) and the presence of continuous and consistent users was found to contribute to its success (Shah et al, 2008). A major player in *Yahoo! Answers* can be defined by three alternative definitions: (a) An opinion leader in the category; (b) A central node in the category and (c) A heavy user in the category. In this paper we define and investigate indicators and characteristics of these major players and are interested in studying the following empirical questions: (1) Existence. Do major players exist in all social networks? (2) Relationships. What is the relationship between major players’ activity and their network’s activity? (3) Modeling. Is it possible to model the activities of a huge social network in terms of topological parameters of its major players?

HYPOTHESES

Our first hypothesis is: (H1) There are differences in the activity level between categories with major players and those without. Next, we build and explore the major players’ network. We look for correlations between several topological parameters of the major players’ network and the activity volume of *Yahoo! Answers*, similar to Barabási et al.’s (2002) findings. Finding such correlations gives an empirical proof to our theoretical assumption that a small group of active users can represent the whole social network. Our second hypothesis is: (H2) There is a correlation between specific topological characteristics of the major players’ network and the activity level in *Yahoo! Answers* and this correlation fits the findings of Barabási et al. (2002).

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic
Center, Emek Hefer, Israel**

METHODOLOGY

The data consists of all the activities in *Yahoo! Answers* between January 1, 2009, and August 31, 2010, excluding July 2009. For each month we defined and extracted the most 20 active askers and 20 best answerers. We further define a user as a major player if and only if: (1) The user has an average of at least one activity (asking or best answering) per day and; (2) The user was nominated in the major players records for at least 6 months of activity. We created a final list of over 1,000 major players who create the major players' network. If the topological behavior of the major players' network can express the *Yahoo! network* behavior then instead of monitoring and analyzing more than 20M interactions monthly, one can analyze the major players' behavior, with less than 50K interactions and 1K users. The weight of a connection is the number of times a major player participated in a category. The parameters of the major players' network were: *The Diameter* (The shortest path between the furthest connected nodes), *No of nodes* (number of categories and major players in each month), *No of edges* (asking and answering activities) each month, *The average weight* (The mean number of "Best Answers" or questions of a single major player in a specific category in a specific month), *The average degree* (The number of categories in which the major players participated on average, OR the number of major players each category has on average, in a specific month) and *GCC* (The highest number of connected categories in a specific month).

RESULTS

Activity in communities

84% of the major players are active in a single category, 12% in two categories 2.7% in three and only 1.3% in more than four categories. These results are in line with Chen and R. Nayak's, (2008, 2012) findings, where most of the answerers prefer to participate in a single (topic) category. More than half of the major players (56%) were nominated as such, for less than half of the time period and only 14% were "major players" for most of the relevant time period.

The Activity's differences between categories with major players and categories without major players

Regarding H1 - A positive correlation was found between the major players' volume of contributions ("Best Answers" and questions) and their categories' volume of activity. A positive correlation was found between the number of the major players (best answerers and askers) and the number of total users in their categories. A significant weak negative correlation was found between the relative share of the "Best Answers" of the major players and the number of the total "Best Answers", the number of users in the category and the number of questions in the category. A positive correlation was found between the category's size (users) and category's volume (answers, questions and Best answers) and the presence of major players in it.

B. The major player's network topology and its correlation with the overall activities

The degree (k) was stable during the relevant time period and can't explain any changes in the size or in the volume of *Yahoo! Answers* network.

Since we have chosen the number of major players to be 20 per month, we actually dictated the number of vertices and the average degree of the network, however the *dynamics of the changes* in the topological values and the longitudinal correlation between the *change* in the topological

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic
Center, Emek Hefer, Israel**

parameters of the major players' network and the *change* in size and volume of the whole network are significant.

Regarding H2 - The longitudinal correlations between the network's topological parameters and the *Yahoo! Answers* parameters:

- A. The number of categories and major players were both positively correlated with the number of questions asked and askers.
- B. The weighted contributions of the major players were positively correlated with the number of answers, the number of users answering, the number of users both asking and answering and the total number of users in *Yahoo! Answers*.
- C. The average degree (K) was positively correlated with the number of answers, the number of users asking, the number of users both asking and answering and the total number of users in *Yahoo! Answers*.
- D. The size of the GCC was positively correlated with the total number of questions, the total number of "Best Answers" and the number of askers in *Yahoo! Answers*.

DISCUSSION AND CONCLUSIONS

Regarding H1 findings

The data support the H1 assumption. Since the causality's direction between the network's topology and *Yahoo! Answers*' size and volume is as yet not determined, analyzing the correlations' results might suggest two alternative explanations. Scenario A – Major players influence their categories. It might be sufficient for a major player to be moderately active (once a day in six months out of nineteen months) in order to influence the category size-parameters. A higher level of contribution or longer periods as a major player does not appear to increase the category activity's volume. So, it seems that even if there is an influence of the major player on the category's activity, the influence is quite limited with an upper limit. Scenario B – Categories create their major players. Categories with a high volume of activity and many participants create a (positive) atmosphere, which can be related to the social capital that enables users to deliver more inputs daily, mostly as "Best Answers", and gradually to become major players.

Regarding H2 findings

We found a significant correlation between the *Yahoo! Answers*' activities and the major players' topology, in a way that the major players' network reflects the activity in the *Yahoo! Answers* network, just as Barabási et al. (2002) found. According to Barabási et al. (2002), contrary to the assumption of conventional models that the average distance should increase slowly as the network grows (like $O(\log n)$), network growth over the years actually increased the average degree and GCC and decreased its diameter and CC. According to Leskovec et al. (2005) while the number of edges grew super linearly, the network density and the average distance between nodes shrunk. We suggest that in order to understand the size and growth dynamics of *Yahoo! Answers*, one can explore the major players' topology (50k monthly interactions) instead of investigating the entire *Yahoo! Answers* network (20M monthly interactions). Since there is an order of magnitude difference between the two networks (50K versus 20M), exploring the major players' network should be much easier and quicker than exploring the actual activities in the whole Q&A site.

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center, Emek Hefer, Israel

In *Yahoo! Answers* one can post their question to a specific category and soon enough, answers will arrive. Major players have an important role in this SQA's mechanism. They are stable, active and have a positive correlation with the activity of the whole network. Apparently, this is the reason we found that exploring the topology of the major players' network, might depict the dynamic of all activities in *Yahoo! Answers*

REFERENCES

- Agichtein, E., Castillo, C., Donato, D., Gionis, A., & Mishne, G. (2007). TECHNICAL REPORT YR-2007-005.
- Barabási, A. L., Jeong, H., Néda, Z., Ravasz, E., Schubert, A., & Vicsek, T. (2002). Evolution of the social network of scientific collaborations. *Physica A: Statistical Mechanics and its Applications*, 311(3), 590-614.
- Chen, L., & Nayak, R. (2008). Expertise analysis in a question answer portal for author ranking. *Web Intelligence and Intelligent Agent Technology, 2008. WI-IAT'08. IEEE/WIC/ACM International Conference on*, 1 134-140.
- Chen, L., & Nayak, R. (2012). Leveraging the network information for evaluating answer quality in a collaborative question answering portal. *Social Network Analysis and Mining*, 1-19.
- Guillaume, J. L., & Latapy, M. (2006). Bipartite graphs as models of complex networks. *Physica A: Statistical Mechanics and its Applications*, 371(2), 795-813.
- Harper, F. M., Raban, D., Rafaeli, S., & Konstan, J. A. (2008). Predictors of answer quality in online Q&A sites. *Proceeding of the Twenty-Sixth Annual SIGCHI Conference on Human Factors in Computing Systems*, 865-874.
- Kerr, E. B. (1986). Electronic leadership: A guide to moderating online conferences. *IEEE Transactions on Professional Communication*, 29(1), 12-18.
- Leskovec, J., Kleinberg, J., & Faloutsos, C. (2005). Graphs over time: Densification laws, shrinking diameters and possible explanations. *Proceedings of the Eleventh ACM SIGKDD International Conference on Knowledge Discovery in Data Mining*, 187.
- Shah, C., Oh, J. S., & Oh, S. (2008). Exploring characteristics and effects of user participation in online social Q&A sites. *First Monday*, 13(9)
- Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications* Cambridge university press.
- Watts, D. J., & Dodds, P. S. (2007). Influentials, networks, and public opinion formation. *Journal of Consumer Research*, 34(4), 441-458.

ELECTRONIC WORD-OF-MOUTH SPREAD IN TWITTER AS A FUNCTION OF THE MESSAGE SENTIMENT

Benny Bornfeld

Department of Industrial
Engineering and Management
Ruppin Academic Center, Emek
Hefer, Israel
bennyb@ruppin.ac.il

Sheizaf Rafaeli

Graduate School of
Management
University of Haifa,
Haifa, Israel
sheizaf@rafaeli.net

Daphne R. Raban

Graduate School of
Management
University of Haifa,
Haifa, Israel
draban@univ.haifa.ac.il

Keywords: Electronic Word Of Mouth, Twitter, sentiment analysis, social computing

INTRODUCTION

Word-of-mouth (WOM) is known to have a strong influence on the user's purchase decision. The recognition of the importance of word-of-mouth in the two step flow theory dates back to Lazarsfeld and Katz (1955). Electronic word-of-mouth (eWOM) is an important product-related message spreading mechanism. The internet based WOM, eWOM, travels fast and can potentially reach very large audiences. One of the most salient internet services today is Twitter. Twitter is a powerful platform for spreading many kinds of messages, including eWOM. Some eWOM messages carry a negative sentiment valence and others carry positive or neutral valence.

Does message sentiment valence influence the extent of message spread? The old marketer's belief that "bad is stronger than good" dominated the pre-internet WOM era. Is this negative bias still dominant in the internet social networks of today? Or is the spirit of Facebook's only "Likes" and no "dislikes" catching in the eWOM communication?

Looking at the question of eWOM spread and influence as a function of the eWOM sentiment valence, there are several theories and evidence which provide support for both directions. Some theories postulate that negative is more influential and some claim that positive is more influential. Others state that both directions are valid and the effect depends on the type of the product.

THEORY AND RELATED WORK SUMMARY

There are more theories and evidence in support of the negative bias. The prevalence of the negative bias across many areas, the adaptive and rarity arguments as presented by Fiske (1980) and Baumeister et al (2001) and the reliability issue (which is associated mainly with positive eWOM) lead to the hypothesis that negative messages spread to a larger extent. Most of the related studies on WOM and eWOM also point in this direction. On the other hand, the reliability is less of an issue in Twitter because the follower knows who sent the message. The need to present one's self in a positive light contributes to a positive bias. Several studies show the moderating role of product type and suggest a more positive bias for hedonic promotion consumption goal products. Since movies are hedonic, promotion consumption goal products

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic
Center, Emek Hefer, Israel**

they predict that negative information will be "discounted". In general, there is more evidence for negative bias and some positive bias evidence for hedonic products.

OBJECTIVES

In light of the theory and related work, there are two motivations for this research:

The contradicting evidence from different studies and the tension between theories supporting positive versus negative bias.

Modest availability of evidence based on updated high volume data collected from online social networks.

In order to be consistent with the view of Twitter as a social network, we examined the WOM flow between ordinary users and not the WOM originating from the highly followed users. Related studies show that we stand on solid ground when choosing Twitter as the data collection field, examining the retweet spread and choosing to study the movies industry.

RESEARCH HYPOTHESES

Consistent with prior research which analyzed the tweets about movies and other products, we hypothesize:

H1: There are more positive than negative tweets in movie-related Twitter messages.

Based on the theory and studies that show support for more spread of positive valence messages in hedonic, promotion consumption goal:

H2: Positive valence movie tweets will spread more, in number of retweets and audience size, than negative valence movie tweets.

METHOD

We measured the message spread (the dependent variable) as a function of the message sentiment polarity (the independent variable). The categorical values in sentiment polarity are positive, neutral, negative. Message spread was measured both as the number of retweets a message got and as the total number of users exposed to the message via the retweet mechanism. The products for which we collected the tweets were movies which came out during the tweets collection time, between the end of 2011 and the beginning of 2012. This method comprises four steps: data collection, data cleaning, sentiment polarity analysis and results analysis. Dedicated software was written to handle all the different stages.

Conclusions

This research is about Electronic word-of-mouth spread in Twitter as a function of the message sentiment, examining movie tweets and using computational social science methods. The special software application developed as well as the research results will be presented if the paper is accepted.

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic
Center, Emek Hefer, Israel**

REFERENCES

- Bakshy, E., Hofman, J. M., Mason, W. A., & Watts, D. J. (2011). Everyone's an influencer: Quantifying influence on twitter. *Proceedings of the Fourth ACM International Conference on Web Search and Data Mining*, 65-74.
- Barbagallo, D., Bruni, L., Francalanci, C., Giacomazzi, P., Fuchs, M., Ricci, F., & Cantoni, L. (2012). An empirical study on the relationship between twitter sentiment and influence in the tourism domain. *Information and Communication Technologies in Tourism 2012*, Helsingborg, Sweden, January 25-27, 2012.
- Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of General Psychology*, 5(4), 323.
- Berger, J., & Milkman, K. (2010). Social transmission, emotion, and the virality of online content. *Wharton Research Paper*,
- Cha, M., Haddadi, H., Benevenuto, F., & Gummadi, K. P. (2010). Measuring user influence in twitter: The million follower fallacy. *4th International AAAI Conference on Weblogs and Social Media (ICWSM)*, 10-17.
- Fiske, S. T. (1980). Attention and weight in person perception: The impact of negative and extreme behavior. *Journal of Personality and Social Psychology*, 38(6), 889.
- Hansen, L. K., Arvidsson, A., Nielsen, F. A., Colleoni, E., & Etter, M. (2011). Good friends, bad news-affect and virality in twitter. *Future Information Technology*, , 34-43.
- Huberman, B., Romero, D., & Wu, F. (2008). Social networks that matter: Twitter under the microscope.
- Jansen, B. J., Zhang, M., Sobel, K., & Chowdury, A. (2009). Twitter power: Tweets as electronic word of mouth. *Journal of the American Society for Information Science and Technology*, 60(11), 2169-2188.
- Lazarsfeld, P. F., & Katz, E. (1955). *Personal influence*. Glencoe, Free Presse,
- Liu, Y., Rui, H., & Whinston, A. (2012). Whose and what chatter matters? the impact of tweets on movie sales.
- Marwick, A. E. (2011). I tweet honestly, I tweet passionately: Twitter users, context collapse, and the imagined audience. *New Media & Society*, 13(1), 114-133.
- Rechavi, A., & Rafaeli, S. (2012). Knowledge and social networks in yahoo! answers. *System Science (HICSS)*, 2012 45th Hawaii International Conference On, 781-789.
- Romero, D., Galuba, W., Asur, S., & Huberman, B. (2011). Influence and passivity in social media. *Machine Learning and Knowledge Discovery in Databases*, , 18-33.
- Rosenman, E. T. R. (2012). Retweets—but not just retweets: Quantifying and predicting influence on twitter.
- Suh, B., Hong, L., Pirolli, P., & Chi, E. H. (2010). Want to be retweeted? large scale analytics on factors impacting retweet in twitter network. *Social Computing (SocialCom)*, 2010 IEEE Second International Conference On, 177-184.
- Zhang, J. Q., Craciun, G., & Shin, D. (2010). When does electronic word-of-mouth matter? A study of consumer product reviews. *Journal of Business Research*, 63(12), 1336-1341.

WIKI DNA: UNCOVERING THE PATTERNS OF ONLINE COLLABORATION

Ofer Arazy

Alberta School of Business
University of Alberta, Canada
ofer.arazy@ualberta.ca

Oded Nov

Dept. of Technology Management,
Polytechnic Institute of NYU,
USA onov@poly.edu

Keywords: Wiki, Wikipedia, Online, Collaboration, Patterns

INTRODUCTION

Recent years have seen the emergence of a community-based model for collaborative work, whereby an online community creates knowledge-based goods (Benkler, 2006). Prominent examples of community-based collaboration are open source software (OSS) projects (Lakhani & Wolf, 2005) and the online encyclopedia Wikipedia (Arazy et al., 2011). Community-based collaborations are often large and involve volunteers, who self-manage work processes. Some argue that “this new of way organizing will eventually displace the traditional corporate structures as the economy’s primary engine of wealth creation” (Tapscott & Williams, 2007, pp. 1-2). However, given the lack of clear monetary incentives for participation and the loose governance, the success of community-based collaborations seems counter-intuitive.

Research to date has shown that collaboration patterns in community-based projects often deviate from the predictions of traditional theories of group work (von Krogh & von Hippel, 2006; Arazy et al., 2011), highlighting the need to developed refined theories of collaboration for this particular setting (Majchrzak, 2009).

The complexity of community-based collaborations presents a major challenge for researchers in the area. Collocated group performance already contains some delicate intricacies, and understanding those requires an analysis of factors at the individual (e.g. motivation, engagement), group (e.g. coordination, trust), and organizational (e.g. incentives and controls) levels. Developing a theoretical understanding of community-based collaboration is yet more challenging, given the complexities introduced by: geographical distribution, IT-mediation, self-governance, ill-defined roles, permeable organizational borders, and the sheer scale of such collaborations. Notwithstanding these challenges, the fact that community-based projects employ a software platform to facilitate collaboration holds a great promise for organizational researchers. The majority of interactions are tracked in system logs and harvesting these logs can reveal important insights regarding members’ ongoing behavior in its natural setting (Kane & Fichman, 2009).

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic
Center, Emek Hefer, Israel**

In this short paper we present an ongoing research project that is intended to discover the patterns of online collaboration. Viewing patterns of work activities (i.e. routines; Teece et al., 1997) as operational capabilities (Eisenhardt & Martin, 2000), we argue that the key to understanding the success of community-based projects is in mapping patterns of collaboration. The underlying premise of this research project is that the analysis of logs of collaborative system would allow tracking the evolution of community-based collaborations. Our focus here is on one particular collaborative technology: wikis. Wiki is a web-based collaborative authoring tool that is designed for openness, anonymity, and egalitarianism (Leuf & Cunningham, 2001; Wagner, 2004).

OBJECTIVES

The primary objective of this research project is to use a grounded theory approach to understand the causal dynamics underlying IT-mediated collaboration. We intend develop a set of hypotheses regarding IT-mediated collaboration processes, which are grounded in the observed wiki data, and informed by extant theories of group work.

METHODS

In order to attain the project's objective, we will create a large bank of empirical data representing the evolution of IT-mediated collaborative projects. Just as the Human Genome Project maps the genes in the human DNA, we will chart the 'DNA' of computer-mediated collaboration. The focus of this project is on one particular collaborative IT: wikis. We plan to generate 'wiki DNA' sequences for 500 different wiki-based collaborative projects, covering projects at various settings (public, corporate, and educations) of different nature (e.g. creating a knowledge base or encyclopedia, project management, idea generation). Similarly to the double helix structure of human DNA, a 'wiki DNA' structure includes two sequences representing work and meta-work activity patterns. Each sequence is comprised of a series of building blocks, where a building block corresponds to a particular collaborative action (work or meta-work), and is characterized by: the actor and his organizational role, time of action, the type (or class) and magnitude of the action. This first phase of the project (illustrated in Figure 1 below) involves data extraction and cleaning, as well as manual classification of collaborative activities. Our plan is to use human-computation systems (such as Amazon Mechanical Turk; M-Turk) or citizen science platforms (e.g. Stardust@home; <http://stardustathome.ssl.berkeley.edu/>) for this manual process, whereby the classification of each edit is outsourced to outsiders (volunteers in citizen science projects and paid contributors in M-Turk).

The second stage of the project involves the analysis of the sequences of collaboration activities using both manual and automated techniques. For the manual analysis, we would start with a pilot study, where the research team would work with a web-based visualization tool. Visualization makes relevant processes visible that would otherwise be difficult to interpret. Our software tool is developed to facilitate this research program, and will allow exploring, analyzing and comparing 'wiki DNA' patterns. The results of this preliminary phase would be an understanding of the available patterns and the difficulty in identifying each pattern. Next, we

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center, Emek Hefer, Israel

would outsource the analysis of the large data set through Amazon M-Turk and citizen science, very much along the lines of the FoldIt (Cooper et al., 2010) and Phylo (Kawrykow et al., 2012) projects, whereby citizens participated in identifying DNA patterns and solving problems in biochemistry.

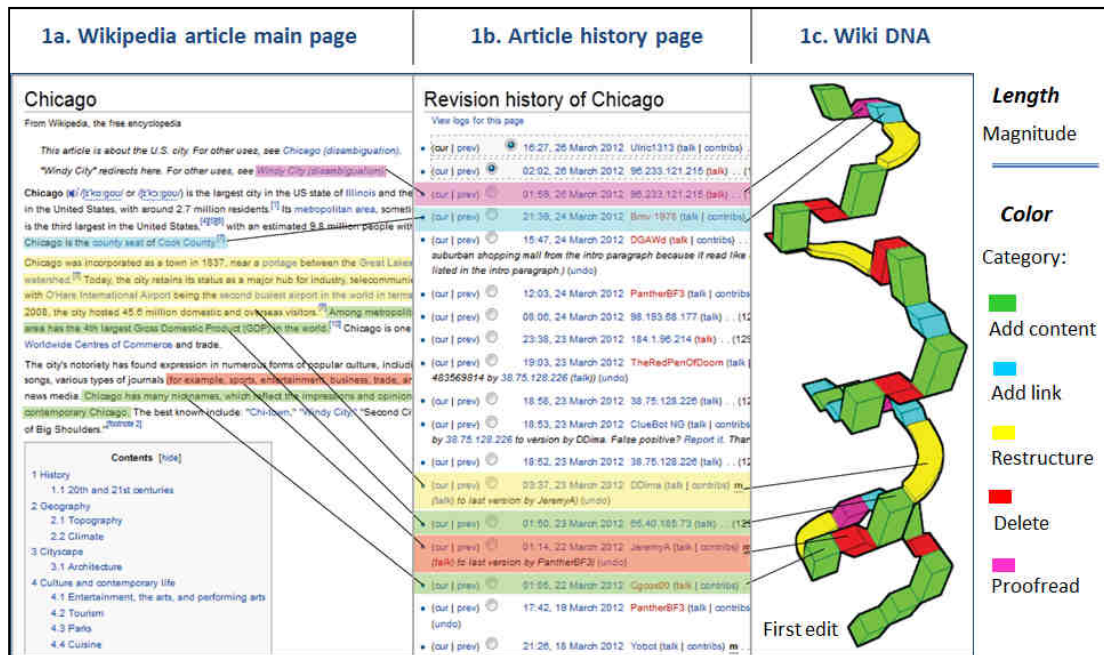


Figure 1: Illustration of the process for generating a 'wiki DNA string'

For the automated pattern detection, we build on the extensive body of literature on biological sequence analysis (MacIsaac & Fraenkel, 2006). Pattern discovery aims at finding unknown patterns that occur frequently in a set of input data (e.g. DNA). Common methods include enumerative and deterministic optimization methods (Dempster et al., 1977). For matching of DNA sequences, various bioinformatics techniques exist, often based on a quantization process, which transforms continuous data values to an alphabet (Lin et al., 2007); then, dynamic programming methods and Hidden Markov Models are used to analyze the patterns (Durbin et al., 2003). Together, these methods provide the algorithmic foundation for the identification, analysis and mining of collaborative work patterns.

The third and final stage of the project involves theory development. Grounded in the observed patterns, and informed by extant theory, our aim in this stage is to develop theoretical understanding of IT-mediated collaboration. Several areas of research within the social sciences inform this investigation, including: social psychology, management, organizational behavior, and information systems. Particularly relevant are prior works in the areas of: the community-based model and knowledge management. By analyzing wiki DNA sequences, we plan to identify some relationship, rules, and patterns, and then contrast these findings with extant knowledge on IT-mediated group work (and theories of team work in general).

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic Center, Emek Hefer, Israel

Currently, we are the early phases of this project. We have begun collecting data, are in the process of developing the classification schemes for collaborative activities, and we began developing an online visualization tool.

CONCLUSIONS

Inspired by the Human Genome Project that aims to identify the genes in the human DNA, the primary objective of this ambitious project is to chart the 'DNA' of computer-mediated collaboration. Our focus is a particular collaborative IT: wikis, the engine underlying Wikipedia. We assume that collaboration tasks - both direct work and meta-work tasks - could be classified into a pre-defined set of categories. Each collaborative action - the "building block" of collaboration - could be characterized by its category, as well as by the time, magnitude, and contributor. Our aim is to represent the evolution of community-based projects as sequences of these building blocks. We expect that the analysis of these sequences would result in the detection of prototypical patterns of online collaboration. Investigation of these patterns would contribute to our understanding of community-based projects and could inform theory in the area.

By making the bank of wiki DNA sequences – as well as the use of the information visualization tool - freely available online, we invite other researchers to join and use this data for further theory development.

At the ILAIS conference, we will present the project and our progress to date.

REFERENCES

- Arazy O., Nov O., Patterson R., and Yeo L. "Information Quality in Wikipedia", *Journal of Management Information Systems (JMIS)*, Spring 2011. Vol 27(4): 73-100.
- Benkler, Y. *The wealth of networks: How social production transforms markets and freedom*. Yale University Press, 2006.
- Cooper S., Khatib F., Treuille A., Barbero J., Lee J., Beenen M., Leaver-Fay A., Baker D., Popović Z., and Foldit Players, Predicting protein structures with a multiplayer online game, *Nature*, 466, 756-760 (2010).
- Dempster et al., 1977, Maximum likelihood from incomplete data via the EM algorithm, *Journal of the Royal Statistical Society*, 39, 1–38.
- Durbin et al., 2003, *Biological Sequence Analysis*, Cambridge University Press.
- Eisenhardt, K. & Martin, J. (2000). Dynamic capabilities: what are they? *Strategic Management Journal*. 21(10-11). 1105-1121
- Kane, G. C. and Fichman, R. G. The shoemaker's children: Using wikis to improve IS research, teaching, and publication. *MIS Quarterly*, 33, 1 (2009), 1-22.
- Kawrykow A., et al., "Phylo: A Citizen Science Approach for Improving Multiple Sequence Alignment," *PloS one*, vol. 7, p. e31362, 2012
- Lakhani, K. R. and Wolf, R. G. Understanding motivation effort in free/open source software projects. In J. Feller, et al. (eds.), *Perspectives on Free and Open Source Software*. Cambridge: MIT Press,

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin Academic
Center, Emek Hefer, Israel**

- 2005, pp. 3-22.
- Leuf, B. and Cunningham, W. *The Wiki Way: quick collaboration on the web*. Boston: Addison-Wesley, 2001.
- Lin J., *et al.*, "Experiencing SAX: a novel symbolic representation of time series," *Data Mining and Knowledge Discovery*, vol. 15, pp. 107-144, 2007.
- MacIsaac & Fraenkel, 2006, Practical Strategies for Discovering Regulatory DNA Sequence Motifs, *PLoS Computational Biology*, 2(4), e36.
- Majchrzak, A. Comment: Where is the theory in wikis? *MIS Quarterly*, 33, 1 (2009), 18-20.
- Tapscott D. and Williams A.D., 2007, *Wikinomics: How Mass Collaboration Changes Everything*, Portfolio.
- Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. *Strategic Management Journal* 18 (7), 509–533.
- von Krogh, G. and von Hippel, E. The promise of research on open source software. *Management Science*, 52, 7 (2006), 975-983.
- Wagner, C. Wiki: A technology for conversational knowledge management and group collaboration. *Communication of the Association for Information Systems*, 13 (2004), 265-289.

MODELING DSM-IV CRITERIA IN THE AUTISM ONTOLOGY

Omri Mugzach
University of Haifa
Omrimg@Gmail.Com

Mor Peleg
University of Haifa
Peleg.Mor@Gmail.Com

Steven C. Bagley
Stanford University
Steven.Bagley@Stanford.edu

Russ B. Altman
Stanford University
Russ.Altman@Stanford.edu

Keywords: DSM-IV, Autism, Ontology, ADI-R, SWRL, Modeling

INTRODUCTION

Understanding disease processes of complex neurodevelopmental diseases such as autism has been attempted for many years with relatively modest success. The mechanism of autism is still unknown, and in order to allow scientists to try and deduce new knowledge about this disease's mechanism based on patient data, it is crucial to organize and semantically integrate patient data concerning genetic and environmental risk factors as well as phenotypic manifestations. Ontologies are important knowledge representations used in information systems and artificial intelligence research, which help in such data integration tasks as a way to standardize data and knowledge related to the disease and to create a knowledge infrastructure for studying how genetic and environmental factors impact the disease development.

There already exists an ontology for autism, the Autism Ontology (Tu et al., 2008), developed at Stanford University and represented in the Web Ontology Language (OWL) (Horrocks et al., 2003). This ontology contains knowledge regarding autism assessment tools and phenotypes related to autism along with a set of 14 SWRL (Semantic Web Rule Language) (Horrocks et al., 2004) rules which allows deduction of specific basic phenotypes based on patient data containing autism assessment tools' results (using a small fraction of the data rather than an actual mapping of the assessment tools

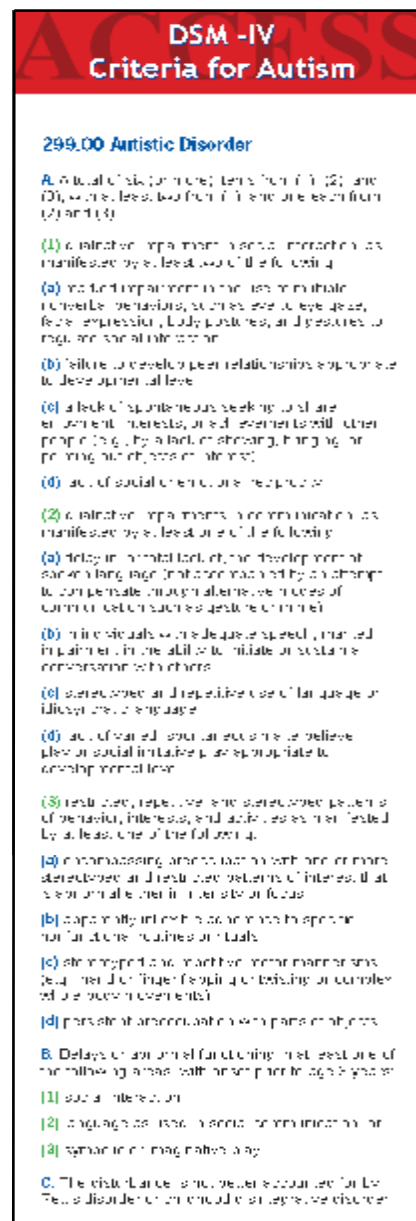


Figure 1. Autism DSM-IV Criteria 26

data into knowledge). However, this ontology does not allow deduction of more complex phenotypes as defined in the state-of-the-art Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) and therefore cannot be used for diagnosis of autism based on patient data. To the best of our knowledge, there is no automatic tool that can check whether a patient meets the DSM-IV criteria based on electronic patient data.

OBJECTIVES

Our goal is to enrich the existing autism ontology with additional knowledge regarding the diagnosis of autism and its associated phenotypic manifestations in order to eventually support the semantic extraction of autism-related information from electronic health records and inference of more complex and abstract phenotypes related to autism. Essentially, we will add new classes, individuals, SWRL rules and plugins to the ontology.

METHODS

We received data from the Simons Foundation Autism Research Initiative (SFARI). This data set includes results from structured 93-items interview used for diagnosing autism called the Autism Diagnostic Interview-Revised (ADI-R) (Lord et al., 1994). We converted this data set into instances of the ADI-R class (one instance per patient) contained in the existing Stanford autism ontology.

The fourth version of DSM-IV, published by the American Psychiatric Association, contains a listing of psychiatric disorders and their corresponding diagnostic codes along with specific diagnostic criteria for each disorder. We would like to extend the existing autism ontology to represent all the DSM-IV autism diagnostic criteria. As can be seen in Figure 1, the DSM-IV

diagnostic criteria for autism are hierarchical. The upper level includes 3 criteria: A, B, and C. The first criterion is the most complex one and includes 3 middle-level sub-criteria (1, 2, and 3), each containing 4 lower-level different patient states (a-d), referring to his/her basic phenotypes. A large portion of the basic autism phenotypes (such as "Delayed Word") are already represented in the existing autism ontology from Stanford.

The existing autism ontology contains classes of basic phenotypes (such as "Delayed Word"), dispositions (such as "Language Skills phenotype") and diagnostic tools (such as ADI-R). While the existing autism ontology includes basic phenotypes such as "Delayed Word" under the quality class hierarchy, we have added a hierarchy of classes referring to humans with findings (i.e., basic phenotypes) treated

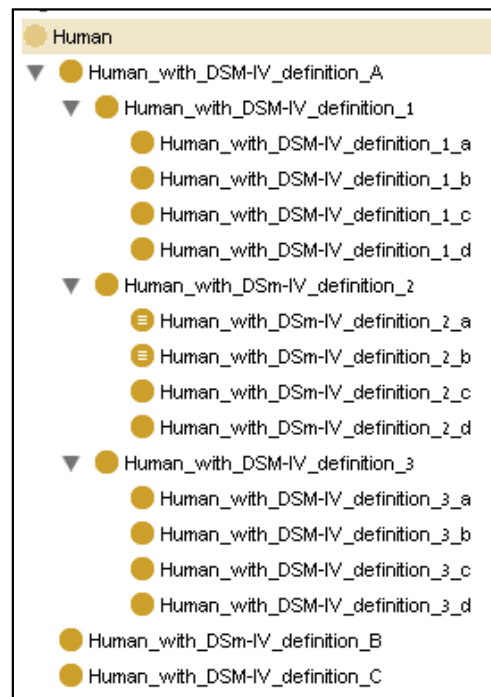


Figure 2. DSM-IV Hierarchical relations structure

as a condition rather than a basic standalone phenotype. For example, *Human_with_delayed_word* is defined in OWL as *Human has_finding has Delayed_Word*. This allows us to infer which basic phenotypes are exhibited by patients (humans) based on their electronic health records (SFARI data set).

As done in (Tu et al., 2008), we used the Protégé knowledge modeling tool to define SWRL rules that operate on the OWL knowledge base. These rules are used to infer basic DSM phenotypes from ADI-R patient data found in the SFARI database that were migrated into the OWL knowledge base. For example, if a certain patient instance had the value 24 for the ADI-R item concerning the age (in months) of first spoken word, we would deduce that this patient has the phenotype of Human who has the finding: Delayed Word. The following SWRL rule describes that deduction. Note that at the beginning of the rule, we include an integrity check that the number specified is less than 900.

```
ADI-2003(?a)  $\wedge$  j.0:SubjectKey(?a, ?id1)  $\wedge$  j.0:ADI_2003_acqorlossoflang_aword(?a, ?aword)  $\wedge$  swrlb:lessThan(?aword, 900)
```

```
 $\wedge$  swrlb:greaterThan(?aword, 24)  $\wedge$  Human(?h)  $\wedge$  subject_id(?h, ?id2)  $\wedge$  swrlb:equal(?id1, ?id2)  $\rightarrow$  has_finding(?h, Delayed_Word)
```

Based on the basic phenotypes, we built the DSM-IV diagnostic criteria using OWL class restrictions (definitions). As shown in Figure 2, we have added the concept of *Human_with_DSM_IV_definition* in order to be able to infer, from electronic medical records, those patients who meet the DSM diagnostic criteria of autism and parts of such diagnostic criterion (such as part 1_a). In order to represent the different sub-criteria of the middle and lower levels of DSM IV, we combine the basic patient phenotypes (e.g., *Human_with_delayed_word*) with logical operators. For example, to represent the criterion A-2(b) shown in Figure 1, we used the following OWL class definition:

```
((has_finding has Functional_use_of_spontaneous_echoed_or_stereotyped_language) or  
(has_finding Fewer_Than_Five_Words_Total_or_Speech_Not_Used_on_a_Daily_Basis)) and  
((has_finding has Social_Verbalization_Clear_Social_Quality) or (has_finding has  
Social_Verbalization_Some_Social_Use)).
```

The middle and upper level DSM-IV criteria A and B involve counting the number of sub-criteria from specific categories that hold, which necessitates support of k-of-N counting. OWL allows use of reasoners. A reasoner is a piece of software able to infer logical consequences from a set of asserted facts or axioms. For example, the Pellet reasoner (clarkparsia.com/pellet/) can deduce that a certain patient instance meets a certain class criteria based on its phenotypes. Since OWL does not have the capability to express axioms that involve counting, we will create a new plug-in which will perform the desired operation. Our new Plug-In will use Pellet's API to allow us to access the reasoner's capability to realize individuals (patient instances) who meet the different criteria and count them. After developing the plugin we will be able to infer whether patients meet DSM middle and upper-level criteria.

RESULTS

45 SWRL rules deducing different basic phenotypes from the SFARI data were implemented for 5 ADI-R items (about 5 SWRL rules for each ADI-R item). For example, regarding the basic phenotype age of the first spoken word, 5 different rules were implemented (delayed word, milestone not reached, no word, word not delayed,

question not asked). Regarding the DSM-IV definitions, class restrictions were implemented for 2 lower level DSM-IV criteria concerning spoken language and social conversation. All restrictions and SWRL rules were successfully tested with actual SFARI data of 7 patients.

CONCLUSIONS

It seems feasible to use OWL definitions and reasoning to infer whether patients meet DSM-IV criteria and sub-criteria based on ADI-R assessment data. Our next steps include: (i) developing the new k-of-N counting plug-in for Protégé, and (ii) automating instance population with SFARI data.

ACKNOWLEDGMENTS

This work was funded in part by the Conte Center for Computational Neuropsychiatric Genomics (NIH P50MH94267)

REFERENCES

- Tu, S. W., Tennakoon, L., Connor, M. O., Das, A. (2008). **Using an integrated ontology and information model for querying and reasoning about phenotypes : the case of Autism.** *AMIA Annu Symp Proc.* 2008 Nov 6:727-31.
- Horrocks, I., Patel-Schneider, P. F., Van Harmelen, F. (2003). **From SHIQ and RDF to OWL: the making of Web Ontology Language.** *Journal of Web Semantics: Science, Services and Agents on World Wide Web* 1: 7-26.
- Horrocks, I., Patel-Schneider, P. F., Boley, H., Tabet, S., Grosz, B., Dean, M. (2004). **SWRL: A Semantic Web Rule Language combining OWL and RuleML.** *W3C Member Submission* 21 May 2004. <http://www.w3.org/Submission/SWRL>, last accessed on 3.3.2013.
- Lord, C., Rutter, M., Le Couteur, A. (1994). **Autism Diagnostic Interview-Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders.** *Journal of Autism and Developmental Disorders*; 24: 659-85.

PHYSICIAN'S PERCEIVED EMR-COMMUNICATION FIT: TOWARDS DEVELOPING A MEASUREMENT INSTRUMENT

Sharone Lev

Department of
IE&M

Ben-Gurion

University

of the Negev,

sharones@bgu.ac.il

Tsipi Heart

Department of
IE&M

Ben-Gurion

University of the

Negev,

heart@bgu.ac.il

Keywords: Task Technology Fit (TTF), EMR, physician-patient communication, perceived fit, primary care, service blueprint

INTRODUCTION

The physician patient communication (PPC) during the medical encounter was found to be a key factor in the success of medical treatment. When good communication is established, patients tend to be more satisfied, more informed and involved in decision making, are more attentive to medical recommendations and clinical outcomes improve (Zolnieriek & DiMatteo, 2009). To this end, physicians should ask patients questions not only concerning physical aspects, but also about their feelings and concerns, verify patient's understanding and encourage patients to participate in decisions concerning treatment (Schirmer et al., 2005). Non-verbal skills are significant as well, and can be carried out by hand shaking, eye contact, smiling, etc. Patients feel less confident and do not reveal as much information in encounters where the physician's eye contact is broken or their facial orientation is indirect (Duggan & Parrott, 2001).

An Electronic Medical Record (EMR) is a medical information system that allows storage, retrieval and modification of medical records. It is believed that the EMR, among other things, will improve the quality and safety of medical care (McGrath et al., 2007). But along with the many benefits, the EMR system has become a third 'party' in the visit that demands a significant portion of visit time, and it may have a negative influence on the physician-patient communication (Ventres et al., 2006).

According to an observation of primary care encounters in Israel, it was found that physicians spend between 25% and 42% of visit time gazing at the computer screen and/or keyboarding (Margalit et al., 2006). Prior research found that extensive use of EMR diminished levels of non-verbal acts including eye contact (Margalit et al., 2006), which are all considered essential to establishing effective PPC. The comprehension of the importance of the communication in the medical interview led to the development of a variety of assessment tools in order to measure the physician's communication abilities, although none has addressed the effect of EMR, and the fit of the EMR system and the communication task.

This study's primary objective is to develop a measurement tool to evaluate the physicians' perception of fit between the EMR and the task of establishing effective communication with their patients during the medical encounter. Since we intend to

measure the fit of the system to a specific task, the content domain of 'fit' must be defined in order to construct a questionnaire that measures it.

THEORETICAL DEVELOPMENT

The theoretical framework that has been set as the foundation of our research is the task-technology fit (TTF) theory (Goodhue and Thompson, 1995), suggesting that positive performance impact results if there is a high correspondence between the technology's functionality and the task requirements by the users. Empirical studies that examined the TTF framework revealed that if the IT matches the task, then enhanced job performance, effectiveness, and efficiency are likely results (Wan & Ortiz, 2010).

The TTF concept is the basis for defining the perceived fit in this study, yet we modified its content domain for the specific task at hand. We use the service blueprint technique to analyse the medical task and depict where the system takes part in the encounter (Figure 3). The blueprint, developed by Shostack in 1984, was used in many contexts, and provides the organization with a precise overview of the process it seeks to analyse (Shostack, 1984).

