A solution for heterogeneous domotic systems integration

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The context

*Domotics Laboratory* at I.S.T.I. (Institute of Science and Information Technologies of the National Research Council of Italy– Pisa)
Summary

- The Domotics
- Problems
- The solution
- The details
- The future
What is domotics?

• New technologies for integrating all house devices in one system in order to achieve home and buildings automation and smart houses

• Advantages:
  • Comfort (Wellness)
  • Security, intended as "safety" or as "security"
  • Increased independence (for elderly and disabled people)
  • Energy saving
  • Entertainment
  • Remote Control
  • Access to external services
Domotic middlewares

- A set of hardware/software technologies to build-up working home networks and applications
- Using different communication standards (Ethernet, FireWire, Bluetooth, Wi-Fi, dedicated buses, etc…)
- Promoted by different consortia and typically constitute proprietary standards
- Konnex, EIB, BatiBUS, EHS, X10, CEBus, LonWorks, HAVi, Jini, OSGi, UPnP
Why the domotic doesn’t take off?

• Because of lack of knowledge often the users are still suspicious of real benefits deriving from domotic devices and installations
• Too many domotic middlewares and lack of a universally recognized domotic standard
• Little interoperability between different middlewares
• Too many standards drive up costs
History repeating…

• ICT market situation in ‘70s/’80s
  – Many proprietary network protocols… then
    → Introduction of TCP/IP the standard
  – Many database protocols … then
    → Introduction of ODBC
  – Video tape many proprietary … then
    → Introduction of VHS

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A possible solution

- Building an infrastructure based on standard technologies independent of all domotic middlewares

- Developing a standard formalism to convoy information on this infrastructure, to guarantee the comprehension between all domotic devices
DomoNet Framework

- Based on a Service Oriented Architecture (SOA) model, in which services coincide with devices’ functionalities
- Using the emergent standard communication paradigm in distributed SOA domain: Web Services
- Using a univocal formalism: DomoML (Domotic Markup Language)
DomoNet: protocol stack

- TCP/IP
- Web Services
- DomoML
DomomL

• An XML standard grammar that aims to become the universal language in every domotic context
• As generic as possible
• A sort of *lingua franca* between entities in the *DomoNet* infrastructure
DomoML

- The grammar specifications have been defined.
- An example of the grammar, in order to set up DomoNet prototype, has been implemented.
- The complete implementation should be realized after an agreement between the most important household appliance producers.
DomoNet

Jini

X10

UPnP

Konnex

Lon

HAVi

DomoNET

JiniManager

X10Manager

UPnPManager

HAViManager

LonManager

KNXManager

DomoNet
DomoNet: from up above

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DeviceWS: Device Web Service

• It manages a specific device category (Lighting, Heating, Safety, etc…)

• It has a standard service interface and useful data structures

• It uses an addressing mechanism in order to identify the devices in DomoNet

• It exposes the devices it manages, to all domotic middlewares in a standard way
TechManager

- The software module working as an *application gateway* between a domotic middleware and the *DomoNet* framework
- Installed on a computer with interfaces towards both the domotic middleware and DomoNet
- Translating the standard formalism *DomoML* in the formalism of the middleware which is related to, and vice versa
- Its implementation can be partially automated through the use of XML-Schemas of DomoML
DomoNet: the first prototype

- The prototype managed only *Lighting* devices
- It considered 3 domotic middlewares (**Konnex**, **UPnP** and **X10**)
- It was composed by:
  - three *TechManagers* developed on different platforms (**Java** and **.NET**)
  - a *DeviceWS* (**LightsWS**)
  - a *web interface* and a *mobile application* at **DomoNet / DeviceWS-level**
The evolution: a typical flat has been simulated using several standards

The entrance
Mutimedia integrated in the system
Kitchen and bathroom
The bedroom
Old projects where we have used Domonet

• Integration with other research projects of the Domotics Laboratory (i.e. NICHE – http://niche.isti.cnr.it)

• Use of new Web Services standards (WSE 3.0)

• Development of more friendly interfaces for mobile devices

• Integration with PUC (Personal Universal Controller) research project (http://www.pebbles.hcii.cmu.edu/puc/ – Carnegie Mellon University)
Current project where Domonet is used

- **DAGON** (Domotics and Automation Government and Orchestration Network) - Project aimed to develop and install domotic systems in the marine area
  - Nextworks s.r.l.
  - Wonder-sys
  - Life Troni
  - Promi
  - ISTI-CNR “Laboratorio di domotica)
Thank you
More details
The interaction model

The generic *TechManager* retrieves *DomoNET* Web Services (*DeviceWSs*), through UDDI.

