Activity-based Adaptive Mobile Learning in Fire and Rescue Services

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Abstract. The broad goal our research is to explore how Activity Theory can be utilised to develop adaptive mobile learning environments to support reflective on-the-job training at Fire and Rescue services. Specifically, we examine how to facilitate crew commanders to develop risk assessment skills. This paper presents the architecture of a personalised mobile learning agent which engages crew commanders in a reflective dialogue tailored to the user's past and current risk assessment experiences, captured in corresponding activity models.

Key words: Personalised Mobile Learning, Activity Theory, Modelling Context, On-the-job Learning

1 Introduction

Mobile learning (or m-learning) enables learning to be positioned to a broader context in a wide range of environments [1, 2]. Consequently, m-learning becomes a powerful instrument for on-the-job learning providing creative ways for integrating learning within the everyday workplace tasks and activities.

Our research considers mobile learning in the emergency sector. Ubiquitous and distributed technologies have brought major changes in emergency services practices: working environments become more dynamic, communication among team members increases, social and community relations emerge, and information access becomes pervasive [3, 4]. However, the new technology has had limited impact on the effectiveness of training in emergency services. Emergency responders usually undertake initial formal training and continuous personal/professional development in line with their roles and operational needs. The existing training models are ineffective due to the reactive nature of the work which involves highly dynamic knowledge and roles. Emergency workers learn mainly experientially from their everyday activities. These activities provide problem-solving situations that *de facto* can create an engaging and relevant syllabus for workplace learning. Adaptive m-learning can provide a radically new dimension for training in emergency services, enabling the effective positioning of learning tasks within the workplace context and facilitating meaningful learning by tailoring training to the users' current and past activities.

The main goal of our research is to examine how to design adaptive m-learning environments to support activity-driven on-the-job learning in the emergency sector. For this, we are developing a Personalised On-the-job Reflective Mobile Learning (PORML) framework, illustrated in a case study for acquiring risk assessment (RA) skills by crew commanders at Fire Rescue Services (FRS). We propose to use personalised m-learning to promote reflection-on-action [5] by providing interactive means for fire fighters to review the risk assessment activity they have been involved in, to explore what they did well and why they acted as they did, and to help them identify the main characteristics of the situation which can be used in future activities.

This paper introduces our approach and proposes the architecture of an intelligent dialogue agent which takes a crew commander through dynamically generated reflective scripts after an incident has finished. The interaction, conducted via a smart phone, will go through the main steps of a RA activity by taking into account contextual information about the activity, location, and the user's experience, in order to diagnose how the user has performed the activity and to help him/her reflect on their risk assessment skills. We will illustrate how Activity Theory (AT) [6, 7] can be used to describe RA activities, which can be combined with semantic-enhanced geographic information to provide an extended context model for activity-driven adaptive mobile learning.

2 Related Work

We will review closely related projects in FRS considering both - mobile technologies to support decision making and technologies for training in emergency situations - in order to identify distinctive characteristics of our research and to position it in the relevant literature.

Mobile technologies have been used in FRS to provide firefighters with timely and relevant information for their tasks. For example, depending on the time, place and some situation factors, firefighters have been offered instructions how to act in the case of a chemical fire or how to get inside a crashed train [8, 9]. Firefighters can be offered relevant geographic information, such as maps of the area and traffic updates, together with an intelligent overview of the situation tailored to the role of each member, e.g. commanding officer, firemen surrounding the commanding officer, or firefighters [10]. Various devices have been used, such as smart phones, PDAs and tablet computers, to assist firefighters with the required information. Different types of information sources, such as geographic data, intervention plans, ontologies, user profiles, and team status, are combined to offer information suited for to the user's role, tasks, and context.

Existing mobile technologies in FRS support firefighters' decision making during fire activity but *are not aimed at promoting learning.* Although different types of information sources are combined and presented to the user according to the user's role, tasks, and situation, the user's experiences, skills and knowledge are not taken into account. Distinctively, our project will examine the use of context to promote on-the-job reflective learning and to recommend learning objects tailored to a crew commander's risk assessment skills and experience. Similarly to existing mobile technologies in FRS, we will use a situation model and will exploit ontologies to guide the process of deriving the current context. They will be integrated in a model of the current activity and utilised for planning a reflective dialogue.

