Using Time and Activity in Personalization for the Mobile User

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ABSTRACT
Mobile clients present a new and more demanding breed of users. Solutions provided for the desktop users are often found inadequate to support this new breed of users. Personalization is such a solution. The moving user differs from the desktop user in that his handheld device is truly personal. It roams with the user and allows him access to info and services at any given time from anywhere. As the moving user is not bound to a fixed place and to a given time period, factors such as time and current experience becomes increasingly important for him. His context and preferences are now a function of time and experience and the goal of personalization is to match the local services to this time-depended preferences. In this paper we exploit the importance of time and experience in personalization for the moving user and present a system that anticipates and compensates the time-dependant shifting of user interests. A prototype system is implemented and our initial evaluation results indicate performance improvements over traditional personalization schemes that range up to 173%.

Categories and Subject Descriptors
H.3.3 [**Information Storage and Retrieval**]: Information Search and Retrieval – *Information filtering.*

General Terms
Algorithms, Design, Experimentation, Human Factors.

Keywords
Personalization, Wireless Users, Context

1. INTRODUCTION
Today it is understood that wireless access is not about browsing the Web on your cell phone; it is about providing personalized services that are highly sensitive to the immediate environment and needs (i.e., context) of the moving user. The most recent efforts to support the mobile user focus to the ability to access **local** and the most relevant information and services. The solution of personalization and user profiling is often used to effectively aid this task. Solutions, however, that was well studied and provided for the desktop user proved to be inadequate for the moving user as these two types of users differ in quite fundamental aspects. The one is restricted in a fixed place, for a fixed period of time and his device (i.e. the desktop PC or even laptop) is not generally used as a *personal assistant*. On the other hand the moving user is quite mobile and at any time, place or situation turns to his mobile device (PDA or mobile phone), the *truly* personal device, for access to information and services that are relevant to his current needs. In essence, the moving user is a new breed of users and his handheld device is constantly complementing his current activities. Looking a bit deeper in the mobile user's environment one can clearly see that the new factors involved are **time** and current **activity**. In reality, the **user's needs**, and thus his context, are a function of time and experience. His interests and needs change along with the time and the situation he's currently experiencing.

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These are new factors to the personalization problem and are introduced mostly because the needs of the moving users are not any more limited to the time he is in front of his office PC, but around the clock, all year long, including weekends and vacations. Imagine the following scenario where a user cruises around at lunch time browsing his favorite content provider through a personalization system. Most likely, the system would provide only the local to him content. However, the provided content, while matching his interests, would not differentiate between restaurant services, bookstores or fax centers in any meaningful way. Thus, if our user was hungry he should first navigate through all the available services find the restaurant services and then invoke them to get the desired information. In this scenario the personalization system ignored a vital piece of information, namely the fact that it is "lunch time". If the system took the **time**, and what time represents into the users day cycle, into consideration it could alter the provided results to display first the restaurant services.

Another interesting, but not thus far utilized, concept is the so called "**user experience**". By "user experience" we mean the activity (or condition) the user is currently experiencing. For example, during normal working days the user experience could be described as "normal day", while when on vacation as the "vacation" experience. Obviously his needs during "normal days" are quite different than during "vacation". Even the day cycle of the user during the various experiences might be different. It is thus, imperative, for the personalization system, to take the changing of activities into consideration. We want to enable, for example, the system to effectively provide, at a specific time, a vacationing user with the nearest bar or pool, while when he's back to work with the nearest business center. Given an experience, time identifies the specific interests of the user during that activity at that particular time, e.g. during vacation at 8 PM, open bars and happy hours are of great interest to vacationers while during normal days, Pizza restaurants and rent-a-movie places might be of interest instead. The task of such a

personalization system is to identify and match these dynamically changing interests to the local services.

