A Situation Aware Personalization in Ubiquitous Mobile Computing Environments

Heeseo Chae[1], Do-Hoon Kim[1], Dongwon Jeong[2], and Hoh Peter In[1,*]

[1] Department of Computer Science & Engineering, Korea University,
1, 5-ka, Anam-dong, Sungbuk-ku, Seoul, 136-701, Korea
{royalhs, karmy01, hoh_in}@korea.ac.kr
[2] Dept. of Informatics & Statistics, Kunsan National University,
San 68, Miryong-dong, Gunsan, Jeollabuk-do, 573-701, Korea
djeong@kunsan.ac.kr

Abstract. The mobile internet environment which is in the limelight as the important platform of the ubiquitous environment gets accomplished by the intimate relation with user. In order to realize the interaction between device and user, it is considered that resource of exterior/interior user information which can be collected by mobile device and the situation-aware (SA) personalization is suggested by applying the context set of collected current situation to the concept of situation-aware. Such a SA personalization is designed to offer advanced personalization using Link Retrieving Algorithm which is emphasized on prospecting. And the Markov Chain Model, prospecting matrix system, is used to support the SA personalization. Using SA personalization system, the custom service which is well-matched on the ubiquitous era and founded on user's current situation will be offered.

Keywords: Situation Aware, Personalization, Prospecting service, Ubiquitous.

1 Introduction

A purpose of ubiquitous environment is accessing to various user-centered information above times and places, and an interaction between diversity devices makes progress to construct the environment. A representative example among the diversity devices is a mobile device and it can build a wide scope computing platform that will become a base of ubiquitous environment through mutuality access and connection between mobile and internet by spread of wireless network.

However, there are fundamental limitations inherent in the wireless Internet access using small handheld devices and wireless networks. Small handheld devices share limitations such as tiny display screens, limited input, less powerful processors, and smaller memories. In order to bring desktop web experience to mobile devices, several wireless web technologies have been developed. These technologies enable users to access desktop-based web contents of existing web sites (currently dominant in the Internet) and mobile web contents of emerging wireless web sites specialized for wireless access through handheld devices. The desktop-based web contents tend to be

* Corresponding author.

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too large to be displayed on a tiny screen. Thus, the contents are split into a small size of multiple pages, each of which is better suited for small displays [1]. In order to support the approach, a concept of situation-aware is imported into a web access process which is suitable for mobile environment. And then it is able to furnish the user-centered personalization service due to the collected data set of exterior situation or data set of user's profile is accepted as a form of sequence of context set. In this connection, prospecting solution of requirement site is provided by Markov Chain Model to be able to approach the necessary information among produced information.

2 The Context: Situation-Awareness and Personalization

2.1 Overview of Situation-Awareness

The most promising issue of the existing research topics related to ubiquitous computing is Situation-Awareness. It plays a role to analyze and understand the relation between actions and multi-contexts in the user viewpoint [1]. In ubiquitous computing environments , where computing resources are available everywhere and a great amount of mobile devices play important roles, middleware serves as an essential infrastructure between networks and ubiquitous computing applications. It hides the heterogeneity of the network environments and provides necessary services to ubiquitous computing applications, such as communication, data access, resource control, and service discovery.

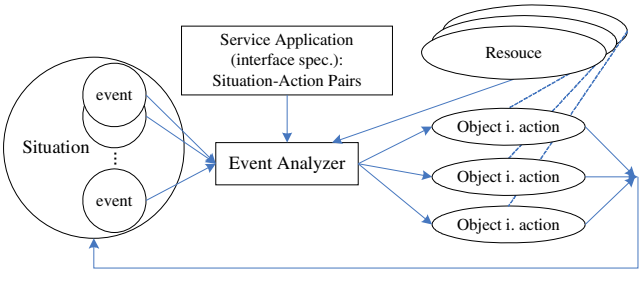


Fig. 1. The Conceptual Model of Situation Awareness (revised)[4]

The conceptual model of situation awareness is depicted in Figure 1. The changes of situation create a set of "situation change" events. The events are captured by an event analyzer, which makes decision on how to react to these events. The event analyzer makes decisions based on an event analyzing plan that prepared beforehand, i.e., the specification of a set of "situation-action" pairs. Since each action requires certain resources, the event analyzer also checks the available resources to ensure that required resources are available before taking any action. Furthermore, the actions eventually taken are also regarded as elements that compromise new situations, and form new events. Situations are used widely in describing different configurations, computing resource availability, dynamic task requirements, environmental conditions, and application conditions [4].

