

Smart Cities, Ambient Intelligence and Universal Access

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Abstract. The future of universal access is very much determined by considerations that reflect also the changes at the global level. One of the key changes is the shift towards an Urban Age. In this paper it is addressed from the perspective of how information and communication technology, in particular ambient intelligence, will influence the future of our cities. The paper presents the concepts of Hybrid, Smart and Humane Cities and their dependencies. They are also used as umbrella scenarios for developing new research lines for ambient intelligence. The paper closes with presenting twelve of these research lines that were developed in the EU-funded InterLink-project.

1 Introduction

When addressing future perspectives for universal access, one also has to include considerations that reflect changes of the situation at a global level. It is not anymore mainly about how to design an interface for users with disabilities at a given computer. It is much more the approach of “designing for all” in an evolving information and knowledge society and providing a technology substrate for eInclusion (Stephanidis, 2009). While this is an important and on-going grand effort, we like to add another perspective in this paper. We argue that the shift towards the so-called Urban Age will be key for many discussions in this realm. The origin and the consequences of this development will be elaborated in more detail in the next section. On the other hand, we have to consider the developments in different technology areas that have strong implications for universal access. Ambient Intelligence is certainly one of these technology areas that will be increasingly relevant. These two developments meet in the concept and realization of so called “Smart Cities” and their transformation into being “Humane Cities”.

2 Urban Age

Already in 2008, half of the world's population lived in urban areas and about 70% will be city dwellers by 2050, with cities and towns in Asia and Africa are contributing the biggest growth, according to the latest U.N. projections. Thus, the year 2008 was a turning point in human history, as more than half of the world's population lived in cities. According to the U.N. estimate, world population is expected to increase from 6.7 billion in 2007 to 9.2 billion in 2050. During the same time period,

the report stated that the population living in urban areas is projected to rise from 3.3 billion to 6.4 billion. Greater Tokyo is currently considered to be the largest mega city with 35 million, which is greater than the entire population of Canada. Cities are becoming increasingly the most relevant places to be observed and understood for instantiating and influencing changes in all fields of economy and society. For example, in 2006 Tokyo generated about 40% of the GDP of Japan and Buenos Aires generated 45% of the GDP of Argentina. Already today, cities are the world's centers of excellence, bringing together people from many areas of life acting as important opinion leaders and initiators of change and providers of new opportunities. At the same time, they are also the target and then home of many people – often with socially deprived backgrounds - hoping for new chances and a better life for themselves and their children. Cities provide opportunities, economies of scale, a future with more choices. On the other hand, cities are also seen as being responsible for creating and exhibiting the divide between rich and poor, diminishing their quality of life, for marginalizing communities, and for causing environmental hazards. They have been castigated as centers of disease, social unrest, instability, and insecurity. Because cities host many more people compared to their originally planned dimensions and grow faster than their infrastructure, cities face high risks from industrial hazards, natural disasters, and the spectrum of global warming.

When speaking of an Urban Age that we have entered, people predict that the economic prosperity and quality of life will largely depend on the abilities of cities to reach their full potential. But the issues mentioned above are at a general level and span a wide spectrum of challenges that are beyond the theme of this session and the limits of this paper. In order to be more specific and make the connections to the role of information technology, we have to orient ourselves via sample application scenarios. The theme of Urban Life Management in Smart Cities was selected as an umbrella scenario. Based on this, we developed the concept of “The Humane City” as our vision for the City of the Future and the future of Urban Living. Within this context, we can observe a development from real cities via virtual/digital cities to Hybrid Cities and then transforming them into Smart Cities. Obviously, there are many ways of addressing the challenges and issues of Hybrid and Smart Cities. One way to orient ourselves is to ask “what kind of city do we want to have? A technology-driven and technology-dominated one? Probably not! So, we developed the vision of a city where people enjoy everyday life and work, have multiple opportunities to exploit their human potential and lead a creative life. We called it “The Humane City”. More details about this approach can be found in the deliverables of the InterLink project (InterLink, 2009). In the next chapters, we will especially focus on the information technology aspects of these activities.

