Supporting Time-based Coordination in Everyday Service Interactions: the Fluidtime System

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ABSTRACT
The need for flexible and dynamic time management is becoming increasingly crucial in our society, especially where it concerns the coordination between individual and organizational time flows. The HCI community's prevailing approach to this issue focuses on personal time management or time-based coordination within teams and organizations. We follow a different angle, looking at the specific temporal relationship that connects individuals (customers) with service providers.

In order to increase people's control over their time when they interact with services, we developed Fluidtime, a mobile phone based information system that provides users with continuous and ambient real-time information directly from the services they are seeking.

The paper describes the Fluidtime system and provides case studies of its implementation. It presents insights from the trials and discusses both the design issues the project raises and new opportunities for using real time information.

Keywords
Time, scheduling, flexibility, mobile interactions, wireless, real-time, ubiquitous computing

INTRODUCTION
The clock and the calendar are the main time-based coordination tools in our society. These "artifacts of temporality" [12] are needed for scheduling appointments on a fixed grid divided into months, day, hours and minutes. However, according to Kretzman [9], the increased inter-connectivity of ubiquitous communication transforms our life and activities into an constant flow rather than a succession of fixed points.

The use of mobile phones, for example, allows people to modulate the fixed coordinating grid of calendars. If linear time has the calendar and the clock as its main artifacts, the mobile phone then becomes a leading artifact for temporality in a flexible society. It breaks the fixed calendar paradigm, where punctuality is the main principle, and fosters connectedness and flexibility.

Friends don't make appointments by the minute when going out in the evening but agree to call each other and slowly tune into each other's flow of time and space, until they meet. More and more, the mobile phone replaces the calendar and the watch.

The constant and flexible coordination via traditional mobile phone works well within a smaller group of people. If the group size increases or if one member needs to update many others (one-to-many), then the constant update through phone calls requires more effort and can become expensive (in terms of both money and time).

A typical situation where this issue is evident is the coordination between service organizations and their customers. People interact with services every day in a variety of contexts from travel, to entertainment, to healthcare. Each service has its own unique, dynamic time structure that is often unpredictable and non-linear. From the customer's point of view, this uncertainty can provoke an unpleasant lack of control on time and activity scheduling, compromising therefore the experience of the service. Following Aleff [2], we believe that time has a central role in the design and management of a service and more flexible systems for time-coordination are necessary to support the demand and supply process.

SERVICES AND REAL –TIME INFORMATION
Digitization opens up new opportunities for improving the service-costumer relationship on a temporal level. Organizations increasingly use digital technology for their internal operations, thus creating real-time information about business processes. This information can be made accessible to customers in order to improve the quality of the service relationship. During the Fluidtime project [4], we investigated existing services, applications, and devices that deliver real-time information about public services and private appointments.

In the context of hospitals and medical examinations, timely coordination between doctors and patients is usually based on standard scheduling tools without any connection between the doctors' and the patients' flows of time. A survey in the UK estimated that eight and a half million patients miss doctor's appointments a year, which adds up to 150 million British pounds of lost appointment time[5]. An interesting response to this problem is the solution developed at the Homerton Hospital in East London. The department of sexual health started using SMS messages to remind patients of their upcoming appointments [7]. According to the first results, the experiment generated a positive response from the users.

The context in which this trend is most evident is travel. Increasingly, people can find real-time travel information at train stations and airports. City transport authorities increasingly provide people with up-to-date information trough special displays located at bus stops or in subway stations. This travel information is increasingly available remotely, through the Internet and recently also through SMS. Many airport websites provide real-time updates of the arrival and departure schedule and some companies like NextBus Inc. [10] in the US, have successfully started offering real time public transportation arrival information via the web.

These examples, among many others, show a clear trend towards the use of communication technology for coordinating the timing of services. Many organizations started using wireless technology, especially SMS, to make this information accessible to people while they are mobile. Adding mobile updates to traditional fixed stationary updates (e.g., displays at train stations or bus stops), provides a new advantage, since the information reaches the customers wherever they are. Nevertheless, SMS has still one big drawback, in that it provides information in a discrete, step-by-step way. The updates do not flow in a continuous ambient way, but through alerting and active manipulation by the user.