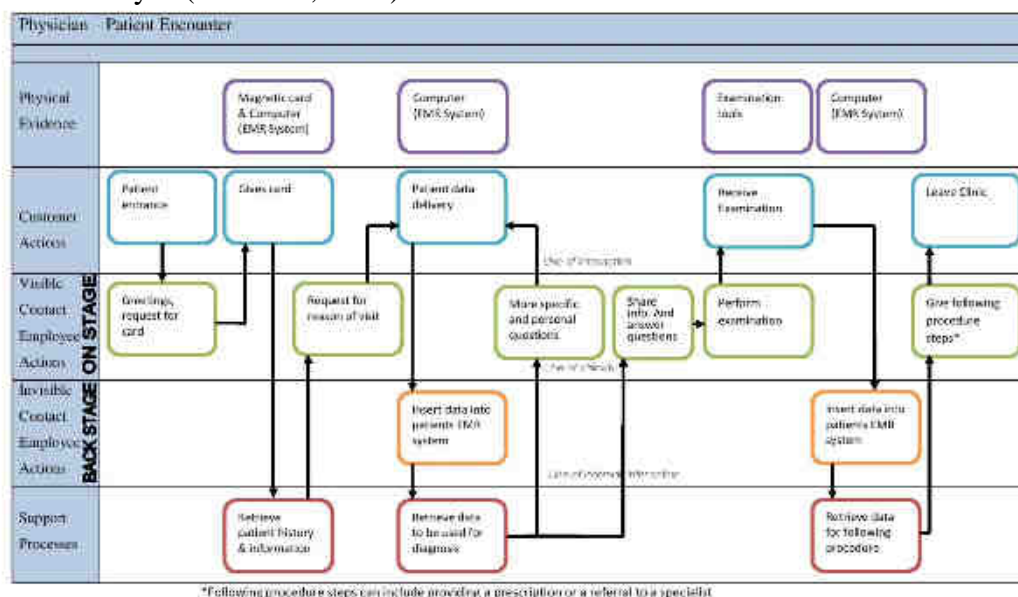


Figure 3. A service blueprint for a typical clinical visit

The first stage in defining the fit would be to define the level of analysis. In our case the physician is defined as the level of analysis, since what is actually measured is his or her perception of fit between the technology and task. **The technology** discussed here is the *EMR* used by the physician during the medical encounter with a patient at the primary care clinic (as opposed to a hospital, where the PPC is carried out quite differently). **The task** is defined as the activities carried out by the physician aimed at establishing effective communication with the patient. Therefore, we define the physician's perceived fit as *"the degree to which a physician believes that use of the EMR system during the medical encounter supports establishing effective communication with the patient"*.

Following the clear definition, four factors were developed to define the perceived fit's content domain. The proposed factors depicted as composing the content domain of the 'fit' construct are based on previous research, including factors from IS theories

and earlier research examining the EMR effect on the physician-patient communication. As in the TTF theory, the factors are divided into task characteristics and technology (system) characteristics. Note that all factors are measured from the physician's perspective, hence they are 'perceived'. We, however, omitted the word 'perceived' from the factors names for clarity's sake.

Task characteristics:

Sharing information deals with the physician's belief that the EMR system's information presentation design supports sharing information with the patient (e.g., shows patient information on the screen) and educating him of his medical situation during the medical encounter.

Task Compatibility refers to the question whether the physician believes that the EMR structure properly guides the medical encounter and matches its order and needs, and whether using the EMR during the medical encounter significantly draws away attention from the patient (e.g., heavy keyboarding), or not.

System characteristics are valuable since they may lengthen the stages where the physician uses the EMR, which was found to hinder the physician-patient communication and will possibly frustrate the physician which may lead to negative outcomes. The two system characteristics are borrowed from the original TTF questionnaire:

System Ease of Use measures the degree to which the physician perceives the ease of using the EMR system as in keying-in patient data and finding needed information during the medical encounter.

Information quality refers to the degree to which the physician believes that the information displayed by the EMR system is accurate, timely (i.e., not outdated) and that the relevant information is available on time when needed during the medical encounter.

DISCUSSION

This paper defines the physician's perceived fit between the EMR system and the task of establishing effective communication with the patient during the medical encounter in primary care. Since the EMR system has a possible negative effect on the physician's ability to carry out socio-emotional behaviours which were found to drive the effectiveness of the PPC, it is of high value to measure the fit of the system to the task, following the TTF framework. The definitions in this project were modified to the task at hand and four factors were described to define the perceived fit content domain. The findings of this study set the foundation for developing and validating a context-specific TTF questionnaire that addresses the medical encounter and communication task. Each factor will be composed of several measures taken from previous frameworks and questionnaires. The questionnaire will be tested by statistical methods for content validity, and followed by statistical methods and Structural Equation Modeling to test scale reliability. If validated, it will contribute first in the ability to assess the fit of EMRs, and second, in suggesting characteristics that the EMR system must consist of in order to fit the communication task that should be taken into consideration when designing an EMR system for a medical clinic.

REFERENCES

- Duggan, P., & Parrott, L. (2001). Physicians' nonverbal rapport building and patients' talk about the subjective component of illness. *Human Communication Research*, 27(2), 299-311.
- Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS Quarterly*, 19(2), 213-236.
- Margalit, R. S., Roter, D., Dunevant, M. A., Larson, S., & Reis, S. (2006). Electronic medical record use and physician-patient communication: An observational study of Israeli primary care encounters. *Patient Education and Counseling*, 61(1), 134-141.
- McGrath, J. M., Arar, N. H., & Pugh, J. A. (2007). The influence of electronic medical record usage on nonverbal communication in the medical interview. *Health Informatics Journal*, 13(2), 105-118.
- Schirmer, J. M., Mauksch, L., Lang, F., Marvel, M. K., Zoppi, K., Epstein, R. M., Pryzbylski, M. (2005). Assessing communication competence: A review of current tools. *Fam Med*, 37(3), 184-192.
- Shostack, G. L. (1984). Designing services that deliver. *Harvard Business Review*, 62(1), 133-139.
- Ventres, W., Kooienga, S., Vuckovic, N., Marlin, R., Nygren, P., & Stewart, V. (2006). Physicians, patients, and the electronic health record: An ethnographic analysis. *The Annals of Family Medicine*, 4(2), 124-131.
- Wan, G. M. B. T. T. H., & Ortiz, J. (2010). Information technology adoption in rural health clinics: A theoretical analysis. *Journal of Information Technology Impact*, 10(1), 1-14.
- Zolnieriek, K. B. H., & DiMatteo, M. R. (2009). Physician communication and patient adherence to treatment: A meta-analysis. *Medical Care*, 47(8), 826-834.

USAGE PATTERNS OF OFEK HEALTH INFORMATION EXCHANGE SYSTEM AT THE SOROKA EMERGENCY DEPARTMENT: RESEARCH IN PROGRESS

Liran Politi

Ben-Gurion University of
the Negev

liranpo@post.bgu.ac.il

Lior Fink

Ben-Gurion University of
the Negev

Finkl@bgu.ac.il

Iftach Sagy

Soroka medical center

iftachsagy@gmail.com

Victor Novack

Soroka medical center

VictorNo@clalit.org.il

Shlomi Codish

Soroka medical center

ShlomiCo@clalit.org.il

Keywords: Health Information Systems, Health Information Exchange, Usage Patterns, Emergency Department

INTRODUCTION

Health information exchange (HIE) systems are health information systems that enable the electronic exchange and integration of patient-level health information across and within organizational boundaries (Hersh 2009; Vest et al. 2011b). These systems have been associated with potential improvements in many aspects of healthcare delivery, the most prominent of which are enhancement of quality of care and patient safety, cost reduction, and increase in efficiency (e.g., Chaudhry et al. 2006; Fontaine et al. 2010; Kaelber and Bates 2007; Vest et al. 2011a).

Salient potential benefiter of an information exchange process are emergency departments (EDs), which are abundant with uncertainty and subjected to time constraints (Shapiro et al. 2007). This is especially the case of critically ill patients requiring resuscitation or other life-saving procedures in the ED. Effectively and correctly diagnosing these critically ill patients in a timely manner is an important challenge physicians constantly face. Information in such cases is often obtained from secondary sources such as family members and information systems, as patients are typically uncommunicative. The care of such critical patients in the ED on the one hand presents one of the scenarios in which an HIE would be most beneficial to clinical decision making and on the other hand often requires rapid decisions in which the perusal of an HIE might not be practical.

Many of the anticipated effects of HIE use are based on theoretical analyses and the empirical literature has substantiated them only partially. Several studies have established that the extent to which these benefits are fulfilled very much depends on the implementation of the HIE system and its integration into the workflow (Frisse and Holmes 2007).

Hence, shedding light on HIE usage patterns and on their integration into the workflow may promote successful realization of their potential benefits. Such an analysis can assist in addressing the explanations of the IT productivity paradox – mismeasurement, mismanagement, and poor usability (Jones et al. 2012) – in the context of HIE systems.

Although some empirical work was dedicated to analyzing patterns of HIE use, these analyses did not account for the implications of user type or patient attributes. Furthermore, usage patterns were usually characterized by the sequence, number, and types of screens viewed by HIE users, and they disregarded time-related traits.

OFEK is an HIE system (developed by dbMotion, Israel) used by Clalit Health Services, the largest healthcare provider in Israel across its 14 hospitals and over 1300 primary care clinics. As such, OFEK is linked to various data sources, which encompass over 50% of the Israeli population's medical data. The use of this system is considerable, particularly in hospitals. Two studies examined factors affecting OFEK's implementation, how it was generally utilized, and the effect its implementation had on quality and medical service utilization (Brainin et al. 2005; Nirel et al. 2010). These studies did not try to indentify use patterns, yet pointed to several significant changes in resource utilization, which occurred presumably due to the introduction of OFEK to Clalit facilities.

Soroka Medical Center is the largest hospital in Clalit's network of hospitals with over 1000 beds. Its ED is the busiest in Israel with over 210,000 visits annually.

OBJECTIVES

The purpose of this study is to identify, describe, and discern between patterns of use of the OFEK HIE system in the specific context of adult critical patients treated at the Soroka medical center ED. This study will also examine how usage patterns are related to physicians' and patients' attributes.

Once patterns of OFEK use are identified, it would be possible to empirically analyze the associations between these patterns and clinical performance measures, such as admission ward (intensive care unit vs. regular ward), length of stay in the ED, and scope of ancillary tests ordered.

This work is performed in cooperation with Soroka's clinical research unit, which is responsible for examining the clinical aspects of treatment given in the ED.

METHOD

The analysis of patterns of use is based on log files extracted from the OFEK data bases. These files contain documentation of all activity that was conducted in OFEK in regards to specific patients who received treatment in Soroka's ED, including the user who accessed the system, the screens that were accessed, the sequence of

accessed screens, and the exact time in which access was made. The log files were screened based on a list of all critical patients requiring resuscitation for medical reasons (excluding trauma) at Soroka's ED in the years 2010-2012, a total of about 1082 patients.

We define a "session" as a continuous stream of clicks that is initiated by the use of the system by a specific physician for a specific patient. The unit of analysis is therefore a single patient-user session. Using a script coded for this research, each stream of clicks is converted into a single tuple (i.e., empirical observation), representing a complete session. A session is characterized by its length (total number of screens accessed), breadth (number of different screens accessed), depth ("level" of information specificity), duration (median duration of screen display per session), and types of information that were accessed.

To classify sessions into homogenous groups, we apply various cluster analysis techniques, including hierarchical and nonhierarchical.

Using data from other health information systems used by Soroka hospital, we intend to empirically examine the antecedents (patient and physician characteristics) and consequences (performance indicators) of OFEK use patterns (session clusters).

PRELIMINARY RESULTS

We are currently in the early stages of data collection and analysis. We intend to present our preliminary results at the conference.

REFERENCES

- Brainin, E., Gilon, G., Meidan, N., & Mushkat, Y. (2005). "The Impact of Intranet Integrated Patient Medical File (IIPMF) Assimilation on the Quality of Medical Care and Organizational Advancements," The Israel National Institute for Health Policy and Health Services.
- Chaudhry, B., Wang, J., Wu, S., Maglione, M., Mojica, W., Roth, E., Morton, S.C., and Shekelle, P.G. (2006). "Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care," *Annals of Internal Medicine* (144:10), 742-752.
- Fontaine, P., S. E. Ross, T. Zink, and L. M. Schilling. (2010). "Systematic Review of Health Information Exchange in Primary Care Practices," *The Journal of the American Board of Family Medicine* (23:5), 655-670.
- Frisse, M. E., and R. L. Holmes. (2007). "Estimated Financial Savings Associated with Health Information Exchange and Ambulatory Care Referral," *Journal of Biomedical Informatics* (40:6, Supplement), S27-S32.
- Hersh, W. (2009). "A Stimulus to Define Informatics and Health Information Technology," *BMC Medical Informatics and Decision Making* (9:1), 24.

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

- Jones, S. S., P. S. Heaton, R. S. Rudin, and E. C. Schneider. (2012). "Unraveling the IT Productivity Paradox — Lessons for Health Care," *New England Journal of Medicine* (366:24), 2243-2245.
- Kaelber, D. C., and D. W. Bates. (2007). "Health Information Exchange and Patient Safety," *Journal of Biomedical Informatics* (40:6, Supplement), S40-S45.
- Nirel, N., B. Rosen, A. Sharon, O. Blondheim, M. Sherf, H. Samuel, and A. D. Cohen. (2010). "The Impact of an Integrated Hospital-Community Medical Information System on Quality and Service Utilization in Hospital Departments," *International Journal of Medical Informatics* (79:9), 649-657.
- Shapiro, J. S., J. Kannry, A. W. Kushniruk, G. Kuperman, The New York Clinical Information Exchange (NYCLIX) Clinical Advisory Subcommittee, and G. J. Kuperman. (2007). "Emergency Physicians' Perceptions of Health Information Exchange," *Journal of the American Medical Informatics Association* (14:6), 700-705.
- Vest, J. R., L. D. Gamm, R. L. Ohsfeldt, H. Zhao, and J. J. Jaspersen. (2011a). "Factors Associated with Health Information Exchange System Usage in a Safety-Net Ambulatory Care Clinic Setting," *Journal of Medical Systems* (36:4), 2455-2461.
- Vest, J.R., Jaspersen, J., Zhao, H., Gamm, L.D., and Ohsfeldt, R. (2011b). "Use of a Health Information Exchange System in the Emergency Care of Children," *BMC Medical Informatics and Decision Making* (11:1), 78.

PERSONAL CONTEXT PROFILE FOR PERSONALIZATION OF CLINICAL GUIDELINES

Adi Fux¹

Adif.pmi@gmail.com

Mor Peleg¹

peleg.mor@gmail.com

Pnina Soffer¹

spnina@is.haifa.ac.il

Sagit Zolotov²

sagitmail@gmail.com

Eddy Karnieli²

eddy@techunix.technion.ac.il

¹Department of Information systems, University of Haifa, Israel

²Endocrinology, Diabetes and Metabolism, Rambam Medical Center and Rappaport Faculty
of Medicine, Technion

Key words: Clinical Guidelines; Decision Support System; Personalization

INTRODUCTION

One of the greatest challenges facing physicians and chronic patients is sustaining patient adherence to treatment recommendations over time. Surveys (Van Dulmen et al., 2007) made in various countries indicate a sad situation where less than half of the chronically ill patients adhere to the treatment recommendations given by medical staff. Patients struggle to meet long-term recommendations as they might contradict their desire to maintain their daily routine. Our study (Fux, Peleg, & Soffer, 2012) and other surveys (Vermeire, Hearnshaw, Van Royen, & Denekens, 2001)(McDonald & Garg, 2002) suggest that one of the main reasons is patients personal constraints, which can vary over time. Many physicians recognize this conflict and try to adjust long-term treatment recommendations to accommodate the patient's lifestyle and habits.

Patient's treatment recommendations are based on narrative clinical guidelines. The narrative clinical guidelines are systematically-developed statements to assist practitioners and patient decision making about appropriate healthcare for specific clinical circumstances (M Peleg & Tu, 2006).

Computer-interpretable guidelines (CIGs) are a representation of clinical guidelines in a guideline modeling language. CIGs help physicians to provide patient-specific recommendation at the point of care during clinical encounters by using Decision Support Systems (DSS) to provide treatment recommendations. The DSS crosses the patient's data from the medical record with the medical knowledge base of the DSS to provide patient-specific recommendations.

However, clinical guidelines do not describe how personal factors should influence the medical decision making process. The personal knowledge is stored in the electronic medical record as text and current DSSs do not consider the personal data in the recommendations.

The medical staff is aware of this and manually adjusts the treatment recommendations based on the patient's steady-state personal status as well. However,

adjustments to changes to the daily routine are harder to support.

We suggest customization of clinical recommendation to the patient's personal state (context) that can react to changes in the patient's context.

OBJECTIVES

Our main motivation is to increase patient adherence to treatment recommendations by systematically adding the patient's lifestyle, habits and other personal categories into the clinical guidelines, thus customizing guidelines to personal context. Based on these categories, key personal context state abstractions are defined, which we refer to as "personal context profile". A personal context profile is a configuration of personal context properties that represents a personal situation that is likely to happen (e.g., a "normal routine" profile and a "travel abroad" profile). We propose to improve the chronic patient care process by providing the physician an option to define a set of alternative personal context profiles for a patient. For each personal context profile the physician will define the most suitable treatment recommendation. This approach will provide customized options that are likely to improve patient adherence.

Our vision is to develop a decision-support system based on customized clinical guidelines that specify care plans customized to different patient contexts. The customized guideline would be encoded in an existing guideline modeling language, such as Asbru, PROforma, or GLIF3 (Peleg et al., 2003). When the decision-support system will execute the encoded guideline, it would provide patient-personalized advice that is based on the patient's current state (the currently active profile) that matches one of the personal context state abstractions in the augmented guideline. Thus, changes in the patient's personal state will be matched with changes in guideline plans.

The physician will be able to define patient's routine context and other patient's context profiles. For each profile the physician will be able to specify the most suitable treatment recommendation, based on the options provided by the customized guideline. The patients will be able to change the active profile to keep on treatment recommendations.

METHODS

Our methods for introducing personal context into a CIG, thereby customizing it, are as follows. We (1) identify decision points in the clinical guideline where several treatment options are offered, (2) consider the most relevant personal categories for a given clinical guideline, and (3) define the effect of each personal category on the treatment recommendations.

We conducted 61 structured interviews with physicians and chronic patients (22 from diabetes, 15 from asthma, 13 from cardiology and 11 from gestational diabetes) to characterize the personal categories that affect the patient's ability to adhere treatment recommendations. Examples of personal categories include family member available to assist treatment, daily routine schedule that is very busy, etc.

The elicited categories and their effect on patient scenarios were evaluated by physicians.

RESULTS

The number of personal categories, defined in medical textbooks includes 3 main categories – family status, occupation and habits (Bickley, Szilagyi, & Barbara, 2002). The personal categories arising from the interviews analysis cover the 3 main

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

categories and include 14 other personal categories that affect treatment recommendations. The personal categories are presented in Table 1 and include diet routine, exercise level, communication level etc. In addition, we analyzed the types of influences personal factors can have on treatment recommendations (e.g., safety thresholds restriction measures), as listed in Table 2.

Table 1: main personal categories affecting treatment recommendations

Personal category	% care providers ¹	% patients ²	example	Category range
Support level	93%	73%	"...if someone lives alone and has CVA starting with insulin..."	Full support, frequent to no support
Daily routine	87%	80%	"...work type and daily routine are important factors in treatment goals..."	Routine, semi-routine, no routine
Alcohol use	83%	87%	"in case of a alcohol excessive use patient can't adhere..."	No use, medium, addicted
Drug use	83%	87%	"should mind the doses..."	No use, medium, addicted
Smoking habits	83%	87%	"in case of a heavy smoker I can't prescribe some medicine..."	No use, medium, addicted
Diet routine	82%	80%	"you see them tense in their chair remembering the pita (bread)..."	Routine, semi-routine, no routine
Physical disability	82%	80%	"if a patient comes with a cane or a wheelchair, we must consider..."	None, some, medium and high
Exercise level	70%	73%	"she is a marathon runner, can we reduce the medication?"	Extreme, moderate, medium, low
Communication level [Cooperation, education, language and trust]	68%	38%	"...patient communication is based on his cooperation, willing to know about his condition, education level, language level and trust with the care provider and is a significant factor in the process..."	High, medium and low level
Financial capabilities	59%	53%	"A 70-year old patient takes a lot of medications. Can he afford it? "	High, medium and low level
Living area accessibility	59%	53%	"does the patient have an elevator, or does he need to climb stairs?"	Easy, medium and difficult access
Distance from medical center (time)	59%	53%	"can the patient will be able to arrive on time to the medical center?"	Immediate, near, distant and isolated
Pain level	52%	67%	"in case the pain is intolerable I need to attend immediately..."	None, light, fair, disturb, hard and intolerable
Stress level	52%	67%	"there are stress period that affect clinical indicators..."	High, medium and low level
Patient's ability to comply treatment	32%	40%	"...will the recommended treatment will be done in the patient status, or we should compromise to make sure some of the treatment will be done?"	Full, partly or low
Patient's ability to comply treatment with help	32%	40%		Full, partly or low
Need for help for treatment process	30%	30%	"...I must explain the care giver, the patient doesn't understand..."	Yes / no

¹ total of 46 care providers

² total of 15 patients

Table 2: personal categories effect on treatment recommendations

Medication change – changes in dose, schedule or type
Measurement modification – changes in schedule, type, doses and frequency
Allowed data item threshold
Physical activity routine
Diet and foods modification
Appointment timing and schedule changes
Treatment performing and informing agent

To demonstrate our vision of customized treatment plans based on personal context, we present the following scenario, based on diabetes domain and referring to a narrative guideline developed by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD) (Inzucchi et al., 2012).

Doron is a 53 year old Caucasian male that was referred for help in managing his diabetes and was advised to start insulin therapy.

The treatment recommendations, based on the diabetes clinical guidelines (page 9 of Inzucchi et al., 2012) offers a variety of insulin regimens. His physician recommended injection of insulin 3 times a day with his meals and measurement of blood sugar. Doron clarified that he is not ready to inject insulin during his routine working day, regardless of the recommendation, and therefore there is a need to recommend another program to fit his preferences.

Based on Doron's condition and the ADA, his physician recommended that Doron will inject a shot of long-term insulin evening (after dinner) and morning (before work), and try to add, at least, one additional measurement during the day to check blood sugar. The physician heard that customized clinical guidelines that include personal context were published and decided to adopt these guidelines. The guidelines include the construction of personal categories tailored for each patient and adjust treatment relationship that meets the clinical objectives.

Doron's physician defined, based on his clinical status, preferences, and personal context, Doron's "workday profile" (with the work hour's injection limitations); and "weekends profile".

During "workday profile" Doron will follow the recommendation of 2 long acting insulin injections. During "weekends profile", where the requirement of no injection during work hours is relaxed, Doron will follow the recommendations that include injecting insulin 3 times a day.

CONCLUSIONS

The abstract presents the personal context profile as a method to tune treatment recommendations to changes in the personal context of patients, thereby improving adherence to treatment. Our scenario illustrates the customization of a clinical guideline to personal context categories and the definition of two personal profiles.

Directions for future research can be the development of computerized customized guidelines that include personal context and treatment effects. These guidelines, integrated in a health system, will help patients adhere to treatment recommendations during their daily routine. Another direction is to develop a system that would also be able to remind, measure, and alert of clinical changes, by synchronizing with a personal diary.

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

Acknowledgement: The study is part of the MobiGuide project, partially funded by EC FP7 grant #287811.

REFERENCES

- Bickley, L. S., Szilagyi, P. G., & Barbara, B. (2002). *Bates' Guide to Physical Examination & History Taking*.
- Fux, A., Peleg, M., & Soffer, P. (2012). How Can Personal Context Improve Adherence to Clinical Guidelines ?
- Inzucchi, S. E., Bergenstal, R. M., Buse, J. B., Diamant, M., Ferrannini, E., Nauck, M., Peters, A. L., et al. (2012). Management of hyperglycemia in type 2 diabetes: a patient-centered approach: position statement of the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). *Diabetes care*, 35(6), 1364–79. doi:10.2337/dc12-0413
- Mcdonald, H. P., & Garg, A. X. (2002). Helping Patients Follow Prescribed Treatment, 288(22).
- Peleg, M., & Tu, S. (2006). Decision Support, Knowledge Representation and Management in Medicine. *IMIA and Schattauer GmbH*, 72–80.
- Peleg, M., Tu, S. W., Bury, J., Ciccarese, P., Fox, J., Greenes, R. A., Hall, R., et al. (2003). Comparing Computer-Interpretable Guideline Models: A Case-Study Approach. *J Am Med Inform Assoc*, 10(1), 52–68.
- Van Dulmen, S., Sluijs, E., Van Dijk, L., De Ridder, D., Heerdink, R., & Bensing, J. (2007). Patient adherence to medical treatment: a review of reviews. *BMC health services research*, 7, 55. doi:10.1186/1472-6963-7-55
- Vermeire, E., Hearnshaw, H., Van Royen, P., & Denekens, J. (2001). Patient adherence to treatment: three decades of research. A comprehensive review. *Journal of clinical pharmacy and therapeutics*, 26(5), 331–42. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/11679023>

DETERMINING CLUSTERING SEGMENTATION VIA FEATURE'S SALIENCY

Barak Aviad

Bar-Ilan University

aviadbarak@gmail.com

Gelbard Roy

Bar-Ilan University

gelbardr@mail.biu.ac.il

Keywords: Data Mining, Cluster Analysis, Classification, Bounded-Rationality, Saliency.

INTRODUCTION

The proposed model enables a user to select a suitable clustering algorithm and determine the number of clusters in a way that reveals and pinpoints the significant attribute features in the dataset according to their saliency. To do so, it has to find the attributes that characterize each one of the clusters; in other words, those attributes that describe the entities of the cluster. Since the main reason for using clustering techniques is to detect special and well-defined sub-groups in the dataset, we also expect the proposed model to provide a measure to assess the ability of the clustering results to produce clusters which have these special characteristics, and thus help the user choose between different clustering algorithms and determine the number of clusters desired. Mathematical development of the model and illustrative examples are described in Barak & Gelbard (2012).

THE PROBABILITY FUNCTION

The probability function represents the probability of a typical user to decide that a certain cluster is characterized by a specific attribute. This function is mainly dependent on two features:

- The distribution of the attribute within the cluster (R_{ijk})
- The distribution of the attribute in the entire dataset (R_{ij})

A mathematical function suitable for this purpose is the logistic function because it has all the desired qualities and built-in parameters for the task.

The x value of the function is the difference between R_{ijk} and R_{ij} (which ranges between -1 and 1) multiplied by 10 to get values between -10 and 10 (in this range the logistic function returns values between 0 and 1).

This logistic based function returns values between 0 and 1 and ensures a steep slope for x values close to 0 (R_{ijk} is close to R_{ij}) because this is the range where every change in R_{ijk} (the inner distribution of a certain cluster) impacts the probability substantially. For x values closer to the edges (R_{ijk} far from R_{ij}) the slope of the function is much more moderate because in this area changes in R_{ijk} have a small effect on the probability.

The probability function described above is suitable for all types of variables: binary, nominal, ordinal and continuous.

TOTAL SALIENCY FACTOR (TSF)

Clustering techniques are used to divide a certain population into meaningful clusters with unique characteristics. Therefore, a useful clustering result is one that creates a set of clusters with a maximal number of significant attribute features.

The saliency measure is defined as the grand mean of the maximal probabilities of all clusters and attributes. The saliency measure values range from 0 (when the distributions of the attributes in all clusters are similar to their distribution in the entire population) to 1 (when the distributions of attributes in all clusters are significantly far from their distribution in the entire population). A high saliency value ensures that the clustering results are significant and useful because it enables the user to describe the special characteristics of each cluster using large numbers of attributes.

MODEL IMPLEMENTATION

Since it is very hard to describe a new model in few pages, we chose to demonstrate the model implementation and contribution using a software tool we have developed as part of the research.

This software tool can calculate the saliency measure (probability function) and the Total Saliency Factor (TSF). Figure 1 shows an example of the output screen of the software tool, based on one of the datasets used for implementing and testing the model. In the right part of the screen, the metadata of the dataset are defined. If the attribute is continuous, it is termed "range", and if the attribute is categorical its possible values are noted.

This tool implements the formulas described above and its output has three main parts:

- Top left table – the statistics matrix which shows the inner median / distribution of each cluster, compared to the general population.
- Bottom left table – the probability matrix showing the results of the probability function for each attribute of every cluster. Probabilities higher than a defined threshold (in this example the threshold is 0.9) are automatically highlighted.
- Saliency – the final result of the saliency measure.

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin
Academic Center, Emek Hefer, Israel**

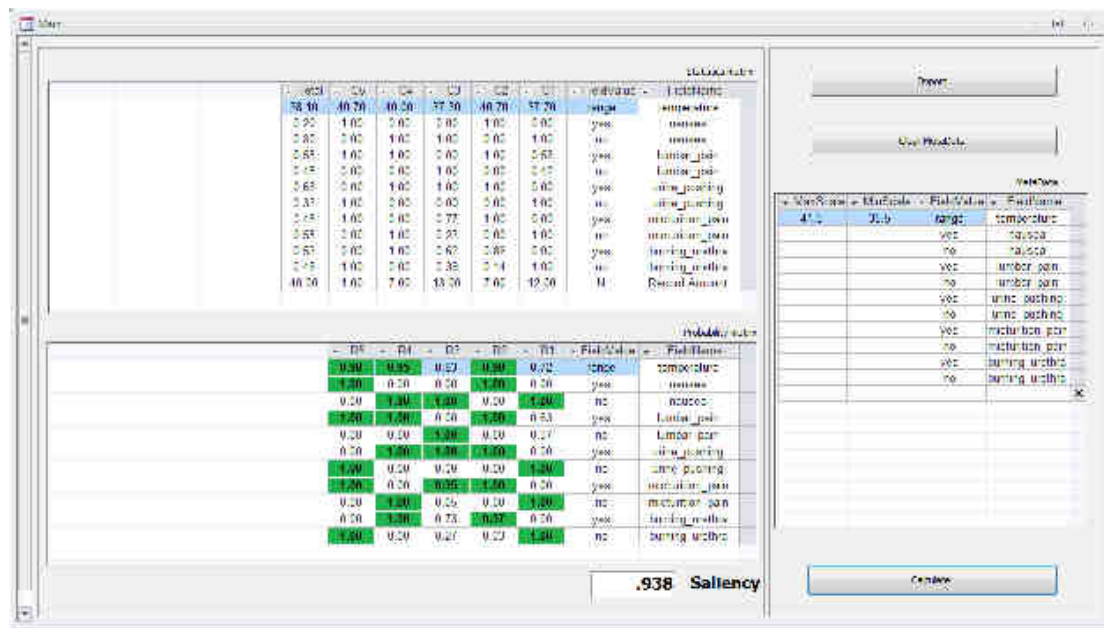


Figure 1. Screenshot of the Software

Using the described model and the software tool, it is possible to get for each clustering division (set of clusters) the special characteristics of each cluster (highlighted in the probability function) and a measure of the division saliency, thus the user may compare and choose between different clustering algorithms and determine the number of clusters desired.

In this way, the proposed method delivers an automatic interpretation of the clustering results, thus pinpointing meaningful hidden insights.

REFERENCES

- Barak A. & Gelbard R. (2012). A Decision Support Method Based on Bounded-Rationality Concepts to Reveal Feature Saliency in Clustering Problems. *Decision Support Systems*, 54(1), 292-303.

THE EFFECT OF MISSING DATA ON CLASSIFICATION QUALITY

Michael Feldman

Ben-Gurion University of the Negev,
Israel

fmichael@bgu.ac.il

Adir Even

Ben-Gurion University of the Negev,
Israel

adireven@bgu.ac.il

Keywords: data quality, missing values, decision making, classification, linear discriminant analysis

INTRODUCTION

The common saying “Garbage in Garbage Out” reflects a key concern in the field of data quality management (DQM) – the negative impact of data quality (DQ) defects on decision making (Redman, 1996; Shankaranarayanan and Cai, 2006; Liu et al., 2010). This study explores that impact through the mediating role played by decision-support models, arguing that a wrong decisions are often the result of an unreliable model that was a built from low-quality data. Decision-making is often supported by a model (Shim et al., 2002) - a form of representation (e.g., theoretical, analytical, visual, statistical) that describes phenomena or behaviors in the real-world. Such a model permit prediction of future behavior to an extent and, by that, assists with the formation of decisions and actions. Following this notion, Decision-Support Systems (DSS) provide the infrastructure and the utilities for building, applying and evaluating models that aid the decision-maker.

Our methodology is conceptualized along three key stages of a typical data-driven decision process (Shim et al., 2002), and the associated quality assessments (Figure 1):

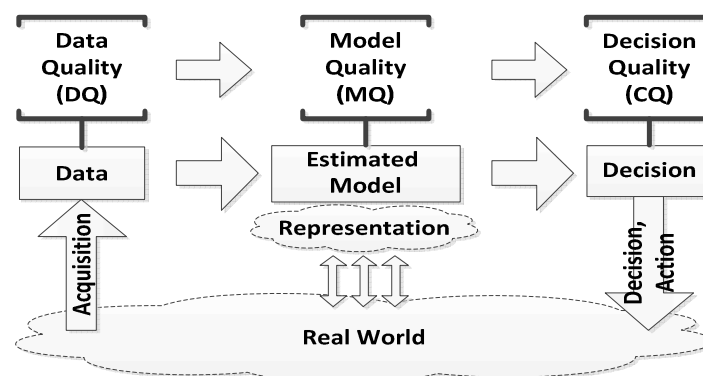


Figure 1: A Decision Process

In this study, we focus on classification – decision scenarios in which we associate a certain object, behavior, or situation with one category (or class) among a set of choices. Many decision scenarios, in different contexts, can be interpreted as classifications – e.g., replenishing inventory items (Davenport, 2006), assigning a customer to a segment (Even et al., 2010), or medical decisions, based on patient diagnostics (Session and Valtorta, 2009). Classification models are often estimated (or “trained”) from a dataset. If the “training” dataset suffers from DQ defects – the estimated classifier is likely to be biased; hence, with a higher likelihood, the resulting

decisions will be flawed. In this study we chose to evaluate our methodology with a relatively simple but common classifier – the binary Linear Discriminant Analysis (McLachlan, 1992). We introduce a methodology that links the quality levels described above – data, model, and decision - and highlights the relationships among them in the context of classifiers. The methodology is further developed for binary LDA – but some of the evaluation and measurement methods applied can be used in broader contexts.

METHOD: BINARY LDA FOR DECISION QUALITY ASSESSMENT

Training Sets and Data Quality Measurement (Q^D): The data stored in organizational repositories can be used for the estimation of classification models. Following common terminology (Duda and Hart, 2001), we refer to the process of estimating the model by “training” dataset used to estimate the model representing the real world behavior. Following common DQ measurement schemas (Even and Shankaranarayanan, 2007), each record is associated with a Q_n measurement of completeness - 0, if one or more attribute values (or the entire record) are missing (i.e., NULL), 1 if the record is complete. The quality of the entire dataset Q^D , in terms of completeness, is defined as the rate of non-missing values in dataset.

Classification Models, and Model Quality Measurement (Q^M): The confidence interval (CI) is a common approach for assessing the reliability of estimated model parameters. For example, when estimating a certain parameter A from a training set – the estimated value \hat{a} is not necessarily the true one. CI assessment would allow us to assume that “with a confidence of g% the true value of A resides within the CI of $[\hat{a}-\Delta_1, \hat{a}+\Delta_2]$ ”. Obviously – the smaller are the CI's for all parameters, the more reliable is the classification model. Further, with classification models that involve CI assessment, it can be shown that the CI gets smaller with a higher N. Adopting the CI-assessment concept - we take L, the length of the confidence interval as a measure for model quality (i.e., if the confidence interval is defined by $[\hat{a}-\Delta_1, \hat{a}+\Delta_2]$, then $L = \Delta_1+\Delta_2$). The model-quality metric has to be defined for each model parameter A. It has to consider the desired target confidence level ρ , the number of samples N in the complete dataset, and the missing value rate (as reflected by Q^D):

$$Q_A^M(\rho, N, Q^D) = L_A(\rho, N * Q^D) \quad (1)$$

Confusion Matrix, and Decision Quality Measurement (Q^C): With binary classifiers (i.e., set of two valid classes), in which the output is either positive (Y=1) or Negative (Y=0), it is common to assess classification performance with the 2-way confusion matrix where a Positive item that was classified as Positive is considered as “True Positive” (TP), and so on (Hanand Kamber, 2006). In addition, the total number of instances per quadrant that represent each possible state are N_{TP} , N_{FP} , N_{FN} and N_{TN} , respectively, where $N_{TP}+N_{FP}+N_{FN}+N_{TN} = N$.

The metrics developed so far, within the measurement methodology introduced in this section, were defined in a general manner that permits their usage in many classification scenarios. However, we suggests that with further analytical development, such metrics can become even stronger tools for assessing and predicting the behavior of discussed three quality levels, and setting DQ policies

accordingly.

Decision Quality Metric for the Binary LDA Classifier: After showing the effect of DQ on MQ, we now show the impact of DQ and MQ on the decision quality CQ; since model quality measurement is based on the precision with which the model reflects the real world state, decision quality metric pretending to take into account uncertainty level of classification estimation. Based on this approach we developed measurement weighting potential misclassification costs and normalizing it by model quality measurement given by Equation 1.

$$U * \frac{\int_{\hat{A} \in CI} \left(\Phi \left(\frac{\hat{A} - \mu_1}{\sigma} \right) + \Phi \left(\frac{\mu_0 - \hat{A}}{\sigma} \right) \right) d\hat{A}}{(1-\rho) * \Delta(\rho, N, Q^D)} = U * \delta(\rho, N, Q^D) \quad (2)$$

EVALUATION

Simulation Results for Model Quality Measurement

Figure 2 shows the model quality (Q^M – the confidence interval length) versus the data quality (QD) for different sample sizes, and with $\rho = 0.05$. The samples were taken from two normally-distributed populations with $\mu_0=2$, $\mu_1=4$ and common $\sigma=3$.

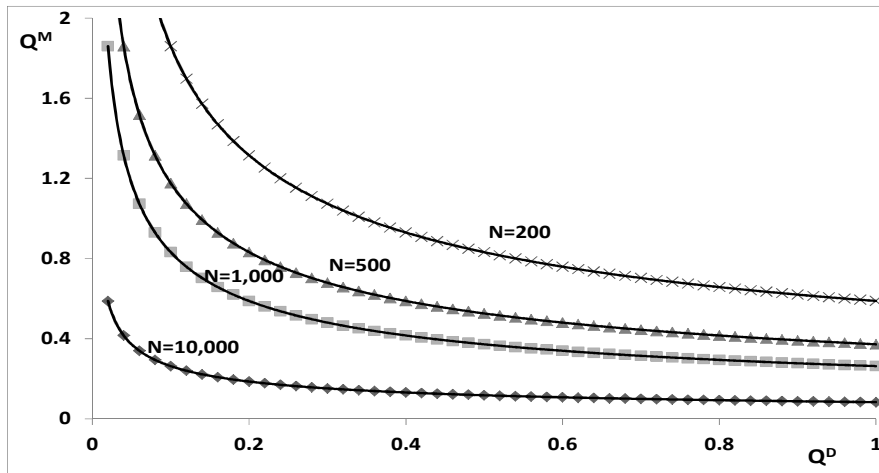


Figure 2. Model Quality (QM) versus Data Quality, with $\rho = 0.05$

The figure highlights that model quality is likely to increase (smaller confidence interval) with a higher N, and with a higher DQ level. Notably, with the highest sample-size shown ($N=10000$), the QM degradation is relatively minor for small QD degradation ($QM(QD=1) = 0.08$, versus $QM(QD=0.6) = 0.1$), but becomes more severe as QD reaches low rates ($QM(QD=0.1) = 0.26$).

Simulation results for decision quality measurement

The expression $\delta(\rho, N, Q^D)$ in Equation 2 reflects the average likelihood that a certain item will be misclassified, given certain values of confidence level ρ , training-set size N, and DQ level Q^D . It is likely to decrease with a smaller ρ , larger N, and/or larger Q^D . Figure 3 shows the expected classification cost (C^C) versus the data quality (Q^D) for different sample sizes, with $U=1$ and $\rho=0.05$ (the same training sets that were used in Figure 4 - $\mu_0=2$, $\mu_1=4$, $\sigma=3$).

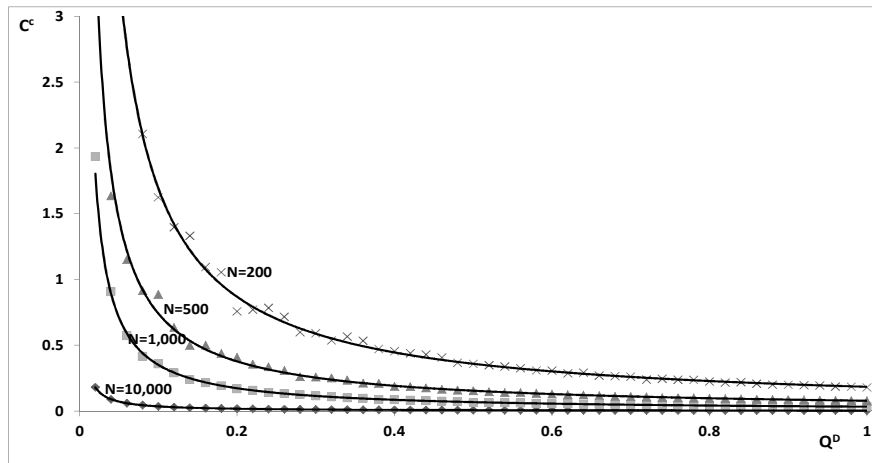


Figure 3. Model Quality (Q^M) versus Data Quality, with $U=1$ and $\rho = 0.05$

The similarity in behavior between Figure 2 and Figure 3 is noticeable – the expected cost is higher with lower sample size, and decreases further as the rate of missing values increases (lower Q^D). With a very large N (here, the maximum take is $N=10,000$), and with no missing values ($Q^D=1$), the expected C^C nearly reaches the optimum ($C^{C*} \approx 0.036$). At this large sample size the impact of missing values is relatively minor – there a significant change in C^C only when Q^D goes below 0.1.

CONCLUSIONS

The negative impact of DQ defects on decision making has been broadly acknowledged in research and in practice. This study suggests that a possible way to understanding and quantifying this impact is by looking into the mediating role played by decision-support models. Such models are often estimated from training datasets – and when such a training dataset suffers from DQ defects, the model and the decisions that it supports are likely to be biased. This claim makes intuitive sense – however, not much was done to support it analytically. This study takes a step in that direction by offering an analytical framework that links the three levels of quality assessment - data quality, model quality, and decision quality. The analytical development demonstrated in this study is relatively simple – and its aim was to highlight and demonstrate the key concepts. Furthermore our goal is to examine comprehensive and complex decision scenarios, in which some of the assumptions made will be relaxed.

REFERENCES

- Davenport, T. H. (2006). *Competing on analytics*. Harvard Business Review, 84(1), 98.
- Duda, R. O., Hart, P. E., & Stork, D. G. (2012). *Pattern classification*. New York: John Wiley and Sons, Inc.
- Even, A., & Shankaranarayanan, G. (2007). Utility-driven assessment of data quality. *ACM SIGMIS Database*, 38(2), 75-93.
- Liu, S., Duffy, A. H., Whitfield, R. I., & Boyle, I. M. (2010). Integration of decision support systems to improve decision support performance. *Knowledge and Information Systems*, 22(3), 261-286.