2. THE PERSONALIZATION PROBLEM

The problem of personalization is a complex one with many aspects and issues that need to be resolved [14]. Some of these issues become even more complicated once viewed from a moving user's perspective. Such issues include, but are not limited to, the following: *What content to present to the user, how to show the content to the use, how to ensure the user's privacy* and *how to create a global personalization scheme.* They could be summarized in the following phrase: "***What, how and for everything.***" There are many approaches to personalization [1-14] and each one of them usually focuses on a specific area, whether this is profile creation, machine learning and pattern matching, data and web mining or personalized navigation. ***Time*** and ***current activity***, however, as factors affecting personalization for the moving user are widely missed. Thus, the summarizing phrase for the personalization issues for this type of users (i.e., mobile and wireless) should actually be: "***When, what, how and for any activity***," where "when" relates content and user preferences to time and current experience/activity.

2.1 Time Based Personalization

Beyond the exploitation of location "***timing***" and "***user experience***" factors seem to have significant importance. These are the. To understand the significance of these factors, one must consider the needs of the mobile user and the effect they may have if exploited. Undeniably his need for content is not limited to a specific time period. Instead the mobile user may browse for content 24 hours a day, 365 days per year. Hence it becomes a reality to have a user where his interests change in an extremely dynamic way (just consider the lunch time scenario where we see this dramatic shift in preferences). A shift that seems to be tied to the various time intervals governing the user's day-cycle becoming even greater when he switches between activities (e.g. taking a vacation after a tiresome business week).

In order to be able to tackle these shifts gracefully we need to know what the users preferences are at any given time. When using user profile for storing those preferences we can easily reach a situation where the user profile is too big to handle and thus useless. Especially when dealing with great continuum called "time". As a first step we can divide the day into several time-zones and store user's preferences per time-zone. These time zones represent the user's day cycle. Yet the problem still remains as there is too much information which must be handled, most of it just replicated. We circumvent this problem by associating each user's interest with a set of weights as they relate to a specific time-zone and experience. This allows the dynamic creation of the user profile based on the current time-zone and activity by applying the relevant weight set on his preferences. In this way time based personalization becomes possible and the benefits seem quite significant (see experimental results in section 5) despite the possibility of higher computational costs.

3. INCORPORATING TIME BASED PERSONALIZATION

Having in place a personalization system that handles user's profiles, content description and application of the user's profiles on that content is the first step towards incorporating time in the personalization process. Most current personalization approaches (that are profile based) handle the following:

- Capture, maintain and adapt the user's preference profile, either implicitly or explicitly. Performed by a "user profile management" component.
- Capture the user's device profile. This could be part of the "user profile management" component.
- Describe the available content. Having a "content description" component suffices.
- Apply the user's preferences on the description of the content in order to select the desired one. A "content selection" component could implement this.
- Reform and deliver the selected content based on the user's device profile via a "content reform" component.

Beyond that, personalization systems that are focused on the mobile user just adapt the user's profile to the local content. Since these systems don't consider the concepts introduced by time and experience certain changes to their design are needed. *The necessary changes affect mainly the selection of the content to be displayed and the user's profile.*

The user profile must be enhanced in order to accommodate all the (newly) required/available metadata such time-zones preferences and user experiences. As a chained reaction the description of the available content may also need to be enhanced, e.g. from a simplistic keyword scheme to a sophisticated ontology scheme. We need better description of the content in order to be able to make more intelligent decisions. Another needed change, is related with the profile maintenance. We show that keeping the user's profile in sync with his interests' shifts in our case becomes more complicated and an even bigger necessity. Now there is also the need to compensate for user timing shifts (time-zone shifts) and thus, the monitoring of user's preferences mechanism should consider (and adapt) this as well.

4. DESIGNING A TIME BASED PERSONALIZATION SYSTEM

4.1 Content Description Format

In order to have a good description of the provided content, ontologies were used. Two major distinctions are made: content categories/subcategories and content instances. The content categories describe general characteristics of some content. A content category does not describe any actual data generator (e.g. the "Paradise Hotel" content page) rather than it groups the characterizing attributes of similar content pages, while content instances provide actual values for content categories.