A simple comparison can help clarify this point. The traditional method of timekeeping is the watch. With this artifact, checking the time takes two to three seconds, not more. When time updates arrive through SMS, it takes about 20 seconds from hearing the reception alert, to taking it out of its pocket, unlocking the phone, navigating to the message, reading it, deleting it and putting the phone back into its pocket. This time span is too cumbersome to balance the value of the information. The intrinsic problem with time planning systems is that it takes time to use them. On one hand, they help us to free up our time or organise our activities in a better way, but on the other hand, we waste time using them, and thus reduce their overall effectiveness. If updating customers with "real"-time information is to be adopted and valuable, these obstacles need to be overcome. The interface to continuous and ubiquitous time information has to be simple and effective.

FLUIDTIME

With the Fluidtime project we aimed to contribute to these developments in mobile and flexible time management. We set out to find engaging, convenient and effective means to view and interact with real-time information in a continuous and ambient way, overcoming the problems discovered in current systems.

The research team developed a mobile phone-based time information system and a series of interface prototypes in order to investigate the opportunities and impact of using real time information.

Our conceptual framework is grounded on a general model that we developed to describe the stages that lead to the consumption of a service. The model refers to the 10 travel stages defined by IDEO [14] but doesn't include the stages that follow the actual consumption of the service. The model (Fig. 1) depicts the relationship and interactions between customer and service organization in six steps and maps them onto the dimensions of time and location.

The first stage of this model is about *planning* and informing. The customer requests and receives information from the service organization in order to make informed traveling choices. This planning activity can either happen through the phone, via the web, or through a printed schedule. If booking is necessary, in the second stage, the traveler will interact with the organization in order to *book* a seat on a particular bus or train and will buy the ticket. In the third stage, the traveler has made all the necessary arrangements and is *expecting* the trip. The trip might still be days away and the service organization could update the customer about any important changes. The day before the travel, the company might remind the customer about the upcoming trip. In the fourth stage, which is now only hours or minutes away from the actual consumption of the service, the traveler leaves home, office or another location in order to *transit* to the bus stop or train station. At this point the service organization will update its customers about any delays or provide other timely updates. Once the traveler arrives at the location of the service interaction, s/he will *orient* himself/herself, for example, by finding the platform, etc. The sixth stage covers the activity of *waiting* for the bus or train to arrive.

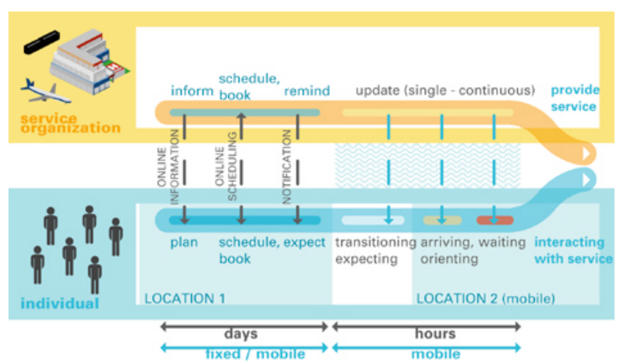

Figure 1: Two path model depicting time-based coordination activities between customer and service organization before the actual consumption of a service.

In the implementation of the Fluidtime system, we applied this model to the context of travel, since it is the domain where most technological development is happening at the moment. We also decided to focus on the task of updating travelers constantly with the real-time arrival information. This task covers the stages of expecting, transiting, arriving, and waiting. These are the stages where the dynamic changes and timetables re-scheduling are most prominent and more frequent; they take place during the time scale of hours and minutes and fall in the domain of the clock rather than calendars.

The prototype system was developed for the public transport in the city of Turin [1]. Turin, located in northwestern Italy, has approximately one million inhabitants who take up to 450,000 rides each day. The transport authorities have already implemented a system that tracks all the buses and trams and calculates real-time arrival times. Travelers can find constant arrival updates either at selected stops, through a website or through SMS. In the last two cases, the traveler inputs the number of the stop and the system lists the waiting time for the next 10 buses. However, there is no way for the user to filter out information and select only the relevant routes.

