Ambient Information Systems – Do They Open a New Quality of IS?

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Abstract: Information Systems (IS) have influenced and changed our lives in the past 50 years more than anything else – be it in the professional, be it in the private sector. Three main qualities have leveraged IS to this extraordinary position: persistence (supporting and extending human memories), individual availability and distribution – now world-wide through the internet and innumerable web-based applications and services.

At the beginning 21st century, new technical prospects are opening new dimensions for IS: Due to the progressive miniaturisation of hardware components, next IS generations are mobile and pervasive, do no longer reside in computer mainframes and workstations but are clusters of "intelligence" which can be implanted almost everywhere and have thus been termed *ambient* or *ubiquitous*.

In this article, we will briefly review the concept and history of IS and try to define what *Ambient Information Systems (AIS)* might be and which role they might play in a future *Information Society*. In particular, we shall deal with the phenomena of *information* and *ambience*, investigate their *semiotic* dimensions – and raise the question whether and how far human qualities like intelligence, intention, etc. can be attributed to impersonal, highly heterogeneous and maybe abstract systems. If we are going to *embed* ourselves in ambient systems, if we grant these to deal with *information* (instead of data) and to *act intelligently*, this might profoundly influence our image of man – in particular as qualities like autonomy, privacy or self-esteem are concerned.

1 Introduction

Information Systems (IS) have influenced and changed our lives in the past 50 years more than anything else – be it in the professional, be it in the private sector. Three main qualities have leveraged IS to this extraordinary position: persistence (supporting and extending human memories), individual availability and distribution – now world-wide through the internet and innumerable web-based applications and services.

Presently, new systems and devices with qualities such as *mobility*, *pervasiveness* and *adaptability* are emerging and finding their way into IS. In order to address the difference to traditional IS we employ the term *Ambient Information System (AIS)* [To+07].

In the following article, we briefly recapitulate the history of IS in order to characterise AIS by their features and then introduce a definition – the discussion in section 5 will contain some examples. In section 3 we will shed light on some aspects of IS and AIS – e.g. on the sign character of data that convey the intended information. For this, *semiotics* (the science of signs) is a good foundation – in particular for understanding the implicit functionality of AIS. In addition, section 4 deals with pragmatic implications of AIS due to their qualitatively new role as "communication partners".

In section 5 we discuss various aspects of AIS – in relation to IS – dealing with their societal implications and particular new challenges to their analysis and design. Issues like *accessibility*, *personalisation*, *privacy*, *control* and *autonomy* are debated and illustrated by examples.

In the final section, we summarise and reflect on our previous discussion, draw conclusions and give an outlook.

2 Information Systems: A brief history

The term *Information System (IS)* was coined in the 1960ies when computer systems were increasingly used in the commercial and business area and large amounts of data concerning customers, products, articles, services, etc. had to be stored and retrieved. *Database Management Systems (DBMS)* were the technical solution for the manifold and increasing requirements on processing and administration of *persistent*, i.e. non-volatile data.

Soon it became clear that dealing with these tasks not only concerned technical issues but that they were closely connected with social requirements and constraints such as data security and privacy, user roles and, related to that, rights and privileges, limited and classified access, etc. This gave reason for introducing a different term when, beside mere databases and DBMS, a broader meaning was to be implied.

The *International Federation of Information Processing (IFIP)* includes a Technical Committee (TC 8) on Information Systems comprising eight working groups which are predominantly dealing with non-technical issues like socio-technical interaction or IS applications. By the end of the 1980 decade, the IFIP task group FRISCO (= FRamework of Information System COncepts) was founded and completed its work with the FRISCO report [Fa+98]. Its introductory chapter already demonstrated the difficulties in precisely determining the meaning and scope of IS:

"Even the term 'information system' itself is interpreted quite differently by different groups of people. It seems to be interpreted in at least three different ways:

- *As a technical system, implemented with computer and telecommunications technology*
- *As a social system, such as an organisation in connection with its information needs.*
- *As a conceptual system (i.e. an abstraction of either of the above)"*

([Fa+98], p. 5)

From today's point of view, we would define IS as a combination of the first two characterisations, whereas we would prefer to call the third version a *model*. The FRISCO authors suggested a combination of all three interpretations, stating:

