Support of Heterogeneous Domains

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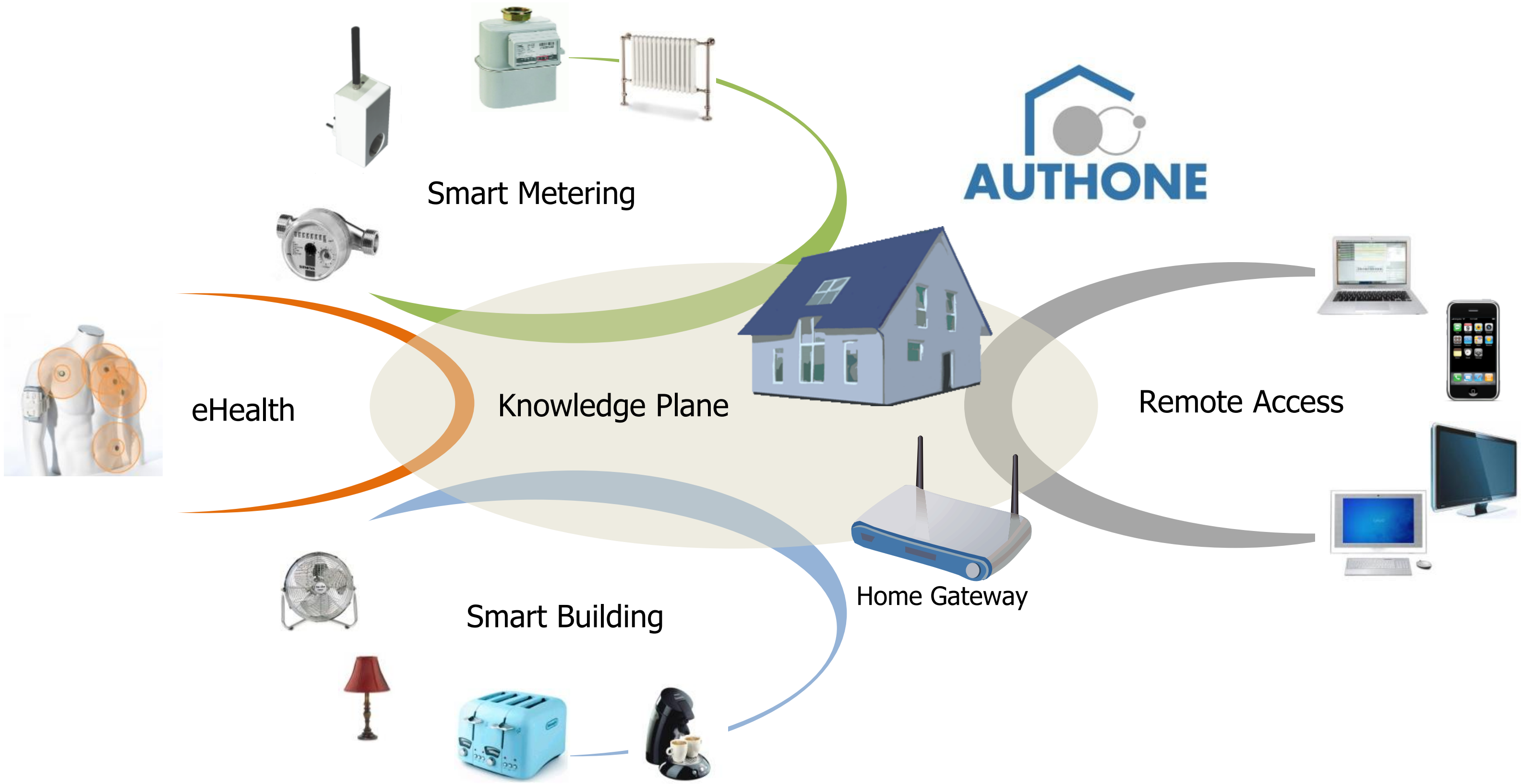
