

Psycho-Social Aspects of Context Awareness in Ambient Intelligent Mobile Systems

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Abstract— This paper gives an overview of driver scenarios in the ongoing e-SENSE European Integrated Project: Capturing Ambient Intelligence for Mobile Communications through Wireless Sensor Networks. The project aims at enabling Ambient Intelligence in “Beyond 3G Systems” using wireless sensor networks for making context-rich information available to applications and services. In e-SENSE project, some application scenarios are developed in order to assess the capability of the e-SENSE architecture to sense user’s context, to pre-process the gathered information into meaningful data to be input to a user’s profile enabling context based services. This paper focuses on the psychological and sociological aspects of context awareness which leads to teach sociology and psychology of user experience to the WSN based system as an integrated feature.

Index Terms— Human factors, Intelligent sensors, Psychology, Social factors, User centered design

I. INTRODUCTION

The ongoing European Integrated Project e-SENSE (Capturing Ambient Intelligence for Mobile Communications through Wireless Sensor Networks) aims at enabling Ambient Intelligence in “Beyond 3G Systems” using wireless sensor networks (WSN) for making context-rich information available to applications and services

In the first section of this paper, we describe the concept of “context awareness” to be developed and evaluated within e-SENSE project. After a short description of the technological e-SENSE concept, we put the emphasis on the user centered approaches of “context” in mobile situations.

The second section presents some examples of e-SENSE scenarios showing WSN based applications which focus on user’s mood sensing in a variety of applications areas in order to assess the context awareness of e-SENSE system. The intended benefits to users and the mood sensing challenges are

illustrated through examples of mobile services.

The third section presents the sociological and psychological issues and challenges in providing the e-SENSE concept with awareness of psychological and sociological layer of “context”. The evolution of the traditional role of user centered approaches in the design process of Ambient Intelligent mobile systems is presented.

II. CONTEXT AWARENESS IN E-SENSE PROJECT

Ambient Intelligence mobile applications are relying on the ability of wireless sensor networks to capture and understand the user’s context. WSN enable “context awareness” which will support, enhance and enrich personal, family and community focused mobile applications and services. A lot of research and development projects, especially IST Mobile projects are addressing the question of “context” as an imprecise notion. Therefore, “context awareness” is a critical issue for the technological and user centred researches within e-SENSE project. e-SENSE project will concretize this notion by focusing on “context awareness” in order to understand what “context” is and how to capture the appropriate context data to enable meaningful applications for mobile user’s situations.

From a technological point of view, the e-SENSE concept will be an essential combination of enabling technologies to help provide a fully seamless and nomadic user access to new classes of applications. Wireless sensors are expected to operate in harsh environments such as close body proximity communications, operate over a long period of time and coexist with other wireless networks. Due to the ubiquitous nature as well as the quantity and spread of sensors within such a system, key requirements for e-SENSE are ultra low power operation (for communications and local processing of sensor information) and support multidimensional scalability with respect to mobility, number of sensors, diversity of sensor classes, sensor network types and sensor payload types. Also presenting captured information to Ambient Intelligent Systems, achieving transparency with respect to underlying sensor systems is of similar importance. By addressing these technological issues, e-SENSE will be able to capture information about phenomena in the physical environment, transport and pre-process the information. This information will then be fed to other mobile/wireless devices or to sensor applications and services in other networks (via service platforms and service providers). Also the mobility of these

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sensor networks range from stationary to very mobile. In particular, Body Sensor Networks (BSN), Mobile Sensor Networks, such as Vehicular Sensor Networks and Stationary Sensor Networks, such as Environmental Sensor Networks or sensor networks integrated in buildings (Home or Office Sensor Networks) are of interest. The sensor networks that collaboratively capture a user's context can be within the vicinity of a user (e.g. BSN), integrated in the user mobile terminal(s), or within the local setting of a user (e.g. Mobile Sensor Networks, Environmental Sensor Networks, etc). The user's environmental context will be also considered in presentation of services and applications to a user as well as playing an important role in the level of privacy and security offered to a user.

From a user centric point of view, the context awareness in e-SENSE is mainly addressed from the perspective of the user context's variations. Indeed, the user's context is changing not only because of user's mobility but also because of social and psychological situation changes and also for the reason that the "context aware systems" impact the user's perception of the context. These three analysis levels of context awareness from a psycho-sociological point of view are detailed below.