> *"An information system is a sub-system of an organisational system, comprising the conception of how the communication- and information-oriented aspects of an organisation are composed (e.g. of specific communicating, information-providing and/or information-seeking actors, and of specific information-oriented actands) and how these operate, thus describing the (explicit and/or implicit) communication-oriented and information-providing actions and arrangements existing within that organisation.*
>
> *…*
>
> *A computerised information sub-system is a sub-system of an information system, whereby all actions within that sub-system are performed by one or several computer(s)."*
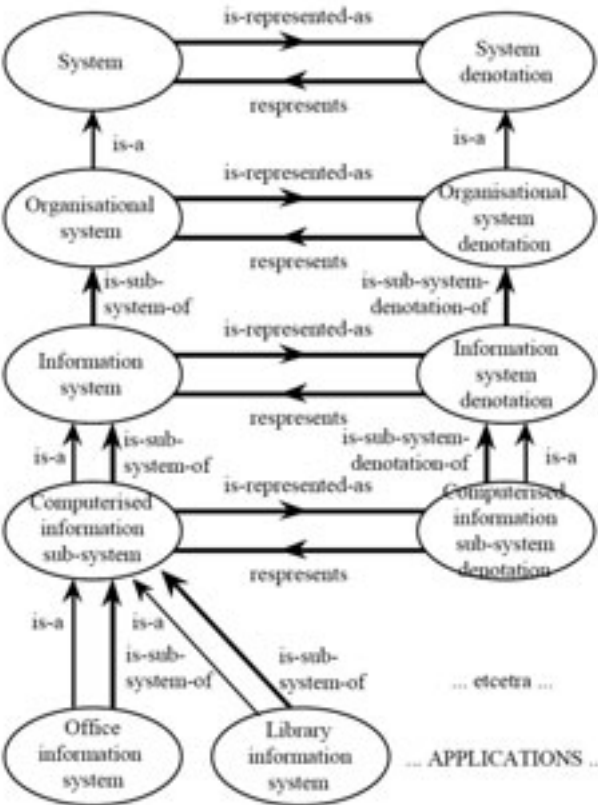> ([Fa+98], p. 72 ff.)

Fig. 1: FRISCO view on Information Systems (from [Fa+98], p. 74])

It is remarkable how closely the FRISCO authors associated IS with *organisations* (cf. fig. 1): IS were primarily considered a working instrument in the hands of professional actors, i.e. employees of an organisation responsible for *"communication-oriented and information-providing actions and arrangements"*[1]. Reviewing the FRISCO report, we have to keep in mind that it was written when *personalisation* of computers was still in progress and the internet and its huge applications were just emerging.

These more recent developments have added at least two further important characteristics to the original persistence feature of IS: *availability* and *distribution*. The use of IS is no longer restricted to professional actors located in organisations, but their services have become available for everybody – be it through his or her personal computer, palm tool, mobile phone or other means. Commercial products and services are no longer exclusively marketed by professional employees but to a large degree directly offered and sold to private "actors" – who have all become IS users this way.

In parallel to this decentralisation on the consumer side, we have a similar change on the producer side: Products, services, scientific results, entertainment articles, etc. are no longer offered by just one producer or distributor but may be distributed over many servers maintained by several organisations, individuals or even automata. Digital libraries or *Wikipedia* are well-known examples of such highly distributed IS. Particularly the latter one illustrates the increasingly blurred line between professionally produced and user generated content.

Now, at the beginning 21st century, with the establishment and dissemination of new technologies like miniaturised hardware components, RFID[2] chips, mobile devices, etc. a new generation of IS is emerging. This generation is characterised by three further outstanding properties:

- *Mobility*: Senders as well as receivers of information conveyed by this kind of systems are no longer tied to fixed locations. Information sources may be moving objects like satellites, airplanes, cars, single animals or persons, and their sent data may be accessed in cars, on bicycles, by mobile phones or other "wearable" computer devices.

- *Pervasiveness*: Data processing capabilities are no longer exclusively reserved to "computers" – i.e. visible, controllable, detachable devices with human-oriented interfaces and dimensions but may be located everywhere, e.g. in supermarket products, in our homes and all "taggable" objects surrounding us including our dress, pets or children.

