Modeling, Managing and Reasoning about Social Contexts for Socially-Aware Applications

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***Abstract*—Despite the huge prospects of pervasive social computing and the extensive work in context-aware applications, so far very limited work has focused on *socially-aware* applications. The key *requirements* to develop such applications are modeling, managing and reasoning about users' social contexts. To fulfil these requirements, in this PhD research, we have made an attempt to *model*, *manage* and *reason* about *social contexts* to aid the development of socially-aware applications. We study different *types* of social contexts, their *use* in various socially-aware applications and possible *sources* to acquire such social contexts. We will investigate existing context modeling and reasoning techniques and will propose an *approach* to modeling and reasoning about different types of social contexts. To aid the development of socially aware applications, we will provide a *middleware* platform for managing the acquisition, changes and provision of social contexts.**

I. Introduction

Pervasive computing envisions environments where people are assisted in their everyday tasks by technologies that recede into the background, being invisible yet significantly helpful [1]. To enable such technologies a rapidly growing research area called "context-awareness" has emerged, as a technique to make pervasive applications more intelligent and accessible. Humans, the centre of pervasive computing, however, are social beings. Hence, the notion of *social awareness* can push the field further in achieving the vision of pervasive computing [2]. With the increased prevalence of advanced mobile devices (the so called "smart" phones), interest has grown in mobile *socially-aware applications*, where applications will be aware of users' social contexts and be able to assist them in their daily activities and ultimately enrich their social well-being. For example, a socially-aware phone call application can reduce interruptions by allowing a user to filter incoming calls based on her social context information (e.g., relationships with the caller, current status); a socially-aware telematics application can make travel safe and convenient by allowing drivers to collaborate and interact with each other based on their interaction relationships. These applications exploit users' social contexts in order to provide services.

Many of the research efforts in the area of context-aware applications are focused on modeling, reasoning and provisioning context information, so as to reduce the complexity of engineering such systems (see [3] for a survey). These efforts have achieved significant progress in formulating context models which are an important prerequisite for building systems that can respond to changes in their environment. In addition, software architectures, frameworks and platforms have also been proposed for developing and managing context-aware applications (see [4] for a survey).

Existing context models, software architectures and platforms for context-aware applications mostly address contexts of a *physical* nature such as location, time, activity, and so on. Comparatively, there have been only limited works investigating contexts of a *social* nature. Even though recently some works have attempted to model social context, they do not consider the *interaction-oriented* relationships which are an important aspect of social context. Furthermore, there is a lack of support for *modeling* and *reasoning* about different *types* of social contexts and for *managing* the acquisition, changes and provision of social contexts [5] [6].

This research explores the concept of *social context* as a means to represent and reason about the *relationships* among actors (e.g., people) and presents a middleware platform to provide higher-level support for developing socially-aware applications by managing such social contexts.We distinguish social context from the concept of context used in previous research by calling the latter physical context. *Physical context* refers to contextual information about systems, entities, and their environments. The term "Social context" in computing is often used to refer to the people, groups, and organizations that an individual interacts with [2]. Taking that view, we define *social context* as a representation of users' *relationships* which we further categorize into interaction- and connection-oriented relationships. *Interaction-oriented* relationships represent *agreements* and *constraints* regarding collaborative interactions among users, while *connection-oriented* relationships represent users' relational *ties*. In section 2, we present the key research challenges in developing socially-aware applications. Our approach to address those challenges is briefly discussed in Section 3. Finally, Section 4 outlines the evaluation plan.

II. The Challenges

The inherent nature of social context poses three main challenges. **First**, Social context needs both *interaction-* and *connection-oriented* relationships to be modeled and represented. Modeling *interaction-oriented* relationships among people in an environment/domain (e.g., home, office, etc.)

