# A Study on Effective Proactive Service in Pervasive Computing Environment

**Joonhee Kwon**

Department of Computer Science, Kyonggi University,
San 94-6, Yiui-dong, Yeongtong-ku, Suwon-si, Kyonggi-do, Korea

**Summary**
Pervasive systems are becoming increasingly popular, with the appearance and penetration of mobile devices such as smart phones. Proactive service is one of the most important fields of research in pervasive computing. We propose a method for an effective proactive service in pervasive computing environment. Most of previous researches do not consider characteristics of both social network and context aware computing. For proactive service, we consider context-aware computing in pervasive computing environment. Moreover, we use social network for proactive service. Our method provides service proactively for each user's context using social relationship.

***Key words:***
*Proactive Service, Pervasive Computing, Context-aware Computing, Social Network Service*

## 1. Introduction

Pervasive computing is about making our lives simpler through digital environments that are sensitive, adaptive, and responsive to human needs [1]. A pervasive computing environment is characterized as one saturated with computing and communication capability. So, pervasive computing is gracefully integrated with users that it becomes 'a technology that disappears [2].

Pervasive computing is complex because it is proactive. Intelligent environments are a prerequisite to pervasive computing. Context-awareness is an intrinsic characteristic of intelligent environments [1].

Context-aware systems offer entirely new opportunities for application developers and for end users by gathering context data and adapting systems behavior accordingly. Especially in combination with mobile devices these mechanisms are of high value and are used to increase usability tremendously [3].

Context-aware systems require proactive information service, where information is presented to the user automatically [4]. Proactive system is intimately connected to the world around them, using sensors and actuators to both monitor and shape their physical surroundings [5]. In pervasive computing, context aware computing enables proactive system.

Recently, social network sites (SNSs) such as Facebook, Twitter, and LinkedIn have attracted millions of users [6]. Unlike the traditional Web, which is largely organized by content, online social networks embody users as first-class entities. Users join a network, publish their own content, and create links to other users in the network called 'friends' [7].

The social network services meet increasing needs of proactive service in context aware pervasive computing environment. However, context has rarely been incorporated into social proactive service so far. Physical context and social context can be useful sources for improving proactive service [8].

This paper proposes a method for effective proactive service in pervasive computing environment. Most of social proactive services are based on traditional recommender system such as collaborative filtering. However, our method uses characteristics of both social network and pervasive computing.

The main idea of the proposed method is consisted of the following three tasks. Firstly, social proactive information rules for each user are extracted. The rules are extracted from logged data. The rules use the friend relationship in social network and friend's context frequency. Secondly, using the proactive information rules, candidate information is extracted whenever user's context is changed. Finally, information is provided proactively to user considering limited resource of mobile device.

This paper is organized as follows. Section 2 introduces related works. Section 3 presents an effective proactive service in pervasive computing environment. Section 4 concludes our research.

Manuscript received August 5, 2012
Manuscript revised August 20, 2012

## 2. Related Works

### 2.1 Pervasive Computing

The term ‘pervasive’ introduced first by Mark Weiser refers to the seamless integration of devices into the user everyday life [9]. Computers are with us everywhere and we are aware of their increasing significance for our lives. One early view was expressed by Mark Weiser, who observed "that the most profound technologies are those that disappear", arguing for a vision of an unobtrusive computer technology called "calm technology" [10].

One field in the wide range of pervasive computing is the context-aware system. Context-aware systems are able to adapt their operations to the current context without explicit user intervention and thus aim at increasing usability and effectiveness by taking environmental context into account [3].

Context is any information that can be used to characterize the situation of an entity. An entity is any person, place or object that is considered relevant to the interaction between a user and an application, including the user and application themselves [11]. Context refers to the physical and social situation in which computational devices are embedded. One goal of context-aware computing is to acquire and utilize information about the context of a device to provide services that are appropriate to the particular people, place, time, events, and so forth [12].

The history of context-aware systems started when a research [13] introduced their Active Badge Location System which is considered to be one of the first context-aware applications. The infrared technology based system is able to determine a user's current location which was used to forward phone calls to a telephone close to the user. Context-aware systems dealing with location information are widespread and the demand for them is growing due to the increasing spread of mobile devices [3].

