Ubiquitous Mobile Awareness from Sensor Networks

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Abstract. Users require applications and services to be available everywhere, enabling them to focus on what is important to them. Therefore, context information (e.g., spatial data, user preferences, available connectivity and devices, etc.) has to be accessible to applications that run in end systems close to users. In response to this, we present a novel architecture for ubiquitous sensing and sharing of context in mobile services and applications. The architecture offers distributed storage of context derived from sensor networks wirelessly attached to mobile phones and other devices. The architecture also handles frequent updates of sensor information and is interoperable with presence in 3G mobile systems, thus enabling ubiquitous sensing applications. We demonstrate these concepts and the principle operation in a sample ubiquitous Mobile Awareness service.

Keywords: context-aware applications, mobile systems, wireless sensor networks.

1 Introduction

People are expecting applications and services to provide value to them, such that they can focus on what is important in life. Recently, vendors of mobile devices (e.g., mobile phones, smartphones, PDAs, etc.) have started to include sensors in these devices (e.g., accelerometers, GPS, photo detectors, short range radio, etc.). Including sensors in a user device offers more information about what the user is doing or what situation the user is in to local applications, i.e., so-called context information. In this case users or applications lack means to share context information with remote users or applications.

Wireless sensors and sensor networks (WSNs) are important sources for context information, for which solutions exist to collect sensor data via gateways, for storage in servers, such as for monitoring the environment. These solutions are an insufficient response to the need for users to share context information in a distributed way.

Earlier work has focused on brokering of sensor information with web services via a 3G mobile system, such as Mobilife [1], brokering of sensor information via SIP servers [2], brokering of sensor information via clients in end-devices (opportunistically) connected with web services to servers on the Internet [3-5], and finally, other approaches offer gateways to mobile system for aggregating information from WSNs and making this available in services [6,7].

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Krco et al. presented an approach [7] providing gateways to mobile systems for collecting data from sensor networks. Sensor nodes lack identities assigned to a mobile device attached to a 3G mobile system or applications running in mobile devices register with a 3GPP IP-Multimedia Subsystem (IMS).

The above solutions are unsatisfactory answers to the challenge that we have identified, which is to provide means for the spontaneous sharing of context information from any locally available sensor with remote users or applications. The purpose of the required solution is to enable the spontaneous orchestration of local service behavior based on context information from locally and remotely available sensors.

In Europe, 3G offers ubiquitous coverage with packet data services (GPRS) via various radio access networks (GSM, EDGE, W-CDMA, HSPA). Thus mobile users can access both services on the Internet as well as services that run on the 3GPP IP Multimedia Subsystem (IMS). We argue that the solution should build on the ubiquity of wireless broadband connectivity for sharing of context between remote users, devices, and applications. In line with this, we present an architecture with support for ubiquitous provisioning and sharing of context information originating from sensors and WSNs via mobile systems. In our approach, end-devices share sensor information both via the Internet and via support in mobile systems.

2 Exchanging Sensor Information with 3GPP IMS

Aggregation of information from sensor networks in mobile devices and provisioning of context data in our support occurs via agents co-located with SIP end points, such as available in mobile phones. Mobile devices exchange information with presence support via SIMPLE [8] signaling using GPRS via 3G access.

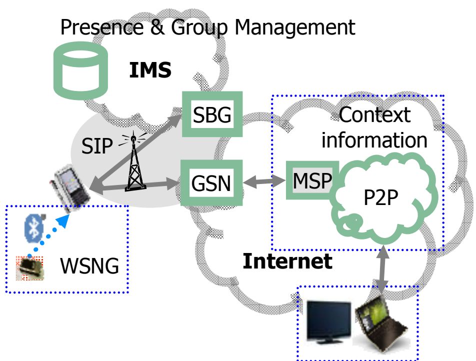

Fig. 1. Overview of the architecture

We require real-time response times in provisioning of context data on the Internet, mandating the exchange of context data via a P2P infrastructure, which employs the Distributed Context eXchange Protocol (DCXP) [9] which coexists and cooperates with 3G IMS (see Fig. 1). DCXP adheres to principles of SIMPLE for event notifications and utilizes an underlying Distributed Hash Table (DHT) as a registry for references to context information. Context sharing via DCXP circumvents severe limitations with IMS presence [10] in that the latter (a) causes long response times, (b) imposes a data model which causes excessive overhead when searching and browsing context information, and (c) has scalability problems due to centralized service access.

Sensor agents running in mobile phones connect to and register with a Mobile Sensor Proxy (MSP) in order to participate in the P2P network. Sensor agents also connect to IMS presence in order to make context information available as presence data. The MSP shields the P2P network from the behavior of the radio link, by shielding it from packet loss and other possible disruptions of the communication with the mobile. Nodes in the P2P network with ample resources may offer persistent storage of context information and to perform aggregation and filtering tasks in search and browse operations.

