Learning at your Leisure: Modelling Mobile Collaborative Learners

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Abstract. Advances in ubiquitious and mobile technologies have facilitated learners to continue their learning outside their classrooms, when and where they desire. Learners are now able to access their learning resources and interact with their peers and teachers through technology. The design and creation of such learning spaces pose many challenges. The learner's context defines the needs of the learner at any time. To meet the needs of the learner, a set of services must be available anytime and anywhere. To establish the learner's context, a model of the learner is essential. This paper focuses on modelling the learner and proposes the use of stereotype modelling to determine the context of the learner and to propose a set of services to the learner to support her learning process. A scenario describes a mobile collaborative learner and the modelling concepts are described using an example.

1 Introduction

Advances in ubiquitious and mobile technologies have facilitated learners to continue their learning outside their classrooms, when and where they desire. Recent research has shown that learners desire to continue their learning processes outside of their classrooms and combine learning with leisure [1] or learn spontaneously, in response to recent, current or imminent situations, but without any time being set aside for it [2]. The term mobile learning has become popular in recent times to denote learning that is conducted while the learner is on the go or when the learner is mobile. Many authors refer to mobile learning as supporting learning via mobile devices such as handheld PDAs or mobile phones, where access to learning material is provided via the mobile device. We consider mobile learning as the learning that takes place or the learning support that is provided to a learner when the learner is mobile, independent of the technology. Mobility is often considered in terms of time and physical space or location [3]. Hence, when the learner is outside the classroom and classroom hours, the learner is mobile and needs access to the learning resources such as books and literature. Similarly, access to people that support the learning process is very important.

They could be the teacher, peer learners as well as any other people that could support the learning process.

Providing access to learning resources and facilitating interaction among learners is an important support for the learning process. To be able to provide such support anytime and anywhere, we envisage the learners' environment being capable of extending this support using technology. Several university campuses have embarked on providing easy access to learning resources for its students by creating wireless hotspots around the campus. Several cities in Europe have launched projects to transform the city into a wireless zone, facilitating easy access to resources and people. The city of Trondheim's Wireless Trondheim initiative is one such project[1]. There is a trend towards ambient intelligence and intelligent environments.

The IST Advisory Group in European Union (ISTAG) defines ambient intelligence as human beings surrounded by intelligent artefacts, supported by computing and network technology embedded in everyday objects. More importantly, the environment should be aware of the presence of a person, perceive the needs of this person and respond intelligently to them in a relaxed an unobtrusive manner [4]. To respond to the needs of the user, there is a need for a user model.

When using systems that require user models to adapt its services some considerations as to the nature of these models and the domain in question must be made. In domains where the user group is highly homogeneous canonical user models are likely to be the best option, whereas in domains where the user group is highly heterogeneous specific user models are likely to be the preferred option. We have earlier suggested an ambient intelligent architecture and implementation where a one-to-one coupling between the system instance and the user exists [5]. In this case the system builds an implicit user model over time, by storing experienced situations as cases and utilising case-based reasoning as the means of adapting its behaviour to the user's idiosyncrasies.

We have previously suggested how to use this ambient intelligent system in a mobile collaborative learning domain [6]. However as users of an ambient intelligent system in this setting presumedly is much less persistent, thus not allowing the case-based reasoning system enough time to adapt its behaviour, some explicit user model is required.

The work presented here suggests the use of stereotype modelling as the means of realising an explicit user model in an ambient intelligent setting. The services that are required by the user are delivered by one or more service providers. Similar to a model of the user and her needs, there is a need for a model of the services and the service providers. A detailed discussion of this is beyond the scope of this paper.

The rest of the paper is structure as follows: First and overview of what constitutes a mobile learner is given. This is followed by the background for the work presented here, as well as selected related work. Thirdly, a scenario containing a mobile language learner sets the stage for the use of ambient intelligent systems.

[1] http://www.tradlosetrondheim.no/

Fourthly, a description of how stereotypes are used to model a learner is given. This is followed by a short example revisiting the scenario. The paper ends with a summary and pointers to future work.

2 Mobile Collaborative Learner

Language learning is an area where the learner has the need to complement the classroom learning with experiences outside of the classroom. In language learning, there is a strong component of informal learning that takes place outside the classroom through interactions with the society that complements and reinforces the formal learning that takes place in classrooms, see Figure 1. Learners often experience situations where they would like to continue their learning processes as they go about their daily lives and while they are mobile. An exploratory study of language learners' use of technology have shown that learners desire to combine learning with leisure and entertainment [1]. For example, a TV program may stimulate them to learn new words in a particular subject area or they may feel the need to learn the appropriate usage of a word or a phrase that appears in a conversation.