The SMS service makes the information available ubiquitously, thus supporting mobile access to information. Nevertheless, it has a major drawback since it requires users to send a request manually every time they want a time update. Another limitation is that the information received upon request is text-based, and therefore difficult to interpret at a first glance.

To overcome these problems, we looked into a solution that supports *quick and easy access* to the information, with simple and immediate checking of the chosen arrival time. The solution also had to support *effortless monitoring* of the information updates. Finally, we aimed to *visualize the data* in an easy to grasp, beautiful and engaging way.

Quick Access

The mobile phone was the most appropriate tool for implementation of the Fluidtime system. It is the most commonly used mobile device in Italy and dedicated applications can be installed onto it; furthermore, the single functionality wouldn't justify the effort of building (and buying) a dedicated device. Also, using a multi-purpose device implies important constraints in terms of the operating system and navigation. The main design challenge was to keep the setup time as short as possible, so that users would not need to spend too much effort and time to launch and run the application.

The solution we adopted has a similar setup time as it would take to read an SMS, but offers the advantage that this procedure only has to be done once during the stages of travel. In our prototype device, the software is located in the folder with all other Java applications on the mobile phone. In this prototyping environment, it takes five keystrokes in order to reach the folder and launch the Fluidtime application. Once started, it prompts the user to input the number of the bus, then the number of the route and then launches the visualization. It takes about 10 seconds from the last keystroke to receive and display the first set of data. After the startup procedure, the user can keep the application running as long as necessary and check for any time changes without any further keystrokes.

Effortless Monitoring

An important strength of the wristwatch is that information is always present in the background and can be accessed without any specific input from the user. We aimed to recreate a similar kind of interaction, providing the user an effortless means to constantly monitor real-time information. Once the application is launched on the mobile phone, it allows the users to check time changes without any further needs for manipulation. While the software is active, it connects to the Fluidtime server at regular intervals of one minute and receives the latest arrival updates.

Data Visualization

Contrary to the SMS system, we aimed at offering the users an immediate and fluid representation of data, providing them with an overview of their relevant travel options moment by moment.

For the visualization of the data we followed a set of design criteria. The user can decide which routes to display on the screen. In order to give the traveler a choice, the interface shows at least three buses on the same route; the three buses are displayed together in relation to how far they are from the bus stop. In order to make the user aware of the transit flow, we displayed on the screen also the buses that had left a few minutes before.

The arrival time is represented visually, without using numbers, better reflecting the fuzziness of the information and its fluctuations. Visual representations also correlate to the flow of the buses more.

We chose to use colour coding of the time-dimension to support the readability of the display (blue for buses prior to arrival, red zone once arrived). The range of the arrival times displayed is between thirty and minus two minutes. (e.g., bus route 36, 25 min, 14 min, -2 min), where minus two means that the bus has already left two minutes previously. The visualization changes once every minute, after the system has received a new set of data.

The interfaces

Based on these general criteria, we developed three different ways of visualizing the data on the screen of the mobile phone.

The Fluidtime interface number 1 (*TakeOne*) represents the arrival times of the three closest buses for the chosen route. It shows a perspective representation, aiming for a direct translation of what a passenger would see while standing at the bus stop. The buses are represented from a frontal perspective, through small icons, with position and size reflecting the movement of the bus approaching the bus stop. Two white lines represent the street and function as a timeline. When the real bus arrives at the stop, its iconic representation moves into the red front-most zone. (See Figure 2).

Figure 2: Fluidtime interface number 1 (TakeOne)

The second interface (*TellOne*) has two sections. The lower section of the screen represents three buses on the same route. The user can see small bus icons moving from left to right. Also in this version, the background is divided into four zones. Once a bus' icon reaches the red zone, it means that the real bus has reached the stop as well.

In the upper section of the interface the arrival time of the closest bus is represented through an iconic character. Depending on how far away the bus is, the character takes a different posture and a different speech bubble is displayed; this representation suggests how the user should behave in order to catch the next bus. (See Figure 3) If the icon displays a tranquil character, the user can be relaxed. If the icon is a running figure, the user knows that the bus is about to arrive.