It can invoke the standard services that *DeviceWSs* expose, to:

1) register itself to interesting *DeviceWSs*,

2) export to *DomoNet* the network configuration of its domotic middleware,

3) obtain the devices managed by each *DeviceWS* which it is registered to,

4) update the entire domotic network topology, through the virtualization of all the devices previously obtained.
Devices’ interaction

At runtime, each middleware has a set of real and virtual devices.

Use of mapping structures both in TechManagers and DeviceWSs.

The Domonet framework intermediates the interactions between devices belonging to different middlewares.
DomoNet: the prototype

Mobile Interface

UPnP

LightsWS

Web Interface

KNX®
DomoML: an example

```xml
<?xml version="1.0" encoding="UTF-8"?>
<Device xmlns=http://hats.isti.cnr.it
    xmlns:xsi=http://www.w3.org/2001/XMLSchema-instance
    xsi:schemaLocation="http://hats.isti.cnr.it.xsd">
    <deviceInfo>
        <deviceType>LIGHT_1_0</deviceType>
        <description>description of the device</description>
        <positionDescription>position of the device</positionDescription>
        <manufacturer>manufacturer name</manufacturer>
        <manufacturerUrl>URL to manufacturer site</manufacturerUrl>
        <serialNumber>manufacturer’s serial number</serialNumber>
    </deviceInfo>
    <servicesList>
        <service>
            <name>GET_STATUS</name>
            <description>
                Command to send to request the current status of the device
            </description>
            <outputParameterList>
                <parameter>
                    <name>returnedStatus</name>
                    <description>
                        The current status of the device
                    </description>
                    <type>_STRING</type>
                    <allowedValues>
                        <anyType xsi:type="xsd:string">ON</anyType>
                        <anyType xsi:type="xsd:string">OFF</anyType>
                    </allowedValues>
                </parameter>
            </outputParameterList>
        </service>
    </servicesList>
</Device>
```
DomoML: an example (2)

```xml
<service>
  <name>SET_STATUS</name>
  <description>
  Command to change the status of the device to ON or OFF
  </description>
  <inputParameterList>
    <parameter>
      <name>newStatus</name>
      <description>
      The desired status after the call. Possible values are ON and OFF
      </description>
      <type>_STRING</type>
      <allowedValues>
        <anyType xsi:type="xsd:string">ON</anyType>
        <anyType xsi:type="xsd:string">OFF</anyType>
      </allowedValues>
    </parameter>
  </inputParameterList>
</service>
</Device>
```
Konnex components

- Bus Konnex/EIB (TP1)
- BCU (interface between PC and bus via RS232)
- Siemens actuator with 4 exits (4 leds)
- A/C Adapter
- ABB dimmer linked to a bulb
- Siemens 8 push-buttons with IR remote control
Konnex configuration

- **S-Mode** Konnex devices
- **ETS2** software to configure the network
- Translation of ETS2 output into KNXManager input
Konnex configuration

Knx configuration

ETS2

RS232

RS232

Konnex/EIB

KNXManager

KNXConfiguration.xml

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KNXManager

- Developed in Java on Windows platform, using NetBeans 4.1 IDE
- Uses Falcon libraries distributed by Konnex/EIB for bus interaction
- Uses JWSDP 1.5 and Apache Axis 1.2 for the interaction with Web Services
- With a simple user interface
KNXManager software architecture

Bus KNX/EIB

KNXServer

KNXConfigurationParser

KNXDeviceController

KNXLightingController

KNXLightingTranslator

KNXDevice

KNXDeviceController

KNXHeatingController

KNXHeatingTranslator

KNXDevice
UPnP components

• A UPnP control point (Intel DeviceSpy)

• Some UPnP appliances (Intel Light Bulb)
UPnP configuration

- TCP/IP network
- Plug And Play so no need for configuration
UPnPManager

- Developed in C# on the Windows platform with .NET Framework, using Visual Studio .NET 2003 IDE
- Uses UPNP.dll library distributed by INTEL to control devices
- With a simple user interface
TechManagers: user interfaces

KNXManager

UPnPManager

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Test scenario
Reached objectives

• Possible solution to the interoperability problem in domotic domains

• Development of a limited, but wide tested and working prototype

• Demonstration of interoperability between distributed application on different platforms (Java e .NET), using the Web Services paradigm
Possible advances

• New DeviceWSs or creation of general purpose web services? (Audio/Video, white goods, ecc…)
• New TechManagers
• Entities controlling automation at DomoNet level
What else?

- Integration with other research projects of the Domotics Laboratory (i.e. NICHE – http://niche.isti.cnr.it)
- Use of new Web Services standards (WSE 3.0)
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- Integration with PUC (Personal Universal Controller) research project (http://www.pebbles.hci.cmu.edu/puc/ – Carnegie Mellon University)
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