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

- McLachlan, G. J. (2004). *Discriminant analysis and statistical pattern recognition* . New York: John Wiley and Sons, Inc.
- Redman, T. C., & Blanton, A. (1997). *Data quality for the information age*. Artech House, Inc.
- Sessions, V., & Valtorta, M. (2009). Towards a method for data accuracy assessment utilizing a bayesian network learning algorithm. *Journal of Data and Information Quality (JDIQ)*, 1(3), 14.
- Shankaranarayanan, G., & Cai, Y. (2006). Supporting data quality management in decision-making. *Decision Support Systems*, 42(1), 302-317.
- Shim, J. P., Warkentin, M., Courtney, J. F., Power, D. J., Sharda, R., & Carlsson, C. (2002). Past, present, and future of decision support technology. *Decision Support Systems*, 33(2), 111-126.

IMPROVING CORRECTNESS OF SCALE-FREE NETWORKS TO MESSAGE DISTORTION

Arie Jacobi

Ono Academic College

jacobi.arie@gmail.com

Ofir Ben-Assuli

Ono Academic College

ofir@ono.ac.il

Keywords: Social networks, distortion of information, organizational communication, scale-free networks.

Regardless of era, people communicate by sending messages to each other. The Web 2.0 information revolution has led to an exponential growth in the numbers of organizations and individuals who communicate by sending messages over electronic social networks. A message can be verbal or written, and the mechanisms for sending messages include real-time chatting applications in an electronic social network, Word Of Mouth (WOM) marketing methods, electronic WOMs (Sohn, 2009), or by forwarding a message in an email with an additional text. These messages, however, are subject to change as they are diffused in the network. A practical example is an advertising campaign in an electronic social network that has a clear and concise message statement, and it should be diffused in a social network as accurately as possible with less distortion as possible. An example of distorted advertising campaign in the internet was for Apple's iPad product. Though it is very successful, its name was promptly changed in the internet into 'iTampon' and many jokes and results. Therefore, practical methods for correcting distorted messages while diffused in social networks are needed.

This paper attempts to calculate the distortion of a message as it propagates in a social network with a scale free topology, and to establish a remedial process in which a node will correct the distortion during the diffusion process, in order to improve the robustness of scale-free networks to message distortion. We test a model that we created using a simulation of different types of scale-free networks, and we compared different sets of corrective nodes; hubs and regular (non-hubs) nodes.

LITERATURE SURVEY

Propagation and Data Distortion via Social Networks

Social network analysis assesses information opportunities for individuals or groups in terms of exposure to information and its control. By identifying existing information exchange routes, information providers can act on information opportunities and make changes to information routes to improve the delivery of information services. Panzarasa et al. (2009) inferred the processes underpinning dynamics of use of network online communities established over time by online messages. They investigated the role played by hubs, which moderators and managers can appropriate to devise appropriate strategies for improving the security of communication and enhancing the effectiveness of information diffusion. Ma et al. (2010) argued that an information explosion can take place in which the number of

distinct pieces of information in the network increases continuously with time, leading to high error probability. They describe a control strategy to maximize the robustness of the network against information explosion. Diffusion of information has been extensively researched and different models have proposed, e.g. Rogers (1995) and Valente (1996).

Crucitti and Marchiori (2001, 2003) introduced a definition of the efficiency of a network to propagate information. They assumed that the efficiency Q_{ij} of the communication between node i and j in a graph G is inversely proportional to the shortest distance: $Q_{ij} = 1/d_{ij}$, $\forall i, j$. The efficiency was defined on global and local scales. Local efficiency was defined as the average efficiency of local sub-graphs.

In this paper, we refer to the concept of robustness with regard to the resilience of a network to distortion of information diffused in it, as opposed to use of robustness in graph theory and network analysis (Crucitti et al. 2003; Singer 2006) that measures the resilience of the network to the removal of edges or vertices. To the best of our knowledge there have been no studies on the robustness of different types of social networks to distortion of information.

METHODOLOGY

In this paper we present a study of the robustness of a scale-free network to distortion of information in the form of a verbal or written message, and ways to decrease the total distortion error. A message has a tendency to change when one person transfers it to another person. Our assumption is that this change in the transferred message, what we call its distortion, is usually reflected in different parts of the message, but some of the information remains unaltered. The simulation involved a model of the network and a model of the distortion process propagating in the network. The propagation model was tailored so as to reflect the realities of the dissemination of information in a social network. To ensure accurate message correction, the corrective nodes are paid.

Proposed Model

Given a network N with n nodes, and a message m which represents a sequence of letters, words, or parts of sentences, without loss of generality in this model we define m as a sequence of letters $\sigma_i \in \Sigma, i = 1, \dots, k$, where $\Sigma \in \{0,1\}$ is an alphabet. Initially, message m is transmitted by l different people in N . These people are called *initial propagators*. A person P_i in network N forwards message m to $0 \leq q \leq k_i$ of his contacts, where k_i is the degree of P_i and q is chosen randomly. The first message that a person P_i receives is denoted as m_1^P and this is the message that P_i remembers. We denote this message as the “message in memory” \hat{m} .

In order to create a mutated “message in memory” \hat{m} , we need to consider all the r messages received by person P , denoted by (m_1^P, \dots, m_r^P) . For every mutated letter $\sigma_i \in \hat{m}$, $i = 1, \dots, k$, σ_i is chosen to be the letter that has the maximum number of occurrences among all letters (the mode) at location i in all the r messages (m_1^P, \dots, m_r^P) . In the case where we have an equal number of different letters the original letter in message m_1^P is chosen.

Dependent Variable - Absolute Error

The absolute error EA^i , for a person P^i , represents the number of mutations from the original message m that was first propagated in the network. It is calculated as follows:

Let $\mathbf{u} = m - \hat{m}^P$ be the difference vector for person P^i . We calculate $EA^i =$ Number of "1"s in \mathbf{u} .

Example: Assuming that the original message $m = [1101111]^T$ and by taking the final message, the difference vector: $\mathbf{u} = m - \hat{m}^P = [1101111]^T - [0101001]^T = [1000110]^T$.

Therefore, $EA^i = 3$ which is the number of "1"s in \mathbf{u} . After the propagation of m in network N that contains n people, we can then calculate the average global absolute distortion value N_A^D for N as $N_A^D = \sum_{j=1}^n EA^j / n$. The absolute error represents the network global average error.

Data Description and Model Simulations

We used network analysis package developed by Barabási's team at Indiana University, and self-written software to produce the different types of networks. The scale-free networks we tested in our simulations have an exponent γ that characterizes human social networks and satisfies $2 \leq \gamma \leq 3$. The tested networks have 30,000 and 50,000 nodes.

We compared the statistical results using mathematical and statistical tools. The algorithm we used to traverse the undirected graph that represents the network under simulation is the Breadth First Search (BFS) algorithm for graph search and traversal.

Research Hypotheses

We tested the following hypotheses for diminishing message distortion in scale-free networks:

H1: The absolute error will be lower after correction using hubs than after correction using regular nodes for the two researched numbers of correcting nodes (one or two).

H2: There is a positive relationship between the number of the correcting hubs and a decrease of the absolute error.

The above hypotheses were based on the assumption that scale-free networks are less sensitive to data distortion after several hubs, regular nodes, or a mix of them have corrected the message (to its first original values). Moreover, the correction will be more powerful if the correctors are hubs instead of regular nodes.

RESULTS

To test for differences in our dependent (the absolute error) continuous variable between two groups of correctors a paired t-test was performed, since we dealt with the same network and the same nodes. To test for differences in our dependent variable between more than three groups, a General Linear Modeling (GLM) for Repeated Measurements was performed.

As shown in Table 1, there were significant differences between the means of the absolute error for all three types of hub correctors (corrections of Hubs: $F=7723.42$, $P < 0.001$; corrections of Hubs: $F=2837.93$, $P < 0.001$). Similar significant findings were obtained in the larger network of 50,000 nodes.

Table 1. GLM for Repeated Measurements for Corrections of (0,1,2) - 30,000 Nodes					
Source		Type III Sum of Squares	Mean Square	F	Sig.
Tests of Within-Subjects Effects - Measure: Hubs Difference					
factor1	Sphericity Assumed	31088.52	15544.26	7723.42	<0.001
	Greenhouse-Geisser	31088.52	15551.9	7723.42	<0.001
	Huynh-Feldt	31088.52	15550.86	7723.42	<0.001
	Lower-bound	31088.52	31088.52	7723.42	<0.001
Tests of Within-Subjects Effects - Measure: Regular Difference					
factor1	Sphericity Assumed	11311.49	5655.74	2837.93	<0.001
	Greenhouse-Geisser	11311.49	5656.96	2837.93	<0.001
	Huynh-Feldt	11311.49	5656.59	2837.93	<0.001
	Lower-bound	11311.49	11311.49	2837.93	<0.001

Testing Our Hypotheses - Comparison between Hubs vs. Regular Nodes

In the following results we tested for the differences in each pair of correctors to analyze the connections between all types of correctors and to test our hypotheses.

Table 2. Absolute Error Comparison of Regular Nodes (1, 2) and Hubs (1, 2) - 30,000 Nodes					
Measured Pair (mean of absolute error)		Mean difference	SD	t	Sig.
Pair 1	One Hub Corrector (3.441) vs. One Regular Corrector (4.256)	-.815	2.05	-68.94	<0.001
Pair 2	Two Hub Correctors (3.243) vs. Two Regular Correctors (3.718)	-.475	2.03	-40.52	<0.001

Table 2 shows that the differences between two pairs of means were significant ($p < 0.001$ in all comparisons). Therefore, the absolute error will be lower after correction using hubs than after correction using regular nodes for one or two correcting nodes (H1 accepted). We expanded the analysis and performed other comparisons between one hub corrector vs. two regular correctors as well, and the results remained significantly in favor of the hub corrections ($p < 0.001$).

The above results (and others that are not presented here), clearly show that hubs are better correctors than regular nodes or combinations of regular-hub nodes.

Therefore, we will focus on presenting results with respect to correction only using hubs. We describe below the comparisons in the larger network of 50,000 nodes.

As shown in Table 3, the differences between all three pairs of means were significant subjected to a paired-sampled t-test ($p < 0.001$ in all comparisons). Therefore, there is a positive relationship between the number of the correcting hubs and a decrease in the absolute error (H2 accepted).

Table 3. Relationship Between the Correcting Hubs and Absolute Error in 50,000 Nodes

Measured Pair (mean of absolute error)		Mean difference	SD	t	Sig.
Pair 1	No correctors (4.87) vs. One Hub Corrector (4.83)	.043	1.4	6.92	<0.001
Pair 3	No correctors (4.87) vs. Two Hub Correctors (4.78)	.091	1.4	14.5	<0.001
Pair 3	No correctors (4.87) vs. Three Hub Correctors (4.75)	.121	1.39	19.5	<0.001
Pair 2	One Hub Corrector (4.83) vs. Two Hub Correctors (4.78)	.048	1.43	7.43	<0.001
Pair 5	One Hub Corrector (4.83) vs. Three Hub Correctors (4.75)	.078	1.38	12.6	<0.001
Pair 6	Two Hub Correctors (4.78) vs. Three Hub Correctors (4.75)	.030	1.4	4.84	<0.001

Summary of the Results:

Our results show significant differences between the means of the four types of node corrector sets in terms of absolute error. All research hypotheses were confirmed. The findings show that using hubs that correct the distorted message while it's diffused, decrease a global error measurement of the distortion, and as a result improve the robustness of the network.

DISCUSSION AND CONCLUSION

In this study we calculated the distortion of a message as it propagates through a social network using a simulated mathematical model. At the end of the diffusion process of the message in a network, we compared the results of the average global absolute distortion value for all types of corrective nodes, to measure the extent to which the correction process decreased the global absolute error, thus increased the robustness of the network to distortion of information.

The results show that hubs that play the role of message correctors are capable of diminishing the average global absolute distortion error. The hubs and the high degree nodes receive a message during propagation, and after the correction of the distorted message the original one, they affect many contacts in the network.

References

- Albert, R., and Barabási, A. L. 2002. "Statistical Mechanics of Complex Networks," *Reviews of Modern Physics* 74, 47-97.
- Barabási, A. L., and Albert, R. 1999. "Emergence of Scaling in Random Networks," *Science* 286, 509-512.
- Barabási, A. L., and Crandall, R. E. 2003. "Linked: The New Science of Networks," *American Journal of Physics* 71, 409.
- Crucitti, P., Latora, V., Marchiori, M., and Rapisarda, A. 2003. "Efficiency of Scale-free Networks: Error and Attack Tolerance," *Physica A* 320, 622-642.
- Ma, X. J., Wang, W. X., Lai, Y. C., and Zheng, Z. 2010. "Information Explosion on Complex Networks and Control," *The European Physical Journal B* 76, 179-183.
- Panzarasa, P., Opsahl, T., Carley M. K. 2009. "Patterns and Dynamics of Users' Behavior and Interaction: Network Analysis of an Online Community," *Journal of the American Society for Information Science and Technology* 60, 911-932.
- Rapoport, A. 1953a. "Spread of Information through a Population with Socio-structural Bias: I. Assumption of Transitivity," *Bulletin of Mathematical Biology* 15, 523-533.
- Rapoport, A. 1953b. "Spread of Information through a Population with Socio-structural Bias: II. Various Models with Partial Transitivity," *Bulletin of Mathematical Biology* 15, 535-546.
- Rogers M. Everett, *Diffusion of Innovations*, Free Press 1995
- Singer, Y. 2006. "Dynamic measure of network robustness," in *Electrical and Electronics Engineers in Israel, 2006 IEEE 24th Convention*, 366-370.
- Valente, *Computational & Mathematical Organization Theory*, Vol. 2, No. 2. 1996

CELLPHONE INDUCED DISTRACTED DRIVING: WORK IN PROGRESS

Eli Rohn

elirohn@bgu.ac.il

Jacob Palachi

kobypal@post.bgu.ac.il

Omri Chen

omriche@post.bgu.ac.il

Department of Information Systems Engineering
Ben-Gurion University of the Negev

INTRODUCTION

Hundreds of people are killed and thousands are injured due to vehicle accidents caused by distracted driving. A significant source of distraction is the smartphone. Drivers are preoccupied manipulating the phone (push buttons, compose text message, key in destination address, dial a number one digit at a time, etc.). Some drivers use it more responsibly, while others don't. Overall, usage of smartphones while driving increases drivers' distraction levels and introduces new challenges for safety on the road.

We have been developing a mobile application for monitoring real time smartphone usage and recording of the vehicle's movements at the same time. Data collected will be analyzed using a variety of advanced computing techniques in order to produce insights, such as actual cellphone usage patterns and a driver's driving profiles.

Data collection via built-in sensors is inexpensive, convenient, and independent of the vehicle. There are two groups of sensors: human computer interface (HCI), such as touch screen, keyboard, volume control etc.; the second group includes: camera, microphone, GPS receiver, motion sensors such as gyroscope, accelerometer and, magnetometer (compass). HCI sensors can tell if the driver operates the smartphone – takes calls, initiates calls, responds to messages or sends them, or manipulates the smartphone for any other (not necessarily known) purpose. Theoretically, it is even possible to assess the driver's mood using voice analysis techniques. Using the smartphone's other detectors it is possible to determine location, acceleration, speed, turn rate and turn direction.

The mobile application operates in two modes: covert monitoring or overt functionality blocking. Insurers may entice drivers to use the application in return for premium discounts. Cheaters will find themselves with less or no coverage if involved in an accident. This is according to known means for behavior modification: provide incentives for desirable behavior, provide deterrents for undesirable behavior. Using the application detailed later in this proposal, society may benefit of a reduction of accidents caused by smartphone induced distraction.

LITERATURE REVIEW

People are as impaired when they drive and talk on a cell phone as they are when they drive intoxicated at the legal blood-alcohol limit of 0.08 percent (Jiangpeng, Jin et al. 2010). While dialing a mobile phone, drivers of light vehicles (cars, vans, and pickup trucks) were 2.8 times as likely as non-distracted drivers to have a crash or near crash. Commercial truck drivers were 5.9 times as likely to be involved in an accident. Young drivers who text spend up to 400% more time with their eyes off the road than drivers who do not text; they have 6-fold greater odds of a collision (Jacobson Pd 2010). It has been established, as early as 1997, that talking on a mobile phone while

driving that there is no difference between those that hold the phone and those who use a hands-free car kit (Redelmeier and Tibshirani 1997). The authors cynically add that the availability of a cellphone after an accident allows for expedited call for help. Regardless of the known risk, distracted drivers still perceive themselves as attentive and good drivers (Murray 2012).

Most of the above data was collected using either questionnaires, simulators, or a combination of both. Some data was obtained from post-accident police investigations. In other words, no data is being collected in real time under natural conditions. This constraints the validity of such studies.

There are three main approaches to driver's behavior modification vis-à-vis mobile phones. Education and regulation is the first one, followed by software engineering for usage reduction while on the move. The third is by hardware and firmware that would block virtually all usage while the phone is on the move (Tomer-Fishman 2010). None of the literature we reviewed suggests context sensitive matching between the smartphone and the driver's driving profile. Further, none distinguish between the driver and passengers traveling in the same vehicle.

Driving patterns analysis, such as aggressive driving, distracted driving, normal driving and so forth can be done using various methods and a variety of input sensors. It is possible to analyze acceleration, turn rate and deceleration using fuzzy logic in order to determine driving patterns (Aljaafreh, Alshabat et al. 2012). A different approach uses statistical analysis of data obtained from the smartphone's accelerometer and magnetometer. It is used to match the data to the three driving patterns mentioned above, and also compare it to the driver's own typical pattern, once this was learned over time. Yet a another approach monitors the user's texting performance and compares it to that user's normative texting profile, where significant deviation from the norm when mobile is interpreted as texting that is being distracted by driving (Watkins, Amaya et al. 2011). Johnson and Trivedi (2011) propose "Dynamic Time Warping" that fuses data from several sensors and produces a unidimensional indicator that typifies one's driving profile.

Existing Applications

This is a tabular list of existing mobile applications directly or indirectly associated with drivers' distraction.

Name	Origin	Description	Platforms	Cost	Reference
Nirsham	Israel	Sharing suspected driver photos for a vote.	Android iPhone	Free	http://www.nirsham.co.il/
Mobile life guard	USA	Rates drivers so that insurance companies can require it.	Android	Free	http://tinyurl.com/LifeGi4
Drive me crazy	USA	Report to each other regarding bad drivers.	iPhone	Free	http://drivemecrazy.mobi
Suma-Ho	Japan	Records and saves 10 sec before and after a car accident.	Android iPhone.	Free	http://www.yomiuri.co.jp/dy/business/T120502005376.htm
Rate my Drive	USA	The application Rates the driver between 0-10 according to 200 miles of driving.	Android	Free	http://www.aviva.co.uk/drive/
Farm	USA	Scores driving and gives	iPhone	Free	http://tinyurl.com/n99bh7k

Name	Origin	Description	Platforms	Cost	Reference
state		tips to help drive better.			
Care Safe	USA	Using the phone cameras to detect driver distraction and road risks. Alert if necessary.	Android.	Free	http://tinyurl.com/gizma13
Taser	U.K	The application combine with a dongle in the car will disable the phone and detect user driving behavior.	Android Blackberry	\$250	http://tinyurl.com/6zapf7f
Speedbump	USA	An application that reports to the parent if their kids are passing a certain speed.	Android	\$9.99 month	http://www.speedbumpgps.com/web/guest/home
Safe Driver Program	N/A	An application that lets you define exceptional value such as speed or acceleration and sends you an SMS if passing one of them.	All platforms – coming soon	N/A	http://www.drivesafe.ly

RESEARCH GOALS

We aim to accomplish these goals:

1. Create a reliable multi-sensor data collection using drivers' smartphones by developing an application for this purpose
2. Identify vehicle movement that matches driving while intoxicated patterns
3. Identify vehicle movement that matches aggressive driving
4. Monitor usage of the device while on the move
5. Provide a "black box" for police and insurers who investigate automobile accidents
6. Analyze the data in order to identify potentially dangerous drivers
7. Provide policy makers data for policy making
8. Evaluate willingness of drivers to operate the application in overt mode
9. Collaborate with insurers to provide incentives to reduce cellphone induced distractions to drivers.

Research Contributions

The proposed application is much more complex compared to driver monitoring applications that exist in the market nowadays. The application can serve as a non-intrusive data collector about natural driving habits, replacing questionnaires and simulators. In addition, the analysis of the data is likely to identify dangerous drivers before they surface on relevant insurers lists and police reports, which happens only after the fact.

Hypotheses

This is a partial list of potential hypotheses (research questions) that can be tested using data collected by our mobile application:

- It is possible to create a unique driving profile for a given driver.
- Drivers prefer the application to be turned on automatically.

- Usage in overt mode reduces the number of cellphone distractions.
- Usage in overt mode reduces the time spent on cellphone distractions.
- Israeli drivers tend to cheat (or be honest) when proclaiming to the system they are currently not the driver

Answers to these and other research questions can contribute to creating policies and regulations that address facts-based issues. Answers can provide insurers with a degree of confidence that they utilize the application in order to improve profits by behavior modification carried out in an ethical manner.

SUMMARY

The development of a complex mobile application is aimed to reducing smartphone induced distraction of drivers. The application can be used by insurers to reward desired behavior and penalize undesired conduct. Reducing the number of vehicle accidents victims is a national priority. It remains to be researched if this application will have contributed to this goal.

REFERENCES

- Aljaafreh, A., N. Alshabat, et al. (2012). Driving style recognition using fuzzy logic. Vehicular Electronics and Safety (ICVES), 2012 IEEE International Conference on.
- Jacobson Pd, G. L. O. (2010). "Reducing distracted driving: Regulation and education to avert traffic injuries and fatalities." JAMA **303**(14): 1419-1420.
- Jiangpeng, D., T. Jin, et al. (2010). Mobile phone based drunk driving detection. Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2010 4th International Conference on-NO PERMISSIONS.
- Johnson, D. A. and M. M. Trivedi (2011). Driving style recognition using a smartphone as a sensor platform. Intelligent Transportation Systems (ITSC), 2011 14th International IEEE Conference on.
- Murray, G. (2012). "Distracted Drivers Think of Themselves as Good Drivers, Research Suggests." Retrieved 17 October, 2012, from <http://www.sciencedaily.com/releases/2012/05/120510095812.htm>.
- Redelmeier, D. A. and R. J. Tibshirani (1997). "Association between Cellular-Telephone Calls and Motor Vehicle Collisions." New England Journal of Medicine **336**(7): 453-458.
- Tomer-Fishman, T. (2010). הסחת דעת בנהיגה בשל שימוש באמצעי תקשורת אלקטרוניים, הרשות הלאומית לבטיחות בדרכים.
- Watkins, M. L., I. A. Amaya, et al. (2011). Autonomous detection of distracted driving by cell phone. Intelligent Transportation Systems (ITSC), 2011 14th International IEEE Conference on.

SOFTWARE VARIABILITY: WHERE STAKEHOLDERS REQUIREMENTS MEET SOFTWARE ENGINEERING

A POSITION PAPER

Iris Reinhartz Berger

Department of Information Systems,
University of Haifa, Haifa 31905, Israel
iris@is.haifa.ac.il

Yair Wand

Sauder School of Business, The
University of British Columbia, Canada
yair.wand@ubc.ca

Keywords: software variability, requirements engineering, software engineering, ontologies

INTRODUCTION

There are many causes for variability in software artifacts. These causes include changes in stakeholders' requirements and market segments, evolution of software products over time, and changes in the underlying technologies and techniques. This has led to the idea of software product "families" (lines) as a way to manage software development (Clements and Northrup, 2001; Pohl et al., 2005). Effective approaches to managing variability can be of substantial economic value to organizations by supporting systematic reuse and adaptation of software artifacts.

Different approaches and methods have been suggested to address various challenges in managing software variability. These methods include techniques such as: managing commonality and variability, model variability, making binding decisions (i.e., decisions on the latest stage in the software development process at which choices of variable elements have to be made), and managing scalability (Ali Babar et al., 2010). Common to these approaches is the view of variability as: "the ability of an asset to be efficiently extended, changed, customized, or configured for use in a particular context" (Jaring, 2005) or "the ability of a software artifact to vary its behavior at some point in its lifecycle" (Svahnberg et al., 2006).

In this corpus of work, software variability is usually addressed only from the perspective of software development, thus neglecting the stakeholders' point of view. Stakeholders – the users, the clients, or any person, group, or organization that is interested in the use of the software product (and not just in its development), may perceive variability differently from software developers. The following two examples demonstrate this difference. First, consider bank accounts management systems and login accounts management systems. Stakeholders may view them as very different as these two types of systems deal with completely different domains and are intended to support completely different operations. However, system developers may perceive these systems as similar due to meaningful overlaps in the functionality and potentially in the architecture of the systems. Second, consider client-server bank accounts management systems and peer-to-peer bank accounts management systems. Stakeholders may consider these two systems very similar if they provide similar functionality and have similar user interfaces. Developers, on the other hand, may be required to use different programming languages, techniques, and tools for the two types of systems, thus perceiving them as very different for development purposes.

OBJECTIVES

The approach to managing software variability can have significant impact on the economics of developing systems and on how well such systems can serve stakeholders. Therefore, it would be very valuable to develop principles to guide the analysis and management of software variability. On one hand, stakeholder needs and requirements should be addressed, as otherwise software projects might lead to systems that do not deliver the expected value. On the other hand, software development considerations should be taken into account, as otherwise development costs might be too high. The purpose of this work is to suggest a framework for bridging the gap between stakeholders' and developers' related perspectives of software variability. In particular, this framework will suggest questions that need to be answered in order to distinguish between (generic) products (with flexible behavior determined at runtime), different versions of the same software product, different software products that belong to the same family, and completely different software products. Such distinctions can have practical implications on software project management. The answers to these questions can be developed in cooperation by stakeholders and developers, thus enabling to bridge the gap between their different perspectives.

METHOD

The suggested framework is based on theoretical, well-formalized principles. It refers to two main dimensions: semantics and implementation. The *semantics dimension* reflects viewpoint of the stakeholders who judge differences among software artifacts based on their requirements and perceptions of the domain of discourse. This leads to the idea of the *semantic distance* which reflects the variability in the *entities (concepts) perceived to exist in the domain*, their *attributes*, and their *relationships*. The *implementation dimension* takes into consideration the developers' perspective. From this point of view, software is a *script* which can be executed on a state machine that can interact with its environment. Accordingly, the *implementation distance* between two software artifacts can be assessed by the degree of homomorphism that exists between their behaviors. A behavior is defined as responses to external stimuli from the environment in which the software operates.

To bridge the gap between these two dimensions, we propose to use an ontological approach. Ontology reflects beliefs about a domain of discourse. Hence it can be an appropriate foundation to formalize semantic differences in domain views. However, as we aim at also representing software developers views, it would be useful if the ontology to be used would enable modeling behaviors in terms of states and stimuli to systems. We use Bunge's work (Bunge, 1977; 1979) which describes the world as made of *things* that possess *properties* and places an emphasis on the notion of systems. Furthermore, Bunge's ontology formalizes the notions of states and events. It has been widely adapted to analysis of modeling in the context of information systems development (Wand and Weber, 1990). Elsewhere (Reinhartz-Berger et al., 2011), we used Bunge's ontology to formalize concepts related to system behavior and for defining types of external variability – namely, differences in software functionality as appearing to stakeholders. In Reinhartz-Berger et al. (2013) we show that the ontological approach can also be used by developers in order to compare alternative solutions to a given set of requirements.

Here we propose to further use Bunge's ontology for deriving practical questions that will help evaluate the semantic (stakeholder-related) and implementation (developer-related) distances between software artifacts. Following are examples of questions based on the ontological framework. The questions can be used for analyzing software variability by addressing them to stakeholders and developers thus enabling variability analysis based on both points of view:

1. What are the types of things in the domain of discourse of the software?
Example: bank accounts vs. computer login accounts.
2. What are the properties (manifested as information attributes) possessed by the things about which information is processed by the software?
Example: account number, owner details, branch details, and balance vs. username, password, owner details, and access information.
3. What are the domains of state variables of the software (namely, the types of attributes and their possible values)?
Example: $\text{status} \in \{\text{'overdraft'}, \text{'balanced'}, \text{'positive'}\}$ and $\text{type} \in \{\text{'current'}, \text{'saving'}, \text{'loan'}\}$ vs. $\text{status} \in \{\text{'active'}, \text{'blocked'}, \text{'suspended'}\}$ and $\text{type} \in \{\text{'admin'}, \text{'regular user'}\}$.
4. What are the external events to which the software reacts? Such events represent changes in the domain of discourse that stakeholders expect to be reflected in the processing systems.
Example: deposit to or withdrawal from a bank account vs. accessing certain information in the system.
These events will be perceived by the developers as the main means for defining the system's interfaces or evaluating differences between user interfaces.
5. What are the responses of the software to a given external event? Namely, do the stakeholders receive the same expected outcome from the compared systems? For software developers this would mean that the scripts behave homomorphically.

As noted, these questions will be addressed to both developers and stakeholders. The responses will be used for calculating the semantic and implementation distances between software artifacts. This will support variability management which can, in turn, improve the management and the development of software products.

SUMMARY

Effective management of software variability is of general interest to organizations because it can impact the quality of systems and the cost of developing and maintaining them. Hence, well-established foundations for software variability can be of practical value. Yet, no such foundations exist. Traditionally, managing software variability was considered in the domain of software engineering only. However, we claim it should take into account both points of view, of stakeholders and of developers. These views might be quite different. We believe that a good approach to software variability can be based on appropriate ontological foundations and propose to use a particular ontological approach. Specifically, we suggest that the approach can provide the foundation for creating questions that stakeholders and developers can

address together. The answers to the questions can guide effective ways to manage software variability. We demonstrate this by suggesting some possible questions.

REFERENCES

- Ali Babar, M., Chen, L., & Shull, F. (2010). Managing Variability in Software Product Lines. *IEEE Software*, 27 (3), 89-94.
- Bunge, M. (1977). Treatise on Basic Philosophy, vol. 3, Ontology I: The Furniture of the World. Reidel.
- Bunge, M. (1979). Treatise on Basic Philosophy, vol. 4, Ontology II: A World of Systems. Reidel.
- Clements, P. & Northrup, L. (2001) Software Product Lines: Practices and Patterns. Addison-Wesley.
- Jaring, M. (2005). Variability Engineering as an Integral Part of the Software Product Family Development Process, Ph.D. thesis, The Netherlands.
- Pohl, K., Böckle, G., & van der Linden, F. (2005). Software Product Line Engineering: Foundations, Principles, and Techniques. Springer.
- Reinhartz-Berger, I., Sturm, A., & Wand, Y. (2011). External Variability of Software: Classification and Ontological Foundations. International conference on Conceptual Modeling (ER'2011), LNCS 6998, pp. 275-289.
- Reinhartz-Berger, I., Sturm, A., & Wand, Y. (2013). Comparing Functionality of Software Systems: An Ontological Approach. Accepted to *Data and Knowledge Engineering*.
- Svahnberg, M., van Gurp, J., & Bosch, J. (2006). A taxonomy of variability realization techniques, *Software - Practice and Experience*, 35 (8), 705-754.
- Wand, Y. & Weber, R. (1990). An Ontological Model of an Information System. *IEEE Transactions on Software Engineering*, 16, 1282-1292.

DEVELOPMENT OF A PHASE-LEVEL SOFTWARE MAINTENANCE EFFORT ESTIMATION MODEL

Michel Benaroch

Whitman School of Management

Syracuse University

mbenaroc@syr.edu

Keywords: software maintenance, cost estimation, cost drivers, team factors.

INTRODUCTION

Software maintenance costs is reported to account for 60 to 80 percent of the total cost associated with a software system (Boehm et al. 2000). Software maintenance addresses three groups of activities: *correcting* a system from actual errors; *adapting* a system to external changes in business rules, government regulations, and technology; and, *enhancing* a system by adding new functionalities requested by users. Software maintenance is challenging because it requires understanding and documenting changes to the system, retaining the system's functional integrity, minimizing structural decay and growth in complexity of the software, and maintaining intellectual control over the system by protecting knowledge from deterioration due to staff turnover and offshoring of work.

Cost and effort estimation is a crucial aspect of software maintenance. It informs the planning and budgeting of maintenance work for existing and new systems, policies for retiring aging systems, strategies for sourcing maintenance work, and so on. Numerous software maintenance effort estimation models have been developed (Nguyen 2010). These vary greatly on the scope of maintenance work they target: a single maintenance *task*, a planned set of maintenance tasks or a system *release*, or maintenance work carried out over a lengthy period or even the whole software maintenance *phase*. The last category of models, phase-level models, is most relevant to our work. Examples are the models integrated into software development cost estimation models like COCOMO and SEER-SEM (Boehm et al. 2000).

This paper develops a phase-level cost estimation model by examining longitudinal data on the cost of maintaining software and its drivers.

DATA

We use proprietary data from a large financial services institution about software maintenance work carried out in the US, UK and several offshore locations. The data document over 7,500 maintenance projects that serviced a heterogeneous portfolio of 421 software systems over a three years period (2009-2011), charging jointly about 15,000,000 person-hours. Most systems are written Java. The raw data include:

- Project charges: daily person-hours and US dollars charged for every person working on a project;
- application attributes: age (years), size (number of LOC), complexity (a composite 'density' factor based on complexity of classes, functions, etc.), info-type handled (public vs. confidential customer data subject to regulatory constraints), and change evolution frequency and scope (proxied by number of projects per system); and

- personnel attributes: employee ID, job title and location (country and site) for every person working on a project.

Based on the above, we derive the system-specific measures:

- System Team Size: number of different persons who worked on projects maintaining a system over a given period,
- System No Team Locations: number of site locations where team members working on a specific system are located.
- System maintenance effort: total person-hours charged of all projects servicing a system over a given period.
- System maintenance cost: total US dollars charged of all projects servicing a system over a given period.

It is important to note that personnel- and team-related factors have been rarely studied in the software maintenance literature (Benestad et al. 2009).

Our univariate analyses show most cost drivers to have power-type relationships with maintenance effort and cost (see examples in Figure 1), consistent with other reports in the software engineering literature (Boehm et al. 2000; Benestad et al. 2009).

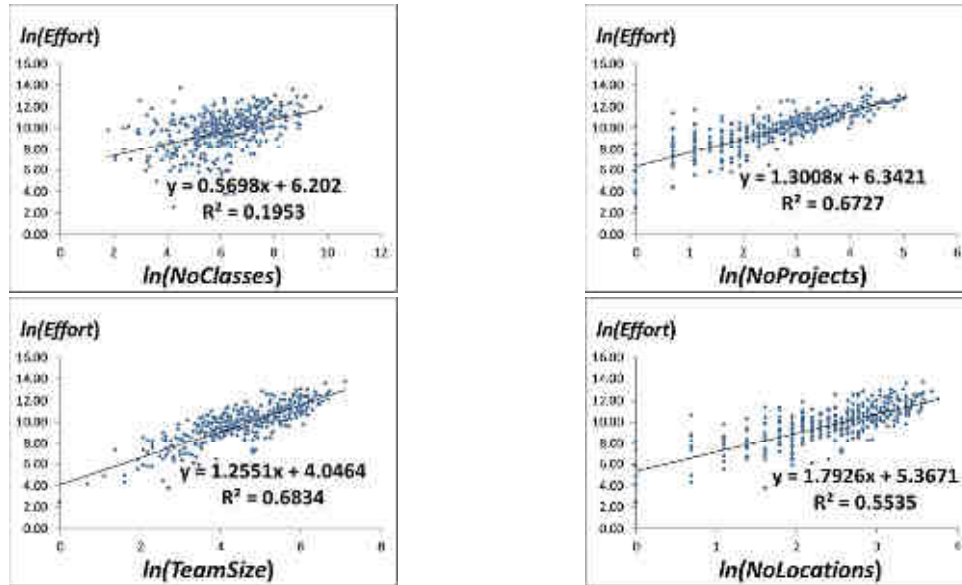


Figure 1: Log-transformed relationships with primary cost drivers

MODEL

Based on these power-type relationships, we formulate a multiplicative model of how the cost drivers jointly impact maintenance effort and maintenance cost:

$$Effort / Cost = \beta_0 \cdot (Age)^{\beta_1} \cdot (Size \& Complexity)^{\beta_2} \cdot (InfoRequirement)^{\beta_3} \cdot \dots \quad (1)$$

In log-transformed form, the equation becomes:

$$\ln(Effort) / \ln(Cost) = \beta_0 + \beta_1 \ln(Age) + \beta_2 \ln(Size \& Complexity) + \beta_3 \ln(InfoRequirement) + \dots \quad (2)$$

We then estimate the effort and cost models in Equation (2) simultaneously, as a

system of Seemingly Unrelated Regressions (SUR), in case standard errors of the coefficients need to be adjusted to account for possibly correlated error terms in the models. We also checked for multicollinearity by computing a condition index for the entire model and variance inflation factors (VIF) for each of the independent variables. None of these tests revealed any diagnostic problems. All independent variables have statistically significant relationships with both dependent variables.

Our phase-level model differs markedly from existing phase-level models. Existing models are integrated into software development cost estimation models like COCOMO and SEER-SEM. In COCOMO, for example, maintenance effort is just one of the estimates produced for a new system, based on the same models used to estimate development cost but with some adjustments. Our model differs in three apparent ways.

1. Our model does not use the ‘size’ of maintenance work as an input, since reliable ‘size’ information is rarely available for actual routine maintenance work carried out over a lengthy period. By contrast, existing phase-level models take the amount of maintenance work needed for a newly developed system of a known size to be a generic quantity of some sort.
2. Our model uses at most five cost drivers, in contrast with over 22 cost drivers in models like COCOMO for maintenance.
3. Our model uses input values for cost drivers that reflect conditions near the time maintenance work is done, whereas existing models plug in forward-looking values based on assumptions made when the new system is developed.

RESULTS

The value of our model is twofold. Our model informs about the relative contribution of different drivers to the relative scale diseconomies characterizing software maintenance effort and cost. Overall, the magnitude of regression coefficients shows team-related characteristics to be significantly stronger drivers of maintenance effort and cost than application characteristics. Specifically, expanding a system’s maintenance team by one person or one location from which the team comes has an exponential relationship with maintenance effort, roughly a power of 1.25 and 1.79, respectively. These large power coefficients indicate an escalating marginal effort of spreading maintenance work across larger teams or one more location, even if it is a low-cost offshore location. For system Age and system Complexity, the power exponents are not nearly as large, roughly 0.51 and 0.56, respectively. That these system attributes are not the primary drivers of maintenance effort and cost is contrary to much of what the literature reports (Banker et al. 1998, Boehm et al. 2000). This indicates the critical role of personnel- and team-related factors in software maintenance effort and cost estimation.

Prediction is another valuable feature of our model. It predicts the effort and cost of maintaining an application for a given period (e.g., year) with a level of accuracy comparable to those reported for estimation models for smaller scope, task- and release-level maintenance work (see Table 1); the literature reports no comparative results for existing phase-level models. This is despite the fact our model uses far fewer cost drivers, not including ‘size’ of maintenance work.

Our study has two primary implications for research and practices. It suggests that less importance be given to system attributes in driving maintenance budgets, system

retirement policies, and the composition of an organization's systems portfolio. It also reveals the consequential effects of expanding software maintenance teams' size and locations over time and the possible economic tradeoff of offshoring maintenance work.

Table 1: effort prediction results against several benchmark studies

Study ^{&}	Goal	Model Type & Cost Drivers	Results	
			MMRE ⁺	PRED(0.3) ⁺⁺
Present	Estimate application maintenance effort for a 3 year phase , based on data on 422 applications	Additive log-transformed linear regression model; 5 cost drivers (Eq. 2)	6.6%	97%
Present	----- “ -----	Multiplicative non-log-transformed model; 5 cost drivers (Eq. 1)	69%	38%
Nguyen et al. (2011)	Estimate effort of an individual maintenance project , based on data about 80 projects	COCOMO for Maintenance; $Size_M$ plus over 22 cost drivers	50%	35%
Jorgensen (1995)	Estimate effort of an individual maintenance task , based on 109 maintenance tasks from different applications in one organization	11 linear regression, neural network and pattern recognition models; 'size' of task and four factors describing the nature of the task	97%	26%*
De Lucia (2005)	Estimate effort for corrective tasks completed over one month, based on 114 data points collected in a software services company	Linear regression; size of system in SLOC and number of code modification tasks, data mis-alignment tasks, and other tasks	32%	49%*
Ramil (2003)	Estimate effort of a set of all kinds of maintenance tasks yielding a release , based on data collected in two cases studies	Linear regression; number of subsystems and number of modules (changed or added)	19%	44%*

[&] All referenced studies and their results are discussed in Nguyen (2010)

⁺ MMRE: mean magnitude of relative error

⁺⁺ PRED(0.3): percentage of effort predictions within 30% of the actual effort

* result is for PRED(0.25)

REFERENCES

- Banker, R., Davis, A., & Slaughter, S. (1998). Software Development Practices, Software Complexity, and Software Maintenance Performance: A Field Study. *Management Science*, 44(4), 433-450.
- Boehm, B.W., Abts, C., Brown, W.A., Chulani, S., Clark, B.K., Horowitz, E., Madachy, R., Donald, J., Reifer, D.J., & Steece, B. (2000). *Software Cost Estimation with COCOMO II*, Prentice Hall.
- Kemerer, C.F. (1995). Empirical Research on Software Complexity and Software Maintenance. *Annals of Software Eng.*, 1(1), 1-22.
- Nguyen, V. (2010). *Improved Size and Effort Estimation Models for Software Maintenance, Doctoral Dissertation*. Computer Science Department, University of Southern California.
- Benestad, H.C., Anda, B., & Arisholm, E. (2009). Understanding software maintenance and evolution by analyzing individual changes: a literature review. *Journal of Software Maintenance and Evolution: Research and Practice*, 21, 349-378.

SIMPLIFYING CONFIGURATION OPTIONS OF DATA AGENTS IN CLOUD COMPUTING ENVIRONMENT

Ron Hirschprung

Dept. of Industrial Engineering
Faculty of Engineering
Tel Aviv University
Tel-Aviv 69978
ISRAEL
ronyh@post.tau.ac.il

Eran Toch

Dept. of Industrial Engineering
Faculty of Engineering
Tel Aviv University
Tel-Aviv 69978
ISRAEL
erant@post.tau.ac.il

Oded Maimon

Dept. of Industrial Engineering
Faculty of Engineering
Tel Aviv University
Tel-Aviv 69978
ISRAEL
maimon@eng.tau.ac.il

ABSTRACT

Cloud computing offers a compelling vision of sophisticated data storage and processing, but it raises privacy concerns for individuals and organizations. We explore an information disclosure agent-based architecture for information sharing in cloud computing environments. As the agent is a complex and sophisticated software, the configuration process can carry a heavy burden if the user's privacy preferences can be elicited at all. We propose a general method, named *SCON-UP* (Simplified CONfiguration Space of User Preferences) to simplify the configuration process, while still guaranteeing adequate privacy control. We evaluate the method using an empirical study (n=350) and show how a small number of representative possibilities can cover a large percentage of people's disclosure preferences in cloud computing scenarios.