The most common technology used to support training in the emergency sector is related to virtual realities and simulations. For instance, simulations of fire incidents have been used to enable command personnel practice decision making skills [11]. In a similar way, a geosimulator has been used to train police officers how to deal with crime in an urban area [12]. The major goal of simulations is to help emergency responders understand the consequences of their actions and the causal relations between events.

Similarly to the existing training projects, we exploit a situation model to promote developing of certain decision making skills. The major difference is that we are developing an approach to *link training with the real, on-the-job activities of emergency responders*, while the virtual environments simulate activities which can be disconnected from the real workplace experience.

To the best of our knowledge, no research has been conducted to support on-the-job reflective mobile learning in FRS. This study is an attempt to fill the gap by developing a personalised mobile learning environment for on-the-job reflective learning in real workplace situations directly linked to the firefighters' current activities.

3 PORML architecture

The PORML framework integrates three services (see Figure 1), which deal with semantic location, user modelling, and intelligent dialogue planning.

Semantic Location Services derive information surrounding the incident site, which can be relevant to the corresponding RA activity. We use the semantically annoatted Master Map data provided from the DigiMap services offered by the UK mapping agency Ordnance Survey[3]. The buildings and places are extracted by calculating distance parameter around the coordinates of the incident site and using an ontology of buildings and places developed at Ordnance Survey to identify the main objects of interest[4]. The location-related information is stored in the current user context, managed by the user services.

User Services deal with managing a user's profile and maintaining a model of the current user context. The user profile provides information about the user, including his/her role and past RA activities. Each past activity is presented as an instantiation of a Generic Risk Assessment (GRA) [13] model and a hierarchical activity model (Figure 2), described in the next section. The user's past activities are presented in the same format, as the user's current activity. This

[3] DigiMap services are available to UK higher education institutions for research purposes from http://edina.ac.uk/digimap/

[4] The buildings and places ontology is available from http://www.ordnancesurvey.co.uk/ontology

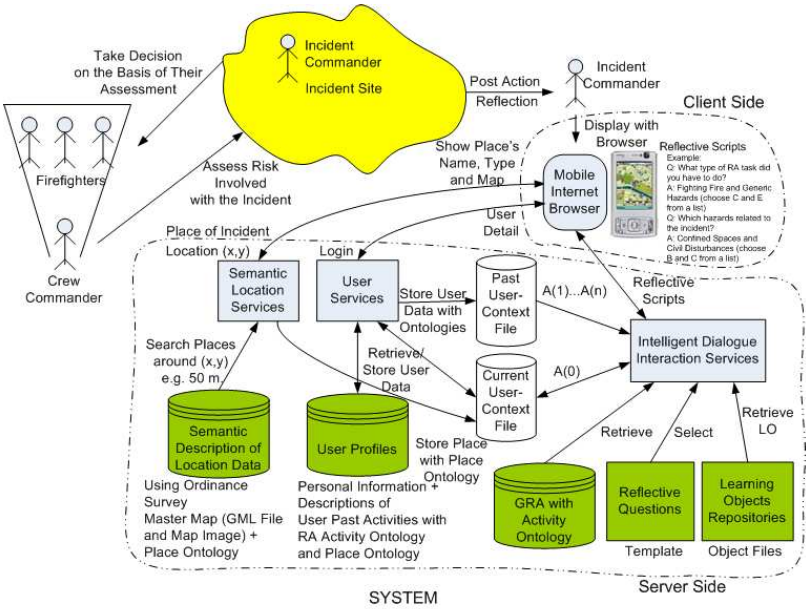

Fig. 1. Architecture of a framework for Personalised On-the-job Reflective Mobile Learning (PORML) in fire and rescue services.

enables comparison between the past activities and the current activity, so that common aspects of RA situations can be pointed during the reflective dialogue.

Intelligent Dialogue Interaction Services manage the dialogue with the user. For this, we utilise the STyLE-OLM dialogue-game-based framework for interactive open user modelling which has been shown to promote reflection [14]. The Generic Risk Assessment model and the hierarchical RA model and used to plan the content of the dialogue. Templates with reflective questions will be used to initiate dialogue games that help the user review his/her risk assessment experience. Following the general RA model, the dialogue will examine general aspects of the RA activity, considering the object, subject, rules, community, division of labour, and available tools. Following the specific RA model mapped to the semantic description of location data, the dialogue will examine the hierarchical structure of the activity and will check with the user which relevant aspects have been taken into account and how. The information provided by the user in the dialogue will be used to build a model of the current activity which will be stored in the user profile.