Context Switching

Basically, when user is mobile the most common way to understand the context aware issues is to say that he switches from a given physical context to other physical contexts. However, from a sociological point of view, it means that user goes through diverse social spheres. Typically, he moves through private sphere, public sphere and professional sphere. This social context switching affects the continuity of the user's activities in mobile lifestyle[1]. It requires a "continuous computing" which is specified by Roush as a physical as well as a social continuity[2]. Therefore, studying the context awareness in mobile perspective means that designers should consider how the context aware applications manage the elasticity of activities from one social sphere to another and also the way these applications manage the porosity of the social spheres towards given user's activities and/or personal information [1].

Context and Situations

The context changes are not only depending on the user's mobility. Even when user is static so that his physical context remains the same, the social and psychological situation of the user can change incessantly. Without moving from a physical area, the user is continuously experiencing several social situations: staying alone then getting a phone call, a visit of a friend, of the boss or even an intruder getting into the house... The fluctuations of the social situations follow the evolution of the user's psychological condition (happy, bored, scared, quiet, excited sleepy...). Even if the user's physical context is static, the context aware applications should consider that the world is moving around and that it potentially affects the social and psychological aspects of user's context[3].

Alteration of Context by context aware systems

From a sociological and psychological viewpoint, the context is also defined as the way users perceive their relation

to the world and more precisely to their environment. In this perspective, the pervasive and embedded technologies are elements of the social context and the user interacts with these technologies as he interacts with all kind of elements of the context. Thus, when trying to learn about the user and to sense the context through WSN, it is useful to keep in mind that the user is also sensing the context. The user knows that a context aware system is watching him and it could affect his ways of doing and being. Actually, sociologists know that when they observe a social context trying to understand sociological phenomena, they affect the context that they are observing. Sociologists become a part of the context and they consider this bias when they analyze the collected data. All the scientists are aware of this epistemological issue which addresses the researcher's condition towards the object he is observing and studying: "*Does my observation and study influence the phenomenon that I am observing?*" In the same way, the Ubicomp designers should address this issue when they build a context aware system: "*How the context aware system does affect the user's context?*"

Through the following presented scenarios, the objective of the human and social scientists in e-SENSE is to consider these three user centered aspects of "context" (context switching, situations and alterations) in order to enhance the context aware applications with an improved sensitivity of psycho-social context.

III. E-SENSE SCENARIOS: MOOD BASED APPLICATIONS

In e-SENSE project, some application scenarios are developed in order to assess the capability of the e-SENSE architecture to collaboratively capture the user's context (mood, gestures and also other human senses), to pre-process the gathered data into meaningful information to be input to a user's profile enabling appropriate context based services. By focusing on context sensing, the e-SENSE architecture will have the capability to observe and interact with physical phenomena in real time, and with a fidelity that was previously unobtainable.

The scenarios are varying the contexts in order to evaluate the e-SENSE system's awareness to physical context switching as well as user's psychological and sociological condition changes in mobile lifestyle.

While user's life goes mobile[4], the cell phone (and its spin-offs like PDA or smart phones) becomes a multifunctional and transversal device which supplies services to the user in every situations, places and social contexts (home, work, public). Whatever the device, it becomes clear that the services and features are converging on totem machines (iPod, MS Origami...) so that these real embedded computers appear to be the appropriate platforms for enabling applications to end-user in mobile lifestyle. The e-SENSE scenarios are developing the concept of a Lifestyle Assistant which provides WSN based services to user in mobile activities and situations.

Original applications developed in e-SENSE scenarios are

enabling Mood Based Services. In essence, these applications are relying on body sensor networks capturing physical information from user's body in order to deduce the emotions, feelings, state of mind, etc. The main idea behind the Mood Based Services is that personal mood variations are inferred from a series of measurements so that appropriate services are provided based on this information. Six promising application areas have been extracted that are more detailed below.

1- Mobile Messaging: It can be envisioned that feelings of distress and fear can be captured, and situations of physical threat can be inferred, triggering a notification to the appropriate people or services. This way, a person who feels scared on her way home at night or is threatened, a notification could reach a friend living close or a police station in the vicinity. Mobile messaging can also be used to socialize with friends in case of positive events, e.g. a pay rise, or when a person is bored and unhappy (Fig.1).