- *Adaptability*: Services of IS can now be tailored to the (assumed) specific requirements and preferences of the particular user – controlled by a personal profile which may be compiled from his or her own specifications but also from data recorded without explicit user consent.

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[1] As a corresponding footnote shows, the FRISCO authors were aware of this possible source of narrowed interpretation and tried to solve the problem by an extended use of "organsation" – including e.g. *"even the community of all Internet users and similar communities"* ([Fa+98], p. 5).

[2] *Radio Frequency Identification*, also known as *smart tags*.

Due to these properties, we will call this kind of IS *Ambient Information Systems (AIS)*. In the literature, there is an increasing use of this term but instead of a clear definition mostly references to related concepts like *Ambient Displays, Ambient Intelligence, Pervasive Computing, Ubiquitous Computing, Internet Of Things*, etc. are given. Some of the existing definitions emphasise the "ambience" of the user interface [To+07] whereas *ambient* is not only understood as physically hidden but also as mainly operating in the background, not distracting users from other – primary – tasks. Often, the terms *Ambient Intelligence (AmI)* and *Ubiquitous Computing (UC)* are used almost synonymously ([Bi+06], p. 12) where AmI emphasises the human-centred and UC the technology-centred view ([FVW05], p. 7). The boundaries of *ubiquitous* technologies are rather fuzzy:

> *"Although some of the features of ubiquitous computing are apparent in many new technologies (for example one could argue that CCTV cameras are more or less seamlessly embedded into public space), they are usually not wholly 'ubiquitous' (CCTV cameras are neither necessarily 'smart' or mobile, nor do they focus on communication) ..."*
> ([KBB07], p. 4)

Thus, the question whether or not a device is *ubiquitous* or *ambient* is more a question of its *use* than of its underlying technology. Similarly, single components of an AIS may not meet all classification criteria for AIS – there may not even exist a fixed AIS but only "ambient components" that can be connected and organised *ad hoc* in order to satisfy the demands of a current user request. Properties such as *proactive computing* [Te00] and *autonomy* which are essential for AmI technology may also – but not necessarily – apply to AIS.

For a definition of *Ambient IS*, we rather consider these details as secondary and prefer a more general definition which is based on traditional IS extended by the three additional properties previously characterised:

> *An Ambient Information System (AIS) is an Information System which offers its user* mobile *and* pervasive *access (mediated by sensors and effectors of their immediate environment) and which is capable of* adapting *itself to the particular user needs and profiles.*

3 A semiotic approach to Information Systems

In order to further investigate the particularities of AIS and compare them with traditional IS, we choose an approach known from *semiotics*, the science of signs and their meaning. This approach has e.g. been followed in the FRISCO report which bases some fundamental definitions on the *semiotic triangle*. Its classical version represents three aspects of some term in question: *syntax, semantics* and *pragmatics* (including their inter-relations). The FRISCO group defined a modified version and extended it to a tetrahedron with an additional *actor* corner (cf. fig. 2): An actor can *perceive* a real world object (domain), understand it by forming a certain *conception*, and *represent* it by data – thus building a *reference* to the object.
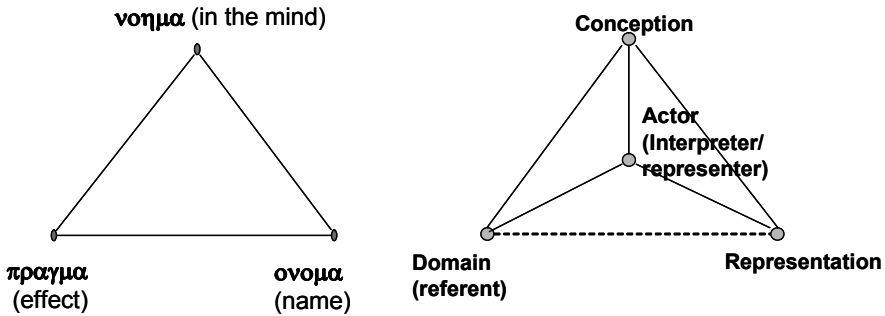
Fig. 2: Semiotic triangle in traditional (Aristotle) and extended FRISCO form

The FRISCO report defines an *"IS in the narrower sense"* as the mere technical system with its hard- and software components whereas *"IS in the broader sense"* includes the organisation surrounding the technical system, consisting of persons as well as of organisational structures and procedures. Technical IS process *data* that represent *information,* i.e. they process *information* exclusively in its *syntactical* aspect [HMR08]. As previously mentioned (cf. chap. 2), we understand IS in the latter, broader sense thus adopting a more holistic view on *information* in IS.

