Digital Aura

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Abstract

Smart space and smart appliances, i.e. wirelessly ad-hoc networked, mobile, autonomous special purpose computing devices, providing largely invisible support and context-aware services have started to populate the real world and our daily lives. In such a world, where literally everything is connected to everything with invisible, wireless data links, we need new styles on how humans and things can interact. We have proposed a "spontaneous interaction" thought model, in which things start to interact once they reach physical proximity to each other: Explained using the metaphor of an "aura", which like a subtle invisible emanation or exhalation radiates from the center of an object into its surrounding, a "digital aura" is built on technologies like Bluetooth radio, RFID or IrDA together with an XML based profile description, such that if an object detects the proximity (e.g. radio signal strength) of another object, it starts exchanging and comparing profile data, and, upon sufficient "similarity" of the two profiles, starts to interact with that object. A "digital aura" depending on the implementation technology, is dense in the center of the object, and thins out towards its surrounding until it is no longer sensible by others. Profiles described as semi-structured data and attached to the object, can be matched by a structural and semantic analysis. Peer-to-peer concepts can then be used to implement applications on top of the digital aura model for spontaneous interaction.

1. Universal interaction

Most recent advances in miniaturized microprocessor-, wireless communication- and versatile sensor-/actuator technologies envision a whole new era of computing, popularly referred to as "pervasive computing" [4]. The continuing trends of embedding information technology like tiny computers, sensors and actuators into everyday objects and spaces like cars, homes, offices, public places, etc. will lead to future daily life situations where people and environments are mediated by various invisible computers, and technology rich objects of everyday use. Due to continuing technological progress, smart environment scenarios appear possible, in which almost any object in our everyday environment will be equipped with embedded processors, wireless communication facilities and embedded software to perform and control a multitude of tasks and functions. Many of these objects will be able to communicate and interact with the

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background infrastructure (e.g. the Internet), but also with each other. More and more autonomous computing devices are being embedded into everyday objects and will deliver services adapted to the person, the time, the place – or most generally: the context – of their use [5]. The nature of computing devices will change to be invisible networked, augmented environments, in which the physical world is sensed and controlled in such a way that it becomes merged with a "digital world" [2][3]. According to D. Norman, computing devices well become more specialized in purpose, and will be designed to serve a well defined set of tasks only. In his work "The invisible computer" [9], Norman claims:

"To me, the primary motivation behind the information appliance is clear: simplicity. Design the tool to fit the task so well that the tool becomes a part of the task, feeling like a natural extension of the person. This is the essence of the information appliance." – and further – "*At the same time, it is important not to lose some of the advantages of the personal computer, such as its ability to combine the output of any arbitrary application into another. To ensure that we keep this power,* ***appliances will need to communicate freely and effortlessly with one another.*** *"*

For developing the "pervasive computer" therefore, simplicity, versatility and pleasurability must be the guiding principles ("*the tool must fit the task*"), while there must be universal communication and sharing – but not only among appliances (or things), but also among things and users, and among users themselves. This work is dedicated to the creation of a universal interaction model, that allows a plethora of future appliances and smart environments to mutually use their services, and combine them spontaneously and in an implicit way.

2. A thought model for spontaneous interaction: The Digital Aura

The vision of pervasive computing tells us that the future landscape of smart appliances and smart spaces will be one in which literally "everything" is connected to "everything", interacting in a collaborative and coordinated way [6]. A whole new class of problems related to the interaction among humans and machines comes along with this prospect, possibly better approached based on new thought models of "interaction", than based on the classical understanding of computing: While Alan Turing's machine model and the abstraction of the von Neumann architecture has been the prevalent thought model in computer science since the 1950s, explain system components in terms of "what they compute", pervasive computing (as a fertile source of research challenges [10]), has at least started to broaden the discourse on principles and methods in distributed systems and the styles of interaction therein. "Interaction models" – expressing how components interact, and how these interactions are coordinated appear to gain more and more importance. This claim for a model able to express "interaction" is by no means new, and many approaches to extend computation beyond "algorithmics" (beyond Turing machines) have been attempted. One such concept is Robin Milner's "Elements of Interaction" [8] originating from the CCS "concurrency" thought model, another one is Peter Wegner's "Interaction Machines", originating from an "interaction" thought model

[11][12]. Recent observations of technological progress supports these thoughts: autonomous, ad-hoc networked, wirelessly communicating and spontaneously interacting computing devices appearing in great number will form a pervasive computing landscape, in which the "physical world" becomes merged with a "digital world". Interfacing these two worlds is the challenge of "interaction" [3].

