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Context-Aware Scenarios
Course on Context-Aware Computing 2003

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Abstract

According to a recent definition by Dey and Abowd context is any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves. A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task.

The following report contains ten scenarios about how context-aware applications could affect ordinary persons in fifteen years. The scenarios have been written by students participating in a course on context-aware computing in the autumn of 2003.

Computing Reviews (1998) Categories and Subject Descriptors:
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H.5 Information Interfaces and Presentation
J.7 Computers in Other Systems
K.4 Computers and Society
K.8 Personal Computing
C.3 Special-purpose and Application-based Systems

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Design, Experimentation, Human Factors, Security

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context aware scenarios, context aware applications, context-awareness, ubiquitous computing, personal computing, wearable computing

Contents

Preface

Following a definition by Dey and Abowd (1999, ftp://ftp.cc.gatech.edu/pub/gvu/tr/1999/99-22.pdf), context is any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves. A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task. Context-awareness is an enabling technology that combines a broad scope of topics in computer science.

A course *Context-Aware Computing* (3 cu) was given at the Department of Computer Science of the University of Helsinki in autumn 2003. For details see the course homepage http://www.cs.helsinki.fi/hiit_bru/courses/582446/. The course was realised as a student-centred learning experience, with emphasis on group work. The form of the course was inspired by the fact that we, the teachers, had participated during 2003 in a course for the personnel on university pedagogic.

The objective of the course was to give an insight into context-aware applications and methods required in their design. The course objectives also included the practical training of working in groups. English was used throughout as the language of the course. This made the course popular among our foreign students and exchange students.

The course included four introductory lectures (by us and Professors Henry Tirri and Hannu Toivonen) and two group work assignments with oral presentations. The resulting reports by the groups are published as two Department of Computer Science Series C reports: this publication is covering Assignment 1 and the other publication is covering Assignment 2. The student groups were required to evaluate their fellow groups. The work was undertaken in the Educosm system (see cosco.hiit.fi/edutech/), a tool for collaborative work, in which documents can be annotated with underlinings and comments. This way, reference documents and draft versions of the reports could be commented by the students.

The topic of Assignment 1 was scenarios, with the aim for the students to get acquainted with context-awareness: visions and problems related to future applications. The scenarios were mainly elaborated in groups of two. The ISTAG Scenarios for Ambient Intelligence in 2010 (European Commission, Community Research, 2001, ftp://ftp.cordis.lu/pub/ist/docs/istagscenarios2010.pdf) were given as example models for the scenarios. The resulting scenarios were presented by the student groups on 13 and 15 October 2003.

We would like to thank our colleagues, who participated in realising the course, as well as the teachers and participants on the course in university pedagogic we participated in. The English language has been corrected by Martina Kurtén at our department. Her tremendous work, for which we are indebted, has greatly enhanced the readability and quality of the texts. We have also had great help from Riku Saikkonen in the finalisation of the text into publishable form, for which we express our thanks. Finally, our thanks go to the students. They have done great work resulting in a successful course.

This publication include all the ten resulting scenarios. We hope that the scenarios are inspirational to the reader and show the combination of innovativeness and realism of our students. Naturally, the opinions, sentiments and views expressed in the scenarios are not necessarily those of the editors or the Department of Computer Science.

Helsinki, 22 December 2003

Patrik Floréen and Greger Lindén

Liqueur shopping – doing it in a context-aware way!

Mikko Laukkanen and Jani Leinonen

This paper presents a scenario where a context-aware shopping assistant helps the user to buy the liquor he or she needs. In the scenario Bill represents a user who is organizing a party, but has forgotten to buy the drinks. With the help from his personal assistant Bob, Bill is able to buy the needed drinks, and even to take into account the preferences of the guests. The first part of this paper presents the actual scenario, whereas the second part contains analysis and descriptions of the issues, devices, services, and innovations in the scenario.

Alko shopping scenario

At the meeting

Max is a PhD student at the University of Helsinki. He has invited his fellow students to his house for a party, but as usual, he has forgotten something – this time the drinks. The party will take place the next day, and Max is currently sitting in a meeting with his professor. Fortunately, Max has asked his personal assistant, Bob, running on his wrist computer, to take care of notifying him, if he forgets something. Knowing the calendar of Max, Bob assumes Max has forgotten the drinks, because the common closing time of Alko stores is getting closer, and on the next day Max has to be at the university the whole day. Therefore, Bob decides to notify Max to buy the drinks today. However, Bob realizes, after verifying with the professor's personal assistant, that Max is currently having a meeting, and the notification had better be given after the meeting is over.

Driving to Alko

The meeting is over, and Max walks to his car. Bob whispers, and informs Max that he should stop by at Alko to buy the drinks for the next day's party. “Gosh, you are right, I had completely forgotten that. Thanks!”, says Max, and asks Bob for the nearest Alko with a good variety of products. Bob acknowledges, and replies that he will get back to Max in a moment. In the meanwhile, Bob recommends that Max could go through the meeting minutes Bob has taken from the meeting with the professor.

Bob contacts the city service directory, and asks for the Alko stores nearby, and along the road to Max's home. There are three available ones, which Bob next checks through. One is already closed, and another one is undergoing some renovations, thus having a limited variety of products. However, the third one seems suitable.

Max has previously listed the invited people for Bob, and the next thing Bob does is to contact the personal assistants of those invited people. Bob asks the personal assistants about the drink preferences of the users, and assembles a draft shopping list with a few choices – Bob knows that although he is basically always right, Max likes to have the final word about these kind of situations. Bob contacts the Alko store, and verifies from its on-line product catalog that all the products on the draft shopping list are indeed available. So they are, and therefore Bob interrupts Max, and tells him that a suitable Alko store has been found. Bob asks if Max wants to drive there by himself, or continue reading the minutes while Bob takes care of driving there. This time Max prefers driving, so Bob uploads the driving instructions to the car's computer and its head up display (HUD).

Arriving at Alko

Max arrives at Alko, and walks in. He picks a shopping cart, while simultaneously Bob initializes and configures the shopping cart agent with the draft shopping list. The shopping carts also include HUD glasses – in case the customers do not have their own with them. Of course, customers with their own glasses or intelligent contact lenses are free to use them. Max forgot to take his sun glasses with him from the car, and therefore uses the ones provided by the cart. Max puts the glasses on, and sees the draft shopping list projected at the lower right hand side of the display. “Hmm, usually Bill prefers Finnish vodka, but this time he has listed sparkling wine as his preference... interesting, maybe he has some joyful announcement for us, maybe the long-awaited engagement announcement with his better half Cathy... Well, let's give him that chance then”, Max mumbles while heading inside.

The Alko store informs Bob that the closing time is getting nearer. Knowing that Max is usually capable of spending tremendous amounts of time while shopping and comparing products, Bob decides to narrow down the shopping list a little bit; he leaves two choices for each guest for Max to choose from.

Choosing products

All the products in Alko have an intelligent tag attached to them. As the shopping cart approaches the products, they identify themselves by giving the essential information about them. Instead of free product-browsing, Max chooses only to see Bob's recommendations, which in turn are highlighted on the list with the product information printed next to it as Max gets close to them. At the sparkling wine shelf, the two recommended sparkling wine products – Elysée Dry and Chardonnay Brut – are highlighted for Max. Bob notices – by monitoring Max's heart rate and other vitals – that Max is not quite sure which one to choose. Therefore, Bob informs Max that assuming the sparkling wine is intended to be shared with Cathy, the Chardonnay would be a better choice. Or at least that is what Cathy's personal assistant told Bob. "You saved me again, Bob", says Max smiling, and picks up the Chardonnay and places it into his shopping cart, "and it seems to be quite reasonable in price also", continues Max after checking the on-line price counter on the shopping cart.

After all the other products have been picked up, one thing is left: the punch. Basically Max knows what ingredients he wants there to be mixed: Finnish vodka, some sort of white wine, strawberry liqueur, and soda. He does not like to have it taste too strong, especially now when there will be a number of female guests coming. Therefore, Max asks for recommendations from Bob. Bob collects a few choices, and lets Max test different mixing ratios. To do this, Max uses the virtual tasting computer available at Alko. Max asks Bob to initialize the tasting computer with the ingredients, places the virtual taste emitter on his tongue, and begins testing. Using the panel on the computer, Max is able to try the different ingredients, and adjust the mixing ratio between them. After a while, Max has found his favorite, and asks Bob to lead him to the shelves where the products are available.

Finally, Max has collected all the drinks he needs, and heads for the cashier counter. Because Bob knows that Max does not have any cash with him, he negotiates with the cashier counter computer to pay with a credit card. Bob uploads the credit card information to the cashier counter, and asks Max for a retinal scan for authorization. After this, Max rolls the shopping cart to his car, empties the drinks from it, and chains up the cart back to the cart rack. In doing so, the cart resets itself for the next customer. "Oh man, isn't it easy to buy the liquors nowadays; hopefully buying jewels for my girlfriend would be as easy as this someday!", laughs Max to Bob. "You know women's personal assistants, they are so hard to understand…", murmurs Bob back to Max as they head for home.

Explanations and comments

Issues

The core idea in this scenario is to have a context-aware virtual assistant for more or less unorganized persons. These kinds of assistants monitor users' actions, schedules and behaviour, and act both reactively and proactively, and maybe most importantly, autonomously. The assistants work not only by themselves for their user, but in collaboration with other users' assistants. In doing so, the amount of contextual information extends to cover other users' contexts also, which is important in a world where people naturally collaborate with each other. When sharing contextual information, problems may arise from the fact that not everyone is willing to share their contexts, but want to uphold their privacy. Therefore, we cannot assume that all the contextual information is always available.

The personal assistant bases its decisions on the state and changes in the context of its users and the contexts of other relevant users. The essential contextual parameters in this scenario are time, the user's preferences and intentions, location, social situation now and in the future, the user's current activity, the physiological state of the user, resources nearby, and the user's schedules (calendar). In the following, we will discuss these in more detail.

Time

The temporal information, such as time of day and date, are mostly used in triggering actions. In our scenario there are many time-related events, such as "party taking place tomorrow", "Max is late" and "the store is closing", which trigger some action by the personal assistant. The actions can be, for instance, planning ahead (something in the calendar requires some pre-work), making the user aware of something important (you are late, you should hurry on with something), or narrowing down some alternatives (because the store is closing soon, the available options to choose from should be minimal).

Preferences and intentions

Actions can be initiated autonomously by the personal assistant based on the information about the user. This kind of information is either learned from the user or input by the user and forms the user profile comprising the user preferences on various things. The user preferences are maintained locally by the personal assistant, and are represented in a semantically meaningful way, for instance using Semantic Web technologies. This allows storing concepts (or objects) and various relationships and dependencies between them. Knowing the preferences of the user, the personal assistant is able to present relevant information to the user, filter out some irrelevant information, and act autonomously for the user. In the latter case, however, it is important not to go too far in autonomy, but leave the user with a feeling that he has the final word in the decision, if he wishes.

When storing large amounts of data, such as the semantically presented user preferences might be, some problems may arise from the fact that an embedded device – such as the wrist computer – usually has a limited amount of both storage space and processing power.

Location

Spatial information, such as location, can vary from geographical location to information about other objects' location in relation to the user's current location. Looking back to our scenario, the former is used in locating Alko stores and route-planning to get to those. The latter, on the other hand, can be used inside the Alko store, when locating shelves and products. In this case it is enough to point the user "to the next shelf" or "to the fifth bottle on this shelf".

Sociality

In the real world people interact with each other, and in many cases the actions and decisions people make depend on other people as well. Therefore, one key point in our scenario is that the personal assistants do not only work on their own for their users, but act in collaboration with other personal assistants. Firstly, the decisions made by the personal assistants can be "backed up" by other personal assistants. Secondly, the assumptions made by the personal assistants reflect better the current state of the world. In our scenario, without on-line collaboration, the personal assistant could not have known about the temporal change in another user's preferences, as was the case with Bill preferring sparkling wine over the usual Finnish vodka. Privacy is one thing that needs to be taken into account while sharing context information. The baseline assumption should be that the context is shared only if the user has granted permission to do so.

Current activities

The current activity of the user usually affects the work of the personal assistant. In practice, the user's current activity may postpone, or cancel altogether, some planned activity by the personal assistant. In our scenario this can be seen in the beginning, where the personal assistant decides to notify its user, but has to postpone it, because the user is having a meeting, and such notification would disturb the meeting.

Physiological state

The physiological changes in the user are contextual parameters, which require some physical monitoring of the user. These kinds of parameters are, for instance, heart rate, respiration, and blood pressure. Taking these kinds of parameters into account, the personal assistant may infer the physical and maybe even the mental state of the user. In addition, when combined with other contextual information, the personal assistant may be able to infer the cause of the physiological changes, and therefore help the user. For instance, without knowing anything else than that the user's blood pressure and/or heart rate is rising rapidly, the personal assistant could call for an ambulance. However, knowing that the user is trying to make up his mind in choosing between two bottles of wine, the personal assistant could try to make the user's task easier.

One interesting question about the physiological sensors and the actions (for instance, an automatic call for an ambulance when the vitals are not normal) is the reliability and vulnerability of them. It could happen that a sensor begins to give false readings because of some interference or even intended misuse, and further triggers improper actions or diagnostics.

Available resources

Resources – or services – available nearby can be located based on other contextual parameters, such as location. In the future, when the environments are moving toward being so-called ambient service environments, it is essential to be able to find the resources currently available, and further, access those resources.

Devices

The devices can be categorized as personal, shared, and infrastructural. Personal devices are specific to a user, whereas the shared devices can be used by anyone. Infrastructural devices are accessed by the personal and shared devices – not usually by the human user herself – and are usually "hidden" from the user. Maybe the most important thing about all these devices is the communication and interoperability between them. The personal and shared devices must be able to discover the infrastructural devices, and interact with them. In the following we will describe these devices in more detail.

Personal devices

In our scenario the user has wearable devices, such as a wrist computer, HUD glasses, intelligent contact lenses, and physiological sensors. The personal assistant follows the user wherever he or she goes, thus, the device that runs the personal assistant should be as easy to carry as possible. Most people use wrist watches, so it is quite a natural choice to embed a wrist computer in the watch and let the personal assistant run there. Figure 1.1 shows what these devices might look like.

The small screen is not a problem, because the interaction between the user and the device is mostly done by voice. What is more important is the wrist computer's ability to communicate with the outside world. Therefore, the wrist computer must support multiple access methods – from personal area networks to broadband wide-area networks – for communications, and allow them to work simultaneously without interfering with each other.

Figure 1.1: An example of a wrist computer. (Figure from http://news.com.com/2100-1040-274286.html?legacy=cnet.)

Figure 1.2: An early prototype of HUD glasses. (Figure from http://www.pediatricsurgery.net/Art_gal/hud.htm.)

The HUD glasses provide an advanced output device for the user. The glasses may vary from traditional virtual reality glasses to contact lenses and design (sun) glasses. The benefit of having HUD glasses instead of for instance external screens is the privacy. With HUD glasses the user can be sure that nobody else is seeing what products – or any other information – he or she is browsing. The other benefit is the ubiquitousness and context-awareness; the glasses provide output anywhere, and the projected objects may be attached to the context. The HUD glasses have a personal area network connection to the wrist computer and/or to the infrastructural devices, with which it interacts. Figure 1.2 shows an early prototype of HUD glasses.

Physiological sensors can be implemented as external (on the skin) or internal (under the skin). The benefit of having internal sensors is the freedom of not needing to attach any patches or monitors on the user. On the other hand, a failure in an internal sensor is harder to fix than one in the external sensor. It is also questionable whether people really want to have some computer chips under their skin.

Shared devices

The shared devices include embedded devices in cars and shopping carts and the virtual tasting device found in the Alko store. Cars will have computers with integrated positioning devices, and they will provide real-time information about both the car itself and the driving instructions between locations. The car computer could look like the one shown in Figure 1.3.

Figure 1.3: An example of a computer embedded in a car. (Figure from http://www.via.com.tw/en/VInternet/carpc.jsp.)

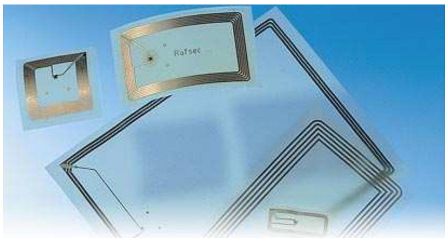

Figure 1.4: An example of a passive RFID tag, which can be attached to products. (Figure from http://www.rafsec.com/products/label_transp_set.htm.)

The shopping carts include a computer with a small display showing the contents of the cart as well as the individual and total prices of the items in the cart. The shopping cart interacts with the products by Radio Frequency Identification (RFID) technology; all the products have an RFID tag, which the shopping cart reads and from which it extracts the product information. An example of an RFID tag is shown in Figure 1.4.

The virtual tasting computer provides the user with the taste of a product – without fear of the effects of consuming the product. In Alko the tasting computer also features mixing two or more products, because drinks are usually a combination of many ingredients. The user places a tasting emitter on his or her tongue, loads the products to be mixed, and adjusts the mixing ratio. As soon as the desired combination is found, the tasting computer contacts the Alko product catalog, and calculates the closest matches for the bottles needed for the mixture.

Infrastructural devices

Infrastructural devices are, for instance, the intelligent tags (maybe implemented as RFID tags) attached to products and (automated) cashier counters with retinal scanners. The RFID technology today provides only passive operation and very limited amounts of storage. In future, the tags will have more memory, and they can be integrated with active sensors. For instance, the wine bottles in Alko could not only provide their name and price, but dynamic information, such as the current quality of the wine, as well.

Automatic cashier counters are definitely what at least the authors would like to see in the future. Instead of queuing in the stores, the customer only needs to roll his or her shopping cart through the cashier. The shopping cart uploads its contents to the cashier machine, which takes care of billing the customer, or the customer's personal assistant. However, there are security issues that need to be taken into account, especially in automatic purchasing. The retinal scan is a good way to authenticate the customer for instance when the cashier machine charges the customer's credit card.

Networks

The network infrastructures are crucial in order to make the scenario possible. The networks vary from wide area networks to personal area networks, and what is the most important thing is the seamless interoperability between and the availability of these networks. In order for a personal assistant to contact another personal assistant, the route from the personal assistants personal area network, via a high-speed wide area network, to the other personal assistants personal area network must be available on demand.

The Universal Mobile Telecommunications System (UMTS) (or its successor) will provide high-speed wide-area network access. Using UMTS, for instance, the wrist computer is able to connect to public services, such as Alko's on-line catalog, from anywhere and at any time. The local area networks, such as the car or the Alko store, will be implemented using Wireless Local Area Network (WLAN) technology. These can be extended by other radio technologies, such as RFID and Bluetooth, for even more local connectivity. The personal area networks are for very short distances. One example of a personal area network is the communication between the wrist computer and the HUD glasses. The networks use short-range radios, such as Bluetooth. In addition, personal area networks are usually of ad-hoc type, meaning that the networks will be set up on demand.

Services

In our scenario we are drawing a picture of a future of ambient networks, where there are a huge amount of services available. The services may be common (the service is available all the time, independently of the user's context), or context-aware (the service is available only in a certain context, for instance in a certain location). The two essential points to raise are the accessibility methods (i.e., how to interact with the service and how to execute it), and service profiles (i.e., how the services are described or annotated in such a way that they can be found based on their functionality and the current contextual parameters). In the following we will discuss the service in our scenario in more detail.

Personal services

The personal assistant is an example of personal service. It is specific to the user, and its primary target is to make the user's life easier. The behaviour of personal services depend heavily on the user's current context. The personal services should be as transparent to the user as possible, and provide flexible interfaces for interaction. Voice recognition and speech are the primary I/O mechanisms for the personal devices.

Public services

Public services are available to everyone, and usually at any time. In our scenario the city directory and Alko product catalog are such services. The public services resemble what the public web sites are today. However, the difference is that in the future, they are not static and meant for a human being, but (dynamic) services, which are represented by and accessible to computers.

Local services

The services in this category are tied to a certain location (or context). In our scenario the services inside the Alko store belong to this category. The intelligent shopping carts, virtual tasting computer, intelligent tags on products, and HUD glass-enabled shopping are specific to the Alko store, and are available only in Alko and during the opening times of Alko.

Required scientific and technological innovations

The required scientific and technological innovations can be roughly divided into the following categories: the next generation computing devices, real-time collaboration between intelligent software agents (personal assistants), and seamless accessibility and interoperability between the devices and the services.