3 Ambient Intelligence

The evolution towards a future information and knowledge society is characterized by the development of personalized individual as well as collective services that exploit new qualities of infrastructures and components situated in smart environments. They are based on a range of ubiquitous and pervasive communication networks providing ambient computing and communication at multiple levels. The collective services are

provided by a very large number of "invisible" small computing components embedded into our environment. They will interact with and being used by multiple users in a wide range of dynamically changing situations. In addition, this heterogeneous collection of devices will be supported by an "infrastructure" of intelligent sensors and actuators embedded in our homes, offices, hospitals, public spaces, leisure environments providing the raw data (and active responses) needed for a wide range of smart services. Furthermore, new and innovative interaction techniques are being provided that integrate tangible and mixed reality interaction. In this way, the usage and interaction experience of users will be more holistic and intuitive than today. It is anticipated that economics will drive this technology to evolve from a large variety of specialized components to a small number of universal, extremely small and low-cost components that can be embedded in a variety of materials. Thus, we will be provided with a computing, communication, sensing and interaction "substrate" for systems and services. We can characterize them as "smart ecosystems" in order to emphasize the seamless integration of the components, their smooth interaction, the "equilibrium" achieved through this interaction and the "emergent smartness" of the overall environment.

This area of technological development is besides ambient intelligence also known under different labels, e.g., ubiquitous, pervasive or proactive computing, disappearing computer (Streitz, et al., 2007). In this paper, we will mostly and wherever appropriate use the term Ambient Intelligence (AmI) and adopt the characterization by the ERCIM Working Group SESAMI (Streitz & Savidis, 2006):

"Ambient Intelligence represents a vision of the (not too far) future where "intelligent" or "smart" environments and systems react in an attentive, adaptive, and active (sometimes proactive) way to the presence and activities of humans and objects in order to provide intelligent/smart services to the inhabitants of these environments. While a wide variety of different technologies is involved, the goal of Ambient Intelligence is to hide their presence from users, by providing implicit, unobtrusive interaction paradigms. People and their social situations are at the centre of the design considerations."

Of course, there exist other characterizations and definitions of AmI, for example an early one by the IST Advisory Group (ISTAG, 2001) of the EU based on the development of different scenarios. With respect to the connection between universal access and ambient intelligence it is worthwhile to note that "The Universal Access Handbook" (Stephanidis, 2009) has in its Part IX which is devoted to 'Looking in the Future' a chapter on 'Ambient Intelligence' (Streitz & Privat, 200). In the provided context of universal access, they discuss new perspectives and propose seven alternatives about AmI as the main core of this paper.

4 Smart Cities

We are proposing now to combine the general issues of cities in an urban age addressed above (of course, only in a limited way) with the motivation to formulate challenges for future research agendas for information and communication technology (ICT) in general and in particular with a focus on ambient intelligence. This was the

main charter of the Working Group 2 in the InterLink project (Interlink, 2009). It resulted in the question:

“How can the realization of a Smart City contribute to reducing and potentially even avoiding some of the problems that are faced by today’s cities and in the future?”

Or in other words:

“How can ambient and ubiquitous ICT help to contribute to Urban Life Management?”

This can be analyzed and has to be investigated from the following two perspectives:

1. How to manage a person’s / a group’s life in today’s and future cities?
2. How to manage the urban environment of today’s and future cities?

While formulating it as two perspectives, it should be clear that they are not independent; but it helps to identify the different user needs depending on who are the users:

- The users are the citizens living and working in the city; searching, checking, evaluating and then utilizing the services that are offered by the urban environment with respect to the different aspects of life
- People who are organizing and administering the urban infrastructure so that the services are available for citizens and visitors.

Examples of how the smart city of the future could operate are: taking care of its individual inhabitants by offering personalized services (e.g. for security, health and administration, but also for leisure, shopping, ...), by providing optimized opportunities of transportation by combining various sources of traffic information at the same time and integrating different means of transportation, by providing opportunities for the involvement of people in the community, e.g., by matching people on the basis of common interests and suggesting common activities or in other words: offering multiple opportunities to be an active part of society. These are only a few examples and more are being developed.