The use of different types of context atoms such as noise, light and location allows the combination to high-level context objects. As an example for this kind of context-aware infrastructures serves the system presented by [14], which extends the instant messaging paradigm by adding context-awareness to support information management within a hospital setting [3].

In recent pervasive computing, researchers have proposed vision, such as proactive computing. Proactive computing focuses on improving performance and user experience through speculative or anticipatory actions [15]. An active context-aware service not only describes applications that autonomously change their own content, but it can also trigger itself for proactive service [16]. Previous research [4] calls the active context-aware service 'proactive'. The 'push' approach described by [17] also uses the same 'proactive' concept, while passive context-aware and personalization services are described as the 'pull' approach.

### 2.2 Social Proactive Service

Social network sites (SNSs) are increasingly attracting the attention of academic and industry researchers intrigued by their affordances and reach. What makes social network sites unique is not that they allow individuals to meet strangers, but rather that they enable users to articulate and make visible their social networks [6]. Social networking is built on the idea that there is a determinable structure to how people know each other, whether directly or indirectly [18].

Social network service technology is in its infancy, but, it has many benefits. Adjacent users in a social network tend to trust each other more than random pairs of users in the network. A number of research systems have already been proposed to exploit this trust. Adjacent users in a social network also tend to share common interests. Users browse neighboring regions of their social network because they are likely to find content that is of interest to them [7].

Social recommender service is one of the most popular proactive services in social network. Social recommendation forms a specific type of information filtering technique that attempts to suggest information that is likely to interest the users. Social Recommendation involves the investigation of collective intelligence [19].

SocialFusion [20] is a framework to support context-aware inference and recommendation by fusing together mobile, sensor, and social data. SocialFusion consists of 3 stages: first, a data gathering and management stage, including a novel K-anonymization algorithm; next, an inference stage that fuses together the diverse data streams using describer modules to extract contextual clues called descriptors; finally, a recommendation stage that leverages the rich assembled data and descriptors to recommend a context-aware action.

SENSE(Socially ENhanced Search and Exploration) [21,22] provides an efficient top-k algorithm that dynamically expands the search to related users and tags. It is based on principles of threshold algorithms, folding related users and tags into the search space in an incremental on-demand manner, thus visiting only a small fraction of the social network when evaluating a query.

The core of SENSE scoring is formed by three different quantizations for friendship strengths, corresponding to the three different searches in communities.

Another approach described by Bender at al. [23] directly exploits social relations by combining semantic and social factors in the ranking. The users, tags and documents are represented as nodes in a friendship graph, in which edges are extracted from relationships like links, content, tagging and rating. Ranking is based on UserRank, an algorithm derived from the PageRank computation on the friendship graph. A document receives an extra friendship score when tagged by a user's friend.

## 3. Proactive Service in Pervasive Computing Environment

In this section we describe our method for effective proactive service in pervasive computing environment. For proactive service, we consider context-aware computing in pervasive computing environment.

Our method provides service proactively for each user's context. Moreover, we use social network for social proactive service. The method is comprised of three tasks. Figure 1 shows the overall tasks.

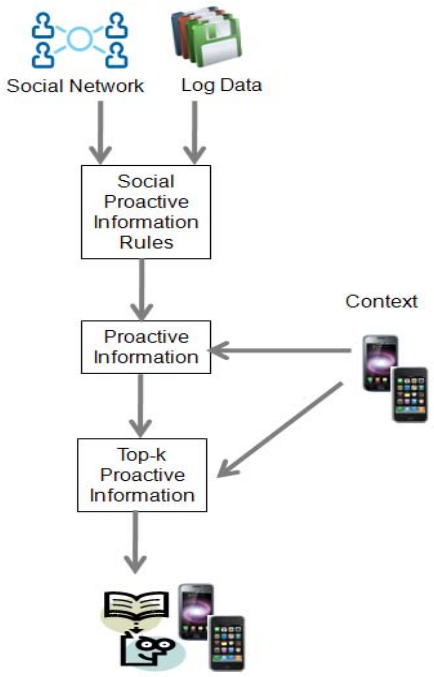


Fig. 1. Overall Proactive Service in Pervasive Computing Environment

First, social proactive information rules for each user are extracted. We consider social network for proactive service in pervasive computing environment. The rules are extracted from logged data using the friend relationship in social network. The left hand side of the rule is the context value and right hand side of it is the information with weight. The weight *W(u,c,i)* is computed using formula (1), where *W(u,c,i)* is weight for each user *u*, context *c* and information *i*.