Our scenario included some innovative devices, which most probably will be available in 10–15 years. Wrist computers and other similar wearable devices are already available, but the computing power, battery consumption, memory needs, I/O, and connectivity are far from those required in our scenario. HUD glasses (virtual reality glasses) are also already available, but not as compactly packed as in our scenario, where they were embedded into normal glasses or even contact lenses. Sensors for monitoring vitals are used in hospitals and some simple ones (heart rate etc) are already available as consumables, but they are not very wide-spread, and more importantly, not available as small as they would have to be – even as a small chip under the skin. The virtual tasting computer might be such an innovation, which probably will not be available even in 20 years.

The real-time collaboration between intelligent software agents basically requires two things: advanced end-user devices in terms of connectivity, and heavy network infrastructure. The end-user device has to have multiple access methods, depending on the context and available networks, and the network infrastructure has to be available all the time – in one form or another.

Finally, having mentioned the devices and the network infrastructure, maybe the most important issue is to have them interoperate and be accessible anywhere and at any time. Seamless interoperability and roaming between the devices and the networks make it possible to have the intelligent ambient environment we envisioned before.

Clarice – a kindergarten child

Jari Alhonen and Kai Hendry

This is a scenario demonstrating several context-aware computing elements for Clarice's morning.

Clarice, who attends kindergarten, is the daughter of professional middle-class parents and has her own computer. She is a normal 5-year-old, so she cannot e.g. read yet.

Scenario

Dad carefully opens Clarice's door and walks in with her tea.

He sees her sleeping softly in her bed and smiles. He puts down the tea and sits down carefully on her small bed after tapping her mirror. This action turns on the system, which is in effect a camera mounted on the mirror. He watches her slowly awaken, and decides to quickly inspect her computer. It is softly glowing proportionally to the sunlight outside, that is if the sun was shining today.

It has been charging on a plate on her bedside table, without unnecessary cabling, and it seems ready for another day with Clarice. He almost feels sorry for the poor thing. It is looking pretty worn and it may need replacing soon. He cleans the camera's optical viewport and attempts to remove the grime in the mic and speaker ports.

He looks at the screen, which is now glowing with a glow suitable for a dimly lit room and inspects the display. It shows Clarice's most recent artwork from kindergarten. It seems to be a boat. He is not entirely sure.

Clarice is now awake and Dad leans over to kiss her. "Dad. . . " "Morning dear! Brought some tea up for you."

"Thanks dad."

"You know you can tell the temperature of the cup with your computer. I am using a cup with a sensor."

Clarice takes the computer from her father and looks at the screen. "Cool. . . well cool enough in 3 minutes for me!"

The computer automatically notices the sensor Clarice's father has attached to the teacup as it is in vicinity, and easily interprets the information received from there. The sensor simply outputs the temperature to anyone who asks, the computer then figures out when it is suitable for drinking based on the room temperature and Clarice's habits which it has learnt previously.

"Where is your little friend on the computer?" asks Dad.

"Oh, I gave her to Stacy to play with."

"Oh right. Dear, I need to drop you off at the kindergarten as I must be off into the city today."

"That's ok dad." She pushes a button or two on her computer. "Cool! It's pirate day. I've made an eyepatch."

"Harrr! Well don't forget it while getting ready for school. I am going downstairs and making you breakfast and sandwiches."

Dad makes breakfast and peers over to the kitchen display to see Clarice putting on her eyepatch via the mirror he activated earlier. He chuckles and says aloud "Clarice, come downstairs for breakfast, I'll help you with your eyepatch."

Dad can speak with normal voice to Clarice upstairs, as the house communication system routes the voice, so no one has to shout. The father is looking at the kitchen display that shows the image through Clarice's mirror, and as both devices are activated the system deduces that he probably wants Clarice to hear what he says and transfers the voice. A similar system works everywhere in the household.

Clarice prods the mirror and Dad's display turns over to the news.

Clarice comes down and Dad remarks that Clarice did not forget her cup. "Yes the computer reminded me. Did you do that?"

Dad grins, "Of course. Now let me tie the eyepatch on. Nice clothes btw."

"Yes there might be stormy weather today!" Clarice exclaims, looking at an animation of a stormy cloud on her computer's display.

"Oh really. HARRR!!"

"HARRR!!!" chimes in Clarice. And the two enjoy breakfast.

As dad prepares her lunch, he checks details relating to her lunch habits from her computer, displaying the information on the kitchen screen. The computer has learned that her previous drink carton was not empty, which it got to know (via RFID) from the recycling machine at school.

"Take your lunch pack dear. I see that you didn't like your apple juice. So let's try orange today?"

"Ok dad." Clarice plays with her computer as a remote control for the bigger display in the kitchen. The computer automatically notices other systems around it and the services they offer to that particular computer. The household systems have been set up to be completely utilised by the personal computers of the family members, while external systems offer only certain public services.

"Mum's sleeping. Awww. Where's is she?" asks Clarice.

"She is in Singapore darling. Shall we see some pictures?" answers Dad.

"Maybe later Dad, Stacy is screaming for me to get to school. . . " answers Clarice. Stacy got to know about Clarice going to the kindergarten that day as Clarice's computer provided Stacy's with this information when enquired, for Clarice had chosen to share this type of information with Stacy.

"Ok, let's get going" and Dad quickly clears the table into the dishwasher.

Dad takes Clarice's hand and the two begin walking to school. Dad remarks that the weather report might be wrong as the sun is now shining. He takes a little detour as he can see on his computer that the council are cleaning the streets on their normal route which might disrupt their quiet morning walk to the kindergarten.

"You can call me today with your computer anytime today. Otherwise I will keep an eye on you. I like your picture of a. . . "

"cloud ship!" Clarice exclaims.

The wind picks up, and Dad asks if Clarice isn't too cold. Clarice says her computer is warming her.

"Oh, I almost forgot that thing can warm up. I need that on my computer."

Her computer loudly rings and mother is on the other end. Clarice excitedly answers the call.

"Hello sweetie! How are you!?"

"Hi mummy. I am a pirate!" Dad joins the call with his computer and grins at his wife in his display, as to get the attention of his wife. Once his wife winks back, he puts the phone back in his pocket. They continue on walking while Dad talks with his wife and child about the work he is doing today, while Clarice stares at her mother in the display of her computer in her right hand, with her left hand in her fathers.

They arrive eventually at the kindergarten, and by that time their call has ended.

"Are you picking me up today Dad?"

"I am not sure yet. I will contact you, ok? Call me if you like today, I shouldn't be too busy"

They sadly part, but Dad knows he can see what she gets up to on the train to the city. He sees she leaves her computer in her bag. "Thank god", thinks dad. Yesterday Clarice was playing hide and seek with it in the park with Stacy.

Dad concentrates now on getting to his task in the city today. Clarice meanwhile is playing with her friends in the classroom, which serves as entertainment for Dad on the train ride to the city.

Explanations and comments

Issues

The mirror and other camera systems within the household are an obvious privacy concern, whereby it is very important that they can be turned off easily, even by children. The cameras in the kindergarten are another case of the same thing, they only allow specific people to access images of specific children (naturally, when the kids are close to each other there end up being images of others, too). These things are agreed upon by the parents and the kindergarten, in accordance with the local legislation.

Devices

The mirror and the house communication system

The mirror was seen as an obvious place for a computer to be mounted. It works as a medium for communication within the household. As the device is quite privacy-intrusive, it has to be specifically turned on by tapping on it. Clarice also has every right to turn this on/off as well, and is encouraged to do so. When she does, the other displays turn to show something else, e.g. the news.

The sound is passed from one room to another whenever the communication systems in these rooms are on and the communication seems to take place between the parties separated by physical space. Thus shouting is no longer needed to communicate.

The computer

It is a small device, roughly the size of the bottom of a tea cup. The display is circular and covers pretty much the whole size of the device. The display adjusts itself automatically based on surrounding lighting so that it can be viewed comfortably in any situation. A camera and microphone are naturally also included. It has some control keys underneath, although the screen is sensitive to touch and that, along with a voice UI, are the main interfaces to the device. The computer may become worn and dirty quite easily, since people carry them along in outdoor activities. This is why it is very handy to be able to replace a damaged unit by just transferring the data from a central machine maintaining the data, e.g. a "family computer".

Programs, such as the Tamagochi type character Clarice plays with, can also be transferred from one device to another with ease.

The computer has Internet access, but the user does not have to deal with the data as provided by the authors. Instead the computer extracts the information required and displays the resulting information in the way it has been set up to do. This could be done with a suitable client and RSS (Rich Site Summary, [RSS]) today. So Clarice just selects kindergarten from a colourful picture menu (sort of similar to the menus in old Nokia phones), and the computer shows her the theme of the day and other things that are likely to be of interest to her. Things such as the weather are also easily picked up from the Internet and displayed in pictures for children.

The computer can also find out if anything out of the ordinary is going on near to where they are, especially in the direction where they are heading. This is how Dad's computer can notify him of the street cleaning done by the council, allowing him to decide to take another route. The entire route could be determined by the computer if he did not know the neighbourhood too well.

Another nice feature in the computer is its reaction to chilly weather. When the computer notices that the temperature is quite low, it connects to special circuitry built into her clothing and emits heat therein, so that the temperature Clarice is feeling would be within the parameters she or a child would feel comfortable. The computer itself could provide warmth like a hot water bottle if she was not wearing the required fabrics.

The computer also functions as a mobile phone, with a picture of the person on the other end of the line. An ongoing call between two persons can be joined by other computers if these are invited to do so by the parties already in communication. This is what happens when the dad joins the call from Clarice's mum to Clarice. The voice is picked up and put onto loudspeakers suitably for the situation, so the father can nicely just put the computer in his pocket and keep talking to his wife. The loudspeakers could be in the ear. But it is hoped that technology could naturally emulate the voice of the mother as if they were walking to school all together.

The whereabouts of Clarice's computer can always be found out by the parents. Other people are not allowed to access this information unless the family has agreed on letting someone else know, like the kindergarten staff. If Clarice chooses not to utilise her computer, it is up to the kindergarten's systems to provide information of her activities and safety. Therefore the emphasis is on the kindergarten's facilities, to provide elements such as cameras which the child's parents can connect their computer to. The computer determines its own location, based on the estimated distances between itself and sensor devices, which also act as the support towers for data communication with the device. These structures are quite dense in populated areas and the required eight [Cao] of them are found within a distance of a square kilometer in cities. In the countryside the positioning may be less accurate. The computer can be set to keep sending this information elsewhere, e.g. to the family computer.

The computer can participate in the physical activities of a child. The game of "Hide and Seek" could be played in such a way that she throws her computer somewhere, and they use Stacy's computer to find it. Or they allow the computer to make an audible noise they need to track down.

The camera in the computer could be utilised as a means of input to computer applications, hence promoting a theme of physical activity. For example, the camera could track her arm movements in order to play a game where she has to hit objects on a large digital canvas or screen. Games are on the market that do this already [Häm]. And it is hoped the technology will improve to become a primary means of input for Clarice to her computer.

The sensors

The sensors, such as the one Dad attached to Clarice's tea cup, are simple devices that just output the temperature of the content to anyone who asks. It is then the task of the computer to notice when these devices are in vicinity and to interpret the information provided. The computer can then figure out when the tea is suitable for drinking based on the room temperature and Clarice's habits, which it has learned previously. Each sensor has its unique ID, and the computer can be easily programmed to keep track of a certain sensor, either to be certain that the temperature of the correct cup is known, or to make certain the cup is not left behind in the scenario above.

Recycling machine

The recycling machine in the kindergarten can be programmed to output data regarding the things it receives to external systems. It can for example detect whether the containers are empty or not, and return this information when data of a specific RFID is asked for.

Kindergarten cameras

The kindergarten has extensive systems, including a lot of cameras, to allow the parents to observe their children. Generally young children would feel reassured that their parents can have an eye on them, and to parents this is an obvious advantage.

Digital canvas

Activities like painting are very important characteristics of child development. Now when Clarice paints on a canvas, this advanced canvas can relay the art in a digital format to the computer.

Services

The systems described above need little external services aside from things existing today, such as information in the Internet. The Internet connection naturally needs to be fast, reliable, and wireless. The same connection would probably be used for the telephone calls and accesses to camera output.

Required scientific and technological innovations

Mostly these things could be done today, aside from the amounts of information passed (faster connections), the size of the devices, and the battery life.

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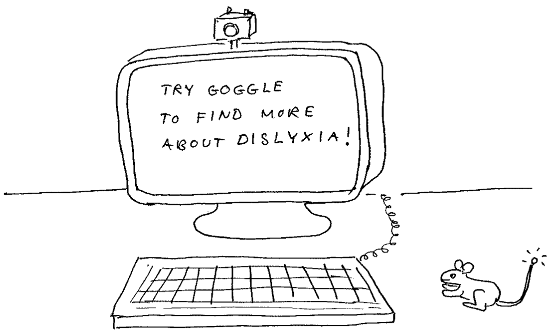
Into Vatinen – a dyslectic professor

Wilhelmiina Hämäläinen and Lauri Hyttinen

The following scenario is a glimpse into the life of a professor of computer science about 15 years from now. To make the scenario more challenging we have selected a professor with *dyslexia* – a reading (and writing) disorder, which is quite common also among the adult population (e.g. in Sweden about 5–8% of the population have significant reading and writing problems [Inta]). After the scenario we will describe the new systems of the story more carefully and consider the scientific innovations behind them. Also the social and ethical issues will be considered.

The scenario

Professor Into Vatinen's[1] working environment has changed a lot during the last decade, when the Department of Computer Science began to implement the new context-aware innovations in a university environment. Both the staff and the students have benefited from the new intelligent environment, but professor Vatinen has found it an especially good aid for his personal problem, dyslexia. Dyslexia is a kind of reading and writing disorder, in which the words easily get reversed, especially under stress [Intb].



[1] We have selected a male professor, because dyslexia is more common in men, even if in our utopia female professors are as common as male in our discipline.

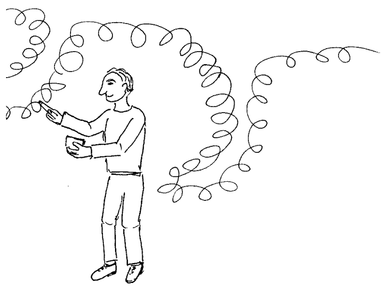
At the same time when the university began to develop the new intelligent environment, an international health care service was developed. A personal *Health Monitoring chip* (*HM chip*) was implemented and professor Vatinen among other volunteers has had such a chip implanted into his armpit. The main purpose of the chip is to monitor general health (body temperature, blood pressure, pulse, etc.) and report to the user about possible disorders. But the chip was also found useful in predicting potential risk situations for people suffering from dyslexia and at the moment the chip information is also used in professor Vatinen's personal *Dyslexia Support System* (*DSS*).

Professor Vatinen is very much into new technological advances and is eagerly using all the new applications and gadgets to improve his work and living comfort. He is really a pioneer of the new experiments as we will see in the next description of his typical working day in the department.

It is 8.55 on Monday morning when professor Vatinen arrives at the Exactum building in Kumpula. The building was quite recently renovated and equipped with the latest technological advances. After he leaves his vehicle and heads for the elevator, the system recognizes his arrival and several things begin to happen in his office. To preserve electricity, the air conditioning and other systems have been switched off in his office for the weekend and now the system notices that the air in the office is very stale and hot. Air conditioning starts to run at a great speed to cool the office. Just moments before the professor enters the office the air conditioning slows down to a moderate level, the lights turn on and the windows become more transparent to let natural light in.

The door opens in front of the professor and he enters the office. A calm friendly voice welcomes the professor and tells him that he has several messages waiting for him. The agenda of the day is also displayed on the monitor. The weekend has been very active and the professor has loads of correspondence waiting for him. He sits down and the light monitor mounted on a small base begins to show the messages according to his preferences. A steaming mug of coffee has been waiting for him brought in by the coffee robot and he sips it while he scans the messages. He makes notes on some of them with his light pen and answers a few of them. One of them is a confirmation message to a conference trip he is about to make and he just lets the computer make the necessary arrangements for the trip i.e. booking tickets, hotels etc. The trip happens to coincide with his lectures and the *Digital Assistant* (*DA*) reminds him about this. He lets the system cancel the lectures for that week and this updates the calendars of all who are using this system and taking those lectures. Those who do not use this new system will receive a regular email notifying them of the change.

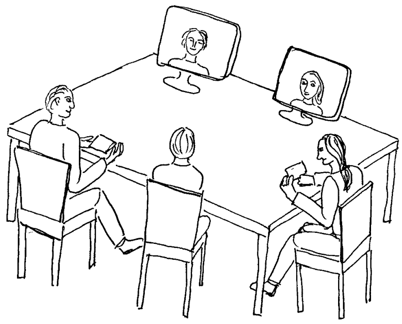
He is reminded by the DA at 9.30 that his lecture start in 45 minutes. He decides to go over the material and picks up the monitor (which is very light) and sits on a more comfortable chair. He begins to doze off, but 15 minutes before the lecture starts the system reminds him, first by a sound followed by the chair vibrating and waking him up.



He leaves the office for the lecture hall and arrives in plenty of time for the lecture. The topic is Computational Biology and he uses the latest hologram technology while teaching the finer points of that field. He stands in the middle of the auditorium and strands of DNA are projected around him, so he can virtually walk inside them and point out the interesting details to the students. He is very interested in the field and rarely needs notes while teaching it so he only scans the prepared material once in awhile. The students use the table-mounted screens to write comments in their own individual notes using their light pens. A student asks a very interesting question and the professor gets carried away with the answer, going into very fine detail. The Digital Assistant gently reminds him, by showing a notification on a nearby monitor, for him to hurry up since he has several topics to cover in this lecture. The professor decides that the question needs a thorough answer and chooses to ignore the DA by pressing the ignore option on the monitor. The DA automatically updates the course material and later, when the professor is preparing the material for the next lecture, the DA will show that the professor did not cover all the topics last time.

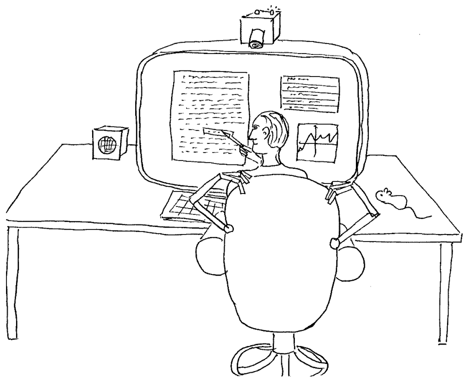
After the lecture the professor heads back to his office. Several new messages are waiting for him but he decides to go over them after lunch. He enters the *Unicafe Food System* (*UFS*), where the different foods are displayed; he has personally opted for the smell option to be turned off. The DSS suggests a choice of foods based on his health status and special diet, but he is feeling adventurous today. He orders a meal and leaves for the cafeteria, meeting several colleagues on the way. At the same time the cook robot prepares professor Vatinen's meal, and seasons it according to his taste (it was recognized that the quality of meals increased, when UniCafe replaced the human cooks with robot ones). The food is delivered very quickly after he has sat down and he spends a good 40 minutes discussing and socializing with his friends and colleagues in the cafeteria. The wall monitor next to him is in contact with his Digital Assistant and at that time it reminds him that his consulting hour is about to begin. He goes back to his office.

Only a few students come with their running errands so he is able to go through the messages that came during the lecture and lunch. The regular mail is delivered to him by the mail robot at this time so he goes through them as well. Near the end of his consulting hours he receives a video phone call from a student about an extension to a deadline to a paper the student is supposed to turn in on Tuesday. The student shows what he has done so far, as the draft is shown on the side of the interactive discussion. The professor agrees to the extension and the digital assistant updates the course information regarding that student's extended deadline.



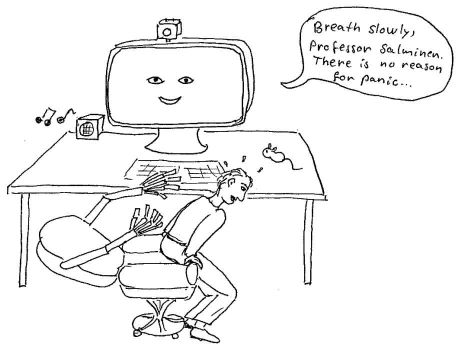
At 1 pm the professor has a meeting about the new professor vacancy, which should be filled. His consultation has been invited for the initial selection of the candidates. Some of his colleagues are present, but two of them are participating in the meeting virtually. The others can still see their holograms on the table and they can participate in the discussion in real time. Professor Vatinen is asked about one candidate, who has been suspected of plagiarism, when he finished his doctoral thesis. Professor Vatinen knows the candidate quite well and does not believe the allegations. Still, he is not sure whether he can assure the others about his honesty. Anyway, he promises to make some further investigations and check the publications the suspicious thesis was based on.