2.2 Personalization

Personalization of services is to adapt services to fit the needs and preferences of a user or a group of users. Personalization is important in today's service-oriented society, and has proven to be crucial for the acceptance of services provided by the Internet and mobile telecommunication networks [5]. In, taxonomy of resource for personalization is given, and two important categories of personalization are given:

- **Exterior Resource Based Personalization**
  The truly example of offering personalization using Exterior resource is a Local Based System(LBS) and this is a technology to measure the mobile device using mobile communication facilities or satellite signal and furnish various service related location which is measured [6].
- **Interior Resource Based Personalization**
  The Interior resource for personalization service is mainly composed of user's static information using profiling. It contains capability of user's device, user preference and user's basic information. The common collection method of profile is a statistical analysis of user's utilization degree, requirement information analysis of transmission and user's directly input [7].

Such divided personalization approaches can be regarded resource providers from a situation-aware view. Therefore two existing approaches for acquisition of user's situation information resource are unified by situation-aware and the concept of situation aware personalization is derived on the background of various resources. also collected resources of user's situation information by each approach will decide value of ρ, situation factor.

3 A Situation-Aware Personalization: The Proposed Model

3.1 Overview

A feature of Situation-aware personalization is prospecting of user's requirement in order to furnish the better user-centered service using various resources. This concept means that providing a simple site in the view of handheld device user and representing a site on the prospected process. The entire operating model including system architecture of SA personalization explains the connection between mobile and internet through middleware interface such as gateway and controller. Also the interaction between some essential parts playing an important role and extractor is described below.

The formation process of access pattern graph is described in the architecture which is composed of the connection the access analyzer and the controller, and wireless/internet gateway and storage. Also supporting a personalization by the calculation of parsed pattern, situation sequence and user context set is expressed. Finally prospecting the expected site of next stage by prospecting matrix using pattern log and node state is an entire operating model of SA personalization such as figure 2.

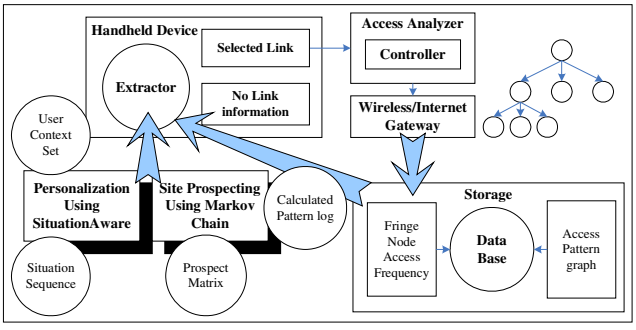


Fig. 2. Operating Model of SA Personalization

3.2 A Definition of Prospecting in Situation-Aware Personalization

The Prospecting means that providing a user's next requirement in advance by grasping the pattern of web access data which is stored as time goes by. This web access pattern can be generalized the state diagram like figure3. Also there are various approaches for the prospecting but this paper suggests the algorithm to calculate a general pattern fitted for mobile environment using web access data and prospect the next state of the pattern using Markov chain model.

The target is a URL of the intended web page that the user wants. The source is a web page containing the link to the target. When a user enters the target or selects from an initial page, NULL is recorded as the source. The initial page is displayed when the handheld device is connected to the wireless network of the service provider. It contains lists of links that the user frequently visits.

S1 of Figure3 is initial state and S6 is a new state which can be prospected on the basis of pattern. On this approach, the recorded user pattern is offered prospecting service which is the final stage of SA personalization through Link Retrieving Algorithm (personalization algorithm) showed on chapter 4.