To illustrate this, let us consider the design of an IS for a "real world application" (cf. fig. 3). First, we inspect *real world objects*. Ideally, i.e. in case of successful communication, we "access" them *objectively* by the shared *reference*, i.e. different persons have the "same" referential access to the same object, but they still may have different *perceptions* (cf. fig. 4). Based on our referential access and our perception, we construct a conception of the "real world object". Note that the conception is only a restricted view or model where only those aspects of an object are considered that we deem relevant for the IS to be built. Our UML models always represent conceptions in this sense since they reduce objects (e.g. *customers*) to a finite set of attributes and operations (e.g. *name, first name, address*, *registering, etc.*) and omit irrelevant ones (e.g. *hair colour* or *shoe size*). Finally, we try to find an appropriate *representation* (e.g. a data record) that can be used by the IS and which suits our conception (cf. fig. 3).
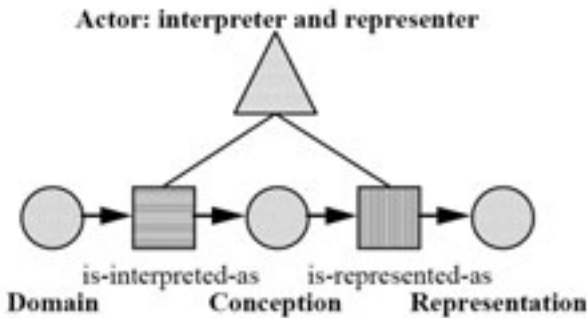

Fig. 3: An *Actor* gathers information from the *domain*, forms a *conception* and then constructs a *representation* (cf. [Fa+98], p. 52)

While using the IS, the system users gather *information* which is entered as *data* into the system. Furthermore, they retrieve *data* from the IS, associate these with a conception and thus interpret them as *information*. Potentially, the same data could be interpreted in many different ways, but in context of one particular IS the interpretation is not arbitrary. It is specified and fixed by the data design which, in turn, was based on the analysis of the "original" information – users know or acquire the correct interpretation of the data by using the IS together with its documentation. Thus, there is a closed *information-data cycle*: Information is encoded into data which after decoding yield the same information – provided that the same interpretation rules are applied.

If we consider IS as communication tools in a sender/receiver context (cf. fig. 4), the communication is only successful, if the receiver can reconstruct the information that the sender intended to convey. However, if data is used outside the IS which it was designed for, the information-data cycle is – possibly – broken. Now, there is no longer a guarantee that the interpretation of the transmitted data corresponds to the original conception. In consequence, *wrong* information may be derived from data and the (indirect) referential relationship – anchoring the representation to the "real world object" – may be violated (cf. fig. 2, connection between Domain and Representation).

Even more questions arise when we inspect the left hand side (referential) corner of the semiotic triangle in more detail. In one (of its many) traditional interpretation(s), this corner marks the "effect" of a speech act, e.g. the stopping of a person confronted with the command or with the traffic sign (= uttered or written representation) *"STOP"*. The FRISCO authors generalised this interpretation by labelling the corner *"domain"* – i.e. what is *referred to* by a representation or other speech act. Note that there is a fundamental difference between the *reference* (= representation) and its *referent* (= domain).

Disputes on what this domain or referent exactly might be, have a long tradition in human thinking and particularly in philosophy. The fundamental problem lies in our inherent inability to "grasp" the "real world" surrounding us. We can observe and perceive "objects" and "relationships", we can describe them but we can never completely penetrate or possess them. From the naïve realist's point of view, "reality" exists, is objectively determinable and – at least in principle – we can approach its "essence" up to an arbitrary precision. However, from the constructivist's point of view, it cannot be determined objectively. At best, we can achieve a mental *(re-) construction* of reality as well as a certain degree of consensus about it and call this "*objectively true*" – but always with the possibility that it might be revised by further cognition and insight.

