Awareness for Fostering Serendipitous Interaction in Public Intelligent Environments

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Abstract. This paper presents possibilities offered by public intelligent environment to foster learning through serendipitous interaction among uncoupled users. Four possible situations of how serendipitous interaction may occur and lead to learning activities are presented. In these situations capturing the right information, modeling it and providing awareness information back to the users plays a major role. Therefore elements that make up this awareness information are presented and a model for fostering serendipitous interaction in public intelligent environments is also proposed.

Keywords. Serendipitous interaction, collaborative learning, intelligent environments, awareness in public spaces

Introduction

Public spaces, defined by Eriksson et al. [1] as “place open to all, free of charge”, offer multiple opportunities for interaction and occasions for situated learning. The notion of situated learning has been introduced by Lave and Wenger [2] and describes learning as the outcome of interaction with the social and physical environment.

In recent years, a growing interest, starting from mobile and ubiquitous learning [3], has moved focus from more formal learning in the classroom, with pre-defined goals and planned activities, towards more emergent and student-led activities outside the classroom [4,5]. This situation is particularly advantageous when promoting contextualized learning experiences through exploration (e.g. by experiencing things at hand in real and authentic settings), interaction (e.g. with more experienced peers and experts in the field), and serendipity (e.g. when “human search for knowledge may occur by chance, or as by-product of the main task” [6] in unplanned, random and unexpected ways) [7].

Intelligent environments (hereof referred to as IE) offer the possibility to take advantage of the resources and people available in a space. IE can sense its inhabitants and the activities going on there and adapt to them to provide “services based upon user preferences and current environmental conditions” [8]. In this perspective, public IE can provide a dynamic configuration of devices, but also support dynamic social configurations, e.g. based on users’ interests or co-location.

In this paper the possibilities offered by IEs to support learning in unplanned, emergent situations are presented. In particular the focus is on how to foster learning
through serendipitous interaction in IEs, i.e. the ability of IEs to trigger unplanned interaction among uncoupled users (i.e. chance encounters that might not know each other). Uncoupled users will be able to get together and start collaborating thanks to awareness information provided by the IEs. Awareness has always been a central issue when supporting cooperation and collaboration, both in working [9-11] as in learning [12,13] and in other social settings [14]. Awareness plays a more relevant role when the environment is highly dynamic and unpredictable [10], like in public IEs.

Many research efforts have focused on providing awareness for serendipitous interaction within established groups of workers, friends, etc. [15,16] focusing on pre-existing social bonds rather than on interaction between uncoupled users. A few other examples aim in this direction. The systems proposed in [17] promote interaction among people that do not necessarily know each other. These systems are running on mobile phones and take advantage only of the social proximity of people. The space and the resources that may be available there are not taken into consideration. On the other hand, Ludvigsen [18] proposed a conceptual framework for interaction in “social spaces” (more details in Session 1) and the iFloor system. This system aimed at connecting library users and trigger discussions as well as introducing new ways of finding materials in the library. This system was based on interactivity, users could post and read questions from other users, and browse them using a shared cursor operated through the physical position of users. Here the users were playing a more active role taking the initiative, rather than the system itself. The goal of this paper is to show how IEs can also play an active role by sensing the social and physical context and providing awareness information to promote serendipitous interactions among users. In Section 1 possible configurations for fostering learning through serendipitous interaction in public IEs are presented. The information IEs have to capture to promote serendipitous interaction is presented in Section 2; while a model for the awareness system of such IEs is proposed in Section 3. The paper is concluded in Section 4.

1. Learning through Serendipitous Interaction

In this paper, the focus is on the possibilities offered by public IE to support learning through serendipitous interaction by providing awareness information to its inhabitants. The conceptual framework proposed by Ludvigsen [18] for social interaction can represent a starting point to understand how interaction among uncoupled users can be fostered. This framework is structured along four levels of engagement as the author explained: 1) distributed attention: “people are merely present in the same space” either physical or virtual. They have different focuses and the interaction is very low; 2) shared focus: when a single focus is shared among its participants. Broadcast entertainment with many people following a football game is an example; 3) dialogue: “participants are engaging in a shared activity in which they are investing themselves and their opinions”; 4) collective action: “when participants are working collaboratively towards a shared goal” [18].