KEYWORDS: Cloud Computing; Software Configuration; Agent-Human Interaction

INTRODUCTION

Cloud computing is a strong trend in IT systems (Columbus, 2011 ; Michael Armbrust, 2009), while introducing new privacy and security risks. The user must express explicit preferences to obtain optimal cost-benefit tradeoff according to her personal judgment (Kevin Lewis, 2008). To achieve this goal, we suggest an agent-based architecture, as depicted in Figure 1. The agent serves as an additional layer in cloud computing architecture. As users have different privacy approaches (Ponnurangam Kumaraguru, 2005 ; Judith S. Olson, 2005), enough feasible options of data disclosure is an important necessity. In many scenarios, including in Online Social Networks, it has shown that people fail to correctly set their privacy settings (Michelle Madejskiy, 2011 ; Alessandro Acquisti, 2005). Therefore, the data agent is complex to manage, possibly a viable obstacle for many users that need to decide whether do disclose large and heterogeneous sources of information.

Trewin argues that "as interfaces become more sophisticated, a corresponding explosion in the number of configuration options is likely" (Trewin, 2000). Complexity of the configuration interface can be tackled with predefined policies (Cranor, 2003). As it turns out, most users do not bother to optimize each configuration factor (Mackay, 1991). Studies show that providing few canonical

configuration options may reduce user burden and even improve the quality of her setting (Ramprasad Ravichandran, 2009 ; Chernev, 2003). Use of defaults approach, can even serves as a potentially lifesaving (Eric J. Johnson, 2003 ; Craig R.M. McKenzie, 2006). This method is already in use by a variety of software systems, such as the web browser Microsoft Internet Explorer, as depicted in Figure 2. Sometimes, a strategy of "choosing as other like-minded" can be adopted (Hill, Stead, Rosenstein, & Furnas, 1995 ; Eran Toch, 2010). However, defaults can be a trap as people tend to use them often while they do not always match their expectations (Ralph Gross, 2005). We are establishing our strategy on canonical choices picked out of true user preferences, and not theoretical lab designs (as in the Explorer example).

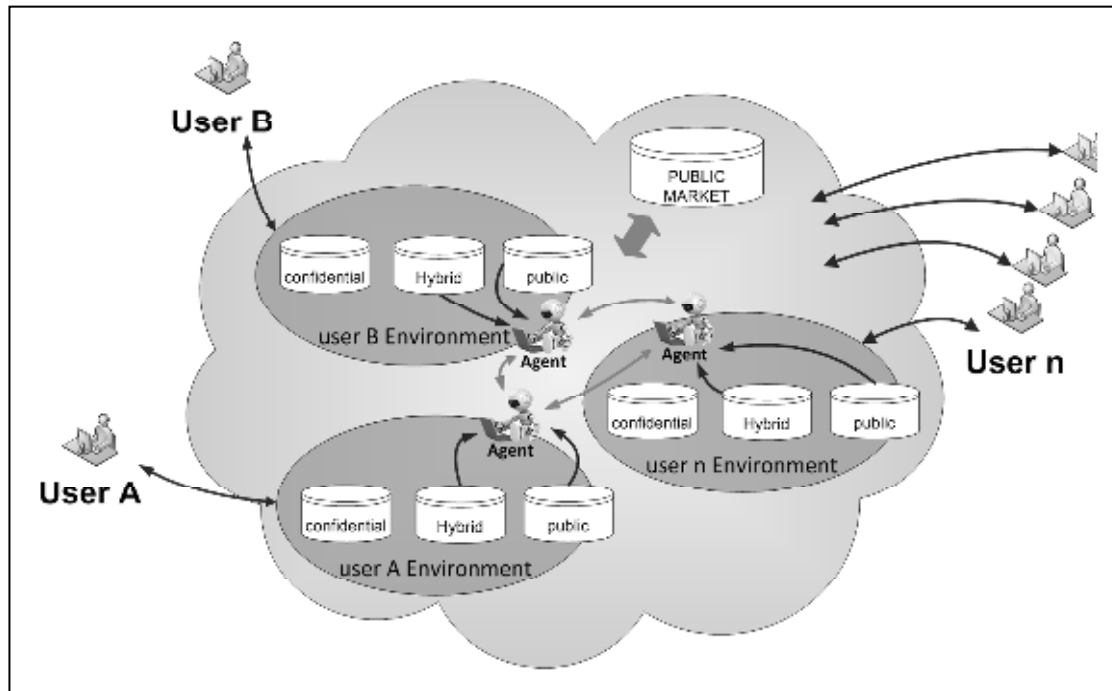


Figure 1: A general description of the agent model.

All the information is stored in one data-center facility, virtually divided into private and shared areas.

RESEARCH OBJECTIVES

We raise the question: "Can few discrete levels of configuration, provide adequate control over the agent, and cover the population?" To address this question, we suggest the following model, which is used as the basis for our empirical study. Assume we have N users. Let vector P be the preferred configurations of the users. Each element p_i ($i=1,2,3,...N$) is the set of preferences of a user i . Let vector C be a collection of specific chosen configurations, T an acceptance threshold (a scalar) and the operator $\|con_i - con_j\|$ an index for the distance between configurations con_i and con_j . Then, the subgroup of users, which will be satisfied by configuration c_i is defined as the set of users u_i that have at least one of their preferred configuration h with distance from c_i that is smaller or equal to T :

$$sp_i = \{u_i | \exists h \in p_i: \|h - c_i\| \leq T\}$$

An element sp_i is then a set of users indexes which are satisfied by a configuration c_i .

The coverage of configuration c_i is given by: $\frac{|SP_i|}{N}$.

For a given set of configurations $C = \{c_1, c_2, c_3, \dots, c_n\}$, the overall coverage over all users:

$$Cvrg(C) = \frac{|sp_1 \cup sp_2 \cup \dots \cup sp_n|}{N} = \frac{\bigcup_{i \in N} sp_i}{N}$$

Let $CCMP$ be the set of all possible configurations, we are looking for the subset $BestCvrg$, which is the set of n best configurations:

$$BestCvrg = \{(s_1, s_2, \dots, s_n) \mid S \in CCMP \text{ and } \max(Cvrg(S))\}$$

To extract the best n configurations, we used our algorithm $SCON-UP$ (Simplified CONfiguration Space based on identification of User Preferences).

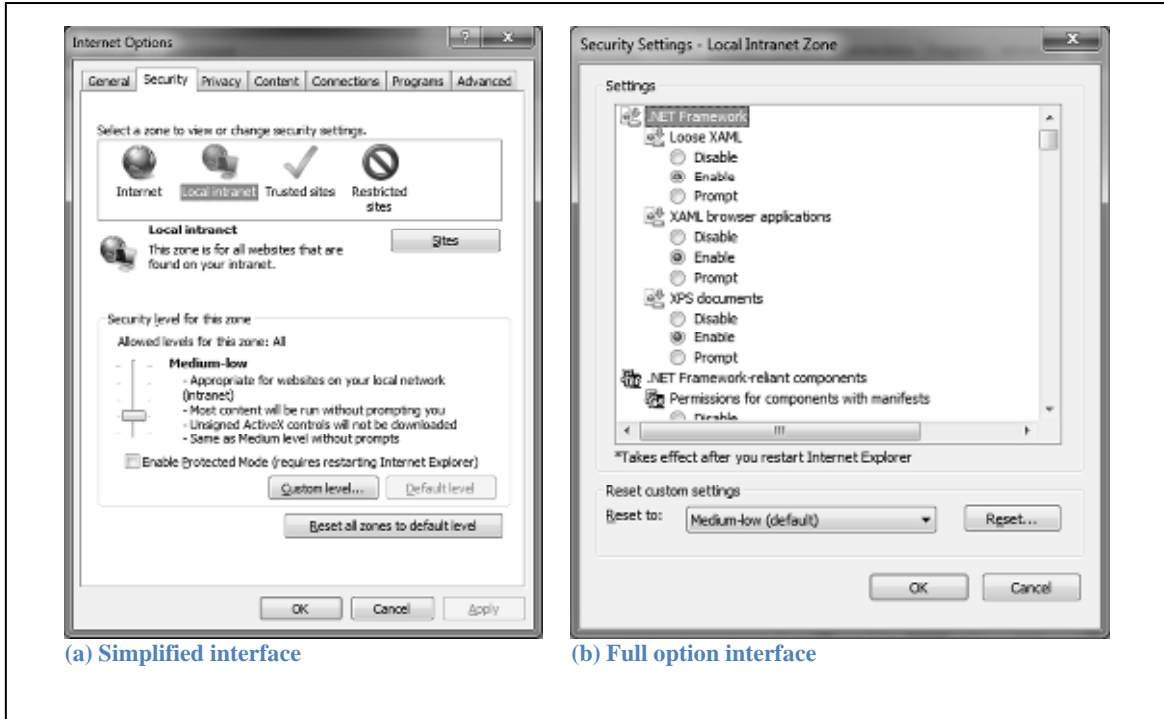


Figure 2: Microsoft Internet Explorer security configuration,

an interface with a reduced decision space (a),

and an interface for full options customization (b).

RESULTS

We conducted two survives. We had asked participants to indicate their willingness to work with the agent under different conditions. Figure 3 depicts the overall willingness to disclose information through the agent.

Let matrix C be the collection of all possible configurations when i is the configuration number and j is the specific parameter:

$$C_{ij} = \begin{cases} 0, & \text{option not selected} \\ 1, & \text{option selected} \end{cases}$$

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin
Academic Center, Emek Hefer, Israel

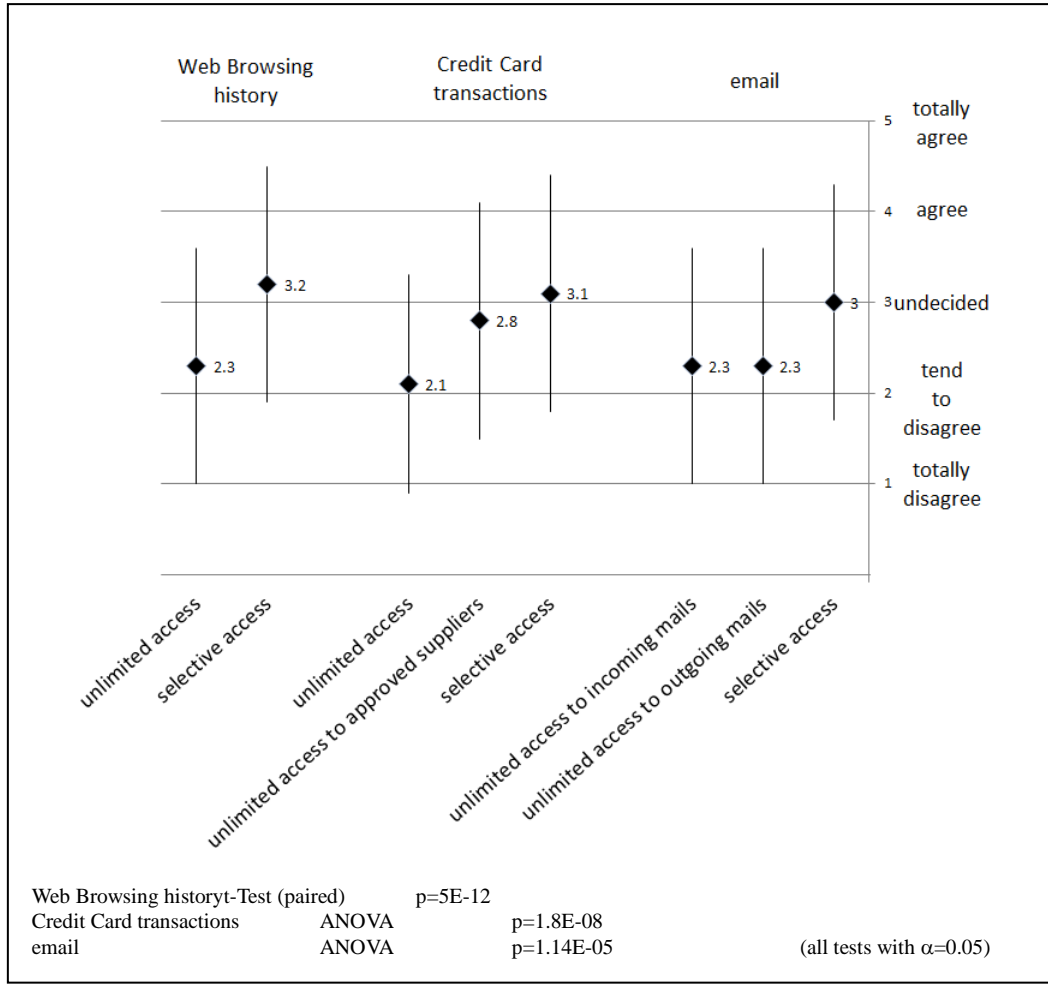


Figure 3: Survey Answers: willingness to use the agent.

If vector P describes a specific selected configuration ($P = \{p_1, p_2, \dots, p_j\}$), then the distance d (satisfaction) between the sample and a specific possible configuration C_i will be given by:

$$d = \sum_j \begin{cases} 0, & C_{ij} = p_j \\ 1, & C_{ij} \neq p_j \end{cases}$$

The overall satisfaction of a specific configuration C_i , when V_s is the collection of all samples $\{1..s\}$ is given by:

$$S_i = \sum_s \sum_j \begin{cases} 0, & C_{ij} = p_{sj} \\ 1, & C_{ij} \neq p_{sj} \end{cases}$$

A threshold value T , was defined to consider a configuration as accepted. For each value of n from 1 to 6 predefined configurations, we extracted the best n configurations that produced the maximal coverage. Our results were significant and show that the contribution is decreasing when the number of configurations increases, and it can be assumed that a small number of configurations (2-4) can satisfy.

A more complex model may be suggested, when both numbers of configuration and the acceptance threshold can be selected. We had given each threshold a grade¹, and

Setting the grade is subjective. ¹

highlighted four sets of configurations which had maximal coverage yet high simplicity. This implies again that agent configuration can be leveled to a very few discrete levels.

The second survey compound true configurations sets defined by the participants, provided their disclosure preferences in several cloud computing scenarios. Thus, configurations can be deduced directly. In order to analyze and process the results, we created a special algorithm *SCON-UP* (Simplified CONfiguration Space based on identification of User Preferences), which was applied in MATLAB, that extracts n best configurations out of the set, than evaluate them. Extracting n best is done in 2 phases:

- a) Eliminating results only to significant configurations, judged according to the criteria of which percentage of population each configuration covers.
- b) Finding the best n configurations, out of all the possible combinatorial combinations in the eliminated list.

An example of applying *SCON-UP* to a real set of preferences depicted on Figure 4. It can be clearly seen that there is no use and need to pick more than 3 configurations. Those results indicate the high efficiency of our algorithm.

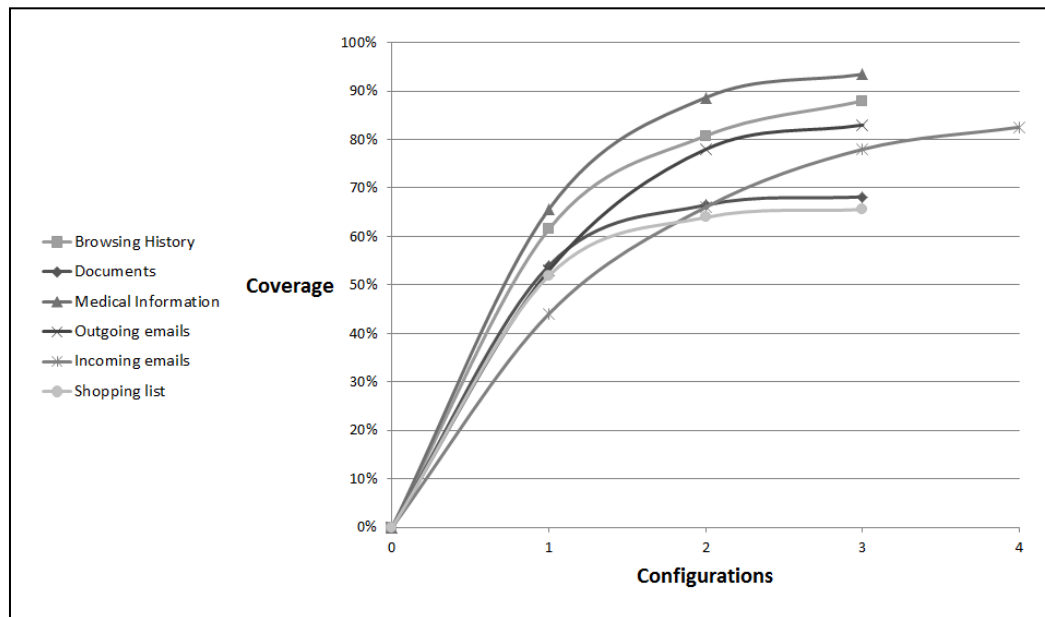


Figure 4: fitting samples (covered) vs. number of configurations for different data types.

It can be clearly seen that there is no use and need to pick more than 3 configurations because the contribution is not significant.

CONCLUSIONS

In this paper we describe a data agent for information-disclosure in cloud computing. Such an agent may be compared to anti-virus software. If we configure anti-virus too loosely, we are taking a risk of virus attack, however too tight configuration will disable legal activities on our workstation. We have shown using our mechanism *SCON-UP* that it is possible to simplify the agent configuration by reducing the configuration space to a few discrete levels, and we had also extract those configurations using *SCON-UP*. Our results show that with a few basic configurations we can satisfy at least 85% of the population for four data types, and over 65% for

other two data types.

REFERENCES

- Alessandro Acquisti, J. G. (2005). Privacy and Rationality in Individual Decision. *IEEE Security & Privacy*.
- Chernev, A. (2003). When More Is Less and Less Is More: The Role of Ideal Point Availability and Assortment in Consumer Choice. *JOURNAL OF CONSUMER RESEARCH*, Vol. 30.
- Columbus, L. (2011). Predicting Cloud Computing Adoption Rates. *A Passion for Research*.
- Craig R.M. McKenzie, M. J. (2006). Recommendations Implicit in Policy Defaults. *University of California*.
- Cranor, L. F. (2003). Designing a Privacy Preference Specification Interface: A case study. *AT&T Labs-Research*.
- Eran Toch, N. M. (2010). Generating Default Privacy Policies for Online Social Networks. *Carnegie Mellon University*.
- Eric J. Johnson, D. G. (2003). Do Defaults Save Lives? *Center for Decision Sciences, Columbia University*.
- Hill, W., Stead, L., Rosenstein, M., & Furnas, G. (1995). RECOMiVIENDING AND EVALUATING CHOICES IN A VIRTUAL COMMUNITY OF USE. *CHI '95 MOSAIC OF CREATIVITY*.
- Judith S. Olson, J. G. (2005). A Study of Preferences for Sharing and Privacy. *University of Michigan, Microsoft Research*.
- Kevin Lewis, J. K. (2008). The Taste for Privacy: An Analysis of College Student Privacy Settings in an Online Social Network. *Harvard University*.
- Mackay, W. E. (1991). Triggers and Barriers to Customizing Software. *Massachusetts Institute of Technology*.
- Michael Armbrust, A. F. (2009). Above the Clouds: A Berkeley View of Cloud Computing. *UC Berkeley Reliable Adaptive Distributed Systems Laboratory*.
- Michelle Madejskiy, M. J. (2011). The Failure of Online Social Network Privacy Settings.
- Ponnuram Kumaraguru, L. F. (2005). Privacy Indexes: A Survey of Westin's Studies. *Institute for Software Research International*.
- Ralph Gross, A. A. (2005). Information Revelation and Privacy in Online Social Networks. *Data Privacy Laboratory & School of Public Policy and Management - Carnegie Mellon University*.
- Ramprasad Ravichandran, M. B. (2009). Capturing Social Networking Privacy Preferences: Can Default Policies Help Alleviate Tradeo Expressiveness and User Burden? *Carnegie Mellon University*.
- Trewin, S. (2000). Configuration Agents, Control and Privacy. *IBM Thomas J. Watson Research Center*.

ISRAELI SMALL BUSINESS INFORMATION SECURITY POSTURE

Eli Rohn

Department of Information Systems
Engineering, BGU
EliRohn@bgu.ac.il

Gilad Sabari

Department of Information Systems
Engineering, BGU
giladsabari@gmail.com

INTRODUCTION

The IT Governance Institute recognizes the central role that information technology now fulfills in underpinning and enabling almost all activities of the 21st century enterprise. Security of information and knowledge is now essential to corporate success ([Williams 2001](#)). Information assurance best practices rely on a three-tier approach: governance, management and technology.

Information Technology (IT) internal controls at a governance level involves ensuring that effective IT management and security principles, policies, and processes with appropriate compliance measurement tools to assess and measure those controls. At the management level controls include usage and adherence to IT standards, the creation, maintenance and re-certification of formal organizational structures, work related procedures, physical and environmental control directive, and more. The technology level in the hierarchy has two types of general controls: systems software and systems development general controls, followed by application-based controls.

Small businesses rely on information technology to manage their affairs no less than large enterprises ([Newman 2010](#); [Chao and Chandra 2012](#)). It is unclear if they place measures to mitigate risks arising from usage of IT, at the governance, management and technology levels.

The purpose of this study is to investigate IT security practices of small and medium enterprises (SME) in various sectors in Israel.

METHODOLOGY

Grounded theory approaches are becoming increasingly common in the IS research literature because the method is extremely useful in developing context-based, process-oriented descriptions and explanations of the phenomenon being studied ([Myers 1997](#)). This study is based on grounded theory principles as a wrapper for COBIT based methods ([ISACA 2013](#)), which are practitioners' favorite. Here we harnesses both qualitative and quantitative data analysis approaches. The data had been collected over a period of 18 months by undergraduate seniors in two Israeli research universities. Students collected data as part of a semester-long assignment given to them in an IT Audit and Assurance course. All students majored in information systems related programs. Their work was based on COBIT version 4.1. It is "an IT governance framework and supporting toolset that allows managers to bridge the gap between control requirements, technical issues and business risks. COBIT enables clear policy development and good practice for IT control throughout organizations. COBIT emphasizes regulatory compliance, helps organizations to increase the value attained from IT, enables alignment and simplifies implementation

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

of the COBIT framework" (ISACA 2013). Students were instructed to focus on the topic "Deliver and Support" (DS) chapter 5 (ensure system security) and chapter 4 (ensure continuous services). As expected from professional auditors, they were encouraged not to ignore findings in other COBIT areas should the students encounter them.

The assignment required students to form groups of four "auditors", having these distinct responsibilities: group manager, audit report writer and two students to perform the field work. Their first task was to find a "client" using networking or cold-calling techniques. This was followed by formulation of an engagement letter and the creation of a risk matrix that focuses on COBIT DS5 (information security). At that stage they were ready to perform the field work, record all evidence, and write their audit report. Each deliverable was reviewed three times by faculty and a seasoned teacher assistant for quality and adherence to professional practices. This approach is used world-wide by regulators and auditors, making it a clear and reproducible methodology. Further, the COBIT framework is used to assess compliance with The Sarbanes-Oxley Act of 2002 section 404 that relates to information systems and specifically to information security as aforementioned (Li, Peters et al. 2012).

In order to ensure a valid representative sample, small businesses were chosen randomly from a variety of economics sectors and geographical locations, in Israel. Sectors were identified using NAICS 2007 version - the standard North American Industry Classification System (NAICS 2007). Geographical location was determined in reference to two cities – North of Hadera, South of Ashdod and in between the two – Israel's center. This is in line with CSI/FBI Computer Crime and Security Surveys conducted from 2003 to date (CSI 2013).

Seventeen IT security surveys (ITSSs) were carried out at 17 different SMEs and not-for-profit organizations. 15 (88%) of the audited organizations are small, 2 (12%) are medium, of these 10 (59%) are private and the remaining 7 (41%) are not-for-profit. Of the audited organizations, 11 (65%) are located in the north, 1 (6%) is located in the center and the remaining 5 (29%) are located in the south. ITSSs split between two universities: 8 (47%) ITSSs were performed by student from Haifa university while 9 (53%) were done by students from Ben-Gurion university.

KEY FINDINGS

A total of 206 COBIT controls were reviewed in all seventeen ITSSs. The leading processes reviewed were:

COBIT Process	Count	Percent
DS5 Ensure Systems Security	54	26%
DS11 Manage Data	20	10%
DS4 Ensure Continuous Service	18	9%
AI2 Acquire and Maintain Application Software	11	5%
DS12 Manage the Physical Environment	11	5%
PO7 Manage IT Human Resources	10	5%
TOTAL	124	60%

Of the 206 total controls, 96 (47%) did not exist or failed to operate as intended, 43 (21%) were partially operational and 67 (32%) operated as intended.

Analysis by geographical location demonstrates that location is not a factor on an organization's information security posture. An analysis by organization type (e.g., either small or not-for-profit) shows that it too is not a factor influencing an organization's information security posture, as depicted in the following figure.

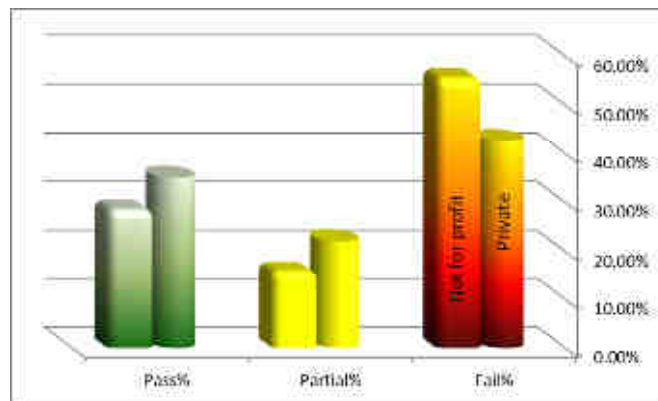


Figure 4: infosec controls at SMEs and not-for-profit organizations

ANALYSIS

IT security surveys carried out by seniors at two Israeli universities strongly suggest that Israeli SMEs typically do not have a good grasp of IT security. There is no significant difference between enterprises located in the North, Center or South of Israel. There is no significant difference among NAICS sectors. There is no significant difference between SMEs and not-for-profit organizations. The overall posture is dismal: more than half of IT security related controls (COBIT DS5) do not exist or failed to operate as intended. A vast majority of disaster recovery related controls (COBIT DS4) do not exist or failed to operate as intended. Governance of IT is virtually unheard of. For example, no SME had a written IT security policy in place. No SME had a written procedure for managing user accounts. Per COBIT's maturity model, IT governance, vis-à-vis IT security, is "non-existent".

SUMMARY

Seventeen information security reviews conducted for this research support the actual findings: SMEs owners and executives are unaware of serious IT security related exposure to their business. Many were taken aback by findings, and expressed a keen interest in fixing at least the most significant exposures. However, only future research, through a repeat visit to the same SMEs will reveal if intentions have materialized, and to what degree.

REFERENCES

Chao, C.-A. and A. Chandra (2012). "Impact of owner's knowledge of information technology (IT) on strategic alignment and IT adoption in US small firms." Journal of

- Small Business and Enterprise Development 19(01)
<http://www.emeraldinsight.com/journals.htm?articleid=17015657&show=abstract>.
- CSI. (2013). "CSI/FBI Computer Crime and Security Surveys." Retrieved May 14, 2013, from <http://gocsi.com/survey>.
- ISACA. (2013). "COBIT 4.1: Framework for IT Governance and Control." About ISACA Retrieved 15 March, from <http://www.isaca.org/Knowledge-Center/COBIT/Pages/Overview.aspx>.
- Li, C., G. F. Peters, et al. (2012). "The consequences of information technology control weaknesses on management information systems: the case of Sarbanes-Oxley internal control reports." MIS Q. 36(1): 179-204.
- Myers, M. D. (1997). "Qualitative Research in Information Systems." MIS Quarterly June 1997.
- NAICS. (2007). "The North American Industry Classification System (Bureau of Labor Statistics, US Government)." Retrieved 15 March, 2013, from <http://www.bls.gov/bls/naics.htm>.
- Newman, P. (2010). Evaluating the effect of information technology in small businesses. PhD, Doctoral Dissertation, Capella University.
- Williams, P. (2001). "Information Security Governance." Information Security Technical Report 6(3): 60-70
<http://www.sciencedirect.com/science/article/pii/S1363412701003090>.

DO INDUSTRY REQUIREMENTS AND ACADEMIC QUALIFICATIONS MEET IN THE CASE OF SOFT SKILLS

Ilana Lavy

Aharon Yadin

The Academic College of Emek
Yezreel

The Academic College of Emek
Yezreel

ilanal@yvc.ac.il

aharony@yvc.ac.il

Keywords: Industry requirements, soft skills, IT graduates, vocational life

INTRODUCTION

In recent years, we have witnessed a change regarding the importance of soft skills to Information Technology graduates future vocation. Soft skills refer to skills that are not technical. Among the required learning outcomes, defined in the Curriculum Guidelines for Undergraduate Degree Programs in Information Technology one may find some soft skills, such as the "ability to function effectively on teams..." and "An ability to communicate effectively with a range of audiences". Due to the rapid advancement in computing technologies, flexibility and the ability to learn become important. In addition, the elevated complexity of the newly developed applications most of the development work is performed by teams of developers. As a result, interpersonal and social interaction skills as well as being able to work in a team-based environment are of paramount importance. Many new developments address various business and organizational issues, so Information Technology graduates; especially the ones who will be involved in designing, defining and developing such systems have to exhibit knowledge regarding business processes and functionality. These new developments in the Information Technology discipline lead to a different understanding that graduates should possess not only technical skills, but soft (or non-technical) skills as well.

RELATED WORK

The IS 2002 Model Curriculum (IS 2002) (Gorgone et al., 2003) as well as the IS 2010 Curriculum Guidelines for Undergraduate Degree Programs in Information Systems (IS 2010) (Topi et al, 2010) defined some categories of non-technical capabilities that are required. Among these non-technical capabilities, one may find "Strong analytical and critical thinking skills to thrive in a competitive global environment", or the graduates have to "exhibit strong ethical principles and have good interpersonal communication and team skills". (Topi et al, 2010). Other researchers and scholars relate to listening skills as one of the "most neglected aspect of communication" (Flynn, Valikoski & Grau, 2008).

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

While a decade ago the market requirements focused mainly on the candidate's technical expertise, currently there is an increased attention to the soft skills as well.

Faheem (2012) reviewed 250 job descriptions for software developers and concluded there were nine soft skills that were required: (1) communication; (2) interpersonal; (3) analytical and problems solving; (4) organizational; (5) fast learning; (6) team playing; (7) ability to work independently; (8) innovative and creative; and (9) open and adaptive to changes. This survey was conducted in several countries and although there were substantial differences between North America and the rest of the world regarding interpersonal, analytical, organizational and open to changes skills, the most important set of skills was communication.

THE STUDY

This study was initiated due to employers' complains about the lack of soft skills among Information Technology graduates. The aim of the study was to map the real market requirements regarding soft skills and examine whether and how the academic programs address this issue. Three research questions were derived from the above aim:

Q1: what are the real soft skills requirements that are represented in the media advertisements?

Q2: is there a difference between the two types of hiring organization regarding the soft skills required?

For that matter, 2000 Information Technology classified advertisements that relate to Information Technology professionals were collected and analyzed.

RESULTS AND DISCUSSION

Since many organizations have different soft skills needs and different understandings regarding their needs, there is some ambiguity in the advertisements attributes. In order to reduce the ambiguity, the advertisements soft skills attribute were classified into the following four main categories: (1) human interaction which includes the skills referring to the interaction with other people (i.e. employees, customers, peers, etc.); (2) task interaction which includes the skills that are necessary for working in a computerized environments and performing the required tasks; (3) organization interaction which includes the skills that are needed for proper functioning in the organization and (4) common or general skills which include the general skills needed for proper functioning in all the above three categories. The four categories and their attributes are described in Table 1

Table 1. Categorized classifications

Human interaction skills	Task interaction skills	Organization interaction skills	Common (or general) skills
Team player	Can-do attitude	Work under pressure	Independent
Human relations	Analytical	Multi-tasking	Flexible
Presentations	Organized	Business oriented	Focused

Service oriented	Self-learner	Systemic/holistic	Highly motivated
Expressive			Creative
Instructor			Initiator/promoter

The study revealed that human interaction skills were high on the demand list (41.2% of the soft skills ads), common (or general skills) were in second place (22.8% of the ads), task interaction were third (20.2% of the ads) and organization skills were the least requested (15.8%) (Figure 1).

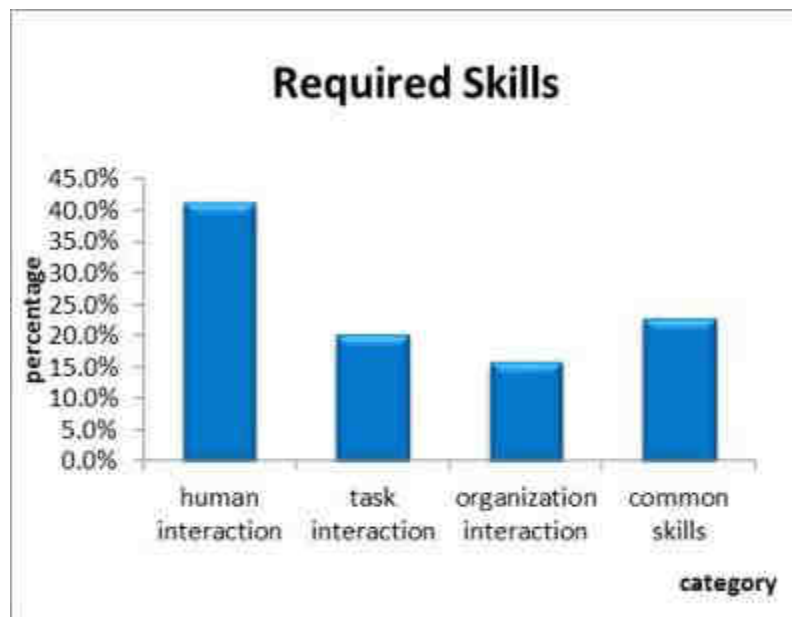


Figure 1. Distribution of skills according to the emerged categories

The study revealed a substantial difference between the two types of recruiting organizations regarding soft skills (Figure 2).

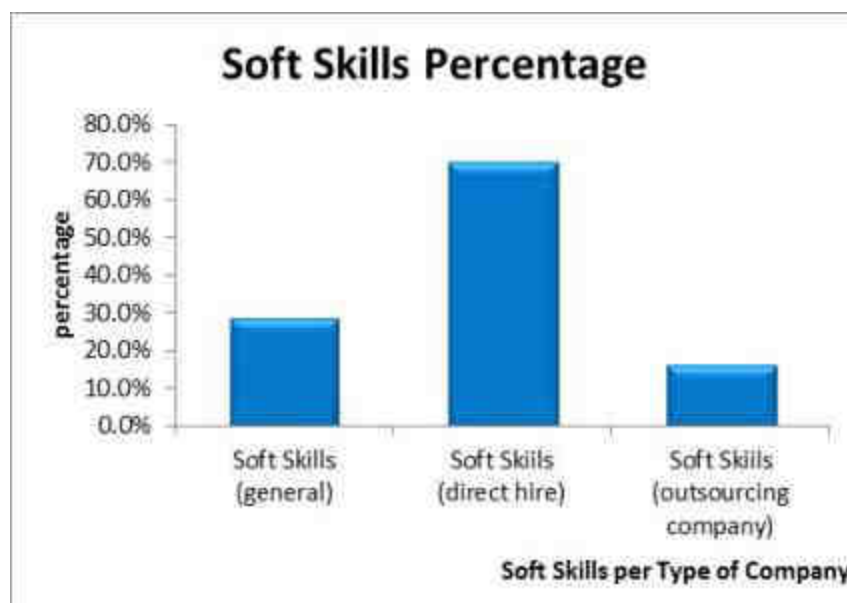


Figure 2. Distribution of skills according to type of hiring

These skills are significantly more important for in-house recruiting since these requirements appeared in 70.2% of the soft skills ads compared to 16.5% for software houses. Although a wide understanding regarding the importance of soft skills for the future vocation of the graduates, already exists, the academic curriculum was very slow in responding to these requirements. In order to nurture these capabilities some additional attention should be given during the learning years. For example using team-based assignments early in the learning process (even during the first year), spending more time on various alternatives to solutions while asking the students to assess their level of creativity. To nurture communication skills, students will be asked to present and defend in class their solution while elaborating on its uniqueness. In addition, for teaching students the importance of soft skills the grade calculation should take into account other aspects such as simplicity, creativity, originality, and not only concentration the technical capability measurements.

CONCLUDING REMARKS

The results received from this study revealed that the IT graduates' soft skills profile as represented by the industry requirements has gone through a big change. Initially, during the hiring process, only technological skills were important and currently the soft skills are equally important in assessing the future employee success.

These results demonstrate the conceptual shift that occurred in the last decade regarding the relative importance of the soft skills for IT professionals. This shift was initiated by the important, sometimes critical role of IT for the organizations' wellbeing and the fact that the IT employees have to communicate with other business functions and all managerial levels. Furthermore, as the IT based solutions become more complex, larger teams are required for development. This implies that the IT professional should possess good interpersonal and team based qualifications. Even the modern agile development methodologies stress the importance of human interaction. The bottom line is that the academic institutes should embrace this change and modify the learning outcomes to include developing and enhancing the soft skills addressed in this study.

REFERENCES

- Gorgone, J., Davis, G. B., Valacich, J. S., Topi, H., Feinstein, D. L., & Longenecker, H. E. (2003). IS 2002 Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems. *The Communications of the Association for Information Systems*, 11, article 1.
- Faheem, A. (2012). Software Requirements Engineer: An Empirical Study about Non-Technical Skills. *Journal of Software*, 7(2), 389–397.
- Flynn, J., Valikoski, T.-R., & Grau, J. (2008). Listening in the Business Context: Reviewing the State of Research. *The International Journal of Listening*, 22, 141–151.
- Topi, H., Valacich, J. S., Wright, R. T., Kaiser, K., Nunamaker, J. F., Sipior, J. C., & de Vreede, G. (2010). IS 2010: Curriculum Guidelines for Undergraduate Degree Programs in Information Systems. *Communications of the AIS*, 26(18).

Virtual Learning Environments and Peer Assessments for Enhancing Students' Decision Making Processes

Aharon Yadin

The Max Stern Yezreel Valley College (YVC),
Management Information Systems Department

aharony@yvc.ac.il

Keywords: Visual environments; collaborative learning; personalized assignments.

INTRODUCTION

This paper describes a learning tactic that was developed to help students grasp the full dimension of issues addressed in a good decision making process, especially under uncertainty. The rapid advancement in technological developments and the wide integration of technology and software based solutions in many of our daily activities affects also the way we teach. In the past, education was perceived mainly as a teaching discipline in which the lecturer delivered the learning content. With the technological progress in the past two decades education has transformed into learning environments in which the students assume a more active role and the lecturer moderates this continuous process. The lecturer usually uses an integrated learning environment which allows the students to acquire information by using a proactive approach and the students' own experiences lead to better understanding. The underlying assumption in the learning by experience is that most of the responsibility for the learning process is transferred to the student while the lecturer acts as a facilitator.

THE COURSE

The decision making course is intended to deepen and widen students' understanding regarding possible ways of improving the decision making process. This is achieved by engaging them in learning, assessing and analyzing different approaches to solving a given problem. For that reason the course employs a visual learning environment that resembles a playing ground in which the students can "play" by controlling and monitoring the activities of a virtual robot. In addition to the virtual robot, the environment contains walls, representing obstacles and "beepers" which are small objects the robot can handle (hear, place, pick and carry). By controlling the robot's movements while performing the predefined assignment and avoiding the obstacles, the students are exposed to various ways of thinking in addressing the problematic situation and completing the task. These playful actions help students build and enhance their analytic and problem solving skills by addressing all available and hidden factors relevant to the decision making process. The environment is using

simple "programming like" instructions that enforce accuracy and paying attention to details.

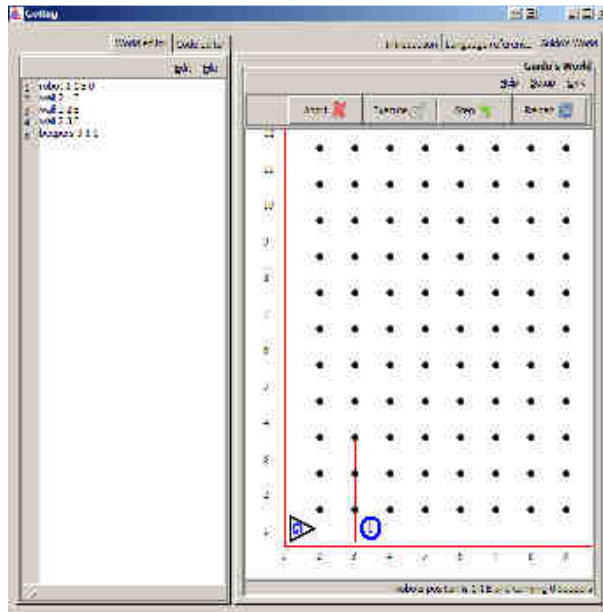


Figure 1. The GvR environment

The course is divided into two distinct parts. The first one which deals mainly with declarative knowledge provides the foundation for problem solving by learning about the environment, the instructions to control the robot and the possible obstacles to be avoided. In this part the students are given simple assignments, since the virtual world is known and visible. By following the robot's movement in the virtual world the students get instant feedback on the quality of their work. The second part which is about procedural knowledge addresses the accumulated knowledge for decision making. In this part the virtual world layout is unknown and the robot has to sense its way avoiding the obstacles that might be hidden there. The course was offered as a workshop in the computer lab with a simple structure which includes lectures and tutorials. The number of students in the workshop was limited to 24 or less. The grade is calculated based on 6 bi-weekly assignments and a final project. The workshop was taught four times (in the years 2009, 2010, 2011 and 2012), all by the same lecturer. The number of students during these three years remains almost constant (20, 22, 22 and 23 respectively).

THE STUDY

The study was initiated due to a large, although partially explainable difference between the average grade of the assignments in the first part to the average grade of the assignments in the second part. In 2009 the difference was 14 points (or 18.6%) and in 2010 it was 12 points (16.2%). The first part that deals with declarative knowledge is simpler and the world in which the robot is living is visible, so it is relatively simple to design and control its activities. The second part that deals with

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin
Academic Center, Emek Hefer, Israel

procedural knowledge is more complex since the students have to integrate the knowledge accumulated in the first part with the decision making skills required here. Furthermore, since the world in these assignments is not visible the robot has to sense its surrounding for example in order to decide whether it is safe to move forward. This is a more intangible type of assignments which requires deeper abstract thinking. Being aware to the students' possible difficulties when proceeding from understanding the environment and its capabilities (the declarative knowledge) to the next level of using this knowledge for problem solving (the procedural knowledge), the course was artificially divided into these two parts. Nevertheless, the difference between the grades of the two parts proved that it is still too complex.