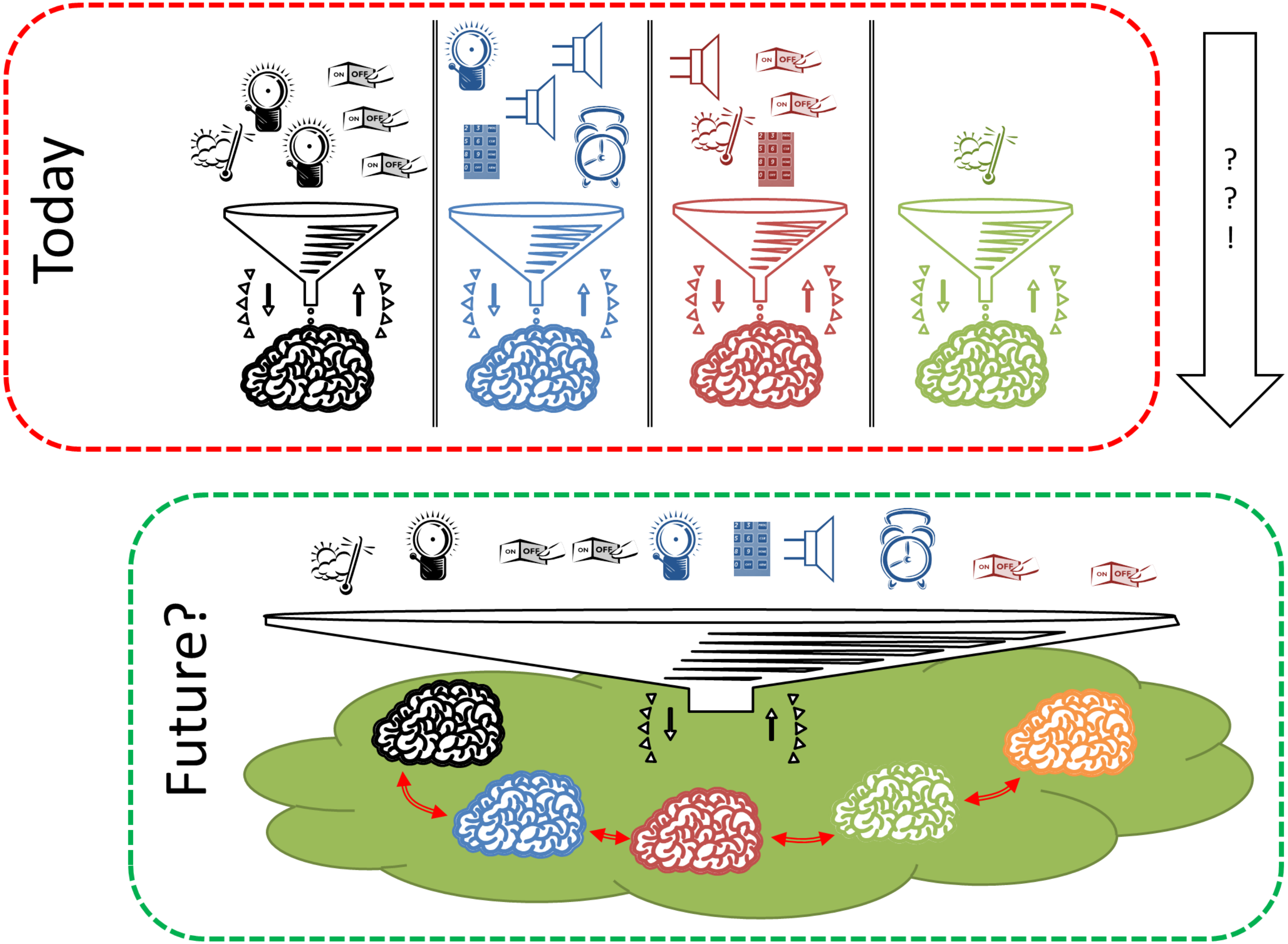
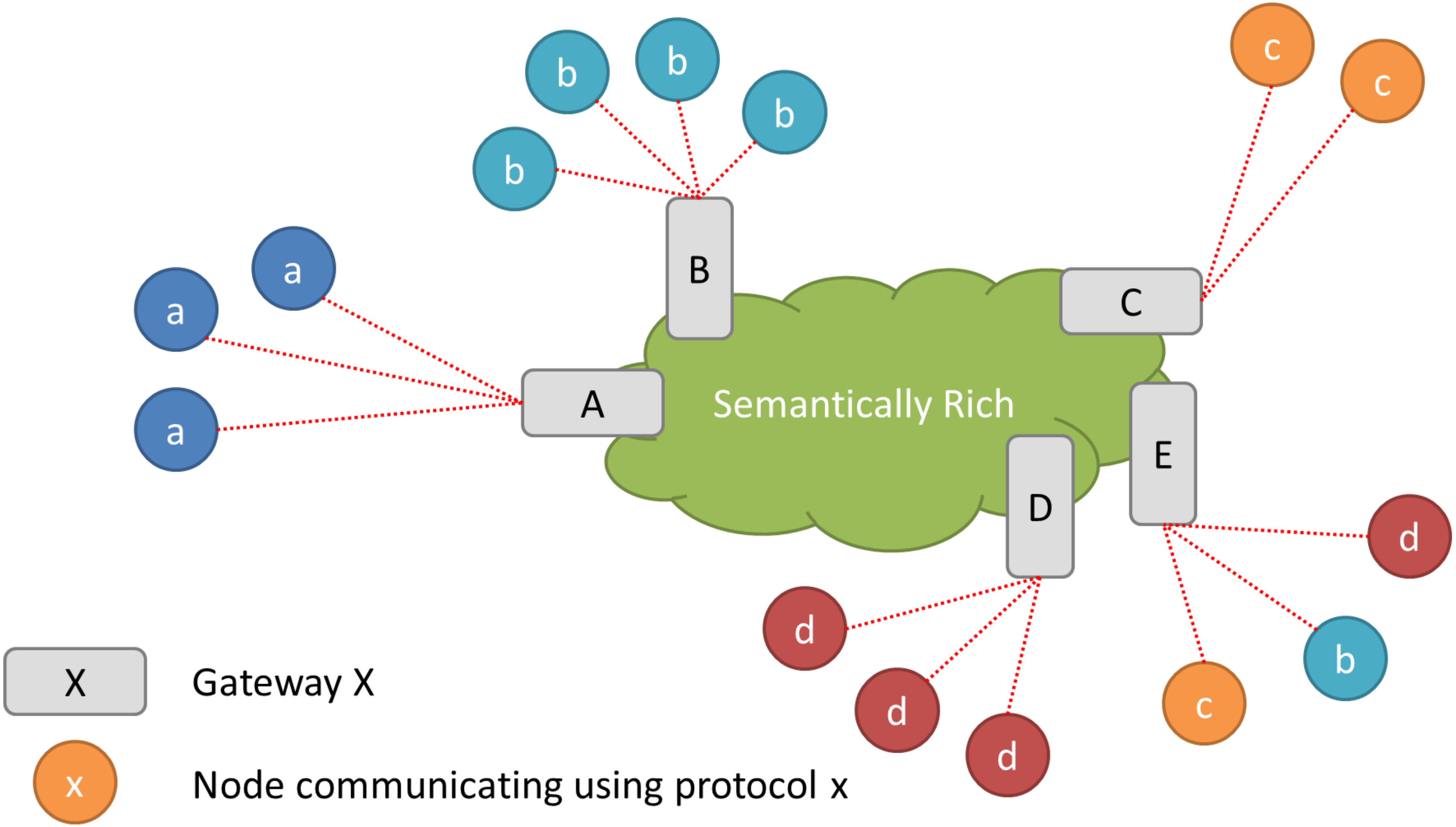
Interconnecting Application Domains