Table 1. Example of Access Data Record

Status	Record description
State1	[phone number, embedded.korea.ac.kr, NULL, 10:00AM, Home]
State2	[phone number, embedded.korea.ac.kr / SituationAware, embedded.korea.ac.kr, 12:00AM, Home]

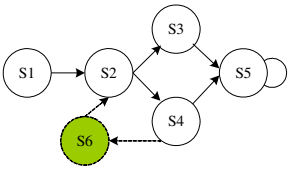


Fig. 3. General State Diagram for Prospecting

3.3 The Prospecting Mode Based Situation-Aware Personalization

The prospecting model can be made up using definition of prospecting as stated above. The records structuring unit is responsible for representing the access records stored for the predetermined period of time based on the time slot of a day and the physical location that the user made in his/her particular requests. The web access pattern of a particular user is represented as a connected and directed graph, where nodes represent URLs and each edge represents source and target relationships of web access between any two nodes

Figure4 illustrates an exemplary access pattern graph, where each edge is annotated with a numeric edge value representing its usage factor. The usage factor represents frequency of access to the target node from the source node of a particular edge for the predetermined period of time. Each node represents a URL of a web page, but for the sake of simplicity, most of the nodes are not illustrated with full URL. It is assumed that the *SA Personalization* system keeps track of full URL

The prospecting model is represented through transforming a state transition diagram described by definition of prospecting into a graph. Also the Link Retrieving Algorithm is suggested and the SA personalization based on the prospecting is depicted through this model.

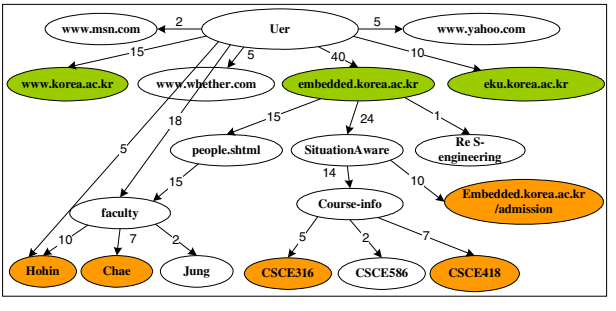


Fig. 4. Web Access Pattern Graph for Prospecting

4 Personalization Algorithm

4.1 Overview of Personalization Algorithm

The procedure of core algorithm, Link Retrieving Algorithm, to reflect the situation information into user's access pattern and prospect the user requirement can be summarized as follows:

Step 1: Determine a set of neighbor nodes, each of which has an edge incoming from the requested node and its edge value is greater than or equal to a threshold.
Step 2: Present states by set of determined neighborhood nodes and prospect the next state by Markov chain.
Step 3: Repeat Step 1 for each sub graph, each of whose root is a node in the set determined at Step 1.

Let N be a set of nodes comprising the web access graph. Let node v be a fringe node of node u if and only if v is included in the set N and $e\ (u,v) > 0$, where $e\ (u,v)$ represents the value of an edge. Outgoing edges from node v are defined as edges between node v and its fringe nodes. Total outgoing edge value for node v is defined as the sum of the edge values of its outgoing edges. The fringe nodes whose edge value are greater than or equal to the threshold are selected. The threshold θ provides a criteria for selecting frequently accessed nodes from the requested node, and it can be calculated as follows:

$$\theta = ((\text{Total Outgoing Link Value}) * \rho) / (\text{Number of Outgoing Links}),\ 0 \leq \rho \leq 1 \qquad \text{(Formula 1)}$$

ρ is a selection factor, which is a predetermined yet adjustable value. The threshold θ can be changed by varying ρ, affecting selection of nodes. These change of ρ values are effected by reasoned Situation Information [4] from various resources and produced value of $0 \leq \rho \leq 1$[2] In this paper, access frequency is used to represent link usage, but it can be combined with other attributes or weights based on system resources and network environment. Also, it is investigated the pattern of node path at this process and it is able to get hold next step node using Markov Chain. The algorithm used in link retrieving is described below:

Link Retrieving Algorithm:

0. Create an empty list;
1. Set an anchor with the requested node;
2. Determine Selection Factor ρ according to Situation information;
3. Calculate θ for the anchor;
4. Select a set of nodes, each of whose incoming edge has a value greater than or equal to θ and adds the nodes into the list;
5. For each of the nodes in the set selected at step 3,
5.1 update the anchor with each node in the set;
5.2 catch the state of updated nodes and get the prediction value sepa rately using Markov Chain.
5.3 repeat steps 3, 4, and 5.