$$W(u,c,i) = \sum_{y=1}^{F} (FS(u,y) \times Frequency(y, c, i)) \quad (1)$$

In formula (1), *FS(u,y)* is the friendship score, where it is proposed from previous research [24]. In this research, the friendship score, *FS(u,y)* is strength between user *u* and *u*'s friend *y* using physical and social contexts. The context is grouped into physical context such as the current user location, time, also social context such as the social network of the user [8].

The friendship score between user *u* and *u*'s friend *y*, *FS(u,y)* combines spiritual friendship score and social friendship score. The spiritual friendship is the relation based on similar behavior such as high overlap in tag usage. The social friendship is an explicit, user-provided relation.

*Frequency(y,c,i)* is the friend *y*'s frequency ratio of information *i* for context *c*. It is normalized by scaling between 0 and 1. *F* is the number of friends for a user *u* and *y* is a friend of user *u*.

Secondly, using the proactive information rules, candidate information is extracted whenever user's context is changed. The extracted information is ordered by the rule weight from first step. The information with higher weight value becomes more important than it with lower weight value.

In the third task, information is provided to users. In pervasive computing environment, a mobile device is usually used but it has limited resource. Therefore we limit the number of information according to resource for each device. In our method, only top k information with higher weight is provided. The number of k is determined by resource of mobile device.

## 4. Conclusion

Pervasive computing refers to the seamless integration of devices into the user everyday life. One field in the wide range of pervasive computing is the context-aware system.

In recent context aware computing, researchers have proposed vision, such as proactive computing.

Recently, social network sites (SNSs) are increasingly attracting the attention of academic and industry researchers. In these days, social network service requires proactive services in context aware computing environment.

There are a few previous researches in proactive service in social network and context-aware computing. However, most of previous researches do not consider characteristics of both social network and context aware computing.

We propose a method for effective proactive service in pervasive computing environment. As compared with previous research, our method uses social network and context in pervasive computing.

We depict overall tasks and describe detailed procedure. Our proposed method extracts social proactive information rules for each user. Then, using the proactive information rules, candidate information is extracted whenever user's context is changed. Finally, only top k information with higher weight is provided proactively.

In future work, we will implement our algorithm using both social network such as Twitter and contexts such as location. We also will make a prototype using our method. Moreover, we will extend this research on Web 3.0 technology.

## Acknowledgments

This work was supported by Kyonggi University Research Grant 2010.

## References

[1] Debashis Saha, Amitava Mukherjee, “Pervasive Computing: A Paradigm for the 21st Century”, IEEE Computer, IEEE Computer Society Press, Vol.36, No.3, pp. 25-31, 2003.

[2] M. Satyanarayanan, “Pervasive Computing: Vision and Challenges”, IEEE Personal Communications, Vol.8, No.4, 2001.

[3] Matthias Baldauf, Schahram Dustdar and Florian Rosenberg, "A survey on context-aware systems", International Journal Ad Hoc and Ubiquitous Computing, Vol.2, No.4, pp.263-277, 2007.

[4] P.J.Brown and G. J. F. Jones, "Context-aware retrieval: Exploring a new environment for information retrieval and information filtering", Personal and Ubiquitous Computing, Vol.5, No.4, pp.253-263, 2001.

[5] David Tennenhouse, "Proactive computing", communications of the ACM, Vol. 43, No. 5, pp. 43-50, 2000.

[6] Danah M.Boy and Nicole B. Ellison,”Social network sites: Definition, history, and scholarship”, Journal of Computer-Mediated Communication, Vol. 13, No. 1, pp.210-230, 2008.

[7] Alan E. Mislove, "Online Social Networks: Measurement, Analysis, and Applications to Distributed Information Systems", Ph.D. Thesis, Rice University, 2010.

[8] Wolfgang Woerndl and Georg Groh,“Utilizing Physical and Social Context to Improve Recommender Systems”, Proceedings of the 2007 IEEE/WIC/ACM International Conferences on Web Intelligence and Intelligent Agent Technology - Workshops, pp. 123-128, 2007.