After the dialogue ends, the user will be referred to additional reading based on the dynamically updated user profile. The learning materials can be visited in the *down time* when the fire officers are not directly involved in fire and rescue activities and can spend time to update their knowledge on particular aspects of their job. Following the interaction with the PORML agent, the recommended reading will be linked to the user's recent risk assessment activities.

4 Using Activity Theory to Model Context in PORML

The kernel of the PORML framework is the representation and maintenance of the user's past and current context, which is the main source for adapting the dialogue to the user. Context can be any information from the situation of an entity (a person, a place, or object) which is relevant to user and application interaction [15]. In our case, context captures the risk assessment activity the user has been involved in. Consequently, to derive a model of context we follow the Activity Theory, the theoretical foundations of which were described by Vygotsky and Leont'ev [6, 7]. Vygotsky introduced the first generation model of AT linking a subject, an object, and tools. The hierarchy structure of an activity has been divided into three levels:

– **Activity level:** An individual activity is for example to perform fire extinguishing;
– **Actions level:** Activities consist of a collection of actions. An action is performed consciously, for example, performing fire extinguishing with water;
– **Operations level:** Actions consist themselves of collections of non-conscious operations, for example, release valve, jet water to the front of fire building.

Engestorm [16] developed an expanded AT model considering social context and adding rules, community and division of labour (Figure 1a). Engestorm's activity model can be mapped to contextual information in mobile scenarios, as described in [17], namely:

– *subject* (defined in the AT model as a person or a group engaged in an activity) is related to *personal context* (which describes any information about the user, e.g. their expertise or capabilities);
– *object* (defined in the AT model as something is held by subject and motivates activity) is related to *task context* (which describes what the user is doing, e.g. goals and tasks);
– *tool (artefact)* (defined in the AT model as instruments for achieving a predefined goal in the work process) is related to *environment context* (which includes information about the user's surrounding related to the activity the user is performing, e.g. available services, people, information access);
– *rule* (defined in the AT model as regulation actions and interactions within the activity system) is related to *task context* (defined above);
– *community* (defined in the AT model as one or more people who share the objective with the subject) is related to *spatio-temporal context* (which includes different parameters like time, location and community present);
– *division of labour* (defined in the AT model as the roles of user related to the activity) is related to *social context* (which describes social aspects of the user related to the activity, e.g. different roles a user can have).

We use the Engestorm's extended activity model to define a Generic Risk Assessment model, which is used in PORML to identify the key context aspects at a general level, see Figure 2. To plan the interaction with the user, we need an elaborated model of the specific risk assessment activity, including the actions and operations. For this, we use follow Vygotsky's hierarchical activity model.

Working in partnership with FRS operating in a large rural area in the UK, we are developing a detailed activity model of the most common risk assessment activities. Figure 2 presents a hierarchical model of assessing chimney fire risks - one of the three most common risk assessment activities experienced in the FRS we are working with. The other common risk assessment activities include assessing home safety risks and road traffic accident, respectively. We are currently modelling risk assessment in dealing with chimney fires, as it is fairly simple and at the same time covers all aspects of the PORML framework. The home risk assessment is fairly simplified, as it does not include much use of location data, while the road traffic risk assessment is highly dynamic and requires active collaboration with external services.