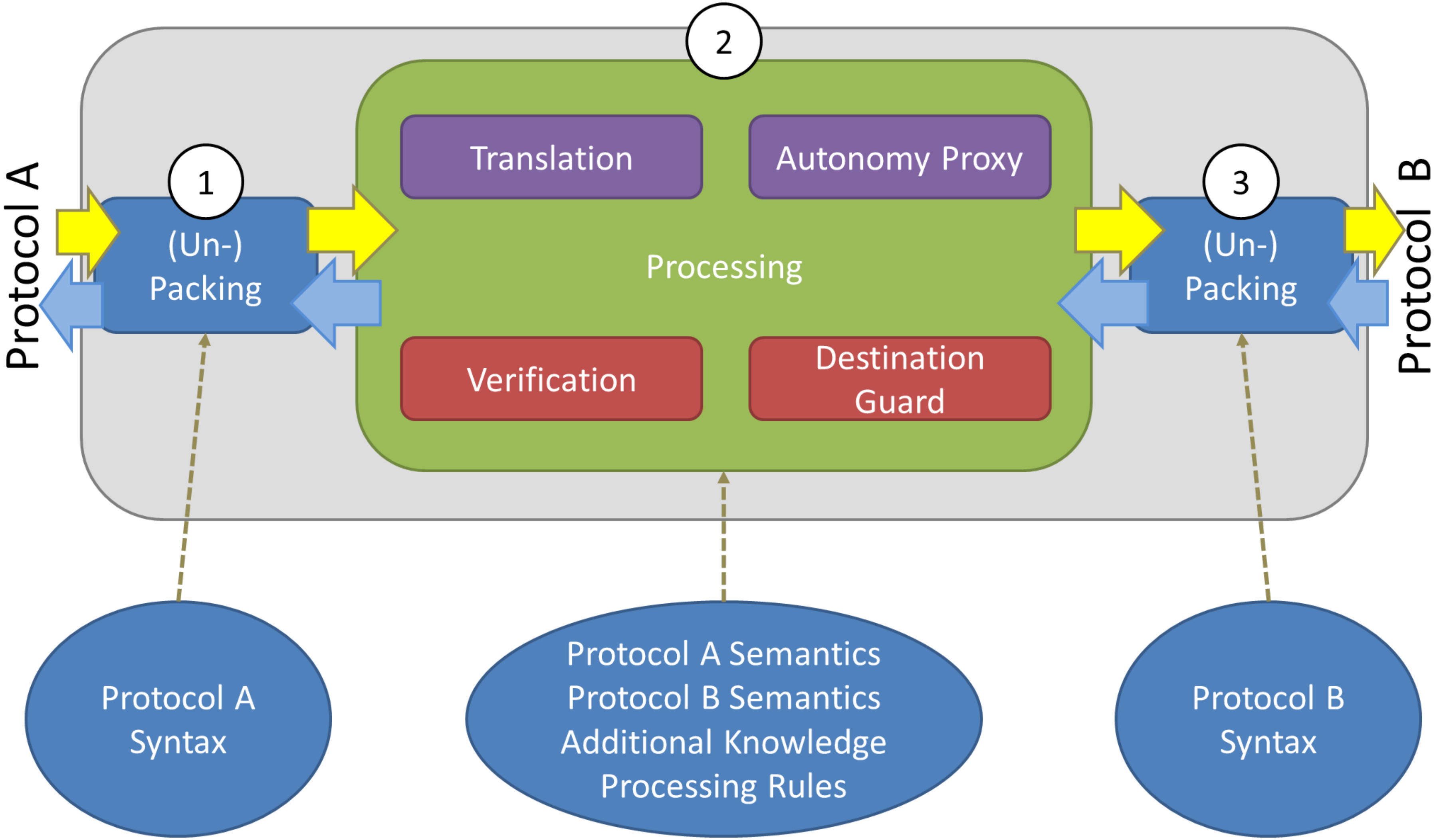
What we have today/ What we want in the future