All the time Professor Vatinen's digital assistant records key words of the discussion and the professor just adds some words with his light pen. He does not know how to spell the name of one university, and so he just dictates it for the assistant, and it checks the correct name.



After the meeting the professor returns immediately to his research work. He has a conference deadline today at 4 o'clock and there is still one hour to finish the paper. The system has already loaded the text on a text processing program, which is integrated with his personal dyslexia supporting system (DSS).

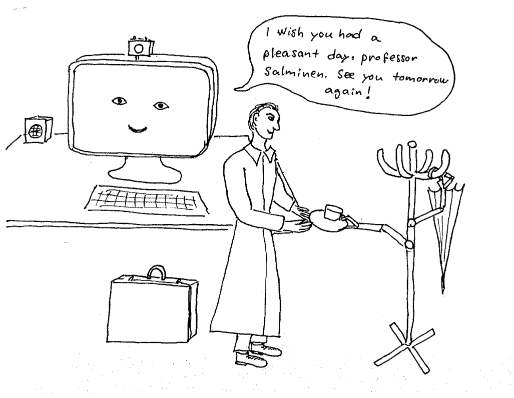
The system has checked the text so far and highlights some suspicious parts. For example, the professor has written "the new ensigns are relative to previous work" and the system suggests that it should be "the new insights are related to the previous work". It shows the alternative as a yellow comment above the sentence and also reads it, both in English and how it would be pronounced in Finnish. The professor agrees and the editing goes on. But when the deadline approaches he becomes more nervous and begins to make more and more mistakes. His body temperature increases and his eyes begin to wander on the rows. The DSS reacts to these symptoms by dimming the screen and suggesting with very soft voice: "Why don't you rest a little bit? Breath slowly and relax..." At the same time it lays the chair down and robot hands begin to massage his shoulders. But Professor Vatinen does not have time to relax now. He tries to activate the text-processing program again, but the relaxing exercises just go on. The Professor swears, jumps up from his chair and takes the old laptop he still has on his table for this kind of situations. He starts the traditional Emacs editor and finishes the text without caring about possible reversions and misspellings. And just a few minutes before the deadline the paper is ready and he can send it to the conference.



At this point the system has finished its exercises and guesses that Professor Vatinen would like to have a cup of coffee and suggests it. Professor Vatinen touches a button in his virtual coffee machine. The coffee machine service is always open in the right-hand side of his electronic notice board and his usual mode – a big coffee with milk and no sugar – is set as default. After a couple of minutes a coffee robot knocks at his door and the robot enters, serving the coffee.

Professor Vatinen still has one thing to do before he can go home: he has promised to read the new chapter one of his students has written for her Master's thesis. He enters the *Pro Gradu Supervising System* (PGSS) and selects the correct student, who is already highlighted as a most probable selection. The professor begins to read the text and makes some marks with his light pen on the screen. He writes question-marks at unclear parts and underlines some sentences. He could also write some notes into the text like in the old Educosm system, but this time he is too tired to fight with his dyslexia supporting system. He just dictates some comments and lets the system write notes. He does not have to be careful about the language and misspellings, because the PGSS helps students with them automatically. The professor is quite satisfied with the text and dictates just the final comments before leaving the program.

The time is nearly 5 o'clock and the system reminds him about going home – it has noticed that the professor is already quite tired and extra work is not recommended. His work station shows the next day's agenda, reminds him to take his brief case, hat and also an umbrella, because it has begun to rain outside. Then it says "Good bye" and dims the screen.



Explanations and comments

Devices and services

HMC, the personal *health monitoring chip* is a technological achievement of biometrics and nanotechnology. The chip itself is implanted near the artery and it monitors blood pressure, pulse, body temperature, and advanced versions also the composition of blood like levels of blood glucose, stress hormone and hemoglobin. The chip is connected to the *individual health care service system* (IHCSS), which can consult the international health service. The system works everywhere in the European Union and suggests the nearest medical services, if needed. The system is adapted to the individual user and learns the normal values and variance of measured items.

When the *dyslexia supporting system* (DSS) was developed for special education purposes, it was recognized that the secondary symptoms of dyslexia – like increased body temperature – can be used as signs of acute reading and writing disorder. It is known that those disorders have a higher tendency under stress and suitable relaxing practices and better motivation can help to overcome them. The system was soon adapted for adult people to assist them in their everyday work.

DSS itself is a larger system, which consists of two modules: the *monitoring module* and the *assisting module*. The monitoring module diagnoses the level of dyslexia disorders based on the primary (errors in reading or writing) and secondary symptoms. The DSS tries to assist in reading and writing under small disorders, but when it recognizes strong symptoms, it suggests a break and offers personal relaxing services. Services can be shoulder massage (by massage robot hands, which are part of the chair), playing soft music, guiding a breathing exercise, etc. The user can select the default cure after trying different alternatives and the system learns the most effective treatment for the current situation.

The monitoring module of DSS has several distributed sensors. For example Professor Vatinen has cameras in his office, which are monitoring his eye and hand movements. When the eyes begin to jump on the lines, return back to check words or right and left eye move differently (the right eye reads and left one checks) the acute reading disorder is recognized. Also some personal manners, like chewing one's nails or tearing one's hair, can signal acute disorder.

The assisting module is integrated to the user's personal computer and digital assistant. It works best with the writing disorder, by checking the text written by the user. Traditional spelling checkers are just part of this checking, because usually adult people with dyslexia write correct words, they just happen to be somehow reversed and strange in the semantic context. That is why the system also has to understand the meaning of the sentence and recognize errors. The system learns typical words that are reversed by the individual user very fast and checks them more carefully by suggesting similar alternatives. In Finnish the system can use auditive checking and read the suspicious words as they are spelled. In foreign languages the system can read the word as it is pronounced correctly and in the Finnish way. However, the textual mode is always available and the possible alternatives are shown on the screen. The short notes with incomplete sentences are harder to check, but in the meetings, for example, the system can follow the discussion and catch the potential word candidates from the speech. Of course, automatic record-keeping is widely used and personal meeting notes are not necessary at all.

The reading disorder is harder to recognize, because the user does not always read the text aloud. The system can still monitor the secondary symptoms and suggest the auditive mode, in which the text is read for the user. The auditive mode can also be used for practicing, when the user is asked to read the text aloud and the system highlights or repeats incorrect words.

The *Digital Assistant* (DA) is an extension of the professor's computer. It is perhaps the most important software on the computer since it has in theory the power to run the professor's life. The DA acts as sort of a nerve center for helping in his daily work. It will answer queries directed to it about the current availability and the user's whereabouts. It is connected to several other systems in the building and at home. It can reserve lecture halls and conference rooms automatically when those are needed and give out suggestions about course schedules in regards to his other work. The user is allowed to prevent other people from seeing his schedule (or parts of it) or his location if privacy is what he wants. The user can also group people so that for example his family members are allowed to get responses from the DA and other people will simply get a non-available (or busy) message.

He can also for example choose a part of his schedule to be visible and accessible to only a certain group of people, some project group for example. All commands can be made using voice commands, but traditional methods like a keyboard and a light pen are also available. The next version of the DA will include a holographic impersonation of a secretary.

In addition to all these systems the building itself is outfitted with sensors that can observe people's whereabouts. People have the option to implant an identity chip in their arms, which speeds up identification and allows different systems to follow them. Otherwise an old-fashioned identity card is available. The user is able to turn the identity chip off using the computer if he so wishes. Each floor is a separate ”entity” taking care of all the subsystems within it. Some redundancy is also provided in case the floor manager entity becomes corrupted or unresponsive. In this case other floor manager entities can extend their area of influence to cover other floors.

The communication with the Digital Assistant is based on either handwriting or speech. Handwriting is a very natural way to communicate, and it has some further benefits compared to speech: it can be used in noisy environments and when privacy is needed. These days handwriting is already commonly used in PDA's. The best systems allow different writing styles, also cursive and mixed style, which are hardest to recognize. The user can set the preferred writing style or train the system to recognize a personal style. When isolated characters are used, the error rate is only 1%, which is comparable to human error rates. As a contrast the error rates reported for cursive and mixed styles are in most cases too high for any practical application. However, the systems reported by Bengio et al. [BLNB95] and Jaeger et al. [JMRW01] seem to perform very well with large lexicons (the error rate is about 3%). Thus we have no reason to believe that handwriting could not be used with our Personal Assistant. The case is more problematic when several users' writing styles should be supported, but it is not necessarily needed in our system. [Vuo02]

Scientific innovations

The main concern in our scenario was Professor Vatinen's dyslexia and what kind of support the new innovations could offer him. Thus the focus is the dyslexia support system (DSS) and the new scientific innovations required to implement it.

The monitoring module of DSS gets information about the errors in writing (primary symptoms) from the assistant module and about changes in the physical state of the user (secondary symptoms) from the health care chip and cameras. Its main task is to collect information about the current state of the user and make decisions on them. The implementation of the HC belongs to the field of biometrics and nanotechnology. We believe that it can already be implemented by the current technology (there already exist e.g. microscopic cameras, which can be sent into veins). Recognizing the gestures from camera pictures is a harder problem and requires some development in animate vision [Bal91].

As a contrast, collecting the signs about primary symptoms is a very demanding task and requires new scientific innovations. It should recognize incorrect words – which are not just misspellings, but correct words in the wrong semantic context – and suggest sensible alternatives. The first task can be divided further into *lexical* (*syntactic*) and *semantic analysis*. The lexical analysis itself is quite a difficult problem, because the natural language belongs to the context-sensitive languages according to Chomsky (i.e. finite or pushdown automata are not powerful enough for parsing, but also the context has to be considered). There already exist lexical analyzers like CIRCUS [Leh88], which use the local context of the word for its syntactic identification. The analyzers work quite well with easy texts, but all the syntactic classes cannot be recognized.

The semantic analysis, understanding the meaning of the sentence, is an even more demanding problem. Summaries of the main ideas can be produced by the techniques used in information extraction [AM03], but understanding the meaning of the whole text is still utopia. Perhaps the new innovations in information retrieval [BYRN99], e.g. a latent semantic model, can offer promising paths here, too.

Adaption to the individual user offers another aspect of the problem. The system can be trained by the texts of the individual user. The model itself can be e.g. a Bayesian network or neural network. In the simplest form, the training set consists of texts and corrections made by a human checker, but it would be more useful if the training could be continuous and no human intervention is needed.

The assisting module of DSS is much easier and we believe that it can be implemented with the current technology.

The relevant alternatives for suspicious words can be learnt from the previous texts of the user, or the system can use existing word lists and search for similar words (i.e. those with minimal editing distance). Thus the suggestion service can be implemented with the existing techniques of machine learning and pattern matching.

The DSS assistant module can also be used in auditive mode, which requires *speech recognition* and *speech synthetization*. Speech recognition is based on pattern matching techniques and there are already some working implementations, although the systems are very incomplete (in general conversation the error rate is about 40% [CKR+00]). Usually the speech recognition system has to be trained for the individual speaker (user), which is enough in DSS. For the digital assistant it would be useful if the system could recognize different speakers and their speech for example to take notes at meetings. This makes the problem harder, because each speaker has a unique voice. In addition, the speaking rate and style may vary with the speaker's emotional state. The system also has to adapt to environmental conditions, like acoustics and noise. [CKR+00]

As a contrast, the speech synthetization is an old invention, and the only challenge is to develop more natural speech [CKR+00].

The *digital assistant* uses advanced software agents when carrying out the tasks required by the user. In the case of the travel arrangements, for example, it will create a suitable agent which then, after gathering the required information, will leave for the travel agency system, and meet with an agent representing the agency, to make the necessary arrangements. What information is required for a given task varies, but in this case, several user preferences are needed to make the trip more enjoyable. The software agent will then return with all relevant information for the user to accept. Also while the user is moving from her/his office (or equivalent) a mobile agent travels with her/him and normally inhabits the nearest computer unit to the user. This mobile agent is in contact with the home agent (i.e. office) and receives periodic updates from it. The information known by the home agent is stored in multiple points around the building so if a failure occurs in one point the mobile agent seamlessly contacts a hot standby home agent. This hot standby has all the information necessary to continue serving the user. The mobile agent uses the guest computers processing power when calculating whether an event at the home agent warrants notifying the user. Software agent technology is a very "hot" topic right now, but many challenges still remain [Laa03]. Especially challenging is how agents will learn new information and how the inner reasoning works within each agent. One essential quality that the agents are lacking is "simple" common sense. Much work remains in this field before fully scalable agent systems are available. Estimates put those at year 2010 [Laa03].

Artificial-life agents and artificial evolution are terms describing new types of agents that program themselves and learn from each other [Mae95]. The future agents will combine themselves to better and fitter populations. Old versions will die out when they become obsolete and their "offspring" will continue serving the user.

Handwriting recognition is usually implemented by statistical and neural methods, especially on HMMs and TDNNs. The recognition methods are used together with linguistic modelling techniques, because the mere pen trace information is often too ambiguous for successful recognition. However, the dyslexia poses extra challenges for this, as considered earlier. In the future also secondary factors, which affect the user's writing style – like context of writing, writing equipment, writing situation, and mood of the writer – could be taken into account. It is also known that the personal writing style may evolve with time and practice, and the system should adapt to these changes. [Vuo02]

Social and ethical concerns

In personally adapted systems there is always a wrestling between privacy and good adaptation. The more personal information we collect the better the system can adapt to the individual user, but also the privacy and security issues become more critical.

The information collected by health care chips is not so harmless as it may sound. The same symptoms which report about acute dyslexia (blood pressure, pulse, body temperature, maybe also stress hormone) are common stress symptoms and are also used in reliability tests (lie detector) and the employer could make serious misinterpretations based on them. The medical information collected can still be useful, if the user really gets sick and the illness history needs to be checked. However, it should be saved into the user's local system database and the user should decide whether to release it further for medical purposes. And, of course, the chips should be voluntary, and nobody is forced to use such a chip.

The cameras which are monitoring employees all the time are also problematic. The employee has no more privacy in his or her office and it can increase the stress (and thus also dyslexia symptoms). The employer could be tempted to use them for monitoring whether the employees are working efficiently. In this case there is no reason to save the data anywhere else but in the user's local system database for training purposes. The user should also be able to switch the cameras off, when he or she wants to.

Another security issue is the mobile agents and the information they carry. This information should be encrypted and inviolable. Another issue about mobile agents is trust, whether the users trust these moving programs as they move around the world doing the user's bidding. Will they make the correct choices for the user? Malicious agents posing as valid agents can cause many problems for the users. Will users be held accountable for the actions of their agents? The users should be given the option to monitor their agents in some visual human-friendly way and in case they want more information this should be provided to them.

The digital assistant is a powerful tool as well and a cause for concern. Do we want such a program running our lives, pushing us around? The design has to be human-focused and it cannot be too pushy for the user. It should act as a friendly caretaker and maybe a future version might have it even as a hologram, to make it more human-like. It is a sort of a replacement for the secretaries of today, so making it act like one might smooth the transition and be a natural evolutionary step in computer programs.

One critical question is, who will pay for all of this and is it worth it? It is widely agreed that prevention is the cheapest way for society, whether it is about illness, alcoholism, or other problems. A diagnosis in the early state usually decreases the costs remarkably and the patient can return earlier to work and pay taxes. So the new medical services with HC chips are consistent with the interests of society. The same argument concerns dyslexia: by an efficient supporting system the education and adaption to working life is easier and dyslectic people pay the costs back in the form of taxes (in addition to being able to make remarkable inventions, which benefit the whole society – we know that dyslectic people are often very talented!).

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Scenario 4

Angela, high school teacher

Rolf Holmberg and Giuseppe Lugano

The following scenario describes a typical day of Angela, a middle-aged school teacher who has very long experience in teaching already. She has experienced all the phases of the introduction of technology at school. The current phase is the most advanced; the programme "Learning in the third Millennium" has brought several innovations: multilingual classrooms with real-time translation, automatic tools to evaluate the students' work and give suggestions to them, unlimited access to huge archives of data as teacher support to the lesson, a semantic web, collaborative environments such as Educosm Nova and meaningful educational software. The article underlines the fundamental role of a good teacher, whose experience and understanding of the learning process will never be substituted by a machine. On the other hand, technology will help teachers, but also students and the school administration, to optimize their work and organize their time.

The scenario

September 1st 2015, 6.30 am: Angela, a middle-aged history teacher, wakes up.

Another year of school has just started. She has already more than thirty years of school experience, and her enthusiasm and motivation from her early years of teaching has matured into a deep understanding of learning processes. This day is special for her, as she has been involved in developing new methods and tools, contributing with a teaching expert's point of view. The new, advanced version of the Eurolearn system is up and running. But this is only the first step. This year fundamental changes will be introduced: the innovative infrastructures designed within the five-year European Union programme "Learning in the third Millennium" are finally ready as a production system and will be introduced during the year.

While having breakfast, Angela thinks about her past, when she started teaching and the Internet was an unknown world to the general public. Now intelligent semantics is essential in searching and retrieval of information. Text processing was only emerging in those days and teachers mostly had to write documents by hand or by typewriter. Hand writing is still around as a fundamentally efficient way of writing, but intelligent interface systems cleverly take care of analyzing the writing, transforming it into computer-understandable form and at the same time improving its own ability to comprehend the handwriting. Of course this goes for speech recognition technology also, which has developed very much in recent years. Grabbing her light bag she thinks about how she used to carry an incredible amount of books to school. Now everything is available online: “Internet”, “networking”, “connected world”, “online”, these words would not go out of Angela’s head. In fact, the Internet was the first big technological innovation for schools, which, together with computing and communication devices, was one of the prime motors for the significant cultural shift that had taken place. And still, it took quite a lot of time to be exploited in a useful way for the learning process, as learning is something much more fundamental than just information manipulation. After the “slow start”, things went better and better: and many new tools were introduced to make the life of teachers and students easier, and at the same time supporting the learning process in new and often unexpected ways, unheard of only 15 years ago.

Angela’s thoughts are suddenly interrupted by an alert on her E-Pal; only 15 minutes to the lesson: she has to hurry up and go to school! She has a quick glance on the Pal at the schedule of the day and notices that she might have to try to make some rearrangements. One teacher is ill and the system suggests an optimal substituting scheme. This does not quite suit Angela, however, so she decides to call upon her network, where a pool of teachers might provide some help.

At 8 am the first lesson of today is about to start. As the students arrive in the classroom, their personal card in their E-Pals updates the teacher register with their presence. As the lesson goes on much more information is automatically transferred and analyzed, even advanced matters related to how the students respond to the teaching, helping to identify flaws in the teaching or special difficulties in understanding and learning. All students have their E-Tabs, essentially mobile, intelligent, multi-channel communicating “screens”, on their desks. Angela starts her first lesson with a welcome speech, because there are new students present.

She then asks each student to introduce himself to the classroom. One revolutionary, cross-cultural innovation introduced by the programme “Learning in the third Millennium” soon comes out: the class now has twenty five students from ten different countries. As they start introducing themselves, a complex voice-recognition and translation system allows everybody to understand what people say through headphones communicating via the E-Tab with the surrounding infranet. Additional services, such as multimedia, information retrieval, videoconferencing and integrated teamwork at a distance, are easily available.

After the presentation of the class, Angela proposes an activity to the classroom that would help each other to understand the different cultures, from a historical point of view. To reach this goal, she has found on the net a collection of documents that are available to everybody in a collaborative learning environment called Educosm Nova. The student assignment is to help the other students to better understand his background, not only by reading the suggested documents, but also adding new ones; persistent annotations and comments are also possible.

At the end of the lesson, Angela introduces the project of the year: a collaboration with the Japanese school of Kyoto about a shared theme. The partner school teacher Mrs Nakata is connected in video conference, and soon the students are divided into groups to start working with their pair. The students are asked to produce some collaborative material using all the facilities they have; the teacher will follow their work as tutor, but great importance is given to independent work.

Both schools are very happy about the new collaboration: students will have the chance to work together and get to know each other, but it is also an opportunity for the teachers to develop their own network of partners around the world, to share experiences with and to exchange ideas about future projects.

