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Abstract
In this paper we present Unified Communications (UC) as a new class of communication systems, marketed by vendors as a means for integrating communication media and creating presence awareness. Designed as complex infrastructures, UC systems enfold their full potential when being customised to a particular social context. In doing so, the technology allows creating context-specific presence signalling solutions. The main contribution of this paper is a conceptualisation of the various design questions relevant in the customisation of UC presence signalling aspects. To this end, we present a seven-step process framework as guidance for implementers of UC infrastructures.

1. Introduction

Unified Communications (UC), as a new and emerging class of systems, is based on the integration of communication media (e.g. Instant Messaging and Voice-over-IP (VoIP) telephony) with presence availability signalling. Being the result of a convergence of the telecommunications and the software market, a range of prominent vendors from both domains are currently entering the market with UC solutions, e.g. Alcatel, Avaya, Cisco, IBM, Nortel, Microsoft, Oracle, or Siemens. UC systems are designed as open infrastructures that allow (and require) customisation and adaptation in context. One claim of UC vendors is to take presence signalling to a new level, e.g. by applying the concept across media classes and by embedding presence signalling in the context of business processes and third party software applications. However, UC is still in its infancy with systems not yet living up to their promises; empirical examples of UC applications in organisations are rare and show that many envisioned features are yet to be implemented. Hence, research at this stage needs to be experimental or conceptual.
In this paper, we explore the complexities of presence signalling in UC systems. We take the standpoint of implementers who want to adapt UC in context and create context-specific ways of presence signalling. Owing to the complexity of UC systems, many design questions can be identified that need to be taken into account. We have structured a range of complexities in a framework. Before we discuss the design and decision areas in the seven phases of our framework, we first motivate our study by briefly reviewing typical communication challenges in contemporary workplaces and by discussing the role of presence signalling in creating awareness in distributed

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contexts. We then introduce UC and its main building blocks, before the main section presents our framework.

2. Presence Awareness in distributed work

2.1. Communication challenges

Work practices in organisations have been undergoing significant changes over the past years, which led to new virtual forms of organising and increased distributed collaboration [6,22,25,30]. At the same time, this development is driven by the emergence of new communication technologies and devices, which on one hand drive organisational decentralization [26] and on the other hand enable people to work across a variety of boundaries [38].
At the same time, new communication channels (e.g. Voice-over-IP telephony, Instant Messaging) have mushroomed, which led to a heterogeneous accumulation of technologies that are available to the average user [21]. Many people today do not just possess one phone number or IM account, but rather they use several channels to communicate with their peers [e.g. 34]. This escalating variety of channels and devices, as well as the ever increasing messaging activity [13] increase drastically the communicative complexity for both initiator and recipient of a communication request. For initiators situations are characterised by a high uncertainty as they have to think about the recipient's context, the appropriate channel or device, and the relevant contact details in terms of accounts and phone numbers [16]. Also, availability of others in distributed contexts is often a serious problem. For recipients the situation creates interruptions and disturbances as asymmetries of interaction become more likely in distributed contexts [15,36]. People are potentially confronted with a level of interaction that might exceed their personal preferences causing interaction overload.

2.2. Awareness of presence availability

A main shortcoming in the above-described situation is a general lack of awareness of other people's location, context, activities, and availability for communication. In traditional workplaces awareness is generally taken for granted and therefore seldom discussed at all [9,27]. Awareness is "an understanding of the activities of others, which provides a context for your own activity" [8, p. 107]. In this paper we are specifically interested in the awareness of other people's presence, i.e. their availability for communication. Without presence awareness, availability of people cannot be easily determined and interruptions though communications requests are more likely. Through ICT people have the means to become available for others. Empirical evidence suggests that technology can be used to facilitate awareness of presence (e.g. location and context) and of presence availability (e.g. availability for communication) and thus mitigate some of the mentioned communication problems [31].

2.3. The role of technology in awareness creation

While it has been argued that awareness can never be a property of technology itself [32], because it results from a learned and skilful action and thus is the result of shared social practices [10,11,35], technologies nevertheless play an important role in enabling and supporting the creation of awareness. ICT has become an integral part of practices of people who use features designed to specifically support awareness creation or appropriate others in ways that makes them useful for doing so. One technology that is marketed with the label of presence awareness attached to it, and which is designed for addressing the above discussed communication issues, is Unified Communications (UC) technologies. UC systems can be interpreted as complex infrastructures,

whose features need to be adapted to and interpreted in social context for them to enfold their full potential [28]. Against this backdrop the main contribution of this paper is to provide a structured overview of design-decisions in the process of customising presence availability signalling features when applying UC in context. Before we present a framework for structuring the steps necessary in the customisation of presence availability signalling, we briefly introduce this new class of systems and give an overview of its features and characteristics.