How we can realize it: gateways



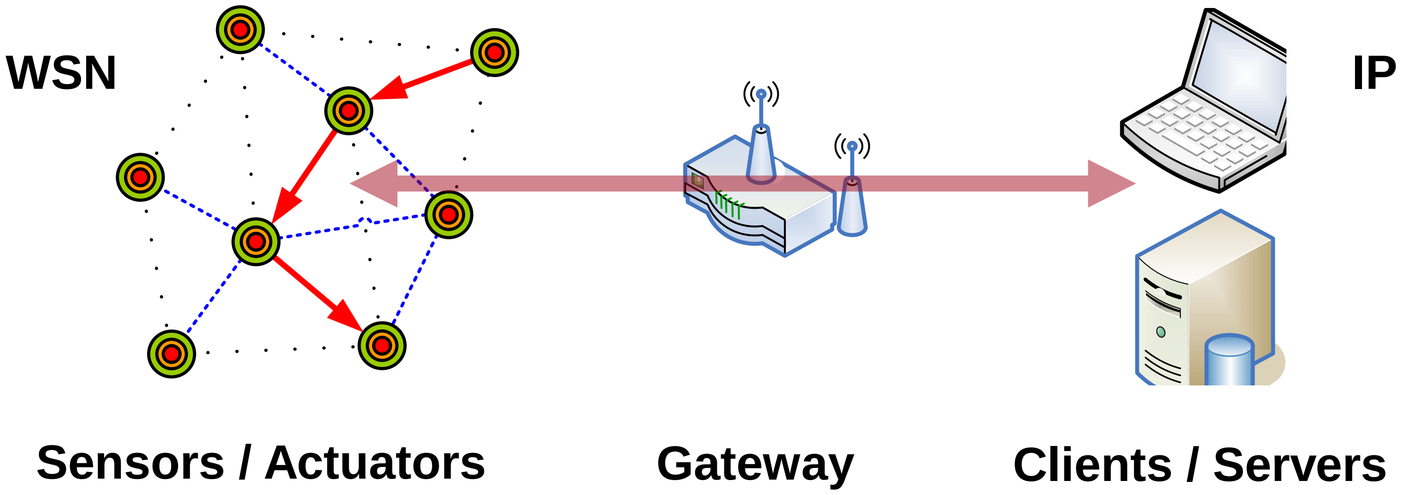
Internal architecture of a gateway



Motivation for Model-based Approach

- **Motivation**: Connecting heterogeneous communication networks
  - Transformation between different message representations
  - Seamless integration of WSN applications with IT domain
  - Support for different (WSN) hardware platforms
- **Approach**:
  - Model-based generation of (WSN) applications
  - Model-based translation of message representations
  - Model-based application-independent components
  - Platform independence (Web-oriented, standard tools)
- **Benefits**:
  - Better time to market (rapid application development)
  - Minimization of bugs at development time
  - Reuse of mechanisms and components (“services”)

Problem: Heterogeneous Networks and Hardware



- ❑ Gateway: application specific (high CAPEX / OPEX)
- ❑ Messaging: network-specific
  - ▪ WSN → simple (binary) representation
  - ▪ IP → rich (XML or SQL) representation
- ❑ Integration of new domains requires new gateways
- ❑ Transformation between formats has to be done “manually”

Approach: Model-based Message Bridge

- Characteristics of model-based approach
  - Provides a common design environment
  - Locate and correct errors early in system design
  - Design reuse, e.g. for upgrades, is facilitated
- Concept of model-based message bridge
  - Domain adapters: model-based transformation between internal message format and domain format
  - Inter-domain routing: dispatching of messages to several different domains supported
  - Model repository: provides model description for different tools
- Major benefits:
  - No application specific gateway necessary
  - Multi-domain bridge avoids tunneling of messages
  - Modular structure facilitates extensions for new domains