In an environment characterized by ‘distributed attention’, users are simply co-located; they are uncoupled users or strangers. In these situations, collaboration might be hard to achieve. Thanks to awareness information provided by the IEs uncoupled users might be able to develop a ‘shared focus’ that can lead to collaboration through ‘dialogue’ and ‘collective actions’. The IE will have to provide awareness information, tools and services to support and promote these engagement processes. During these
processes strangers might get engaged in interaction and become part of a group (an ensemble of people engaged in the interaction). Participants of a group are then no longer considered as strangers but rather as engaged individuals. Individuals need to be kept aware of what is going on in the group they are in, but also about other groups that already exist and that they may join.

Two dimensions and four possible configurations have been identified in situations where serendipitous interaction can be triggered. The first dimension is represented by the fact that interaction can be based on an activity or around a shared learning object (LO). Second, users can interact with physical co-located people in the same IE, but also with distributed peers in an extended IE. The term extended IE is used in this paper to refer to different IEs which are interconnected to allow cooperation.

1.1. Activity-based Serendipitous Interaction: Co-located vs. Distributed

Activity-based serendipitous interaction is triggered by an IE or by an extended IE that promote engagement in an activity. Users getting engaged could require a tighter collaboration and synchronous communication to coordinate work [19].

An example of co-located activity-based interaction (Figure 1a) could be represented by strangers visiting an IE museum (distributed attention). They are notified of the possibility to engage in a collaborative game (shared focus) that will allow them to explore the surrounding while interacting with others (dialogue). They form a group to complete the collaborative game (collective action) playing against the system or other groups.

Interaction can be triggered also when users are distributed (Figure 1b) in an extended IE. E.g., two learners (distributed attention) can start collaborating while visiting two different IE museums after they have been notified of the possibility for engaging in an activity together (shared focus). Based on information available in the IEs they can solve a series of questions that leads them to a treasure (collective action).

1.2. LO-based Serendipitous Interaction: Co-located vs. Distributed

This kind of interaction is triggered by IEs when people get engaged in interaction around a shared LO that could require more loosely coupled collaboration, where

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1 The Learning Technology Standards Committee defines a learning object as "any entity, digital or non-digital, that may be used for learning, education or training" (http://ieeeltsc.org).
learners are more autonomous and weakly interdependent, and communication more likely to be asynchronous [20].

An example of co-located LO-based interaction (Figure 2a) can be represented by a user visiting a museum (distributed attention) and receiving a message about the presence of an audio file that augments an exhibit object. He accesses the file and makes extensions to it. The environment notifies other co-located users interested in the same object (shared focus among strangers), they gather around the LO forming a group, discussing about the LO (dialogue through face-to-face or asynchronous communication services offered by the IE), interacting and contributing to enhance the audio file together (collective action).

Figure 2. LO-based serendipitous interaction a) co-located and b) distributed.

In case users are distributed (shared focus), the interaction can be triggered by an extended IE by the use of an object reproduced in different sites (e.g. copies of an exhibit in different museums many people can interact with), also at different time. They all have knowledge of or a particular interest in it (shared focus). People may be interested in interacting with other peers that know more about it, like experts. Their interaction (dialogue) can lead to a tighter collaboration to achieve a common goal together (collective action), Figure 2b.

2. Awareness for Serendipitous Interaction: What Information?

To start building up a model for awareness system of IEs that aim at fostering serendipitous interaction, the framework for workspace awareness proposed by Gutwin and Greenberg [11] has been used as starting point. The focus in this paper is on the first part of the framework that specifies the information that makes up awareness [11]. This framework focuses on workspace awareness and is intended for supporting a pre-defined group of workers engaged on a specific task in a given workspace. In this paper, the focus is on emerging groups of uncoupled users that do not necessarily share any previous social bonds.

