A Smart Calendar Application for Mobile Environments

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ABSTRACT

Traditional e-calendar applications limit their usage in simple operations such as scheduling appointments, storing and managing contacts and reminding their users of significant facts that they have entered by themselves. A nice graphical user interface is responsible for displaying the calendaring information to the user either on demand or proactively using sound or text alerting mechanisms. More intelligent applications have advanced features such as peer coordination for the scheduling of a meeting but they have not found wide acceptance in the market due to their complexity and computationally intensive operations. However, there is still no application taking advantage of the ever increasing digital and networking convergence happening in our days. In this paper, we envisage the design and implementation of a Smart Calendar that goes beyond the state of the art because it can act proactively and on behalf of the user. Its purpose is three-fold: a) organize the existing time schedule of a user according to his busy/free time slots, b) propose interesting events or actions that he may undertake during a time period and c) guide him to accomplish his obligations in a timely manner.

Categories and Subject Descriptors

J.1 [**Computer Applications**]: Administrative data processing, business, education, mobile services.

General Terms

Your general terms must be any of the following 16 designated terms: Algorithms, Design, Security.

Keywords

Mobile services, personalization, electronic calendar, recommendation system.

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1. INTRODUCTION

The vast amount of information modern users have to process, has led to the necessity of organizing the data using time as an additional parameter. Various electronic calendars exist allowing a person to register his duties and obligations (either professional or personal) into a clear and easily accessible application. They usually offer some simple and effective operations to the end user such as alerting mechanisms for reminding him of a registered meeting or important dates. Nevertheless, these applications suffer from some major drawbacks. Apart of the lack of any intelligence in their core specifications, each one of them is also proposing its own standard for specifying calendaring objects. This situation changed on November 1998 when the Network Working Group of the IETF has published three specifications which defined a commonly accepted format for calendar objects. Recent developments in the area try to take advantage of this format so as to allow for cooperation and enhancement of the services with Google Calendar and Sun Calendar Server leading the way.

It is becoming apparent that there is necessity for an "intelligent" calendar which will be able to track the user's needs and behavior and subsequently propose to them events/activities that might be of interest. In our case, we were aiming for creating a complete mobile application which facilitates the users in their everyday operations by automating some of the tasks and by acting in a proactive way even before the user's request. This goal was realized by the aggregation and coupling of different technological areas into one discrete and solid service. Thus, the novelty behind our work lies in the way we approach the problem giving it a user-centric solution by having as common denominator the users' modeling and personalization. The proposed system implements a core calendar application which incorporates advanced features such as automatic location discovery and time awareness. The underlying intelligent techniques take advantage of this "extra" information for offering value-added services that go beyond the state-of-the-art in the calendaring applications.

2. THE ROADMAP TO THE SMART CALENDAR APPLICATION

The Smart Calendar's software architecture is mainly based on the INTGUIDE platform [7] which was developed by Intracom Telecom S.A. It is the practical outcome of the necessary expertise acquired within the framework of various European Research Programs mainly in the IST program of the European

Commission. In order to avoid extreme diversification, the application domains were restricted to the following three: applications in cultural heritage, sports and interactive television and the retail industry. It is clear that the common denominator of all these application areas is the generic profile of the end users.

INTGUIDE's aim was to create a generic platform for enabling the setup and delivery of context aware services featuring advanced visualization techniques and interaction modes. Some of the most fundamental European projects that comprised the cornerstones of INTGUIDE were aiming at providing European citizens with ubiquitous services for *personalised, tourism-oriented multimedia information related to the location and orientation* within cultural sites or urban settings, occasionally enriched with relevant advertisements.

INTGUIDE is mainly targeting mobile environments by trying to integrate portable devices along with advanced localization techniques. The product takes advantage of different localization mechanisms and as such the best one is, each time, selected depending on the level of detail and type of localization we want; for example, for exterior positioning GPS was used while for interior positioning a triangulation technique based on wireless technology was exploited. Moreover a strong focus was set on information visualisation aspects.

Having this basic infrastructure, Smart Calendar was built as a valuable extension to this system, providing it with the additional dimension of time.

3. PROFILE BUILDING AND PERSONAL RECOMMENDER

Smart Calendar's goal is to provide its users with automated and proactive mechanisms such as propositions and operations scheduling. For the scheduling problem, there are two parameters we have to take into account. First we have the user's personal information which includes meetings registered into his calendar, past accomplished events, free time etc. and secondly we have events, activities and advertisements published by various organizations or companies. The personalization server consults the user's profile and tries to filter out those events that might be of interest to him. However, not all events – even if they are interesting - are feasible in the user's current context. By current context we mean time, location and situational information. For example, a user may be interested in watching a newly arrived action movie but he is currently at a meeting; therefore such a proposition is invaluable. As such, the user's context in Smart Calendar is modelled as an object in a three-dimensional space where each axis represents a different context, namely time, location and personal preferences. The filtering process takes into account all these dimensions.