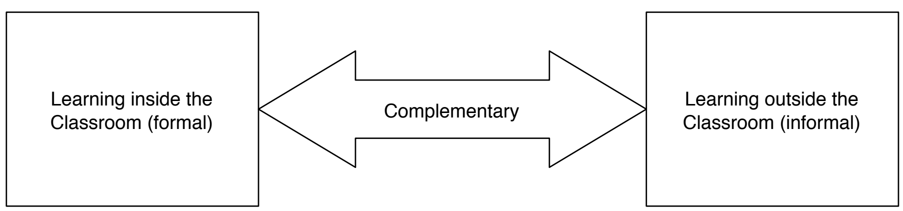

Fig. 1. Complementary Language Learning Situations

Learning as a social activity has been the discussion of several books and articles (e.g. [7] and [8]). Many scholars agree that learning is most effective when it takes place as a collaborative rather than an isolated activity and when it takes place in a context relevant to the learner [9]. In our work, a socio-constructivist approach to language learning is considered where learning is supported by collaboration and the interaction with others [10]. In collaborative language learning, the social construction of knowledge occurs through the learners? interaction with other learners, teachers and various communities that support the learning process. Similarly, conversation has been identified as an important aspect of learning where learning is considered as a continual conversation with other learners and teachers [11]. This is particularly important in language learning where the learning is strongly influenced by situations [12] and culture [13]. It is important for a language learner to learn in an appropriate cultural context and to interact with communities that exist in the cultural setting and practise the language with native speakers, fluent speakers and peers. A learner that is mobile and collaborates with other people as a part of her learning process is a mobile collaborative learner.

3 Background and Related Work

To achieve environments such as the ones described in the ISTAG report [4], several different paradigms and technologies must be integrated. The complementary use of a number of technologies is essential, drawing from their strengths and characteristics. Such scenarios describe an ambient intelligent environment. The concept of ambient intelligence has been described as humans being surrounded by intelligent interfaces supported by computing and networking technology that is embedded in everyday objects such as furniture, clothes and the environment [4]. The environment should be aware of the presence of a person (the user) and perceive the needs of the person and adapt and respond intelligently to these needs. We see ambient intelligence as a combination of a number of paradigms; ubiquitous computing [14], pervasive computing [15] and artificial intelligence [16], see Figure 2. The ubiquitous computing aspect addresses the notion of accessibility of the technology, where the technology and connectivity is available through everyday objects that are in the user's environment. Artificial intelligence techniques provide the context awareness to establish the user's needs and the appropriate response and the pervasive computing aspect supports the architectural aspects to realise the situation.

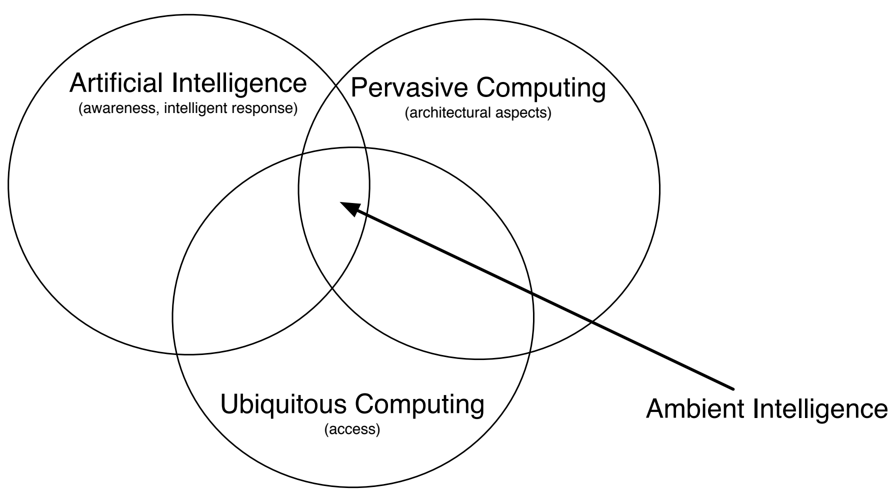

Fig. 2. Paradigms Related to Ambient Intelligence

Similar to the paradigms, several different technologies are required to achieve the desired effects. Mobile technologies, such as mobile phones and handheld devices, provide access while on the move; personal technologies, provide the means of accessing the appropriate content when desired, i.e. the personalisation and contextualisation of the content for the user; embedded and ambient technologies, such as shared displays, and interactive technologies, such as interactive white boards, are becoming popular in different environments for collaborative work and learning. An example of the use of shared displays in an office environment is described in [17] and in a learning environment in [18].