For our semiotic triangle this means: All "natural" (i.e. non-artificial, not human-crafted) domains are principally *inaccessible* for us. Thus there are no "fixed point referents" except for precisely defined artefacts as e.g. mathematical formulae or theories.

4 Information and pragmatics handled by AIS

Following this semiotic approach we can consider IS as communication tools (using the data-information cycle as sketched above) but also as mediators between senders and receivers with respect to their referents, i.e. what they are *communicating about*. For

traditional IS, senders and receivers are clearly defined: They are registered or volatile users of the system – or groups of known or anonymous members – for example: providers, scientific or social organisations, commercial firms, political parties, press and broadcast institutions, etc. Many *references* refer to objects of the "real" world which are "outside" the IS (i.e. not tangible). Their *referents* have thus to be substituted by data available for the IS, as e.g. provided by IS owners and customers via inscription or account opening. Their mutual "understanding" is always restricted by the above mentioned conceptual ambiguities and – even worse – the coincidence of their "real world" referents can never be proven since all possible agreement on such referents necessarily relies on reductionism, i.e. on their substitution by data sets describing just some selected features (cf. fig. 4 and [HMR08]).
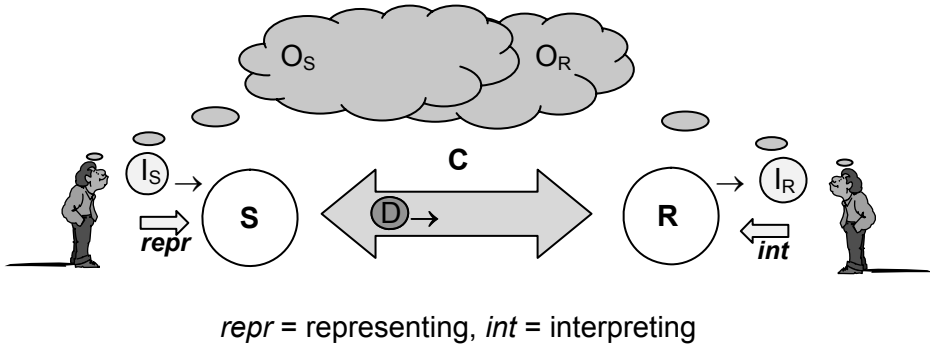

repr = representing, *int* = interpreting

Fig. 4: Sender (S) and receiver (R) actors communicating data (D) through a channel (C), conveying information (I) about an object (O)

With AIS, we arrive at a changed situation offering a – seemingly – new quality. Now, senders and/or receivers of "messages" mediated by the AIS are highly *virtualised* and/or *anonymous* [MRH07]. *Actors* are no longer exclusively humans but, to a great part, virtual "agents" who exchange data (representations) following certain pre-programmed strategies and procedures. *Conceptions* are replaced by implemented *models* which represent the condensed knowledge as far as it has been deemed necessary for their actions. Note that this affects the data-information cycle essentially and that "information" gets a highly metaphoric meaning when attributed to automated agents. The virtues and effectiveness of such systems go along with their abilities to deal with "real world pragmatics" – or in other words with the abilities of their designers to treat the *referent* corner of the semiotic triangle appropriately.

Human actors build their conceptions on the basis of (potentially unlimited) knowledge which allows them to associate these to real-world domains in a non-formalisable but nevertheless mostly effective way – as described above (cf. fig. 4). For agents, this knowledge has to be gathered and sampled by so-called *ontologies*, i.e. formalised or semi-formalised compendia of everything that might be necessary or useful for an agent to deal with in a certain domain. Note that ontologies often are more comprehensive than conventional *models* since the latter is a deliberately reduced portion of knowledge (with

respect to a certain project or application) while an ontology should provide domain knowledge in the most open, general and application-independent way (cf. [He05]).

