Enabling context-aware applications

Per-Oddvar Osland*#, Brynjar Viken*, Fredrik Solsvik*,
Gaute Nygreen*, Jan Wedvik**, Stein Erik Myklbust***

* Telenor R&D. E-mail: { per-oddvar.osland , brynjar-age.viken, fredrik.solsvik, gaute.nygreen}@telenor.com
Address: Otto Nilsensv 12, 7004 Trondheim, Norway

** Sun Microsystems. E-mail: jan.wedvik@gmail.com Address: Haakon VII's gt. 7B, 7485 Trondheim, Norway

*** Gintel AS. E-mail: stein-erik.myklebust@gintel.no Address: Otto Nilsensv 12, 7004 Trondheim, Norway

Primary recipient of correspondence

1. Introduction

The objective of pervasive computing [Weis92] is to hide technology from the user by seamless integration into everyday life. The focus is on the services that allow the user to solve his tasks while devices and technology fade away into the background. Context-aware systems are a vital part of pervasive computing. Context information gives applications entirely new opportunities to offer new services and adapt their behaviour according to the situation of the mobile user. This increases system usability tremendous by reducing the demands on the end-user and minimizing the need for user attention.

Obviously, it is not desirable that every application implements a context engine to gather and process specific context information; rather a generic context platform/infrastructure that supports applications by gathering, processing and managing context information is needed. Such a generic context infrastructure is an essential component of pervasive computing.

In this paper we present a basic context model and an infrastructure for context management. Based on this, we implement a Context Manager for experimental purposes. The applicability such a component is vast, and it may serve as an enabler for a wide range of context-aware applications.

This work is carried out within the Akogrimo project[1]. The Context Manager is a part of the Mobile Network Middleware Architecture, which one of the four layers in the Akogrimo architecture. In the project a set of scenarios have been presented where user context is used to enhance the provided application [Loos05]. These include several scenarios within eLearning, eHealth, and crisis handling and management.

1.1. Background

The dictionary defines context as “The interrelated conditions in which something exists or occurs”. In the literature many definitions and examples of context information are found. [Dey01] reviewed previous context definitions, and provided the following general definition of context: “Context is any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.”

[SAW94] states that the important aspects of context are: where the user is, who the user is with, and what resources are nearby. Context attributes can also be classified as internal (logical) and external (physical) [BaDu04].

2. Basic context model

The approach is to define a context information model that captures information common among multiple applications e.g. focusing at communications, user guidance, and user assistance. Our information model focuses on the situation of the user. The main entities are user and devices/local services, as shown in Figure 1. Location is presented as an important context attribute. This model is inspired by Henriksen et al [HIR02].

---

[1] Akogrimo (Access to Knowledge through the Grid in a mobile World) is a project funded by the EC under the FP6-IST programme. The Akogrimo project team comprises of totally 14 European organizations, and the vision is a world in which grid services, pervasively available, are eventually meeting the needs of fixed, nomadic and mobile citizens in the ‘everywhere at every time in any context’ paradigm. Network and service operators are viewed as contractors that are able to develop new business activities and to provide profitable services in such an integrated world based on grid and mobile communications concepts. See www.akogrimo.org for more information.