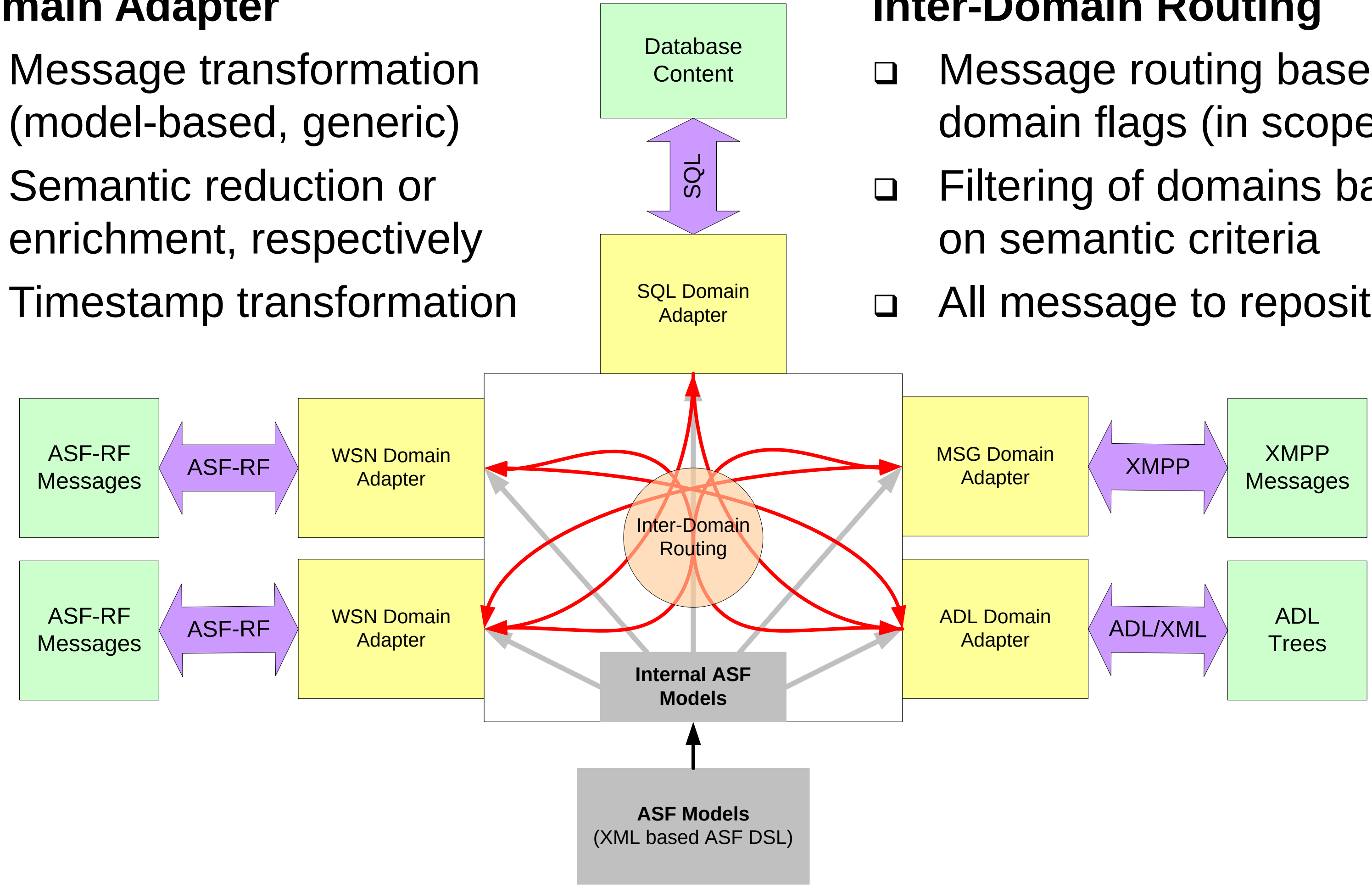
Solution: Extensible Message Bridge

Domain Adapter

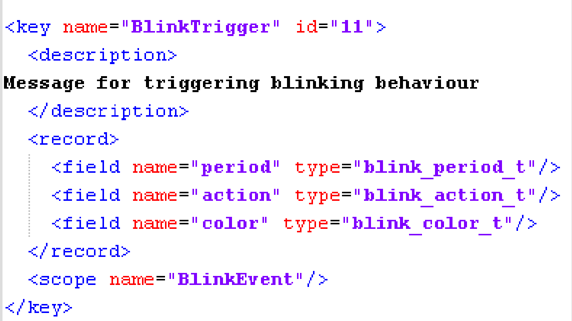
- Message transformation (model-based, generic)
- Semantic reduction or enrichment, respectively
- Timestamp transformation

Inter-Domain Routing

- Message routing based on domain flags (in scope)
- Filtering of domains based on semantic criteria
- All message to repository



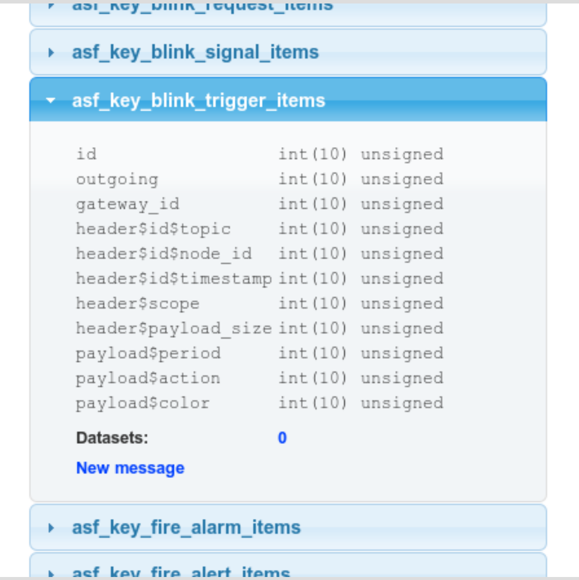
Demonstrator – Message Formats



```
<key name="BlinkTrigger" id="11">
  <description>
Message for triggering blinking behaviour
  </description>
  <record>
    <field name="period" type="blink_period_t"/>
    <field name="action" type="blink_action_t"/>
    <field name="color" type="blink_color_t"/>
  </record>
  <scope name="BlinkEvent"/>
</key>
```

ASF XML

- ❑ ASF model specified in XML
- ❑ Model checking by ASF Parser (impl. in Python)
- ❑ Stored in Model Repository (MySQL database)
- ❑ Transformed into:
  - nesC struct (for TinyOS)
  - Plain text (for XMPP)
  - ADL XML (for ADL Knowledge Agent)
- ❑ Model Repository used by:
  - ASF Bridge
  - ASF Web Server



- asf_key_blink_request_items
- asf_key_blink_signal_items
- asf_key_blink_trigger_items

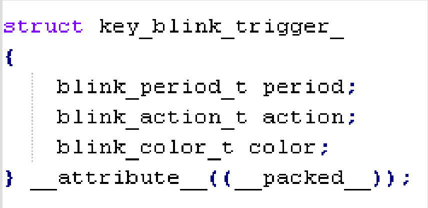
```
id                  int(10) unsigned
outgoing            int(10) unsigned
gateway_id          int(10) unsigned
header$id$topic     int(10) unsigned
header$id$node_id   int(10) unsigned
header$id$timestamp int(10) unsigned
header$scope        int(10) unsigned
header$payload_size int(10) unsigned
payload$period      int(10) unsigned
payload$action      int(10) unsigned
payload$color       int(10) unsigned
```

Datasets: 0

New message

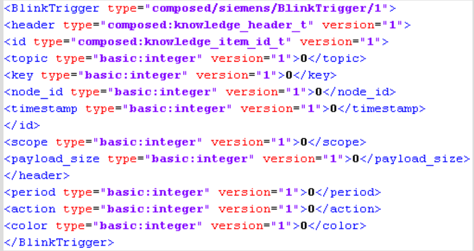
- asf_key_fire_alarm_items
- asf_key_fire_alert_items

Database (SQL)