A combination of technologies is often required to obtain the appropriate set of services that are required. An example of blended technologies is described in [18], where an interactive shared display in combination with email, SMS and other applications are proposed for collaboration among teacher trainees during their practice period. In [19], they describe the combined use of interactive television with SMS for language learners while watching TV.

We have earlier introduced an ambient intelligent architecture [5] and demonstrated how an implementation can support context awareness and context sensitivity in a hospital ward domain [20,21]. The existing system proposes a subjective perspective on context and situations, which is well suited for domains where the user is a long term user, giving the system a possibility to adapt to the specific user's idiosyncrasies. However, as discussed in [22] the use of an ambient intelligent system in domains where users are non-persistent poses some new challenges to how users are perceived and modelled. Specifically, in domains where users are persistent no explicit user model is required as it is implicitly gathered over time by observing the user's behaviour. In domains where users are non-persisten, such as a tourist domain or mobile learner domain, it is not possible to apply a costly knowledge acquisition process regarding a users, and it is impossible to learn the specific user's behaviour over time. However, to allow an ambient intelligent system to perceive its users' needs and respond intelligently to them [4], some sort of explicit user model is required.

Jayaputera et at. describes the eHermes system, which is a a multi-agent system for adaptation of content delivered to users based on their context [23]. The context model used encompasses the capabilities of the user's device and the bandwidth available. The main idea is, based on user request, to generate plans and execute them in run time. Jayaputera et at. approaches the problem of user modelling by employing stereotypes, in the tradition of Rich [24]. The authors use a "User Profile" to describe the specific user and a "Device Profile" to describe the devices available. The stereotypes contain two parts: The classification part and the predictive part. The classification part contains context independent information, such as the user's demographical information and device information; and context dependent information, such as the user's current location and the user's current environment. The predictive part contains predictions about the user's needs, preferences and behaviour of their devices. When a user or a device enters eHermes for the first time, the user or device is mapped to an existing stereotype, which is used for personalisation.

4 Scenario

Astrid is a German student that is new in Trondheim. She has just started the "Norwegian for Beginners" course at the university and is hoping to get to know the city of Trondheim and learn some Norwegian as soon as possible. The city of Trondheim has a number of services to support newcomers to the city and to help them in learning Norwegian. Astrid has registered to these services and provided information about her interests such as history and outdoor life.

Astrid walks around the city hoping to learn some new Norwegian words and to learn more about the city. She has her mobile phone with a camera and voice recording capabilities and she activates the services that she has registered on to. She is presented with an augmented map of the city that helps her to find audio traces that others have left behind. She arrives at the city square where there is a farmers' market on Saturdays. She is intrigued to see the different kinds of berries and uses the glossary service via her mobile device to learn the Norwegian names for the products in the farmers' market. When the glossary service is activated, she is also informed that a certain chapter in her Norwegian textbook relates to the subject that she's looking up in the glossary service and she is asked if she wishes to view that chapter. As she walks around the square, her current location on the augmented map is highlighted and her mobile phone gives an audio signal to inform her that audio files that have been left behind by previous visitors are available in that location. She activates the audio trails to listen to the experience of previous visitors. She is very excited to hear that one of the previous visitors had actually been picking some cloudberries[2], just outside Trondheim and had left directions to that place. Astrid leaves an audio recording of her impressions of the city centre.

She receives a message on her mobile phone that there will be a concert by a local group in the square starting in 10 minutes. She notices that several people have started gathering around a stage on one side of the square. Astrid moves towards the group to find a place with a good view of the stage. She is keen to share her city experience with her classmates from the Norwegian class. She activates a service so that other users of the system and who are in the vicinity would know that she is in the area. In a short while, another German student Helga sends her a message saying that they could meet up.