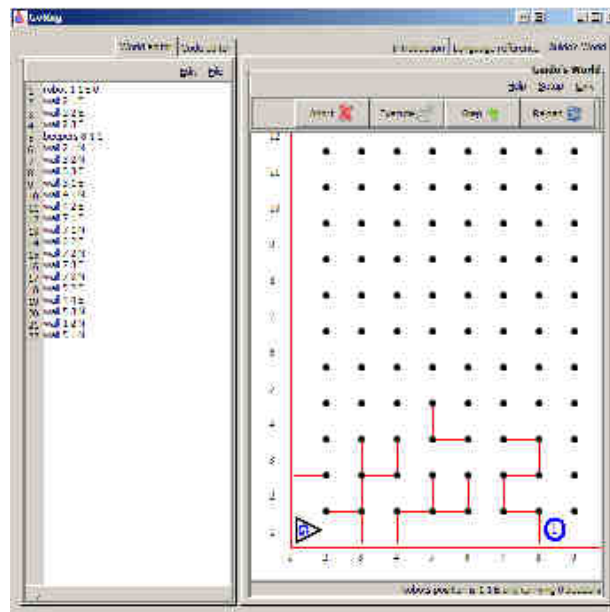


Figure 2. A second part assignment example

In dealing with this complexity and in an effort to help students better understand the more abstract issues a different approach was taken. The course structure and the grades calculations remained unchanged; however a more structural teaching method was applied. For each assignment the students were required to first verbally define the problem and outline the possible solution. Only in the second stage and after carefully assessing the solution, they had to define the instructions for the robot. In addition, to minimize the possibilities of sharing solutions with peers, the assignments were personalized and each student received a different version. Each assignment was assessed by both the lecturer and an additional student. When assessing a fellow student assignment, the assessor student had to provide constructive feedback on the solution as well as comment on his or her own assignment. The comments should represent any new insight to solving the problem that was accumulated by evaluating and assessing the peer's assignment. Employing this tactics had almost no effect on the average grade of the first part; however it increased the average grade of the second part from a difference of 14 and 12 points in 2009 and 2010 respectively, to a

difference of less than 5 point in 2011 and 2012. These 5 points of difference between the grades of the two parts are normal, since the second part is more difficult due to it being more abstract.

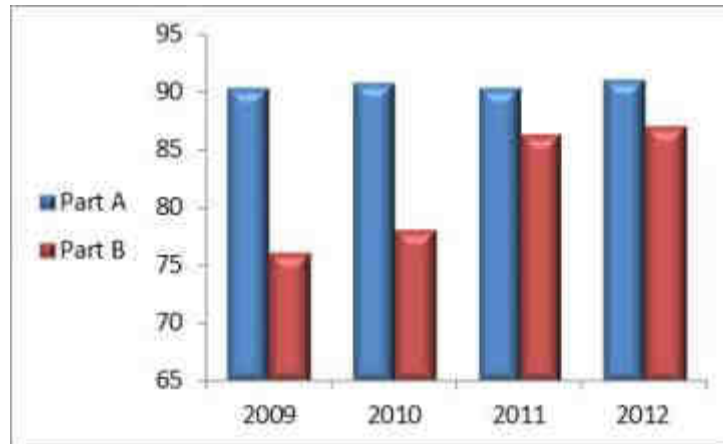


Figure 3. Average scale

RESULTS AND CONCLUSIONS

The importance of visual environments like GvR for simplifying abstract concepts is not new and was already addressed by many researchers (Dagdilelis & Satratzemi, 2001; Hoyles, Noss & Adamson, 2002; Sarama & Clements, 2002 to name a few). This study; however revealed that it is not sufficient. The visual environment may have helped better understanding the abstract concepts, but utilizing individual assignments with peer assessment and reflections, or self-assessment was even more successful in helping students' understanding. This was demonstrated by the lower difference between the grades of the two parts of the workshop (4.6% in the new course structure compared to an average of 18.6% (2009) and 16.2% (2010) in the original course structure). The positive effect of peer and self-assessment on the learning outcomes that was observed in this study supports previous finding by many researchers (McDonald & Boud, 2003; Willey & Gardner, 2009), especially when it is used not only for grading the peer's work but also when it is used for reflection on one's own assignment and relating to issues to be enhanced based on observing the other solution. This means that the peer assessment provided additional understanding and enhanced the mental model not only by doing, but also by evaluating.

REFERENCES

- Dagdilelis, Vassiliov and Maya Satratzemi. 2001. Post's Machine: A Didactic Microworld as an Introduction to Formal Programming, Educational and Information Technologies, 6(2): 123-141
- Hoyles, Celia, Richard Noss, Ross Adamson. 2002. Rethinking the Microworld idea. Journal of Educational Computing Research, 27(1&2): 29-53.
- McDonald, Betty, and David Boud. 2003. The impact of self-assessment on achievement: the effect of self-assessment training on performance in external examinations, Assessment in Education, 10 (2): 209-220

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

- Sarama, Julie and Douglas H Clements. 2002. Design of Microworlds in mathematics and science education. *Journal of Educational Computing Research*, 27(1&2): 1-5.
- Willey, Keith. and Anne Gardner. 2008. Using self and peer assessment for professional and team skill development: do well functioning teams experience the benefits? *Proceedings of the ATN Assessment Conference – Engaging Students in Assessment*, South Australia

MOBILE VIDEO: OPPORTUNITIES AND CHALLENGES FOR LEARNING (RESEARCH-IN-PROGRESS)

Nitza Geri

The Open University of
Israel

nitzage@openu.ac.il

Ruti Gafni

The Academic College of
Tel Aviv Yaffo, and The

Open University of Israel
rutigafn@mta.ac.il

Amir Winer

The Open University of
Israel

amirwi@openu.ac.il

Keywords: mobile video, mobile learning, diffusion of mobile video, online video lectures.

INTRODUCTION

Mobile devices, such as tablets and smartphones, are being used for increasingly growing sorts of activities, so it just seems natural to use them for mobile learning. However, learning requires a relatively high cognitive effort, and the learners must usually pay attention, and concentrate on the delivered content. This study focuses on the use of mobile video for learning. On the one hand, 44% of American cell phone owners use them for recording video (Duggan & Rainie, 2012), therefore, it looks as if video watching is a conventional use of mobile devices. On the other hand, most of the general videos are short clips, lasting less than a minute or two, whereas educational video lectures are much longer. Beside the issue of engaging the attention of the learners, there are other obstacles, such as the small screens that may not be fit for certain types of content, the high prices of mobile internet surfing, the pace of downloading the data, and the need for electricity resources. It is important to examine the suitability of mobile video for learning because providing video content via mobile devices requires resources, planning, and adjustments (Gafni & Geri, 2013).

OBJECTIVES AND RESEARCH QUESTIONS

The purpose of this initial study is to evaluate the potential of using mobile devices for learning in higher education. The study takes the perspective of the students, and examines their actual use of mobile video content, specifically:

1. Do students try the mobile video option?
2. Do students that have experienced the mobile video option continue using it?
3. Are there different or similar patterns of using mobile devices for learning in general and of using them for video?
4. Does content matter? I.e., does the pattern of use depend on the content of the videos, or some other characteristics of the learning context?

Most technology acceptance studies deal with intention to use, and are based on subjective perceptions. This study measures objective data of actual use of video lectures for learning, via mobile and stationary channels.

It is important to measure actual use rather than perceptions and intentions to use because there is a gap between perceptions and actions. A study by Steimberg et al. (2010), which measured student perceptions, found that 93.6% of the students thought that watching video lectures might improve their understanding of learning materials. However, actual viewing data during recent years indicates that many students do not watch video lectures, or if they do, their use is relatively low.

METHODOLOGY

The main methodology used in this study is data analytics (LaValle, Lesser, Shockley, Hopkins, & Kruschwitz, 2011). Since one of the authors is involved in the process of implementing mobile learning at the Open University of Israel, there are also some aspects of action research (Robson, 2002). Various sorts of video lectures and tutorials have been offered to the Open University students for years, and currently there are video elements included in hundreds of the courses. However, the videos are available only via stationary devices, i.e., personal computers, including laptops and netbooks, but not via mobile internet, i.e., smartphones and tablets. For the purposes of this study, laptops and netbooks are considered stationary although they are mobile, for various reasons, including their compatibility with video for stationary devices.

During the first semester of 2013 (thereafter, 2013A), a pilot was conducted in order to examine the feasibility of offering mobile video in sufficient quality. The option to view video lectures via mobile devices was offered in two undergraduate courses: the first one, "Marketing Management" (hereafter, Marketing) is a compulsory regular course in Management, and the second course, "Genocide", is a popular elective course in Political Science and International Relations. The usage data was obtained from the Open University website via Google Analytics (Clifton, 2012), and further analyzed with IBM® SPSS® Statistics.

INITIAL RESULTS

Table 1 summarizes webpage displays data for the two courses during semester 2013A. Two webpages were examined, the course main webpage, and the video main page, through which the students access the video lectures.

Table 1: Summary of webpage displays

Course	Marketing		Genocide	
	Course main webpage	Video main webpage	Course main webpage	Video main webpage
webpage displays: via stationary (Percentage of total displays)	48,427 (94.5%)	4,020 (93.4%)	18,795 (94.0%)	3,212 (93.5%)
webpage displays: via mobile (Percentage of total displays)	2,833 (5.5%)	284 (6.6%)	1,203 (6.0%)	222 (6.5%)
Total displays per webpage	51,260	4,304	19,998	3,434
Students (who took the exam on the regular date)	805		348	
Average displays per student	63.7	5.3	57.5	9.9
<u>Total video main webpage displays</u> Total course main webpage displays	8.4%		17.2%	
<u>Video main webpage: via mobile</u> Course main webpage: via mobile	10.0%		18.5%	
Returning visits: via stationary (Percentage of total stationary displays)	41,594 (85.9%)	3,447 (85.8%)	16,057 (85.4%)	2,694 (83.9%)
Returning visits: via mobile (Percentage of total mobile displays)	2,338 (82.5%)	227 (80.0%)	972 (80.8%)	162 (73%)

As shown in table 1, the students of both courses have tried the mobile video option, but only about 6.5% of the video main page displays were via mobile devices. Since

the mobile video use was limited, it was hard to identify meaningful growth patterns. However, the data clearly indicates that students who have tried the mobile video continued using it. The last two rows of table 1 present data of returning visits, as a percentage of the total displays of the webpages via stationary and mobile channels. At least 73% of the mobile video displays were for returning students. Actually, the proportion of returning displays is even higher. The data suggests that content and context matter, as the use of video in the genocide course (17.2%) was significantly more extensive than its use by marketing students (8.4%), $\chi^2(1, N = 78,996) = 889.64$, $p < .0001$. Further results will be presented at the conference.

CONCLUSIONS

Our findings indicate that the “innovators” and “early adopters” (Rogers, 2003) among the students are already using mobile video for learning. Furthermore, those who have tried the mobile video option, have returned, and continued using it. The socially engaging rich video format makes it a prime application for mobile learning. As usually happens with new technologies, the prices of mobile internet surfing will keep declining, and at some future point there will be adequate solutions for the required electricity resources. The current challenge is to improve the pedagogic aspects of mobile video learning.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge that this research was supported by a grant from the Israel Internet Association [ISOC-IL].

REFERENCES

- Clifton, B. (2012). *Advanced web metrics with Google Analytics*. Indianapolis: Wiley Publishing Inc.
- Duggan, M., & Rainie, L. (2012). Cell phone activities 2012. *Pew Research Center* 2012. Retrieved from: http://pewInternet.org/~media/Files/Reports/2012/PIP_CellActivities_11.25.pdf
- Gafni, R., & Geri, N. (2013). Adoption patterns of a mobile juridical knowledge base. *Journal of Information, Information Technology, and Organizations*, 8, 25-39. Retrieved from: http://www.iiakm.org/jiito/articles/Volume_8/JIITOV8p025-039Gafni-Geri.pdf
- LaValle, S., Lesser, E., Shockley, R., Hopkins, M. S., & Kruschwitz, N. (2011) Big data, analytics and the path from insights to value. *MIT Sloan Management Review*, 52(2), 21-32.
- Robson, C. (2002). *Real world research: a resource for social scientists and practitioner-researchers* (Vol. 2). Oxford: Blackwell.
- Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New-York: The Free Press.
- Steimberg, Y., Guterman, E., Mermelstein, B., Brickner, R., Alberton, Y., & Sagi, R. (2010). Students' perspective on teaching and learning with video technology at the Open University of Israel. In Y. Eshet-Alkalai, A. Caspi, S. Eden, N. Geri, & Y. Yair (Eds.), *Learning in the Technological Era: Proceedings of the Chais Conference on Instructional Technologies Research* (pp. 186H-194H). The Open University of Israel: Raanana, Israel. [in Hebrew] Retrieved from: http://telem-pub.openu.ac.il/users/chais/2010/after_noon/4_1.pdf

**EXPLORING USER CHOICES IN GAME-BASED
EDUCATIONAL SOFTWARE FOR KINDERGARTEN
CHILDREN – RESEARCH-IN-PROGRESS**

Rina Zviel-Girshin

Ruppin Academic Center, Emek Hefer, Israel

rinazg@ruppin.ac.il

INTRODUCTION

In recent years, the term “edutainment” has become a reality. Educational software and educational digital games are widely used, and have become an integral part of our daily lives. Digital games are recognized as a tool that may enable a new paradigm for education (Prensky, 2001). Discussions about negative impacts of playing digital games or using blended learning in education have become more and more rare (Van Eck, 2006). Evidence of computer games replacing more traditional games as leisure activities are more vivid (Connolly, 2012). In recent years, more interesting discussions concentrate on: how to use digital games in regular education; what a correct architecture of educational software is; how to discover an optimal learning flow for each user; and how to understand, predict and use users’ choices, behaviors and preferences? (Steiner, Kickmeier-Rust, & Albert, 2009; Kirriemuir, & McFarlane, 2004)

Monitoring and exploring user choices have become one of the techniques used in game-based learning research. In recent years, several methodologies to bring users into the development process were developed. Users can be active partners, testers, or research participants to be monitored and observed. Children users are less involved than adults in such studies and development. However, the potential of involving children in technology design is being increasingly acknowledged (Nousiainen, & Kankaanranta, 2008). Since children and teenagers are one of the major groups of digital games users, it seems only fair to draw on their knowledge and practices as a basis for research (Druin, 1999).

This paper explores choices and attitudes of 4-6-year-old children using specially designed educational software for learning to read in Hebrew. The major goal of this software was knowledge acquisition in the field of reading, but additional aims were to investigate some issues in game development. The author of this paper, like many other researchers in the field of game-based learning, believes in cooperative inquiry, and that design for children should involve children (Guha, Druin, Chipman, Fails, Simms, & Farber, 2005). However, involving kindergarten children in software development is relatively difficult, and keeping in mind that these are online users, it seems to be even more difficult to apply different gathering techniques and practices. Therefore, monitoring and observation seem to be a good choice.

BASIC SYSTEM DESCRIPTION

In our study, we used a custom-made system, which was designed as part of more complex game-based learning software for kindergarten children. The major goal of

the system is to teach preschool children to read using digital game-based learning (DGBL) techniques. The designed software uses Israeli Ministry of Education kindergarten and school programs for reading. It has two major modes:

- A presentation mode, in which each letter, sound and syllable is presented and explained using multimedia and flash programs. Each presentation ends with a small and very simple game. 22 different games were developed for each letter of the Hebrew alphabet;
- An active game playing and testing mode, which teaches, improves and tests various tasks and skills.

The software has an additional part designed for the educator/parent. This part helps to observe the child's progress and to monitor results. An educator can be a passive or an active user of the system. A passive educator only receives learning outcomes. An active educator receives learning outcomes, but can also change/advise the system to use another basic algorithm or learning flow, or can upload additional materials to be used in games and tests.

The system administrator has the power to change learning flows, results, algorithms, and parameters of the games; to delete, add or edit users; and to upload contents. Neither educators nor system administrators are relevant to the topics discussed in this paper, and will consequently be ignored.

HYPOTHESES

Many questions can be asked about the players. Does gender matter in GUI player choices? Do we have to develop different games for girls and boys? Do learning patterns change for different ages? Is it possible to discover if scored games are better than games without scores? Is it possible to predict gender-specific behavior of players? Are the majority of users motivated to move forward to the higher level and to improve their learning outcomes? Is game playing more fun for girls or for boys? Can game playing improve the child's learning abilities? (Piaget, 1962; Prensky, 2001; Connolly, Boyle, MacArthur, Hailey, & Boyle 2012)

Since it is difficult to involve children in this age group in system design, it was decided to observe their choices and attitude towards the games and tests. This paper presents the following observations:

1. GUI choices are different between girls and boys;
2. There is preference of scored games vs. un-scored games with feedback;
3. A majority of the players were motivated to move to the higher level as soon as possible.

These observations became hypotheses H1, H2 and H3 of this paper.

METHODOLOGY

This study employed a qualitative case study methodology. To check the hypotheses, two groups of players were selected. One group of 4 to 6 year-old children played the designed games under grownup supervision in a private kindergarten. The participants

consisted of 36 children ($n=36$) of which 19 were girls ($g=19$) and 17 were boys ($b=17$). The same grownups were presented during the trials. Children were selected according to basic computer literacy and reading knowledge (basic usage of mouse was required and no knowledge of the Hebrew alphabet). Another group was chosen from active online users who defined themselves as 4-6 year-old users ($n=113$, $g=63$, $b=50$). An “active user” is a user who uses the system at least twice a week for a period of 10 weeks at least. It is difficult to gather correct information about online users, especially users who cannot read and write. This fact was taken into consideration by the system developers during system creation and games design. Principles of child computer interaction (CCI) were applied (Read, 2005). Special login registration forms were built. Each user was required, in a friendly way, to choose his or her age and gender, to define favorite colors, fonts, and images, and to perform additional tasks. Users that used the system for a period of 10 weeks were assumed to be users of the correct age.

RESULTS

The software monitored the players’ activities and collected data about users’ choices, game use and attitude, test results and game scores, flow choices and time. The first group was monitored during September-December 2012. The second group was chosen from a set of players who used the system during July-December 2012.

Several studies suggest the existence of gender differences in game playing. Some studies show that men and women appear to have different game preferences (Amory, & Molomo, 2012). In younger age groups those differences are less obvious, since some of the differences relate to social stereotyping practices and are not strongly present in this age group (Ridgeway, & Correl, 2004; Amory, & Molomo, 2012). Regarding H1, the collected data showed a difference in several categories of GUI choices between girls and boys. Differences were found in color choices, the personal image that represented the player, and in the choice of the character (figure) to play the game. These gender specific differences were found in both groups.

To check hypothesis H2, the original software was slightly modified. The same game (with the same logic, learning algorithms and learning outcomes) was developed with three slightly different interfaces: a game without a visible scoring mechanism, a game with a scoring mechanism that grades the game results, and a game with different types of prizes. Players in the first group were shown all three types of games and were given a choice to continue with the preferred game. 77% ($n=27$, $g=15/b=13$) of players preferred to continue with one of the scored games. In the second group, only users who played all three types of the game (at least once) were chosen from the group of “active users”. In this case, most of the users 71% ($n=80$, $g=44/b=36$) also chose to continue with scored games. More specific results are shown in Figure1. In both groups, no gender-specific differences were found between the players.

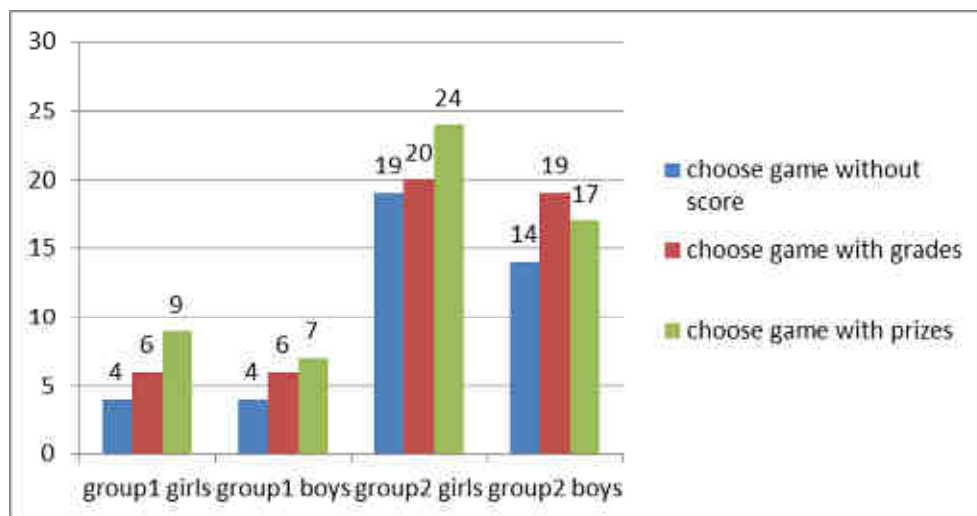


Figure 1 – Scored vs. un-scored games preferences

The same method was implemented in another game. Different interfaces and paths were created, but the same learning algorithm was used. Once again, most of the users preferred scored games: group1 - 71% (n=25, g=13/b=12) and group 2 - 69% (n=78, g=41/b=37). Therefore hypothesis H2 was supported. There is a significant preference of scored games versus un-scored games. It seems that feedback and assessment are very important for users.

The third hypothesis H3 was checked using the collected data about user choices of the next game and/or learning flow. The majority of players indeed moved to a higher level as soon as possible. In group 1 80% (n=28, g=14/b=14) and in group 2 79% (n=89, g=49/b=41) continued to the “next level” defined by the system. Therefore hypothesis H3 was supported. Later, most of the players remained on this next level for several games before they managed to continue. One quarter of the users were automatically returned to the previous level: group 1 - 26% (n=9, g=5/b=4) and group 2 - 25% (n=24, g=14/b=10). This may be an interesting outcome since it seems that these players reached this so-called “next level” by luck and not by using required learning skills.

CONCLUSION AND DISCUSSION

Many studies of games for learning exist. The majority of the studies applied to older age groups. Kindergarten children and their game playing choices and attitudes are rarely explored. Perhaps the problem is an ethical issue with this age group, or perhaps because it is very difficult to gather data from this age group. Exploring user choices, observing online and offline users, and analyzing gathered data showed some interesting outcomes. As was assumed, a gender difference in GUI design preferences was found, and should be taken into consideration by game designers (Steiner, Kickmeier-Rust, & Albert, 2009). In future studies it would be interesting to check additional user choices and gender-related attitudes for this age group.

Preferences of scored games by the majority of players showed competitiveness in kindergarten children. Therefore, motivated games with some kind of feedback are advisable for game-based learning. Also, willingness to move to the next level as soon as possible showed a real interest to achieve the final goal and to learn to read. Both

these facts should be combined and used to achieve better learning outcomes. Thanks to observation of user choices and attitudes, games can be shaped and changed in ways that may be useful for future game designers.

Acknowledgment

I want to thank my former students, Yossi Kandinski and Ron Zoran, who helped to build this educational software and made the required changes in order to conduct this study.

REFERENCES

1. Amory, A., & Molomo, B. (2012). Gendered Play and Evaluation of Computer Video Games by Young South Africans. *Gender, Technology and Development*, 16(2), pp. 177-196. doi: 10.1177/097185241201600203
2. Blunt, R. (2007). Does Game-Based Learning Work? Results from Three Recent Studies. I/ITSEC conference 2007
3. Connolly, T.M., Boyle, E. A., MacArthur, E., Hailey, T. & Boyle, J.M.(2012). A systematic literature review of the empirical evidence on computer games and serious games. *Computers and Education*, 59 (2012), pp. 661 – 686 .
doi:10.1016/j.compedu.2012.03.004
4. Druin, A. (1999). Cooperative inquiry: developing new technologies for children with children. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '99)*, USA, pp. 592–599
5. Guha, M. L., Druin, A., Chipman, G., Fails, J. A., Simms, S. & Farber, A. (2005). Working with young children as technology design partners. *Communications of the ACM*, vol. 48, no. 1, pp. 39–42.
doi:10.1145/1039539.1039567
6. Kirriemuir, J. & McFarlane, A. (2004). Literature review in games and learning. A Graduate School of Education, University of Bristol Press
7. Nousiainen, T., & Kankaanranta, M. (2008). Exploring Children's Requirements for Game-Based Learning Environments. *Advances in Human-Computer Interaction*, Volume 2008. doi:10.1155/2008/284056
8. Piaget, J. (1962). Play, Dreams & Imitation in Childhood. W. W. Norton NY
9. Prensky, M. (2001). Digital game-based learning. New York, McGraw-Hill
10. Read, J. (2005). The ABC of CCI (Child Computer Interaction). *Interfaces* 62, pp. 8–9
11. Ridgeway, C.L., & Correl, S.J. (2004). Unpacking the gender system. A Theoretical Perspective on Gender Beliefs and Social Relations. *GENDER & SOCIETY*, Vol. 18 No. 4, August 2004, pp. 510-531.
doi:10.1177/0891243204265269
12. Steiner, Ch.M., Kickmeier-Rust, M.D., & Albert D. (2009). Little Big Difference: Gender Aspects and Gender-based Adaptation in Educational Games. *EDUTAINMENT* 2009, pp. 150-161. doi:10.1007/978-3-642-03364-3_20

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin
Academic Center, Emek Hefer, Israel

13. Van Eck, R., (2006). Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless. *EDUCAUSE Review*, vol. 41, no. 2 (March/April 2006), pp. 16–30

USING DISTRIBUTED COGNITION THEORY FOR ANALYZING THE DEPLOYMENT ARCHITECTURE PROCESS

Naomi Unkelos-Shpigel, Irit Hadar

Information Systems Department, University of Haifa
Carmel Mountain 31905, Haifa, Israel
{naomiu, hadari}@is.haifa.ac.il

Keywords: deployment architecture, distributed cognition, qualitative research.

INTRODUCTION

Deployment architecture is an important part of the software development lifecycle. Our preliminary research indicates that the process of constructing the deployment architecture holds several challenges which, if not properly met, may hinder the success of the project and result in low customer satisfaction. In this ongoing research, we analyze this process in different firms, in an attempt to understand its challenges towards proposing strategies for its improvement. To this end, we collected data via 25 questionnaires at a global IT firm, and 12 in-depth interviews with architects from 10 firms. Analyzing the data qualitatively, through the lens of distributed cognition theory, helped us to understand the structure and flow of this multiple-stakeholders process and identify common potential pain points and challenges that need to be addressed.

OBJECTIVES

The objective of this ongoing research is to enhance the deployment architecture process, resulting in better solutions and higher customer satisfaction. Accordingly, as a first step, our empirical study aims at identifying the challenges and difficulties that may hinder its success. To this end, we study the flow of the architecture deployment process, its different participants, and their decision-making and cognitive processes.

Some attention has been given in the research areas of software and IS engineering to cognitive processes related to different activities of development. For example, a survey on cognitive studies in the context of software analysis and design can be found in [1]. However, we could not find empirical studies investigating cognitive processes of software architects in general and of deployment architects in particular. In this study, we aim to make a first step towards investigating the construction of deployment architecture from a cognitive point of view. Considering that the creation of deployment architecture involves several different sources – both human and non-human – we recruited for our analysis the theory of distributed cognition. Distributed cognition separates a system, e.g., a collection of people and tools working together to achieve a goal, to subsystems, referring to the cognition of each subsystem in the

process as a separated unit [2]. It addresses the concerns of the different subsystems, their interaction, conflicts and dilemmas that stem from their different points of views. Distributed cognition further proposes strategies to improve the systems and its processes based on the identified conflicts. This theory fits very well to our objective since the creation of the deployment architecture solution is a complex process, which involves different stakeholders and various tools and artifacts. Addressing each of these as a unique subsystem, with its own cognition and perception of the process, can provide us a better understanding of the process, its weaknesses, and accordingly, opportunities for its improvement.

METHOD

According to our main objective, we conduct a qualitative research, where the investigator does not have a pre-defined theory about the environment inspected, but rather uses techniques and tools to explore and discover phenomena [3]. We use tools and methods based on the grounded theory methodology [3]; data is collected from the field and inductively analyzed.

We initiated our research at a global, large-scale IT firm by a pilot of interviews, for a first acquaintance with the firm and its deployment division, followed by distributing an open-questions questionnaire to deployment architects. The questionnaire was aimed to achieve a preliminary identification of the major concerns of the process and opportunities for improvements, as perceived by architects. In order to enrich our data beyond this single case study [4] we collected data via in-depth interviews in additional firms. All together, ten global firms – six hi-tech firms, two communication firms and two shipping firms – were included in the research so far. Only global firms that regularly execute major deployment projects were included in the research. The interviewees were experienced deployment architects, working with customers as well as with internal divisions responsible for defining products. In what follows we present preliminary results obtained thus far in this research.

FINDINGS

The main principle of distributed cognition is to determine the unit of analysis, in which cognition will be examined. Since we explore the process of deployment architecture, we defined the unit of analysis to include all stakeholders of this process, as well as the resources and systems used. The different subsystems included in our unit of analysis, based on the data collected, are described in figure 1. In what follows we present and briefly explain each category and its related challenges. Due to space limitations, we will not present here exemplary quotes.

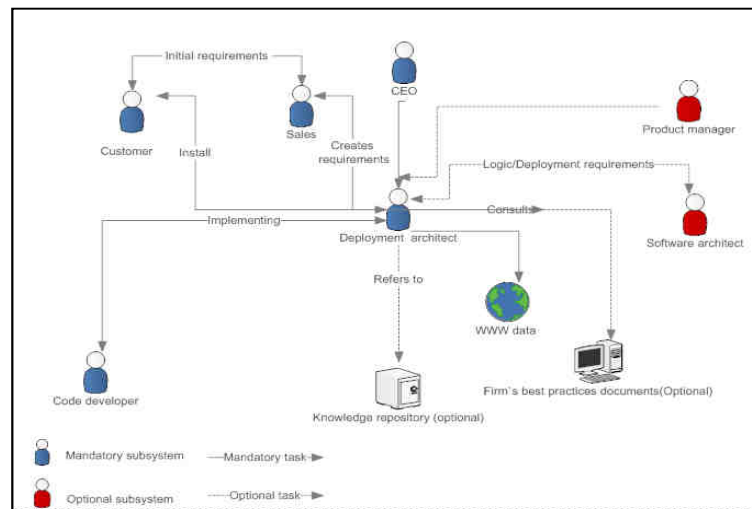


Figure 1. Subsystems in the deployment architecture process

Memory distributed among subsystems: Having the memory distributed among subsystems results in different subsystems having different view of the process [5]. This often leads to conflicts and contradictions between subsystems.

Internal and external representations of concepts/artifacts: Each subsystem has its individual cognitive processes based on its own knowledge and point of view [5]. This results in interpretation of an external representation of information (e.g., requirements document) to an internal, often different representation of this information, which affects the decisions made by the subsystem.

Interaction among subsystems: The different subsystems communicate with each other in order to complete the process successfully [2,p.251]. However, this dependency on communication might lead to tension and conflicts between stakeholders. We encountered several cases in which the communication between code developers and project management was weak or non-existent. Thus, managers are often not informed about problems related to product development. Only later, during the deployment, the product is found to be not eligible to be deployed at customer's site:

Interface with tools: Interaction between human and non-human subsystems and the effect of the latter on the cognitive processes of the former is another focus of distributed cognition. As illustrated in figure 1, the deployment architect uses other subsystems, which are automated tools, such as remotely accessible knowledge repositories or the Internet. However, having a variety of tools causes the architect to waste additional time on looking for data in multiple tools and systems, viewing only fragments of the information at a time, which makes it difficult to see the bigger picture. Moreover, some tools are over complex for their purpose, leading stakeholders to work with simpler tools (e.g., excel), which are sufficient for them but do not provide the wide perspective needed for the architect.

Cultural environment: Culture influences cognitive processes both within and between subsystems [5]. A good example, which we witnessed in several American

firms, although global in nature, is the tendency to neglect addressing international regulations. Firms failing to consider these factors, usually when management does not put enough emphasis on the matter and due to the natural focus on the local market, often face severe problems when deploying their product in countries where unique regulations on this type of product are defined.

CONCLUSION

This report demonstrated the analysis of the deployment architecture process through the lens of distributed cognition. Using this theory we were able to refer to each stakeholder and tool as a separate subsystem, having its own cognition and interactions with other subsystems. We used this perspective to analyze the data we collected on the deployment architecture process, and to identify the challenges deployment architects face and their sources.

REFERENCES

- [1] Hadar, I.: When Intuition and Logic Clash: The Case of the Object Oriented Paradigm, Science of Computer Programming. In press, DOI: <http://dx.doi.org/10.1016/j.scico.2012.10.006>
- [2] Hutchins, E.: Cognition in the Wild. Cambridge, MA: MIT press (1995)
- [3] Strauss, A. and Corbin, J. "Basics of qualitative research grounded theory procedures and techniques", Sage Publications, Inc (1990)
- [4] Walsham, G.: Interpretive Case Studies in IS Research: Nature and Method," European Journal of Information Systems (4:2), 1995a, 74-81 (1995)
- [5] Hollan, J., Hutchins, E., and Kirsh, D.: Distributed cognition: toward a new foundation for human-computer interaction research. ACM Transactions on Computer-Human Interaction (TOCHI), 7(2), 174-196 (2000)

UNIFYING EVENT LOGS TO ENABLE END-TO-END PROCESS MINING

Lihl Raichelson

University of Haifa

lihiraos@gmail.com

Pnina Soffer

University of Haifa

spnina@is.haifa.ac.il

Keywords: process mining, end-to-end-process discovery, integrating log files.

ABSTRACT

Organizations constantly strive to improve their business processes and achieve better business performance. Process mining techniques support process analysis and identification of improvement opportunities. However, processes are often comprised of separately managed procedures, impossible to mine in an integrative manner. The paper addresses end-to-end process discovery, discussing the difficulties and challenges associated with this task, and proposing a method that provides a model of the end-to-end process.

INTRODUCTION

Organizations constantly desire to improve their business processes facing a dynamic and changing environment. For effective improvement, it is necessary to properly understand those processes. A common situation is that core procedures are addressed, analyzed, and supported as independent processes, while an integrated view of the end-to-end process they are part of is missing. Each of those procedures is specified as a single process, yet the interactions among procedures constitute a top-level process. We argue that in order to identify and solve problems that might exist in the end-to-end process, an integrated view is needed.

Process Mining (PM) methods are used for discovering actual business processes from the event logs of the systems that support and manage them[1]. In addition, PM allows extended process analysis regarding diverse issues, like performance bottlenecks and organization flow [2]. However, PM considers a single event log, while often, different process procedures use different systems and thus have separate logs. To establish a full analysis, process mining should use a log containing all relevant activities of the end-to-end flow. This can only be obtained after identifying relationships between logs corresponding to same process.

To illustrate, consider the following example. An employee enrollment process includes a step of requesting access permissions for him according to his role requirements. The permission requests are handled by a request approval process, which is triggered when a request is entered, progresses according to defined approval procedures, and ends when the request is either approved or denied. Following this, the enrollment process can proceed. For various reasons, these two processes are separately managed by two different (interacting) information systems. To analyze and improve the end-to-end process, an integrated process model is needed. Note that in many cases the integrated process might be composed of several different procedures, each calling and triggering the other.

OBJECTIVES

Our aim is to obtain an integrated view and analysis of processes that comprise several separately managed procedures, using process mining techniques. This raises several challenges and difficulties. Consider the above discussed enrollment process, and assume we have separate logs for employee enrollment and for permission requests handling. To enable mining the end-to-end process (ETEP), the following difficulties should be addressed.

(1) Non-matching case ID's in different event logs. In our example, each procedure has its own ID numbering. Still, some information items in the two logs contain shared values, such as user, timestamp, and other properties, albeit these do not necessarily establish a conclusive match between log entries.

(2) Have many-to-many relationships (see Figure 1). For example, an employee might require permission to several different systems, thus one employee enrollment process would result in several approval procedures. Furthermore, all the required permissions can be requested in one form, triggering a procedure which is then split into several approvals. Moreover, each approval can end independently of the others (i. e., they do not synchronize before returning to the enrollment process). The challenge is to (a) define an appropriate granularity level for the ETEP, (b) identify and collect all relevant instances of each procedure into one case of the ETEP.

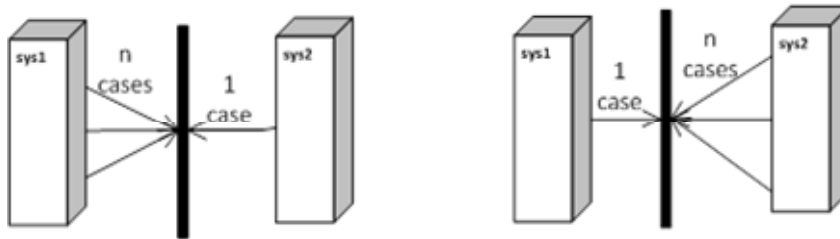


Figure 1: many-to-many relationships among procedures

(3) Use different terminologies and formats (e.g., SQL, XML, free-text properties). These gaps need to be addressed during pre-processing, possibly using existing tools[4][6].

Note that a similar problem has been addressed by [5], where a method for integrating logs of different systems has been proposed. However, the problem addressed there assumes the same ID used by all systems, and at most one-to-many relationships among cases. Hence, it does not meet the above discussed challenges.

METHOD

Our method, aimed at analyzing and improving the ETEP, includes the following three main phases.

(1) Pre-processing of event logs for integration purposes, to obtain unified logs that contain all the events related to the same ETEP. These logs can then be mined and yield a model of the ETEP. For analysis purposes, the model will be represented as a Petri nets. This phase needs to overcome all the above mentioned challenges.

(2) Applying Petri nets verification techniques to the generated ETEP model extracted from the unified logs. Using the mined model, we will be able to apply verification methods (e.g. for soundness[3]) and discover deadlocks and live locks, for improvements purposes.

(3) Using simulation methods in order to identify performance problems and achieve further process improvement. The scope of simulation will address all issues within process life cycle up to organizational impacts.

We will go into detail regarding the pre-processing phase, which is currently at a final stage of development. It includes five main steps.

1. Acquire domain knowledge by interviewing the key people involved. As a result, an initial model of the ETEP is created, and sub-processes that correspond to separately managed procedures are identified. In addition, the relevant logs are identified and studied.
2. Each log is mined separately to obtain a model of the procedure it reflects. The models are analyzed to identify possible interfacing points between them based on the ETEP model.
3. Characterize the relationships between the procedures, namely, whether they are one-to-one, one-to-many, or many-to-many. Establish a mapping between information objects that can potentially represent the same entity or property.
4. Define criteria for identifying matching logs related to the same ETEP. This can be done using schema matching techniques [4][6].
5. Integrate the logs using the defined criteria. The resulting log reflects the ETEP and can then be mined using appropriate process mining techniques.

RESULTS

We are currently working with real-life processes in an international company, attempting to accomplish pre-processing and integration of event logs related to various processes that use a permission request handling procedure. We demonstrate the above discussed five steps using a detailed example taken from the real logs.

Step 1: Gaining initial understanding of the domain and identifying relevant logs.

We currently study a permission handling procedure which can be triggered by different processes. The procedure opens a "ticket" (request), assigns it to a resource, which triggers another procedure where permissions are given. Once the second procedure completes, the request is closed. Examples of the relevant logs are given in Figures 2 and 3.

KeyId	Date	Resource	Activity	Category
184065	7/25/2012 15:11	aerez3	Opened ticket	unix groups permissions
184065	7/25/2012 17:22	Tsela	Assigned	unix groups permissions
184065	7/25/2012 17:22	Tsela	Closed ticket	unix groups permissions

Hey,
The students got their unix permissions.
Need to open the following groups for them:
mpgall mpgdsgn gsrall sklall gsr_rtl skl_rtl cpu1270 cpu1272_upf
For users: aluz hsreter
Thanks
amit

Figure 2: Example part of the access permission request event log, including mandatory fields and accompanying textual request.

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin
Academic Center, Emek Hefer, Israel

```
=====
Status: COMPLETED RequestID: 8a08b7fa-7731-4b2c-8a88-89cdb744308a
Approval requested: 2012-07-25T17:14:40
Approval request submitted by: ger\tsela
Approval request submitted for account: ger\aluz
Approval request submitted for group: amr\ec amr unix sklall
Approval stamps:
    Approver: ger\tsela
    Approved: true
=====
Status: COMPLETED RequestID: 36c99a89-ab11-4d2b-b290-693f4f7ca547
Approval requested: 2012-07-25T17:16:37
Approval request submitted by: ger\tsela
Approval request submitted for account: ger\aluz
Approval request submitted for group: ger\ec ger unix iil gsrall_dbadmin
Approval stamps:
    Approver: ger\tsela
    Approved: true
=====
Status: COMPLETED RequestID: a0f245b7-6731-4e95-b16d-2f7679a2fc1f
Approval requested: 2012-07-25T17:20:56
Approval request submitted by: ger\tsela
Approval request submitted for account: ger\aluz
Approval request submitted for group: amr\ec amr skl cpul272 upf
Approval stamps:
    Approver: ger\tsela
    Approved: true
=====
```

Figure 3: Example part of the event log containing approval status in textual format.

Note that the log of the approval procedure (Figure 3) includes only completion report for each request, while the approval steps are either not logged anywhere or included in another log that should be identified for a full representation of the ETEP.

Step 2: Mining each log separately. In our example, since the second log includes only one entry for each case, we only mined the "main" procedure (procedure 1 – see Figure 4). The mined model includes a gap (as compared to the process learnt from the interviews) – requests are opened and then assigned and closed, without any action in between. It is hence clear that information from the other log should fill this gap and its events should take place between opening a request and closing it.

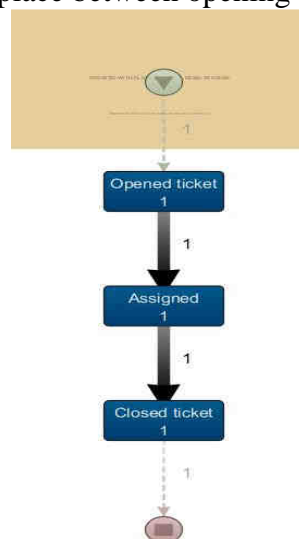


Figure 4: Mining results of procedure1

Step 3: The relationship between the procedures is revealed to be many-to-many.

The specific example includes three cases of the second procedure triggered by one case of the first one.

Step 4: Based on domain knowledge (e.g. team member interviews) and text mining techniques, the criteria identified for matching cases include (a) proximity of *timestamp*, (b) *user* (log 1) = *submitted for account* (log 2), and (c) *groups to open* (log 1) overlap *submitted for group* (log 2). Note that (b) and (c) rely on the textual request attached to log 1 and not to structured data (marked yellow in both logs).

Step 5: The integrated log is given in Figure 5, and the resulting mined process model is illustrated in Figure 6.