3. Unified Communications Systems

Being a result of market convergence, UC has its roots in both the telecommunications and the groupware market. Consequently, UC systems, as complex infrastructures, integrate groupware functionality with (IP-based) communications media (computer-based telephony, voice, and video services) with presence technologies and business applications [34,16,3,23].

3.1. UC building blocks

The general idea of UC systems is to help people juggle with their communication requests in the face of interaction overload [24] and to improve people's accessibility by providing presence availability information and by integrating media and devices [13]. As such, UC is the product of the integration of various components and features.
First of all, UC is based on the idea of media integration (unified communications): Devices are registered within the system and users are aided by a communication middleware in their management through a rule-based coordination and filtering system. Typically such systems provide users with a universal phone number, which finds them wherever they wish to be found [13,33]. On the technical level, this media integration is based on IP-technology [33,37].
Moreover, one of the main features of UC lies in the provision of presence information in regards to the availability of the user and his/her media and communication devices (see below). Thirdly, UC systems unfold their strengths when integrated within the context of the user, in particular with organisational processes and third party business applications (e.g. ERP systems). A core idea thus is to circumvent the need to pre-schedule communication and to solve the users' information needs by immediately allowing them to communicate [16].

3.2. Presence signalling in UC systems

The signalling of presence availability is a defining feature of UC, which distinguishes it from traditional synchronous communication technologies. Much like the increasingly popular Instant Messaging (IM) tools, UC systems come with a presence awareness capability [4] or presence management feature [17]. The idea of this presence information is for a user to signal to the initiator of a communication act, independent of a recipient's physical location, the availability for interaction, i.e. the "ability and willingness to communicate" [7, p. 84].
Two characteristics set apart corporate UC systems from simple IM tools: openness and complexity. UC systems are complex infrastructures that on the one hand allow adaptation and customising in context, in order for UC implementers to create context-specific UC solutions that become embedded with the workspaces of corporate users. On the other hand, UC infrastructures bring in a range of means to design complex presence availability signalling mechanisms. While UC systems are seen by many vendors as a solution to the above portrayed problems, we argue that UC, as open, flexible infrastructures, require adaptation and a certain degree of customising in context in order to live up to their promises. In the following, we present ways in which UC infrastructures can be adapted by moulding their features in the process of implementing the technology.

4. Framework for customising UC presence signalling

The main contribution of this paper is a structured overview of design decisions likely to be encountered by those who want to customise or adapt to an organisational context the presence signalling aspects of UC infrastructures. In doing so however, we will not delve into the richness of signalling practices that are likely to emerge in context as the result of tool appropriation by users, for a related study see [29,31]. We approach our exploration of signalling design questions from the perspective of implementers and introduce a process framework, which presents design areas that, as we argue, should be considered during the process of adapting UC infrastructures to a specific organisational context (see table 1). The process begins with more technical or systems design considerations and then moves gradually to the more social/contextual design decisions.

Step	Description	Design question
1	Generating presence availability information	How are user states determined?
2	Defining the status types	What are the status categories (states) available to users?
3	Presenting the signals	How are signals conveyed/visualized within use context?
4	Enriching the availability status information	How can the availability status be complemented?
5	Embedding in context	What objects will the status signals be attached to?
6	Differentiating for different recipients	Who is allowed to see what kind of status?
7	Supporting UC adoption in context	How can users be supported in adopting signalling?

Table 1: Process steps of our presence signalling framework

4.1. Step 1: Generating presence information

In a first step, UC implementers have to decide on how the presence availability information is generated, i.e. is it automatically determined by the UC system, e.g. by using device states, or is it based on explicit user entries? In its most simple form, the presence status is derived from the user being logged on to the system [2]. As such, the status merely signals whether the user's computer system is currently online or offline [5]. In addition, in UC systems presence information can originate from all devices a user possesses [14]. Since every communication device needs to be registered with the UC system, information of the current technical availability of all user devices exists (e.g. IM, cell phone, landline/IP phones). This information can by used as a proxy for user availability. However, the availability of devices serves only as a fairly inaccurate proxy. Consequently, one important factor in applying availability signalling is exploring and determining ways in which more accurate information can be (automatically) gathered by the system in a given context [39].
A further source is monitoring and interpreting user activities within the context of the UC system. Being based on IP-technology the system can derive the technical states of phones and hence deduce current user activity. Moreover, the system might be able to recognize from which device a user is logged on to the system thus conveying that a user is currently travelling (e.g. when being logged in from a PDA device) [20]. Also, various other sensors (e.g. Smart cards) can be used to track user activity and infer user availability (e.g. the user entering a meeting room). Finally, the availability states can be explicitly selected by the user from a set of standard states [12].

4.2. Step 2: Defining presence states

Having introduced several ways to determine and automatically infer user availability states, the next decision area is defining the actual range of states available for signalling. Typical IM and UC systems usually come with a range of around seven different states (see figure 1 for an example).

