

A Reflective Middleware for Controlling Smart Objects from Mobile Devices

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Outline

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Motivation

- Latest mobile devices used mainly for communication, entertainment or as electronic assistants
- However, their increasing:
 - Computational power
 - Storage
 - Communications (Wi-Fi, Bluetooth, GPRS)
 - Multimedia capabilities (Camera, RFID reader)
 - Extensibility
- Ideal to act as intermediaries between us and the environment:
 - Aware (Sentient) Devices
 - Powerful devices
 - Always with us anywhere at anytime
- **Our mobile devices can turn into our personal butlers**

Motivation



- Our goals are to **build Smart Spaces** and **transform mobile devices into Universal Remote Controllers** of Anything Anywhere at Anytime
 - Mobile devices equipped with Bluetooth, cameras, barcode or RFID are sentient devices
 - <http://www.ctme.deusto.es/mobilesense>
 - A **Smart Space** is a container, either indoors or outdoors, of Smart Objects
 - A **Smart Object** is an everyday object (e.g. door) or device augmented with some computational service.
- Definition of suitable AmI architectures may be a good starting point to make AmI reality



EMI²lets Platform I

- EMI²lets is a middleware to facilitate the development and deployment of mobile context-aware applications for AmI spaces.
- This software platform provides the infrastructure to:
 - convert physical environments into AmI spaces
 - augment daily life objects with computational services
 - transform mobile devices into remote controllers of those Smart Objects



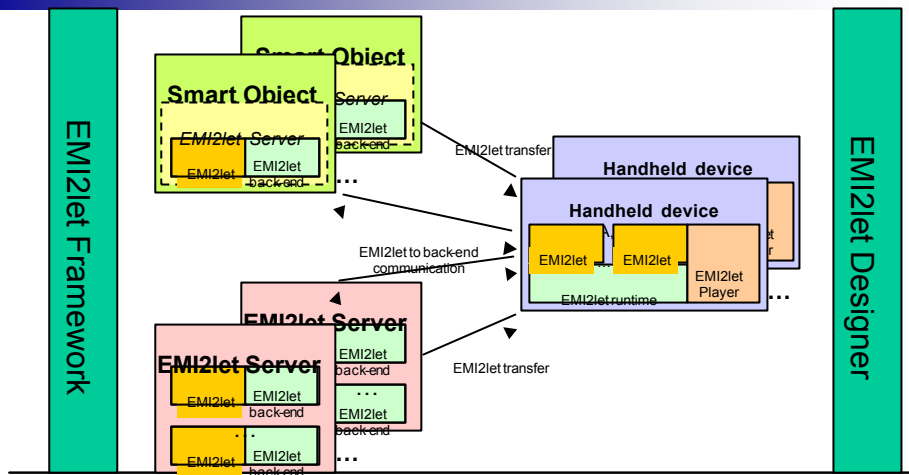
EMI²lets Platform II

- EMI²lets is an AmI-enabling middleware
 - addresses the **service discovery and interaction** aspects required for **active influence** on EMI²Objects
- Follows a Jini-like mechanism and Smart Client paradigm
 - once a service is discovered, a proxy of it (an EMI²let) is downloaded into the user's device (EMI²Proxy).
 - An **EMI²let** is a mobile component transferred from a Smart Object to a nearby handheld device, which offers a graphical interface for the user to interact over that Smart Object

Design Objectives

1. Transform mobile devices into remote universal controllers of Smart Objects
2. Enable local (Bluetooth, Wi-Fi) and global access (GPRS/UMTS) to Smart Objects
3. Develop middleware independent of a particular discovery or interaction mechanism.
 - Abstract the programmer from the several available discovery (Bluetooth SDP or wireless UPnP discovery) and interaction mechanisms (RPC or publish/subscribe).
 - Allow this middleware to easily adapt to newly emerging discovery (e.g. RFID identification) and interactions means
4. Make use of commonly available hardware and software features in mobile devices
5. Generate software representatives (proxies) of smart objects which can be run in any platform
 - **“write once run in any device type”** philosophy

