M2MGen - An Application Generator for Machine to Machine (M2M) Applications

Chanan Glezer[1], Sudha Krishnamurthy[2], Kilian Schloeder[2]
Omer Anson[1] and Gil Tahan[1]

[1]Deustche Telekom AG Labs at Ben Gurion University of the Negev
Beer Sheva 84105, Israel

[2]Deutsche Telekom AG Labs, D-10587 Berlin, Germany

Abstract. This research conceptualizes an architecture (M2MGen) aimed at generating M2M applications as a service offered by a telecommunications network provider. M2MGen employs various plug-ins and knowledge constructs which can be configured to meet requirements of clients from various industry sectors interested in deploying M2M applications. The architecture addresses the following aspects: Data-acquisition Management, Communication Management, Business-service Management and Control Management.

1 Introduction

Machine to Machine (M2M) is a term used to describe the technologies that enable computers, embedded processors, smart sensors, actuators and mobile devices to communicate with one another, take measurements and make decisions - often without human intervention [1].

M2M enabling technologies add value in a variety of application domains. The consumer goods supply-chain (via RFID on UHF bands), homeland-security, facility management, military, automotive industry, and the health care sector have each had major efforts in sensor networking over the past several years and decades [2-4, 8-10].

2 Related Work

In the consumer goods sector, the support of a broad array of major firms such as Wal-Mart, Gillette, and Procter & Gamble has contributed to RFID's momentum and has helped advance the formation of standards via EPCglobal. Both Wal-Mart and the Department of Defense have mandated suppliers to deliver EPC-tagged cases and pallets that are ready for RFID tracking. Broad adoption of case- and pallet-level

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tagging is expected by 2007 or 2008. Forecasts by various market researchers indicate the RFID tracking market will reach more than $4 billion in 2007 [2].

Among the key initiatives of the Homeland Security Agency is to develop a common data highway for a comprehensive set of homeland security sensors. The US DoD's **Global Information Grid (GIG)**[1] has been a major program emphasizing broad use of advanced information technologies (IT) to create "decision superiority" by providing the ability to collect, fuse, process and disseminate an uninterrupted flow of information, command and control.

The automotive industry has historically been a driver of low-cost, rugged sensors. Next-generation sensor systems for automotive applications must operate in an increasingly networked environment. **FlexRay**[2] is a communication system developed by a consortium founded in 2000 by BMW, DaimlerChrysler, Motorola, and Philips Semiconductors that now has nearly all major players in the world committed. FlexRay is designed for the high data transmission rates required by advanced automotive control systems. These systems are expected to replace nearly every hydraulic line and mechanical cable in today's automobiles with wire-based networks.

Devices within the health care system generally do not function as a system - yet in many cases would benefit from such an approach. This creates a number of limitations, including the inability to easily fuse data, share resources, upgrade algorithms, and systematically collect data for further analysis. **CIMIT**[3], a consortium of Harvard teaching hospitals with scientists and engineers from Massachusetts Institute of Technology (MIT) and Charles Stark Draper Laboratory (supported by over 50 major pharmaceutical and medical device firms), is applying a systems perspective and introducing new technologies in re-architecting an array of current medical systems. Specific design goals are for networks that 1) support a variety of devices in a reliable, yet flexible manner, 2) are sufficiently low-cost to make wide deployment feasible, and 3) are sufficiently simple so that they can be installed and used by existing personnel during a medical procedure - all in a way that makes it easy for medical professionals to act on relevant information in real time.

The Facility Management domain and its typical scenarios is the chosen test bed for the proposed M2MGen Platform. Examples of M2M-enabled applications for facility management include Frankfurt's Airport (Fraport) which implemented a new maintenance process replacing the paper-based process with mobile and RFID technology [9]. Fraport's air-conditioning and ventilation system has 22,000 automatic fire shutters and numerous fire doors and smoke detectors. The new system's architecture consists of RFID tags on the fire shutters; mobile devices bundled with an RFID reader and mobile application; and an SAP-based middleware interconnecting with a back-end asset management system. Pakanen et al. [8] proposed a system where a