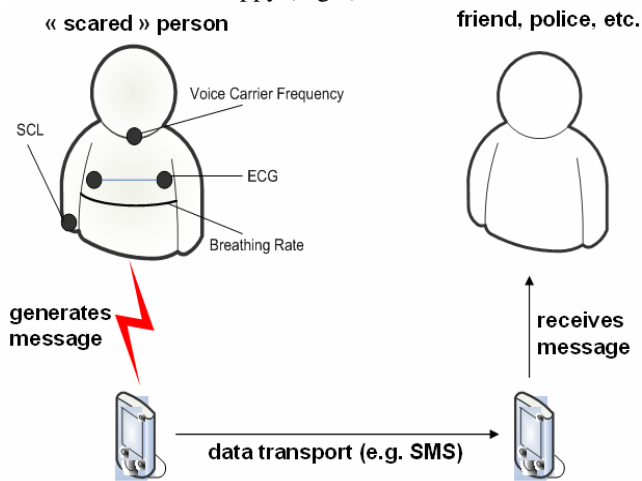


Fig. 1: Mobile Messaging

2- Instant Messaging: This service has evolved from simple text conversation to more multimedia content sharing. Users usually manually insert *emoticons* or *smilies* in a messaging conversation to illustrate their emotional state. We can imagine that this insertion can be automated using the “user mood capturing” device which can infer the mood state from a set of physiological measurements, and automatically display the appropriate emotional icon. This principle can be extended to virtual conversations, where avatars can reproduce the emotional state of the user (e.g. using facial expressions, sounds, etc) (Fig.2).

3- Games: The mood can be captured and recreated or amplified in a gaming environment, to “blend” the user experience with the “actor” actions, for improved sensations and feelings of immersion. Physiological and mood sensors can be used in hyper-realistic games, videos, software. Such an application enables the user to experience more himself in virtual world, enhancing presence in virtual world

4- Health counseling: Potential uses of mood sensors concern people who have constant fear (e.g. phobia) or suffer from depression. They can be monitored by psychologists and counselors to provide advice and support to overcome their

fears.

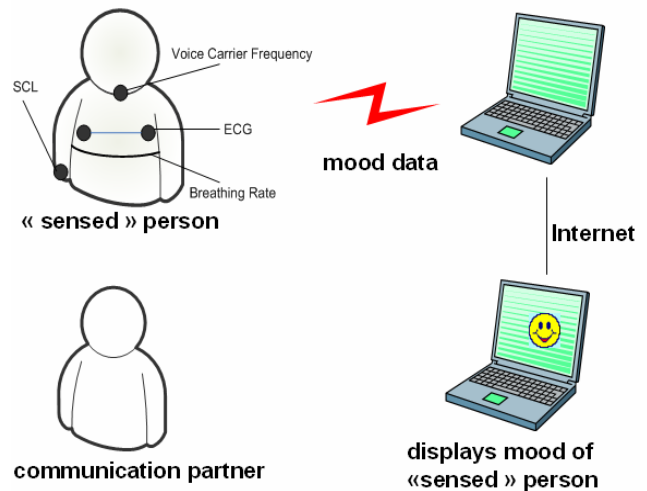


Fig. 2: Instant Messaging

Additionally, friends and family members could be involved in the treatment, especially for bipolar disorders (manic-depressive people) in which mental states may lead to severe personal states and social support is likely to alleviate the consequences.

5-Social networking: Body area networks (BAN) can carry information about the individual, his/her list of favorite movies, his/her mood, what makes him/her happy, etc. Once this person is in a public place, his/her BAN can “interact” with another person’s BAN, if a potential match is found, one of the two parties can initiate a “human” conversation. This service is particularly useful as a facilitator for dating services (Fig.3).

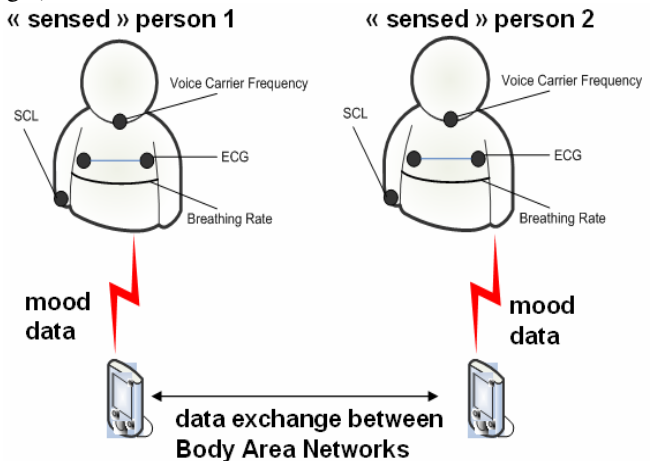


Fig. 3: Social Networking

6- Group's mood: A group of movie/play spectators equipped with mood sensors can provide important indicators about how they feel while watching the show (i.e. angry, happy, sad, etc), and may help the producers/play writer to better engage the audience. A similar approach can be used by TV sit-com producers for probing the feelings of the audience while watching a show, then select the appropriate TV commercial (e.g. propose a CD collection of smooth music for stressed viewers) (Fig. 4).