During the break, Angela leaves the classroom to meet her headmaster, Mr Smith, who is going to give a speech to all the personnel of the school about the new system. Suddenly she remembers to try to rearrange an afternoon lesson, and through E-Pal she describes her need, contacts the teacher pool after getting two optimal suggestions, places a request and gets an almost immediate response. Problem solved. She prints out the information on electronic paper and leaves it on the table in the teachers' room for the attention of others. While speaking, Mr Smith points out that the life of school teachers is much easier nowadays, even the traditional tedious writing of administrative documents. In fact, a database of templates and clever automatic editing is available and online experts can be consulted anytime. One of the hardest tasks of the teachers is still the evaluation of the student, and the understanding of his weaknesses. Human judgment will not be substituted by "intelligent machines", but evaluation can be helped by technology. This task is now made easier with the E-Pal device. The E-Pal looks like a palm computer, and can utilize a vast number of services, such as a highly configurable curriculum planner and student-life recorder. The history of each single student is recorded there and can be analyzed according to the needs of the teacher in the best interest of the student. Huge amounts of data can be analysed to give advices about the evaluation of a student and on the best way to proceed and individualize the teaching. The E-Pal is also used by the teacher to understand how his/her way of explaining things and capturing the interest of students could be improved. Students are encouraged to give feedback about the teacher, and all the information is analyzed by the E-Pal. The E-Pal can connect to a database of companies that might be interested in financing the realization of the best school projects such as multimedia production or school exchanges with foreign partners.The traditional task of raising funds for the projects was a time-consuming task for the teachers, who can concentrate more on their work now. Loud applause follows the headmaster's speech: teachers, especially those who had a fear of losing their central role because of the technology innovations, are now happy because their work has been made easier.

Angela's next lesson is starting in a few minutes; she is a bit worried because the pupils of that classroom did not get very good results last year, and the current year is the last for them: the demanding final exams will soon be very close!

The lesson seems to start well: the pupils are not sleepy, as they were, but very motivated, asking questions and trying to understand the subject. As always, the unexpected is behind the corner: a sudden electric power blackout brings many machines down. Although the scenario had been foreseen and alternative power sources activated, something goes wrong: the E-Pals start behaving strangely, and the real-time translation system becomes unusable.

After a few minutes of chaos, where everyone realizes how difficult it is to understand something when listening to many different languages at the same time, both teacher and students switch off their E-Pals and start speaking in English, the language that has become a de facto standard through the years. Angela talks about the Second World War, reads some articles and a discussion follows. Michael gives his point of view, showing some photos of his grandfather's personal experience. E-Pal's data recording is not available and many hi-tech features cannot be used during the lesson, but still, everybody enjoys it and learns something.

Going home, Angela is thinking about the past, present and future: in comparison with the past, students have many more opportunities to learn.

But teachers can also now exploit them, because the learning process is lifelong. How good is it not to benefit from the wonders of technology and without relying on them!

Explanations and comments

Issues

Learning: each generation has to learn everything relevant to their time, to be able to carry the cultural heritage and the “added value” further. Although there are inherent boundary conditions related to this, new learning methods, ease of retrieval, manipulation and presentation of information and the increasing integration of the human mind with information machines greatly enhance this.

Dependence on technology: technology should not create dependence in users, because if it would not be available, they could not do their job anymore. Teaching and learning can benefit from new tools and services, but teachers should have the freedom of choosing how to teach and pupils how to study. Every task has to be accomplished in different ways; technology, in most cases, will help the user to complete more tasks in less time (efficiency). For instance, it could take hours for a teacher to compute by hand the statistics about a single student, and even more time to compare them with the data of other pupils.

Some services, especially those involving real-time communication, would not be possible without technology. An interesting feature of the new school system is the possibility to have multilingual classes. In this scenario, the real-time translation system allows everybody to speak his/her own language; looking at the complexity of the problem and at the slow developments done in this field over the years, one might be quite pessimistic. If such a system would exist in a few years, doubts could arise about the dependency of people on this system concerning the communication. If a well-known language would be adopted as a standard, then all doubts would be wiped out. English seems to be the best candidate for it, since it is already used widely among people who do not speak the same language, even if none of them is a native English-speaker.

Security, trust and privacy: Since security and privacy are fundamental values for everybody, a strong effort, based on both legislation and technology is needed to support the feeling of freedom, privacy needs and total individual control of the use of information related to oneself. There must be a strong and deliberate drive toward a policy of not controlling individuals, but supporting them. The goal is to make life easier with the devices. In this respect, the perception of present-day computers and systems among the public is negative to a high degree: common opinions are “things are difficult” and “machines do not work properly”.

In order to understand whether there are some privacy issues to consider, an analysis of the interactions between the different components of the system has to be performed, with a deeper consideration of which information can be used by whom.

Three entities have been found: School, Family and Company. In School, three sub-entities are present: Teacher, Student and Administration.

Teacher $\longrightarrow$ Student: a teacher (and his/her E-Pal) has access to all the personal data of the students he/she is teaching. Personal information includes email address, too. A teacher also has access to all the information about courses which the student is attending in the current year, but also to courses the student attended in his/her history, including the marks he/she got.

All the information is needed for communication, personalisation of the student career, including suggestions on study methodology and course frequency.

Teacher $\longrightarrow$ *Administration:* a teacher has access to all the administrative public information like weekly announcements, teacher meetings and weekly school calendar. His/her E-Pal can communicate with the administration in order to optimize the times for substitutions and school plan.

Teacher $\longrightarrow$ *Company:* a teacher, through his/her E-Pal, can access all the public information of a company that might be interested in financing or supporting a certain project. If the project is about telecommunications in Finland and Italy, the E-Pal would retrieve the names and contacts of Nokia, Sonera and Telecom Italia; the same information that the teacher would find anyway, but only after wasting a lot of time browsing the Internet.

In addition, a teacher has access to all the services and products provided by a company that has some products that might be of interest for the education and learning (a list of movies available from an archive, for example).

Teacher $\longrightarrow$ *Family:* a teacher has access to the phone number, home and email address of the family of each student, in order to contact them whenever he/she wants.

Teacher $\longrightarrow$ *Partner School:* each teacher has access to the general information about the Partner School (name of the school, address, telephone, email) and about the person who is responsible for the project (usually another teacher). Depending on the kind of project, the names and information of the other school project participants might be public.

Student $\longrightarrow$ *Teacher:* a student (and his/her E-Pal) has access only to school-related teacher information and his/her email address. Such information includes the teacher's office hours and the teacher's weekly schedule.

Student $\longrightarrow$ *Administration:* a student has only access to the email address and telephone number of the administration office and chairman of the school.

Student $\longrightarrow$ *Partner School:* each student has to be able to contact his/her partner. Email address of the person responsible for the project (usually a teacher) and of the other students who will work with him/her will be provided.

Company $\longrightarrow$ *Administration:* each company that is involved in education, has a list of schools with their general information and how to contact them to promote new services and products. Schools can be contacted only trough the administration. Access to other data is forbidden.

If the company has received a proposal for a project from a teacher, then they could also contact that teacher for more information about the project and to agree about the financing.

Business behind education: In the scenario, teachers seem to make great use of software and audio-visual resources to support their teaching.

Since there are companies producing these contents that want to gain profit, it is clear that the licenses and fees that have to be paid to them become an important issue.

Teachers should be free to use any kind of support for their teaching without any worries about the cost. So, it follows that the fee does not have to come out of their pockets.

The school is another candidate to pay the licenses. If so, a dangerous contrast between rich schools that could afford buying the best products, and poor ones, would arise. Thus, this candidate seems again not to be a good one.

Since governments are paying for the education, it seems reasonable that they should pay the licenses and fees to the companies. A fixed amount of money per year has to be paid for the unlimited use of resources, which must be used only at school. In this way, problems concerning copyrighted movies, music and text would be avoided.

Products

Devices

- E-Pal: a device of small physical size, which enables storing, transmitting and presenting information by fast, multichannel communication with the surrounding electronic network, the infranet and its hosts. Information is stored both in the E-pal and in distributed databases on the infranet. In addition, it possesses many autonomous functions. The general idea is to have it available continuously and to personalize it by using the E-card. All information is protected and requires authorization by the user for transmission or presentation, either by legislation, general rules, detailed personalized rules or in some cases by user action. The user does not in general have to worry about security, as it is guaranteed and policy-based. Eavesdropping and listening to the communication is not an issue because of the advanced encryption.
- E-Tab: a tablet, basically a high-resolution screen with an advanced user interface. The screen can be written on, pointed at, used as a virtual keyboard, spoken to, operated on at a distance using E-Pal or other E-Tabs or by the infranet. Hard copies can be transferred to electronic paper, and retrieved e.g. by another E-Tab. The device is required at school, as it is the means of communication and information manipulation. The newest versions are flexible mats, which can even be rolled up or folded, but the price is still prohibitive.
- Holomem: an evolving technology solid-state, holographic, non-volatile, high-capacity and high-speed memory for various devices. Recently the physical information transfer mechanisms have developed into electrically controlled solid state devices
- Electronic paper: Electronic paper has the look and feel of ordinary paper, but can be written on electronically and the information can be retrieved electronically.
- E-net: the high-coverage electronic network, “infranet”, is the basis for the functionality of the system and its services.
- E-card: the card provides basic personal information, complete security and some additional, changing information such as monetary status and transactions, health info, for flexible, everyday use in various places. Everybody has this card. It can be used in a variety of devices or in connection with other devices, such as E-Pal. The owner has full control of the use of the information as a result of the uniqueness, advanced encryption techniques, and physical security of the design. Its use requires automatic, biometric identification of the owner by redundant and diverse methods.
- E-Board: the E-Board corresponds to the legacy device called blackboard. It can be seen as a large version of E-Tab, but comes with even more versatile properties, it can especially display information from the students’ E-Tabs. It is often used in connection with E-Tabs, but especially when such are not available or not needed e.g. in one-way presentations, it is used for large-size visual displays.

Services

A wide range of services is available in the background, which in the teaching case are communicated via fast, multi-channel connections through reliable links. Most important for the teacher is the access to vast banks of information, which can be retrieved efficiently by natural language-like definitions of contents, significance, description of context, level of detail, quality, reason for the need, level of understanding and background for assimilating the information. The general information retrieval service (today's search engines on the net) has evolved into a semantic system, which at least in simple cases works pretty well. The user describes the problem using natural language, including e.g. description of problem domain, intended use of the information, quality and reliability requirements, level of detail, etc. and receives a readable small set of information, presented in a way corresponding to the specifications given in the request.

Another important service is the trainer agent, with which exercises can be performed with students who need additional training in specific subject areas. The system could automatically analyze student performance, and then suggest the amount and level of additional training. On the other hand, students who wish to develop more rapidly should have access to these on a voluntary basis.

An important service is the intelligent curriculum and schedule planner, which taking into account boundary conditions, restrictions, wishes and preferences of teachers, searches for the optimal solution, suggests several near-optimal options and through a dialog with the person doing the planning and possibly by checking the options with other people involved fixes the solution. It can also be used to personalize the individual students' curricula according to personal choices, preferences, ambition level and ability.

Electronic library: books, magazines, newspapers, news, music, movies, various multimedia presentations, scientific reports can be reached and either handled on-line or downloaded once and for all, when needed. The service fees are reasonable and teachers have the resources available to use the service without restrictions.

A flexible system of peer-to-peer communication, which eliminates much of the need for actual meetings and face-to-face communication is available, even if such systems have been criticized for impairing understanding between people, as much of the more subtle signals, e.g. body language, is not there.

The main communication devices are the E-Tab and its simplified version, the E-Pal. Various supporting systems for teachers, such as automatic curriculum and schedule planning, based on logic and optimization techniques, are available e.g. for real-time rearranging and rescheduling of teaching whenever needed. The system keeps track of available teaching resources, produces a bid after optimizing the situation, and responds to the acceptance or rejection after a request. Teachers can comment on, and finally accept or reject the solutions. And the collaborative learning environment Educosm Nova, the advanced version of Educosm, has finally matured.

Required scientific and technological innovations

Important developments and innovations needed are listed in the following. Some of them already exist in some form, or can be extrapolated from emerging technologies, other ones would require significant scientific and technological breakthroughs.

The main bottleneck is the difficulty and effort needed to produce all the various software required. Such software include tools for efficient information storage, search, retrieval, communication, AI-type advanced information manipulation, etc. Much effort should be put in finding new, innovative ways of generating clever, functional, error-free software in an economically feasible way. Looking at much of today's software leaves one quite pessimistic. There is a trade-off between programming at a low level and the actual logic and functional requirements of a very high-level system. One significant improvement therefore is to develop higher-level programming languages which lump “elementary” programming tasks (which themselves of course can be demanding) and hide them. The actual problem-solving/programming effort must shift more clearly to the high-level functionality instead. Generation of such program generators can be a prohibitively demanding task in itself. The problems related to this have been around for very long, and there does not seem to be any very promising solution in sight, therefore there is a need for a very forceful, well orchestrated and co-ordinated assault on this problem. Combining and merging several different techniques, not adhering to a single, orthodox one could be fruitful in the essential software production.

The term “artificial intelligence” should be changed to “virtual intelligence”, as there is no real intelligence there, only intelligence-like behaviour. The techniques used, however, are extremely useful and there should be a strong emphasis on developing them further.

Wireless communication must evolve into a fast, reliable, robust system, which would probably require an ever-present background “infranet”, which itself will be optically wired. This will unquestionably happen. Bandwidth (transmission speed) questions are crucial, but based on present-day WLAN technology it does not seem impossible to develop technologies to handle even crowded situations

Very large and fast solid-state memory devices must be developed (hopefully with no moving parts). They could be optical or in some sense holographic. The development of holographic memories is well under way, with a promise of densities in the TB/cm^3 range. Entire pages of information are stored and retrieved quickly in 3D in e.g. lithium-niobate crystals or photopolymers. Constructing the holographic image and retrieving information requires a laser, optics, CCD detector, plus extreme accuracy in directing the laser beam.

Electronic paper technology is emerging, and there is hope to be able to develop portable paper which can be updated without using large power sources. This can be used for uploading today’s newspaper (personalized, of course), displaying videos and many other applications. The ability to display and shift colors quickly can be used to display video clips in magazines, instead of still pictures. In a school environment, one can imagine many useful ways of utilizing E-paper, such as visually more informative books. One significant innovation would be to create efficient methods to maintain and further develop existing information systems in a very non-homogeneous environment, as the systems should be allowed to be developed without technological restrictions. An analogy might be connecting different diverse networks to the Internet. This should probably be an integral part of system design itself.

Human interface-related research seems very essential, because the functionality and actual usefulness is strongly dependent on this. It includes interface-related issues in general, taking into account human psychology, need for personalization, interface adaption by learning, clarification of the “intuitive”, as well as specific technologies such as speech recognition, machine vision, recognition of handwriting, biometrical methods in connection with security and identification issues, possibly robotics, and automatic language translation.

Scenario 5

The bike messenger

Cristiano di Flora and Oriana Riva

> *We colour all cities. The urban arena is our office. Whether it's San Fran, DC, London, New York… Without us there would be no function in any city… Without us there wouldn't be this El Dorado style shirt riding around like a maniac, hanging on to cabs crossing all borders, jumping over tracks and delivering packages on time. We make lawyers make money. Everyone makes money off of us. And if we were to stop in one city there would be no more business.*
>
> – DC Steve@CMWC 95

Figure 5.1: Bike Messenger, New York City 1898 American Distributors Messengers, Western Union Tel. Co. Photo by Alice Austen. (Quote and figure from http://www.messengers.org/messville.)

Background

Nowadays being bike messengers is a tough job. It demands physical, mental, and spiritual determination and effort. It means zipping in and out of traffic in a big city to deliver letters, documents and packages and get paid $5–10 for each delivery and eventually suffer broken bones and head injuries. Bike messengers provide a valuable service for businesses, especially in big cities. Based on a study conducted in Boston [DM02], these daredevils on wheels work an average of 40.3 hours per week, 8.5 hours per day and make 28.5 deliveries per day. For each delivery, a messenger must ride his bike about one mile. The percentage of bikers injured is quite high because of the heavy downtown traffic and often "unpleasant meeting" between messenger and cars: 90% of the bike messengers reported that they had been injured on the job. Of those injured, 55% said that their injury was serious enough to seek medical help and 27% of them had to visit the hospital. The messengers themselves think their job is dangerous.

The main operation of a bike messenger is to pick up packages at a given customer site, transport the package to another customer and deliver it. Today the *state-of-the-art* of such a job is not very exciting. A bike messenger starts the day jumping into the traffic with an approximate schedule of the deliveries of the day. He is equipped with a cellular phone, usable whenever the battery and reception are good. While biking to pick up the first package of the day, he runs into heavy traffic due to an overturned lorry; hence, he chooses an alternative (longer) path, and he calls the customer to inform him about the delay. The customer will leave the package at the reception of the building since in half an hour he has an important meeting. Finally, the messenger reaches the building and picks up the package; unfortunately, the addressee's name and street number are fairly unclear, and the customer is not available anymore. Anyway, after spending 10 additional minutes in gathering information among people living in the same street, he delivers the package. At that moment his company asks him to insert an urgent delivery into his schedule. He has to pick up a package in the countryside in the outskirts of the city. He does not know the fastest way to get there, thus he needs to check it on the map.

The scenario

New York, September 26th, 2018. The sun is shedding some light on the city. It is yet another Wednesday morning and Willie the messenger is still sleeping softly. His smart digital assistant is watching over him, and takes care of waking him up at the right time. It knows all his morning habits, his first bike mission, as well as traffic and weather conditions of the day. Thus, before going to sleep, Willie did not need to worry about setting the alarm clock or checking the weather forecast. Furthermore, his assistant knows his food preferences perfectly and, according to a balanced diet program, it will indicate the healthiest breakfast to face the day. As the weather is expected to be rainy starting from the early afternoon, it will suggest him to bring a water-proof rain suit.

At 7.10 am the assistant plays Born in the USA. . . , one of Willie's favourite songs. As Willie awakens, he eats the proposed breakfast. He gets dressed, goes downstairs to the garage, puts the smart assistant on the bike's handlebars, and finally puts on his smart helmet.

The smart assistant displays the schedule, including pick-up and delivery addresses, as well as customer data and estimated times for completing each errand. This information is retrieved directly from the base station of the company Willie works for, namely7.10 the Speedy Messenger LTD.

The first customer is Mr Bruce Mason, whose office is located on 24 7th

Avenue. Mr Mason is an old lawyer who recently fell sick. This morning he urgently needs to sign some important documents that are stored in his office. Neither his wife nor his secretary can help him, thus he decided to contact Willie's company in the early morning. The company selected Willie as the most suitable messenger for this delivery, since he lives nearby.

The assistant displays the route for picking up Mr Mason's documents. After a few minutes, Willie reaches the destination and gets off the bike, holding his assistant. The secretary, who needed to be at court all day long, has put the documents in a secure smart mail-box before leaving. As Willie stops in front of the mail-box, it recognizes him as the authorized bike messenger and opens its sliding door. Willie picks up the package, and while putting it on the bike, he hears a message confirming that the payment transaction has been committed, and ensuring that the package contains no dangerous materials (i.e. drugs or explosives).

The lawyer lives in the countryside, in the outskirts of the city. Even though Willie has no idea of where his house is located, he trusts his assistant and follows the route directions. While Willie is biking to get out from the centre of the city, the assistant autonomously decides to route Willie on a longer way, since the shortest connection is affected by heavy traffic (due to an overturned lorry).

Willie has worked very hard during the last few days, and the weather has been rainy and cold, hence, his health condition is not optimal. The assistant detects his tiredness and sets the gear system to a low-stress speed.

He leaves 7th Avenue and bikes west, and then south to Columbus Circle via the Lincoln Centre. Suddenly his smart helmet alerts him to the danger of a fast car driving the wrong way up a one-way street. Willie slows down in time, letting the car pass.

Finally, he reaches the destination, and delivers the documents to Mr Mason by putting them in his private smart mail-box. He jumps back on his bike, and goes on picking up and delivering items until noon.

Willie has worked hard and he is quite hungry. It is time to eat! He asks his assistant to retrieve the location of restaurants in that area. The assistant presents Willie with a list that is tailored to his preferences (e.g. food price, waiting and serving times) and to weather conditions (e.g. no outdoor restaurants since later it will rain). Finally, Willie chooses the "Zio Pepe" restaurant, and while getting there, the assistant even proposes some dishes to him. Upon arriving at Zio Pepe's, Willie turns off his assistant because he wishes to have a relaxing and work-less pizza! The restaurant is quite empty, and his pizza arrives soon.

After his pleasant lunch, Willie gets out of the restaurant, and turns on his assistant. Unfortunately, his assistant is not able to establish a direct connection to the company, due to an unpredictable network infrastructure outage. Anyway, it is capable of contacting other messengers, establishing a temporary direct connection to one or more of them, and retrieving Willie's schedule and other relevant information. Willie notices that his next pick-up has been delayed, and the assistant suggests that he uses the additional time for having a longer rest, also reminding him that his tyre pressure is getting low, and the water tank is almost empty.

During the afternoon, the sky gets darker and darker. While Willie is biking to deliver a package, suddenly it starts to rain heavily. Fortunately, Willie has brought his rain-proof clothes. He stops and puts them on in a few minutes. Meanwhile, the assistant switches to an audio-based mode for providing him with route and delivery information, as the rain would dramatically reduce its display visibility.