5 From IS to AIS: A new quality emerging?

In this section, we are going to investigate our introductory question whether, where and to which degree AIS go qualitatively beyond traditional IS. The definition of AIS in section 2 suggests that traditional IS can be extended to AIS, e.g. by "simply" adding new access features providing *mobility*, *pervasiveness* and *adaptability*. AIS might be seen going beyond IS similarly as IS did some decades ago in relation to DBMS.

While the addition of such features to IS seems to be a technical – and sometimes even a relatively simple task – their effects and ramifications can be fundamental. Take for example mobile phones: Adding the feature of mobile access to telecommunication systems had a deep impact on our communication behaviour which has even escalated to wider societal effects. This is not only true for developed countries but even for developing countries in which, for example, the lightweight infrastructure facilitates the establishment of communication networks.

Similarly, the availability of mobile power supply – in combination with higher energy efficiency – has profoundly influenced individual as well as societal life. These changes are examples of non-linear developments and as such they deserve special interest. In the following paragraphs, we will discuss some particularly important features and challenges of AIS.

Explicit vs. implicit user interfaces

Traditional IS are used *explicitly* – with workstations or terminals as interfaces. For AIS, *implicit* human-computer interfaces will become important as well and maybe even dominant. Examples of such input interfaces are video cameras and sensors integrated in everyday objects and hidden in our surrounding environment. New forms of export interfaces might represent data quite differently from traditional 2-D displays, e.g. water fountains visualising currency rates [To+07].

While the explicit nature using a terminal or mobile device is clear, in case of ambient interfaces (e.g. hidden sensors) the state of the user's mind is essential: He/she must be aware of the interface and have the intention to use it; which – among other things – also implies that he/she has some idea how to manipulate the AIS through the sensor in order to reach his/her goal – e.g. in case of gesture recognition which gestures are recognised and how the system reacts to them.

Research on implicit human-computer interfaces plays a major role in new fields such as AmI. Here, computer systems are meant to be *proactive* instead of *interactive* [Te00] – they now are supposed to pre-emptively recognise the intentions and needs of users and satisfy them without the user even having to express them explicitly. Brey argues that technology following this paradigm runs the risk of producing systems that are either rather "dumb" but predictable for users or – if complementary advances in

Artificial Intelligence research can be accomplished – systems that are patronising, i.e. designed to "know better" than their users what they want [Br05]. Spiekermann and Pallas use the term *technology paternalism* [SP06], if control is taken away from the user, i.e. he/she is not allowed to override or circumvent a system decision.

Most ambient sensors and effectors are not or hardly visible and cannot be controlled by their users – if at all. It is not always transparent and – as a result of composed services maybe indeterminable – who is the "sender" of an AIS supporting my house, car, garden or whatever. Responsibilities of such systems or components may be blurred or even not relatable.

Personalisation

Personalised AIS act individually and take account of the user's specific requirements, preferences and constraints – "controlled" by a personal profile. Here we can differentiate between two categories of AIS: In the first case, the user provides his/her profile, e.g. by wearing a personal device which can be queried – AIS do not store any profile data permanently. In the second case, AIS store data about users permanently; either by extending user-provided data or by relying completely on the system's profiling mechanisms. Here, it may not be clear how this profile is created and updated and to which degree it can be influenced by the user.

Principally, these personalisation functions are already in use, albeit usually accessed by explicit interfaces – even if the corresponding data is collected and used invisibly from the users' point of view. For example, in case of web applications *cookies* or profiles configured by users are quite common. Furthermore, some web shops provide suggestion-systems that present customers "similar" items to the one he/she currently selected or bought – whereas discovering the "similarity" could be a very sophisticated process or as simple as looking at previous purchases of (other) customers who brought the selected items.

With AIS, implicit personalisation comes much more into focus. For instance, by surveying users with (ambient) sensors or querying mobile devices for their profiles – which, in both cases, could be un-requested or even undesired by users.

Autonomy and control

Another important question concerns AIS and human autonomy. If we define autonomy *"as self-governance, that is, the ability to construct one's own goals and values, and to have the freedom to make one's own decisions and perform actions based on these decisions"* ([Br05], p. 160) we can see that information plays an essential role for human autonomy – e.g. in the context of *informed decisions*. On a first glance, we might consider systems that offer us a larger amount of information as contributing to more autonomy. But IS operate with *data* rather than with information. Thus, whether AIS amount to better informed users or not, mostly depends on how far they will enable their users to derive useful *information* from the data selected and presented.