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[1] http://www.mitre.org/news/the_edge/july_01/miller.html
[2] http://www.vector-imagineering.com/vi_flexray_solutions_en,,223.html
[3] www.cimit.org

microprocessor device interfaced to an Air Handling Unit (AHU). The idea was to observe the recently installed AHU in order to see if it fulfils the requirements set by the customer. The microprocessor device measured temperatures at a number of locations, such as the leaving water temperature of the heating coil, the supply air temperature and the outdoor temperature. Sensor data from the AHU was relayed to the Internet through a Public Switch Telephony Network (PSTN) and GSM networks. In addition, a Web-user interface was created to enable remote control of the AHU. Watson et al. [10] applied M2M technology to five commercial buildings in a test of Demand Responsive (DR) energy management. The goal was to reduce electric demand when a remote price signal rose above a predetermined price. Chow et al. [3] present an RFID based Resource Management System (RFID-RMS). The system is designed to help users to select the most suitable resource usage packages for handling warehouse operation orders by retrieving and analyzing useful knowledge from a case-based repository of solutions in both a time saving and cost effective manner. Jedermann et al. [4] propose a quality index for controlling quality of agricultural products in transit. This index was generated from raw values that could be permanently measured inside a container. These are the environmental conditions like temperature and humidity and gaseous metabolism products like carbon dioxide and ethylene. The autonomous monitoring system for means of transport (MOT) consists of three layers: the *sensor nodes*, an *internal wireless network* and the *assessing unit.*

3 Problem Statement

Forrester Research analyzed the M2M software vendors and categorized them into four broad areas: RFID pure plays, application vendors, platform giants, and integration specialists [6]. Each of these groups has a different focus. Pure plays offer products that integrate with RFID readers, filter and aggregate data, and incorporate business rules. Application vendors market a plethora of RFID-compatible applications from warehouse and asset management to more sophisticated solutions with reader coordination, data filtering, and business logic capabilities. Platform giants are providers of strategic RFID middleware architecture, which leverages the vendors' application development, data management, and process integration products. Finally, integration specialists add RFID capabilities such as reader coordination to their existing technologies.

M2M-enabled applications are typically tailor-assembled per customer by combining instruments from a technological "toolbox" comprising among others: standardized communication protocols, RFID/sensor technologies, and middleware (event processing, billing, integration, and interfaces with legacy enterprise application).
There has been no attempt however to provide a single, generic platform capable of defining, generating, deploying and managing a variety of M2M applications in different application domains (i.e., facility management, transportation and logistics, health, military, automotive, etc.). It is expected that such a model and system can simplify and enhance the efficiency of handling M2M-enabled application especially for Small-Medium Enterprises (SMEs). Such organizations are usually not equipped

with the know-how and experience for handling the complexities in deploying M2M-enabled applications. The goal of this paper is to present a conceptual model of such a platform, namely the M2M application generator (M2MGen) which is currently developed and tested by deploying a variety of scenarios in the area of Facility Management.

4 The M2MGen Architecture

Figure 1 depicts the architecture we propose for an M2M application generator (M2MGen). The architecture comprises of the following three elements in congruence with the above requirements: Data Acquisition, Communication, Business Service and Control Management.

Data Acquisition Managers (DAM) is in charge of importing AIDC data from various readers that interact with a plethora of sensors. The DAM serves as an interface for configuring various AIDC devices (i.e., readers, analogue sensors) and accommodating new devices via a standard API. The DAM communicates with numerous RFID readers and other devices and the information collected about an RFID tag or other devices is then forwarded to the BSM. The DAM resolves the heterogeneity among readers, converting different read records into a single representation.

Communication Manager (COM) is responsible for connecting multiple DAM servers with the BSM. The main purpose of the COM is to mobilize AIDC data, configuration commands, and notifications about situations (business events) across the M2M platform network. The COM supports both wired/wireless communications for long/short ranges across Internet/Intranet/Extranet networking infrastructures.

Business Service Manager (BSM) receives AIDC raw events collected and transmitted by one or more DAMs. The goal of the BSM is to store, process and analyze the AIDC low-level events, thereby inferencing and alerting about new or changing situations (business events) such as equipment malfunctions; transactions; service requests; EPC[4]Global product decoding (lookups). The BSM incorporates knowledge of various kinds to support its functionalities such as: rules for conversion of low-level to business-level events (Complex Event Processing using IBM's AMiT[5]); dependability and failure prediction algorithms (using SHARPE[6]) incorporating thresholds and critical values for alerts with varying urgency-levels; subscription rules for situation notifications propagated to human users ,(facility managers, technicians etc.) and external applications such as Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Customer Relationship Management (CRM), etc. Business events generated by the BSM need to be prioritized and distributed based on the capacities of their subscribers (human and application consumers) to handle the events.