It stops to rain only when Willie is back home. He takes a fast shower, and soon joins some friends for a relaxing dinner. Will he miss his bike and his efficient assistant?!?

Explanations and comments

Issues

The scenario described in the previous section implicitly pointed out some crucial requirements of the Bike Messenger System (BMS). In order to describe the fundamental issues in realizing the BMS, we have grouped them into several main categories, each related to a specific requirement. In this section we analyze each category separately, and we consider technological, architectural, and human interaction issues, as well as privacy and security concerns.

Social issues

The scenario assumes a substantial redesign of the urban system, since at the core of the BMS there is a completely renewed and pervasive traffic management infrastructure. This implies the monitoring of vehicle attributes (i.e. speed, location) and eventually a study of people's daily routines. The major social issue relates to whether there is too much social engineering in this approach [DBS+01]. What pressure would society have to face to accept this level of indirect (i.e. psychological) intervention in freedom of movement? What would be the effects of the BMS on the biker's private life? And what about the effects on his work habits and preferences? How will the minimization of human contacts impact on his mind?

It is also worth noting that the user may likely accept all the processes, products, and services introduced by the system if advanced security functionalities and privacy guarantees are provided.

Device-specific issues

Physical dimensions and the weight of a biker's devices must be limited, as components should never obstruct his primary goal, and the security of the biker himself should not be compromised either. Moreover, the weather conditions are crucial issues to address when supplementing the devices. Hence:

- materials should be light and resistant to i) bike crashes, ii) mechanical stresses (especially the ones used for the helmet), and iii) atmospheric agents (i.e. rain, extreme temperatures);
- the bike should be stable, resistant, and safe;
- the assemblage, the placement, and the configuration of the biker's equipment must fit the user;
- the system must be as pervasive as possible (e.g. integrating sensors and antennas into the bike's frame or into the biker's clothes);
- the user needs freedom in placing the devices according to his preferences and situations at hand [PRM00];
- bike tyres should be strong, less prone to punctures and they should provide a better, more smooth, and responsive, ride.

System functionality issues

A Bike Messenger's day consists of the sequence of several phases (pick-up, transport, drop-off, break); the type, frequency, and arrival-time of incoming messages (e.g. coming from wearable and bike devices) should take into account his current working phase. For instance, messages concerning collision detection should not be delivered to the biker when he is not on the bike (e.g. during a package pick-up from a Smart Box inside a building). Moreover, as different devices are available for presenting messages to the biker (e.g. audio output from the helmet, visual display on the assistant), the smart assistant should be able to choose the most suitable for the biker's current context. Achieving such context-awareness is a challenging issue [SMR+97, DA00], since it implies the dynamic representation of a human activity.

As far as communication between the Bike Messenger and the company's base station is concerned, two different operation modes must be taken into account, namely the disconnected operation mode and the connected one. Upon switching from the disconnected to the connected mode, the messaging system has to be able to proactively restore the overall state by i) updating biker location parameters, ii) taking care of transactions eventually launched before or during the disconnection (e.g. payment parameters transfer), and iii) retrieving (and sending) all messages and information (e.g. the job-log) explicitly requested or sent by third parties (i.e. clients, base station, peers).

Furthermore, the Bike Messenger System is characterized by different timing requirements: timely completion of some tasks is a desirable feature in some circumstances (soft real-time requirements) and critical in others (hard real-time requirements). The former regard several classes of message, such as biker location, biker's assistant updates and possible variations to the current delivery schedule. The latter concern events related to the critical health condition of the biker (excessive tiredness or high blood pressure), and collision detection (with smart vehicles or obstacles).

System architecture issues

The complexity of interacting systems (sensing infrastructure, messaging system, traffic management infrastructure, pick-up and delivery bays) poses problems in the overall architecture design and development. Middleware technologies will play a crucial role in context-aware computing applications, because they are suitable for: i) managing sensor networks [XZAM03], ii) addressing interoperability issues, and iii) supporting the enhancement of non-functional requirements (dependability, quality of service, reconfigurability, and extensibility). Hence, the overall architecture might consist of several inter-connected networks, middlewares, and sensory infrastructures, each responsible for specific tasks [CMY+02]. Dealing with the heterogeneity of components and infrastructures is not a trivial issue; the different levels of heterogeneity raise substantial integration problems [XZAM03], including interoperability, data-dissemination, and data consistency, as well as adaptive presentation and adaptive delivery. Finally ad-hoc networking is required between all devices that have been deployed on the messenger as explained in [CMY+02].

System interfaces

Generally, the biker's main attention is not directed toward the terminal in use, but to several signs and symbols that appear in the environment in which he is moving, such as street signs, traffic lights, and movement of traffic flow. Hence interaction with the communication system must be simple and intuitive, and most of the functionality (especially the one needed when the biker is moving) should be accessible through a hands-free interface. In order to guarantee the usability of the biker's equipment the combination of several user interfaces for commands and data I/O should be considered. The effectiveness of a visual interface depends on display dimensions, the limited visual attention capacity of the biker, and other related problems; to cope with these constraints the assistant's visual interface could be structured as a set of layered screens, one for each kind of information, as proposed by Pascoe et al. in [PRM00]. Additionally, the usability of visual interfaces is further influenced by the outdoor context (e.g. high-resolution LCD displays are not suitable for operating in the presence of strong sunlight). The audio/speech interface presents some characteristics that make it unique for spontaneous and hands-free navigation and notification functionality in wearable computing [SS00]. However, the usage of voice input and audio output raises non-trivial usability issues. Firstly, voice commands may result in an excessively slow and tedious interaction between the messenger and his wearable devices. Secondly, the biker operates in a noisy environment; hence, speech recognition might significantly degrade, thus making the interface less responsive. Thirdly, speech commands and audio output raise security and confidentiality problems, since some information is strictly confidential and might be heard from a malicious third party (e.g. client's private data). Finally, audio output devices should not exclude background environmental noise, because such noise provides important navigational cues and warnings to the biker.

Technological issues

Some substantial technological issues have to be addressed when designing the Bike Messenger System:

- Device-related issues: existing positioning system terminals, such as Global Positioning System (GPS) devices, may have cost, weight and power consumption requirements that may not match the constraints imposed by the bike messenger assistant. Additionally, most of them are based on a visual interface; therefore, as already mentioned, they pose some non-trivial usability problems, considering that the bikers' activity usually engages eyes, hands, and attention.
- Communication subsystem roaming from one network to another should be totally transparent to the user [PMP03, HHNS02].
- Outdoor operation may be subject to several disturbing factors, such as rain attenuation, noise, path loss, and multi-path fading, causing disconnections, transmission errors, and signal alterations. In this context, providing reliable services using radio waves is challenging because maintaining radio links under varying environmental conditions is not straightforward [FRHF03, Bor02]. In particular, as pointed out by [FRHF03], rain is the most significant and uncontrollable variable, leading to signal attenuation, service disruption, and uncertainties in system operation.
- Location data management: in order to support the traffic management infrastructure, a complex and heterogeneous sensor-network should be deployed on all the vehicles. As far as sensors are concerned, two key requirements may be identified: i) the dynamic reconfiguration of the sensor network. (i.e. dynamic mapping between geographic topology and network topology) , and ii) sensor miniaturization. As far as the management infrastructure itself is concerned, the following problems must be considered: a) managing the huge quantity of geo-spatial data which can be acquired by road, building and traffic sensors; b) managing the increasing complexity of geo-spatial data; and c) understanding and modelling human interaction with the gathered geo-spatial information.
- Overall System Life cycle: all devices and infrastructures should be considered to be long-lived systems.

Satisfying basic requirements such as maintainability, extensibility, portability, interoperability, and modularity is not straightforward.

Context-variation

The region in which the Bike Messenger operates can be subject to several variations due to climate attributes (i.e. weather, temperature), types of road, surrounding environment (light conditions, noise), infrastructure condition (network connectivity/coverage, presence/absence of fixed-infrastructure agents), people, and other devices. For instance, the delivery of a package in the evening is affected by a low-light condition, whereas the delivery on a sunny day is under a strong light condition. Visual devices should adapt themselves to such a dynamically changing environment. More generally, in order to achieve awareness of such a dynamic context, devices must be able to detect or measure the significant attributes we have mentioned. The heterogeneous nature of these attributes, along with their unpredictability, makes their measurement a hard issue. The key challenge in this context is realizing an error-resilient conversion of status phenomena (things which constantly have a value that can be sampled) into events, understandable by computation and sensing devices [DRD+00].

Dependability

Dependability is a measure of the "trust" that users place in system operation; according to the presented scenario, dependability requirements include reliability, security, and privacy. The system needs to support the following techniques for: 1) reliable messaging and group communication; 2) secure id authentication; 3) biometric authentication (fingerprint, iris scanning or speech); and 4) micro-payment systems, digital time-stamping.

Since security functions are typically based on computationally intensive cryptographic algorithms, achieving this goal is not a simple task, for the following characteristics of adopted devices: 1) limited computing power and energy, and 2) constraints imposed by peculiarities of the software platforms [CdFM+03].

As regards the privacy issue, the ways in which the application uses information must be clear to the users. The user must be able to understand and control how information about the context is distributed to other people [PMP03, BBL+00].

Devices and services

In this subsection, we propose an architecture for addressing the previously analyzed issues. As shown in Figure 5.2, we identified seven main entities, each responsible for guaranteeing specific services. In order to represent the physical distribution of services upon the involved entities, we used the UML Deployment Diagram notation. In particular, we depicted each entity as a node, and each service as a component package. It is worth noting that each component package may consist either of software components or physical devices. More specifically, the nodes are:

1. Bike Messenger Assistant (BMA)
2. Bike Messenger Station (BMS)
3. Bike Messenger (BM)
4. Customer
5. Traffic Management Infrastructure (TMI)
6. Smart Bike (SB)
7. Bank System (BS)

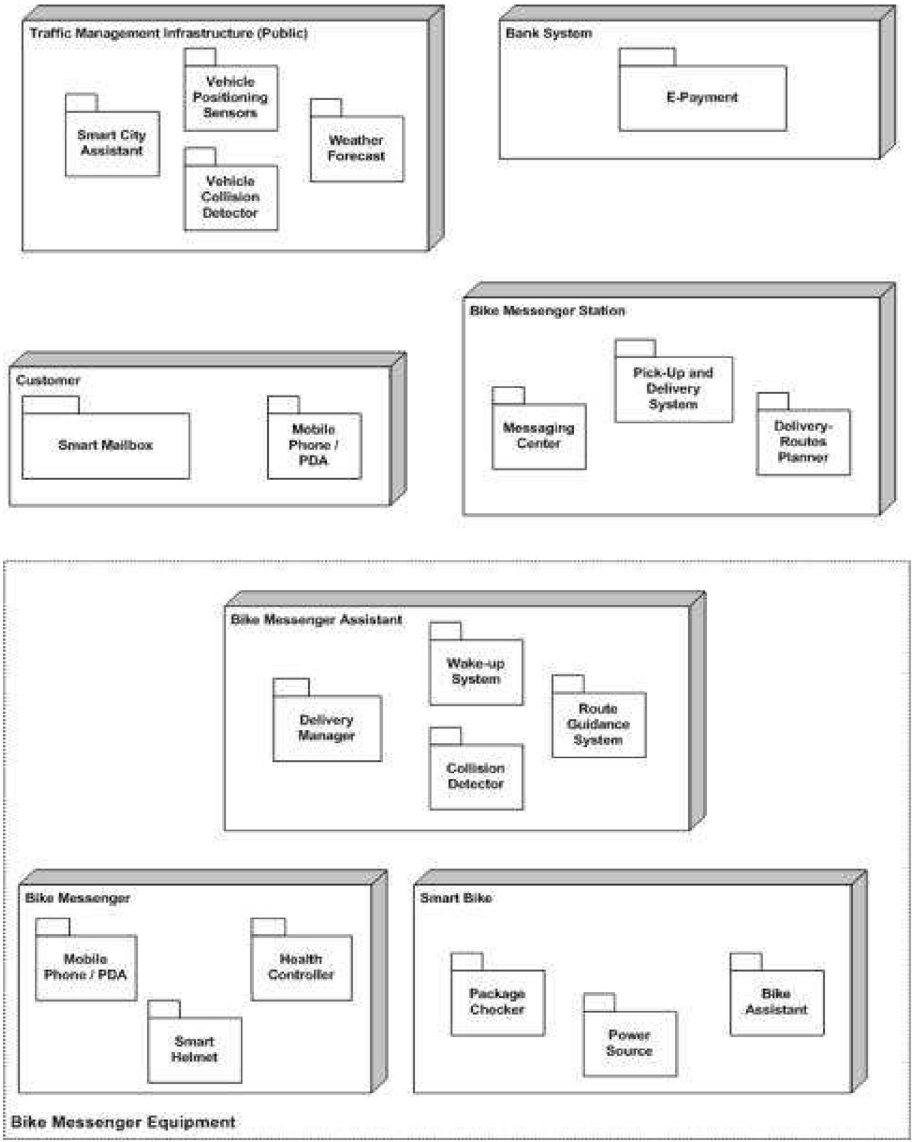

Figure 5.2: Bike Messenger System.

In the rest of this subsection we analyze each node, briefly describing the main functionality of their components.

Bike Messenger Assistant (BMA)

The *Route Guidance System* (RGS) provides two main functionalities, namely biker localization and route planning; its user interface is based on the combination of visual and audio signals.

The *Collision Detector* (CD) is responsible for informing the biker of possible incoming dangerous collisions with human and non-human obstacles, by combining information gathered from infrared sensors on the bike and from the Vehicle Collision Detector as well; the output consists of a binaural signal that the user listens to through the Smart Helmet. The result is a voice that provides information regarding the kind of danger, and seems to come from a given environmental location, suggesting the obstacle's direction (the current direction of the obstacle's movement, or direction in which the user is facing) and current distance.

The *Wake-up System* (WS) takes as input: i) the daily traffic and weather conditions, ii) the biker profile (biker preferences and morning habits), iii) the data regarding the delivery schedule for the day, and, by combining them, it calculates the wake-up time; finally it produces an output that is tailored to the user profile, and may consist of several kinds of audio signals or mechanical stimuli. For instance, it could interact with smart-home appliances for waking up the biker and cooking his breakfast too.

The *Delivery Manager* (DM) is the core component of the Bike Messenger Assistant, since it provides some crucial functionalities: i) it displays the up-to-date delivery schedule based on requests coming from the Bike Messenger Station; ii) it manages all administrative tasks regarding deliveries (micro-payment, authentication, and delivery notification messages); iii) it locates the other biker messengers (peers) and allows to communicate with them; and iv) it allows the user to directly communicate with the Bike Messenger Station either by real-time audio or text messages.

Bike Messenger Station (BMS)

The Bike Messenger Station's main functionality is to collect customers' requests and assign them (in an optimal way) to the available Bike Messengers. The task is carried out in three sequential activities, each managed by a different component, as shown in the following:

The *Pick-up and Delivery System* (PDS) collects incoming delivery requests and stores information regarding the customer's identity, profile, and location; it encodes delivery request parameters and sends them to the Delivery-Routes Planner. The delivery request usually arrives directly from the Customer or possibly from a bike messenger who cannot take care of a previously assigned delivery.

The *Delivery Routes Planner* (DP) receives delivery request parameters and, based on bikers' workloads and locations, as well as geographical and topological information, it assigns the delivery to the most suitable Bike Messenger; it is worth noting that, in order to do this, it exploits the Traffic Management Infrastructure services.

The *Messaging Center* (MC) receives the delivery request parameters (customer location, type of delivery, payment modeà) and the bike messenger selected for the task. It forwards them to the selected biker in the form of a coded message specific for the Delivery Manager component currently employed. The MC is responsible only for the delivery of the request message to the biker; in case the bike messenger is not able to accept the request, he will directly contact the Pick-Up and Delivery System.

Bike Messenger (BM)

The *Mobile Phone/PDA* is used for private and emergency communication, and for contacting (and being contacted by) delivery customers as well; it is capable of establishing an FM radio-channel based communication, broadcast to other Bike Messengers and to the BMS.

The *Health Controller* (HC) provides the BM with information regarding his health-status, and may eventually signal critical conditions through the Smart Helmet; it monitors blood pressure, heart rate, lung respiration, and sweat level through several types of sensors, located according to the biker's preferences (e.g. embedded into its clock, clothes, handlebars); in case of any emergency it can autonomously broadcast an SOS message to any Smart-City Assistant.

The *Smart Helmet* (SH) protects the BM from head-injuries; a surrounding audio-rendering system and microphones are embedded into the SH. Other devices, such as the RGS, the DM, the CD, and the HC, exploit the SH as their main audio I/O devices.

Customer

The *Smart Mailbox* (SM) is used for picking up and dropping off packages; SMs may be located in a building, a specific area or a private house. The SM can authenticate customers either directly, or by forwarding a request authentication to the BMS. Before accepting a package, the SM checks delivery parameters such as the addressee's location, package weight, physical dimensions, and time requirements, always through the BMS support. It provides as output the delivery price, and the assigned Bike Messenger's contact information. The SM is equipped with an iris-scanning device for Bike Messenger authentication. Upon authentication, the SM sends the delivery parameters to the BMS in order to start the e-payment transaction.

The Mobile Phone/PDA is used for private communication and for being contacted by (or contacting) the Bike Messenger or the BMS.

Traffic Management Infrastructure (TMI)

The *Smart-City Assistant* (SCA) consists of several smart devices: i) intelligent traffic lights, capable of adapting to traffic conditions, and ii) SOS gateways for contacting healthcare centers upon the reception of SOS request messages.

The *Vehicle Positioning Sensors* (VPS) locate vehicles through sensors placed on them, providing an active and up-to-date view of traffic conditions.

The *Vehicle Collision Detector* (VCD) exploits the VPS functionality for detecting possible accidents or dangerous situations.

The *Weather Forecast* (WF) provides weather information.

Smart Bike (SB)

The *Package Checker* (PC) is used for fastening the package to the bike, performing additional security-related checks (i.e. presence of drugs or explosives). It constantly monitors the package position and eventually alerts the bike messenger in order to guarantee a safe journey, especially in case of a fragile content.

The *Power Source* (PS) converts kinetic energy into electricity, in order to support power consumption.

The *Bike Assistant* (BA) is responsible for detecting critical bike conditions (i.e. low tyre pressure, components consumption, faults of the braking and gear systems); moreover, it provides an automatic and adaptive gear system, which aims to keep the Bike Messenger's cadence (cycling frequency) to a constant level (e.g. setting a low gear when cycling on a slope).

Bank System (BS)

The *E-Payment* (EP) receives the payment parameters from the BMS, and guarantees a secure payment transaction.

Required scientific and technological innovations

As far as usability problems are concerned, a general solution could be derived by extending the technique (called MOTILE) proposed by Kristoffersen [KL99], and the approach proposed by Pascoe [PRM00] based on the so-called Minimal Attention User Interface (MAUI) concept. A case-study application of such techniques has been described by Holland and Morse in [SM01]. In this work they propose a prototype audio user interface for a Global Positioning System (GPS) – called AudioGPS – to allow mobile computer users to carry out their location-dependent tasks, while their eyes, hands, and attention are often otherwise engaged. The AudioGPS is based on an informal pilot formative evaluation of the audio representations of direction and distance, both with musicians and non-musicians. The distinction between being in front, behind, to the right, or to the left of the user is easy to discern, as are the intermediate four compass points. This audio-based representation of distances and directions could be cleverly exploited by our Smart Helmet for rendering alarm messages received from the Collision Detector.

As the proposed system provides substantial location-aware services, several research challenges must be solved. Before location-aware computing can become commercially viable, more research on developing a standardized location-sensing infrastructure is needed. In particular, the main difficulties consist in the number of variables to keep under control, and many dimensions in which location-sensing mechanisms can vary. Moreover, the implementation of both the RGS and the SCA requires specific techniques for tracking and predicting the precise location of bikes and other vehicles. The goal of future location-prediction research should be to detect motion patterns that can be partially periodic, are not perfectly repeated, and have multiple periodic cycles, and use this information to estimate where a vehicle is most likely to be [PMP03]. User mobility needs to be accommodated by new technologies and methods. Personal wireless communications will be implemented using a combination of several network architectures and technologies, including both wired and wireless systems [HHNS02]. Mobile device characteristics should be enhanced by leveraging security, robustness, and computing power. Moreover, novel resource management strategies are requested, in order to address power consumption issues and to cope with unreliable, low-performance networks. Wireless network characteristics should be improved in terms of link performance, reliability, and security.