This becomes even more relevant when these systems are expected to recognise and satisfy the user's intentions and needs automatically – as is the case with AmI. One goal of AmI is giving humans more control over their environment and making it more responsive to human needs, but *"paradoxically, [...] this control is supposed to be gained through a delegation of control to machines"* ([Br05], p. 160).

In [Bi+06] quantitative and qualitative studies are examined that show – among other things – that acceptance of UC strongly correlates with perceived control over such systems, i.e. users want to maintain an option for the "final say". Furthermore, users want to know explicitly where and to which degree they are observed.

Privacy and control

AIS may raise problems concerning privacy to a new level – not only quantitatively but qualitatively. Weiser remarks that *the "[social] problem [associated with UC], while often couched in terms of privacy, is really one of control"* (cit. cf. [Bi+06], p. 82).

A frequent argument is that a new technology does not provide anything that has not been principally possible before (e.g. cf. [KBB07]). But, for instance, there is a fundamental difference between a time-consuming and costly observation gathering data and the instant access to someone's – readily gathered – personal data. It is a difference between deploying and using an observation camera and just flipping a switch gaining access to someone's *smart housing* system. In contrast to traditional observation tools which had to be deployed and used *in situ,* AIS are connected to global communication networks – the circle of persons who can gain access to personal data or surveillance systems is considerably larger.

Moreover, people have to learn that personal data can be gathered not only when using a computer system but also by "calm" ubiquitous computing devices (sensors and effectors) blended into our everyday environment. The Microsoft patent application for "Monitoring Group Activities" [Ma+07] can be taken as a recent example for the new quality of surveying AIS: A system is envisioned which employs *"one or more physiological or environmental sensors to detect at least one of heart rate, galvanic skin response, EMG, brain signals, respiration rate, body temperature, movement, facial movements, facial expressions, and blood pressure"* in real-time and stores these data for profiling [Ma+07].

The notion of sensors embedded into our surrounding environment combined with the agenda of *calm technology* raises questions about *senders* and *receivers* [MRH07] in AIS. Will the individual be better informed about his environment by AIS or will others be better informed about the individual? A crucial factor for answering this question lies in AIS design: Do AIS allow users control over their data? Can the surveyed individual control whether an AIS is allowed to process, store or transmit data about him/her?

The concept of AIS also gives new substance to the vision of a *Panopticum* which was updated and transferred to the area of modern IS by Rheingold [Rh93]. In the classical Panopticum one single warden has the total surveillance capabilities over all inmates of a prison while the latter cannot see whether they are currently observed or not. A key idea behind this concept is that the personal presence of the warden is even unnecessary: The

mere knowledge on potential observation is sufficient to influence the inmates' behaviour. Rheingold calls to attention that a Panopticum-like installation on internet basis is a real possibility. With upcoming AIS, this risk is even increased. Now, users cannot only be observed while being engaged in "online activities" but also through their everyday environment by hidden and calmly operating ambient technology. In its end, this holds the risk that people may be forced to censor themselves constantly without any real chance for private area.

6 Conclusions and outlook

In the previous sections, we have taken a look at the new and rising trend of so called *ubiquitous* or *ambient technology* reflected in terms like Ubiquitous Computing, Ambient Intelligence (AmI), Internet of Things, etc.

So far, the term *Ambient Information System* (AIS) is mostly used without clear definition or with a disproportional strong emphasis on the system's user interface (e.g. AIS = Ambient Display, cf. [To+07]). This seems to be justified by the observation that studies concerned with *ambient technology* – in difference to *ubiquitous technology* – are user-centred and the user interface is the most visible part of an information system to its users. However, we propose a more general approach to AIS definition extending the FRISCO definition for Information Systems (IS) by additional features like *mobility*, *pervasiveness* and *adaptability*.