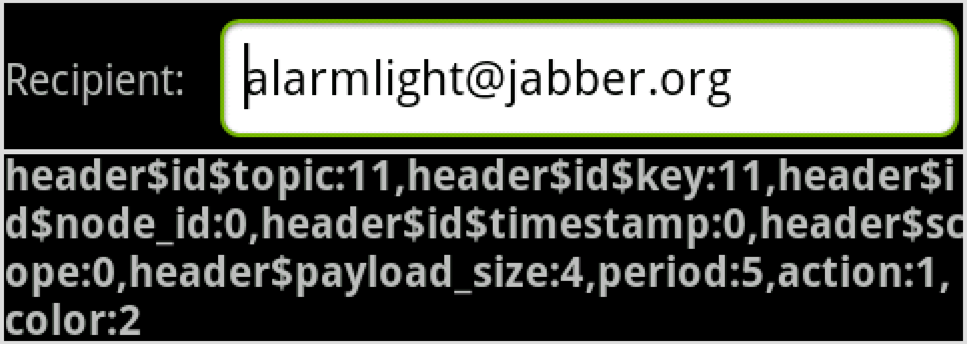
```
struct key_blink_trigger_
{
    blink_period_t period;
    blink_action_t action;
    blink_color_t color;
} __attribute__((__packed__));
```

nesC (TinyOS)



```
<BlinkTrigger type="composed/siemens/BlinkTrigger/1">
<header type="composed:knowledge_header_t" version="1">
<id type="composed:knowledge_item_id_t" version="1">
<topic type="basic:integer" version="1">0</topic>
<key type="basic:integer" version="1">0</key>
<node_id type="basic:integer" version="1">0</node_id>
<timestamp type="basic:integer" version="1">0</timestamp>
</id>
<scope type="basic:integer" version="1">0</scope>
<payload_size type="basic:integer" version="1">0</payload_size>
</header>
<period type="basic:integer" version="1">0</period>
<action type="basic:integer" version="1">0</action>
<color type="basic:integer" version="1">0</color>
</BlinkTrigger>
```