The aim of the present work is to identify the information that the designers will have to capture and distribute or what information makes up awareness for serendipitous interaction in public IEs. The elements of such information answer questions like “who” can the users interact with, “what” are they doing, “where” are they, “when” did something happen, and “how” did that occur, as suggested in [11]. This are the kinds of information people may find useful to start interacting with others, but also the information designers have to consider for fostering interaction. In Table 1
and 2 the basic elements of awareness and their related questions are listed following the “who, what, where, when and how” categorization as in [11]. The difference are highlighted in italics. Table 1 contains elements of awareness related to present situations.

Table 1. Elements of awareness related to the present as modified from [11]

<table>
<thead>
<tr>
<th>Category</th>
<th>Element</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who</td>
<td>Presence</td>
<td>Is anyone in the IE?</td>
</tr>
<tr>
<td></td>
<td>Identity</td>
<td>Who is that?</td>
</tr>
<tr>
<td></td>
<td>User type and</td>
<td>Are they strangers or are they engaged individuals? If any groups, which ones they participate to?</td>
</tr>
<tr>
<td></td>
<td>participation</td>
<td></td>
</tr>
<tr>
<td>What</td>
<td>Action</td>
<td>Who is doing that?</td>
</tr>
<tr>
<td></td>
<td>Intention/Activity</td>
<td>What goal is that action part of?</td>
</tr>
<tr>
<td></td>
<td>Artifact/LO</td>
<td>What object are they interacting with?</td>
</tr>
<tr>
<td></td>
<td>Device</td>
<td>What devices are they carrying?</td>
</tr>
<tr>
<td>Where</td>
<td>Location</td>
<td>Where are they?</td>
</tr>
<tr>
<td></td>
<td>Distribution</td>
<td>Are they co-located or distributed?</td>
</tr>
</tbody>
</table>

Table 2, instead, presents those elements regarding the past since history has always played a major role in interaction as highlighted in [21-23]. In the next section it is clarified how this information can be captured and modeled by IEs to finally be able to provide awareness information and foster serendipitous interaction.

Table 2. Elements of awareness related to the past as modified from [11]

<table>
<thead>
<tr>
<th>Category</th>
<th>Element</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>How</td>
<td>Action history</td>
<td>How did that operation happen?</td>
</tr>
<tr>
<td></td>
<td>Artifact history</td>
<td>How did this artifact come to be in this state?</td>
</tr>
<tr>
<td>When</td>
<td>Event history</td>
<td>When did that event happen?</td>
</tr>
<tr>
<td></td>
<td>Presence history</td>
<td>Who was here, and when?</td>
</tr>
<tr>
<td></td>
<td>User type history</td>
<td>What changes happened to user type?</td>
</tr>
<tr>
<td>Where</td>
<td>Location history</td>
<td>Where has a person been?</td>
</tr>
<tr>
<td></td>
<td>Distribution</td>
<td>What has a person been doing?</td>
</tr>
</tbody>
</table>

3. How IE Uses Awareness Information

In order to support and foster learning through serendipitous interaction, the IE has to: 1) capture information from the environment (Section 2); 2) model this information based on model of social structures and collaboration; and 3) provide awareness information to its inhabitants. In Figure 3 a model for an IE awareness system is presented. Each of the above functions identifies a level of the system. These levels and the way they are interrelated is presented here.

In the capture level information will be collected in many different ways. For instance presence information can be detected through motion sensors; identity information through devices carried by users, or in spaces like museums users might carry audible devices equipped with RFID tags; and so on and so forth.