EMI²lets Deployment



EMI²lets Platform Deliverables

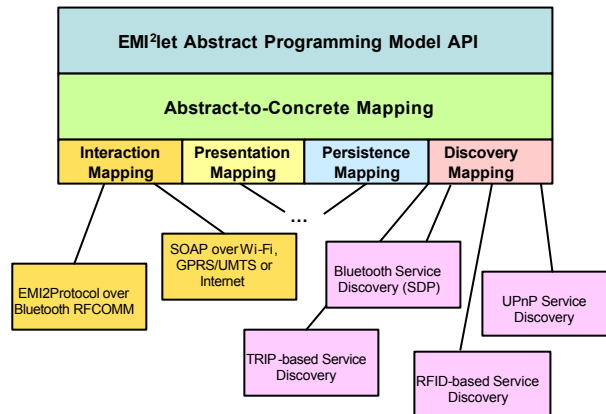
- The EMI²lets platform consists of the following elements:
 - A programming framework
 - An integrated development environment, named EMI²let Designer
 - A runtime environment installed on EMI²let-aware devices for executing downloaded code.
 - An EMI²let Player to discover, download, verify and control the execution life of a downloaded EMI²let.
 - An EMI²let Server which acts as repository of EMI²lets and as running environment of EMI²lets server-sides

Does it work?

Line	Configuration
10000PC	2.3
10001PC	AND 015
10002PC	3.7
10003PC	316 030
10004PC	3.7
10005PC	316 314

from Mobile Devices

EMI²lets Internal Architecture



EMI² Internals

- 3-tier software architecture
- EMI² framework defines **4 programming abstractions**:
 - Discovery
 - Communication
 - Presentation
 - Persistency
- An **EMI²let plug-in** = abstraction implementation
 - Common plug-ins: Bluetooth, Wi-Fi, UPnP
 - Special purpose: TRIP (Target Recognition using Image Processing)
- **Assembly fusion** at runtime
 - Reflection does the magic!!!

EMI²lets Implementation

- Reflection is used to verify that the code arriving as part of an EMI²let complies with the EMI²lets framework and can be trusted.
- The EMI²let base class defines a set of methods that rule the life cycle of an EMI²let:
 - Start, Pause, Destroy, NotifyDisconnected
- ... and its metadata:
 - GetUUDI
 - SetProperty/GetProperty
 - GetAddresses
- The binary code downloaded is linked dynamically (late bound) with the runtime installed in the target device
- Our first implementation has been done in .NET available for PC, PDA and Mobile Phone

TRIP EMI²let Plug-in



- 2-D barcode with ternary code (<http://www.ctme.deusto.es/trip>)
- 4 20 bit **code encoding rings**:
 - 1 sector synchronisation
 - 2 for even parity checking
 - $15^{17} = 98526125335693359375 = 2^{66}$ codes
- Applied to:
 - Encode 48 bit BLUETOOTH_ADDR
 - 8 character <http://tinyurl.com> addresses
 - <http://tinyurl.com/8ggaj> <-->
<http://wap.deusto.es>



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Conclusion

- EMI²lets = middleware providing universal active influence to mobile devices over Smart Objects:
 - Transforms mobile devices into universal remote controllers.
 - Enables both local and global access to those Smart Objects (anywhere/anytime).
 - Independent and extensible to the underlying service discovery and interaction, graphical representation and persistence mechanisms.
 - Enables AmI spaces using conventional readily-available hardware and software.
 - Follows a “write once run in any device type” philosophy
- EMI²lets won the Spanish Imagine Cup 2005

López de Ipiña et al. A Reflective Middleware for Controlling Smart Objects from Mobile Devices sOc-EUSAI



Questions



EMI²lets Applications

- We have created EMI²lets for different application domains:
 - Accessibility: blind (bus stop), deaf (conference)
 - Home/office automation: comfort (lights), entertainment (WMP), surveillance (camera)
 - Industry: robot
 - Public spaces: restaurant, parking, airport