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requires capturing the *obligations* and *constraints* underlying the interactions between collaborating actors of that domain. On the other hand, users' *connection-oriented* relationships can be acquired from the different Online Social Networks (OSNs) applications such as Facebook, LinkedIn, Twitter, and so on, as people use those applications to specify their relationships, update their status and share contents. Thus, the challenge is to consistently *model* and *represent* different types of social contexts to facilitate applications use. **Second**, Social contexts that capture *interaction-oriented* relationships are not just a modeling or design time construct, they are also runtime entities which *mediate* runtime interactions between actors. They typically evolve and many aspects of social contexts such as topology, interaction constraints and non-functional quality properties *change* frequently in response to changes in user requirements and environments. Thus, it is necessary to support the *management of adaptation* in such social contexts. Compared to interaction-oriented relationships, social contexts that capture connection-oriented relationships have a more stable structure and are not a run time construct but information. Such social context information (SCI) can be acquired from different OSNs and can be used by various socially-aware applications. Thus, it is necessary to provide a mechanism to *acquire* SCI from different sources and support efficient *access* to this SCI while respecting information owners' *privacy*. **Third**, A socially-aware application may need high level and/or abstract social context information (e.g., social *situation*) that is not directly available from context sources but can be derived from basic acquired or defined information. Thus, the challenge is to support *inferring* more meaningful abstract SCI from basic context information, and to support *reasoning* about situations by observing and analyzing current and past interaction events and utilizing ontological knowledge about such events.

III. The Approach

A. Modeling

We adopt a *role-based* approach to model *interaction-oriented* relationships in social contexts as it is very useful in modeling entities, their relationships, responsibilities and interactions. We model such social contexts from both the domain and player (user) perspectives [5]. The *domain-centric* model captures the *relationships* among *roles* associated with a particular domain or environment such as home, office, and so on. These relationships are represented in terms of *interactions*, *conversations* and *obligations*. The *player-centric* perspective provides an *overall* view of all the relationships of an *individual* over different domains.

To model and represent *connection-oriented* relationships with its *semantics*, we adopt an *ontology-based* approach as it has been evaluated as most promising for context modeling in pervasive computing. To ensure users' *privacy* preferences, we propose an ontology-based *socially-aware access control policy* model. Our policy model provides intuitive support by considering *social relationships*, *social roles* and *status* information when defining privacy preferences [6].

B. Managing

We will propose a Social Context as a Service (SCaaS) *middleware* platform that facilitates the *runtime* realization of *interaction-oriented* relationships which mediate interactions in collaborative pervasive applications. The key features of our approach include *externalizing* relationships from the application, implementing them using a *service-oriented* paradigm and supporting their *runtime adaptation*. SCaaS will implement management operations, and support both structural and parametric adaptations in a social context and adaptation propagation across social contexts, to cope with the *changes* in user requirements and environments.

To acquire *connection-oriented* relationships and manage social context information, we propose a SCI Management System [6]. SCIMS implements a set of social *sensors* to collect users' social data from different sources such OSNs. It *stores* information into a knowledge base, allows information owners to specify their *privacy* preferences, and provides an interface for the application developers to *access* users' SCI.

C. Reasoning

We consider users' *interactions* in different platforms (e.g., OSNs, Email, Blogs, Collaborative applications) as temporal thematic events where an *event* is an interaction or a sequence of interactions a user performs with other users. We aim to exploit and combine *interaction events* and adopt a knowledge-based complex event processing technique to *reason* about users' *situations*. Thus, each user can get a personalized service based on a specific situation detected for her.

To *infer* abstract social context information (e.g., family, best friend) from *acquired* information (e.g., father, school friend), we aim to propose an ontology-based reasoning technique as it allows us to specify *semantics* and *inferring rules*.

IV. Evaluation Plan

We will demonstrate the *applicability* of our approach by developing a number of socially-aware applications. We will evaluate the *performance* of SCIMS using real data from OSNs. We will also evaluate the SCaaS middleware *adaptation overhead*, *resource consumption* and *system performance*.

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