

Association for Information Systems

**AIS Electronic Library (AISeL)**

---

ICEB 2004 Proceedings

International Conference on Electronic Business  
(ICEB)

---

Winter 12-5-2004

## **Extracting Requirements for Ubiquitous Computing Technology-based IS Using Factor Analysis**

Natalia Em

Euiho Suh

Keedong Yoo

Follow this and additional works at: <https://aisel.aisnet.org/iceb2004>

---

This material is brought to you by the International Conference on Electronic Business (ICEB) at AIS Electronic Library (AISeL). It has been accepted for inclusion in ICEB 2004 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact [elibrary@aisnet.org](mailto:elibrary@aisnet.org).

# Extracting Requirements for Ubiquitous Computing Technology-based IS Using Factor Analysis

Natalia Em, Euiho Suh, Keedong Yoo

Dept. of I.E., Pohang University of Science and Technology, 790-784, Republic of Korea  
{natalia, ehsuh, kdy}@postech.ac.kr

## ABSTRACT

The paper describes a methodology for extracting the requirements for ubiquitous computing technology-based information system (IS) using factor analysis. The early idea of ubiquitous computing was articulated by Mark Weiser in 1988 and since then has been constantly developed. However, so far there was no any or few research on application of ubiquitous computing to IS. Prior to the development of a ubiquitous computing-based IS model necessary requirements are to be identified. To derive the requirements we refer to conventional research on ubiquitous computing, ubiquitous service and ubiquitous environment, and hence, to their characteristics. Having specified those requirements using factor analysis technique it will be easier to develop a consistent ubiquitous computing-based IS.

**Key words:** ubiquitous computing, information system (IS), factor analysis.

## 1. INTRODUCTION

In this paper we attempt to develop a methodology in order to identify the requirements for ubiquitous computing-based IS with the help of data analysis. Numerous projects and research were done in the field of ubiquitous computing, service and environment since the first attempts to identify ubiquitous computing concept have been undertaken by Mark Weiser. Conventional research can be categorized into four main areas: U-Device, U-Environment, U-Media and U-People [14]. With ubiquitous computing advent research was mainly focused on creating a proper hardware such as active badges, beacons, smart tags (U-Device). Meanwhile, other explorations were undertaken in developing ubiquitous computing technology-enabled environments, so called "smart environments" (U-Environment). Yet, U-Media area has not progressed as much because of "users' often conservative attitude toward new media, as well as the technical complexity in fitting the new types of media to users" [15]. Despite some technical complexity, researches concentrated on the development of new concepts of interface patterns for users with disabilities are conducted in U-People field.

However, only few works have been carried out towards the connection of the notions of ubiquitous computing and IS so far. One can try to develop a model of IS based on ubiquitous computing technology. Still, before one does this, the requirements for such a model are to be defined. Otherwise, ignoring the requirements can lead to development of an inconsistent model.

In order to derive the requirements specific for the development of ubiquitous computing-based IS related

literature, namely, conventional literature on ubiquitous computing must be examined. Having reviewed the literature we then outline certain characteristics and

features that are intrinsic to ubiquitous computing. Out of the multiple characteristics it becomes possible to determine particular keywords that can serve as a platform for formulating necessary requirements for ubiquitous computing-based IS.

For obtaining the requirements a formal tool should be used. Factor analysis is one of them since it is a statistical tool that is determined to reduce the number of variables as well as to detect structure in the relationships between variables.

The remainder of the paper is organized as follows. Section 2 reveals related works. Section 3 is dedicated to the methodology. Finally, section 4 concludes the paper with summary and future work.

## 2. RELATED RESEARCH

### 2.1 Ubiquitous Computing

The concept of ubiquitous computing was first proposed by Mark Weiser in early 1990s. In his early works he describes ubiquitous computing or "Ubicomp" as a way to augment computer usage by "making many computers available throughout the physical environment, but making them effectively invisible to the user" [12, 13]. The technology requirements comprise three aspects: cheap, low-powered computers with convenient displays, a network that unites them as well as software systems implementing ubiquitous applications [14].

Hence, multiple issues have arisen with the advent of ubiquitous computing, particularly related with the development of proper hardware and devices, software and applications, environment, etc. Beader et al. [2] in their research investigate the usage of mobile location aware systems equipped with Badge based location and environment sensors where they tried to overcome the

deficiencies connected with environment awareness. Xerox PARC carried out explorations of the capabilities of mobile computers in an office setting which have resulted in the development of PARCTAB system prototype [11]. Narumi et al. [9] pose the technology requirements for ubiquitous environment and describe Fujitsu's real-time communicator ubiquitous middleware. Meanwhile, the FUSE (Future Ubiquitous Service Environment) group's focus is software architectures for ubiquitous service environments designing as well as privacy and context sensitivity [8]. Epp [5] stresses privacy and authenticated identity issues within ubiquitous environment. Burrell et al. [3] discuss the design and development of Semaphore, a contextually aware application for use in wireless networked environments.

## 2.2 Ubiquitous IS

As it was mentioned above, only few explorations have been done in this direction. However, we give a brief description of more or less corresponding works. "Docodemo-Display" is one of them and is a recently developed ubiquitous IS. It is a display-centric communication system, which is portable, interactive, and collaborative [10]. The goal of "Docodemo-Display" System is to increase the value of the place with helping to form local communities at that place. Another research is by Balke et al. [1]. In their work "A Situation-aware Mobile Traffic Information System" they present a prototype of traffic IS offering advanced personalized route planning, including added service like traffic jam alerting by means of SMS.

## 2.3 Factor analysis and Its Applications

Factor analysis is a branch of applied mathematics [6] and is generally referred to as a statistical tool for reduction of the number of variables and structure detection in the relationships between variables. First applied in psychology this method quickly became popular in other fields like economics, medicine, sociology, etc. as they often need to outline dominating factors out of huge volumes of variables they have to operate with.