To this end we propose an interaction thought model that considers presence, physical proximity, locality, spontaneity and implicit communication, that is appropriately explained using the concept of the esoteric "*aura*", i.e. "*a subtle sensory stimulus*" coming from "a*n energy field that is held to emanate from a living being*" [Merriam-Webster 2004]. In esotericism, the aura of a person (or a thing) is *"an oval shaped, etheric, subtle, invisible emanation or exhalation"* that radiates from the body in a spatially limited range, dense and thick in the portion nearest the body, and thins out as distance from the body increases. Implicit interaction is explained to be governed by the *"law of attraction"*, i.e. the aura is said to deliver *"signals of attraction"* to the near surrounding inviting for interaction, or to digress.

Much like Benford and Rodden's spatial focus and nimbus model, where the concept of *focus* describes an observers level of attention, and the concept of *nimbus* describes the observed object's manifestation of observability – such that the observer's awareness of the observed object is then a combination of the observed's nimbus and the observer's focus – we define mutual spontaneous awareness as a result of the physical proximity of the individual *"auras"* of persons or things. A metaphorical "digital aura" can be built on the proximity area of a wireless sensor node, determined from the received radio signal strength (or the signal to noise ratio, SNR), as available from many wireless MAC layers for technologies like Bluetooth, RFID or IrDA. In our approach, a self describing interest profile, encoded in XML, is being attached to each individual object, and exchanged among objects that have approached physical proximity to each other (see Figure 1). A structural and semantic analysis determines the extent of "similarities" among the encoded interests. If "sufficient" mutual similarity in their profiles has been detected by the two nearby objects, interaction is being invoked at the application level (details on the profile description language, PPDL, and the concepts and methods for similarity analysis of semi-structured profile data are beyond the scope of this paper and documented elsewhere). This whole concept of spontaneous interaction based on the metaphor of a "digital aura" has been implemented in the SILICON P2Pcomp software framework [7]. A blend of some of the application scenarios developed in SILICON P2Pcomp are presented in the video, and through the rest of this paper.

Figure 1 The Digital Aura approasch for spontaneous iteraction:
among humans and humans (*left*), humans and things (*center*), and things and things (*right*)

2.1. The Digital Aura identifies matching interest

Surrounding persons within a distance of a few feet all around the body, the digital aura sends "*signals of attraction*" to its vicinity, to find other persons with similar interest, preference, attitude, background or needs. Technically, once the "signals" of one persons digital aura comes across the "signals" of another persons digital aura, a spontaneous, wireless data exchange of the self describing interest profiles is induced, similarity analysis is performed upon those profiles, and eventually the application is triggered accordingly. In the video we present a scenario, where Alice, a student, looks for help with pattern recognition algorithms for her algorithms class. She encodes a request for help in her interest profile, stored on her Bluetooth enabled PDA. As she walks around the university campus (Figure 2 (a)), Bob, a PhD student and expert in algorithms, passes by (Figure 2 (b)). His Bluetooth enabled smart phone recognizes and alerts him Alice's request (Figure 2 (c)). He dials the mobile phone number that has been transferred with Alice's profile to his smart phone (Figure 2 (d)), and the two get in contact.

(a) (b) (c) (d)

Figure 2: Identifiying matching interest en passant

2.2. The Digital Aura picks up information "en passant"

Not only persons, but also everyday objects are eligible for a digital aura. Equipped with local storage and wireless communication technologies, literally every thing can store its interest and preferences and exhale it into the vicinity. In this sequence of the video, a poster equipped with a Bluetooth badge encodes a talk announcement in its profile. If sufficient similarity is found among the keywords of the announcement, and the interest profile of the person passing by, the event is scheduled in the time planner of that persons´ smart phone – again using Bluetooth as a proximity sensor and for wireless data transport (Figure 3, left). Later on, more details about the announced presentation – like the abstract of the talk, or a web link to the home page of the speaker – can be accessed on the mobile phone (Figure 3, center and right). The respective data has been transferred to the smart phone wireless and unobtrusively – during the time while looking at the physical poster, and because the interest profile of the person allowed it to access his calendar tool. Adding a digital aura to boards, signs, posters, panels, and public displays leverages their utility from being passive information displays to active information appliances that deliver information depending on user interest, and user context like time, location, temperature, lighting, noise, user goals, or even mood. The SILICON P2Pcomp digital aura software framework is based on a peer-to-peer communication architecture, and with Bluetooth, GPRS and Wireless LAN data transport facilities also allows to exchange multimedia or streaming media content among smart signs and smart phones, as is also demonstrated in the video.