Even though the content description format is not directly related with time-based personalization we need to have knowledge of both the category schema and category instance when we incorporate timing factors in the user's profile. By using an ontology we know what the content category is and what the restaurant type of the described specific node is. This is important as it allows prioritization based on both, the category and the instance of a content node. In this way timing and the user's experience can be used with both of these, thus leading to the case where they can effect the selection of an entire content category (e.g., display or not any restaurant), as well as, the selection of specific instances of a category (e.g., display ***only Chinese*** restaurants).

4.2 User's Theme Profile Format: Time and Experience Factors

In order to be able to match the user's interests with the provided content we capture the user's preferences using the same content categories and instances as the ones in the content description. However, this merely enables us to know if a user is interested in something or not. We need to assign a weight to each of the user's preferences to differentiate among them. Weights in effect, show how much a user likes or dislikes a specific content category and/or instance. To achieve time based personalization we need to know how the user's preferences change over the 24 hour day cycle. To represent time we divide the day into different time-zones. This is possible if we study the daily routine of our users and then split it into time-zones based on their activities. By dividing the day in time-zones, we drastically reduce the possible combinations between time and user's preferences, keeping our design scaleable: ***we just need to record how the weight of each preference changes over each time-zone***. Figure 4.1 shows how time affects the user's restaurant preferences in relation with the restaurant type (i.e., cuisine). In figure 4.1 we show weights for both category and instance, defining how much weight the characteristic 'cuisine' has on the user's preferences (line 1 of fig. 4.1) as well as the weight of other values for that characteristic. Figure's 4.1 example means that finding a restaurant that has a desired cuisine is averagely important for the user, in addition (regarding the cuisine of restaurants) between 9 and 12 'Kebab House' is preferred over 'Cypriot' cuisine.

```
<restaurantsTypeByTime categoryWeight="50">
    <timeZone time="0-3">
        <restaurantType name="Fast Food" weight="90"/>
    </timeZone>
    <timeZone time="3-6"></timeZone>
    <timeZone time="6-9"></timeZone>
    <timeZone time="9-12">
        <restaurantType name="Fast Food" weight="90"/>
        <restaurantType name="Greek" weight="70"/>
        <restaurantType name="Cypriot" weight="60"/>
        <restaurantType name="Kebab House" weight="95"/>
    </timeZone>
    <timeZone time="12-15">
        <restaurantType name="Pizzarias" weight="85"/>
    </timeZone>
    <timeZone time="15-18"></timeZone>
    <timeZone time="18-21">
        <restaurantType name="Chinese" weight="90"/>
        <restaurantType name="Italian" weight="80"/>
        <restaurantType name="Mexican" weight="75"/>
    </timeZone>
    <timeZone time="21-24"></timeZone>
</restaurantsTypeByTime>
```

Figure 4.1: User's restaurants preferences based on time.

User experiences. By just adding another set of weights we can record the user's preferences for a new experience and then for each experience we associate the appropriate weight set.

4.3 Matching User Interests with the Content

The high level algorithm for selecting content is the following:

1. Find the interesting content categories using the "How much I like a given category – e.g. Restaurants" weight.
2. Evaluate each characteristic of each content node in the given category that is present in the user's profile using the following formula: ("How important is this factor to me - e.g. Cuisine type" weight * "How much I like this value for this factor - e.g. Italian" weight) / 100.
3. Assign the average of the previous evaluation as the selection rank of each node.
4. The results are presented to the user sorted, based on the selection rank. Nodes with lower rank than a user selected threshold are completely omitted

4.4 Manipulating the time based profile

The system accepts weights in the range -1 to 100. Value -1 enables the system to completely disregard certain content categories and instances. Updating of the user profiles is based on user selections. Each time a user selects to view a given content service the system tracks it and updates his profile, thus leading to a convergence with his actual interests. The high level algorithm of this procedure would look like this: For the category of the selected content node do:

1. For all characteristics that are present in both node description and the user's profile increase their weight in the user's profile by 1.
2. For all characteristics that are present only in the user's profile decrease their weight in the user's profile by 1 (in order to phase out outdated preferences).
3. Add all characteristics that are present only in the node description to the user's profile (with initial weight 50 which indicates possible interest - neither high nor low).