ADL XML

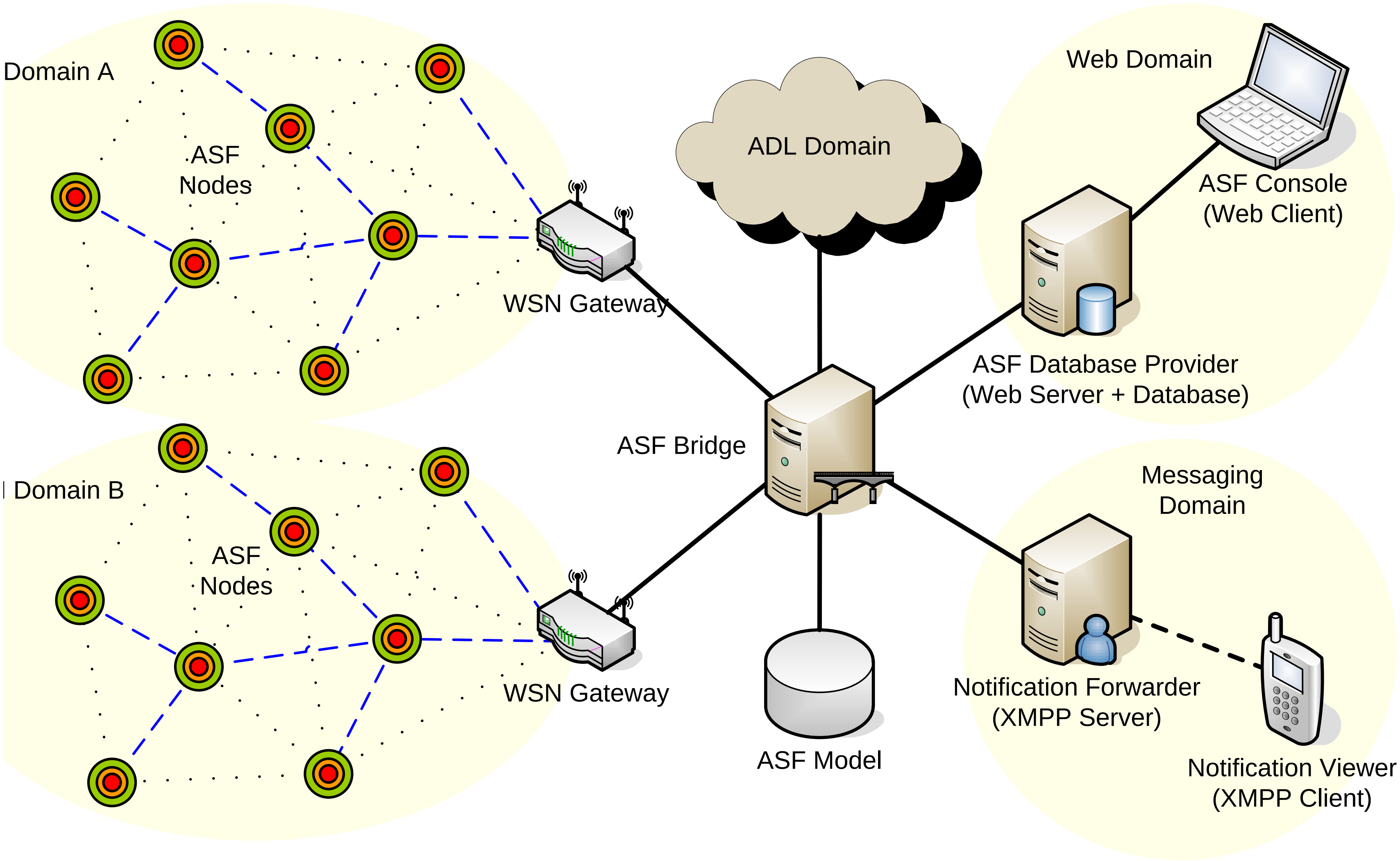


Recipient: alarmlight@jabber.org

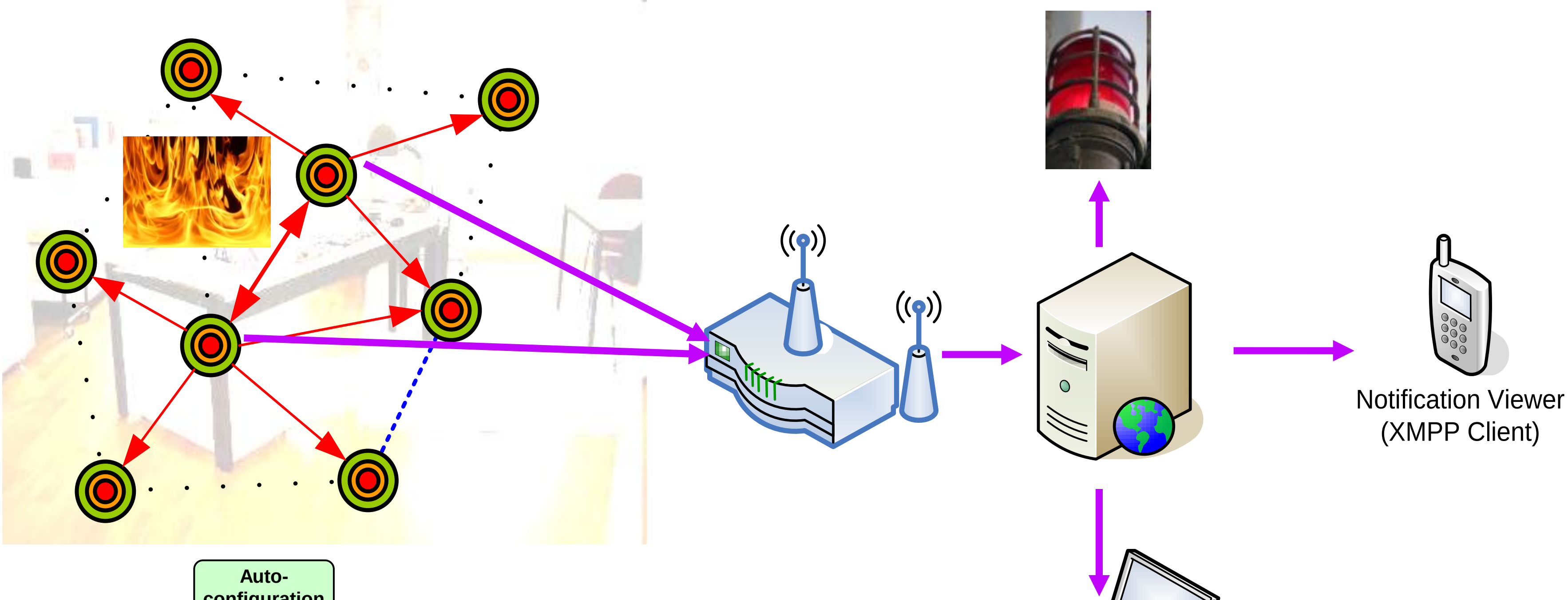
```
header$id$topic:11,header$id$key:11,header$i
d$node_id:0,header$id$timestamp:0,header$sc
ope:0,header$payload_size:4,period:5,action:1,
color:2
```