Experiment result of chapter 5 illustrates exemplary linkage information displayed on a mobile handheld device according to the *SA Personalization* operation with the access graph shown in Figure 4.When the user is connected to the wireless network of the service provider, the threshold is $\theta = (2+15+5+18+5+40+10+5) * \rho / 8$. If we consider the selection factor (current situation information) $\rho = 0.8$, then $\theta = 10$. Thus, nodes {embedded.korea.ac.kr}, {www.korea.ac.kr}, {eku.korea.ac.kr}, and {faculty}, which are rooted from node 'User' (saying, "phone number") and whose values are greater than or equal to θ (e.g., 10), are first selected. In this example, only node {embedded.korea.ac.kr} has an outgoing edge, so the link retrieving process continues with the sub graph, which is rooted at the node, {embedded.korea.ac.kr}. Similarly, when a user selects a link from the screen, the same link retrieving procedure is applied. The Controller wraps the links in the selected nodes and sends them to the user for display.

4.2 Applying Markov Chain to Personalization Algorithm

In this section, the Markov Chain model which is an important part of prospecting algorithm is described on the line of Link Retrieving Algorithm

If the Markov Chain model was inducted based on the selecting node algorithm on the standard of threshold θ then the next node, the next step site selected by user, can be predicted. One way to do this is to assume that the state of the model depends only upon the previous states of the model. This is called the Markov assumption and simplifies problems greatly. When considering the SA personalization, the Markov assumption presumes that current node can always be predicted solely given knowledge of the node of the past few nodes (web site). Defined first order Markov process consisting of SA personalization is described below:

- **States:** Web-Page1 (linked), Web-Page2 (linked), ….. Web-Page n (linked).
  Transitions for SA personalization in Figure 5 are converted into a state transition diagram in Figure 6(a) without loss of meaning. Note that the transition probabilities from state $s_{A,2}$ to states $s'_{A,1}$, $s_{A,3}$, $s'_{A,4}$, and $s_{A,5}$ are p_{21}, p_{23}, p_{24}, and p_{25}, respectively, in Figure 6(a). The state transition diagram in Figure 6(a) can also be assumed to form a Markov chain, because mostly the transition to the next state depends on the current state and, specially, the transition from the thinking state, $s_{A,2}$ to other states depends only on the current access pattern links.
- **Π vector:** Defining the probability of the system being in each of the states at time 0(Initial Vector). It can be consider that Π vector is a threshold θ.
  Through analyzing the most recent data, the initial probability vector is calculated us ing the formula (1) satisfied by the condition (2).

$$I(S_1, S_2, \ldots\ldots S_n) = I(\alpha/F, \beta/F, \ldots\ldots, \delta/F) \quad (1)$$

$$F = \sum_{i=1}^{n} fi = \alpha + \beta + \ldots\ldots + \delta \quad (2)$$

(Formula 2)

$$\sum_{i=1}^{n} I(Si) = 1 \quad (3)$$

- **State transition matrix:** The probability of current nodes is expressed by the previous node (web site). Any system that can be described in this manner is a Markov process.

$$S = \begin{array}{c} \\ S1 \\ S2 \\ S3 \\ \cdots \\ \cdots \\ Sm \end{array} \begin{array}{c} \begin{array}{cccccc} S_1 & S_2 & S_3 & \cdots & \cdots & S_n \end{array} \\ \begin{bmatrix} a11 & a12 & a13 & \cdots & \cdots & a1n \\ a21 & a22 & a23 & \cdots & \cdots & a2n \\ a31 & a32 & a33 & \cdots & \cdots & a3n \\ \cdots & \cdots & \cdots & \ddots & & \cdots \\ \cdots & \cdots & \cdots & & \ddots & \cdots \\ am1 & am2 & am3 & \cdots & \cdots & amn \end{bmatrix} \end{array}$$

S is the transition probability matrix form.