Besides their obvious benefits (e.g. in offering more comfort or health and safety, cf. [KBB07]), AIS imply new risks as well as elevating old risks. In high risk environments, e.g. in case of pilots and astronauts, the regular monitoring of medical data is already practised. But despite its apparent usefulness, this kind of round-the-clock surveillance affects human privacy profoundly and may raise impulsive resistance. For example, the Apollo 13 commander James Lovell is said to have uttered a sentence to the effect of: *"I am sick and tired of the entire western world knowing how my kidneys are functioning!"* followed by ripping of his medical sensors [IM07].

We discussed some problems known from IS that may become even more urgent if disregarded in AIS design. For example, "truthful" interpretation of data is established during IS design and ensured by diligent IS – guaranteeing that the data conveys the information that it is supposed to represent. For data which are used outside their original system, this information-data cycle might be broken – running the risk of unintended or intended misinterpretation. This seemingly subtle problem may become more pressing since AIS have a more fragmented and distributed character than classical IS. It is still open to which degree the problem may be mitigated by using meta-data and formal ontologies that describe data in a fashion suitable for machine processing.

Another series of problems results from the fact that IS do not operate with "real world objects" but have to rely on – inherently reduced – data representations. For naïve observers, new RFID-based technologies seem to open a new quality of accessing the (material) world – advertised by slogans like *Internet of Things*. The left hand "referent" corner of the semiotic triangle (cf. fig. 2) always was impenetrable and could be "approached" only by imperfect and contestable perception – now it seems to be directly

accessible by a simple technical trick, the RFID tag. In fact tagging may make an object machine-identifiable – i.e. tangible by sensors and effectors – but also the tag can, at its best, only store a finite set of data that represent some reduced selection of object features. Thus any processing is limited to this – still incomplete – digitalised representation. Even identification itself may pose many problems e.g. concerning the boundaries of objects. What happens if the tagged object is disassembled into parts or broken into pieces – or, in general, if the physical object is modified without the attached tag or chip "sensing" it? For a more detailed discussion cf. [He08].

The notion of *intelligence* takes AIS a step further, as for example in the vision of AmI: Not only is the technology "ambient", but also it is supposed to interact with users intelligently or better yet, proactively i.e. to pre-emptively guess what the users want – even to the point where the users themselves may not yet know what they want – and satisfy this ascribed "need" [Br05].

Now, we are coming back to our initial question concerning the "new quality". Taking into account all hitherto given points and arguments, the answer has to be ambivalent. On the one hand, the additional dimensions of *mobility*, *pervasiveness* and *adaptability* altogether have not only opened new *quantities* to IS dispersal and use but with their implicit, ubiquitous and mostly hidden functions they create a new *quality* as well. Thus, a quick answer might be "yes".

However, the "new quality" comes not without problems: For example, who will be able to access and use AIS, in terms of resources and knowledge? A problem also known as *digital gap*, not everyone may be able to afford the expensive new technology that allows access to these systems – or possess/gain the knowledge necessary to use available systems. Sophisticated decisions concerning user interfaces as well as other societal factors – e.g. the matter of how much influence and control users will be allowed – have to be considered during design and development of such systems. Additionally, AIS call for much more analysis and design of real-time processing problems, e.g. due to demands of instantaneous context recognition and adaptation.

On the other hand, we are confronted with a number of limitations and problems which are either immanent for any IS or even new and specific for AIS. The most profound of these restrictions concern human autonomy and responsibility. To whatever degree of automation and implicitness IS might be empowered – technical systems cannot free humans from their obligation for responsible action and will fail wherever they cause inexpugnable conflicts with the natural human desiderata for autonomy.

With AIS machine-based *data processing* seems to close in on human *information* processing. But nevertheless, the principal difference in quality between these two categories of processing cannot be transcended. Fundamental philosophical and semiotic problems, as e.g. discussed in section 3, cannot completely be solved by AIS. But the growing pervasion, the comfort offered by AIS – possibly supported by reliance and beliefs of uncritical individuals – might lead to a new quality of our social behaviour and, in consequence, impact our image of man. The prospects on this image are – once more – ambivalent. They reach from *informed*, *inspired* and *liberated* humans profiting from more comfort, physical health and safety to *dependent*, *subdued*, *addicted* creatures who are subject to ubiquitous observation, surveillance and control by eager ad and sales companies, Orwellian police states or just by curious neighbours.

Acknowledgement

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