Unify KeyId	Date	Resource	Activity	Category
184065A	7/25/2012 15:11	aerez3	Opened ticket	unix groups permissions
184065A	7/25/2012 17:20	tsela	COMPLETED	ec amr skl cpu1272 upf
184065A	7/25/2012 17:16	tsela	COMPLETED	ec ger unix iil gsrall_dbadmin
184065A	7/25/2012 17:14	tsela	COMPLETED	ec amr unix sklall
184065A	7/25/2012 17:22	tsela	Assigned	unix groups permissions
184065A	7/25/2012 17:22	tsela	Closed ticket	unix groups permissions

Figure 5: Integrated log

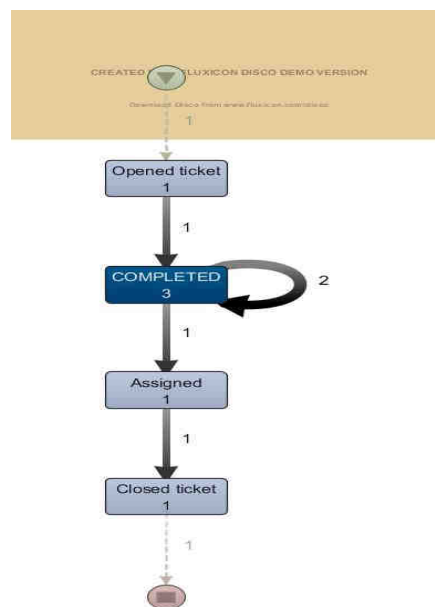


Figure 6: Process mining results of the unified log

CONCLUSIONS

Process mining techniques, which are useful for discovery and analysis of actual processes, are not capable of addressing processes that include separately managed procedures with separate logs. In this paper, we attempt to discover an end-to-end

process in such situation. We present the challenges faced and propose a method for integrating the logs so an ETEP model can be mined. The method is illustrated by an example taken from a real log. Currently, the preprocessing algorithm is being implemented and we intend to apply the method to real logs and evaluate the results in terms of procedures and recall. Next, we will extend the method to support further analysis and improvement of the ETEP.

REFERENCES

- [1] W.M.P. van der Aalst. *Process Mining: Discovery, Conformance and Enhancement of Business Processes*. Springer-Verlag, Berlin, 2011.
- [2] W.M.P. van der Aalst, et al.: *Process mining manifesto*. In: Business Process Management Workshops (1), pp. 169–194 , 2011.
- [3] W.M.P. van der Aalst, K.M. van Hee, A.H.M. ter Hofstede, N. Sidorova, H.M.W. Verbeek, M. Voorhoeve, and M.T. Wynn. *Soundness of Workflow Nets: Classification, Decidability, and Analysis*. BPM Center Report BPM-08-02, BPMcenter.org,2008.
- [4] Bellahsene Zohara, Bonifati Angela, Rahm Erhard (eds), *Schema Matching and Mapping*, Springer 2011.
- [5] Claes Jan, Poels Geert. *Integrating Computer Log Files for Process Mining: a Genetic Algorithm Inspired Technique*. Advanced Information System Engineering Workshops, Lecture Notes in Business Information Processing. Volume 83, 2011, pp 282-293.
- [6] Rahm Erhard and A. Bernstein Philips. *A survey of approaches to automatic schema matching*. Very Large Database J.,10(4):334–350, 2001.

MODEL-BASED DOCUMENTS AUTHORIZING WITH OBJECT-PROCESS METHODOLOGY (OPM)

Alex Blekhman

Technion, Israel Institute of Technology
Haifa 32000, Israel
blekhman@tx.technion.ac.il

Dov Dori

Technion, Israel Institute of Technology
Haifa 32000, Israel
Massachusetts Institute of Technology,
Cambridge, Massachusetts, USA
dori@ie.technion.ac.il

Keywords: conceptual modeling, specifications, systems engineering, OPM.

INTRODUCTION

Technical documents in general and standards in particular aim to convey structured, exact, and supposedly well-defined information. Currently, these documents are built with no comprehensive base reference with which to measure the coherence of technical statements they convey. The lack of an underlying analytical process that would accompany the creation and maintenance of technical documents also limits the practical length and complexity of a comprehensible document.

Although scientific, technical, and industrial specifications are regularly expressed in free text, they commonly describe an underlying scheme, be it a block diagram, a flow chart, a state machine, or some informal, ad-hoc schema. In many cases, this hidden structure bears the true value of sometimes wordy and confusing specifications.

OBJECTIVES

We wish to uncover, rely on, and work with the actual scheme underlying the technical document text, rather than interpret the free text with its accompanying disparate figures and mostly informal diagrams. The combination of underlying model and text that relies on that model allows for the document content to be presented in an unequivocal manner, providing an analytical representation of the authors' intent.

The model can serve as a solid, consistent and unambiguous basis for analyzing the system, comparing it to models of other systems, and even generate code for the relevant software-intensive portions of the system. Specifically, Model-Based Documents Authoring with OPM is a process that is aimed at the significant reduction of internal and external inconsistencies in technical documents through the introduction of graphical model presentation that is concurrent with the textual content. This model provides the necessary reference for the authoring and managing of consistent specifications, still leaving text as the main modality.

A simple example of text-underlying model is given in Figure 5. There, a text paragraph that describes a Welding process is shown next to OPM model that conveys the exact same semantics of the text. Moreover, text and model are managed concurrently in Model-Based Authoring of Specifications Environment (MBASE – see Figure 6), so that changing the model triggers an automatic change of text and vice versa.

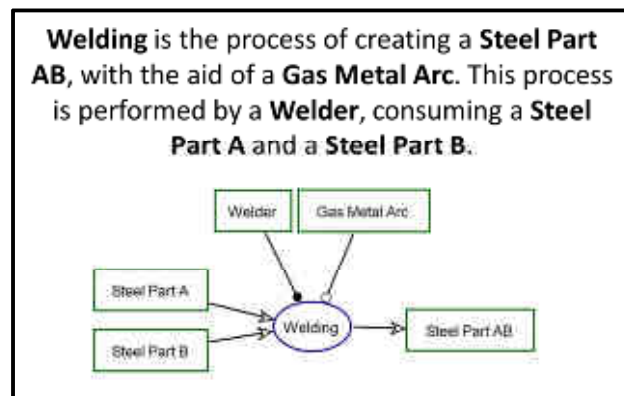


Figure 5: A model that underlies the text: text (top), OPM model (bottom)

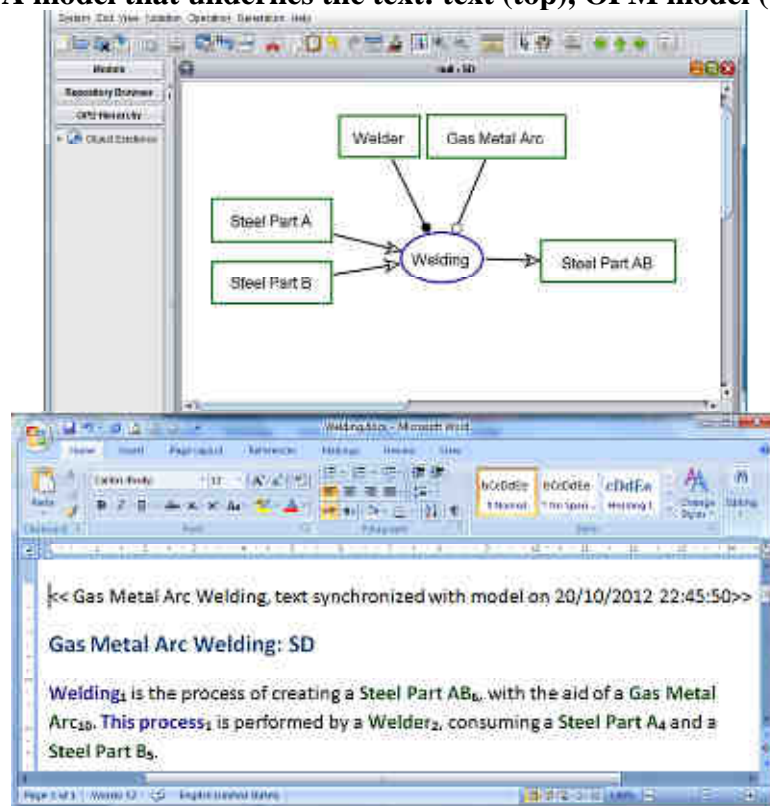


Figure 6: Model-Based Authoring of Specifications Environment (MBASE)

METHOD

The main use of Model-Based Documents Authoring with OPM is creating consistent and well-structured specifications either from scratch or by analyzing existing material. Typical course of work includes the following steps:

1. Create an OPM model of technical content, either new or based on existing specification.
2. Using MBASE, automatically generate text skeleton, based on the model.
3. (Manually) adjust text skeleton and form a structured specification. MBASE tracks changes and assures that text remains consistent with the model at all times.
4. If applicable, replace existing free-text specification with structured specification above and its corresponding OPM model.

RESULTS

The research was initially inspired by International Organization for Standardization (ISO). ISO standards, as well as those of other standards organizations, are often criticized as being difficult to use for a variety of reasons, including inter- and intra-standard inconsistency, low accessibility, poor traceability, and ambiguity. ISO TC184/SC5 started an activity on exploring the usefulness of Object Process Methodology (OPM) for creating, designing, analyzing, and simulating models of standards to improve their development, communication and understanding.

A group of 27 experts from 12 countries, who had expressed interest in participating in this activity, took part in online sessions and electronic exchange of documents and models over a period of more than two years. During the work under ISO TC184/SC5 auspices, Model-Based Documents Authoring with OPM methodology was developed and applied to several manufacturing, control and enterprise standards, including IEC 62264, ISO 19440, and ISO/IEC 15416 (see for example Figure 7).

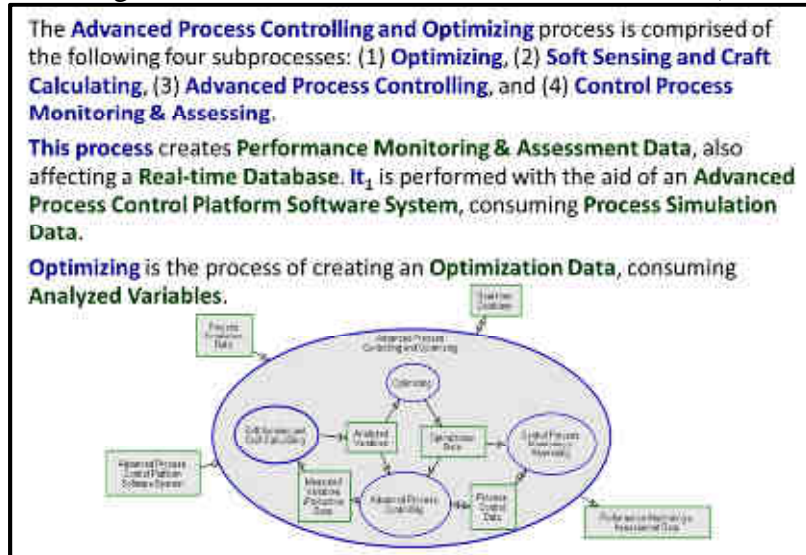


Figure 7: ISO/IEC 15416-1 analysis

Analyzing existing standards with this methodology has exposed inconsistencies, mismatches, missing and confusing definitions, and contradictions between figures and text. Some of the documents examined were approved technical standards that are in current use, emphasizing the importance of streamlining technical specifications in a consistent, standard manner.

Based on experience gathered from the work indicated above, the following conclusions were agreed upon and submitted to ISO TC184/SC5 plenary:

1. OPM offers a modeling methodology that can be applied to a wide variety of ISO TC184/SC5 and other ISO and IEC standards.
2. OPM advocates top-down refinement beginning at the System Diagram and aligns well with the way standards are structured beginning with a statement of scope.
3. OPM models of specific clauses assist in identifying inconsistencies within or between standards.
4. Using a modeling language in general and OPM in particular significantly improves the quality and the value of standards.

The following limitations of the proposed method were reported:

1. Learning OPM is not difficult: there is a minimal set of concepts and just one type of diagram that integrates function, structure, and behavior. However, the power of the set of simple concepts means using them well in a wide variety of situations, and this is not a trivial task.
2. While OPM models of specific clauses may assist in identifying inconsistencies within or between standards, there seems to be little benefit from the extraordinary amount of effort required to produce OPM models for the entire standard.
3. Domain expertise is critical to the preparation of a satisfactory OPM model.
4. Domain-specific ontology and practice are implied qualities of a standard that cannot always be overcome without extensive revision.

CONCLUSION

The evaluation of Model-Based Documents Authoring with OPM in the area of enterprise standards has demonstrated the value of this methodology as an aid for authoring technical specifications that are more consistent and more complete than those produced by a traditional text-centered approach.

Limitations of the proposed method include the extensive amount of work required for using existing tools in a realistic scenario and the need for domain-specific support.

Following these identified issues, we plan to continue the work at both the conceptual and the technical levels. In parallel, together with ISO TC184/SC5-WG1 we have been developing OPM as an ISO Publicly Available Specification (PAS), which is in its finalizing stages and the ISO Draft International Standard for Model-Based Documents Authoring with OPM.

VARIABILITY MODELING IN BUSINESS PROCESSES: EXISTING SUPPORT AND DEFICIENCIES

Inbal Mechrez

Information Systems Department,
University of Haifa, Haifa 31905, Israel
inbalma@gmail.com

Iris Reinhartz-Berger

Information Systems Department,
University of Haifa, Haifa 31905, Israel
iris@is.haifa.ac.il

Keywords: Process Modeling, Business Processes, Variability Modeling, Design
Time Variability, Configuration

INTRODUCTION

A *business process* is a set of activities performed by a business, initiated by an event, transforms information, materials, or business commitments, and produces an output. Business processes have drawn much attention over the years. They affect organization's performance, cost, and customer's satisfaction and are considered one of the key concepts to successful businesses. A common way to represent a business process is through a *business process model* which expresses the relationships and restrictions of the activities of the process [2], [13]. Different graphical languages have been proposed for specifying business process models, e.g., EPC, UML Activity Diagrams, Petri nets, and BPMN.

A single organization may handle many business processes which are not necessarily far apart from each other; they may be variants which are commonly considered as specializations of "abstract" business use cases [11]. Sometimes the existence of such variants indicates on a high variance in the business processes and thus on a low standardization in the organization. However, in many cases the variants are utilized by different organizational units or are used for developing different components or information systems. Thus it is important to be able to manage families of business processes, and not just individual business processes, effectively and efficiently. For this purpose, languages for specifying the commonality that exists and the variability that is perceived among business processes that belong to the same family are required. Indeed, in the last decade, several studies have been done for incorporating support for modeling variability in existing business process modeling languages, e.g., [3, 8, 9, 10, 11]. These languages actually extend existing business process modeling languages, most notably BPMN and EPC, with variability aids or suggest orthogonal variability models. However, the evaluation of these languages is still in an inceptive stage.

In this work, we investigate the support for variability management in existing business process modeling languages. As this support is important for evaluating and comparing the expressiveness of languages (and potentially for choosing the most appropriate one to a task at hand), we examine whether existing languages supply

enough support to model variability in business processes. In particular, we examine the existing support in four commonly studied perspectives of business processes [1, 6, 12]: (1) the *functional perspective* which represents what process elements are being performed; (2) the *behavioral perspective* which represents when activities are performed and how they are performed; (3) the *organizational perspective* which describes the organization structure and, in particular, its agents (participants) and in which way they are involved in the business process; and (4) the *informational perspective* which represents the information and data produced or manipulated by a business process and their interrelationships. We further aim to conclude the variability of which perspectives (and constituent elements) is not sufficiently supported in existing extensions of business modeling languages.

METHODOLOGY

We searched for graphical business process modeling languages that explicitly refer to variability or configuration at design time. We excluded languages that do not extend existing business process modeling languages but rather introduce new proprietary languages. We also excluded studies that were published before 2005, in order to focus on recent studies. We resulted with 22 languages²: 7 languages extend BPMN, 6 – EPC, 2 – YAWL, 2 – UML Activity Diagrams, 1 – UML State machines, 1 – EWF-nets, 1 – Petri-nets, 1 – goal models, and 1 – SAP WebFlow. Most of the languages (20 out of 22) extend the base notation and introduce a single (unique) model that captures both commonality and variability. This kind of languages is commonly called *annotation-based* as variability is annotated on the base model. A few languages distinguish and keep the base model separate from the variability model. This kind of languages is termed *composition* as it proposes ways to combine or compose the two separately handled models, the base and the variability models, in the form of, e.g., a resolution model [7].

For each language, we further examined the variability of which perspectives and process elements can be modeled.

RESULT & CONCLUSIONS

Reviewing the 22 languages, we found that the most handled perspectives are the functional and the behavioral ones that refer to what elements are performed and how they are performed, respectively. These aspects are the most prominent ones in standard (“regular”) business process modeling languages and here we see that they remain prominent when dealing with families of business processes and business process variability. Variability modeling in the informational perspective is supported to some extent, mainly in the context of data-related elements, such as data storage,

² An extended version of the review and comparison is available at <http://mis.hevra.haifa.ac.il/~iris/BPvar.pdf>.

resources, objects, inputs, and outputs. Variability of events, which also belong to the informational perspective, is almost completely neglected. A possible reason for this may be that events, as opposed to functional and behavioral units and data-related elements, are considered external and independent of the organization (i.e., often the organization cannot directly affect the events of its business processes). Thus, each event is differently handled and variability of events is not commonly modeled. Lastly, variability modeling in the organizational perspective is almost completely neglected. The reason for this may be that the reviewed studies selected to extend languages that do not focus on the organizational perspective, such as EPC and BPMN, and did not adopted more holistic methods, such as ARIS [12].

We further found that all the examined languages support variability within the same kind of elements, e.g., variability in functions. They completely neglect variability that may occur between different element kinds. For example, hiring an employee may be a complicated function in a certain organization, justifying its representation by a compound process that includes sub-processes (for getting the initial information about the candidate, interviewing him/her by different roles in the organization, sending him/her to external exams, and so on). The same process may be very simple in a small organization, requiring only manager's impression and justifying its representation as an atomic task. Moreover, we can find cases in which variability goes beyond the perspectives' boundaries. As an example, consider the same function of hiring employees. In one organization, this function is internal, calling for its representing in the functional perspective, as a compound process or an atomic task, depending on the function complexity. A different organization may use an external agency for hiring employees. In this case, one may consider representing the function of hiring employees as an (external) event that may cause the activation of different functional units when occur (i.e., when the agency finds the appropriate employee to hire). As noted, this kind of variability is not supported by any of the reviewed languages.

SUMMARY & FUTURE DIRECTIONS

Analyzing variability of business processes is important within an organization and between organizations that seek for cooperation or interoperability. The main way to represent the outcome of such analysis is through variability models. Several modeling languages have been suggested for modeling variability in business processes. These languages commonly extend existing business process modeling languages or suggest an additional orthogonal variability model. We examined the expressiveness of these languages taking into consideration four commonly discussed perspectives, namely functional, behavioral, organizational, and informational perspectives. We pointed on the deficiencies we found with respect to neglected perspectives, neglected elements, and missing support for combinations. In the future, we plan to provide concrete suggestions for improving the expressiveness of

variability modeling languages in business process modeling and overcoming the aforementioned deficiencies. We further plan to empirically evaluate the influence of these suggestions on the usability of different extensions of visual business process languages that support variability modeling.

REFERENCES

1. Curtis, B., Kellner, M., & Over, J. (1992): Process Modeling. *Communication of the ACM* 35 (9), 75-90.
2. De Bruin, T., & Rosemann, M. (2007): Using the Delphi Technique to Identify BPM Capability Areas. *The 18th Australasian Conference on Information Systems*, 642-653.
3. Hallerbach, A., Bauer, T., & Reichert, M. (2010): Capturing variability in business process models: The Provop approach. *Journal of Software Maintenance and Evolution: Research and Practice* 22 (6/7), 519-546.
4. Lapouchnian, A., Yu, Y., & Mylopoulos, J. (2007): Requirements-driven design and configuration management of business processes. *Business Process Management conference (BPM'2007)*. LNCS 4714, 246-261.
5. Liaskon, S., Lapouchnian, A., Yu, Y., Yu, E., & Mylopoulos, J. (2006): On Goal-based Variability Acquisition and Analysis. *The 14th IEEE International Conference Requirements Engineering (RE'2006)*, 92-96.
6. List, B., & Korherr, B. (2006): An Evaluation of Conceptual Business Process Modelling Languages. *The 21st ACM Symposium on Applied Computing (SAC'06)*, 1532-1539.
7. Machado, I., Bonifácio, R., Alves, V., Turnes, L., & Machado, G. (2011): Managing variability in business processes: an aspect-oriented approach. *The 2011 international workshop on Early Aspects, ACM*, 25-30.
8. Puhlmann, F., Schnieders, A., Weiland, J., & Weske, M. (2005): Variability Mechanisms for Process Models. *PESOA-Report TR 17/2005, Process Family Engineering in Service-Oriented Applications (PESOA)*.
9. Reinhartz-Berger, I., Soffer, P., & Sturm, A. (2009): Organizational reference models: supporting an adequate design of local business processes. *International Journal of Business Process Integration and Management* 4(2), 134-149.
10. Reinhartz-Berger, I., Soffer, P., & Sturm, A. (2010): Extending the adaptability of reference models. *IEEE Transactions on Systems, Man, and Cybernetics, Part A* 40(5), 1045-1056.
11. Rosemann, M., & Van der Aalst, W. (2007): A Configurable Reference Modelling Language. *Information Systems* 32 (1), 1-23.
12. Scheer, A.W. 2000. ARIS – Business Process Modeling. *Springer, 3rd edition*.
13. Thomas, O., & Fellmann, M. (2007): Semantic EPC: Enhancing process modeling using ontology languages. *Semantic Business Process and Product Lifecycle Management (SBPM) workshop*, 64-75.

CHARACTERISTICS RELATED TO ACCESSING HEALTH IT

Ofir Ben-Assuli

Ono Academic College,
Israel

ofir.benassuli@gmail.com

Itamar Shabtai

College of Management
Academic Studies, Israel

itamar@colman.ac.il

Moshe Leshno

Tel-Aviv University, Israel

leshnom@post.tau.ac.il

Keywords: electronic health record (EHR), health information technology (HIT), Health information exchange (HIE)

INTRODUCTION

Implementing health information systems is a complex issue (Heeks, 2006; Kaplan and Harris-Salamone, 2009). There have been both successful (Ben-Assuli et al. 2012; The NYT, 2009) and unsuccessful implementations of medical information systems (IS) worldwide (Anderson et al. 2006; Øvretveit et al. 2007). Previous research has identified the main factors in the adoption of health information technology (HIT) (Mantzana et al. 2007). This study is aimed at understanding the factors which influence physicians to use HIT. Specifically, we explored which characteristics cause physicians to view historical medical information provided by electronic health record (EHR) systems in emergency departments (ED).

OBJECTIVES

This study seeks to acquire a deeper understanding about the characteristics that affect physicians to use HIT in EDs as a tool that supports their clinical decisions. The study focuses on EHR systems as an important source of medical history. These factors might have importance in guiding physicians and policy-makers on how to facilitate successful future assimilation of HIT. This study targeted one of the main health maintenance organization (HMO) in Israel. The HMO deployed an EHR system. The system gathers historical patient data from the other healthcare information systems at the HMO's hospitals and community clinics.

METHOD

Log-files were retrieved from the HMO for ED referrals. The following variables were derived from these files: The independent variables were health insurance provider (HMO vs. other), Type of ED, Hospital, Admission decision (1= admit; 0=discharge), Differential diagnosis (CP=chest pain, AP= abdominal pain, GE=gastroenteritis, UTI=urinary tract infection, PO=pneumonia organism) and patient demographics. The dependent variable was the usage of EHR system to view medical history (1= EHR viewed; 0= not viewed).

RESULTS

Descriptive Statistics

Table 1. Characteristics of the study sample

Characteristics	Total Study Sample n=209,434	EHR Was Not Used n=108,087 (51.6%)	EHR Was Used n=101,347 (48.4%)
Age (years)	52.16±25.5	49.26±26	55.24±24.5
Gender (% Male)	99,930 (47.7%)	51,023 (47.2%)	48,907 (48.3%)
Insurance (% main HMO)	161,680 (77.2%)	80,771 (74.7%)	80,909 (79.8%)
Admissions (%)	88,689 (42.3%)	45,438 (42%)	43,251 (42.7%)
Admission Period (days)	5.1±6.8	4.66±6.07	5.56±7.4

Data are mean (±SD) or number of subjects (proportion)

The percentages of EHR usage, in terms of patient characteristics, were calculated. Table 1 shows that in 48.4% of all referrals, patients' historical information was viewed via the EHR. We chose a subset of patients from several main diagnoses, in which EHR usage would probably be greater than the average EHR usage.

The Outcomes of the Regressions

The logistic regression included several blocks of variables as made in previous research (Ben-Assuli et al. 2013). These were the blocks: Main variables (age, gender, insurance provider, admission status and main differential diagnoses (DDs)), Control variables for type of department and for different hospitals (These two blocks are not shown here, but were included in these regressions).

Table 2. Logistic regression on the decision to use EHR

Characteristics	B	S.E.	Odds Ratio	95% Confidence Interval	
			OR	Lower	Upper
Gender	0.025	0.011	1.025 *	1.004	1.047
Age	0.010	0.000	1.010 ***	1.010	1.011
insurance	0.068	0.013	1.070***	1.043	1.097
Is Admitted	0.088	0.011	1.092 ***	1.069	1.116
CP	-0.234	0.020	0.791 ***	0.761	0.822
AP	0.089	0.023	1.093 ***	1.045	1.144
GE	-0.263	0.038	0.769 ***	0.713	0.829
UTI	0.002	0.040	0.998	0.922	1.080
PO	-0.166	0.044	0.847 ***	0.777	0.924
Constant	-0.818	0.234	0.441***		

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$; (CP=chest pain, AP= abdominal pain, GE=gastroenteritis, UTI=urinary tract infection, PO=pneumonia organism); Goodness of Fit: -2 Log likelihood= -2.2Mega, Nagelkerke R-Square=0.4

Table 2 reveals that AP and Previous admissions have the highest positive association with accessing the EHR. When the patient complains about abdominal pain the rate of EHR usage increases by 9.3% (OR=1.093). When the patient is currently admitted, the rate of EHR usage increases by 9.2% compared to discharged patients, after controlling for several characteristics of the patients' data. Out of all presented DDs, PO, CP and GE had a negative association with EHR usage (-84.7%, -7.91%, -7.69%). Moreover, the probability of using the EHR increased by 1% for every additional year of age. This may be the result of deteriorated medical conditions typically associated with increased age.

Additionally, when the insured patients were members of the main HMO, the rate of using the EHR increased by 6.8%. The increased rate of using the EHR for the main HMO members suggests that the additional patient data available for the main HMO members may increase admission decision certainty and thus improve efficiency, enabling more confidence in the dismissal decision. Finally, for male patients, the rate of using the EHR increased by 2.5% compared to female patients.

In sum, the results show that viewing the EHR system was associated positively with AP, admitted, insurance, gender and age. At the same time, it was associated negatively with PO, CP (internal DDs) and GE.

CONCLUSIONS

Experts consider HIT as a key to improving the efficiency and quality of healthcare (Chaudhry et al. 2006). One of the major critical factors in the assimilation process of a new technology in a healthcare setting, is to understand when physicians are more likely to view EHR data, probably when it is essential to improving healthcare outcomes.

This study contributed to a better understanding of the characteristics that are related to accessing HIT by investigating what affects the use of EHR systems in EDs. The EHR usage rate was higher for male patients, for older age patients, for insured patients by the main HMO and for patients whose DDs were of a more internal nature. These findings suggest that attention should be paid to those factors (such as patient medical status and patient demography) that may hinder or ease the EHR implementation process.

REFERENCES

- Anderson G.F., Frogner B. K., Johns R. A. and Reinhardt U. E. (2006). Health Care Spending and Use of Information Technology in OECD Countries. *Health Affairs (Millwood)*, 25, 819-831.
- Ben-Assuli O., Leshno M., and Shabtai I. (2012). Using Electronic Medical Record Systems for Admission Decisions in Emergency Departments: Examining the Crowdedness Effect. *Journal of Medical Systems*, 36 (6), 3795-3803.
- Ben-Assuli, O., Shabtai, I., and Leshno, M. (2013). The Impact of EHR and HIE on Reducing Avoidable Admissions: Controlling Main Differential Diagnoses", *BMC Medical Informatics and Decision Making*, 13 (49).

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

- Chaudhry B., Wang J., Wu S., Maglione M., Mojica W., Roth E., Morton S. C. and Shekelle P. G. (2006). Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care. *Annals of Internal Medicine*, 144 (10), 742-752.
- Heeks R. (2006). Health information systems: failure, success and improvisation. *Int J Med Inform*, 75(2), 125-137.
- Kaplan B. and Harris-Salamone K. D. (2009). Health IT success and failure: recommendations from literature and an AMIA workshop. *J Am Med Inform Assoc*, 16(3), 291-299.
- Mantzana V., Themistocleous M., Irani Z. and Morabito V. (2007). Identifying Healthcare Actors Involved in the Adoption of Information Systems. *European Journal of Information System*, 16(1), 91-102.
- Øvretveit J., Scott T., Rundall T. G., Shortell S.M. and Brommels M. (2007). Improving Quality Through Effective Implementation of Information Technology in Healthcare. *International Journal for Quality in Health Care*, 19 (5), 259-266.
- The New York Times. http://www.nytimes.com/2009/11/08/magazine/08Healthcare-t.html?_r=2&hp. Retrieved 2012-07-27

THE SOCIETAL EFFECT OF HEALTH WEBSITES AFFORDANCES: IS IT A UTOPIAN LENS OF EXPLORATION?

Esther Brainin, PhD
Ruppin Academic Center
estherb@ruppin.ac.il

Efrat Neter, PhD
Ruppin Academic Center
netter@ruppin.ac.il

Keywords: health websites, eHealth Literacy, technology affordances, webmasters, usability

INTRODUCTION

The assertion that the Internet has the potential to inform and empower patients to become active participants in their treatment disregards the fact that a representation of the users is built in to the system of health websites, as these presuppose certain cultural and eHealth literacy abilities. To prevent the intrinsic representation of the user, webmasters and content managers must acknowledge the diverse human and artifactual elements that typically have to be configured for a technology affordance to emerge. Gibson (1979) coined the term ‘affordance of an object’, as a perceivable property that allows a particular individual the opportunity for action. Engstrom (1990) further suggested that we must ask not only what a given affordance of a technology is, but for whom it is intended and in what contexts it should be applied, since each user’s set of circumstances presents a diversity of particulars that bring forth (or fail to bring forth) a corresponding variety of sociomaterial arrangements necessary to use the technology. Thus, the affordances of technological objects cannot be easily separated from the arrangements through which they are realized in practice (Bloomfield, Latham & Yurdubakis, 2010). As a consequence, we could argue that for a technology affordance to emerge (thus allowing or forbidding from the actors a course of action), the diverse human and artifactual elements of potential users have to be configured in advance.

The objectives of our study were: to map, on the one hand, the “for whom health websites are intended..” – the health websites users’ characteristics and needs, and on the other hand, to find out whether the “diverse human and artifactual elements” are considered by those who are in charge of determining the affordances of these websites and thus, are responsible for the arrangements through which diverse human and artifactual elements are realized in practice.

METHOD

In order to portray the health websites users’ characteristics and needs and Internet use for health purposes patterns, data was collected on May 2008 from a nationally representative random-digital-dial (RDD) telephone household survey of Israeli adult population (eighteen and older). Calls were placed to 4286 residential households to identify 2201 eligible potential respondents who use the Internet. Of these respondents, 1289 used the Internet for health purposes. Our survey included questions related to the following topics: *Health information content* on the Internet was examined by asking: “How often do you search the Internet for information

related to a list of eight domains and actions linked to health information (seeking information about: physicians, institutions that provides health services, potential treatments, and social support). A five point response scale was used (Several times a week – Never) ($\alpha = 0.80$). *Perceived eHealth Literacy* was examined using Norman and Skinner (2006) Scale. Respondents were asked to check the answer that best reflects their attitudes and experiences right now (“ I know where to find helpful health resources on the Internet, I know how to find helpful health resources on the Internet, I know how to use the Internet to answer my questions about health, I know how to use the health information I find on the Internet to help me, I have the skills I need to evaluate the health resources I find on the Internet, I can tell high quality health resources from low quality health resources on the Internet, I feel confident in using information from the Internet to make health decisions”). A five point response scale was used (Strongly agree – Disagree) ($\alpha = 0.86$). *Digital literacy* was tapped by asking for the frequency of engaging in six activities (visit blogs, participating in discussion forums, playing games, downloading or listening to music, downloading software, emailing with friends) ($\alpha = 0.75$). *Search strategies* employed to obtain digital health information was examined by asking: “In order to find health information on the Internet you usually do the following...” A list of five common search actions was presented (use a site that my physician recommended, follow links that appears on websites, ask questions in forums, use my "favorites" list, use a site that a friend recommended). A five point frequency response scale was used (Always – Never) ($\alpha = 0.64$). Finally, *Perceived Outcomes* of seeking health information on the Internet were examined by asking: “Do you agree or disagree that seeking health information on the Internet ...” A list of nine outcomes, adapted from Baker, Wagner, Singer, & Bundorf (2003) were presented (improved your ability to manage your health needs; enabled you to ask your physician questions resulting from the information you acquired on the Internet, enabled you to show your physician the information that you retrieved, raised your sense of power in your encounter with the physician, improved your understanding of the symptoms, conditions or treatments in which you were interested, updated your knowledge in health innovations, led you to take independent steps, enabled you to think about alternative treatment options, made you more aware of patients’ insurance rights). A five point response scale was used (Strongly agree – Disagree) ($\alpha = 0.87$). In addition, we conducted twenty three semi-structured in-depth interviews with different people who were responsible for building and maintaining the sites, managing and making decisions regarding health websites such as HMO and hospitals’ websites, NPO and NCO’s websites (Sample questions included: How are objectives defined? How is content selected? How are end users perceived? Are there criteria for success? How is content supervision conducted?). This data collection process was open and inductive, in order to explore the cultural world of site builders and to use an interpretive understanding of the manner in which they see the task of site building and the site’s users. All interviews were taped, transcribed, and analyzed using the Atlas software for qualitative analysis.

RESULTS

Our findings suggest that despite the increased availability of health information, many potential user populations are effectively excluded, due to low digital literacy

levels: the use of the Internet in the health domain is related to social inequality. The level of eHealth literacy needed in order to make proper use of electronic health resources varies even among those accustomed to dealing with medical information. The literature on informed choice demonstrates (Woolf, Chan, Harris, et al., 2005) that there are many ways of presenting information and choices, and it exhibits genuine efforts and achievements in presenting complex medical information to laypeople. However, our analysis of the interviews with websites policy makers, webmasters and content managers revealed that there were no planned actions for content elicitation or for determining the optimal website structure for a wide range of potential users. Rather, webmasters and content managers relied on their own judgment and on feedback from family members and friends as a standard for determining the quality of content and structure. In other words, their aim was to create website content and structure compatible with their mental images of themselves and of their significant others. Site and content managers seemed to have no knowledge about relevant segmentation of users according to characteristics, even in organizations that provide face-to-face health services. None of the interviewees mentioned carrying out activities, either in regard to design or content preferences, addressing their users' possible low digital literacy. Although interviewees described user comfort as the guiding principle in website content organization, none of them portrayed a process through which potential users were surveyed about content organization. None of the webmasters of these sites conducted preliminary activities in an attempt to include user input (e.g., focus groups, representative informants) in determining the content or its comprehensibility.

CONCLUSIONS

Uncovering the web masters' approach to their task is important, given that their approach has the potential to affect the technology's affordances, and thus determine the site's usability and flexibility. Ideally, health websites, especially those run by public health organizations, should be inclusive, aimed at extremely wide sections of the population, regardless of the expense involved in understanding and reaching disparate groups. Accordingly, the question arises as to the types of end-users envisioned by the webmasters and content managers who design these sites. More specifically, do these designers perceive websites as a deterministic, almost rigid technological platform or as a flexible one that can be molded in different ways to meet the needs of varied end-user populations?

The self-embodiment or website imprinting process that characterizes the professional conduct of health website content and structure management creates new cleavages rather than new opportunities. At present, using the self-embodiment approach by webmasters and content managers of health websites, excludes large portions of the population from exploiting the services offered on these websites, because some users have low digital literacy, and low eHealth literacy.

FURTHER DISCUSSION

Is it a utopian lens to explore health websites affordances in order to show the urgent need for stakeholders – government, public and private – to work together to set up abiding standards which might yield enhanced adherence to basic professional standards, and to allow varied end-user populations access to the sites and improve

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin
Academic Center, Emek Hefer, Israel

the structure and content on health websites?

REFERENCES

- Baker, L., Wagner, T.H., Singer, S., & Bundorf, M.K. (2003). Use of the Internet and e-mail for health care information: Results from a national survey. *The Journal of The American Medical Association*, 289(18), 2400-2406.
- Bloomfield, B.P., Latham, Y., & Yurdubakis, T. (2010). Bodies, technologies and action possibilities: When is an affordance? *Sociology*, 44(3), 415-433.
- Engestrom, Y. (1990). When is a Tool? Multiple Meanings of Artifacts in Human Activity, in: *Learning, Working and Imagining: Twelve Studies in Activity Theory*, 171–195. Helsinki: Orienta-Konsultit.
- Gibson, J.J. (1979). *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.
- Norman, C.D., & Skinner, H.A. (2006). eHEALTH: the eHealth literacy scale. *Journal of Medical Internet Research*. 8. Available from: <http://www.jmir.org/2006/4/e27/>.
- Woolf, S.H., Chan, E.C.Y., Harris, R., et al. (2005). Promoting informed choice: Transforming health care to dispense knowledge for decision making. *Annals of Internal Medicine*, 143(4), 293-300.

USER PREFERENCES: APPLYING A COST-BENEFIT APPROACH TO HUMAN COMPUTER INTERACTION

Adi Katz

Industrial Engineering and Management Department, SCE

adis@sce.ac.il

Keywords: human-computer interaction, cost-benefit, user evaluations, personas.

INTRODUCTION

This study suggests a framework that analyzes individual preferences towards a system by modeling the cognitive costs and benefits of users' evaluations and tying it to a HCI design methodology of personas.

Cost and benefit considerations play an important role in many areas of our lives. A cost-benefit lens was previously used to explain different phenomena related to how people act in different tasks or contexts (e.g. Weick and Sutcliffe 2001; Majchrzak et al. 2005; Katz and Te'eni, 2007). In this research we present a cost benefit approach to predict users' evaluations and preferences of interactive applications. We follow a previous cost-benefit approach that is applied in the area of systems analysis and design in the stage of selecting the optimal computer system among alternative proposals (Shoval and Lugasi, 1987; 1988). While the original model refers to the costs of purchasing or developing a system for organizations in monetary terms, the current research is concerned with costs in terms of an individual's perceptions of the cognitive resources he needs to consume when using a system, such as effort and time. While the original model refers to the overall benefit of the system to the organization, which is derived from a list of relevant criteria (e.g. quality of the development team, reliability of the hardware, perceived usefulness, improving customer service etc.), the current research is concerned with the benefits that a user predicts he would achieve during or after using a system. The original model deals with business or work organizations goals, but a system must fulfill also personal goals. Our framework expands the original model of cost-benefit considerations and takes a step further from a macro-level (organizational) perspective to one that is micro-level (individual, cognitive).

Indeed, monetary cost is an important factor in choosing among alternative systems, but in this study we are more interested in user considerations that are goal and task oriented. Therefore, we consciously leave financial considerations out of the scope of this study; but of course we cannot ignore the fact that financial constraints can tip the balance and determine which system will be finally selected.

At the heart of costs and benefits consideration lays the phenomenon of instrumental conditioning, which is about acquiring knowledge about the relationship between our acts and their outcomes (Nolen- Hoeksama et al., 2009). Using an application can lead to positive outcomes, such as having a higher level of task performance, succeeding in fulfilling a certain goal, making better decisions, having a pleasant engagement, and so on. However, using an application may lead to less desirable outcomes, such as a high level of cognitive load, feeling frustrated and spending a lot of time and effort on the expense of other tasks. It is reasonable to

expect that users, if given a choice, would prefer applications with high benefits (positive interactions and outcomes) and low costs (less effort and time spent). Since many applications require the devotion of many user resources to reach desirable outcomes, it is most interesting to know how much cost a user would invest to achieve a certain benefit.

In this study, both costs and benefits are measured in subjective terms: a cost that may be perceived high by one individual may be perceived low by another. The same can be said about benefits. Importantly, the current context of use determines his momentary goals and motives; affecting the cost that the user will be willing to invest to achieve them. A well known user centered design (UCD) method in HCI developed by Cooper (1999), is defining *personas* (prototypical users) to understand the needs and the goals of users. Following Miaskiewicz and Kozar (2006) who believe that personas can be used as a tool to measure the design's effectiveness, we integrate personas in the cost-benefit framework to predict user preferences. Using personas reflects a goal-directed design approach, which focuses on the motives (purposes; desired outcomes) behind users actions. While personas are defined by their goals, we take a more holistic view to cover not only goals (the end condition of the system usage), but also the task (the intermediate process necessary to accomplish the goal). We consider user's personal characteristics (traits) that are task relevant, along with his current usage situation (state) such as motives or context, as important factors to affect the cost-benefit comparison process.

When judging technological products in order to choose among them, it is important to create a list of criteria that play a role in the context of the individual user. According to the HCI literature that deals with user experience evaluations, a list of perceived aspects of interactive systems can be assigned to the costs (e.g. perceived complexity, difficulty or effort needed to use the system) and to the benefits considerations (e.g. pleasure to use, expectations to accomplish effective performance, etc.). A partial list of literature to create the list includes Nielsen's famous model of system acceptability (1993), the well known technical acceptance model (TAM) (Venkatesh et al., 2003), and Hassenzahl's model of user experience (2003).

OBJECTIVES

Understanding how users choose among systems is important theoretically and practically. Our theoretical objective is to test whether the 'macro-level' cost-benefit approach for selecting alternative systems can be applied to the 'micro-level' of predicting users' acceptance of alternative interactive applications. Modeling the cost-benefit considerations of user preferences can set a bridge between IS models of system acceptance to HCI models. Specifically, we intend to show that the relation between cost-benefit considerations and the user's traits and state (reflected in personas) can be presented graphically. Practically, we believe that this presentation can improve the prediction of user preferences with respect to certain personal characteristics and motives, and can help designers in defining personas, that properly cover the different needs and goals of different users.

METHOD

The applicability of the cost-benefit framework for analyzing individual preferences

towards a system had not yet been tested empirically, but we intend to test it in the near future. Here we suggest directions for doing so.