Figure 1: Presence states in Skype™ and Microsoft Live Messenger™.

While all UC systems come with a range of predefined states, most systems provide means to override the default states in order to establish a custom-made (context-specific) way of signalling. In doing so, we propose that presence states be selected according to the following quality criteria: completeness, semantic clarity, mutual exclusiveness, and simplicity.

The range of available states should be complete in a sense that for every situation one state exists that signals best the user's availability in this situation to the user's peers. This does not mean that UC systems should provide a long list of different states for every possible situation, because this is in conflict with the requirement of simplicity. We reason that only a short and comprehensive list of signals can be grasped easily by the average user and thus be incorporated in their daily work practices. For doing so, the list of states also needs to be semantically clear; the user should be able to immediately understand what a status means and when to use it. It should also be unambiguous in a sense that consensus on when/how to use a certain state is easily (intuitively and naturally) be achieved within the relevant peer group. For example, in the Live Messenger™ example (figure 1) it is not immediately clear how the states 'be right back', 'away' and 'out to lunch' (Live Messenger) should be interpreted in terms of the time span the user is likely to be unavailable. Also, states such as 'away' and 'out to lunch' are not mutually exclusive – a user who is out to lunch is also 'away'. In order to make both signalling and the interpretation of signals easier and clearer, the users should know exactly what state to choose in a given situation. And in order to achieve a main goal of UC – improving availability for communication – it is necessary for users to be able to infer from a presence status the time span for which a user is likely to be unavailable.

A trade-off exists between the granularity (or specificity) of states and its average correctness in context. For example, in an extreme form the system might allow users to specify (e.g. in minutes) the exact time s/he is likely to be unavailable. The complexity and interconnectedness of a typical office or work setting however renders impossible the prediction of such exact time spans. The likely consequence is that most signals in context would be incorrect and thus perceived as unreliable, with possible negative ramifications for system adoption. Hence, we reason that the more specific the range of states is in terms of time, the more likely it is to signal incorrectly. Consequently, the actual range of states should convey a sense of time span for unavailability but in a more general sense.

4.3. Step 3: Presenting the signals

The next step is designing the ways in which the states are conveyed to users within the workplace context. Several ways exist in which signals can be presented to the user: states can be visualized using iconographic designs and/or colour [12], sound might be used to convey certain status changes. In IM tools the colour green seems to be the dominant choice to convey availability, while red signals unavailability. This colouring obviously relates back to traffic light colours; using such a colour code for signalling has the advantage that it is inter-culturally unambiguous. Again, it would be preferable to have signals (icons/colour dots) that are easily understandable and self-explanatory in order to reduce cognitive burden for the user and allow for a seamless adoption process. Drawing on well-established colour codes and metaphors/icons serves as a good rule of thumb in this decision area.
In addition to visualizing the different states, the changes between states can also be signalled using visual or sound signals. For example, some IM tools indicate with small pop-up windows (or a sound) whenever a contact in the user's buddy list becomes available (i.e. logs on to their computer). However, in many contexts this might cause too many unwanted interruptions for the average user; it might thus be offered as an additional feature used to be notified when one is waiting for another user to become available.

4.4. Step 4: Enriching states with context information

Up to now, we have introduced design areas concerned with determining, defining and presenting user availability states in a way that is, in its most simple form, well-known from IM tools. However, the idea of providing as presence information one status for every user (e.g. 'away'), is rather limiting in terms of estimating the time-span for the user to become available again. Hence, we can complement the availability status with other information, which can be made available within UC systems.
Ageing information can be used to determine the age of a current signal. For example, when a user signals 'be right back', other users expect her/him to become available within a reasonably short time-span. However, they do not know how old the signal is. By adding ageing information, which reveals the time since the status was changed, users are able to better assess the actual availability.
Another way to improve status interpretation is to provide access to (selected) calendar entries. When a user signals 'away' and her/his calendar entry for this time shows that s/he is in a meeting, others can much better anticipate future availability than without the additional calendar information.
A different kind of context information is location data. Location data provides users with awareness of users' whereabouts, which also aids in assessing user availability. Researchers have demonstrated ways to infer and convey location information in office settings [19]. In flexible office settings that allow people who are travelling frequently (e.g. sales people,) to book a desk for a day (so called non-territorial office, hotelling or desk-sharing concept) [18,1], the UC system can signal to other users the actual desk the user is working at in order to make it easier to arrange for ad-hoc meetings.
A simple yet effective way to provide additional information about one's availability is a short text message, a so-called presence messages [40]. Users can type in a short message that is then listed alongside the presence availability status explaining absence and future availability.
Finally, in addition to the user presence status, which signals general availability of the user, UC infrastructures allow inferring and presenting separate availability states for the different devices or media channels available to contact a user. For example, designers might decide to provide availability data on the device level, i.e. data on whether the mobile phone is currently booked in to the system, or whether the IP phone is currently online or engaged.