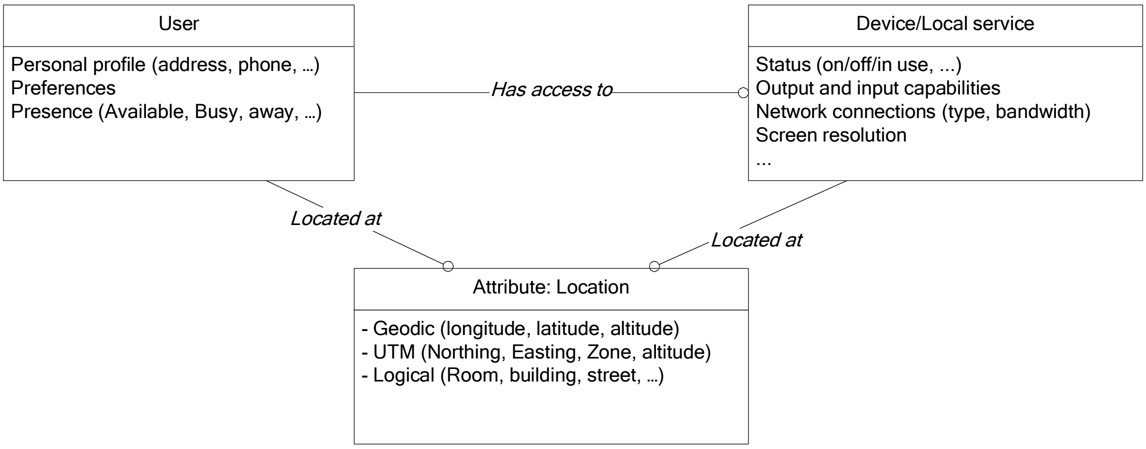

Figure 1 User–oriented context model.

2.1. Context attributes

In this section we describe user context with focus on presence, location, and device availability.

Presence

Presence information is the basis of instant messaging (IM) and refers to information about the state of users such as availability, reachability and other information set by the user (e.g. mood, interests, etc.). Presence information is dynamic and may change frequently. The changes can occur manually by user interaction or automatically based on available context information (e.g. location, user talk on the phone etc.).

Currently, there are multiple protocols for handling presence information such as:

- Parlay PAM
- Parlay X Presence
- IETF Working groups, including IMPP (Instant Messaging and Presence Protocol) and SIMPLE (SIP for Instant Messaging and Presence Leveraging Extensions)

Location

Location systems deliver geographic coordinates of people (things and devices). The geographical coordinates can be used to infer details about where the user is, e.g. room, street, at home, in the car. There exists a multitude of technologies for locating and tracking individuals (based on GPS, WLAN, GSM, RFID, active badges etc) that are becoming increasingly more common.

There is no common protocol for exchange of location information, examples of available protocols are Parlay (X) Location and OMA Mobile Location Protocol [MLP]

Device availability

Devices and local services in the immediate proximity of a user are often an integral part of the application provided to the user. Hence these device's attributes may be an important part of the user's context. We consider the following ways to relate a user to a device/local service:

- User is logged onto a device. This is the case for a mobile phone or for a PC where the user is using a SIP User Agent.
- A user has devices within a reasonable range. The size of such a range, and the usability of the devices within that range, depends on the application.

The following is some of the Device context information is needed to provide general services:

- Screen Size ++ (pixels, color depth etc.)

- Operating System (version)
- Memory
- Network connections
- Browser
- Installed SW and players

3. An infrastructure for context management

In a general setting, context data is obtained form a number of sources, and requested by interested parties, i.e. context-aware services. In the trivial case, sources and consumers would interact directly with each other. However, we suggest a mediator infrastructure in the data flow, know as the context manager (see Figure 2). The context manager would address issues such as:

- Filtering out relevant data and forwarding those to the interested parties.
- Converting heterogeneous context data to a uniform format.
- Resolving situations where context data are incomplete or inconsistent.
- Inferring higher-level context data from basic data, e.g. by mapping the location of a user onto a map of a building.

Introducing a context manager hence improves the overall scalability of the context system, and also factors out functionality that would otherwise have to be duplicated in each context-aware service.

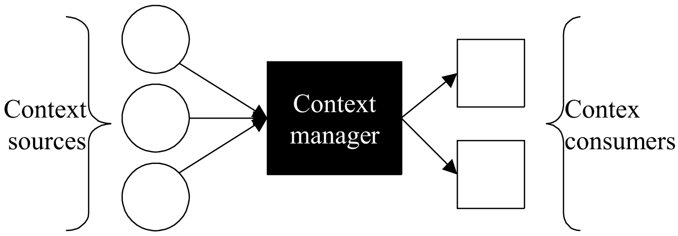

Figure 2 Generic flow of context data.

In the following, some issues that are of particular importance for the design of context management are discussed. The separation of basic context gathering and processing from the applications has several advantages such as:

- Hiding low level-details from applications
- Accessing standardized APIs facilitates the usage of context by applications
- Applications can add domain specific context handling as needed
- Context data sources are reused across applications
- End-systems (e.g. mobile terminals) do not have to perform context processing

Performance and scalability are two major concerns for the design of a context management infrastructure. The factors contributing to the problem is the highly dynamic nature of context information, large number of mobile users, the huge amount of context data collected and processed from a variety of sources, and near real-time requirements for delivery of context info to consumers. Dynamic context information is useless for context consumers if it is out-of-date or incorrect.