We demonstrate our method by presenting three applications dealing with trip routes planning. The applications vary in the levels of cognitive complexity (a cost factor) and utility (a benefit factor). Application 1 proposes the user a number of preset itineraries of a country, and the user needs to choose among them. Application 2 proposes this also at the first step, but in addition the user may choose to make changes to any or some of the itineraries previously chosen, by switching points of interest (sites) located along the chosen itinerary with offered alternative points of interest. Application 3 proposes the user points of interest, with no preset itineraries and the user will form the itineraries "from scratch" by graphically adding routes between points of interest. Of course, all applications can supply information about the various points of interest and itineraries in terms of approximate duration, monetary costs, and so on.

On the one hand, the transition from Application 1 to 3 is followed by a gradual growth in cognitive resources consumed, from an easy to use system for planning a trip in minimal time and cognitive effort, to a complex system that requires maximum time and effort. On the other hand, transition from application 1 to 3 demonstrates a gradual shift from a low utility system, in which a user can choose only from a limited predefined set of itineraries, to a system of maximum utility, which allows means to create customized (user "tailored") itineraries, therefore optimal for planning a trip to meet his specific desires or needs.

Following the original cost-benefit approach, the overall cost and benefit of each application can be calculated by HCI professionals and graphically presented on two vertical axes. As in the original model, the horizontal axis is the weights scale that expresses the relative importance of the cost and benefit factors. A holistic view of the user-system interaction takes many factors into account, as influencing the positioning of each user on the horizontal axis. These factors create a combination of the user's personal traits relevant to HCI (e.g. novice versus sophisticated user, etc.), with factors that influence his current usage state (e.g. motives and context). Using the personas method, we demonstrate how different users can be positioned on the cost-benefit relative importance axes. Some users may be highly motivated to have "the perfect" trip and would be willing to spend a lot of time and effort to create it. Think of Dan as a persona who plans a six day trip to France, and desires an ideal trip for his family of wife and small children and wishes to include as many most popular sites. On the other hand, other users may be willing to settle for a "good enough" trip, as long as they do not have to work too hard to plan it. Think of Rita as a persona, a single mother with little computer experience, who seeks to simply join an organized trip with a predefined set of itineraries because she prefers a guided tour with other people, which may expand her social interactions and expose her to new dating opportunities. As presented in figure 1, according to the cost-benefit graphical model, each one of the applications is positioned on a graph, according to its overall cost and overall benefit. Personas like Rita are positioned at any point on the axis to the left of the intersection b will prefer application 1. Personas like Dan are positioned at any point on the axis to the right of the intersection a, will prefer application 3. A third group of personas that are positioned at any point on the axis between these intersections will prefer application 2.

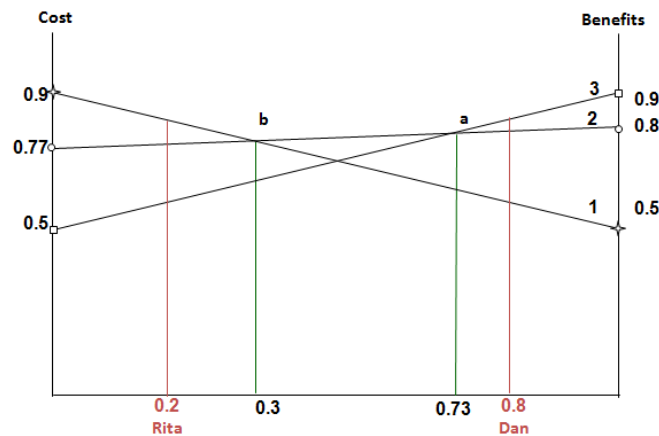


Figure 1. A cost-benefit graph including personas

We expect that we receive cost-benefit graphs that are similar to the original cost-benefit approach. Users would prefer applications that are designed to meet their needs and current motives. We intend to have HCI professionals' ratings of different variations of an application on the cost and benefit factors, following a list of criteria derived from the HCI literature. Accordingly we will create a cost-benefit graph. We will then ask potential users questions that derive the relative importance they give the cost factor versus the benefit factor. Finally, we will expose these users to the applications, and ask them to state which one they prefer most. We expect that the location of a user on the horizontal axis (cost-benefit importance) will be somewhere in the range where the maximum values on the vertical axis belongs to the exact application that he preferred. This will prove the framework is suitable for the field of HCI.

REFERENCES

- Cooper, A (2003). *The inmates are running the asylum*, Sams Publishing, Indianapolis, IN, 1999.
- Hassenzahl, M. (2005). The thing and I: Understanding the relationship between user and product. In *Funology: From Usability to Enjoyment*, Blythe, M.A., Overbeeke, K., Monk, A. F. and Wright, P. C. (eds.), 31-42. Springer.
- Katz, A., Te'eni, D. (2007). The contingent impact of contextualization on computer-mediated collaboration, *Organizational Science*, 18, 261-279.
- Majchrzak, A., Malhotra, A., John, R. (2005). Perceived individual collaboration know-how development through information technology-enabled contextualization: Evidence from distributed teams, *Information Systems Research*. 16 (1), 9-27.
- Miaskiewicz, T., Kozar, K, The use of the Delphi method to determine the benefits of the personas Method – an approach to systems design, in Proc. SIGHCI2006, Paper 7.
- Nielsen, J. (1993). *Usability Engineering*. Academic Press, Boston.
- Nolen-Hoeksema, S., Fredrickson, B., Loftus, G., Wagenaar, W. (2009). *Atkinson & Hilgard's Introduction to Psychology (15th ed.)*. Wadworth/Cengage Learning.

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

- Shoval P., Lugasi Y. (1987). Models for computer system evaluation and selection, *Information & Management*, 12(3), 117-129.
- Shoval P., Lugasi Y. (1988). Computer-systems selection - the graphical cost-benefit approach, *Information & Management*, 15(3), 163-172.
- Venkatesh, V., Morris, M. G., Davis, G. B., Davis, F. D. (2003). [User acceptance of information technology: Toward a unified view](#), *MIS Quarterly*, 27(3), 425–478.
- Weick, K., Sutcliffe, K. H. (2001). *Managing the unexpected: Assuring high performance in an age of complexity*. Jossey-Bass, San Francisco, CA.

INTEGRATING HCI ELEMENTS INTO THE WATERFALL METHODOLOGY TO EASE NOVICE DEVELOPERS TO DEFINE SYSTEM REQUIREMENTS: RESEARCH-IN-PROGRESS

Dizza Beimel

Department of Industrial
Engineering and Management,
Ruppin Academic Center, Emek
Hefer, Israel
dizzab@ruppin.ac.il

Efrat Kedmi Shahar

Usense - UI research & design;
Department of Industrial
Engineering and Management,
Ruppin Academic Center,
Emek Hefer, Israel
efrat@usense.co.il

Keywords: SDLC, Waterfall, Development phases, HCI, Visualization

INTRODUCTION

Building an Information System (IS) is a challenging process. Some of the challenges stem from the selected development methodology. When using the *Waterfall* method, challenges arise from the *transitions* between different development phases defined by the methodology [1]. In particular, the non-trivial transitions from the “existing state study” phase (source side) into the “future system requirements definitions” phase (destination side). This transition is in actuality a **GAP**, as the source side of the transition applies to modeling of an **existing** state, while the destination side of the transition applies to the creation of requirements for a **completely new** IS.

In the phase of “existing state study” (existing phase for short), a development team elicits, analyzes and documents information that relates to the organization's business processes, using structured techniques and methods (e.g., via interviews and documenting a business process using activity diagram modeling). In the next phase of “future system requirements definition” (requirements phase for short), the team has to identify and define the requirements of the new system. For that phase, there are guidelines and tips. However, there is no structured method which produces a satisfying set of system requirements.

An experienced development team, making use of accumulated knowledge, will traverse the gap between the existing phase and the requirements phase and will provide the customer a set of system requirements. Of interest, however, is to know whether this process is the same for an inexperienced team – or for a group of students during their first attempts at building an Information System?

For several years, we have functioned as advisors for students during their first IS projects. The students used the waterfall methodology for developing an information system for actual customers. They started with working on the existing phase by carrying out a thorough study of the organization. They then defined the system

requirements via UML Use Case Model [2]. To this end, they created a use case diagram along with detailed specifications for each use case.

While working with the students on these projects, we observed the complexity of bridging the gap between the existing phase and the requirements phase, which in our case included the creation of the use case diagram and specification. We found that it is easier for the students to identify the system requirements if they "visualize" the future system by creating a navigational screen map which describes the workflow of the user in the system.

Motivated by this insight, we structured the "visualizing" manner, by adopting *Human-Computer Interface* (HCI) elements and methods as well as integrating them into the waterfall methodology. In addition, we carried out a control experiment to test whether the refined waterfall methodology helped the students create a better set of requirements.

OBJECTIVES

The desired outcome is to ease the transition from the existing phase to the requirements phase for novice developers and to assist in the definition of a robust set of system requirements via the use case model.

To this end, we suggest **refining** the waterfall methodology by adding an **intermediate visualization phase**. In this phase, the developer creates a *visualized model* of the system by using elements from the HCI domain. In practice, the developer is required to (1) reasoning of the user mental model (i.e., the user's perception of the system: how it works, what is the functionality, etc.); and (2) creating of the derived navigational screen map (i.e., describing the screens flow) which should support the organization work processes.

In order to clarify our suggestion, we present a case study. This case study refers to an organization that manages volunteer projects. The main actor/user of the system is a project coordinator, who is concerned with two main processes: a) coordinating volunteer activities and b) coordinating overall projects.

Regarding the case study, we need to define the requirements of a future information system that will support the project coordinator to efficiently carry out the two main processes. To this end, we analyzed the case study via both a navigation screen map (exhibited in figure 1) and a use case diagram (exhibited in figure 2). In figure 1, a set of screens of the future information system is displayed. In figure 2, a set of use cases, which stands for system requirements, is displayed. One can clearly see the synergy between the two models. For example, a use case of "add a new projects" is reflected by the "add a new project" screen.

As noted, figure 1 exhibits a possible navigation screen map for the case study, which is the outcome of the intermediate visualization phase. We believe that completing the visualization phase eases the transition to the next phase (the requirements phase).

We decided to test our suggested refinement of the waterfall methodology through a controlled experiment. The experiment aims to test whether adding an intermediate visualization phase (i.e., creating an HCI mental model and its related navigation screen map) **before** defining the system requirements, helps novice IS developers to identify and create a better set of system requirements modeled via a use case diagram.

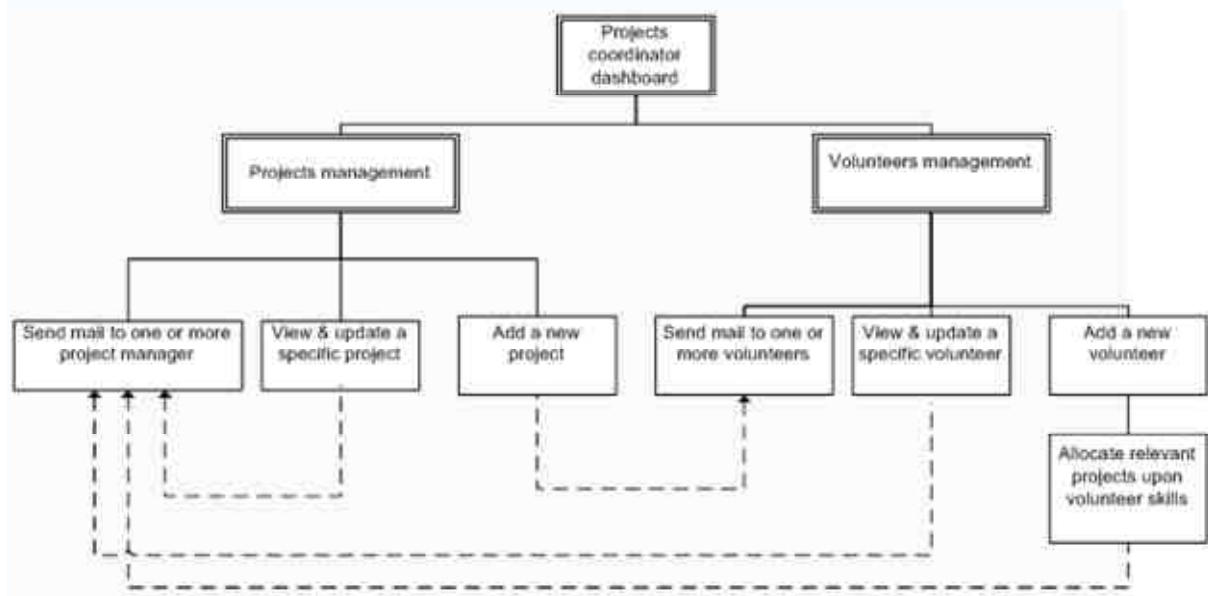


Figure 8: an example to a navigation screen map

METHODS

The participants in the controlled experiment were second year students, majoring in information systems studies. They completed several IS courses, including a core course “Analysis and Specification of Information Systems”. During that course, they learned and practiced how to elicit, analyze and document information, related to business processes in organizations. They learned the HCI approach for creating a navigation screen map, and they performed a tutorial relating to the use of a mockup tool named Lumzy [3] for planning and designing navigation maps. Last, the students learned about the UML use case model [2], which is used for modeling and defining system requirements.

The experiment was carried out via a midterm assignment that the subjects performed. This midterm assignment included a description of an existing state of a real organization, with focus on its core business processes and its related actors/users. The students were required to perform two assignments: A) to model the system requirements via a use case diagram, and B) to conceptualize the corresponding mental model via a navigation screen map.

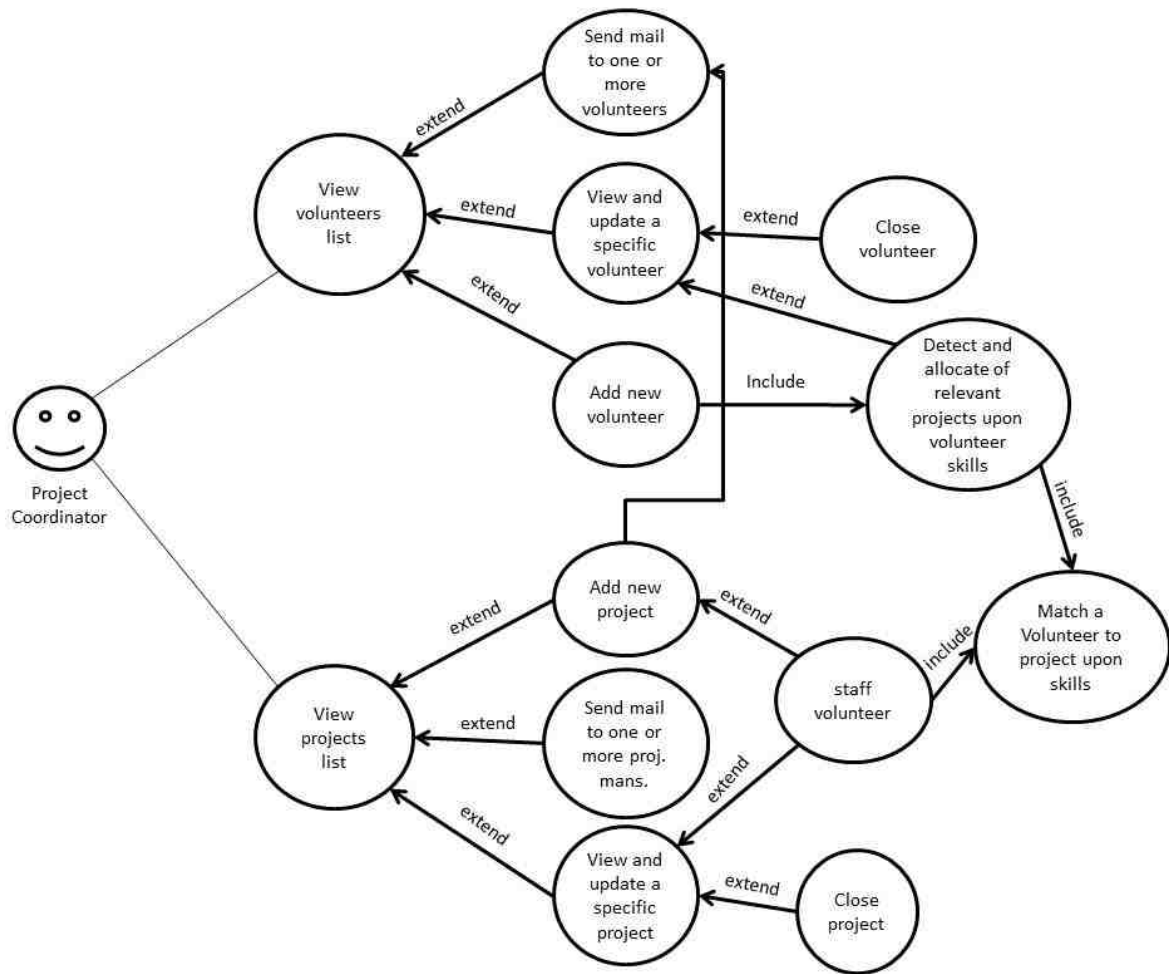


Figure 9: Defining system requirements via a use case diagram

The subjects were divided into two groups. Each group members were required to perform both assignments, except in a different order: Group 1 performed the navigation screen-map assignment first and then the use-case diagram assignment. Group 2 performed the use-case diagram assignment first and then the navigation screen-map assignment. They were given 45 minutes each.

Our hypothesis was that Group1 will manage to create a better use-case diagram. As so, the dependent variable is the use-case diagram. We test it by several criteria such as: the number of missing use-cases, the number of redundant use-cases, the number of incorrect links, etc.

For analyzing the results, we use the Wilcoxon signed-rank test [4], which is a nonparametric test that can be used to compare the achievement of two groups on tests with repeated measurements on a single sample. To this end, the subjects were paired in couples. Each couple included two students, with similar academic profiles (i.e., grades average, etc.). Each student in a couple was assigned to one of the experiment groups.

RESULTS

The results of Group 1 (navigation screen-map assignment first) are displayed in table 1.

Average grade for the use-case diagram assignment (out of 60)	Average grade for the navigation screen-map assignment (out of 40)	Average grade
47.1	27.2	74.3

Table 1: the results of Group 1

Average grade for the use-case diagram assignment (out of 60)	Average grade for the navigation screen-map assignment (out of 40)	Average grade
39.9	20.1	58.5

Table 2: the results of Group 2

The results of Group 2 (use-case diagram assignment first) are displayed in table 2. The results of Group 1 are better than the results of Group 2 in both assignments. In addition, The Wilcoxon statistical test α value, calculated for the use-case diagram assignment is 0.01 in favor of Group 1, and the α value, calculated for the navigation screen-map assignment, is 0.02 also in favor of Group 1.

The results show that our hypothesis regarding the ability of Group 1 to create a better use-case diagram is correct. The results of Group 1 were significantly better than the results of Group 2. Thus, we can conclude that creating a navigation screen-map assisted the students in creating a better set of system requirements.

CONCLUSIONS

According to Zhang et. al. [5], "incorporating an HCI perspective into the SDLC is necessary for IS success". As so, the authors propose a Human-Centered Systems Development Life Cycle (HCS DLC) model for developing IS that consider both organizational and human needs.

In this paper, we continue developing this approach by integrating HCI elements into SDLC. We suggest refining the waterfall methodology by adding an intermediate visualization phase prior to the requirements phase. In the traditional waterfall, the aspects of HCI are considered at the design phase and are engaged mainly in the manner of screen interfaces. Our proposed approach not only precedes the practice in HCI, but also adds a methodological phase that relates to the system's mental model and navigation as well as to the screen flow. By this refinement, we hope to ease the completion of the system requirements definition mission, with special regard to novice developers.

The effectiveness of our suggested refinement is examined using a controlled experiment, including two groups. One group's assignment is to create a requirements model (via use case diagram) before creating the navigational screen map, the second

group's assignment is to create the navigational screen map followed by the requirements model. The results of our experiment show that creating a navigation screen map indeed helps the students to bridge the gap between the existing phase and the requirements phase.

REFERENCES

1. W. Royce, "Managing the Development of Large Software Systems," Proc. Westcon, IEEE CS Press, 1970, pp. 328-339.
2. G. Booch, J. Rumbaugh, I. Jacobson, "The Unified Modeling Language User Guide", Addison Wesley, Reading MA, 1999.
3. LUMZY, www.lumzy.com
4. S. Siegel, Non-parametric statistics for the behavioral sciences. New York: McGraw-Hill. 1956.
5. Zhang, P., Carey, J., Te'eni, D., and Tremaine, M. 2005. "Integrating Human-Computer Interaction Development into the Systems Development Life Cycle: A Methodology," Communications of AIS (15), pp. 512-543.

RANKING SUPPLIERS OF MULTI-ALTERNATIVE PROPOSALS OF IT PROJECTS THE GCB METHOD

Peretz Shoval

Department of Information Systems Engineering, Ben-Gurion University, Beer-Sheva

Shoval@bgu.ac.il

Keywords: Cost-benefit analysis; IT project management; RFP; Selection of alternative proposals.

INTRODUCTION AND OBJECTIVES

Ben-David et al. (2012) proposed a method for analyzing multi-alternative proposals for agile projects, in which the requirements are likely to change dynamically during the development phases. They suggest a method for bid evaluation, in which each bid can be composed of several alternative contract formats. The client's task is to select the supplier who tailors the contractual suite that best fits the client's objectives, since one cannot anticipate with absolute certainty which proposal will actually emerge as preferable as the project progresses.

Their method for ranking the supplies extends the Graphical Cost-benefit (GCB) method developed by Shoval and Lugasi (1988). The GCB method assumes that each alternative proposed by a supplier has certain cost and benefit. The expected benefit of any proposal is the weighted average of its cost and benefit, where the weights indicate the relative importance of the two factors. These weights are determined by the decision maker prior to the RFP stage. Ben-David et al. claim that in the agile framework these weights cannot be determined. In order to find the most attractive supplier they suggest a method called "Area Under Cost-Benefit Curve" (AUCB), which does not assume that there is a certain relative weight of the cost and benefit factors but rather that all weights are possible. According to this method, the ranking of suppliers is based on the aggregation of all possible expected benefits of the suppliers' alternatives.

I find some problems with the AUCB method regarding the computation of the expected benefits of the alternatives proposed by each supplier, and the assumption that all weights of the cost and benefit factors are possible. Instead, I propose an alternative method to select the top ranked supplier of multi-alternative proposals that is based on the original GCB method.

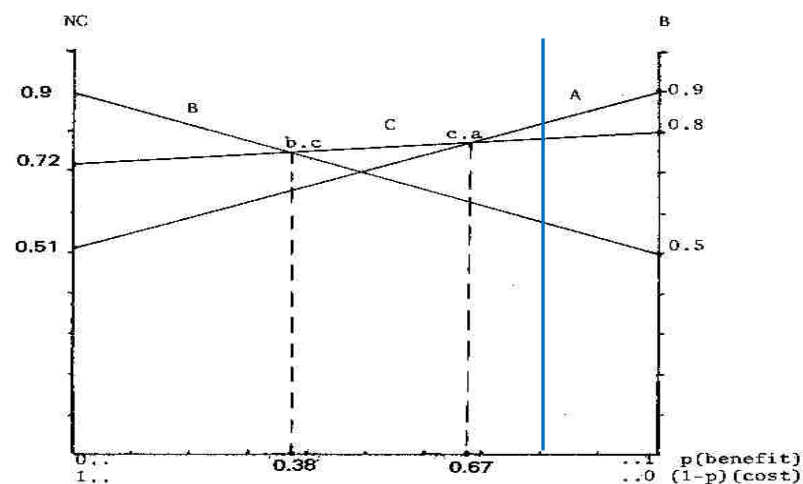
ESSENCE OF THE GRAPHICAL COST-BENEFIT METHOD (GCB)

Shoval and Lugasi (1988) presented the GCBs method for selection of alternative systems, which considers the relative importance of the benefit and cost factors in a given situation. It is assumed that in response to an RFP, each supplier submits a proposal; the cost and benefit of each proposal is determined – cost in monetary terms and benefit on some subjective scale. In order to enable computing the expected benefits of the alternatives, the costs of the proposals are transformed onto the benefits scale such that least costly proposal gets the highest value, and the other proposals get lower values, proportionally. Several methods of cost transformation (also termed cost normalization) are possible. Here is, for example, a linear cost normalization method: $NC_{max} = B_{min}$; $NC_i = [CN_{max} * C_{max}] / C_i$. Namely, the most costly alternative NC_{max} gets a normalized-cost value that equals the least

beneficial alternative B_{min} ; the normalized cost of any other alternative NC_i is increased proportionally.

The GCB approach assumes that the decision maker determines the relative weight/importance of the cost and benefit factor. The expected benefit of any alternative i is computed as follows: $B_i * w + NC_i * (1-w)$, where w denotes the weight (importance) of the benefit factor, and hence $(1-w)$ denotes the weight of the cost factor. The value of w depends on the financial/economic situation of the organization; it does not depend on the suppliers, the proposals, the development method, etc. For example, a "wealthy" organization (that is in a very good financial situation) may decide that $w=1$, namely that only the benefits of the proposals matter. Contrarily, a "poor" organization may decide that $w=0$, namely that only the cost matters. In an "ordinary" case, w would be set between the two extreme points, depending, as said, on the monetary/economic situation of the organization.

The GCB method enables to show the relevant data in a graph, which also helps to examine the sensitivity of the decision to the value of w . Fig. 1 shows an example of a GCB graph. It demonstrates 3 alternative proposals A, B, and C, each having a certain benefit and (normalized) cost. The costs have been transformed onto the benefits scale according to one of the cost normalization methods. Each line represents the expected benefit of the proposal for any level of w . The sections of the lines above the upper intersection points (the "upper cover") are relevant for the decision because they represent the best possible expected benefits. In this example, when $w > 0.67$ proposal A should be selected; when $w < 0.38$ proposal B should be selected, and when $0.38 < w < 0.67$ proposal C should be selected. If, for example, we assume that the decision maker has determined that $w=0.8$ (blue line), it is easy to see that proposal A



should be selected.

Fig. 1 – Example of a cost-benefit graph

ESSENCE OF THE AUCB METHOD AND ITS PROBLEMS

Ben-David et al. (2012) proposed to extend the above GCB method as follows: After determination of the benefits and costs of each of the proposals of each of the suppliers, they present a cost-benefit graph **for each supplier and his proposals**. For example, Fig. 2 (taken from their paper) presents 4 alternatives proposed by one supplier. Ben-David et al. assume that in agile projects "every value of w is equally likely". They call the curve that represents the higher bound of the area included in all

the supplier's proposals Least-Assured curve (marked with downward arrows), and the curve for the higher bound of the area that subtends the most attractive sections of the supplier's proposals - Efficiency-Frontier (marked with upward arrows).

Then, they form a single graph of the Least-Assured curves of all suppliers. Fig. 3 (taken from their paper) presents the Least-Assured curves of two suppliers. They explain that for values of w left of the intersection of the two curves the alternatives of supplier A (the blue curve) are preferable, and the opposite is true for values of w right to that intersection.

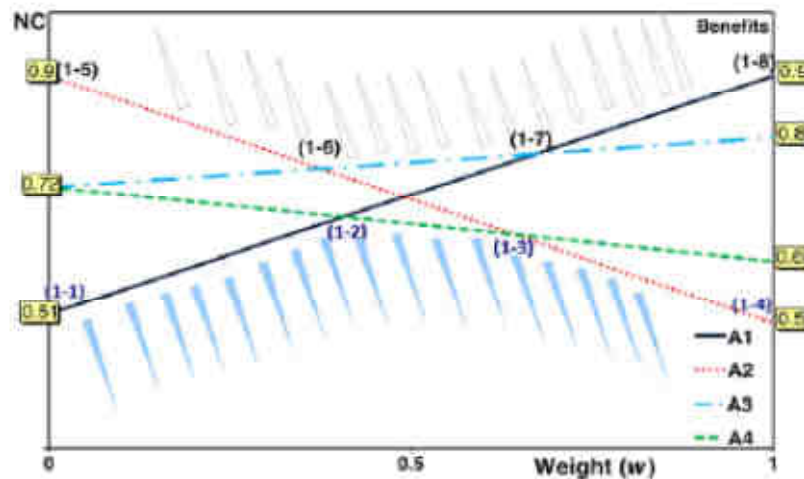


Fig. 2 – Example of a supplier's cost-benefit graph

But note that this is based on the Least-Assured curves of the suppliers, which represent the **worst expected benefits** of the alternatives proposed by the suppliers (while the best are represented by the Efficiency-Frontier curves). The meaning of the value of w at the intersection point is not explained.

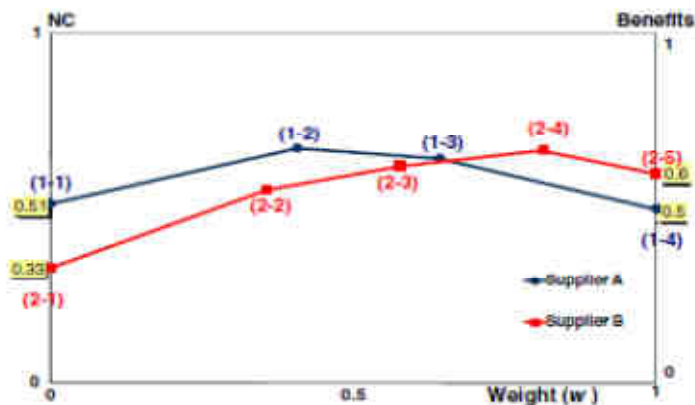


Fig. 3 – Cost-benefit Least-Assured curves of two suppliers

But this is not the main point of the AUCB method. Later on, Ben-David et al. claim that the ranking of the suppliers should be based on **all values of w** , since "all values of w are equally likely". They say that the area which is bounded by each supplier's Least-Assured curve (or Efficiency-Frontier, if chosen) gives a good indication of the supplier's rank: the larger the area – the better. This area is calculated by summation of the areas under the line segments of the cost-benefit curves of each supplier. In the

example of Fig. 3 it turned out that $AUCB_{supplierA} > AUCB_{supplierB}$. (Computations are provided in their paper.) Note again that this is based on the **worst** proposals of each supplier. Ben-David et al. admit that using the suppliers' Efficiency-Frontiers curves (i.e. of the best proposals) could have led to a different ranking.

In conclusion, the AUCB method assumes that in agile projects **every value of w is equally likely**, and therefore the ranking of a supplier is based on the total area under the curves. Is this assumption reasonable? In my opinion, not all values of w are equally likely; there is a certain value or range of values that should be determined by the decision maker (prior to the RFP) - irrespective of the development method (agile or not agile) and the number of proposals submitted by any supplier. As said, w represents the relative importance of benefit and cost of any investment; it depends on the monetary/economic situation of the organization. Since it is not easy to determine confidently the level of w , it is reasonable to determine a certain range (for example, between 0.6 and 0.8). In summary, since not all values of w are equally likely to occur, the total area, under or above the curves, cannot be used to rank the suppliers.

THE GCB METHOD FOR RANKING SUPPLIERS SUBMITTING MULTI-ALTERNATIVE PROPOSALS

Based on the above arguments, I propose an alternative method for ranking suppliers who submit multi-alternative proposals, which is based on the original GCB method:

- a) Determine the cost and benefit of all alternative proposals of all the suppliers, and normalize their costs using a certain cost normalization methods. (No change compared to the original method.)
- b) Eliminate inferior proposals. This phase is part of the GCB method, which has been neglected by Ben-David et al. In the example presented in Fig. 2, this means that the green proposal should be eliminated. After this elimination we have alternatives all of which are relevant candidates.
- c) Determine the level of w . As said, this level depends on the financial/economic situation of the organization, irrespective of the type of proposals, development method and agreement contracts. If the decision makers cannot determine a certain value, they should determine a range.
- d) For each supplier, compute the expected benefit of each of his proposals using the (original) GCB method and the pre-determined w . If the decision maker prefers to determine a range of w 's, then compute the expected benefit of each proposal at the **mid-range**. (This is identical to computing the expected benefits at the two edges of the range and then their average. For example, if the range of w is between 0.6 and 0.8, compute the expected benefit at $w=0.7$.)
- e) For each supplier, compute the **average expected benefit**. This can be a "simple" average of the expected benefits of each supplier's proposals, assuming that all of a supplier's proposals are equally likely to occur. However, it is reasonable to assume that some alternatives may be more or less likely to occur than other; if this is the case, the decision maker has to determine the probability of each proposal (of each supplier), and based on that to compute its **weighted expected benefit**.
- f) Select the supplier who gained the highest weighted expected benefit.

**Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin
Academic Center, Emek Hefer, Israel**

REFERENCES

- Ben-David, A., Gelbard, R. & Milstein, I. (2012). Supplier ranking by multi-alternative proposal analysis for agile projects. *Int'l Journal of Project Management*, 30, 723-730.
- Shoval, P. & Lugasi, Y. (1988). Computer systems selection: the graphical cost-benefit approach. *Information & Management*, 15, 163-172.

SUCCESS AND RECIPROCITY IN CROWDFUNDING NETWORKS

David Zvilichovsky
Recanati Business School
Tel Aviv University
davidz@tau.ac.il

Yael Inbar
Recanati Business
School
Tel Aviv University
yaelinba@tau.ac.il

Ohad Barzilay
Recanati Business School
Tel Aviv University
ohadbr@tau.ac.il

Keywords: Crowdfunding, Reciprocity, Social Networks, E-Finance

ABSTRACT

Crowdfunding, the process of directly financing projects and ventures over the internet, is gaining momentum. Industry reports estimate that sums raised on crowdfunding platforms have nearly doubled in 2012, totaling close to US\$3.0B.³

This study evaluates the impact of a project initiator's crowdfunding network history on her fundraising success. We find that project initiators which have backed other projects prior to starting their own venture significantly increase the funding success for their projects. Furthermore, we find that the rate of success increases in the number of previous backing actions performed by the project initiator. We also find that an initiator's previous crowdfunding success has a positive impact on the probability of successfully financing her next crowdfunding projects. Initiator experience alone, as indicated by the number of previous projects created by the same owner, does not increase the funding success of a project. To the best of our knowledge, evaluating the impact of pre-project crowdfunding actions by project initiators has not been previously studied.

INTRODUCTION

Crowdfunding platforms create a dynamic network of projects' owners and funders. Some of these platforms are gradually adopting social networks attributes (Ward & Ramachandran 2010) and funders are looking for social interactions on those platforms (Gerber et al., 2012). Research in the area of peer-to-peer lending platforms, has found that the social capital of the borrower can serve as a trustworthiness signal to potential lenders (Lin et al. 2011; Krumme & Herrero 2009). Another recent finding suggests that a borrower's lending history impacts loan outcome (Yum et al., 2012). In the context of venture financing, the history of entrepreneurs has been shown to provide information regarding their ability to succeed in subsequent ventures. Previous success indicates a higher rate of future success (Gompers et al 2010).

Exploring the impact of network interactions, social norms and signaling in crowdfunding platforms may provide significant insights into the dynamics of such platforms.

³ <http://www.crowdsourcing.org/document/crowdfunding-industry-report-abridged-version-market-trends-composition-and-crowdfunding-platforms/14277> (visited March 27 2013)

OBJECTIVES

The virtualization of the physical funding process (Overby et al. 2010) has allowed exposure of information which was less accessible in the "real world" of fund raising – such information includes the project initiator's profile (including her social ties), her history of initiating projects and information regarding other projects she supported. Crowdfunding platforms serve as two sided markets (Eisenmann et al., 2006) which facilitate this information flow and influence the actions of both project owners and backers.

This study evaluates informational and social aspects of crowdfunding networks with special attention to pre-project actions and the on-platform history of project initiators.

METHOD

We focus our study on Kickstarter, one of the most successful crowdfunding platforms which has launched more than 90,000 projects since inception⁴. In 2012 over 2 million backers pledged over 300 million dollars to Kickstarter projects⁵.

We screened all Kickstarter projects that completed their financing cycle by March 21st, 2013. The data extracted includes a total of 78,061 projects, created by 68,732 unique project initiators and backed by an aggregate of 6,812,159 (non-unique) backers. 48% of the projects in our dataset succeeded in raising their stated financing goal. For each project we collected project and owner specific attributes such as: financing goal & duration, categories, location, reward structure, the various interactive tools used to promote and support the campaign, as well as the identity and profiles of all project backers and the project's financing outcome. For each project & initiator pair we collected the initiator's on-platform history prior to the creation of said project.

We performed a set of logistic regressions to predict the odds of a project achieving its financing goal. As a baseline prediction model we used available project characteristics as well as the project initiator's relevant static attributes.

In order to test the impact of the project initiator's history on the project success, we introduced new variables: we compute the number of projects backed by the initiator prior to creating this specific project (*NumProjectsPrevBackedByProjectInitiator*) as well as binary variables representing the fact whether the project initiator has created projects before (*HadCreated*); whether the project initiator previously created projects which were successfully funded (*HadSucceeded*); and whether the initiator has backed other projects before this specific project (*HadBacked*).

Compared to the baseline regression model, we built multiple regression models that include subsets of the project initiator's history attributes, in order to test their influence on the project success as measured by the ability to achieve the financing target by the allocated time.

RESULTS

Evaluating the successful financing of crowdfunding projects we find that an active history of backing other projects prior to project creation significantly increases the funding success of newly initiated projects. We also find that having a previous project successfully financed significantly increases the financing success of later

⁴ <http://www.kickstarter.com/help/stats> (visited March 27 2013)

⁵ <http://www.kickstarter.com/year/2012> (visited March 27 2013)

projects. Platform experience, as demonstrated by the number of previous projects created by a project initiator does not necessarily increase a project's financing success. In a regression model containing *HadBacked* and *HadSucceeded* (in addition to the baseline variables), both variables have a significant positive effect on the project success odds (*HadBacked* OR= 2.019, *HadSucceeded* OR= 1.632, $p<0.01$). When testing *HadSucceeded* along with *NumProjectsPrevBackedByProjectInitiator* – both had a significant positive effect on the project's success odds (*NumProjectsPrevBackedByProjectInitiator* OR = 1.063, *HadSucceeded* OR= 1.773, $p<0.01$).

Testing *HadBacked* together with *HadCreated* revealed that *HadBacked* had an even stronger positive effect on the project financing success ratios (OR = 2.153, $p<0.01$); However, *HadCreated* had a negative effect (OR= 0.894, $p<0.01$). This result requires further research into the dynamics of serial project initiators.

CONCLUSION

This study has demonstrated that the project initiator's history has a significant effect on the ability of a project to successfully achieve its financing targets. We find that project initiators which have backed other projects prior to starting their own venture significantly increase the funding success for their projects. Furthermore, we find that the rate of success increases in the number of previous backing actions performed by the project initiator. We also find that a project initiator's previous crowdfunding success has a positive impact on the probability of successfully financing her next crowdfunding projects. The impact of previously backing other projects was found to be stronger than that of previous success. Project initiator experience alone, as indicated by the number of previous projects created by the same owner, does not increase the funding success of a project and may even decrease its chances for success.

These findings suggest further investigation into the mechanisms of learning, signaling and reciprocity in crowdfunding networks.

REFERENCES

- Eisenmann et al. 2006 Eisenmann, T., Parker, G. & Van Alstyne, M. W. (2006), 'Strategies for two-sided markets', *Harvard business review* 84(10), 92.
- Gerber, E.M., Hui, J.S., and Kuo, P. (2012). Crowdfunding: Why People are Motivated to Post and Fund Projects on Crowdfunding Platforms. Illinois: Creative Action Lab, Northwestern University.
- Gompers, P., Lerner J., Scharfstein D. and Kovner A. (2010). "Performance Persistence in Entrepreneurship and Venture Capital." 98(1), 18-32
- Krumme, K. A., & Herrero, S. (2009). Lending behavior and community structure in an online peer-to-peer economic network. In *Computational Science and Engineering, 2009. CSE'09. International Conference on* (Vol. 4, pp. 613-618). IEEE.
- Lin, M., Prabhala, N., & Viswanathan, S. (2011). Judging borrowers by the company they keep: friendship networks and information asymmetry in online peer-to-

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

peer lending. In *Western Finance Association 2009 Annual Meeting Paper*. Available at SSRN 1355679.

Overby, E., Slaughter, S. A., & Konsynski, B. (2010). Research Commentary—The Design, Use, and Consequences of Virtual Processes. *Information Systems Research*, 21(4), 700-710.

Schwienbacher, A., & Larralde, B. (2010). *Crowdfunding of small entrepreneurial ventures*. *Handbook of Entrepreneurial Finance*, Oxford University Press, Forthcoming.

Ward, C., & Ramachandran, V. (2010). Crowdfunding the next hit: Microfunding online experience goods. In Workshop on Computational Social Science and the Wisdom of Crowds at NIPS2010.

Yum, H., Lee, B., & Chae, M. (2012). From The Wisdom of Crowds to My Own Judgment in Microfinance Through Online Peer-to-Peer Lending Platforms. *Electronic Commerce Research and Applications*, 11 (5) , 469-483

**THE CONTRIBUTION OF INTERORGANIZATIONAL
SYSTEMS TO INVENTORY MANAGEMENT: A
FINANCIAL STATEMENT ANALYSIS PERSPECTIVE
(RESEARCH-IN-PROGRESS)**

Ronen Bar Lev

Department of Information
& Knowledge Management
University of Haifa, and
The Academic College of
Tel Aviv Yaffo
ronenbar@mta.ac.il

Nitza Geri

Department of
Management & Economics
The Open University of
Israel
nitzage@openu.ac.il

Daphne R. Raban

Department of Information
& Knowledge Management
University of Haifa
draban@univ.haifa.ac.il

Keywords: supply chain management, inter-organizational systems (IOS), objective value of information systems, inventory turnover, measurement of IOS effectiveness.

INTRODUCTION

Measuring the value of intra-organizational information systems is challenging (Ahituv, 1989; Raban, 2007). The difficulty stems partly from the fact that one can evaluate the financial investment in these systems but has a problem to assess the direct, and even more so, the indirect, financial contribution arising from their use. Measuring the value of inter-organizational systems (IOS) is even harder, because the contribution of these systems is not limited to one company, but associated with inter-company workflow (Geri & Ahituv, 2008).

Most studies conducted on the contribution of IOS to date (such as Dedrick & Kraemer, 2010; Yao, Palmer, & Dresner, 2007) used questionnaires and interviews as their research tool. Those tools express subjective opinion (the perceived value of information).

This ongoing study attempts to examine the contribution of interorganizational systems to a company's economic value by using a more objective source: annual financial reports. These reports enable the examination of factual data over time, in order to assess the realistic (objective) value of information. Due to the lack of means for direct measurement of this contribution, we propose an indirect index: the turnover of inventory. We argue that there are three major operational factors that take part in the supply chain, and consequently, require monitoring during the management of the supply chain: customers, inventory, and suppliers. Of these three factors, the level of inventory can be relatively easily controlled by the company. This level is partly an economic and strategic decision based, among others, on the cost of inventory to the company (e.g., holding, storage, and obsolescence).