Figure 3: Information pickup: announcement poster (*left*), back in the office (*center*), calendar tool (*right*)

2.3. The Digital Aura protects your privacy

The spontaneous and implicit exchange of personal profile data raises issues of privacy and the potentials of misuse of this data. The digital aura framework for this purpose offers two basic mechanisms to control the amount of attraction signals sent and received: (i) *active privacy control* prevents you from profile information being propagated in a particular context or situation, whereas (ii) *passive privacy control* delimits the amount of profile information accepted from the environment in that context. As Figure 4 suggests, both active and passive privacy control can be understood as information shields or filters, whose transmissibility automatically adapts with the situation of a person or a thing. These filter transmissibility changes can be triggered by context changes perceived in the digital aura framework via a multitude of sensors (time, location, velocity, acceleration, sound, light, temperature, etc.). So while for example moving to a different place, the active privacy control filter could (without explicit user interaction) open up widely, or shut down completely at a later time of the day.

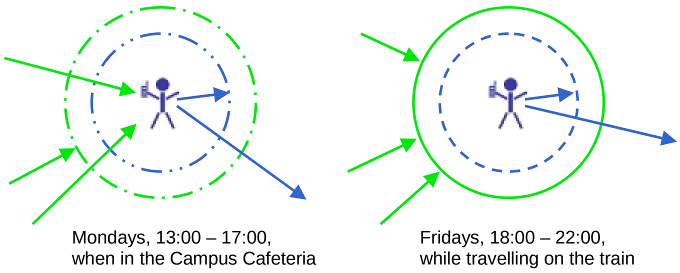

Figure 4: *Active* (inner circle, blue) and *Passive* (outer circle, green) *Privacy Control*

The video presents a scenario where students – Alice, Julie and Petty – meet in the campus cafeteria (see Figure 5). Alice's digital aura in this situation accepts profile information from colleagues attending the same class, and denies accepting profile information that comes from students not in her class (Figure 5, left). Julie's digital aura in this cafeteria situation is very restrictive with her personal information: she does not give away any information about herself, but accepts information from other students nearby (Figure 5, center). Petty, although open for spontaneous interaction in other situations, does not want to be bothered by anyone in the campus cafeteria. The passive privacy control shield blocks any incoming information. She allows some of her preferences be seen by others, but she would not respond to requests in this situations, maybe in others (Figure 5, right).

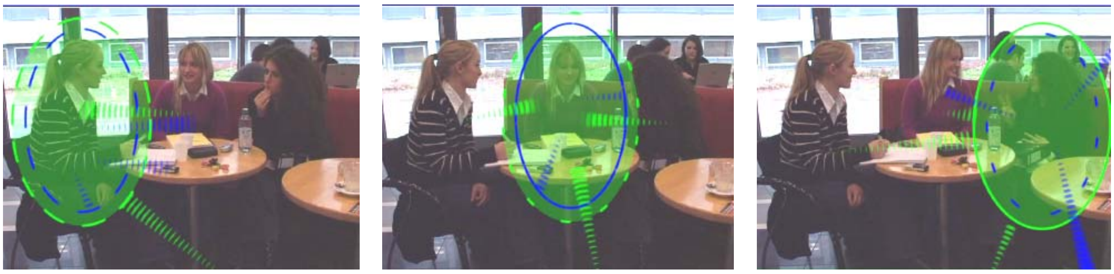

Figure 5: Situative *Active* and *Passive Privacy Control*: Alice (*left*), Julie (*center*) and Petty (*right*)

3. Conclusions

Recent advances in microprocessor-, communication- and sensor-/actuator technologies envision a whole new era of computing, popularly referred to as "pervasive" or "ubiquitous computing". The appearance of computing devices will change to be invisible, networked, reacting spontaneously, and augmenting everyday environments with "hidden" services. To harness such an information technology rich world, in which literally everything is wirelessly connected to everything, the digital aura project proposes a "spontaneous" style of interaction, in which things start to interact once they reach physical proximity to each other. A software framework based on the concept of the digital aura to ease the development of context-aware peer-to-peer applications has been developed [7], and a variety of demonstration scenarios has been built using this framework. A selection of these scenarios has been sketched with this video.

4. References

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