As already mentioned, understanding which is the best moment to provide a user with information and/or messages is another crucial issue, and the effectiveness of the system itself depends mostly on its suitability for addressing it. The work in [SMR+97] proposes a strategy for allowing wearable devices to infer when users should be interrupted; this strategy is based on the combination of sensors and user modelling for detecting the interruption instant, and on a visual unobtrusive output device for notifying the user about the presence of incoming messages. Hence, functionality must be carefully deployed on voice-based, button-based and pen-based devices (e.g. tasks requiring fine control or repetitive input are better accomplished using button or pen input) taking into account all the described issues. As regards the materials used to build the bike itself, they are continually being developed for improved strength to weight ratios and air corrosion, as well as for a major lightness (e.g. using titanium and carbon fibre frames). In this context, a new constraint must be considered, regarding electromagnetic properties of the used materials: a new kind of material, with a lower radio-signal-screening factor could allow active sensors (or other wireless devices) to be embedded into the frame without a significant degradation of the radio signals.

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Audience member at rock festival

Janne Pasanen

The scenario

It is a beautiful Friday afternoon in the beginning of June. Tens of thousands of people are gathering for a traditional rock festival in a small town in western Finland. The train from Helsinki slowly comes to a halt, and people start pouring out. Tom steps out of the train and feels the heat rising from the platform. Not a cloud in the sky.

The festival is not held far away from his hometown, but he has spent the last year in Helsinki where he has completed his first year of computer science studies at the University of Helsinki. It feels good to be so close to home, though the city itself is not familiar to him. He has only visited it a few times as a kid. This is the weekend he has been looking forward to for well over a month now when he and two of his best childhood friends, Daniel and Erik, decided to buy the tickets. They all three now live in different cities and have not seen each other in the flesh since last Christmas.

He throws his backpack on and starts walking straight toward the parking space. He knows that his friends are waiting for him there because he checked their location on his P-Com just before the train arrived at the station; actually, he has checked their location several times during the day, just for fun. After a joyful reunion they drive to the camping area, put up their tent and head quickly to the festival area.

When they approach the entrance to the festival area they can see that some lines are already building up at the gates. They are much like the gates at the metro stations in Helsinki, but unlike them, where a gate identifies your travel card remotely, here you have to confirm your identity with your fingerprint, like when you pay digitally in stores or borrow books from the library. Although he knows that the system is very reliable he sometimes has the feeling, what if it won't work. When it is his turn he puts his thumb on the reader, and tenths of a second later a green light is lit and he goes through the gate soon followed by his friends.

When they walk toward the main stage Daniel says that he could do with a pint of cold beer right now. It does not take any convincing to get Tom and

Erik to join him. They sit down by a table in the shadow with their pints and Tom takes a look at his P-Com. There is an offer to subscribe to a package of P-Com services of the rock festival, it includes news, live video, interviews with artists and even promises to help you find your soul mate. It is not exactly cheap, but Tom finds the offer reasonable; after all, you get a 50% refund of the pint of beer you just bought. After choosing to accept the offer he is presented with a license agreement, he knows that he should probably read it but he also knows that there is some legislation regulating what information can be shared and how so he is not too paranoid. While finishing their beers, they check what artists are performing today; nothing really catches their interest so they decide to just walk around. Before they go they return their empty pints and get their deposit, which was included in the price of the pint of beer.

A few hours and some beers later they are sitting by a tree near the second stage. A relatively unknown group that none of them has heard of before is playing. Tom takes a look at his P-Com that has some background information about the group as well as an option to buy the song that they are currently playing. He wonders for a moment if the good atmosphere with friends, sun and some beer could make the song sound better than it normally would do back in his flat in Helsinki. Then he notices that the song is significantly cheaper when he has the service package that he bought earlier; he decides to buy the song.

Around midnight Erik is not feeling too well and wants to call it a day, but Tom is in a good mood and would like to stay and hear the big-name artist conclude the first day of the festival. Daniel is a bit tired as well so he and Erik head for the camping ground. One and a half hour later when the music ends, Tom feels a bit lonely and starts walking back toward the camping ground as well. It is still not very dark but he checks his route on the P-Com just in case. He feels that most people on the camping ground have not planned to go to sleep just yet. Music is playing and there are smaller parties everywhere. As he approaches their tent he notices that there is some kind of party behind the neighbouring tent, mostly girls by the sound of it. As he gets closer he feels how his P-Com starts vibrating and he takes a look at it. The screen is red and it displays Soul Mate Near: RockGrrl 94%. He stops and takes a look at that loud group of people; then he notices it, something red glowing around another wrist. A good reason to meet the neighbours, Tom thinks.

Explanations and comments

Issues

Privacy concerns are the same general concerns as with many other ubiquitous computing applications. In this scenario there are issues concerning location services, electronic payment and digital rights management.

With the implementation of location services there are obvious privacy concerns. Because your location is strongly connected with your activity it is a very sensitive piece of information. You have to have control over what kind of information is disclosed about your location and to whom. Hengartner and Steenkiste have analysed these aspects and provided a sample implementation [HS03].

Record companies at the moment think that digital rights management is vital for artists, and themselves, to be able to make a profit. Today when ordinary people have got the feel for how easily you can get almost any song from the Internet in a matter of minutes there is no other way than for record companies to adapt to the new way of distributing music. At the moment they see digital rights management as the solution to this, but it might not work and other models addressing the need for content providers to get their fair share has been proposed. Mark Manasse is one of the critics and he proposes a digital rights licensing system instead [Man01]. He argues that rights management systems do not prevent large-scale piracy; instead they work by discouraging small-scale sharing of goods.

In all of the three above-mentioned services a lot of different kinds of information are gathered about the user, some of witch can be very personal. The matchmaking service in this scenario would probably include very personal information about the user, some of this information he might not even want to share with his best friends. To make it possible for the user to maintain his privacy, a concept called identity management has been proposed. It works by disclosing different information in different situations [JKZ02].

There are of course legal aspects to all of these issues as well. Who will be allowed to gather and access the vast amount of information collected? Will the police be allowed to access the movement of people? Can you lend the song you have bought to a friend? These are issues which are facing lawmakers in the European Union already to some extent, and other countries as well.

Products

In this scenario the most central device was the P-Com, which is a result of the convergence of mobile phone and PDA. It would have a high-quality colour display, camera, software radio, GPS (or other system to get the user's location), low power consumption and be lightweight. In this scenario the P-Com has to be able to work in the rough environment of a rock festival. This means basically that it has to be water- and shock-resistant.

The infrastructure for these devices ranging from the physical networks to standards on how to share information between different services is, of course, essential. Building a new infrastructure is not cheap and companies are not going to do it without expectations of good profits.

In this scenario Tom buys a song on his P-Com. He is able to buy the song when he hears it in the concert and then listen to it on the train back or on his home entertainment system. It would be possible for him to watch concerts live on P-Com or even later watch some performances that he might have missed. The songs and videos might be downloaded to his device or kept on his account on the server of his service provider. The payment depends on the business model, pay-per-view, a licensing system or something else.

Location is probably one of the most obvious contexts that a context-aware application could find useful. Location services can be used by parents to track their children, employers to track employees or as in this example, friends to track each other. These services already exist for ordinary mobile phones, and it is obvious that this will soon be a part of everyday life. Advertising is one obvious field where location information could be useful, not only for the advertiser but for the consumer as well. When you think of what advertising is like today, it is obvious that the consumer will have to feel that she is in control so as not to find it intrusive. For some applications there might also be a need to convert the coordinates given by the GPS to something that is more meaningful for some applications like street addresses or a type of location.

Required scientific and technological innovations

There are really no scientific technological innovations required for this scenario, in principle it could be built today. The biggest obstacles are the issues mentioned earlier concerning privacy and digital rights management. Devices will get cheaper, smaller, faster, more powerful and at the same time less power-consuming. It will not be long before fuel cells and thin flexible displays will make their way into consumer products. More complex and therefore more difficult things to predict are the social and economical aspects.

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A context-aware personal assistant for medical staff

Tea Silander

The scenario

Doctor Rodney Wilson wakes up in his home at 6 am when his PDA's alarm clock rings. It is his first shift after a one-week holiday. He goes downstairs to have his breakfast when he receives a message to his PDA that he should leave home 15 minutes earlier than usual because there is road work in progress on the way to the hospital.

Doctor Wilson arrives at the hospital parking lot and starts to walk toward the hospital entrance. At 7 am sharp he receives a message on his PDA that informs him that one of his patients' blood pressure has gone alarmingly low. He also receives the patient's medical record which includes the patient's recent medication and treatment during his visit at the hospital. Doctor Wilson finds out that the patient has been in an operation last night and that the lowering of blood pressure is quite normal. He confirms the system's suggestion for corrective medicine and sends a message to the nurses to give the medicine to the patient.

During this operation Doctor Wilson has walked to his locker room. He changes his clothes and leaves for his rounds. During his rounds he arrives to the patient whose medication he prescribed by PDA. When he approaches the patient's bed he receives a description of the patient's medical condition and recent changes in it. He checks that the medicine he prescribed did work as it should have. Doctor Wilson finds out that the patient's blood pressure is now at the level it should be and the patient's condition is good.

Doctor Wilson continues his rounds and after a while receives a message from another of his patients. This time the patient, an old lady who has difficulties walking from one place to another, wants to know what is wrong with her leg when it has rapidly swollen a lot. She also sends some digital photos of her leg and wants to know if it is better to come to the hospital to get treatment and painkillers. Because the email was delivered to Doctor Wilson the database did not have any matching cases. Doctor Wilson draws the conclusion based on the pictures and the fast swelling of the leg that the leg has been inflamed badly. He prescribes a two-week course of antibiotics and sends it to the old lady. He also chooses the system to reserve time for her to get a blood test done to check that the antibiotic treatment has worked. Doctor Wilson also reminds her that if the swelling has not lessened in three days she should come to the hospital. During this process Doctor Wilson's patient, a mother of two young kids, sends an email regarding a weird rash on her kids. Based on the pictures she sent, the system automatically finds out that the symptoms match measles and sends a message including a prescription for a salve.

After the round, Doctor Wilson moves on to the surgery room where one of his patients is scheduled for a heart intervention. The entire operation is monitored using an ISensed device fitted with a camera, microphone and loudspeakers. The device is connected via a wireless network to the sensors that monitor the patient's vital signs. The purpose of the ISensed device is to continuously attempt to identify high-level operations specific to the type of surgery being performed. At some point, Doctor Wilson is confronted with an unexpected complication. The ISensed device correctly identifies the situation, which correlated with the patient's abnormal vital signs and triggers a search against the hospital's repository of surgery scenes. Due to an efficient retrieval algorithm, an existing similar surgery situation is quickly identified and the device suggests to read the audio annotations associated with that situation. The information proves to be relevant to Doctor Watson's current operation, which is completed successfully.

Doctor Wilson finishes his round. Besides his colleague's retirement party, Doctor Wilson's day goes as every other day. When Doctor Wilson ends his day at 7 pm he receives his working schedule for next month. He had four appointments in his calendar and he checks whether he got those days free. To his disappointment he has a shift marked on the 16th when he had planned to go to an ice hockey game. "Well, three apppointments out of four is much better than none", he thinks and leaves the hospital parking place.

Explanations and comments

Tasks

Delivering information selectively depending on a doctor's status

Every doctor has a status. The status could be for example "working", "free" or "occupied". When the doctor is on holiday his status could be "occupied" and no information about patients will be delivered. When the doctor is off duty, information about his or her patient will be delivered only if the information is relevant for the patient's health, for example the patient's condition has become worse. When the doctor is working at a hospital, all relevant information (changes in a patient's condition) will be delivered to the patient's doctor. The system could try to extract the status from information available for example in the calendar or emails.

Scheduling shifts depending on a doctor's calendar

The system also manages doctors' working schedules. Based on the information available from a doctor's PDA, electronic calendar, emails or other possible sources it tries to allocate a free doctor to every shift. If a doctor has an important occasion to attend he or she can notify the system not only by marking the occasion in question in his or her electronic calendar but also by giving a priority to it. If the system cannot allocate a free doctor to a certain shift, it notifies the head doctor in the department in question and gives the head doctor the possibility to choose someone to take that shift.

Automatic email reply based on similar previous emails

Patients can ask about their symptoms by email. Sending a message might be better for a patient when the patient has difficulties to get to the hospital, for example lives far from hospital or is disabled. In order to make the doctors' workload lighter the system processes email questions before they are sent to a doctor. Patients can send not only textual information but also pictures and other information collected by some devices like blood pressure apparatus. The hospital gives a personal digital identificator to a patient to identify him or herself with when sending questions to the hospital. When a patient sends a question with the identificator the system also gets the patients medical information.

When an email enters the system the symptoms in question are extracted from the email. When the symptoms are known the system compares those with the symptoms recorded in a database. The database includes information collected from all previous emails and the information that are used for automatic treatment recommendation. It also includes information about some cases treated in the hospital before. If a match is found the system replies to the patient with the treatment recommendation given in the matching case. If necessary, the system changes, for example, the medication corresponding to the patient for whom the diagnosis was made.

If a matching case is not found in the database, the email is delivered to a doctor. When a doctor answers the question, both the question and the answer are recorded in the database. None of the personal information is recorded in the database, only the necessary information of the case, for example, the patient's weight for prescribing the medication.

Automatic recommendation of treatment depending on previous similar cases

A doctor's daily activities involve, among other tasks, diagnosing and prescribing medication for various patients. Considering the high precision of current and future medical sensors, it is possible to construct a feature space where the different feature vectors are strongly correlated with the pathology of corresponding diseases. Such a feature space can be clustered, indexed and searched, thereby offering great potential for automatic diagnosis.

PDAs tend to be standard equipment already for medical personnel. Given such a device that is wirelessly connected to the hospital's network, a doctor can get diagnostic suggestions immediately after receiving a new patient. An immediate application of such a system is in the ER (emergency room), where sensors detect the arrival of the patient and run a series of standard tests. Depending on the results, the most probable diagnostic is computed and the appropriate specialists can be notified automatically. For instance, in case of a car accident, the patient arrives in the ER with symptoms of broken bones and internal bleeding. The system can then choose to notify an available surgeon and orthopedist. The doctors are not only informed about the patient's symptoms, but are also offered suggestions about possible courses of action (in case of surgery) or medication (type of pain killers, antibiotics, etc).

Automatic patient-identification

A very simple but powerful application of context-sensitivity is provided by automatic patient-identification. A doctor visiting patients recovering from surgery can simply pass by each bed in a hospital hall. An IR beacon identifies individual patients, allowing the doctor to instantly access the patient's file.

Figure 7.1: An example of a smart bed that monitors the patient and reports the changes to the system. (Figure from www.pervasivehealthcare.dk.)

Detection of similar surgery situations

The operating room is equipped with cameras and microphones. While a doctor performs the operation the cameras record all actions taken. The doctor can also commentate the operation. Audiovisual material from previous surgical operations is stored in the hospital database. The system records all audiovisual material from the operation and compares it to the information in the database. When it finds a similar situation it informs the doctor what actions the doctors in the audiovisual material performed in a similar situation and what the result was. The system keeps giving this advice while the operation proceeds. The information can also be categorized to speed up the comparison because the information about a knee operation will not be needed for a bypass operation.

Issues

The most important privacy concern is the fact that a doctor's PDA (or other device that receives the messages) can be stolen or lost. In such a case, the person who has control of the device is able to receive confidential data which may include patients' personal information, ranging from personal details, to health records, etc. Therefore the device must have an identification system based, for example, on the owner's fingerprint or retina.

Products: devices

Every doctor must have a PDA or some other mobile device to receive messages and interact with the hospital network. Computers, displays and sensors need to be embedded into beds. The intelligent bed in Figure 7.1 can monitor different physiological variables of the patient, such as temperature, blood pressure, etc., and report this to the electronic patient record. Sensors, computers and displays can also be embedded into different objects like lifts, pill trays and medicine cabinets. Another example of this integration is the intelligent pill tray in Figure 7.2 which identifies the patient and shows the medicine dosage.

In order for a doctor to automatically receive medical information, every patient must be uniquely identified by means of a device similar to an active badge. The device cannot simply broadcast information to anyone. Instead, the communication protocol must support some form of authentication which allows only authorized personnel to receive the patient's medical

Figure 7.2: An example of an intelligent pill tray that informs the nurse about the medicine dosage. (Figure from www.pervasivehealthcare.dk.)

information. Doctors can configure their PDAs to periodically poll directly the sensors monitoring the patients. Alternatively, if a doctor's PDA is out of range, the patient information can be monitored by a hospital server. When the doctor connects his PDA to the hospital's network using VPN over a high-speed data call or GPRS, the information about his patients can be automatically pushed by the server to the PDA. Several similar systems and devices have already been developed including the Active Badge System [WHFG92] and Finnish VTT's SOAPBox (Sensing, Operating and Active Peripheral Box, [TYo02]).

Products: services

Locating service

The system uses two kinds of location information, the location inside the hospital and the location outside the hospital. Inside the hospital sensors provide fine-grained information about the location. Outside the hospital location information does not have to be so accurate and a satellite-based locating service can be used for tracking the doctor's location. The locating service could also be used for authentication. It could check that nobody without satisfactory permission could enter certain facilities. This could for example prevent others than employees from entering the personnel's premises.

When locating people, like the doctors in this case, there is always a danger that a person's privacy is invaded. The location information could be used in an offensive way for example for tracking where a certain person visits and what people this person meets during a day. There are situations when a person does not want to be located and this person should be able to determine when the system can locate him or her and when not. Therefore there should be a policy which determines when the location information could be used and who gets to use it. For example the location information should not be used when a doctor is on his or her vacation. Depending on the policy the location information could be used when a doctor has a day off and a massive accident happens and there is a serious shortage of doctors.

Automatic patient identification

Each patient is identified with an infrared beacon. When a doctor approaches a patient the sensors notice it and may send the patient information to the doctor's handheld computer or PDA if the doctor so wishes.

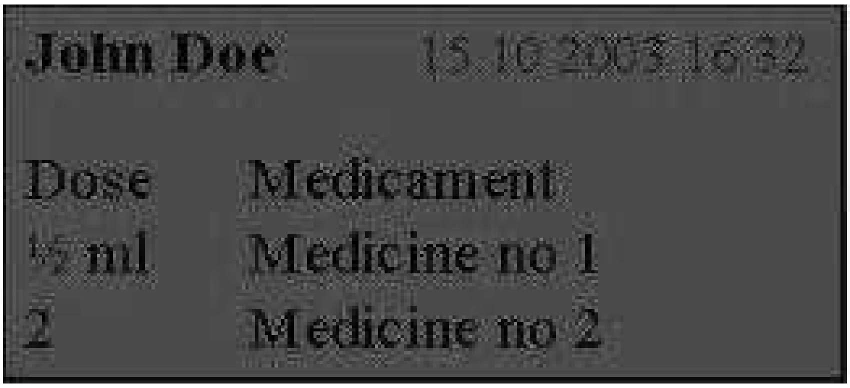

Figure 7.3: An example of a message shown by the intelligent pill tray. (Figure from www.pervasivehealthcare.dk.)

The patient identification is also needed when delivering the medicine for each patient. The intelligent pill tray in Figure 7.2 is equipped with a display that shows the patient's name and medication doses when the nurse approaches a patient's bed. An example message about the medicine dosage is shown in Figure 7.3.

Similar to location information when identifying a patient, the information should be available only to the patient's doctor and the doctors in the same department. To ensure this a policy similar to the preceding one should be developed that informs what information could be given and to whom this information should be granted.

Context observer

The context observer provides the system with context information and reports relevant changes in the information. It observes for example each doctor's status and location. Context includes for example the time of day, location or the task that the doctor is performing. The context observer uses a locating service and information available from the doctor's calendar to determine the doctor's status. The doctor can also explicitly determine his status, for example, when he wants to be logged out of the system on his holiday.

Context is needed for example for scheduling the shifts and sharing the patients between the doctors. A doctor might be very busy so it might be that he will not accept new patients at a certain moment. Patient context could be used for automatic medicine dosage. At the right time a context-aware medicine container (Figure 7.4) could inform the user that it is time to take the medicine. This could also be used at home, for example, when a person has difficulties to remember to take his or her medicine at the correct time.

Automatic email reply service

The automatic email reply service should prevent drug abuse. It is possible that a person addicted to painkillers could try to get these drugs by faking situations where painkillers would be prescribed for example for a fracture or sprain. To prevent this, the system records all prescriptions and whenever possible tries to prescribe drugs that are sold without prescription instead of strong painkillers.

Figure 7.4: An example of a context-aware medicine container. (Figure from www.pervasivehealthcare.dk.)