Figure 3: Fluidtime interface number 2 (TellOne)

The third interface (*TakeThree*) uses the same type of representation as the lower section of the TellOne interface. But in this visualization, the user has more information for planning. This interface allows the user to define up to three different routes and up to three different stops. This information is necessary for travelers who need to change buses, or who have the option to walk to two different bus stops nearby.

Figure 4: Fluidtime interface number 3 (TakeThree)

Each phone that was used in the trial had all three applications installed on it.

Technical setup

In order to support these interactions, our prototyping device had to be able to connect to the wireless Internet in an always-on manner. We chose the mobile phone model 6610 from Nokia since it is able to execute Java applications and can communicate via General Packet Radio Service (GPRS). This digital mobile phone technology provides high-speed data transfer compatible with GSM networks. It utilizes packet-based communications: if a user sends no data, the frequencies involved are free to be used by other senders. Using GPRS to connect, the phone doesn't need to dial up to the network provider, but can exchange information faster and at any time.

The Fluidtime server consists of a PC running Java-based web services software. It receives http requests from the mobile phone applications, then pulls the real-time information from the Turin transport authorities, translates it into the appropriate data format for the phones and passes it on to the clients.

USER EXPERIENCE TRIALS

Method

We evaluated the prototypes through a qualitative user study. The interfaces for mobile phones described in the interface section were tested in Turin between May and June 2003.

The main objective of this trial was to understand how the system and interfaces that we designed could be integrated in people's everyday life and what their impact would be on the users' organisation of time.

As Palen et al. [11] argued, the use of service-based wireless devices is influenced by dynamic environmental and social conditions that cannot be reproduced in an experimental context. In order to capture the real experience of the users while interacting with our tools, we decided to conduct the trials in a natural way, letting a group of people use them in their daily life for a consistent period of time, without any specific assignment.

In order to obtain richer results in our tests, we sought people who use the public transport system on a daily basis, once or more per day. The best candidates in this range were local commuters who used buses or trams to travel to and from work. During April 2003, a letter of invitation and a questionnaire were distributed via email to a number of commuters living in Turin in order to find volunteers for testing. Through the questionnaire we were able to identify four suitable people on the basis of their mobility habits, their familiarity with mobile phones and their willingness to be involved into the project. The selected users were four young professionals, two males and two females with different professional profiles who use different bus and tram routes.

The candidates were each given a mobile phone with the Fluidtime applications installed and were shown how to interact with them. We also provided a small instruction manual describing the steps for using the applications.

The duration of the trial was a month; during this period the candidates were interviewed twice, once after ten days of usage and once at the end of the trial, for about one hour each time. The first interviews were audio-recorded and the second ones were video-recorded in order to collect material for the final video documentation.

With the interviews, we sought to capture different aspects of the users' experience with the prototypes. One group of questions was focused on evaluating the interfaces in terms of usability, pleasantness of use, and aesthetic appeal. The goal was to find out which aspects could be improved for the next release.

Through another set of questions we wanted to understand the impact of the Fluidtime system at a more general level, evaluating how it would influence people's habits and use of time and whether the users would find it valuable for their daily life. In this part of the interview we wanted to capture individual differences and emergent behaviors related to the adoption of the Fluidtime system.

Usability and aesthetics

The aesthetic qualities of the interfaces were generally very much appreciated by the users. All of them found the interfaces aesthetically pleasing and gave them marks like "beautiful", "cute", or "entertaining". The two women also demonstrated an emotional attachment to one of the three versions, defining it respectively as "My TellOne" or "My TakeOne".

None of the users reported to have read the manual; for all of them, using the interface was intuitive enough. However, certain usability issues reduced the quality of the experience.

From a systemic point of view, a major limitation pointed out by all users concerns the identification of the bus stop numbers. In order to access the information about the status of a bus or tram, the users must know and remember the number of the stop, which is completely arbitrary.

Another problem with the application release used by the trial candidates is that it did not allow the storage of frequently used bus routes and stops; every time they used the application they had to choose the bus or tram number and the number of the stop. For three of the users, this turned out to be the biggest handicap of adoption.