THEORETICAL BACKGROUND

The Information Systems Value Perspective

Madlberger (2009) defined interorganizational systems as electronic linkages between trading partners that can eliminate manual information transfer, and can largely enhance collaboration between firms in supply chains. The need to reduce costs due to the intense competition among companies has increased the importance of IOS as a factor that can lead to improved competitiveness.

The main issue is the evaluation of existing IOS, as a way to assess their contribution.

This assessment is important, first and foremost, from an economic perspective of further investments in these systems. Geri (2006) emphasized the difficulty to assess the economic profitability of investment in information systems because of two main reasons: first, many of the costs are intangible and cannot be quantified using financial terms, and second, this investment involves great uncertainty. However, in the absence of economic evaluation, managements will not agree to invest in such systems. Raban (2007) claimed that the value of information is in the eyes of the beholder. It is user-centered and therefore it is dynamic: the value of information perceived by the user may change with changing market or social influences. It may change over time or due to the accumulation of experience. Geri, Neumann, Schocken, and Tobin (2008) reviewed from an economic perspective, the three main approaches to measuring the value of information: normative value (theoretic and based on mathematical models that define ex-ante the best course of action), real value (empirical, quantitative, and objective measures) and perceived value (also referred to as subjective value). Geri et al. (2008) indicated that perceived value is the most common in empirical research literature, since it may be easier to measure.

The Supply Chain Management Perspective

According to Dubois, Hulthen, and Pedersen (2004), the concept of supply chain was mainly used to discuss the benefits of integrating a firm's internal business functions such as purchasing, manufacturing, sales, and distribution. This scope was later extended beyond the boundary of the local manufacturing firm to include 'upstream production chains' and 'downstream distribution channels'. This complementary perspective gave an inter-organizational rather than intra-organizational focus to what was defined as supply chain management. Lin and Wang (2011) explained that the cooperation and collaboration of upstream and downstream entities allows chain partners to run the most cost-effective operation, and in the meantime they can quickly respond to the variety of consumer demands.

A literature review of published research between 1992-2011, by Osborn and Nolt (2012) showed that problems concerning supply chains have significant impact on profitability, not only at a single firm level, but potentially for the many firms involved in almost any given supply chain and that most problems were found within the area of material flow.

The Financial Statement Analysis Perspective

Bushman and Smith (2001) adopted the classic agency perspective that the separation of corporate managers from outside investors involves an inherent conflict. They defined "corporate control mechanisms" (p.238) as the means by which managers are disciplined to act in the investors' interest. From the perspective of shareholders and creditors of the company, financial accounting systems provide direct input to corporate control mechanisms. Revsine (2002, p.137) used the phrase "selective financial misrepresentation". He argued that these misrepresentations allow managers to achieve bonus goals, shareholders to benefit from higher share prices, and auditors to placate clients. Revsine claimed that extreme incidents like the Enron scandal (caused, in part, by lack of auditors' independence) were inevitable in the then existing financial reporting environment.

THE RESEARCH QUESTION

The research question is: to what extent do interorganizational systems contribute to the management of inventory levels of companies and thus lead to an increase in the economic value of the company? If interorganizational information systems are effective, it should be reflected in lower inventory levels. As explained before, reduced inventory means, under certain conditions, higher profits, and presumably, increased economic value of the firm.

METHODOLOGY

The basic question of this ongoing study relates to the impact of IOS on profitability, as expressed, in the financial statements, through net income (i.e., profit). Since profit is influenced by many other factors, which some cannot be measured quantitatively (i.e. intangible assets held by the company, for example, goodwill) and some are not related to operational factors (i.e. tax rate), we selected a quantitative measure: inventory turnover, namely, the number of times the inventory is sold during a fiscal year. This measure is calculated as the ratio between two components, as explained below. Using a ratio enables us to neutralize the effects of economic and financial factors like changes in the value of money, changes in exchange rates, and different accounting measurement methods.

The turnover of inventory is calculated as a the result of dividing the annual sales (from the profit and loss report) by the average of inventory level between the beginning of the fiscal year and the end of the year (obtained from the balance sheet). The components of the calculated ratio are expressed in monetary terms, due to lack of information about the quantity of the units sold.

The data is collected only from annual reports due to accountants' audit that enables us to rely, at some level, on the presented data. We use public companies' reports since these financial reports are accessible to all investors, so we are able to examine relatively easy, data related to the subject of this study from various industries.

Longitudinal data analysis will be performed in order to find any changes in the turnover of inventory for 20 years, considering the enormous development of interorganizational information systems. This requires, at first, finding and neutralizing extraordinary events that can lead to changes in sales volume and in inventory level and ,therefore, in the turnover of inventory but don't have any connection to the development of information systems, like the loss of market share or change in ownership or management (of a specific company). Subsequently, to counteract changes in any specific company within a specific industry, the analysis will be made in terms of what we define as "industry weighted average", which takes into account the volume of sales of each company as a measure of its share in the relevant industry. The analysis will attempt to neutralize, as possible, the impact of changes which influence the selected industry unrelated to the development of information systems, such as economic slowdown.

To examine the validity of inventory turnover, we started a pilot study for Israeli companies from various industries. According to data collected so far, it seems that over the years there is an increase in inventory turnover in light of investment in information systems. More detailed initial findings will be presented at the conference.

CONCLUSION

This ongoing research attempts to develop an objective measure of the contribution of interorganizational systems to companies' value, which is considered difficult to assess. The proposed inventory turnover measure is based on data of financial reports, in contrast to conventional ways that were used in prior research, such as questionnaires, surveys and interviews. Initial findings indicate, to some extent, a contribution of information systems development to profitability, via increased inventory turnover.

REFERENCES

- Ahituv, N. (1989). Assessing the value of information: Problems and approaches. *Proceedings of the 10th Annual International Conference on Information Systems*, Boston, MA (December), 315-325.
- Bushman, R. M., & Smith, A. J. (2001). Financial accounting information and corporate governance. *Journal of Accounting and Economics*, 32(1-3), 237-333. doi:10.1016/S0165-4101(01)00027-1
- Dedrick, J., & Kraemer, K. L. (2010). Impacts of internal and interorganizational information systems on the outsourcing of manufacturing. *Journal of Strategic Information Systems*, 19(2), 78-95. doi:10.1016/j.jsis.2010.02.002
- Dubois A., Hulthen, K., & Pedersen, A. C. (2004). Supply chains and interdependence: A theoretical analysis. *Journal of Purchasing & Supply Management*, 10(1), 3-9. doi:0.1016/j.pursup.2003.11.003
- Geri, N. (2006). *Selected topics in economics of information goods*. Raanana, Israel: Open University Press (Hebrew).
- Geri, N., & Ahituv, N. (2008). A Theory of Constraints approach to interorganizational systems implementation. *Information Systems and e-Business Management*, 6(4), 341-360. Doi: 10.1007/s10257-007-0075-8
- Geri, N., Neumann, S., Schocken, R., & Tobin, Y. (2008). An attention economy perspective on the effectiveness of incomplete information. . *Informing Science Journal*, 11, 1-15.
- Lin, C. C., & Wang, T. H. (2011). Build-to-order supply chain network design under supply and demand uncertainties. *Transportation Research Part B*, 45(8), 1162-1176. doi:10.1016/j.trb.2011.02.005
- Madlberger, M. (2009). What Drives Firms to Engage in Interorganizational Information Sharing in Supply Chain Management? *International Journal of e-Collaboration*, 5(2), 18-42. doi: 10.4018/jec.2009040102
- Osborn E. B., & Nault, B. R. (2012). A classification of Supply Chain Problems. *Engineering Management Research*, 1(2), 1-15. doi:10.5539/emr.v1n2p1
- Raban, D. R., (2007). User-centered evaluation of information: A research challenge. *Internet Research*, 17(3), 306-322. doi: 10.1108/10662240710758948
- Revsine, R., (2002). Enron: sad but inevitable. *Journal of Accounting and Public Policy*, 21(2), 137-145. Doi:10.1016/S0278-4254(02)00044-3
- Yao, Y., Palmer, J., & Dresner, M. (2007). An interorganizational perspective on the use of electronically-enabled supply chains. *Decision Support Systems*, 43(3), 884-896. doi:10.1016/j.dss.2007.01.002

FACTORS THAT IMPACT THE OUTCOME OF ACQUISITIONS OF ISRAELI HIGH TECH COMPANIES

Rafi Cohen

Ruppin Academic Center

rafic@ruppin.ac.il

Keywords: Mergers and acquisitions, technology driven sector, strategic management.

INTRODUCTION

Acquisitions of small technology-driven companies are an important source of technological inputs for established firms. (Kale, Puranam 2004; Eisenhardt & Prescott 2004). In a fast changing technology environment acquisition is often the fastest (if not the only) way to keep up-to-date with the new technical developments. In Israel, a significant player in the technology sectors, over 820 acquisitions of technology driven firms with accumulated value of over \$45B were reported since 2001. See Figure 1 below.

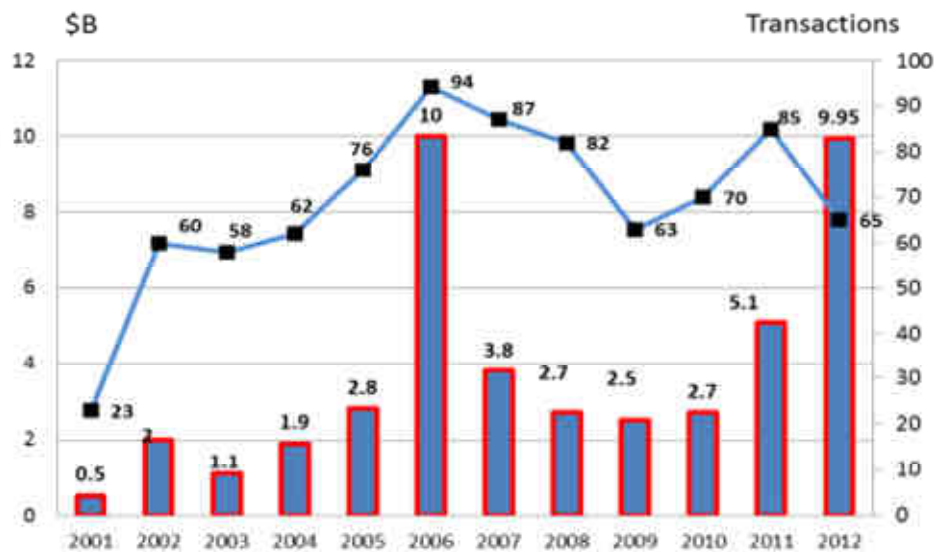


Figure 1. Israel Hi-Tech M&A environment.

Source: Israeli High Tech industry Association

However, the success rate of these M&As follows the global statistics and most of the transactions failed to deliver the value the buyers were hoping for. As an example, in May 2000 Lucent Technologies Inc. acquired Chromatis Networks for \$4.5 billion, and a year later closed the operation. Granted, little transparency exists when evaluating the success or failure of M&A and each evaluation method has clear disadvantages. Yet, if we accept the failure rates reported in various studies as a fact,

at best M&A do no harm and their outcome is arbitrary. (Marks, Mirvis 2011; Finkelstein 2010; Brakman, Garretsen & Van Marrewijk 2008).

Considering its importance, M&A phenomenon was researched for over 30 years. Yet, according to J. Bower, *"We know surprisingly little about mergers and acquisitions, despite the buckets of ink spilled on the topic. In fact, our collective wisdom could be summed up in a few short sentences: acquirers usually pay too much. Friendly deals done using stock often perform well. CEOs fall in love with deals and don't walk away when they should. Integration's hard to pull off, but a few companies do it well consistently."* (Bower 2001).

The goal of the described research was to improve the success rate of acquisitions in the technology driven sector in Israel through the identification of the most significant factors that affect the outcomes of acquisitions and the way they impact the results.

METHODOLOGY

For several decades M&A researchers adopted the positivistic paradigm, looking for key variables that can be used to predict (or control) a success or failure of an M&A (Cartwright, Schoenberg 2006). However, considering the poor results of most M&As, several scholars started to challenge the positivistic approach in the context of M&A research (Meglio 2009). The main posture here is that the rather complex phenomenon of mergers and acquisitions, in particularly its multi-disciplinary nature, is too complex to be investigated under such paradigm. Another issue of the quantitative approach is the fact that M&A is a multi-facet phenomenon and each case has its unique characteristics. "Not all M&As are alike, and that matters" (Bower 2001)

In light of above challenges, in particularly the uniqueness and complexity aspects of each acquisition, the described research is based on the interpretive epistemological philosophy and case study strategy. This approach can provide an in depth, holistic, data rich information on the particular studied cases. (Patton 1990; Yin 2009). The research is focused on three acquisitions of Israeli Hi Tech companies. In all cases the acquirer and the target companies operated in the semiconductor for mobile broadband internet access market. The acquirers were global leaders in the semiconductor market and the acquired companies were small and medium size entrepreneur companies, specialized in broadband wireless communication. Figure 2 below summarizes the three cases.

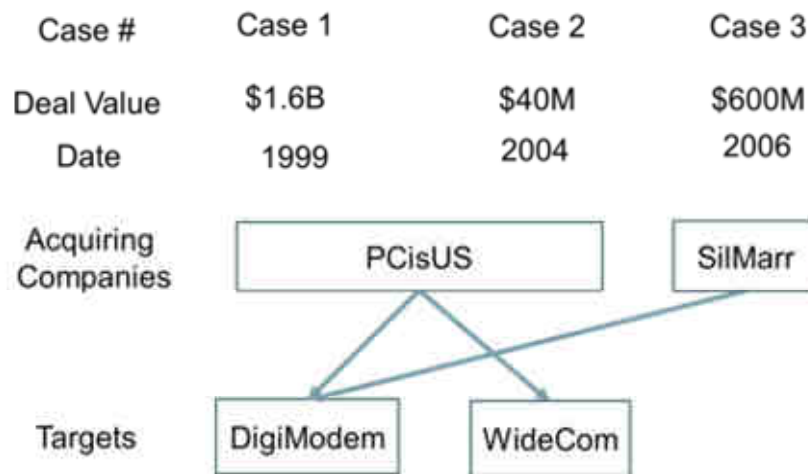


Figure 2: Test case summary. (all names are pseudonym)

Data gathering included over 50 interviews with top level management and senior managers at both the acquiring and acquired companies, public and internal documents (under the permission of relevant corporate authorities), as well as direct observations and the researcher's own involvement in the described cases. The data was triangulated with other resources to ensure its validity. The findings were analyzed using content analysis methodology (Elo, Kyngäs 2008; Creswell 2009) and utilized Nvivo® software tool.

RESULTS

The list of factors that impacted the results must be viewed in light of the overall success or failure of each particular transaction. In case one the buyer failed to achieve its business goals and sold the target seven years after the acquisition at a significant loss. In case two the buyer failed to achieve its original business goal, but successfully reassigned the acquired employees, as a team, to other significant assignments within the buyer's organization. In case three the buyer created an \$800 Million business and successfully transferred the knowledge to other teams in the company. Figure 3 below summarizes the key factors that impacted the outcome of each case.

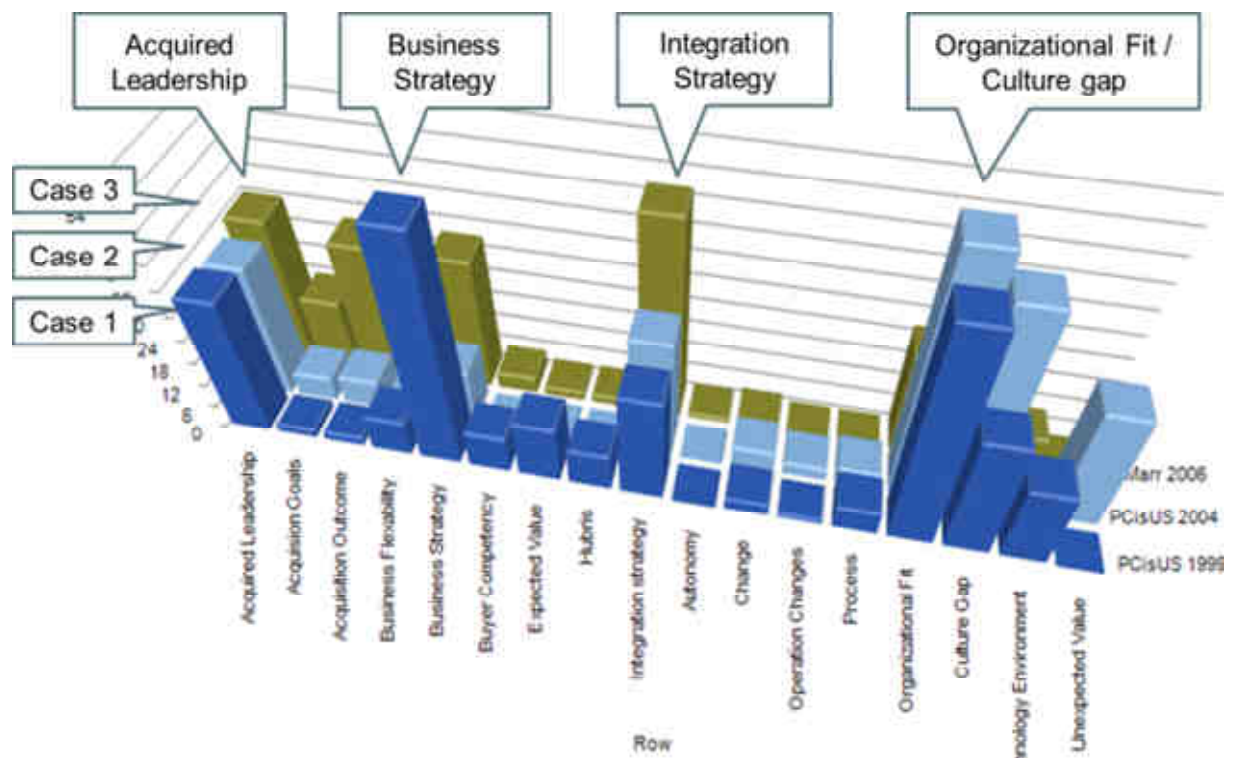


Figure 3. Key Factors that impacted the results

As can be seen from the chart, each case is unique and factors that significantly impacted one case were less significant in another. Yet, apparently there is a pattern of common factors that had higher significance in all cases. These factors are: (1) the business strategy the buyer pursued to achieve its business goals, (2) the organizational fit between the buyer and the target, (3) the integration strategy the buyer implemented after the acquisition and (4) the role the acquired team management assumed during the integration time. Other factors that are mentioned in the literature like CEOs hubris (Roll 1986) or employees stress (Philippe C. Haspeslagh, David B. Jemison 1991) were not identified as significant factors in the above particular cases. The next section provides an analysis of each of the above factors and the way it impacted the acquisition's results.

ANALYSIS AND CONCLUSIONS

Business Strategy: In all three cases the buyers had a similar strategic objective, namely entering the mobile broadband internet access market. However, although the strategic objectives were similar, the business strategies to achieve these objectives were very different and directly impacted the end results. While in case one and two the buyer tried to penetrate the market through the introduction of best-in-class technologies (which turned out to be less relevant to the particular market), in case three the buyer simply opted for lower cost strategy that turned out to be more successful.

Organizational Fit: Since all four companies involved in the research were technology companies in a similar industrial sector, as expected they shared many organizational

attributes. However, several fundamental organizational differences found to have significant impact on the integration processes and on the end results of the acquisitions. From strategic/operational perspective, business and technology relatedness, team size and planning processes found to have a significant impact on the acquisition's results. From cultural perspective, managerial practices, decision making processes and process vs. result orientation topped the list of relevant organizational attributes.

Integration strategy: The integration processes in all three cases were affected by two key factors: Acquisition goals and level of organizational fits. In cases one and two the buyer wanted the acquired companies to work closely with many teams within the buyer's organization so significant efforts were spent regarding the integration processes. However, in case one the buyer took an aggressive integration approach that ignored fundamental differences between the companies and contributed to the overall failure. A more relaxed integration approach in case two contributed to the successful (though unexpected) results.

Acquired Team Leadership: In all three cases the acquired team leadership played a critical role in the final results. The most significant case of target's leadership role was case two, where the acquired leaders took a very active position in the integration process. The team leaders drove key integration decisions, managed internal integration and proactively accelerating coordination across the two companies. A key buyer's decision was to assign the acquired management a cross organizational responsibilities. From the acquired team's perspective this act gave them the ultimate proof that they are considered to be an integral part of the buyer's organization.

Figure 4 below depicts the interrelated relationships among the four factors. The business strategy sets the acquisition's goals which, in turn, impact the expected value of the transaction and the integration strategy. The integration strategy must be driven by the acquisition goal on one hand and the organizational fit on the other hand.

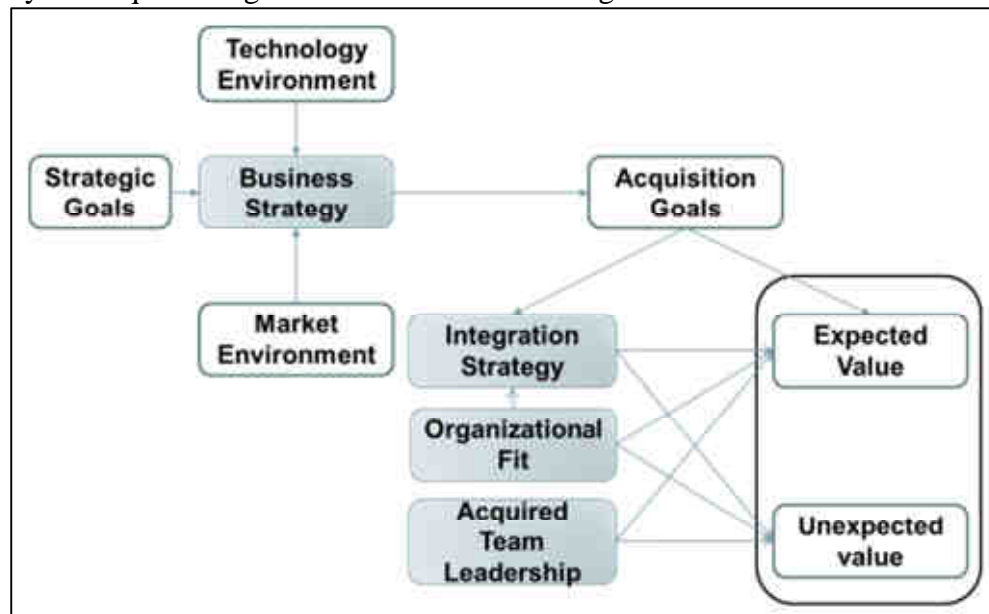


Figure 4 – A Model for the significant factors

The above analysis suggests several conclusions. First, buyers must carefully assess their business plans before signing a deal and in a case of a low relatedness to

acquired business the buyers should evaluate their strategy with the target companies. In case one and two the buyer's strategy simply did not fit the new market the buyers tried to get into, partly because lack of in-depth understanding of market dynamics and players. Second, buyers should craft a "build to order" integration strategy that takes into account specific organizational fit issue, balance short and long terms needs and should be driven by both the buyer and the target's management teams. Third, the acquirer and the target's management must work together to create an environment of a true partnership between the firms to enable a successful acquisition.

REFERENCES

- Bower, J.L. 2001, "Not all M&As are alike--and that matters", *Harvard business review*, vol. 79, no. 3, pp. 92-101, 164.
- Brakman, S., Garretsen, H. & Van Marrewijk, C. 2008, *Cross-border mergers and acquisitions*, Tinbergen Institute.
- Cartwright, S. & Schoenberg, R. 2006, "Thirty years of mergers and acquisitions research: Recent advances and future opportunities", *British Journal of Management*, vol. 17, no. S1, pp. S1-S5.
- Creswell, J.W. 2009, *Research design: Qualitative, quantitative, and mixed methods approaches*, Sage Publications, Inc.
- Elo, S. & Kyngäs, H. 2008, "The qualitative content analysis process", *Journal of advanced nursing*, vol. 62, no. 1, pp. 107-115.
- Finkelstein, S. 2010, *Advances in mergers and acquisitions*, Emerald Group Publishing.
- Kale, P. & Puranam, P. 2004, "Choosing equity stakes in technology sourcing relationships: An integrative framework", *California Management Review*, Vol.46, No.3, Spring 200.
- Marks, M.L. & Mirvis, P.H. 2011, "Merge ahead: A research agenda to increase merger and acquisition success", *Journal of Business and Psychology*, pp. 1-8.
- Meglio, O. 2009, "MEASURING PERFORMANCE IN TECHNOLOGY-DRIVEN M&As: INSIGHTS FROM A LITERATURE", *Advances in Mergers and Acquisitions*, vol. 8, pp. 103.
- Patton, M.Q. 1990, *Qualitative evaluation and research methods*. Sage Publications, Inc.
- Philippe C. Haspeslagh, David B. Jemison 1991, *Managing Acquisitions: Creating Value Through Corporate Renewal*.
- Roll, R. 1986, "The hubris hypothesis of corporate takeovers", *Journal of business*, vol. 59, no. 2.

CLINICAL DECISION SUPPORT THROUGH THE AUTOMATED APPLICATION OF CLINICAL GUIDELINES

Erez Shalom

Ben-Gurion University
of the Negev
erezsh@bgu.ac.il

Yuval Shahar

Ben-Gurion University
of the Negev
yshahar@bgu.ac.il

Eitan Lunenfeld

Soroka Medical Center,
Ben Gurion University of
the Negev
lunenfld@bgu.ac.il

Key words: Medical Decision-Support Systems, Guideline Application, Knowledge Engineering, Medical Informatics, Telehealth

INTRODUCTION

Since the 1990s, there has been a growing interest in Clinical Guidelines (GLs), which are text document that describe the best evidence-based medical management or treatment for certain types of conditions or diseases. A recent report (Graham, et al. 2011) of the Institute of Medicine (IOM) suggests methods for developing GLs to ensure that these GLs will bring more evidence to bear on clinician and patient decision making, in order to reduce adverse events and costs. Clinicians, however, rarely have the time at the point of care to look up any text-based GL. Therefore, care providers, health care managers, and patients would highly benefit from a complete process that includes a formal, machine-comprehensible specification and representation of clinical GLs, and their automated dissemination, runtime application at the point of care, and retrospective quality assessment, by suitable decision-support systems (DSSs) (Elkin, et al. 2000, Rutten, et al. 2005, Isern, et al. 2008).

There are multiple approaches to the task of providing automated support for GL application (de Clercq, et al. 2004, Peleg, et al. 2003, Wang, et al. 2002); these approaches usually implement some version of the architecture shown in figure 1: They all include methods to convert the mass of free-text guidelines gradually into machine-comprehensible language in order to apply them. This process is called *knowledge acquisition* and is usually performed by a Medical Expert (ME) who is familiar with the GLs, and a Knowledge Engineer (KE) who is familiar with the formal representation language. During the knowledge acquisition process two types of knowledge are elicited: (1) *Declarative knowledge*—includes the definitions for medical concepts ("**What is**"). An example of declarative knowledge is the definition of "high blood pressure" in a particular context (e.g., pregnancy), given raw systolic and diastolic blood pressure values, and (2) *Procedural knowledge*— the decomposition of medical procedure ("**How to**"). An example of procedural knowledge is the specification of a daily work-up procedure for inpatient care. This knowledge is saved in a unified *Knowledge Base* (KB) (No. 1 in figure 1). In addition, this architecture includes an *Electronic Medical Record* (EMR) in which the patient data are stored and retrieved from (No. 2 in figure 1), and a GL-application engine that interprets the formal representation of the GL and sends recommendations accordingly to the GL (No. 3 in figure 1). The GL application engine obtains the procedural knowledge from the KB (for example the GL-based treatment plan for gestational diabetes), and applies it to a patient record that is retrieved from the EMR (for example, the patient's blood glucose history).

The application of the GL by the DSS engine can be initiated by the physician or by the patient, i.e., in a *User Driven* mode (for example, a physician who wishes to get the latest recommendations for treating gestational diabetes), or in a *Data Driven* mode, when for example, a new abnormal blood glucose value is entered into the EMR, initiating a new GL-application session. In addition, the GL-Based DSS engine can provide quality assessment reports for clinical administrators, based on the application log stored in the complementary data base (DB), which is created during the GL application process (No. 2 in figure 1).

We implemented this architecture in our Digital Electronic Guideline Library (DeGeL) (Shahar, et al. 2004), which supports all of the design time and runtime tasks involved in guideline-based care. The DeGeL framework's guideline knowledge-base and various task-specific tools were designed to handle all of the hybrid guideline representation levels, enabling incremental specification in collaborative fashion between the ME and KE. It includes a procedural and declarative knowledge-acquisition tool called GESHER [Shalom et al, 2008, Shalom et al, 2009, Hatsek et al, 2010] and a stand-alone GL application engine called Spock [Young et al, 2007]. We used the Asbru GL specification language (Miksch, et al. 1997), which was developed as part of the Asgaard project (Shahar, et al. 1998), as the GL formal representation language.

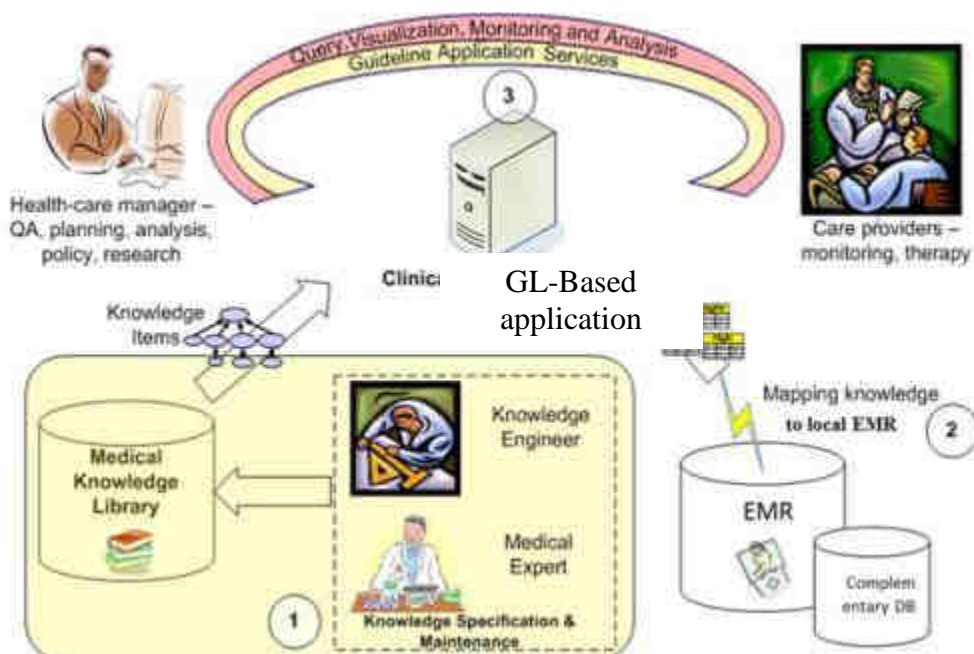


Figure 10. An abstract view of the architecture of knowledge-based medical decision-support systems

THE PICARD DSS: A MULTI-DIMENSIONAL FRAMEWORK FOR GL APPLICATION

Although it seems there are many GL-application frameworks, not many studies show their effectiveness, nor a resultant improvement in the quality of clinicians' decision making. For most of the frameworks, only a technical evaluation was performed, without evaluating a real or simulated multi-episodic interaction with physicians. In addition, there is a need to evaluate a GL application engine before applying it in a

real setting. Finally, such an engine should support longitudinal application over significant stretches of time.

Given these challenges, we developed a comprehensive detailed multi-dimensional framework, which supports GL-based care along several dimensions, such as different levels of formal specification of the GL, or of the medical record data, and implemented it through a new GL-application engine, the *PICARD Decision-Support System* (DSS) (Shalom et al 2013). We will briefly present two examples of the PICARD DSS implementation, in two different clinical domains.

Example 1: Using the PICARD DSS in the Cardiology Domain in a Telemedicine Setting

Figure 2 shows a prototype we had developed for a telemedicine call center, in which trained nurses can modify doses of drugs such as the *Coumadin* (*Warfarin*) anti-coagulant. For the patient at home, we had developed a mobile client application. The patients can use it every day, or whenever necessary, to transmit their weight, heart rate, and their systolic and diastolic blood pressure measurements to the call center via a telemedicine system. This application demonstrated the asynchronous mode of the PICARD DSS engine: the patient's data are constantly monitored, and when the patient is eligible to one or more GLs, a message is sent to their mobile. At the call center, the nurse can browse the transmitted clinical data using time-oriented visualization graphs; quick patient-state indications are provided through context-specific colored labels. For example, the blue label at the upper-right corner in figure 4 indicates that the patient is out of the target INR using. When the nurse initiates a telemedicine call with a patient who is taking Coumadin she might apply the GL for Coumadin dosing using the PICARD DSS engine. As a potential result, a set of recommendations, alerts, or notifications for changes of doses are sent to the mobile phone of the patient. In addition, the recommended schedule for taking the drugs and other daily activities is set at the mobile phone's calendar.

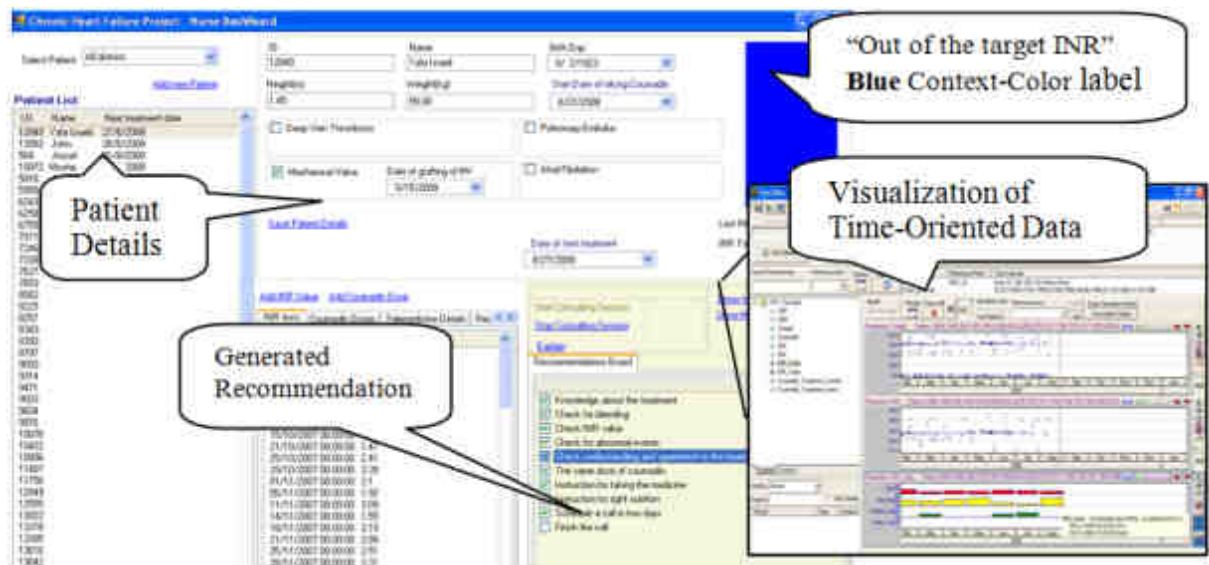


Figure 2. Supporting nurses in a cardiology telemedicine call center. The consultation "dashboard" is on the left. The visualization tool is on the right.

We performed a technical evaluation of the cardiology call center framework using 73 enhanced patient records, 36 potential scenarios of treatments of the Coumadin GL, and several specific complex cases that were embodied within the patient records. All sample cases were applied correctly by the PICARD DSS engine, as confirmed by the health-maintenance organization's senior cardiologist, who served as our main domain expert. The call center implementation provided us with better insights into the needs of realistic GL application. For example, the importance of supporting several different *user types* (e.g., a physician, a nurse, and a *patient* who can get a recommendation through her mobile phone), as well as different *interaction modes* (e.g., answering a query initiated either by the nurse or a patient, versus responding to a data-driven alert raised by an abnormal laboratory test result inserted into the patient's record).

Example 2: Using the PICARD DSS in the Preeclampsia/Toxemia Domain in a Hospital

In the second example, we have designed and implemented an evaluation methodology to answer three specific research questions, defined in the context of the framework: 1) Is the overall multi-dimensional framework for GL application feasible? 2) Does it improve the physicians' compliance to GL recommendations? 3) Is the framework considered helpful by the clinicians?

To address those three research questions, a study was performed using the preeclampsia/eclampsia/toxemia (PET) GL. This included performing first a technical evaluation of the PICARD DSS by a new simulation engine developed in our laboratory, using 20 guideline-based simulated scenarios. Then, a functional evaluation of the multi-dimensional framework was performed through the automated generation of patient records that simulated six clinical guideline-based scenarios and a total of 60 decision points. Finally, a cross-over "in-vitro clinical evaluation" was performed with the help of 36 different clinicians at the OB/GYN department of the Soroka Hospital, Ben Gurion University's academic medical center. Each clinician managed half of the scenarios (a total of 30 decision points) manually without using the PICARD DSS, i.e., in a *Non-DSS mode*, and half (for a total of another 30 decision points) using the PICARD DSS, i.e., in a *DSS mode*. *Correctness* and *completeness* of the actions relative to the GL were used as the main measures to assess the quality of management in both DSS mode and non-DSS mode, by comparing them to a GL-based gold standard. A subjective questionnaire was also administered to the practitioners to assess the subjects' perceptions regarding the use of the DSS. Sessions were held in the clinicians' common office in the Obstetrics ward.

Results: Mean completeness level rose from 0.4725 ± 0.25 in the Non-DSS mode to 0.9334 ± 0.06 in the DSS mode. Correctness rose from 0.3274 ± 0.22 in the Non-DSS mode, to 0.9911 ± 0.01 in the DSS mode, for every scenario, for every clinician, for every level of training, and for every decision type. Variance across all aspects was significantly reduced for both measures when using the DSS. Thus, the GL-based PICARD DSS creates an independence of the quality of the decision from any particular physician, clinical scenario, or decision type within a scenario. The mean subjective perception of the users of the DSS mode was higher (5.25 ± 1.21) than the

random mean of 4, on a scale of 1 to 7, where 1 is worst and 7 is best.

Currently, the PICARD DSS is a core component in the Seventh Framework EU MOBIGUIDE project (MobiGuide, <http://www.mobiguide-project.eu/>), which focuses on remote monitoring and care of chronic patients, using mobile devices to send GL-based alerts and reminders to the patients, and GL-based recommendations to their care providers.

REFERENCES

- De Clercq, P. A., Blom, J. A., Korsten, H. H. M., & Hasman, A. (2004). Approaches for creating computer-interpretable guidelines that facilitate decision support. *Artificial Intelligence in Medicine*, 31(1), 1-27.
- Elkin, P., Peleg, M., Lacson, R., Bernstam, E., Tu, S., Boxwala, A., Shortliffe, E. (2000). Toward standardization of electronic guideline representation. *MD Computing*, 17(6), 39-44.
- Graham, R., Mancher, M., Wolman, D. M., Greenfield, S., & Steinberg, E. (2011). *Clinical practice guidelines we can trust* Natl Academy Press
- Hatsek A, Shahar Y, Taieb-Maimon M, & al. (2010). A scalable architecture for incremental specification and maintenance of procedural and declarative clinical decision-support knowledge. *The Open Medical Informatics Journal*; 4, 255.
- Isern, D., & Moreno, A. (2008). Computer-based execution of clinical guidelines: A review. *International Journal of Medical Informatics*, 77(12), 787-808.
- Miksch, S., Shahar, Y., & Johnson, P. (1997). Asbru: A task-specific, intention-based, and time-oriented language for representing skeletal plans. Paper presented at the Proceedings of the 7th Workshop on Knowledge Engineering: Methods & Languages (KEML-97), 9.
- MobiGuide. Retrieved from <http://www.mobiguide-project.eu/>
- Peleg, M., Tu, S., Bury, J., Ciccarese, P., Fox, J., Greenes, R. A., Kumar, A. (2003). Comparing computer-interpretable guideline models: A case-study approach. *Journal of the American Medical Informatics Association*, 10(1), 52.
- Rutten, F., Brouwer, W., & Niessen, L. (2005). Practice guidelines based on clinical and economic evidence. *The European Journal of Health Economics*, 6(2), 91-93.
- Shahar Y, Miksch S, Johnson P.(1998) The Asgaard project: A task-specific framework for the application and critiquing of time-oriented clinical guidelines. *Artificial Intelligence in Medicine*; 14(1), 29-51.

Proceedings of the 7th ILAIS Conference, July 1, 2013, Ruppin

Academic Center, Emek Hefer, Israel

- Shahar, Y., Young, O., Shalom, E., Galperin, M., Mayaffit, A., Moskovitch, R., & Hessing, A. (2004). A framework for a distributed, hybrid, multiple-ontology clinical-guideline library, and automated guideline-support tools. *Journal of Biomedical Informatics*, 37(5), 325-344
- Shalom E, Shahar Y, Taieb-Maimon M, & al. (2008) A quantitative assessment of a methodology for collaborative specification and evaluation of clinical guidelines. *Journal of Biomedical Informatics*; 41(6), 889-903.
- Shalom E, Shahar Y, Taieb Maimon M, & al. (2009) Ability of expert physicians to structure clinical guidelines: Reality versus perception. *Journal of Evaluation in Clinical Practice*; 15(6), 1043-1053.
- Young O, Shahar Y, Liel Y, & al (2007) Runtime application of hybrid-asbru clinical guidelines. *Journal of Biomedical Informatics*; 40(5), 507-526.
- Shalom, E., Friedman, I., Shahar, Y., Hatsek, A., and Lunenfeld, E. (2011). Towards a realistic clinical-guidelines application framework: Desiderata, Applications, and lessons learned. *Proceedings of the 3th international workshop on knowledge representation for health care (KR4HC'11)*, Bled, Slovenia. Published in: Lenz, R., Miksch, S., Peleg, M., Reichert, M., Riaño, D., and ten Teije, A. (eds): *Process Support and Knowledge Representation in Health Care. Revised selected papers from the Proceedings of the BPM 2012 Joint Workshop, ProHealth 2012/KR4HC 2012*, Tallinn, Estonia. *Lecture Notes in Artificial Intelligence* 7738, Springer-Verlag, Berlin, Heidelberg, 2013, pp. 56-70.
- Wang, D., Peleg, M., Tu, S. W., Boxwala, A. A., Greenes, R. A., Patel, V. L., & Shortliffe, E. H. (2002). Representation primitives, process models and patient data in computer-interpretable clinical practice guidelines: A literature review of guideline representation models. *International Journal of Medical Informatics*, 68(1-3), 59-70.