The order in which each one filtering step is performed has an actual impact on the system's response and performance because each step reduces the search space of the propositions. The general intuition is that first we need to perform the filtering along the dimension of location, then along the personal preferences and finally along the time.

In Smart Calendar the user's context is represented by a tree structure as shown in Figure 1. This allows for further enhancement and extension of the model with more features or dimensions. The user's preferences dimension is the most complex one because it can contain everything related to the user's likings. The user's profile is defined in two ways: explicitly and implicitly. In the explicit way, the user inserts some basic information about his profile by himself through the declaration of his preferences in specific thematic areas (e.g. favourite restaurant kind). In the implicit way, machine learning algorithms are employed in order to produce association rules about what the user likes or not. In the current implementation, the rule inference mechanism is only applied to the movies profile. However, in the future we envisage the improvement of the personalization service through the appliance of intelligent algorithms to the whole profile.

In the core of the intelligent component of Smart Calendar lies a recommendation module which consults the user's profile and filters out any possible propositions. The machine learning algorithms used so far are C4.5 and Slipper which generate association rules. Another decision is made for the explicitly declared profile according to a hybrid extended Boolean/PAICE model. The recommender outputs a final decision based on a weighted voting on the confidence values of the decisions of all the algorithms.

The localization sub-component is currently based on GPS while Galileo is planned to be supported as well. Time is represented as period intervals. While user's actions are stored along with their time signature in a dedicated transactions database, there is still no support for performing data mining on this information. Data mining on such databases can yield valuable association rules which reveal periodical trends. These trends offer an extra layer of intelligence to the application and can increase the overall reliability of the scheduling and propositions mechanism.

The ultimate goal of an intelligent calendar is to try to organize the user's time according to his schedule. For that reason, all the propositions should both perfectly fit inside his schedule and accommodate the user according to his context. This is an optimization problem and can be viewed in two different granularities: a) fine grain optimization and b) coarse granularity. More specifically, each granularity refers to the detail of scheduling we want to accomplish along the dimension of time. For example, fixing the user's short-term calendar requires more detailed scheduling and fine-adjusted propositions with respect to time. On the other hand, the system may try to propose some activities to the user for the near future without specifying exactly the time or even the day that these have to be accomplished. In such way, the user is both informed about the event/activity and he is comfortable to accommodate it whenever he wants. In the following paragraphs, we will discuss how each contextual entity is represented in Smart Calendar.

4. CONTEXT MODELING

Knowledge and context representation is one of the most important aspects of an intelligent system. Appropriate representations that reflect the actual problem need to be designed. Smart Calendar is quite a complex application that needs to model many different context situations of the user. More specifically, the context entities that the system has to represent initially are listed below as well as in Figure 1:

1) **User prefences**
   a) Movie preferences
   b) Food preferences
   c) Accommodation preferences
   d) Transportation preferences
2) **Location information**
   a) Country
   b) City
   c) Province
   d) Street

3) **Calendar**
   a) Meetings modeling
   b) Time modeling
   c) Periods modeling