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[4] www.epcglobal.org
[5] http://www.haifa.il.ibm.com/dept/services/soms_ebs.html
[6] http://www.ee.duke.edu/~kst/

Control Manager (CON) is responsible for managing the configuration of the M2M platform, that is, deploying the various managers and incorporating knowledge about the usage scenarios. The scenarios, modeled by defining CEP rules including critical thresholds, are uploaded into the BSM upon deployment of the application instance for each client of the system. The CON can duplicate instances of the managers or employ virtualization technology which enables separation of the three managers

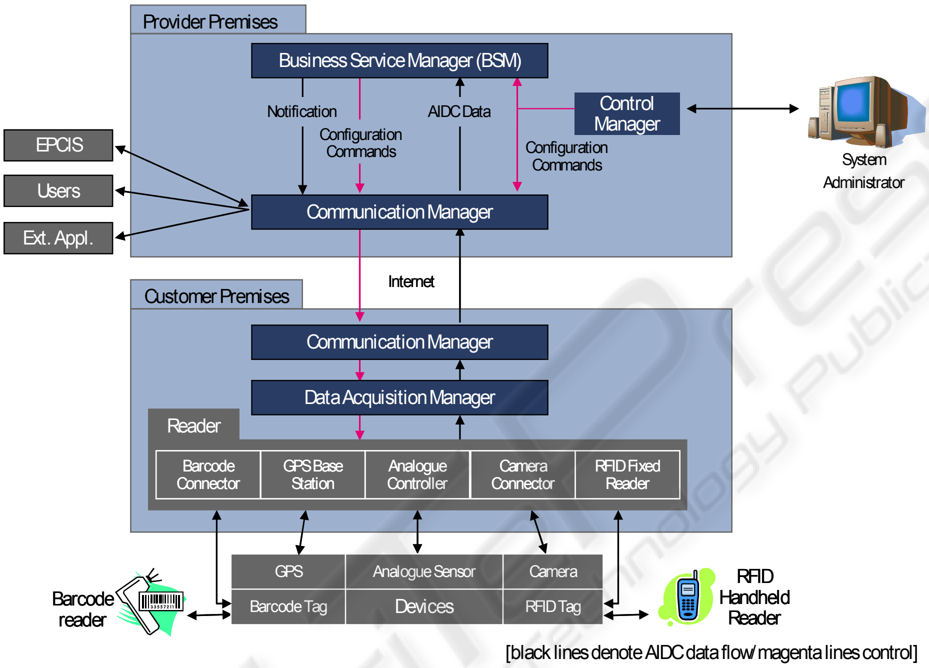

Fig. 1. Architecture of M2MGen Platform.

(COM, BSM, DAM) of different clients on the same physical machine. This later will also provide better security because data of different clients will be separated.
All in all, the M2MGen platform network includes many instances of DAMs. Each DAM instance serves one customer and is connected to its supervising BSM. The CON enables control over a DAM for all clients by using virtualization technology. Each physical DAM server runs multiple logical DAM instances of different customers and CON will depict them as separate DAMs under the menu-tree. The COM and BSM also use distinct logical servers for each client that can also be virtualized on a single physical server for each.

5 Demonstration of the M2MGen Architecture

The M2MGen platform is demonstrated by developing a prototype and deploying on it several scenarios in the area of Facility Management. The scenarios involve typical work activities of in-house and 3rd party service personnel in charge of maintaining technical equipment in office buildings (i.e., HVAC, elevators, electricity, photocopiers, printers, vending machines etc.).

The scenarios include: access management; data logging of maintenance operations on RFID-tagged equipment; inventory control (registration, verification and synchronization with backend legacy systems); remote monitoring and control of analogue sensors (i.e., temperature); over the air software updates; Real-time Location System (RTLS) tracking; and predictive maintenance (to forecast and prevent faults and handle buy vs. fix decisions).
Following is an illustration of a scenario for remote monitoring and control of devices which has been formalized using the Event Condition Action (ECA) notation. The Complex Event Processor attempts to detect whenever the devices in the server room are too hot, and decide by that if the server room itself is too hot. The stages in the scenario are as follows:

Device Alarm
1. A device declares it is too hot. A *lifespan*[7] is initiated. An action could also tell the device to minimize its power usage, and by that reduce the heat it is producing.

2. From here on, there are two possibilities:
(a) Other devices declare overheating. In this case, a *situation* occurs after n such complaints.

> i. After n complaints from devices about overheating, a *situation* occurs. This situation should turn on the air conditioning units in the room, in order to cool it down.
>
> ii. If the devices did not notify that they returned to normal temperature after a specified interval, a second *situation* occurs, which should alarm to add an air-conditioning unit to the room.

(b) The device that declared it is too hot is the only device to declare such an event. In this case, the problem is in the device. A situation occurs, which, by its actions, can

[7] temporal interval during which active behavior is relevant. It is bounded by two events called *initiator* and *terminator*. An occurrence of an initiator event initiates the lifespan and an occu rence of a terminator event terminates it. Lifespans express the temporal perspective of Amit context. (ieeexplore.ieee.org/iel5/8595/27234/01210216.pdf?arnumber=1210216)

alert the need of maintenance to the device, and minimize its power usage, as in stage 1, some more. Perhaps even shut the device down, to avoid damage.