Required scientific and technological innovations

This scenario does not require any special scientific or technological innovations. Instead there should be fundamental changes in people's attitudes. People should realize that pervasive computing is much more than tracking, locating and monitoring people and their activities. Especially it is not a question of spying, snooping or controlling people. But it should not just evolve without any policies or rules. The user should always have authority over the system and the user should be able to turn off location and other services, especially those which include decision-making on behalf of the user.

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Sinikka – the hitchhiker

Petteri Nurmi and Jörg Schummer

Introduction

What is hitchhiking? This is the first question that must be answered. We do not need a formal definition but we need to point out a few things that can be used to characterize hitchhiking.

First of all, hitchhiking is based on free will and uncertainty. You cannot make somebody give you a ride and you do not know whether you will be offered a ride at all. We can help our hitchhiker by helping her/him get a ride, but we should not implement a scenario where these aspects are neglected.

Usually hitchhiking is considered free of charge (at least in the sense that the driver does not expect any payment). The hitchhiker can offer it if he/she chooses to (perhaps something to compensate petrol consumption).

The scenario

It is Saturday morning, the first day of Sinikka's holidays. Because her PCA (Personalized Communications Agent) is aware of this fact, it does not wake her until late. After she gets up and has breakfast, she decides to go on a trip for a few days. Being a very spontaneous person, she never wants to plan her holidays but rather lets her mood decide what to do. Having not seen her brother John, who lives some 500 km away, for a long time, she thinks it would be nice to visit him.

She uses her PCA's screen extension to call John via videophone to announce that she would like to stay at his place for a couple of days. John is very happy about his sister's plans and agrees. Having arranged her stay with John, Sinikka now has to plan her journey. Her PCA had been extracting relevant information during the conversation using speech recognition [BJ01]. It has concluded that she is going to visit her brother today. Taking into account Sinikka's personal preferences, the PCA is able to calculate and present possible routes to her after she has hung up. Because she does not want to spend much money on the journey, she decides to have her PCA select a route that involves hitchhiking!

Because she wants to hitchhike the journey cannot be planned entirely. Otherwise her PCA could arrange the whole journey and minimize waiting times etc. Her PCA connects to a traffic central and from there it gets the current traffic density amounts and proposes a place nearby, where she is likely to get a ride. Sinikka knows the place she is going to but allows her PCA to give her directional information using speech output. Finally Sinikka arrives at the proposed hitchhike place. Her PCA starts broadcasting hitchhike announcements as she approaches the site.

Antero is driving on the highway. His car is quite new so it has a centralized NavComputer. He likes to have hitchhikers for company so he has enabled hitchhike announcements. When his computer receives Sinikka's hitchhike request, he decides to give her a ride. Antero is not going to the place where Sinikka wants to go, but a few kilometres short. He has entered his journey plan into the NavComputer so he just submits a reply message.

Sinikka's PCA receives Antero's message and she decides to accept the offer, so she sends Antero the coordinates of the place where she is. Because it is friendly to give some id information, Sinikka attaches her public ID to the message. Antero can verify it and that way be sure that Sinikka is a decent person.

When Antero's NavComputer receives Sinikka's reply and notices the public ID attached to the reply, it automatically checks the ID. Antero sees a popup on the display which shows that Sinikka's ID has been verified. He normally sends his ID to the hitchhikers so they can verify it likewise; the NavComputer proposes that Antero sends a reply message with his ID attached. When Sinikka gets the message her PCA checks Antero's ID in the same way.

Antero is approaching the place where Sinikka is waiting, so the NavComputer suggests to slow down. When Antero stops to pick up Sinikka the car door opens automatically. The NavComputer has a built-in event log that stores the event of Sinikka entering the car. Sinikka's PCA knows where she is travelling to so it sends John a message saying she got into a car. Later on, when they arrive at the destination, Sinikka's PCA sends John a message that she got out. Antero's NavComputer also stores the event.

Antero's car uses automated traffic guidance so his NavComputer checks the current traffic jams, accidents etc. from a traffic central. The NavComputer does not steer the car but gives information that helps him drive the car and choose the best route.

By the time they arrive at the destination, Sinikka decides that she could pay some of Antero's petrol expenses so she uses her Purse to transfer 5 euros to Antero's Purse. As Sinikka has not arrived at her brother's place yet she must have the remaining part of the journey planned. Because the place where Antero has dropped her off is very near her brother's home, she arranged for her brother to pick her up. Because the arrival time is impossible to know beforehand she has to wait for few a minutes although the PCA has been sending updated arriving times along with their probabilities as she came closer to her destination.

Finally after a few minutes John arrives. Sinikka says that she is a bit hungry so John suggests that they should go to a restaurant. This time they do not need to use their PCAs because they have always eaten at the same place, which is their favourite restaurant. As they approach the place John notices that there is something wrong with the car so he pulls over and steps out to check the car. O no, a flat tire – not even ambient intelligence can take away bad luck!

Explanations and comments

Issues

Security & privacy

The society is changing but are we? As new technologies are invented more and more ways of misusing them are found. Technological security, confidence, physical security, ownership of data and privacy – there are many issues and only few ready answers.

Authentication and encryption are major issues in technological security. The protocols used must offer secure authentication and strong encrypting services – we must know with whom we are talking! We also would like to know that nobody is eavesdropping. Most of the data submitted would not be that sensitive so encryption requirements can be relieved for some parts like for the video phone.

The main problem is the use of a personal ID. What is it? How often is it submitted? How long is it valid? If we send SSN numbers (encrypted), we must be sure about the sender's identity. The SSN is quite short so breaking the encryption is possible in short time. In the (far?) future it could be possible to generate the ID from DNA but in our scenario we limit ourselves to timestamps, public key cryptography and secure channels [NT94].

Why store information about a hitchhiking event in a log file? When storing 'personal' data, we must have a reason for it. Hitchhiking (usually) involves two people, who do not (necessarily) know each other beforehand. So what if something happens? By storing some information about the event in a log file, the driver can feel safer. Also the ID-checking and the part where Sinikka's PCA sends information about the event (got in car, got out of car) to her brother make hitchhiking safer for both persons.

Who has control over data that is submitted? Everything can be done the old-fashioned way by turning off the PCA. If we want to use the PCA, can we decide what data is sent and what not? Can we also decide, who can see it? When Antero sends Sinikka his ID for checking purposes, Sinikka would not see the IDs anywhere as the protocol would hide sensitive data. This also means that neither Sinikka nor Antero are aware of the logging events and that they cannot prevent them.

Communications and society

This scenario takes place in a society where telecommunications are everywhere and are applied to nearly everything. This would require building supportive infrastructures such as link stations and specialized servers. One important issue is the change in the way people think. People must be ready to use these kinds of technologies and that is probably one of the main things that slow down the evolution of AmI technologies [DBS+01].

Society needs specialized servers that are capable of serving thousands and thousands of requests with a minimal response time. In addition they must be capable of processing contextual data and output useful data from it.

Products

Devices

As in many other scenarios referring to ambient intelligence or a highly context-aware environment, this scenario is based on one central highly personalized communications (agent) device, the PCA [DBS+01]. Though

Figure 8.1: An example of a screen extension. (Figure from http://www.howstuffworks.com/plasma-display.htm.)

the PCA could be a mobile computer of almost any kind, its size is not much greater than that of a mobile phone these days. The functions which it definitely must support and which are likely to be implemented as single applications are:

- Finding a good place to hitchhike from
- Negotiating the journey with the driver (or the car computer) of an approaching car
- Calculating possible routes for the journey if a car cannot take the hitchhiker directly to his destination but to another place close by.
- Providing context-aware action proposals with the help of speech recognition

For mobile visual interaction, there is a rather small display embedded in the PCA. A speaker and a microphone, which are needed for speech recognition and speech output, are also built into the device itself. The large screen extension, which Sinikka uses to make the videophone call, is not considered to be of a mobile kind (Figure 8.1). Additionally, the user can wear a large mobile display, which is of much greater size than the PCA itself. This display could be worn embedded in a jacket sleeve [RM00].

Another very important device in this scenario is the car computer (NavComputer), which – in this form – would be part of all cars that were built from 2010 onward (Figure 8.2). One of its main functions is navigating the car. Unlike existing navigation systems it has to effectively process and update traffic information (such as traffic jams, stop and go traffic), which it retrieves via mobile communications from a central traffic information provider.

Another function of the car computer is the negotiation of the journey with the hitchhiker. The driver may switch off this function by telling the system that he does not want to take on any hitchhikers at all. Likewise, he can tell the system that he would like to pick up any hitchhiker on his way. The navigation system just tells him to stop the car at a certain place in order to pick up the hitchhiker. In interactive mode, the car computer just presents the data the hitchhiker is providing about himself to the driver and the driver has to decide on a case-to-case basis whether he wants to give a particular person a ride.

Figure 8.2: An example of a car computer. (Figure from http://build.bmwusa.com/yourbmw/detail/zseries/0609.htm.)

Matters to be negotiated may include the number of breaks on the journey, the temperature inside the car, or any information about the hitchhiker and driver, such as age, gender, number of hitchhikers, or whether they would like to smoke. Of course, the hitchhiker, as well as the driver, may provide restrictions and preferences about these matters so that the devices are able to negotiate automatically without any user interaction at all.

If a hitchhiker would like to be given a ride, the car computer asks the hitchhiker's PCA to send over his public ID. If this feature is enabled, the car computer can then check via mobile communications whether the hitchhiker is registered or not. Vice versa, the hitchhiker's PCA can ask the car computer for the driver's public ID and check his records.

The videophone application, which Sinikka uses to call her brother, mainly works in the way a telephone works nowadays. Without her PCA screen extension, Sinikka is able to make ordinary phone calls. The only difference to a modern-day phone might be that the phone number can be replaced by some other data (IP-address, name of place etc.) which uniquely identifies the place to be called.

The last device to mention is the Purse [DBS+01]. Like a bank card or credit card, it is used for transferring money from one point to another without cash being involved. Unlike a bank card, the amount which is transferred does not refer to money in a bank account but is rather stored on the Purse itself.

Having identified its owner correctly, the Purse asks its owner about the amount which he wants to be transferred. After stating the amount, the money can then be transferred to any device that is Purse compatible. The transaction is carried out wirelessly, but the Purse should only be able to transfer money to any nearby devices.

Services

For the videophone, there has to be a special phone service. This service is mainly provided to people via cable since the amount of data is likely to be too large for it to be transmitted wirelessly. Nevertheless, there may also be a wireless videophone service which is then rather expensive to use since the number of people carrying out videophone calls has to be restricted in order to save bandwidth.

The car computer, which is supposed to process traffic information, has to connect to a service that provides this information (Figure 8.3). This service has to be provided in a wireless way, i.e. it would require long range communications. The information about traffic jams, 'stop and go' traffic, etc. could be put into the system by officials (police) and by car drivers themselves. This service is free of charge, costs are covered by the car tax. But there may be an extended version of this service, which also announces pre-

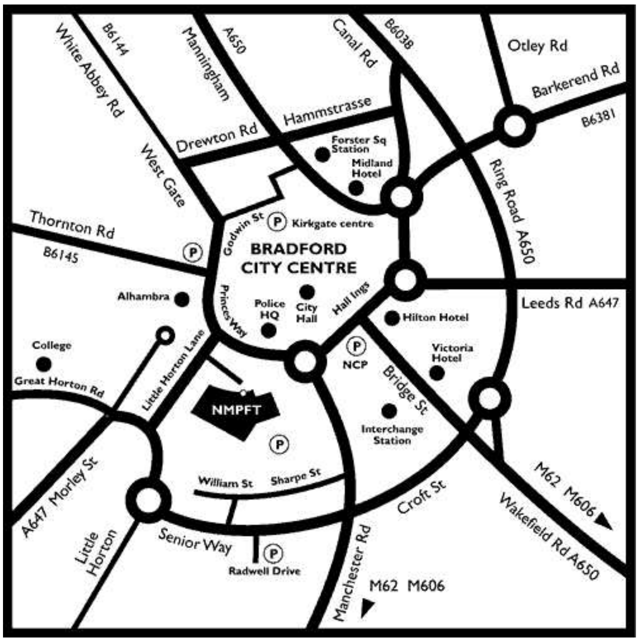

Figure 8.3: An example of a car computer's navigation view. (Figure from http://www.nmpft.org.uk/visitor/nmpftinfo.asp.)

dicted traffic densities. A fee is charged for the usage of the latter.

Another service involved in this scenario is one which provides hitchhikers with the information where to best hitchhike from. This information is based on the traffic density in different places as well as the possibility to safely stand near a road. This service is provided by a hitchhiker database. Like the traffic information, this information is accessed via long range communications.

The most sensitive service in respect to security and privacy is the ID service (Figure 8.4). It must be provided by the state and allow certain people to check other people's police records. For this, the person to be checked has to explicitly issue a certificate to the person checking the records. This certificate is bound to certain properties of the records. In this scenario, it works in the following way: when the car approaches, the driver and the hitchhiker exchange their public IDs. The driver can then issue a certificate allowing the hitchhiker to check for a limited set of information. Also, a certificate is valid for a limited period of time.

All of the devices and services described above can be built and provided using today's technologies, though some functionality might need thorough testing. However, it is a fact that these inventions would be much too expensive for a large market at the moment.

Required technological innovations

Communications technologies

The communication technologies used in this scenario include both long and short range communications. People are mobile and the need for short range communications is evident as we want to minimize the required data flow (overall). Mobile phones are already everywhere so they form a good basis for long-range communications. What about the short-range communications then?

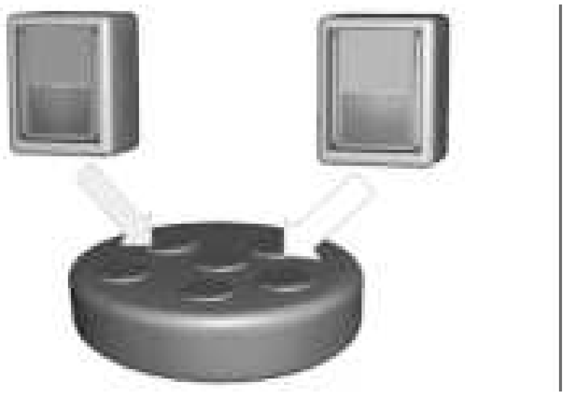

Figure 8.4: An abstract overview of a distributed ID service. (Figure adapted from http://www.intamission.com/solutions/default.asp?PageID=30.)

WLAN is becoming more popular in universities, big cities and companies. WLAN offers high transfer rates but no mobility (during the connection) so a possible solution is integrating WLAN and mobile technologies and embedding them in the PCA. The PCA sends a short-range signal that uses WLAN techniques to provide some services (like the hitchhike announcements).

Computer innovations

The traffic guidance system needs some kind of real world input, which it processes accordingly and responds to traffic queries. Either there must be a distributed network of servers that covers the whole country or supercomputers that can handle the processing and have the required capacity to respond to numerous queries. Also there must be some kind of technologies for extracting data from the real world and transforming it into a form that a machine can understand. These methods can be based on existing technologies and standards. XML with specialized DTDs can make information retrieval from standardized sources possible (traffic announcements etc.). For dynamic and non-discrete information there must be other means of representing and handling data.

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An ambient intelligent e-learning system in the year 2020

Baiquan Fan

The scenario

It is the year 2020 in an international middle school in China. The school is equipped with an ambient intelligent e-learning system (AI E-Learning) that has been developed with the latest learning theories and computing technologies. The school equips every teacher and student with a personal mobile digital assistant, the Ambient Intelligent PDA (AI-PDA), that uses 3G technology and works as a terminal to access the AI E-Learning services. (The services could also be accessed from other types of terminals like stationary and tablet PCs).

Schedule awareness

Ms. Jie is a teacher in the school. She normally wakes up at 7 o'clock in the morning and the school starts at 8 or 9 o'clock in the morning. Ms. Jie always has her AI-PDA with her since it serves not only as a PDA but also as an active badge and a personal navigator for the GALILEO global satellite navigation system [GAL]. Just at 7 o'clock the AI-PDA beeps to awake Ms. Jie although she has already woken up. At 7:30 after getting dressed up and breakfast, the AI-PDA reminds Ms. Jie again with the beeps, and saying "You have to go now, there is a metro coming in 5 minutes. Don't forget your key!". Ms. Jie knows the ambient intelligent system can figure out her own schedule according to her present position and the public transportation schedule. She rushes away to the metro station in 3 minutes and catches the metro.

Location awareness

On the metro, Ms. Jie opens her AI-PDA seeing that some of her students are already on the way to school since as a teacher the students will be in her custody after they leave home. She also knows from her AI-PDA which students have done their e-learning-based homework. She notices that Yoko, one of her students from Japan, is sick today and Yoko will take today's lessons with the home-based learning system which is part of the school Ambient Intelligent E-Learning System.

Registration-in-school awareness

When Ms. Jie enters the school area she is instantly registered to be at work because her AI-PDA sends a registration signal to the school's ambient intelligent system. It is already 7:50 when she comes to her office, and she knows from her AI-PDA that 19 out of 20 of her students are already in the classroom, since every student is registered to the school's ambient intelligent system when he/she enters the school area. At 7:58 just 2 minutes before the class starts, Ms. Jie's AI-PDA vibrates to remind her to go to the classroom for her Chinese lesson.

A virtual classroom

The classroom is equipped with tablet PCs at each desk where a student can take notes or issue commands with a pen, but the images, text, and digital video can be summoned by voice command [VIS]. The computers are networked to access the services of the ambient intelligent e-learning system.

It is about 8:00 when Ms. Jie enters the classroom. All her students except Yoko are sitting at their desks and logged into the ambient intelligent e-learning system. Even Yoko is sitting in a sofa with her tablet PC at home and logs into the system so that she can join the learning group of the class and do video-conferencing with her teacher and classmates. The lesson is about Chinese characters and their pronunciations and is provided by the AI E-Learning system. The teacher works as a mediator.

Subject context

Marianne is from France and French is her mother tongue. She can speak very little Chinese. The Chinese tones are still difficult for her and the Chinese characters are even more difficult for her. However, Yoko is from Japan and the Chinese characters are quite familiar to her. The only difficulties are the Chinese pronunciation and grammar since characters have a different pronunciation in Chinese and Japanese. Seung-yun comes from Korea and the Chinese characters and their pronunciations are less difficult for him than for other students.

The AI E-Learning system knows the relations among languages and the language proficiencies of all the students from the students' profiles, and the system could choose the best learning strategy for each individual student so that a student could progress his/her learning according to his/her own pace and the system provides the right content according to the learning process context.

Learning process

The AI E-Learning system starts the lesson with a Chinese character 中 that consists of 4 strokes. The Character is easy for Yoko and Seung-yun, and they write it on the screen and pronounce it. The system quickly responds "Writing: Perfect! Pronunciation: Good!". However, the character is very difficult for Marianne and she has to draw (not to write) the character on the screen.

The system does not recognize her writing and provides detailed strokes. The screen shows the vertical stroke first and Marianne draws it; and then the horizontal-vertical stroke, horizontal stroke, finally the long vertical stroke. At the same time Yoko and Seung-yun have proceeded with the following characters, and they finish the learning unit quickly.

Learning process awareness

Marianne's progress is far behind Yoko and Seung-yun. When Yoko and Seung-yun finish their tasks, the AI E-Learning system asks them whether they want to help other students or proceed with the next unit. Yoko is very tired since she is sick. She refuses to give any help to other students and goes to bed. Seung-yun accepts the demand to help other students to write and pronounce Chinese characters.

Collaborative learning

Marianne receives a message from the system, “Do you want help with your task from Seung-yun?” Marianne answers to the system “YES!”. The system informs Seung-yun that Marianne has accepted his help. After Seung-yun acknowledges to the system, the system synchronizes Seung-yun's progress with Marianne's and turns their screens into sharable mode so that they can see each other's screen and listen to each other's pronunciation. With Seung-yun's help, stroke by stroke, Marianne learns how to write (not to draw) Chinese characters with their complex strokes and Chinese pronunciations with the difficult four tones.

Learning assessment

The Chinese lesson finishes and Ms. Jie already knows how well each student progresses with his/her study. The system tells her Marianne needs more practice and she could go through the lesson again with her AI-PDA on the way home or with her tablet PC at home since her learning processes during class has been recorded into the database of the AI E-Learning System, unit-by-unit, section-by-section, with a timing frame. She could even ask Seung-yun to join and to share their screens and sounds like a face-to-face classroom.

Explanations and comments

Explanations

Architecture and services of the ambient intelligent e-learning system

The ambient intelligent e-learning system has a multi-layer architecture. It includes communication infrastructure, legacy e-learning system, the GALILEO global satellite navigation service [GAL], the public transportation schedule service and the context-aware services.