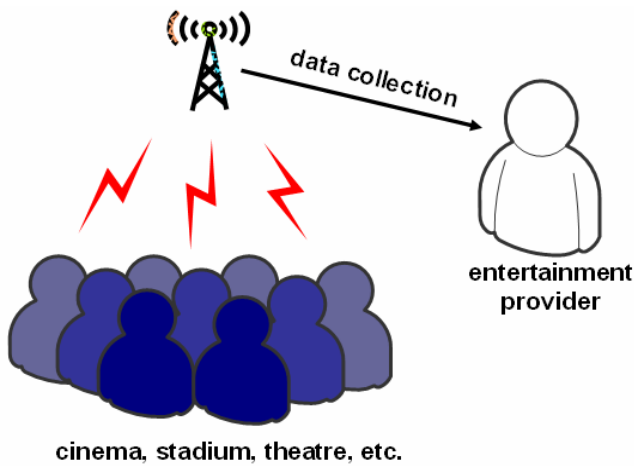


Fig. 4: Group's Mood

Mood sensing challenges

Psycho-sociological context, especially mood, is a complex human aspect that is complicated to capture and interpret. Biosensors alone may not be sufficient to assert the emotional expression; complementary technologies may provide additional clues. Face recognition, voice tone recognition and ambient sensors can provide additional information. For mood measurement an underlying dimensional model seems most suitable (Fig.5).

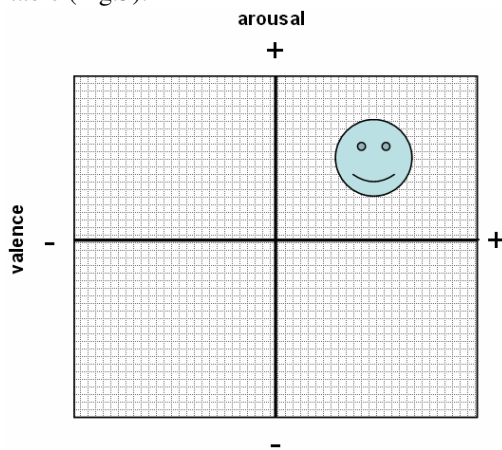


Fig. 5: Mood Sensing Model

This model implicates the existence of four main areas that emotions can fall in:

- positive arousing emotions
- negative arousing emotions
- negative calming emotions
- positive calming emotions

The origin of the matrix constitutes an emotional state of neutral valence and arousal at a medium level. Mood in this model can vary in two dimensions – arousal and valence. Appropriate physiological measures within a Body Sensor Network (BSN) will be mainly used as indicators for the arousal level of the model. An integration of BSN and environmental sensors supports the detection of information about the valence of the situation.

Appropriate measures for mood sensing are:

- ECG and Heart-Rate Variability: long-term variations of

operator state (activation and relaxation)

- Skin-Conductance Level: responds to fast emotional changes
- Electromyogram: indicates expressional responses of facial muscles
- Breathing Rate and Pulse: long and short-term variations of operator state
- Voice-Carrier Frequency: long-term variations of operator state, especially excitation

However, it is not obvious how to capture gradients of emotional feelings (not just extreme once), and how to distinguish between two emotions that have the same external “symptoms”. To feed intelligent devices with the mood measured and trigger the appropriate adaptive response, the measurement has to be interpreted and categorized. The interpretation is complex but could become more reliable with the measurement of several relevant physiological parameters and environmental data and their integration.

IV. SOCIAL AND PSYCHOLOGICAL AWARENESS

As Dey specifies, the interaction *between the place, things and people* [5] determines the context data to be processed for providing user with the appropriate services. It means that “context” comprises also a psycho-sociological layer. However, it is a challenge to define and to consider the psycho-sociological context when designing a context aware system because the required data are not only and purely physical or biological.

Thanks to WSN, each event of user's life is potentially captured by ambient intelligence systems. Greenfield points out that Ubicomp technologies (WSN, RFID...) enable to make information about events in real life visible which existed before in a latent state in our life [6]. These technologies can now allocate to objects and slices of life a digital value and thereby make them perceptible, accessible and usable on networks[7]. A digital existence is given to the physical environment and the people's life so that each object and person will get a digital reflection. Little by little, the definition of digitalized real life is increasing, confirming the Weiser's prophecy: in ubiquitous computing environments, sensorised technologies “will weave themselves into the fabric of everyday life until they are indistinguishable from it”[8].