One also has to note that there are already some efforts to realize Smart Cities, in particular in Asia. For example: the “u-Cities” (ubiquitous cities) program in Korea, the Ubiquitous Networking Forum and the notion of a “U-Japan” in Japan, and the iN-2015 Masterplan of an “Intelligent Nation Singapore”. Research in this area is concerned with the creation of a future society in this kind of Smart Cities. In Europe, one can mention examples like the EU-funded integrated project IPCity addressing interaction and presence in urban environments and the T-City Friedrichshafen, Germany, a practice experiment of the German Telekom. In many projects primarily technical issues such as the usage of different broadband networks and interoperability of devices are in the foreground. Other European activities are using the label “smart cities” with a focus on establishing administrative and social collaboration networks between cities fostering innovation and e-services. They address partially also issues of eInclusion. We argue that social impact and social mobility combined with universal access in Smart Cities should be more in the focus of the research

efforts. This includes also the change or even disappearance of the traditional orientation “metaphors” based on place and time. The definition of methods for data provision and privacy and security restrictions, the identification of new stakeholders, and the understanding of upcoming new social interaction principles will have to be discussed intensely.

5 Humane Cities

We have the vision that our cities should be places and environments where people enjoy everyday life and work, have multiple opportunities to exploit their human potential and lead a creative life. We call them “*Humane Cities*” in order to add another dimension (e.g., addressing values that guide the city’s development) on top of the more technical notions of a “smart” or “hybrid” city. As a side effect one, ‘users’ are now being viewed as ‘citizens’(with all the implications) because that is what they are actually are.

The notion of a “Humane” City describes the character of what it should be in terms of requirements for the communication, interaction, collaboration and social networking opportunities for the citizens. In this context, it is useful to distinguish the following three dimensions for investigating the issues of smart cities and their transformation into Human Cities (see fig. 1).

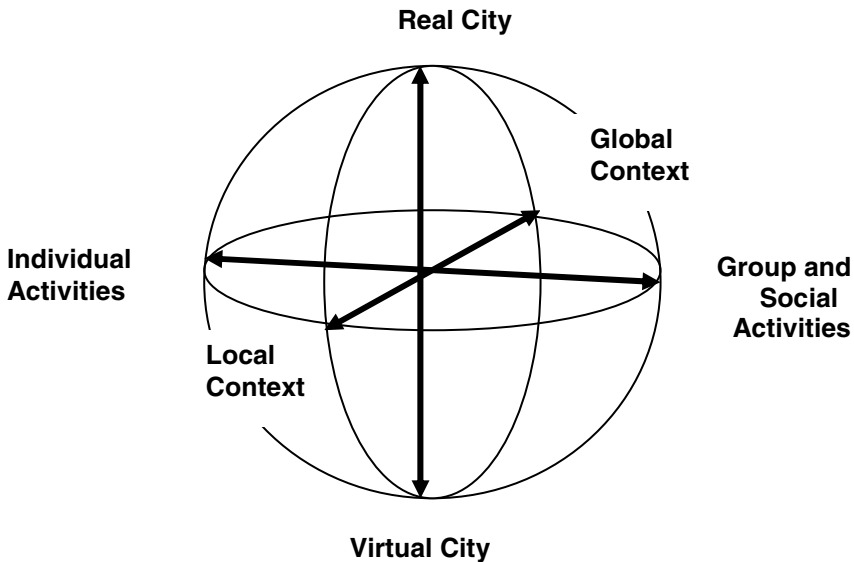
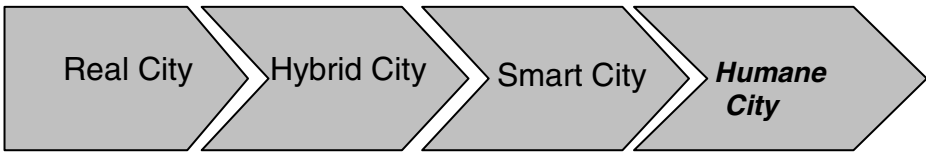


Fig. 1. Three Key Dimensions of Humane Cities (there are more but not depicted here)

In a nutshell and necessarily simplified, one can summarize the development from an ‘ordinary’ city to a ‘humane’ city by the following progression:



Extrapolating from what we know today, the development towards a Humane City will be based on the following three progressive steps which in some areas and to some degree can be realized in parallel.