A third important usability handicap was the presence of several menus and choices before opening the application within the phone. This problem affected primarily those people using the *TakeThree* interface, who had to input information about two or three tram/bus routes. Again, this effort is too great in order to be useful on an everyday basis.

Half of the users wanted us to add a number to the visual representation indicating the exact number of minutes remaining before the arrival of the first bus.

Users had different attitudes about the differences between the three kinds of visualizations. The iconic representation of *TellOne* received positive comments in terms of aesthetics, but was also criticized for the arbitrariness of the messages. The connotations afforded by the animations are in fact not always appropriate; the way in which the user should behave depends on the distance from the stop. Only one user didn't consider this aspect as a major problem and adopted this interface as her favorite. The other testers used either *TakeOne* or *TakeThree* depending on the number of routes available to reach their destination: the former, if there was only one option, the latter, if they could chose among several alternatives.

Use of time: general habits and emergent behaviors

A first general result to consider in terms of system use is the high level of adoption that we found in our users. According to the interviews the candidates used it almost every time they used public transportation: the frequency varied from twice a day, three days a week, to three to four times a day five days a week.

The interfaces were in most cases consulted on a daily basis on weekdays, going to and from the workplace. Only one person used Fluidtime during the weekends, while the others had alternative means of transportation.

The moment and the duration of the connections varied from individual to individual. Two people preferred to connect from home or from the office, while the other two started the application once in the street, on their way to the bus stop or upon arrival. The duration of the connections seems to be related to the distance from the bus stop. When the users were close to it, they would stay connected for a short time, because they could easily evaluate the remaining walking time to reach the bus stop. In those cases where the distance from the stop was bigger, they found it more convenient keep the connection active, in order to check the progress of the bus/tram.

Interestingly, all testers used the same expression to define the reason why they were using the system: it allowed them to avoid what in Italian language is called *tempi morti*, which literally means "dead time". In other words, the system was perceived as an aid for not wasting time. As Perry et al. have found [13], dead time is an expression widely used by travelers to define the time they spend "outside the trip's scheduled activities." In our case, dead time consists mostly of waiting time at the bus stop or longer traveling time that all users perceived as wasted. However, each of them had their personal stories to tell about how Fluidtime allowed them to transform this dead time into something else. Looking at the users answers, we tried to identify some general categories of time use that can be supported by the adoption of our system.

Decision making

Usually, local routine-based traveling does not require much effort for planning. Because of the repetitive nature of the trip, people tend to perform the same actions in a mechanical way, without making decisions in advance. However, this regular flow is sometimes disrupted, requiring a decision-making effort. In our study, the most common situation of this kind is when users could choose between different travel options: they had more buses or more combinations of buses available for the same path. In these cases, making the wrong decision means taking a bus that takes a longer time to reach the destination or missing the best combination, and therefore spending more time on the bus.

For several people, the Fluidtime applications were a support for making rational decisions and avoiding this type of time waste. These behaviors were particularly connected to the use of the *TakeThree* interface, where more routes are visualized. The interface allowed rational travel planners to choose the best option in terms of time convenience. An interesting example of this was given by a user who changed his habits during route changes : "*After going out from the first bus I had two possible connections; I used to go to the corner to see which one was arriving first, but I wasn't able to know when the other one would arrive. Now, I can see it on the screen and decide if it's worth taking the first one or waiting for the other one*".

Opportunism

When people travel locally (especially in Italy), they have to deal constantly deal with the uncertainty of the scheduling system. Having no control over the time of transit, travelers often find themselves waiting at the stop. As we have already discussed, this waiting time is often perceived as dead time, in that it is not considered to be part of the scheduled trip. The stationary displays introduced by many transport authorities are not a great help for avoiding this waiting time, since the information they provide cannot easily be used to reschedule activity.

Thanks to their portability, the Fluidtime applications allowed people to better respond to the unpredictability of the travel system and take advantage of opportunities in a situated way.

For example someone used to connect to the server before leaving the office: "*If the bus is arriving, I go out and catch it; if I see that there are some minutes left, I do something else, like answering a friend's email*".