The legacy e-learning system provides e-learning services with secured connections through a local area network (Ethernet, Wi-Fi), 3G network, and the Internet, which can be accessed with stationary PCs, tablet PCs and hand-set devices (AI-PDAs, mobile phones). The legacy e-learning system consists of the following services and components:

- Learners profile service
- Course administrative service

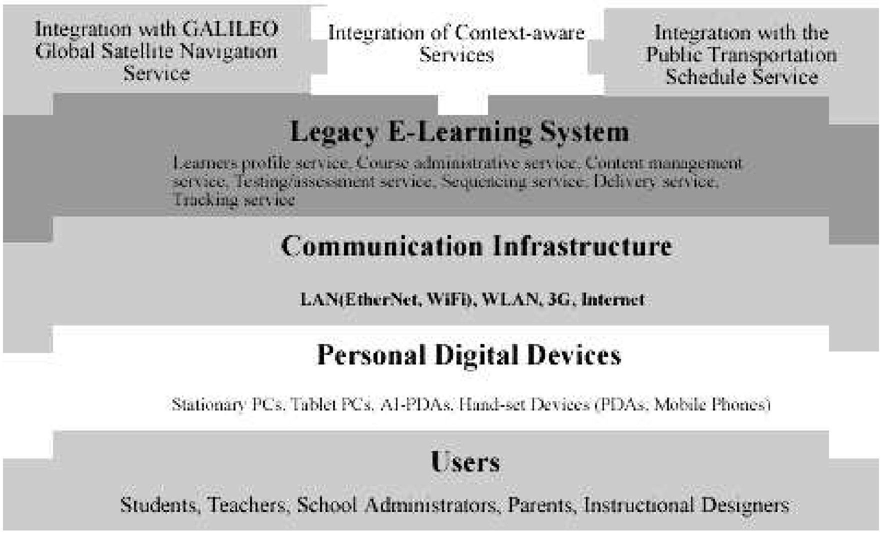

Figure 9.1: The Architecture of the Ambient Intelligent E-Learning System.

- Content management service
- Testing/assessment service
- Sequencing service
- Delivery service
- Tracking service
- Local and remote content repositories
- SCORM API adapter

With the above services and components, the system could reuse the learning objects through organizing the raw data media elements (audio, video, text, illustration, animation, simulation, etc.) into information objects (procedure, principle, concept, process, fact, overview and summary), from information objects into application objects (learning objects, supportive objects, etc.), which are enabling objects. Lessons, chapters, units, brochures are aggregately assembled as the terminal objective. The collections of the aggregate assemblies make stories, courses, books and movies with themes [ADL].

Integration with other services

The GALILEO global satellite navigation service is integrated to the legacy e-learning system to provide a location-aware service so that the teachers and parents could be aware of the locations of the students during their school time. When a teacher requests a student's location with his/her AI-PDA, the AI e-learning system turns the request to the student's AI-PDA and the student's AI-PDA sends the location information back to the AI e-learning system and then to the teacher's AI-PDA. The teacher could also send a group request for the locations of his/her students, and the locations of the students could show on a map on AI-PDA.

The public transportation schedule service is integrated into the sys-

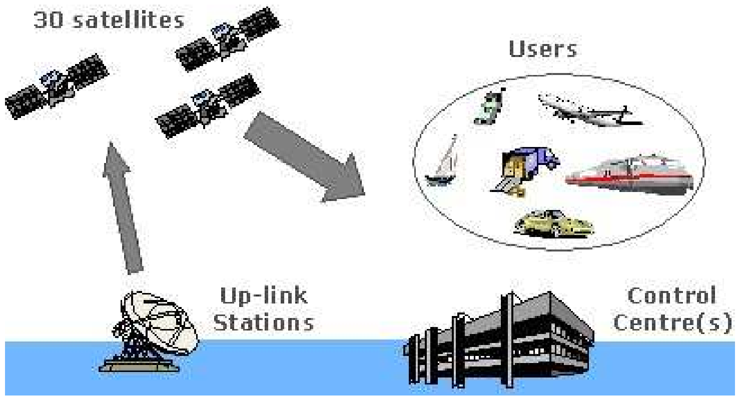

Figure 9.2: GALILEO Satellite Navigation System [GAL]. (Figure from [GAL].)

tem to provide public transportation information. The context-aware services are based on the above two services to provide the users with the location-aware service, schedule service, location-and-schedule-aware service, registration-in-school service, learning-process-aware service. The context-aware services are characterized by schedule awareness, location awareness, location-and-schedule awareness, registration-in-school awareness, and learning process awareness.

– Schedule awareness: The AI E-Learning System provides the schedule-aware service that could arrange the timing of the user's activities based on his/her personal schedule (lessons, meetings, tasks) and the schedule of the school. The tasks in school have the highest priority and the task information is shown on AI-PDA.

– Location awareness: With the integration of the GALILEO global satellite navigation service, the teachers are aware of the locations of their students during school time.

– Awareness of present location, personal schedule, and public transportation schedule: The public transportation service could be used together with the location service and personal schedule to make the location-and-schedule-aware service. The location-and-schedule-aware service alerts the user of the best choice of transportation (bus, tram, metro, etc.) and timing to a destination according to the user's personal schedule, the public transportation schedule and the user's present location.

– Registration-in-school awareness: A student or a teacher will be registered in default when he/she enters the school area. This is done with his/her AI-PDA since a GALILEO receiver is integrated with the AI-PDA and a registration-in-school aware application is installed on the AI-PDA. When the AI-PDA enters a predefined school area, it will automatically register the student or the teacher with his/her ID (an electronic signature) to the AI E-Learning System.

– Learning process awareness: The AI E-Learning System is aware of the students' learning context and learning processes from the legacy e-learning services, e.g. learner's profile service, testing/assessment service and tracking service. Based on the data from those services, the system through its intelligent agents could select the best learning strategy for the learners by dynamically assembling learning objects or by recommending the learner to switch from the individualized learning mode to the collaborative learning mode or vice versa in the classroom, at home, or even during travel.

Privacy concerns

During school time, the AI E-Learning System is aware of every student's location. The monitoring of a student's location has consent from his/her parent. Only authorized teachers and the student's parents can access the data of the present location or even the past location of the student.

Products

Devices

AI-PDA: The Mobile Ambient Intelligent PDA features not only a legacy PDA but also a personal navigator for the GALILEO global satellite navigation system and an active badge. An AI-PDA is 3G-networked with the school ambient intelligent e-learning system. With its multimedia GUI and an embedded digital video camcorder, users can view video streams and do videoconferencing.

Tablet PC: The Tablet PC contains Chinese character and Chinese speech recognition applications.

Applications

An active badge application should be installed on the AI-PDA so that the application could check if the AI-PDA is in a predefined area (e.g. the school area, which is synchronized with the predefined areas in the AI E-Learning System). If the AI-PDA is in the predefined area, the AI-PDA will take some actions (e.g. register the AI-PDA user to the AI E-Learning System).

Philosophical issues

Building a context-aware system requires no philosophy. However, some philosophical issues could be raised with context-aware computing. Literally, aware implies knowledge gained through one's own perceptions, as of the attitudes of others, or by means of information; conscious emphasizes the recognition of something sensed or felt. Human beings are characterized by consciousness, rationality and free will.

Can we build a complex context-aware system (e.g. robots) that is as conscious as the human mind or more than the human mind? Can a context-aware system have self-consciousness and free will?

According to the dualist tradition of philosophy, the world consists of or is explicable as two fundamental entities, such as mind and matter. Context-awareness concerns not only the physical world but also the mind state (e.g. in an intelligent tutoring system). Computers can be aware of some aspects of the mind state through psychometrics and human behaviours just as we do in monitoring the learning process. However, can a computer measure the free-will of the mind state by embedding a chip in human brain so that the machine could be aware of the mind state?

The above questions are the philosophical issues in artificial intelligence, robotics as well as context-aware computing.

Required scientific and technological innovations

The following scientific and technological innovations are needed for the future ambient intelligent e-learning system:

– Integration of the GALILEO satellite navigation system with the legacy e-learning system.

– Integration of the public transportation schedule with the legacy e-learning system.

Context service based on the learning context and learning process:

– Intelligent agents that can adjust the curriculum.

– Intelligent tutors that can dynamically assemble learning objects.

– Content can self-adjust or be created.

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[GAL] GALILEO – European satellite navigation system. http://europa.eu.int/comm/dgs/energy_transport/galileo/index_en.htm.

[VIS] VISIONS 2020 – Transforming education and training through advanced technologies. http://www.technology.gov/reports/TechPolicy/2020Visions.pdf.

Peter – a novice business person working for an international consulting company ACME

Jukka Kohonen and Otso Virtanen

The scenario

Peter started to work for ACME only two weeks ago. Luckily ACME, being a spearhead company in using technologies, has given him a handheld communications and computing device, also called *P-Com*. Peter has already found P-Com very useful, especially after he got through the tedious configuration phase of the device, e.g. recording Peter's voice, pictures of Peter and several biometrical measurements. The picture-taking was especially amusing: pictures had to be taken with different lightning surroundings and from different angles (so that P-Com has quite a precise 3D model of its owner's face).

Today, the most important task Peter has marked in his calendar is a meeting with a company that is considering using Peter's competence in their forthcoming project.

In the afternoon Peter is notified by the P-Com saying that it should be about time to leave for the meeting with the client. Peter drives to the client's address and easily finds the main entrance and the waiting room.

Hit music

When pacing around the waiting room, an interesting song catches Peter's attention, coming from a radio nearby. Peter finds the song entertaining and starts recording the song with his P-Com. After the recording, the P-Com automatically contacts a highly popular music database service which offers recognition services for unknown tunes. It will also contact Peter's favorite on-line music store for a price quote and some background information (rumours one could say...) about the band.

Figure 10.1: The P-Com is worried. (Figure from http://www.chick.com/reasons.asp.)

Bandwidth crisis

While Peter is still nervously pacing around, he tries to have a glance at ACME's multimedia product catalog on P-Com. He initiated its download over the public wireless network service (e.g. GPRS) when leaving his office. To his great surprise, the download is only 4% complete and will not be finished when the meeting starts. Apparently either Peter or P-Com had overestimated the available bandwidth (Figure 10.1).

Peter gives negative feedback to P-Com, indicating that he really wants the catalog. What is more, he will always want it available when meeting any customers.

As an immediate remedy, P-Com tries to find a way to gain better bandwidth. In fact, P-Com remembers that when Peter came in there was a WLAN available at the 2nd floor entrance, so walking back is one possibility. P-Com also broadcasts a "bandwidth query message" to the *proximity network* of P-Com, to which the client company's network responds that there is a wired network access point in the next room. P-Com does some quick calculations, and after a few seconds it shows Peter two alternatives both as text and as a rough map (see Figure 10.2; notice also the compass directions given by P-Com):

– *Walk back 80 m south, then 30 m east to "2nd floor entrance". WLAN available, your file will be downloaded in 8 minutes (plus your walking time).*

– *Walk 15 m west to "Wired network access point, room C224". You'll need to have network cable. Your file will be downloaded in 1.5 minutes.*

Luckily Peter has a cable in his suitcase, so he goes to C224 and P-Com starts downloading as soon as the access point is in range.

As a long-term precaution, P-Com makes a record that whenever a customer contact can be expected, an up-to-date version of the catalog must be available; initiate download well in advance if needed.

Meeting

When the meeting starts, a person previously unknown to Peter is present. Since Peter does not want to be intrusive he does not want to probe electronic information originating from the unknown persons P-Com directly,

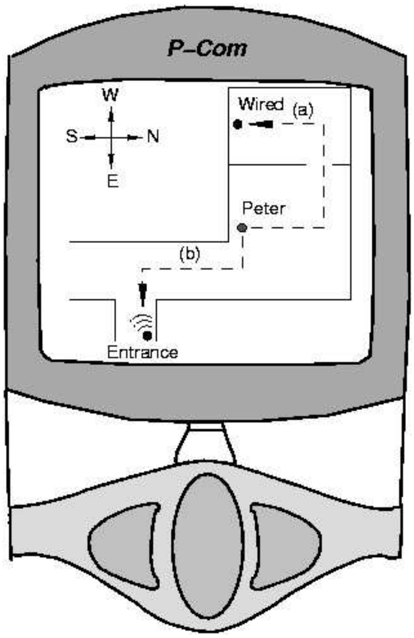

Figure 10.2: Options presented by P-Com.

rather he asks about it in person. Since the unknown person gives his approval for the probe, Peter's P-Com automatically reveals all the prior business contacts between this person and ACME by receiving information from the other person's P-Com. It seems that the person has had some contacts to another division of ACME, but none to the division where Peter works.

Normally, in this kind of situation, the meeting's chairman would propose this before the meeting starts, e.g. saying something like "Shall we keep our e's open?". This would give the "social approval" for the P-Coms according to the nature of the meeting (sales, legal etc.). Some of the services P-Coms offer would then be possibly unavailable, e.g. in trusted meetings no sound recording should be possible.

Factory floor

After the meeting, Peter is taken to a tour inside the client's highly sensitive high-tech factory. The following items are of interest:

1. The client regulates the P-Com, which is possible since Peter has e-signed an agreement when entering the client's premises that the client has a sort of a veto for disabling certain services like taking photos and audio recording.

2. As an extra safety measure, at the client's factory floor the robots notice Peter's presence from a beacon signal originating from P-Com. Also, when arriving in highly sensitive areas, P-Com is not allowed to use its high-power radio transmitter to contact the public mobile network, since the RF-interference might affect the machines in a harmful way. Instead, it is redirected to use the factory's local WLAN at low transmission power; the local network will act as a relay to the public network.

Figure 10.3: An example of how Peter's P-Com could look like. (Figure from http://www.nec.com.tw/product/pda.asp.)

Explanations

The center of the scenario is "P-Com" which is similar to PDAs and mobile phones existing today. The model we pictured here is a serious-looking one, or "professional" suited to a businessman. Other people may prefer more fashionable models.

The configuration of the device was found difficult, which is due to the fact that machine learning methods require some data prior to correct working. This training data had to be asked directly from Peter: voice recordings, sample pictures of Peter and Peter's iris etc. Luckily, the data captured once should also be available later on, so if Peter decides to buy a new P-Com the laborious configuration phase can be avoided.

When Peter arrived at the client company, P-Com automatically contacted the company's *electronic presence server*. The server then informed Peter's hosts that he is now present. Also, after having the contact to the server, P-Com now knows that a suitable mode of operation is something like "in a meeting" (silent tunes etc.). Previously P-Com was perhaps in a mode called "owner is driving a car".

The music-matching worked automatically: the P-Com had noticed that if Peter recorded music he normally contacted a certain music service with the recorded tune. The fact that this signal was music was inferred from the signal itself (NB. this is getting increasingly difficult due to the nature of modern music...). Technically the P-Com noticed a strong relationship with the actions and decided that it should pursue the actions without Peter's manual consent. The technique to utilize in this example is e.g. Markov chains or episode rules. Tune recognition was performed with standard string-matching techniques [CBM]. This would have been easier if Peter would have been listening to the music straight from the P-Com and P-Com could have utilized the services offered by this radio station website (currently playing...).

P-Com keeps a history of recent events like movement, network availability etc. It remembers the time and location of the events, so it is able to "look back" in case something is needed. When bandwidth was urgently needed, it found the recently seen WLAN access point in its memory. Finding the wired network access point was more complicated. This involved contacting the *proximity network* of P-Com, which is a low-bandwidth connection between nearby devices (e.g. Bluetooth [Blu]). Calculating the necessary time needed for the two options (components needed + catalogue etc.) was then performed by P-Com.

The map of the building was given by the presence server contacted when Peter and P-Com arrived at the premises. If there had not been such service in the building P-Com would have tried to form a rough sketch of the surroundings by combining information from its built-in video camera and distance probe (e.g. radar, sonar). Forming this kind of a map is of course quite challenging and the resulting map may be quite imprecise.

Coordinates are mapped to humanly readable location names like “2nd floor entrance”. This information could be provided by the surrounding network infrastructure (again the presence server). On a larger scale (outdoors) coordinates could be mapped to a publicly available street map, e.g. the device could tell Peter that something interesting was “at 1205 Maple Street, on the south side, near the intersection of Fifth Avenue”.

Future planning should avoid the absence of multimedia catalogues when in customer premises or meeting a client elsewhere (e.g. restaurant). P-Com could have a model that “predicts” customer contacts based on calendar entries, current time, location and movement (e.g. heading to a client’s office), etc.

At the meeting the P-Com started automatically to “mine” data using the data of the person that was not known to Peter before. This required a contact to ACME’s data base server that offers this kind of services. Normal tasks at the server side are, e.g. association rule mining about the contacts and possibly notifying the persons at ACME that are doing business with the unknown person. Notice also the consent that was asked from the unknown person prior to the “probe”. This suggest that if a device queries something it also leaves a trace to the device contacted and thus it is polite to ask before performing the action. Normal rules of social encounters will be applicable in digital space as well.

The services available in P-Com vary according to the nature of the meeting or according to the place (see the example from the factory floor). It is not considered to be polite to record or to photograph without permission. In some countries this is also considered illegal and the trend is toward higher regulation and control. A number of devices that detect or jam cellular phones can be found as well as software that turns off the possibility to photograph from a mobile phone.

At the factory floor, there are a number of wireless sensors and services:

- Motion detector, for two purposes: both for personnel safety (against moving robots) and for factory security (against unauthorized people).
- Beacon detector.
- Local general-purpose network (“WLAN”).
- RF signal detector; a high-power RF signal could interfere with the factory equipment.

Issues

Problems and risks, e.g. privacy concerns.

- If Peter and his P-Com say “Ok, I’m not recording or taking photos”, what if they lie? Would people usually trust such statements, or would the client actually require Peter to leave his P-Com at the entrance? One possibility is to have a sort of middle-ware layer which forces the shutdown or lack of certain actions. This of course is based on the assumption that 1) you can trust the middle-ware and 2) the

Figure 10.4: An example of a detector for RF-signals. (Figure from http://ucables.com/ref/RF-DETECT1/.)

user cannot modify it.

Products

Devices, services.

- P-Com
- access points (wired and wireless)
- positioning service
- electronic presence service of the customer's building
- database server for employees of ACME (contacted over the public network)

Bibliography

[Blu] http://www.bluetooth.com/.

[CBM] Content-based music (information) retrieval, CBMR. see e.g. http://www.cs.helsinki.fi/group/cbrahms/.

Appendix: the assignment

The aim of this assignment is for the students to get acquainted with context-awareness: visions and problems related to future applications.

The work will be performed in groups of two persons with another group acting as referee. The work to be done will consist of writing usage scenarios with heavy use of context-awareness, for a particular type of user and usage situations, as chosen by the group. Each group must also review and grade the assignment of another selected group. Of course, the group may comment any other group's work, as well.

Each group will be assigned a topic for its scenario.

Suggested topics

Write a five page scenario of the daily life (10–15 years from now) of a person with one of the following occupations/activities.

1. House manager (Fi. isännöitsijä)
2. Waiter/waitress in a restaurant
3. Emergency service worker (police, fire-fighter, or such)
4. Medical doctor at a hospital
5. Housewife/husband with children
6. Elementary or high school teacher
7. Child in kindergarten
8. Competitive athlete, e.g. in track and fields or swimmer
9. Politician/parliamentarian
10. Linguist in field work
11. Messenger on bicycle (Fi. polkupyörälähetti)
12. Hitchhiker
13. Shop assistant in liquor shop (Fi. Alkon myyjä)
14. Audience member at rock festival
15. Retired trickster (Fi. eläkkeellä oleva avioliittohuijari)

16. Visually impaired horse rider
17. Professor with reading-writing disorder (“Dyslectic prof”)

Groups may also suggest topics to be approved by the teachers.
The text to be produced has the following structure.

1. The scenario (2 pages)
2. Explanations and comments (3 pages)
   (a) Issues (problems and risks, e.g. privacy concerns)
   (b) Products
      – Devices
      – Services
   (c) Required scientific and technological innovations
3. References (if needed)

The final text should be about 5 pages.

A draft text must be put into the Educosm system by 29 Sep 2003, to be reviewed by the referee group by 3 October 2003. The group will present the resulting work in a seminar session on 13 or 15 October 2003. The final texts should be of publishable quality, with the aim to collect them into a department series C publication.

The Wiki system lets you write the text and publish it for others to read in the Educosm.

(If you prefer to write the text in LaTeX, you must use, e.g. latex2html before inserting the text into Educosm.)

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ftp://ftp.cordis.lu/pub/ist/docs/istagscenarios2010.pdf.

The scenarios have been written with the aim of describing what living with Ambient Intelligence might be like for ordinary people in 2010. The scenarios work as models for the scenarios in assignment 1. The report includes four different scenarios. (Note that there are two versions of each scenario, a one-page short version of the scenario and a longer version with explanations in the appendix.)