3 Ubiquitous Mobile Awareness Services

We built a prototype of our system and developed a Ubiquitous Mobile Awareness (UMA) application on top of it. The UMA application currently visualizes sensor information related to objects in Google Maps and also alerts the user to changes such as passing of other objects belonging to the user's group. The icon of each mobile user can expand to display sensor values, see Fig. 2.

Using this service, you may position members in groups and query their presence profiles regarding associated sensor data from IMS. With a PC, you may also utilize the extra computing power and larger display to create views with more objects and sensors.

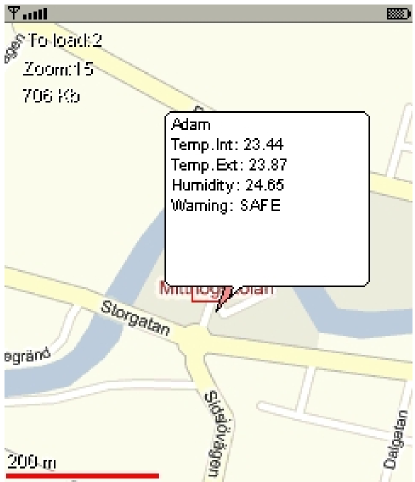

Fig. 2. The user interface of the UMA application

For the design, we used the Ericsson Mobile Java Communication Framework [11], which offers java libraries with SIP support according to JSR281, to create MIDlets that run on top of Sony Ericsson C702, or other Java ME capable mobile phones. We built a wearable bridge to associate WSNs with a mobile phone or any other mobile device with a Bluetooth interface. Our current prototype employs mobile phones which read values from humidity and temperature sensors and forwards these to both a presence server in IMS and a Mobile Sensor Proxy. The mobile phones may also utilize the built-in GPS for positioning.

The wearable bridge can easily be extended to hold more than humidity and temperature sensors, e.g., compass, accelerometers, CO_2, and radiation. Availability of such information enables monitoring of environmental parameters and traffic conditions, etc., and emphasizes the important of sharing of sensor information for creating ubiquitous awareness in on-line communities and mobile applications.

4 Conclusions

In this paper we presented an architecture for the sharing of context information derived from sensor networks wirelessly attached to mobile phones and other devices. The architecture handles frequent updates of sensor information in real time and is interoperable with presence in 3G mobile systems, thus enabling ubiquitous sensing applications in mobile devices for groups and individuals. Our future work will focus on scalable real-time provisioning and distributed storage of multi-dimensional sensor information and exploring its utility in ubiquitous mobile awareness scenarios.

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References

1. Klemettinen, M. (ed.): Enabling Technologies for Mobile Services: The MobiLife Book. John Wiley and Sons Ltd, Chichester (2007)
2. Angeles, C.: Distribution of Context Information using the Session Initiation Protocol (SIP). Master of Science Thesis, KTH ICT school, Stockholm, Sweden (2008)
3. Abdelzaher, T., Anokwa, Y., Boda, P., Burke, J., Estrin, D., Guibas, L., Kansal, A., Madden, S., Reich, J.: Mobiscopes for human spaces. Pervasive Computing 6(2), 20–29 (2007)
4. Hull, B., Bychkovsky, V., Zhang, Y., Chen, K., Goraczko, M., Miu, A., Shih, E., Balakrishnan, H., Madden, S.: Cartel: A Distributed Mobile Sensor Computing System. In: 4th international conference on Embedded networked sensor systems, pp. 125–138. ACM Press, New York (2006)
5. Grosky, W.I., Kansal, A., Nath, S., Liu, J., Zhao, F.: SenseWeb: An Infrastructure for Shared Sensing. Multimedia 14(4), 8–13 (2007)
6. Hjelm, J., Oda, T., Fasbender, A., Murakami, S., Damola, A.: Bringing IMS Services to the DLNA Connected Home. In: Pervasive 2008, 6th International Conference on Pervasive Computing (2008)
7. Krco, S., Cleary, D., Parker, D.: P2P Mobile Sensor Networks. In: HICSS 2005. Proceedings of the 38th Annual Hawaii International Conference on System Sciences, p. 324c (2005)
8. Rosenberg, J.: SIMPLE made Simple: An Overview of the IETF Specifications for Instant Messaging and Presence using the Session Initiation Protocol (SIP). Internet-Draft, IETF SIMPLE Charter (2008)
9. Chazalet, B.: Opportunistic Media Delivery: utilizing Optimized Context Dissemination via the Service Interface in Ambient Networks. M.Sc. Thesis, Royal Institute of Technology (2007)
10. Lin, L., Liotta, A.: A Critical Evaluation of the IMS Presence Service. In: 4th International Conference on Advances in Mobile Computing & Multimedia, pp. 19–28 (2006)
11. Mobile Java Communication Framework. Ericsson Labs Developer, released (November 2008), http://dev.labs.ericsson.net/tiki-view_blog.php?blogId=2&first=1