4. A multi-purpose Context Manager

In this section we describe the Context Manager, an infrastructure that has been developed as part of the Akogrimo project. The implementation is in line with the theory presented in the previous sections. However, its scope is limited to experimental use, hence context gathering focuses on a smaller set of context sources.

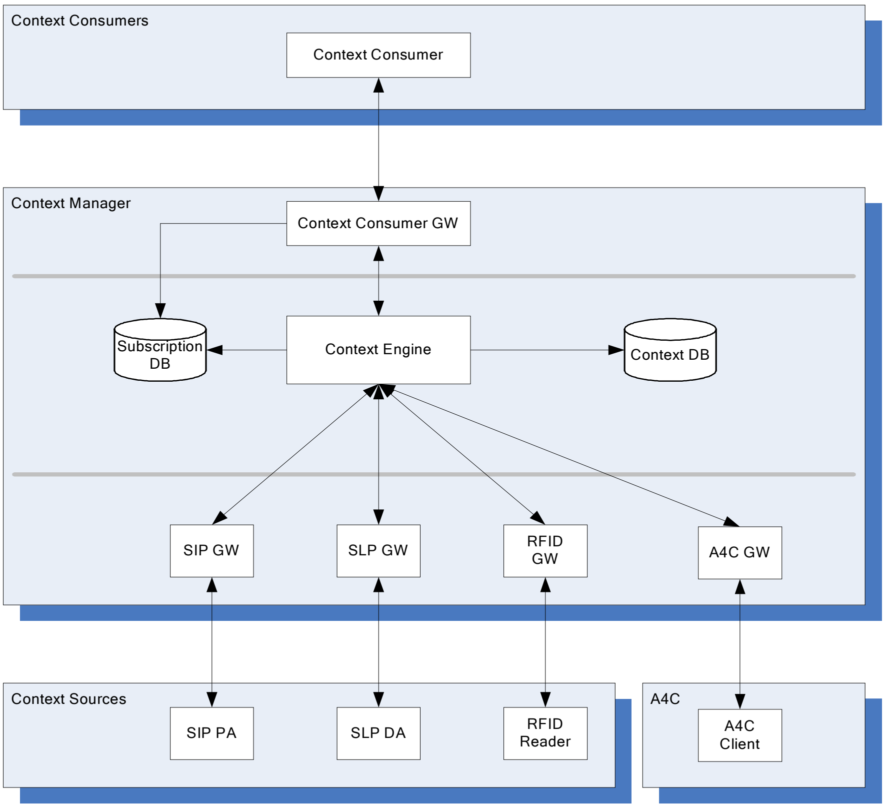

Figure 3 Context Manager architecture

The Context Manager, which is shown in Figure 3, has three major parts:

- Context gathering gateways, which are responsible for handling communications with the context sources. Currently the following gateways are present:
  - SIP Presence GW: Acts as a SIP watcher, i.e. it subscribes to presence information for a presentity.
  - RFID GW, where position is based on RFID technology (Radio Frequency IDentification)
  - SLP GW (Service Location Protocol). SLP may be requested for services of a specific type. Or, once the user position is known, SLP is searched for services in a given area around the user. In Figure 4 three devices are registered with location parameters.
  - A4C (Authentication, Authorization, Accounting, Auditing and Charging) gateway is used to perform authorization operations, e.g. verify that a context consumer has right to access context for a specific user.
- Context Engine (including persistent storage), responsible for
  - Initiating context request towards context gateways
  - Storing context information
  - Keeps track of which consumers should receive notification about updated context
- Context Consumer GW
  - Provides a Web Service interface towards context consumers: It receives subscriptions and returns notifications when updates occur. Subscriptions specify user and scope, e.g. how much context is desired. In the example in Figure 4 the subscription is requested to devices of type “plasma screen”.

The example in Figure 4 describes a case where the context consumer, a context-aware application, is interested in knowing which users are close to a large display. The application may e.g. use this information to decide which user should be included in a communication session.