Two users reported about situations where, on their way to the stop, they used the information they received about the next bus in order to perform some additional activity, like buying newspapers, cigarettes or looking at shop windows.

Someone else happened to use the applications while in a bar with friends; since the bus was late, he could spend some more time there instead of waiting at the stop.

Pacing

When people are very worried about being late, they often run to the stop without knowing whether the bus or tram is actually arriving. In many cases, this rush is not justified and they find themselves waiting at the stop after an unpleasant run.

Some of our testers used the applications as a mean to fluidly adjust their internal clock to the external time constraints, thus avoiding wasted effort as well as dead time at the stop.

A typical example of this is one person who, on her way from home to the bus stop dynamically regulated the pace of her walking with the progress of the bus: "*I look at the screen again when I'm walking to the stop; if I see that the remaining time hasn't changed I keep with the same walking speed, otherwise I accelerate.*"

In this case, having access to the state of an external constraint allowed her to modulate her own rhythm in a fluid and natural way. According to this user, this helped her to calm her anxiety about missing the bus and arriving late to work.

Game play

Although this can be considered as a secondary effect of the Fluidtime prototypes, it is interesting to notice that in several cases, people enjoyed using the application as a game or a divertissement. One of the candidates liked to stop randomly at some bus stop, start the application and wait until the selected bus arrived. Another one invited a friend to follow him to the bus stop to check the precision of the data. Although these are marginal episodes, probably related to the novelty of the experience, they demonstrate a certain level of engagement and enjoyment in using the interface and in being able to access information that is not available for others.

Functional value

All testers found the service valuable to some degree, although no one defined it as essential. However, as one user pointed out: "*It's also a matter of getting into the habit; before we didn't consider the mobile phones as a necessity while now we are all addicted to them*".

Besides the usability problems, our interviewees identified a series of variables that could influence the usefulness of the service and consequently their use beyond the context of testing. The contextual factors that seem to influence the value of Fluidtime can be summarised in the following way:

Regularity and frequency of the buses

The value of the service seems to be inversely related to the efficiency of the transportation service: the less trams and buses are frequent and punctual, the more critical it is to access real-time information about their status. For all users, the situations where Fluidtime is most valuable are the ones were they cannot rely on the timetables or, even more importantly, where the transit is infrequent and missing one bus or tram could create a significant delay. For those living in a well-connected area or traveling during rush hours, when the transits are very frequent, using Fluidtime was more "optional" than "necessary".

Quality of the waiting
Waiting for a bus in the middle of the night, or when the weather is cold and rainy can be much more unpleasant than in the middle of a sunny day. Being able to access real-time information about the bus in these cases can be of a much greater value, allowing the person to spend more time at home or to wait in a bar with friends.

Flexibility of personal engagements.
In addiction to these external variables, the value of Fluidtime is also influenced by the personal schedule of the user. In several cases, our testers mentioned their situation at work as a discriminating factor; when the schedule is more flexible, the information provided by Fluidtime becomes an additional and useful input for organizing time and regulating one's mobility. Conversely, some users reported that if they already knew that they would leave home or work at a certain time, they wouldn't consider the availability of public transport as a crucial factor for their management of time.

Time personality
Dealing with time is a habit that develops throughout a lifetime. Therefore, many time habits depend on individual psychological structures. We can also identify an idiosyncratic variable in how people manage time in general. In our interviews we asked our users to define their time personality; interestingly, the persons that defined themselves respectively as "very punctual" and "always in advance" are also the most enthusiastic about Fluidtime.

Location
In several cases our testers mentioned the fact that using Fluidtime would be particularly interesting in situations that are not routine-based. While shopping, sightseeing, wandering in town, people often find themselves in locations where the transit of public transports is not as familiar as in their home or work areas, and a service like Fluidtime could be of great help. At the same time all the interviewees mentioned the identification code for the stop (see "usability and aesthetics") as a major obstacle for using the service in this kind of situations. In order to access the information about the status of a bus or tram, the users need to know the number of the stop, which is typically not the case for someone who is unfamiliar with a certain area.