However, even though the omnipresence of sensors and the availability of sufficient computing power enable contexts' digitalization, full context understanding is by far not achieved. It is not enough to enable the environment to watch users by means of WSN: the most important question is the way of looking on us the devices will follow. Thinking about the eye of the system on people is an important issue since today personalization to user's profile, adaptation to user's situation and proactive anticipation of needs are required functions of modern devices. Those devices must be able to observe precisely and infer usage intentions from obtained data. The eye of devices on user's life should be a sociological eye. As mentioned above, WSN turn the environment in a

potential “sociologist system”: ubiquitous computing observes users, trying to understand and predict their behavior, thoughts or mood like the sociologist does[3]. Smart devices are like concealed participant observers of user’s life trying to understand what they see like the sociologist who watch on people and who tries to keep a low profile. Such discretion is the reason why WSN based systems must be physically as well as sociologically pervasive.

The role of the human and social scientists in e-SENSE is to enable the development of WSN based application incorporating multifarious aspects like social and psychological awareness as depicted earlier and summarized in Figure 6.

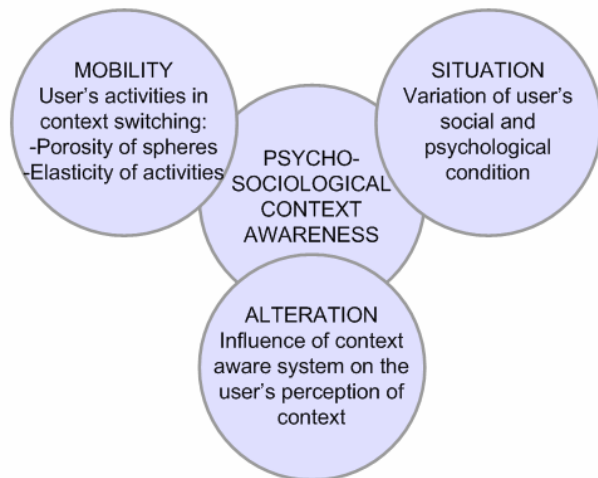


Fig. 6: Social and Psychological Context Awareness

Traditionally, the role of the user centered approaches was to make devices smoothly and unobtrusively integrated into the user’s physical environment. Today, as personalization, adaptation and anticipation of uses are becoming features of surrounding objects, the sociology and psychology aspects should become integrated functionalities to the devices and Ubicomp systems. User centered approaches are changing from a role of usage aided design to one of an embedded feature of Ambient Intelligence. That is the reason why, especially because life goes mobile, it is not enough to assess well integration of devices in user’s environment as a static context. Today it is necessary to develop systems that are able to react suitably, actively and even proactively to context evolutions. It is required to teach the systems how to design appropriate response to the sensed social context as sociologists or psychologists could do. When monitoring user’s activity, a WSN based application should be able to react and adapt automatically the services to the user’s situation which is sociologically defined as, for example: user’s existing techniques, usual practices, self identity and relationships [9].

e-SENSE researchers aim at incorporating such sociology and psychology of user experience criteria to the Ambient Intelligence Mobile Systems in order to make them able to understand what they sense.

V. CONCLUSION

As Ambient Intelligent mobile systems are relying on the capacity of wireless sensor networks to capture and identify the user’s context, the e-SENSE project focuses on the notion of “context” in order to understand how to capture the appropriate data to enable meaningful applications. The e-SENSE human and social scientists will put the emphasis on the psycho-social aspects of the context in order to enhance the context awareness by considering:

- the user’s activities in mobile lifestyle (context switching),
- the variations of psycho-social conditions of the context,
- the alteration of user’s perception of context in ambient intelligent environment.

The e-SENSE scenarios are carefully selected and designed for the development and evaluation of Ambient Intelligent mobile systems’ sensitivity to diverse social and psychological contexts. The e-SENSE scenarios are centred on Mood Based Services provided to the user in a variety of application areas enabling the variation of psychological, sociological and physical aspects of the context that e-SENSE system will sense and process.

The original aspect of the human and social scientists approach in e-SENSE project is that their role is not only to design the system to get an unobtrusive and usable system. The role of user centred approaches in e-SENSE project is also to integrate sociology and psychology of user experience into the system as a new functional feature of context aware applications in order to enhance the meaning of use.

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