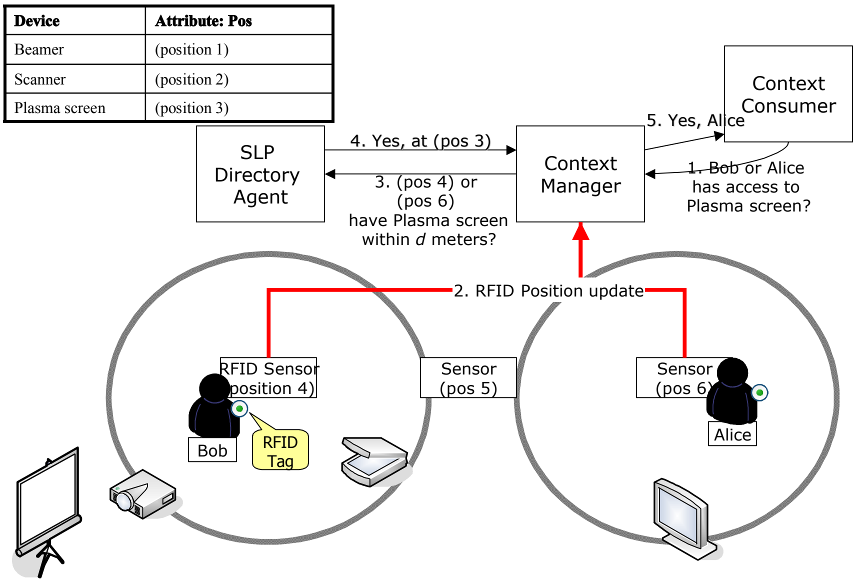

Figure 4 RFID and SLP as context sources

An application has been developed that uses context to decide on transfer of an ongoing communication session between devices [OOK]. Moreover, a context-aware application is currently being developed for realization of a scenario from the Akogrimo project. However, the applicability of the Context Manager is vast. Although it's currently limited to gather context from a small set of sources, it may serve a wide range of context-aware applications. Moreover, the Web Service interface makes it easy to use for context consumers.

5. Conclusions and further work

A basic context model and an infrastructure for context management have been presented. Based on this, we have implemented a Context Manager for experimental purposes. Context-aware applications using this component are under development. The Context Manager currently serves as part of the Akogrimo architecture. The applicability of the Context Manager is vast, and it may serve a wide range of context-aware applications.

Further work includes

- To design and build more context-aware applications
- To develop an ontology-based interface for context consumers
- To add more context sources, e.g. to use Bluetooth on the user's terminal for discovering Bluetooth-enabled services around the user

References

[BaDu04] M. Baldauf & S. Dustdar, *A Survey on Context-aware systems*, technical report, Distributed Systems Group, Technical University of Vienna, 2004

[Dey01] A. K. Dey, *Understanding and Using context*, Personal and Ubiquitous Computing Journal, Volume 5 (1), 2001, pp. 4-7.

[HIR02] K. Henricksen, J. Indulska, and A. Rakotonirainy, *Modeling Context Information in Pervasive Computing Systems*, Proceedings of the First International Conference on Pervasive Computing, 2002.

[Loos05] Christian Loos et al: *Testbed description*, Akogrimo deliverable 2.3.1. February 2005. URL: www.akogrimo.org -> Downloads -> Deliverables -> Akogrimo Testbed Description

[MLP] Open Mobile Alliance, *Mobile Location Protocol*, 3.2Draft Version 2004-11-02, http://member.openmobilealliance.org/ftp/public_documents/loc/Permanent_documents/OMA-MLP-Spec-V3_2-20041102-D.zip

[Most03] S. Kouadri Mostéfaoui, G. Kouadri Mostéfaoui, *Towards A Contextualisation of Service Discovery and Composition for Pervasive Environments*, University of Fribourg, 2003.

[OOK] Østhus, Egil C., Osland, P.O., Kristiansen, Lill, "ENME: An ENriched MEdia application utilizing context for session mobility; technical and human issues" (accepted for publication in proceedings UISW in LNCS, Japan Dec. 2005)

[SAW94] Schilit B., Adams, N. & Want, R. (1994). *Context-aware computing applications*, Proceedings of the 1st International Workshop on Mobile Computing Systems and Applications, 85-90. Los Alamitos, CA: IEEE.

[Weis92] M. Weiser, *The Computer for the Twenty-First Century*, Scientific American, pp. 94-10, September 1991.