5 Learner Modelling

As aforementioned, an explicit user model has not been a focus in our work so far. However, as the nature of the mobile learner dictates that our system moves from a subjective perspective on the world and its user, to a more objective view, an explicit user model is required. The work presented here suggests the use of stereotype modelling in the tradition of Rich [24] as the means of constructing a user model.

[2] Cloudberry (Rubus chamaemorus) is a wild berry that is abundant in marshes in mid-northern Norway

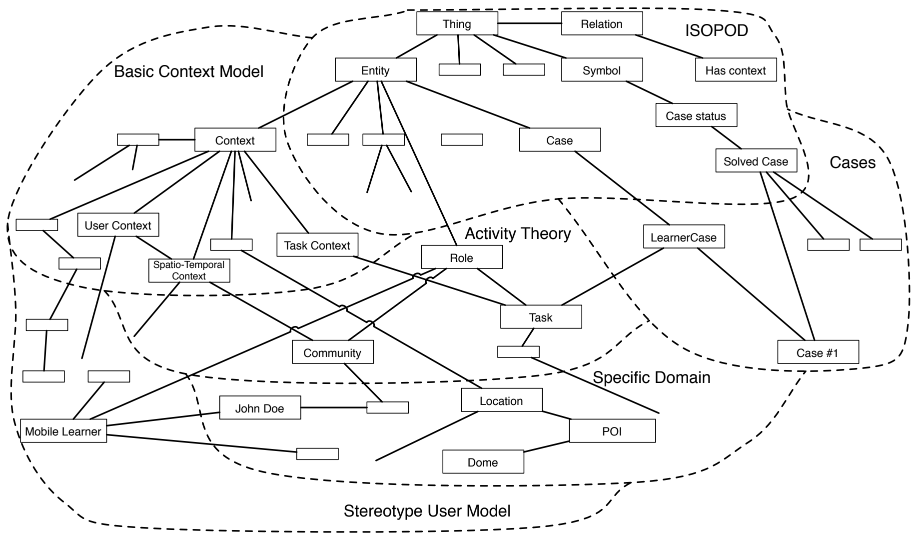

Fig. 3. Knowledge Model Layers

The user model is an integrated part of the system's knowledge model. This model is depicted in Figure 3. With the addition of the user model, the knowledge model now contains six different areas all interconnected in a multi-relational semantic net. The `ISOPOD` model contains the basic constructs required to explicate the rest of the model, as well as relations and concepts required for the case-based reasoning to function [25,26]. The `Basic Context Model` contains a meronomy of knowledge that is used to structure the perceived data into a coherent structure [27,5]. The `Activity Theory` part contains the knowledge captured through the socio-technical analysis required to model ongoing activities [28]. The `Cases` contains perceived situations represented as episodes in the case-based reasoning framework. Finally, the `Specific Domain` contains factual knowledge about the domain of discourse. The figure does not give credit to the multi-dimentional nature of the knowledge model since it does not carry well in two dimensions.

The `Stereotype User Model` is a directed acyclic graph in a "generalisation of" hierarchy, see Figure 4. The root node of the graph contains the most general stereotype (`any-person`), and the leaf nodes the most specific. Each of the stereotypes contain a set of *facets* with a *value* and *rating*. Following Rich, each of the facets' values are in a linear scale ranging from -5 to 5, where a positive value indicates that the stereotype is positive to the facets, and a negative value indicates that the stereotype is negative to the facet. The ratings range from 0 to 1000 indicating the degree of certainty in the facet-value pair. Except for the `any-person` stereotype, no stereotype contains all facets.

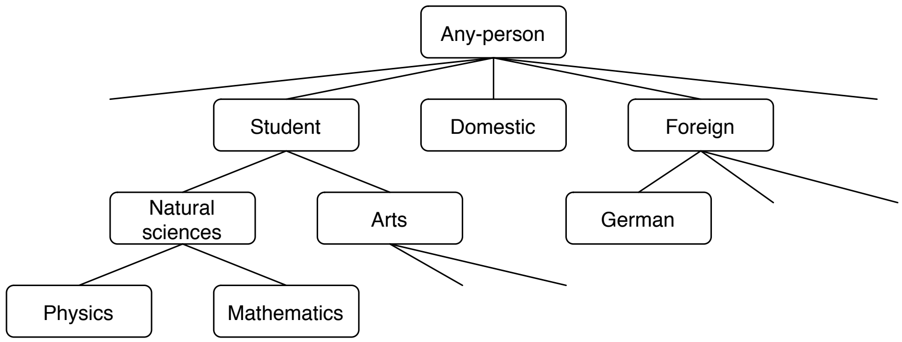

Fig. 4. Hierarchy of Stereotypes

The specific user model, know as the *User Synopsis (USS)* in Rich, contains a specific model for each of the individual users. This model is summary of the different stereotypes that is found relevant for the user. In addition to the facets, values and rating triplet, each tuple also contains a justification; that is the name of the stereotype that has supplied the specific triplet.