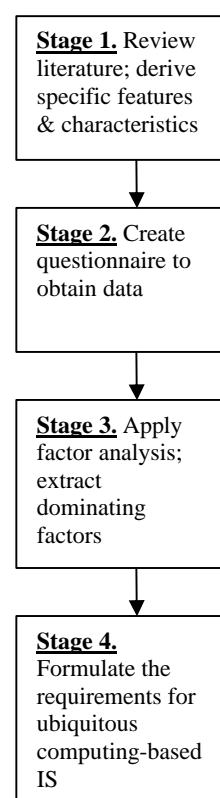
One of the conventional works using factor analysis describes the application of the latter to tests on Cheshire cheese [7]. The study reveals the relationships between a number of rheological experiments and essential subjective judgments on cheese. Another research applies factor analysis to psychological diagnostics [4] and particularly to the development of psychological tests and models such as the Cattell 16 Personal Factors model.

Numerous studies in various fields using factor analysis can be found. However, no studies seem to be carried out towards extracting the requirements for ubiquitous computing technology-based IS using factor analysis.

## 3. METHODOLOGY

Owing to well-developed concept we find factor analysis applicable to extracting essential requirements for ubiquitous computing-based IS. However, due to impossibility to collect data necessary for conducting empirical tests in a short period of time we describe only a methodology that comprises several stages (Figure 1). The first stage considers reviewing conventional literature in ubiquitous computing, services or environment fields and deriving specific features and characteristics. Next, on stage two we create a questionnaire for the experts in the related fields. The questionnaire will include the list of the derived features and characteristics that must be evaluated by the experts in terms of their significance. Having done this, we will get a data sample. The data will perform experts' estimations of the characteristics in scores. Having obtained the essential data we then apply factor analysis on stage three and extract dominating factors. Eventually, on stage four, relying on the results of factor analysis we formulate the requirements for ubiquitous computing-based IS.

Figure 1. Methodology of extracting the requirements to ubiquitous computing-based IS.



## 4. SUMMARY AND FUTURE WORK

The fact that very few works can be found on application of ubiquitous computing to IS and, therefore, the requirements for such an IS are not clearly articulated, makes this paper unique for it aims to

extract and classify those requirements. In this paper we delineate a general methodology of extracting the requirements using such a common statistical tool as factor analysis.

The future work within the research will lie in applying the described methodology to practice. Probably the most time-consuming stage will be collecting necessary data as it requires direct participation of respondents. However, having done this, it will be possible to acquire significant results which, in turn, will make a valuable contribution in ubiquitous computing-base IS development.

### REFERENCES

- [1] Balke, W.-T, Kiebling, W., Unbehend, C., "A Situation-aware Mobile Traffic Information System", *proceedings of the 36<sup>th</sup> Hawaii International Conference on System Sciences*, 2002
- [2] Beadle, Peter H. W., Maguire Jr., G. Q., Smith, M. T., "Location Base Personal Mobile Computing and Communication", [http://www.it.kth.se/~maguire/LocationAware/ieee\\_lan\\_98/](http://www.it.kth.se/~maguire/LocationAware/ieee_lan_98/), 1998
- [3] Burrell, J., Treadwell, P., Gay, Geri K., "Designing for Context: Usability in a Ubiquitous Environment", [http://www.hci.cornell.edu/LabArticles/DesigningContext\\_Burrell.pdf](http://www.hci.cornell.edu/LabArticles/DesigningContext_Burrell.pdf)
- [4] Chaplina, G., "Application of Factor Analysis in Psychological Diagnostics", <http://www.monax.ru/eleme.cgi?1889>, 2001 (in Russian)
- [5] Epp, E. C., "Relationship Management: Secure Collaboration in a Ubiquitous Environment", *Pervasive Computing Mobile and Ubiquitous Systems*, Apr-June 2003
- [6] Harman, H. H., *Modern Factor Analysis*, Chicago: The University of Chicago Press, 1976
- [7] Harper, R., Baron, M., "The Application of Factor Analysis to Tests on Cheese", *British Journal of Applied Physics*, Vol., 2, pp 35-41, 1951
- [8] Jansson, C. G., Lonnqvist, P., "Ubiquitous Service Environments", *ERCIM News*, No. 47, October 2001
- [9] Narumi, K., Yuhara, M., Matsumoto, T., "Technology Requirements for Ubiquitous Environment and Fujitsu's Realtime Communicator Solution", *Fujitsu Sci. Tech. J.*, 40, 1, pp 29-34, June 2004
- [10] Sekiguchi, T., Iguchi, S., Ishii, M., Maeoka, J., Ito, A., Furuhashi, T., "A Display Centric Ubiquitous Information System-"Docodemo-Display", *Symposium on Applications and Internet-WorkShops (SAINT 2004 Workshops)*, <http://csdl.computer.org/comp/proceedings/saint-w/2004/2050/00/20500709abs.htm>, January 2004
- [11] Schilit, B., Want, R., "The Xerox PARCTAB", <http://sandbox.parc.xerox.com/parctab/parctab.html>, 1995
- [12] Weiser, M., "Hot Topics: Ubiquitous Computing", *IEEE Computer*, October 1993
- [13] Weiser, M., "Some Computer Science Issues in Ubiquitous Computing", *Communications of the ACM*, July 1993
- [14] Weiser, M., "The Computer for 21<sup>st</sup> Century", <http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html>
- [15] Yoo, K., Kwon, O., Suh, E., "UbiDSS: A Proactive Intelligent Decision Support System as an Expert System Deploying Ubiquitous Computing Technologies", 2004 (to be appeared)