1. The first step is (or was, because it is already happening today to some degree) the extension of the real city into the virtual world. The integration of real and virtual parts – complementing each other – results in the *Hybrid City* which is also characterized by the equal importance and interconnection of both worlds.
2. The second step is the transformation of the different types of services that are available in our current cities into smart services and thus the city into a *Smart City*
3. The third step is the adoption of certain requirements during its realization so that we do not end up with a technocratic Smart City which is monitoring and controlling its citizens in the interest of only a few stakeholders creating a “big brother” society. Thus, privacy is becoming an increasingly important issue. The realization of a Humane City facilitates opportunities to keep the citizens in the loop of decisions, to empower them and to provide socially aware smart environments where privacy and trust are respected values and provide the basis for fostering a creative, all-inclusive and humane society with a high quality of life.

6 Social Awareness and Privacy

The approach to design Smart and Humane Cities by creating ambient intelligence environments evidently faces a large number of issues and challenges. Having to be selective, two grand themes are highlighted here: “Socially Aware Ambient Intelligence” and “Privacy, Trust, and Identity”. They were also identified in the EU-funded project InterLink (2009).

6.1 Social Awareness

Social aware people are community minded and socially active in their social context. Communication between humans as part of a more comprehensive social dialog can also involve different artefacts as part of a socially aware system. Whereas embedded sensors and devices are already common in today’s environments, the future challenge is the creation of intelligent or smart environments which behave in an attentive, adaptive, and active way to provide specific services in these environments. Applications and services will behave in a “socially aware” way. This means that they will provide a sense of involvement and knowledge about the social behaviour of other persons, e.g., their degree of attention, desire for customization and control, their emotional state, interests as well as their desire to engage in social interactions. Socially aware ambient environments will be composed of a collection of smart

artefacts understanding social signalling and social context, resulting in the capability of improving social orientation and collective decision making.

6.2 Privacy

In today's connected world, where computers mediate frequently our interaction and communication with our family, our friends and the outside world, many people suffer from the 'Big Brother' syndrome. Especially "privacy" is an elusive concept, because not everyone's sense of privacy is the same. Moreover, the expectations of privacy are unstable, because people's perception of privacy is situation-specific, or more general, context-dependent. The issues of changing views on privacy, trust and identity are mainly a result of the tricky trade-off for creating smartness. We distinguish here between a) System-oriented, importunate smartness and b) People-oriented, empowering smartness where they Human is in the Loop. (Streitz et al., 2005). It is becoming more and more obvious that there is an interaction and balance/trade-off between a) being able to provide intelligent support based on collecting sensor data for selecting and tailoring functionality to make the system "smart" and b) the right of people to be in control over which data are being collected, where, when, by whom, and how they are being used. This calls for the development of Privacy Enhancing Technologies (PETs) and especially for making it a standard part of system design by addressing the conflict of ubiquitous and unobtrusive data collection/provision with human control and attention in an open fashion and at an early stage of design.

7 Proposals for a Future Research Agenda

In order to contribute to overcoming the gap between today's situation and the vision of the future as expressed in the goal "Towards the Humane City: Designing Future Urban Interaction and Communication Environments", we developed in the InterLink project twelve research lines (R1-R12) as constituents of a future research agenda. Due to space limitation, only their headings can be listed here:

- R1: Rationale for Humane/All-inclusive Cities (users are citizens)
- R2: Tangible Interaction and Implicit vs. Explicit Interaction
- R3: Hybrid Symmetric Interaction between Real and (multiple) Virtual worlds
- R4: Space-Time Dispersed Interfaces
- R5: Crowd and Swarm Based Interaction
- R6: Spatial and Embodied Smartness (distributed cognitive systems, outside-in robot)
- R7: Awareness and Feedback (sensors, physiological, environmental ...)
- R8: Emotion Processing (affective computing)
- R9: Social Networks and Collective Intelligence
- R10: Self-Organization in Socially Aware Ambient Systems
- R11: Realization and User Experience of Privacy and Trust
- R12: Scaling (as the major horizontal issue)

The interested reader will find detailed descriptions of each of the twelve research lines in the final report of the InterLink project (2009).

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