Initially this model is constructed partly by supplying information that the user has submitted before entering the course, such as sex, age, nationality and major; and partly by allowing the user to fill in a short questionnaire before instantiating the service. This questionnaire contains questing related to the person's interests besides the academic, such as a interest in history, concerts, or outdoor life. All of the information supplied by the user function as a way of activating triggers for the stereotypes. For an example, being a female, German physicist with a interest in the outdoors, might trigger the `female`, `german`, `physics student`, and `outdoor person` stereotypes.

For the specific user model to function the tasks that the ambient intelligent system is to perform must be modelled in accordance with the user model. That is, each of the possible task has facets and values assigned to them.

The initial stereotypes are constructed based on available knowledge about students attending language courses at the learning facility. Likewise, the assignments of facets and values to the different tasks are based on a combination of the curriculum required for the language students, and prior experiences from the learning facility and the local tourist centre.

6 An Example

To demonstrate the sequence of events that takes place when a new user approaches the system. Lets revisit Astrid who is learning Norwegian as part of her visiting the university in Trondheim.

Initially Astrid has filled in the necessary form when she applied for the Norwegian course. From this form we learn that Astrid is doing her master degree in physics, she is German and female. As aforementioned this information will trigger stereotypes such as `physics student`, `master student`, `german` and `female`. In addition she fills in a short questionnaire when signing up for the Wireless Trondheim service. Here she tells the system that she is interested in history and outdoor life, which triggers stereotypes such as `history person` and `outdoor person`. Once the initial specific user model has been constructed the following sequence is executed:

1. Select suitable sequence of tasks for the user model
2. Construct sequence of actions based on the stereotype modelling
3. Populated the sequence of actions through activation of a virtual enterprise
4. Ask the user to verify the plan. Return to 1 until the user is satisfied

The system can now construct a sequence of tasks that the ambient intelligent system and user are to carry out together. These tasks might be interacting with the locals, suggesting relevant cultural events, experiencing the outdoors and supplying dictionary services. There are many possible actions that might execute any give task. For an example, a map service might be supplied by any number of commercial actors. Therefore, the system can now, taking into account any stereotype given constraints, construct a sequence of actions that will execute all the required tasks. Finally, the virtual enterprise that are to cooperate in executing all the actions are gathered.

When the sequence of actions has been constructed it is presented to the user. The system might have selected some unsatisfactory stereotypes leading to a sequence of actions that the user does not agree with. It is now possible to lead a type of conversation where the system suggests new action sequences until the user is satisfied, thereby also updating the specific user model,

7 Discussion and Future Work

This paper has described why a user model is a requirement for an ambient intelligent system to function. It has further demonstrated how stereotype modelling is a promising candidate for quickly constructing user models with minimal effort from the user. However, some issues are still to be resolved.

Contrary to the original Grundy system described by Rich, and ambient intelligent system does not necessarily has the privilege of being able to conduct a conversation with the user. More often the primary interface between the system and its users are behavioural interfaces. Here users can observe the results of the system though its behaviour and influence the system through their behaviour. Likewise, the system can observe the effects of its behaviour by observing its users' behaviour, thereby reasoning on the success of its behaviour. Thus, to adapt the specific user model the system has to monitor the users' behaviour and look for triggers that might reinforce the existing user model, or in case of unexpected behaviour adapt its model of the specific user to include previously non important stereotypes.

Further, the nature of an ambient intelligent system dictates that is must adapt to the user continuously. Currently we have not defined how the populated sequence of actions might change if the user changes her mind or something unexpected happens. The main challenges here does not lie in adapting the specific user model based on behavioural input from the user. Rather, the challenge lies in restructuring the virtual enterprise constituting the populated sequence of actions, in particular when dealing with commercial partners. Some measures for sharing profit and cost between the affected partner must be conceived. We are currently investigating ways of agreeing on common business models between commercial partners in ambient intelligent systems. However, no conclusive results have been achieved yet.

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