In the model level, based on the data and history captured the IE can structure this information to identify affinities and common interests among users. Based on this and on the information on repositories, the IE can suggest opportunities for interaction (activity-based or LO-based) and support appropriate collaboration models. For instance, if the serendipitous interaction is articulated around an activity (Sections 1.1), the IE should support social structures configurations that provide tighter collaboration.
Interaction and action history information (Table 2) will play a major role in these scenarios. The user engaged in this interaction will need to know about what others are doing and what they still need to do to achieve the goal of their activity. On the other side, if the interaction is based around a LO (Sections 1.2), the collaboration to be supported should be more loose and asynchronous. In this case artifact and interaction history (Table 2) will be more important to keep track of how the object has been modified and who has interacted with it.

In the provision level, once the IE awareness system has gathered the information and identified the possibilities of interaction for its users, it still has to provide the right awareness information with the most appropriate modalities. Considering the public nature of the space, the system should take into account the fact that this space is open to everyone and quite dynamic. In such settings privacy represents a critical aspect. For instance, when dealing with strangers the system will provide more provocative awareness information [24] and use abstract representations as presence indicators, removing part of the data from the original signal [22]. These should simplify issues related to privacy, but create difficulties of interpretation or immediateness of the reading of these representations, especially for unfamiliar users.

Figure 3. Model of the IE awareness system.

Moreover, how the system provide awareness information to the users should consider, among other things, the social context the users are immerged into, the tasks they are engaged in or that are available there and the devices one can access and their configuration. For instance, the IE should provide indication on high activity in a space or around an object, e.g. through visual cues with a brighter display or vivid color changing more frequently with increased activity.

In other cases the awareness information might be more direct, e.g. with individuals and groups already engaged in interaction. In this case the system will have to provide more specific awareness information related to: 1) people connected to spaces; 2) people connected to LO; 3) groups and learning activities, and in particular their status and participants.

Information about people connected to spaces is particularly important in case of co-located or activity-based interaction. For instance, the IE could display the presence of others or the interest of users about that space by showing bubbles on a display [25]. More glowing bubbles would represent bigger interest about that space, while larger
bubbles would represent people proximity\textsuperscript{2}. In this way a small glowing bubble will represent a person far away that is particularly interested in what is going on there.

Information about people connected to LO is of course more important for LO-based interaction. Also in this case people connection to an object could be represented with bubbles, like in the example above, and displayed in the artifact tag where users can already find information about artist, year, etc.

Information about learning activities will be more relevant for those engaged in activity-based interaction, however also those involved in more loosely coupled interaction like in LO-based activity could benefit from it. Information about the status or progress of an activity could be displayed on the interfaces used by individuals and groups during interaction. Simple forms like a progress bar could represent this information based on the actions performed by individuals or sub-task accomplished by the group. Information about other participants should also be available. The group might want to know who is active in that moment and the IE might display passive/inactive users with opaque user representations.

The IE should give the possibility to interested visitors to register for a service of notification on modifications that happen in the IE, like feed services for LO, spaces and activities. Moreover, when activities will be initiated, the IE has to facilitate them, providing services and resources for supporting coordination and communication (e.g. IM, chat, forum, etc.). The spaces chosen to foster interaction should consider rules of conduct that are valid in the public IE, e.g. supporting discussion through virtual spaces or context-aware chat room [26] when strangers are present; and when face-to-face interaction is necessary suggesting spaces like library cafés rather than reading rooms.

4. Conclusion

The possibilities for contextual learning in public places are enhanced by people, resources and technologies available there. In this paper the focus was on public IEs that can foster learning through serendipitous interaction. This can be achieved by providing awareness information and support to interaction.

Designers of such IEs needs to be aware of what kind of scenarios they will have to face and what kind of information they need to gather. In order to get a better understanding of such situations four possible configurations for learning through serendipitous interaction in public IEs were presented; the information needed to be captured were proposed together with a model for how IEs can elaborate this information to provide awareness to their inhabitants and trigger interaction among them.

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\textsuperscript{2} Redström et al. [23] raised an interesting issue regarding proximity in space vs. proximity in place. Proximity should not only be considered in terms of physical distance, but also incorporates the social context.
References