[9] Mark Weiser, “The computer for the 21st century”, Scientific American, Vol.265, No.3, pp.94–104, 1991.

[10] Streitz, N. and Nixon, P., “The Disappearing Computer”, Communications of the ACM, Vol.48, No.3, pp. 32-35. 2005.

[11] Gregory D.Abowd, Anind K.Dey, Peter J.Brown, Nigel Davies, Mark Smith, and Pete Steggles, “Towards a Better Understanding of Context and Context-Awareness”, Lecture Notes In Computer Science, Vol. 1707, pp. 304-307, 1999.

[12] Thomas P. Moran, Paul Dourish, "Introduction to this special issue on context-aware computing", Journal Human-Computer Interaction, Vol.16, Issue 2, pp.87-95, 2001.

[13] Want, R., Hopper, A., Falcao, V. and Gibbons, J., “"The active badge location system"', ACM Transactions on Information Systems, Vol. 10, No. 1, pp.91–102, 1992.

[14] Miguel A. Muñoz, Victor M. Gonzalez, Marcela Rodríguez and Jesus Favela, “Supporting context-aware collaboration in a hospital: an ethnographic informed design”, Lecture Notes in Computer Science, Vol.2806, pp.330-344, 2003.

[15] M. Satyanarayanan, "A Catalyst for Mobile and Ubiquitous Computing", Pervasive Computing, IEEE, Vol. 99, No. 1, pp.2-5, 2002.

[16] Ohbyung Kwon, Keedong Yoo and Euiho Suh, "ubiES: An Intelligent Expert System for Proactive Services Deploying Ubiquitous Computing Technologies", Proceedings of the 38th Hawaii International Conference on System Sciences, pp.85-92, 2005.

[17] Keith Cheverst, Keith Mitchell and Nigel Davies, " Investigating Context-aware Information Push vs. Information Pull to Tourists", Proceedings of Mobile HCI, pp.1-6, 2001.

[18] Elizabeth F. Churchill, Christine A. Halverson, "Social Networks and Social Networking", IEEE internet computing, Vol. 9, No. 5, pp.14-19, 2005.

[19] Irwin King, Michael R. Lyu and Hao Ma., “Introduction to social recommendation”. Proceedings of WWW, pp.1355–1356. ACM, 2010.

[20] Aaron Beach, Mike Gartrell, Xinyu Xing, Richard Han, Qin Lv, Shivakant Mishra and Karim Seada, “SocialFusion:Context-Aware Inference and Recommendation By Fusing Mobile, Sensor, and Social Data”, Technical Report CU-CS 1059-09. University of Colorado at Boulder. Dec. 2009.

[21] Tom Crecelius, Mouna Kacimi, Sebastian Michel, Thomas Neumann,Josiane Xavier Parreira, Ralf Schenkel and Gerhard Weikum, "Making SENSE: Socially ENhanced

Search and Exploration", Proceedings of the VLDB Endowment, Vol. 1, No. 2, pp.1480-1483, 2008.
[22] Ralf Schenkel, Tom Crecelius, Mouna Kacimi, Thomas Neumann, Josiane Xavier Parreira, Marc Spaniol, and Gerhard Weikum, "Social Wisdom for Search and Recommendation", IEEE Data Eng. Bull., Vol. 31, No. 2, pp. 40-49, 2008.
[23] M. Bender, T. Crecelius, M. Kacimi, S. Michel, T. Neumann, J. X. Parreira, R. Schenkel and G. Weikum, “Exploiting social relations for query expansion and result ranking”, Proceedings of ICDE Workshops, pp.501-506, 2008.
[24] Joonhee Kwon, Sungrim Kim, “Friend Recommendation Method using Physical and Social Context”, International Journal of Computer Science and Network Security, Vol.10, No.11, pp.116-120, 2010.

**Joonhee Kwon** received the B.S., M.S., and Ph.D. degrees in Computer Science from Sookmyung Women’s University, Seoul, Korea in 1992, 1994 and 2002, respectively. She is currently an associate professor, Department of Computer Science Kyonggi University, Suwon-si, Kyonggi-do, Korea, Her research interests are ubiquitous computing, social network services, information retrieval, context-aware computing, mobile computing, spatial database.