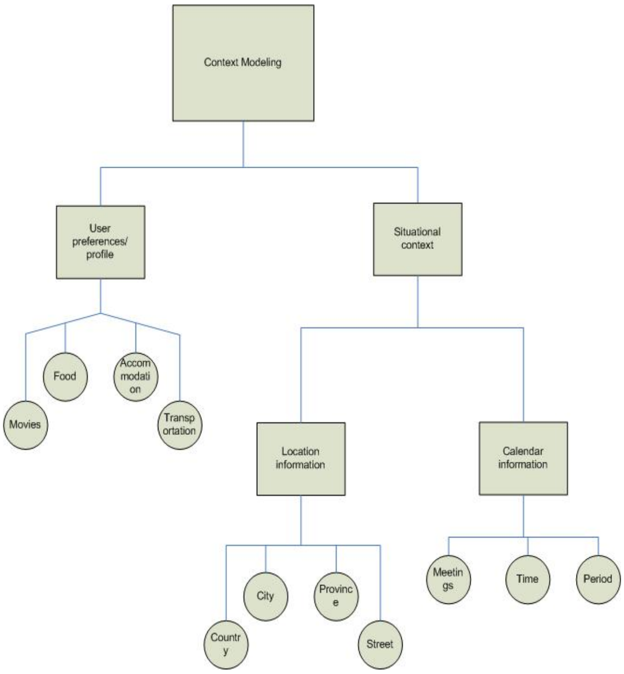

Figure 1: Context modeling structure

Structuring the context information as a tree helps the application to be designed in a modular fashion. Moreover, it gives scalability to the knowledge representation module by allowing new context entities to be inserted or removed on demand, under the condition that they adhere to specific standards. Each leaf node in the tree represents a complete personalization sub-problem. Thus, we can optimize each distinct sub-problem by applying different AI and machine learning techniques to each one of them. Taking into account that each algorithm models the problem of personalization in a different way, it is essential that we select algorithms that generate the same output. For example, neural networks have excellent performance but their major drawback is that their internal structure, weight adjustment and output (whether it's a decision or a proposal or a prediction) is not human understandable. On the other hand, decision trees and rule-based systems generate readable rules that can be easily evaluated by humans. Apart from this, rules have other excellent properties such as the fact that they can be easily combined with other rules in order to generate more generalized and compact decision making entities.

Each leaf node in the contextual tree is further analyzed into attributes. The feature extraction process is something that is usually done by intuition. Feature selection techniques do not have usually good performance and they still need an initial feature set provided by an expert.

4.1 USER PREFERENCES

The user habits are a list of the user's personal preferences in various different fields. The attributes can be set-valued, categorical or continuous.

4.2 LOCATION INFORMATION

The location information describes the user's current and permanent location. The attributes include the street information, the country, etc. The permanent location is inserted by the user himself while the current location is constantly updated by a module which communicates with a positioning system like Galileo and GPS. The location preferences help to further reduce the search space of the events to be proposed by selecting only those that are in close proximity to the user.

Location information may need to be exchanged frequently between the mobile device and the appropriate servers. The use of standards for the most appropriate representation of it can severely affect the system's performance. At this point in time it is assumed that the use of an XML-defined specification can be the optimal choice for interchanging location information. The tagged structure of XML files assist in defining hierarchies in attributes.

4.3 CALENDAR INFORMATION

Calendar information includes not only tasks to be done and meetings to be attended but other objects as well. Smart Calendar adheres to the iCalendar specifications for describing its various objects and the communicating protocols with other applications. In this way, it ensures compatibility with existing applications and gives the ability to external partners to publish their events or advertisements into the public general calendar server.

5. HIGH-LEVEL SYSTEM ARCHITECTURE

The system's architecture has been driven primarily from its requirements which are the following:

1. Scalability: The system has to be able to accommodate a big number of users and on the same time process their profiles either in real-time (for small and easy tasks like short-time scheduling of operations) or before the required deadlines (for more complex tasks like the scheduling of a whole week).

2. Innovative intelligent mechanisms: The system has to support a number of advanced techniques for the provision of high-quality services to the end-user. For that purpose, there needs to be support for a number of different algorithms which, when combined, give the utmost results and counterattack each other's drawbacks.

3. Corporative interfaces: Such a system can be a failure if it is not supported by the market. Thus, there is a necessity for an API through which the various companies – such as advertising companies, private or public institutions, web sites that annotate events in various locations – can provide the system with useful information and gain value from it.

4. Semi centralized computing architecture: We need to remove the burden of computationally intensive operations from the mobile devices. A cluster of servers will provide the highest percentage of the intelligence of the system by processing annotated data and users' profiles.

5. Security: Since private data is being interchanged between servers, security issues become a concern. Privacy information cannot be encrypted since it needs to be processed by the central system. Thus, highly secure authentication, authorization and registration (AAR) mechanisms (like Kerberus) need to be employed in the system.

Figure 2 presents the proposed Client Server architecture. The majority of the processing takes place in the Server tier. Here, there are two kinds of server clusters: one cluster is responsible for the security aspects of the system using a ticket-granting security scheme and the other one is responsible for all the intelligent filtering and proposing mechanisms of the system.

Smart Calendar enhances the current state of the art by incorporating intelligence inside its core functions. The user is able to register meetings and activities into his mobile device and also has the freedom to indicate which information is going to be available to the centralized system. The mobile device registers with the secure server, obtains a service ticket which grants it access to the various services, and transmits the user's schedule. The central server consults the personalization database for obtaining the user's profile. It then starts processing the available information. The system processes data related to the user's situation context (stored locally in his mobile), user's profile, user's location or user's intended location and the available events which are advertised by various providers. The order in which each one of the three filtering steps is performed has a big impact in the system's performance. For that purpose, these steps need to be as much modular and independent as possible in order to allow final evaluation tests to be performed. It is intuitive that the filtering mechanism should be applied first to the location parameters, giving a much smaller search space for the application. Next, the user profile should be consulted for evaluating the most interesting events and finally a local processing held in the user's device can further minimize the propositions according to his context information.