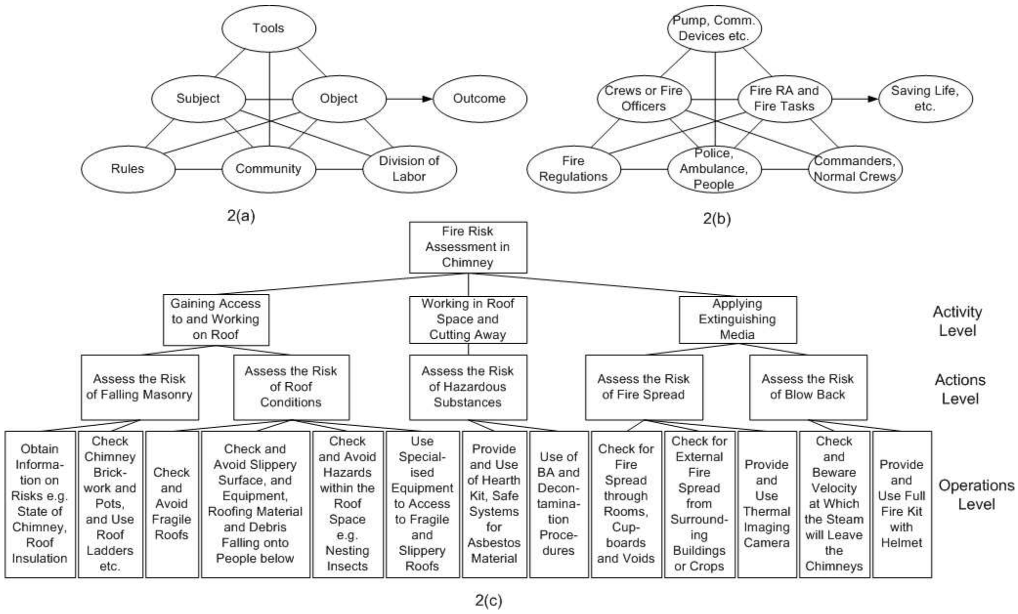

Fig. 2. (a)Expanded model of AT by Engestorm[16]. (b)Mapping to FRS's Fire Risk Assessment Activity (c)Hierarchical Structure of AT of Fire Risk Assessment in Chimney

The activity model, including both the generic risk assessment model and the hierarchical model of the specific risk assessment activity undertaken, are used in PORML to plan the interaction with the user. We are currently preparing a study with fire fighters to validate the activity models, which have been derived using mainly FRS documentation.

5 Current State and Future Work

Our research follows a methodology which combines methods from Social Science and Artificial Intelligence, in the following steps:

Step 1. Identify activity where mobile technologies can facilitate on-the-job reflective learning of firefighters and identify which tasks are related to the chosen activity. For this, we this we have analysed data and learning material obtained from representative FRS including available resources, external data and services. Based on this, we have develop scenarios for on-the-job reflective learning to show how mobile technologies can be embedded in work practices of firefighters to provide reflective personalised learning.

Step 2. Develop a conceptual model of user activities based on activity theory to define the context dimensions and integrating this model with both semantic topographic data to identify relevant objects and the user's past experiences related to the current activities. We have derived a conceptual model based on resources provided by FRS, and are preparing a study with firefighters to tune and validate the conceptual model. At the same time, we have examined semantic structures for representing the conceptual model and have defined an initial conceptual model in OWL [5].

Step 3. Design a framework for on-the-job reflective learning which utilises a user and context model and provides adaptive interactions to help the user become aware of their risk assessment skills and to suggest resources for further studies. The architecture if this framework has been outlined in Section 3.

Step 4. Implement a prototype to validate the PORML framework. Currently, we are implementing the conceptual model, as pointed above. We are also developing algorithms using OWL reasoners, such as Pellet and Jena, to interrogate the activity model in order to define the content of a reflective learning dialogue.

Step 5. Evaluate the potential of the new technology to provide reflective-on-action learning and transform the inexperience crew commander learning practices in FRS. Firstly, new technology will be evaluated by putting data from a few sample activities and examining the outcomes so as to test working of the prototype in technical aspect. Secondly, hypothetical situations will be modeled and then tested by comparing between situations using tradition and using mobile technology. Thirdly, Activity Theory will be exploited for analysing FRS training activities and reflection learning activities in a focus group with crew commanders, in order to identify how PORML can be applied to the working practices and what benefits this may bring.

6 Summary and Main Contribution

This paper has presented a new opportunity for personalised mobile environments to promote reflective learning in emergency services based on the user's

[5] http://www.w3.org/2004/OWL

real job experiences. We have argued that a holistic model of context is paramount, and have shown how this can be achieved based on Activity Theory. We have also presented a general architecture for a personalised mobile learning agent which engages the user in a reflective dialogue tailored to the user's past and current experiences.

The research presented in this paper is conducted in a PhD project, which is entering its second year. The expected research contribution of this work is: (a) new context modelling algorithms that capture users' risk assessment experience based on semantic-enhanced geographic data and ontological models of general RA activity; (b) demonstration how these algorithms can be utilised in a novel pedagogical environment to promote reflective learning; (c) examination of whether the new technological solutions could be deployed in the FRS training practices and what benefits/drawbacks this might bring.

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