4.5 Keeping in Sync the Profile and User's Timing

The monitoring mechanism that watches over user's preferences must be extended to incorporate "time" as well. In our case, we monitor and log the click stream of the user in order to know when and what the user selected. Later on we analyze this log (when the user is offline or on a different machine) to detect anomalies in the timing. Such anomalies include the user consistently requesting a specific service during a time period that he is not expected (based on his current profile) to do so. A minimum consistency of the anomalies found should be met before considering them to be timing shifts in order to avoid having the casual fluke influencing the profile. The high level algorithm of this procedure would look like this:

1. Monitor and log the user's click stream.
2. Flag potential anomalies with various degrees of priorities and log them.
3. Analyze the anomalies log for timing shifts and adapt the user profile. This is periodic with high frequency.
4. Analyze the click stream log to identify new time zones as well as timing shifts missed by the previous analysis. This is periodic with low frequency.
5. Based on the previous analysis we add new or adjust existing time-zones.

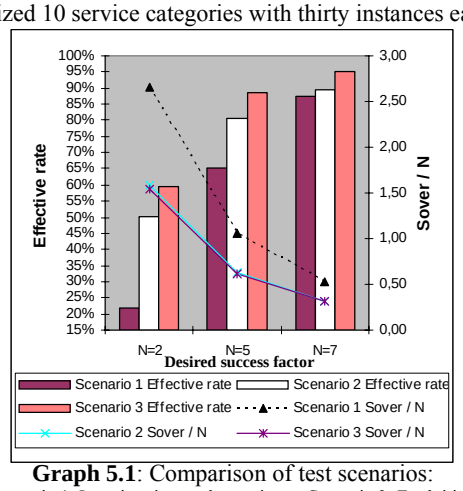
5. PROTOTYPE AND EXPERIMENTATION

Our prototype is derived from the mPERSONA [14] system. In our current version, we focused and experimented on the new factors (time and experience). Thus we modified only the content description, selection and profile management components.

***Metrics*:** In order to show that time and user experience are important factors in the personalization process we need to define a way to measure its effect. We do so by comparing the results of personalization without using timing or user experience versus using them. To do this comparison, we need to measure the quality and quantity of the effect of personalization. Towards this end we define the "effective rate" as a quantitative metric and the "overall success factor" as the qualitative metric. The "effective rate" is the percentage of the times the system was successful in providing what the user wanted. A provided result is considered successful if the user finds what he wants within the first N

provided choices. That is if the user chooses the n^{th} element of a given result, then the provided result is considered successful if, and only if $n \leq N$. We denote n as the "actual success factor" and N as the "desired success factor". Having a high effective rate while keeping the desired success factor low indicates that the personalization process works well and that the users profile accurately presents his interests. The "overall success factor" S_{over} is denoted as the average of the "actual success factor" for all provided results. Lower values mean that the quality of the personalization results is high. The ratio between overall success factor and desired success factor (S_{over} / N) provides an indication if a personalization system meets the given quality restrictions. Furthermore, keeping N value fixed enables the comparison of the result quality of two (or more) personalization systems.

***Experiments*:** Three different scenarios were tested. Under the 1st scenario, a set of users request a predefined set of services without exploiting time and experience. The service set is defined by random selection. Which services are selectable is determined according to the high-level user's interests (e.g. likes Chinese restaurants). The users' requests are made during the whole period of a week at 4 different time-zones per day. Scenario 2 is similar to the 1st with the difference that time is used (user's experience is still ignored). In the 3rd scenario we repeat the previous scenario but this time we include user's experience as well. The test bed used utilized 10 service categories with thirty instances each.



Graph 5.1: Comparison of test scenarios:
Scenario 1: Ignoring time and experience, Scenario 2: Exploiting time/Ignoring experience, Scenario 3: Exploiting time and experience

Graph 5.1 is a direct comparison of the three scenarios. We repeated our measurements for the values 2, 5 and 7 as the desired success factor. Since the lower the desired success factor the higher the expectations from the systems our results look very promising. Even though our initial results show 8% to 173% gain (for N=2 scenario 3 is 173% better than scenario 1 while for N=7 only 8%) we expect that having more services the gain will be significantly higher due to the number of available choices and the degree of differentiation. Considering the second measurement that shows ratio between the "overall success factor" (S_{over}) and the "desired success factor" (N) we can see that the 3rd scenario also performs better. Recall that lower values mean better quality results (scenario 3 gives 42% lower values than scenario 1).