- **Prediction of next web link:** In 'Prediction of next web link' step, the probability and frequency of click-occurrence is estimated, which will occur in the future, using the transition matrix created and the initial probability vector created. Next formula depicts the computation of probability of click-occurrence.

$$I(S_1, S_2, \ldots, S_n) \times \begin{array}{c} \\ S1 \\ S2 \\ S3 \\ \cdots \\ \cdots \\ Sm \end{array} \begin{array}{c} \begin{array}{cccccc} S_1 & S_2 & S_3 & \cdots & \cdots & S_n \end{array} \\ \begin{bmatrix} a11 & a12 & a13 & \cdots & \cdots & a1n \\ a21 & a22 & a23 & \cdots & \cdots & a2n \\ a31 & a32 & a33 & \cdots & \cdots & a3n \\ \cdots & \cdots & \cdots & \ddots & & \cdots \\ \cdots & \cdots & \cdots & & \ddots & \cdots \\ am1 & am2 & am3 & \cdots & \cdots & amn \end{bmatrix} \end{array} = P(S_1, S_2, \ldots, S_n)$$

P is occurrence probability and next state(Web site) can be predicted.

In this way, a user can get links associated to a particular link (web page) until the user explicitly specifies that s/he wants to get contents instead of links or there is no link available associated to the selected URL. When the user wants the web contents of a selected link or no link information is available by the access analyzer, the Controller sends through the Wireless/Internet Gateway URL corresponding to the selected link to the Origin Server to retrieve web contents.

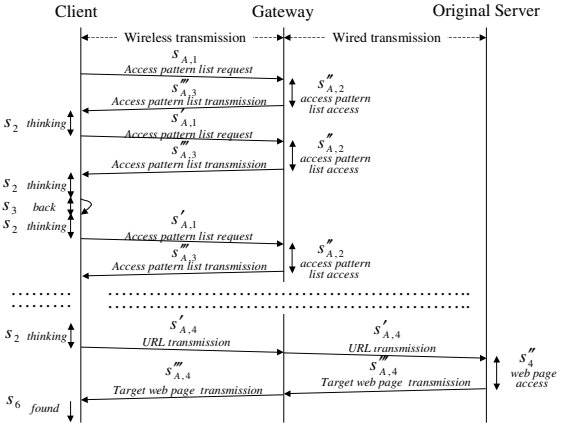
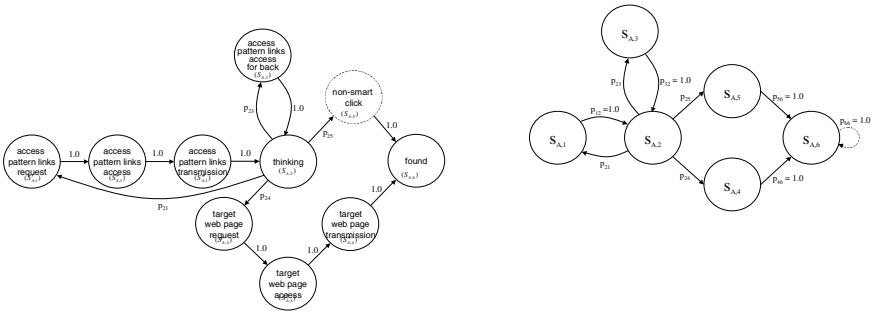


Fig. 5. Sequence Diagram of Access Pattern



(a) Markov Chain for SA personalization

(b) SA personalization Markov Chain simplified by grouping interested states

Fig. 6. Markov Chain for SA personalization

5 Experiment

5.1 Experimental Setting

As mentioned above, situation-aware personalization provides user customized service by ensuring exterior/interior user information resource. Unlike general user interfaces of desktop PC, mobile devices has personalized user interfaces, so these devices store situations and patterns of service use through user information and history. Applying SA personalization into mobile devices, distinct environments which can extract situations by stored resources are provided. Therefore, SA personalization system in Fig7 offers a function to supply situated sites based on various factors, i.e., access frequency of visited sites or access pattern, and a user context set from a handheld device.

Prospecting which is one of important components in SA-personalization system is a reliable estimated-value generating system which complements a weak point that handheld devices are difficult to change states quickly. Such SA personalization is implemented as follows.