4.5. Step 5: Embedding of signalling in context

So far, we have discussed signalling on the user level (and in relation to his/her devices). In a next step, these user availability states can be embedded within the group and business process context. For example, user states can be aggregated on the group level in order to provide a sense of group availability; i.e. a maximum status shows 'available' when all group members are available within the sphere of the UC system, e.g. to initiate a conference call. The minimum status shows 'available', when at least one of the group members is available. This status can be used when the user "would like to talk with someone with similar interest or expertise but don't care who the specific individual is" [2, 12].
Presence states can also be attached to and be aggregated on the level of almost any object available in the electronic workspace of users, i.e. wherever objects have ownership or are otherwise related to people and can thus inherit their presence states. For example, in a hospital scenario, presence information of authors of laboratory files or patients records can indicate their accessibility for urgent call-backs by the doctor on duty. Through aggregation on the file level, the doctor might be able, in case of an emergency, to get in immediate contact with specialists, who can give background information related to the particular file or to otherwise consult with these colleagues.

4.6. Step 6: Differentiate states for various recipients

So far, we have mainly taken the perspective of the initiator who wants to determine people's availability (or the time of non-availability). We have asked questions in regards to what kinds of presence information might be needed in a particular context, where to gather this information, how and where in the work context this information might be presented. Now, we will turn to the perspective of the one who is signalling availability.
The first question in this area is to determine whether signals should have global validity or whether people should be able to restrict certain signalling to (sub)groups. When signalling, people sometimes need to convey certain information (e.g. with regards to location or tasks) to some people within their peer group, but not to others. Also, people, in some situations, might want to be available for some group members, while at the same time signal unavailability towards the rest. Hence, UC implementers need to explore, if such a differentiated signalling is needed in a particular context and how to implement it.
A solution seems to be a concept, in which the user defines different groups for which he/she can (but needs not to) signal different states of availability. Such a group concept might be modelled as user circles with the inner circle having access both to the most accurate information and to more context information (see step 4). An outer circle then only sees a basic presence status, which, if required, can be set to signal unavailability to temporarily reduce communication load, e.g. in tight project situations.

4.7. Step 7: Support adoption of signalling in context

This last step in our framework again takes the perspective of the user who actively signals availability. In many situations the user has to actively change the states in the UC system in order to truly reflect current availability. We acknowledge that signalling can be cumbersome and that users might neither be able nor willing to change significantly the way they work in order to incorporate signalling in their routines. Hence, UC implementers need to explore ways in which the user can be supported by the system and in which the changing of states can be attached to existing user routines without the user having to pay explicit attention to the changing of the status

(piggyback routines). In the literature authors have argued for a need to support signalling "in a way that uses human capability to peripherally process non-attended aspects." [39, 298]
One such way is using sensing devices. Siemens AG for example, as part of their research on the use of their Openscape UC system, have developed a prototype extension which allows the user status to be changed on the basis of a Bluetooth connection between user computer and the user's cell phone. Users who carry a Bluetooth-capable mobile phone can activate the service and link it with their computer; the UC extension then monitors this connection and changes the availability status to signal '(temporal) unavailability' whenever the user leaves the vicinity of the computer. Another technology again uses the cell phone; it piggybacks with the user routine of muting the ring tone whenever entering a meeting. A service can send a short message (SMS) to the UC server initiating the corresponding status change.

5. Conclusion and outlook

Despite a boom of new communication services and devices individual and organisational communication problems have increased with the number of communication partners across projects and time zones and with a steep increase in computer-mediated communication encounters. The industry appears to respond to this situation with more devices, more services, and even more features ('more of the same'). UC systems are a manifestation of this trend.
However, extending communication options (i.e. by integrating media and combining it with presence signalling) in itself does not automatically solve communication problems. Rather, these infrastructure technologies need to be adapted and interpreted in a concrete social context.
Our framework is meant to elaborate on design parameters likely to be encountered by UC implementers when confronted with the task of applying UC to a specific organisational setting. We have presented a structured overview of the various complexities encountered by those who customise UC presence signalling aspects in context. In doing so, we have discussed in detail seven design and decision areas, which describe the complexities of presence signalling in UC systems when implemented in a social context. While our framework can be used by UC implementers as an overview and a first guide to approaching the customisation and embedding of an UC system in context, at the same time the framework points to the need to carry out empirical studies to better understand signalling and its implications on people and their work practices, i.e. once actual UC implementations become available in organisations.
The framework has been the result of mainly conceptual work, but it is grounded in a series of design and case studies as well as workshops with representatives of UC vendors and designers. Nevertheless, it represents only a first step and a starting point in exploring the richness and challenges of UC as a technology when being applied in organisations.

6. References

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