6. CONCLUSIONS

Mobile users are a new and more demanding breed of users and they differ significantly from the traditional desktop users. In this paper we have identified factors that until this day were overlooked in the design of personalization systems for this type of users. These factors are related to time. We presented two major factors, time and user's experience, showing their importance. We showed that exploiting time enables us to capture the shifts of user's interests based on the time of the day and adapt his preferences accordingly. User experience, takes the concepts introduced by timing one step further. It provides a means to effectively merge many different instance of the user's profile (one instance for each state of mind, e.g. vacation, work etc.) into one dynamic profile. This dynamic profile can accurately cover the preferences of a user at all times and situations. We have identified which parts of a personalization system is affected by these factors (i.e. profile). We devised appropriate metrics, implemented a prototype and via experimentation demonstrated the viability of our proposal. Our first results, considering the small size of services used, are quite encouraging indicating performance improvements up to 173%.

7. REFERENCES

[1] Corin R. Anderson, Pedro Domingos, and Daniel S. Weld. "*Adaptive Web Navigation for Wireless Devices*." In Proc. of IJCAI-01. 2001.

[2] Corin R. Anderson, Pedro Domingos, Daniel S. Weld. "*Personalizing Web Sites for Mobile Users.*" In Proceedings of the 10th Conference on the World Wide Web, 2001.

[3] P. Maglio,R. Barrett, *Intermediaries Personalize Information Streams,* Comm. of the ACM, 43(8), p.96-101, Aug 2000.

[4] C. Thomas and G. Fischer. "*Using agents to personalize the web*". In Proc. ACM IUI'97, p.53-60, Florida, USA, 1997.

[5] Rucker J., Marcos J.P,"*Siteseer: Personalized Navigation for the Web*", Comm. of the ACM, p.73-75, 40(3), March 1997.

[6] Adomavicius, G., Tuzhilin, A. "User profiling in personalization applications through rule discovery and validation." KDD-99, 1999.

[7] E. Adar, D. Karger, and L. Stein. "Haystack: Per-user information environments". In Proc. of the CIKM 1999.

[8] Haym Hirsh, Chumki Basu, Brian D. Davison. *"Learning to personalize"*. Comm. of the ACM, 43(8), Aug 2000.

[9] Kurt Bollacker, Steve Lawrence, C. Lee Giles. *"A system for automatic personalized tracking of scientific literature on the web"*. In Digital Libraries 99 - The 4th ACM Conf. on Digital Libraries, p. 105-113, 1999.

[10] S. Myaeng, R. Korfhage. *"Towards an intelligent and personalized information retrieval system"*. Tech. Report 86-CSE-10, Dept. of Computer Science and Engineering, Southern Methodist University, Dallas, Texas, March 1986.

[11] M.M. Lankhorst, H. van Kranenburg, A. Salden, A.J.H. Peddemors, *"Enabling technology for personalizing mobile services"*. Proc. of the 35th HICSS, p.1107-1114, Jan 2002

[12] N. Bogonikolos, D. Fragoudis, S. Likothanassis, *"ARCHIMIDES: an intelligent agent for adaptive-personalized navigation within a WEB server"*. Proc. of the 32nd HICSS-32. Volume: Track 5, Jan. 1999.

[13] Doron Cohen, Michael Herscovici, Yael Petruschka, Yoëlle S. Maarek, Aya Soffer, "Personalized pocket directories for mobile devices". Proc. of the 11th int. conf. on World Wide Web, p. 627-638, isbn 1-58113-449-5, Hawaii, USA, 2002.

[14] Christoforos Panayiotou, George Samaras, *"mPERSONA: Personalized Portals for the Wireless User: An Agent Approach"*. Journal of ACM/Baltzer MONET, special issue on "Mobile and Pervasive Commerce"