The transactions of a user are stored into the Transactions Database. Data mining mechanisms can process this data and generate useful temporal association rules. These association rules may be applied either to a personal level (specific user's trends and habits) or to social level (generic habits). In order to make more personalized propositions to a user and plan his schedule, we need algorithms that process his specific profile. To this aim, there is a huge amount of available techniques and algorithms in the literature. However, there is not a single one of them that can be applied to all problems with the same success. All algorithms need to be tailored according to the specifications of the problem, in order to achieve acceptable performance. The high availability of suitable algorithms has mandated that the architecture be designed in such a way that allows the easy insertion and removal of any machine learning algorithm as long as it adheres to specific requirements. One of the major requirements is that the decision be accompanied by a confidence value which shows the degree with which the algorithms supports this decision. Subsequently, the predictions of each algorithm are fed into a decision maker or voter which investigates independently each prediction and gives a final decision based on a weighted average voting mechanism.

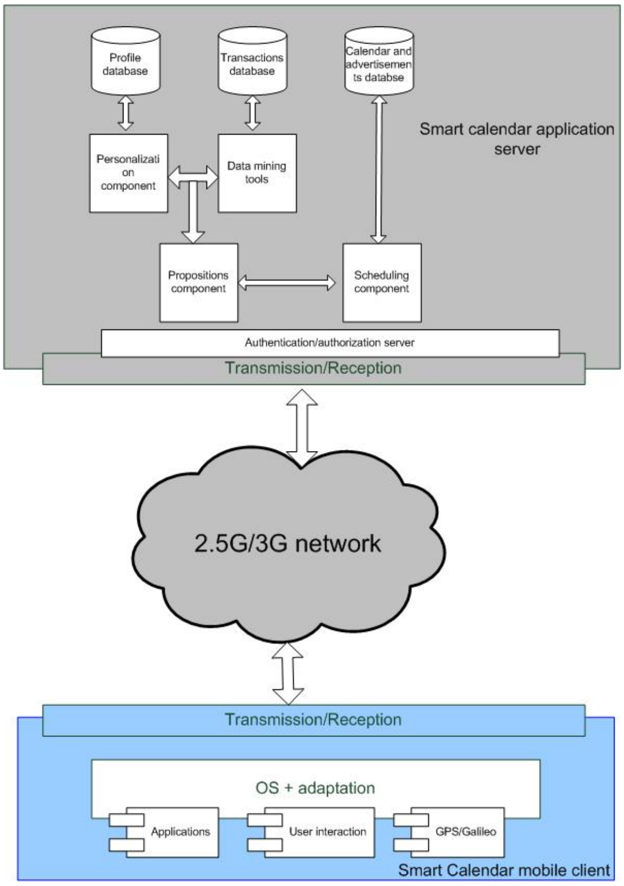

Figure 2: High-level architecture of Smart Calendar

6. FUTURE WORK

For the next step in Smart Calendar we would like to continue our research in the areas of personalization and data mining. More specifically, we will investigate novel algorithms and evaluate their suitability into the mobile and dynamic environment of the Smart Calendar application. We are primarily interested in taking advantage of the information proliferation that such an application offers. Currently, the team is working towards applying various machine learning algorithms to every contextual aspect of the user. The next step will be to exploit various data mining techniques that find useful associations in large data repositories and between similar users.

Mining association rules in temporal databases can help such systems discover possible correlations between users' transactions and time. A very well known algorithm with many enhancements found in the literature is the Apriori algorithm [1], [2]. It tries to find general trends occurring in transactions of various users. Other techniques for mining association rules exploit the use of fuzzy theory [3] by constructing fuzzy representations of the calendars.

Clustering is another tool that can both greatly enhance the performance of the system and be a valuable asset for the provision of value-added services in a mobile context. Clustering algorithms group the users into such a way where users belonging to the same cluster have the same properties and behavior. The benefits for a service provider are numerous and range from better customer satisfaction and high quality of services to the generation of new revenue models where advertisers can have access to these clusters and offer personalized advertisements to the system's users.

The system will also be enhanced by additional services such as automated booking of tickets, transportation planning etc. This will allow for fine-grain optimization of the schedules and propositions inside the user's available time. Once recommendation and personalization mechanisms will generate their propositions, the system will try to optimize them in order to be fit inside the user's schedule.

Apart from the ongoing research in the fields of artificial intelligence and machine learning, we will also focus on human-machine interaction issues and general context extraction methodologies and techniques. We aim at building special software on the client side that will be able to "sense" the user's environment and automate some of his tasks. For example, the tagging of pictures, videos or other multimedia data can be automated since the mobile clients will have built-in location discovery components and clocks. Automatic tagging removes this annoying task from the users and can greatly enhance the machine learning components by providing more information that could otherwise be missing. Moreover, such features can provide the necessary ground for the design of new services such as buddy finders, "large games" and social networking.

As a conclusion, we would say that the possibilities are numerous and feasible but only when you have a complete and working prototype that encompasses technologies from a large range of fields.

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