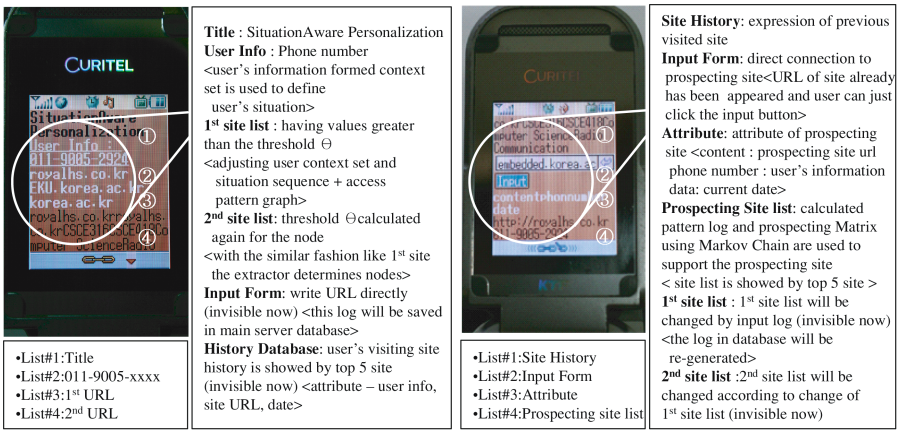


Fig. 7. Prospecting Based Personalization

User situation information supporting situation-awareness are provided in a sequence of a context set through the mobile device identified by a user's phone number as shown in [figure7, left].

- *List#1:Title*
- *List#2:011-9005-xxxx*
- *List#3:1st URL*
- *List#4:2nd URL*

[Figure 7, left]

the situation which is a user's current location or current time can be known through the user information and also the user information decides the selection factor ρ, then it effects on the whole Link Retrieving Algorithm. Through these stages, 1st site list on top 3 and 2nd site list depended on the first one is suggested like a [figure7, left].

- *List#1:Site History*
- *List#2:Input Form*
- *List#3:Attribute*
- *List#4:Prospecting site list*

[Figure 7,right]

In the display of [Figure 7, right], the status of updated node is caught on the basis of threshold θ by Link Retrieving Algorithm. And then the prospected site which user wants by the history of the selected node of just previous stage is indicated as a Data-Grid form in [figure 7 - ④, right]. The user recommended this information directly connects the 1st site list and 2nd site list depended on the first one through threshold θ or the prospected site.

5.2 Experimental Results

Link Retrieving Algorithm using Situation factor or prospecting method shows the web link corresponded with user situation through the display suited to mobile device. It can show available resource of SA personalization compared with legacy system in Table2. The legacy system means smartclick[1] which is a forerunner of SA personalization and proposed SA personalization system is compared with a smartclick.

Also, Table3 describes the capacity of SA personalization compared with existing system. It can show that user can access the contents which user wants with a little number of click and without passing through a lot of page.

As a result, SA personalization can be estimated that it provides more developed mobile environment through the personalization algorithm focused on the prospecting and situation aware approach. But, this test to generate these experiment value is executed in small test set (must not exceed 100 access). And the effect of this limit on initial group, F [Formula 2 -(1)], of Markov Chain Model is not considered.

Table 2. Resource of each system

System	Exterior resource	Interior resource
SmartClick	-	access pattern
SA Personalization	current location	access pattern, user profile, user preference,

Table 3. Evaluation of each system

System	Average number of Click	Depth	Degree of association
SmartClick	4.5	3	0.24
SA Personalization	1.8	1	0.83

6 Conclusion

It is possible to provide the base platform in ubiquitous environment when the mobile device is established strict interaction with internet circumstances.

We considered various user information resources to establish such a interaction and also proposed SA personalization by applying the concept of situation-aware to

collected context set of user situation. This SA personalization could serve developed personalization distinguished from the existing other systems through the Link Retrieving Algorithm focusing on the prospecting. We could compare the actuality implemented SA personalization system with others and overcome the limit of mobile environment through various tests.

The future work is described this: above all things, we will provide well-balanced service through more testing in order to case study of implementation as occasion demands of various user's data and developed contribution. Also, the continual research is needed in order to obtain more sophisticated result in record time by the light-weighted Markov Chain Algorithm which can give a little load in the embedded environment. Finally, we will have to expand to collect and use the Situation information and try to serve the ideal personalization.

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