The CEP makes sure that the device does not report twice, and thus confuse the CEP into thinking more machines are overheated.

Device Alarm (ECA notation)
event: deviceOverheat
Type: Input Event
Condition: The device is too hot
Attributes:
deviceID: The ID of the device. Within this ID is incorperated the ID of the room in which the device resides.
event: deviceNoLongerHot
Type: Input Event
Condition: The device is back to normal heat
Attributes:
deviceID: The ID of the device. Within this ID is incorperated the ID of the room in which the device resides.
Actions: Unique
1. Stop the RoomDidntCool alarm
Condition:
1. A device reports that it is no longer hot
Actions: Recurring
1. Sound an alarm
Condition: One of:

1. At least one device stated overheating. Alarm type can be dynamic in accord of the number of overheating devices in room.

The M2MGen Prototype is currently being developed using a plethora of AIDC enabling technologies. The DAM accommodates: standard High-Frequency (HF) and Low-Frequency (LF) proximity readers and a programmable logic controller for the access control scenario; HF analogue temperature sensor and Zigbee motes for the remote monitoring and control scenario; UHF passive and active RFID tags for the data logging and inventory control scenarios. The CON is implemented using Microsoft .Net Framework and the DAM, BSM are implemented using Java. The connectivity between DAM, BSM and CON is provided by the COM and is realized by employing Web services over wired and wireless WAN connections (DSL, cellular).

6 Conclusions

Current RFID developments represent opportunities to smaller manufacturers and other small and medium-sized enterprises (SMEs). Nevertheless, limited budgets, lack of in-house expertise, and lack of access to the newest technologies are but a few of the significant barriers faced by SMEs. Many entrants that are newly thrust into RFID technology assessments and selections view RFID as primarily consisting of only tags and readers. The full scope of technologies often needed to implement RFID, either on the shop floor or throughout a supply chain, is wider and more complex. In addition to tags and readers, SMEs need to consider appropriate sensors, computers, middleware, database systems, enterprise applications, business processes, networking, and business process management tools to fully implement RFID (Montes, et al., 2005).

This research conceptualized a model for a M2M application generator intended to assist SMEs in overcoming the hurdles and complexities of deploying M2M applications in various domains. A detailed design spec has been completed and a prototype of the platform is under development. The prototype will be used to evaluate the feasibility of the proposed model to serve SME clients interested in leveraging M2M solutions. The initial scenarios demonstrated and tested are in the domain of Facility Management (i.e., tagged-device data logging, access management, inventory control, etc.).

References

1. G. Allmendinger: The Ubiquity Shift The Age Of Smart Services, Presentation at M2MExpo Harbor Research (2004).
2. J. Dexheimer and R. Hannemann: Investement Opportunities in Sensor Networking: Dust, Hype, Fuzz, and Reality, *First Analysis, Physical Sciences Inc., and DS3 Partners*.
3. H. K.H. Chow , King Lun Choya, , W.B. Lee , K.C. Lau: Design of a RFID case-based resource management system for warehouse operations*, Expert Systems with Applications,* 30, 561–576 (2006).
4. R. Jedermann, C. Behrens, D. Westphal and W. Lang: Applying autonomous sensor systems in logistics—Combining sensor networks, RFIDs and software agents, *Sensors and Actuators A: Physical,* In Press, Corrected Proof, Available online 13 March 2006,
5. G. Lawton Machine-to-machine technology gears up for growth, *Computer*, 37 (9), 12- 15 (2004).
6. S. Leaver et al.: Evaluating RFID Middleware: Picking The Right Solution For Integrating RFID Data Into Business Applications, Forrester Research Inc (2004).
7. S. Montes, L. Astor, T. Rhoades, D. Caprio, C. Londono, S. Millick, B. Vickery, J. Ng: Radio Frequency. Identification. Opportunities and Challenges in Implementation”. *Technical Paper,* Department of Commerce. Washington D.C.. (2005).
8. J.E., Pakanen, K. Hakkarainen, K. Karhukorpi, P. Jokela, T. Peltola, J. Sundström: A Low-Cost Internet Connection for Intelligent Appliances of Buildings, *Electronic Journal of Information Technology in Construction*, 7, 45(2002).
9. C. Legner, F.Thiesse, "RFID-Based Facility Maintenance at Frankfurt Airport," *IEEE Pervasive Computing* ,vol. 05, no. 1, 34-39 (2006).
10. D. S. Watson, M. A. Piette, O. Sezgen, and N. Motegi, Machine to Machine (M2M) Technology in Demand Responsive Commercial Buildings, Proceedings from the *ACEEE 2004 Summer Study on Energy Efficiency in Buildings: Breaking out of the Box*, August 22-27 (2004).