Cost
As we could expect, the users mentioned the cost of the service as a major discriminating factor. Although in our trials the use of the service was free, during the interviews the testers were asked to evaluate the economical effort they would accept in order to use Fluidtime. In all cases they mentioned a subscription system as the best option. According to one user the subscription could be included into the transport fees "*It would be great if on my monthly ticket, I could find the code to access the Fluidtime service.*"

CONCLUSIONS

Through our research, we tried to explore the impact of real-time information on service pre-consumption, focused specifically on local transport. Rather than testing a specific hypothesis, we were interested in provoking behaviors and understand new design opportunities. We believe that our experience with Fluidtime raised some encouraging results as well as interesting research directions.

First, we found that real-time information access combined with ubiquitous technology has the potential to increase people's sense of control over time. The actual time of service consumption doesn't change and the customer still depends on unpredictable and external time constrains; if there is any delay this information service doesn't affect it. However, the possibility of monitoring such a dynamic flow gives people the freedom to actively react to it. Whether this leads to rational decision-making, where this access is used to choose between different travel plans, or to an opportunistic use of the waiting time, the pre-consumption phase becomes less unpleasant and more fruitful.

Looking back at the model that we have discussed above (Fig. 1), we can say that real-time updates can shift passive waiting (dead time) into active time use.

The test results also suggest that the value of this information can be connected to the attitude of different people toward time use. Although our work does not include an accurate analysis of users' time personalities, we see interesting opportunities for relating our results with the work produced by marketing and social sciences in this field [e.g., 2; 16; 8].

The "time managers" that Aleff [2] describes as punctual people, who make an efficient use of time, trying not to waste it, could appreciate Fluidtime as a support for rational planning. On the other hand, his unpunctual and less time-driven "time squanderers" are more likely to use it to seize opportunities, making last-minute decisions or using it in a playful manner. The test results also point to another time-related category mentioned by Usunier [16]. As reported by one of our users, real-time information can be a way to reduce the anxiety for travelers who are concerned about missing their means of transport, and influence their pacing, so they don't need to hurry to their bus stops.

The interfaces for the mobile phone have been a clear step towards increasing the accessibility of constant time information, but there are still opportunities for further improvement.

Due to the limitations of the operating system of the phone we used, it took some effort to launch the application. In future releases, it will be important to find ways to speed up the start-up procedure.

In order to improve the usability of the arrival information, the display needs to contain dual information: both visual and numeric, indicating the exact number of minutes remaining before the arrival of the first bus.

From the trials, we learned that we have to take into account different modes of use of our system. For routine use, the means of personalization through shortcuts and bookmarks was a missing requirement. This functionality has already been introduced in a further release, developed after the trials.

For occasional users (or for routine users in unfamiliar locations) the problem is missing contextual information. They first need to go to the stop in order to find the necessary information to start the application, which would limit their ability to optimize their use of time.

This breakdown in our users' experience raises a more general issue, which is the lack of connection with the real world (outside the computer) in ubiquitous computing systems. A greater effort needs to be made in order to integrate these kinds of applications with the surrounding unpredictable conditions. In our case, the most critical issue related to the location of the user. A system that intends to support mobility should also take into account spatial information, providing travelers new to a location with cues for orientation. Integrated travel information where route direction, stop number and location are accessible on the phone itself would bring increased usability.

Finally, the results that we obtained trough our experimental study should be augmented with a deeper understanding of the business opportunities offered by the use of real-time information in ubiquitous services.

Looking at current developments, Townsend [15] writes that "time becomes a commodity that is bought, sold, and traded over the phone. The old schedule of minute, hours, days, and weeks becomes shattered into a constant stream of negotiations, reconfigurations and rescheduling." Several elements indicate that people are willing to pay for time since it is a highly-valued commodity. A survey that was done after the implementation of the new traffic information system in Turin [6] indicates that people would be willing to give money for real-time arrival information. A report by Alpern et al. [3] shows a possible revenue model of how money could be made on real time information for public transport.

It is the decision of the individual company whether this service would be offered for free to customers (in order to improve the service experience), or if it would be used to generate revenue. Our results suggest that a subscription-based mode of payment would better support routine users, while a low-cost and use-based payment system is more likely to fit occasional users. Time will tell which models will work and which ones customers will not accept.

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