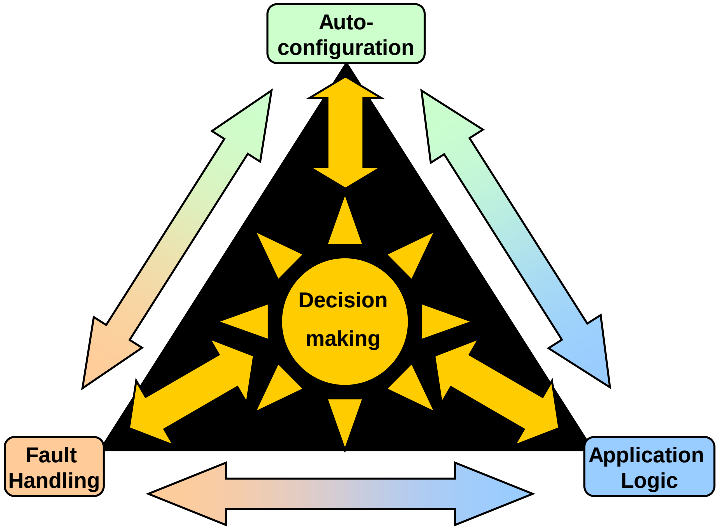
XMPP

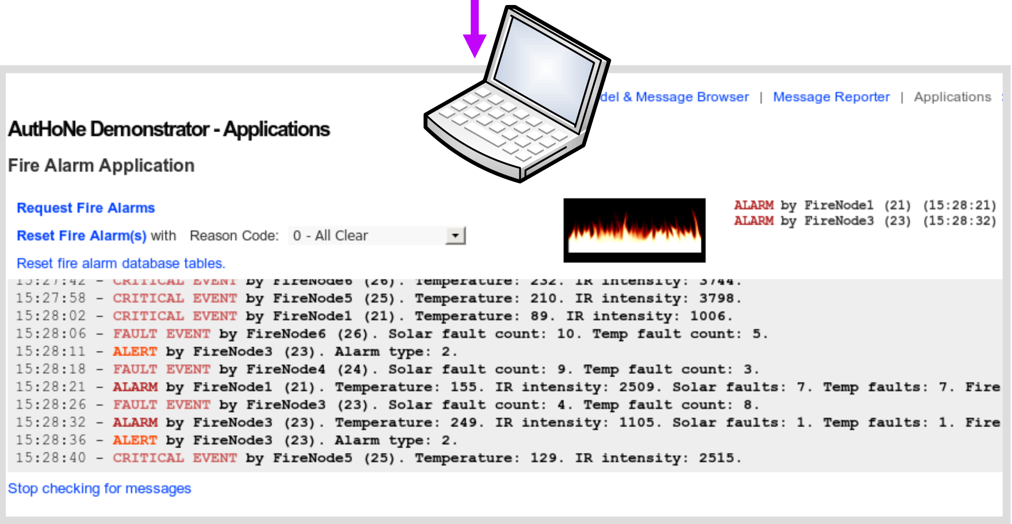
Demonstrator System Architecture



Demonstrator – Fire Alarm Application







del & Message Browser | Message Reporter | Applications

AutHoNe Demonstrator - Applications

Fire Alarm Application

Request Fire Alarms

Reset Fire Alarm(s) with Reason Code: 0 - All Clear

Reset fire alarm database tables.

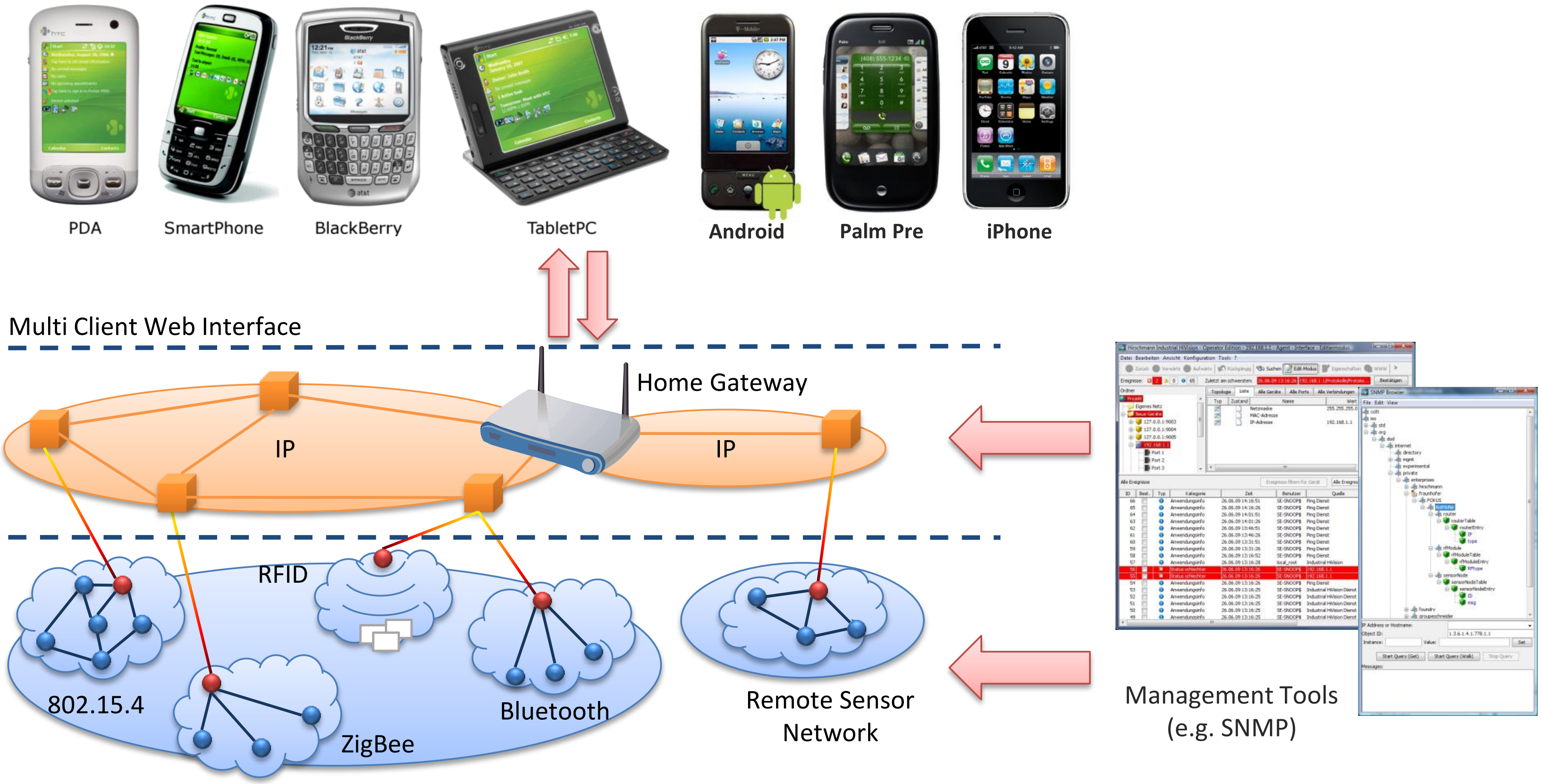
```
ALARM by FireNode1 (21) (15:28:21)
ALARM by FireNode3 (23) (15:28:32)
```

```
15:27:42 - CRITICAL EVENT by FireNode6 (26). Temperature: 232. IR intensity: 3744.
15:27:58 - CRITICAL EVENT by FireNode5 (25). Temperature: 210. IR intensity: 3798.
15:28:02 - CRITICAL EVENT by FireNode1 (21). Temperature: 89. IR intensity: 1006.
15:28:06 - FAULT EVENT by FireNode6 (26). Solar fault count: 10. Temp fault count: 5.
15:28:11 - ALERT by FireNode3 (23). Alarm type: 2.
15:28:18 - FAULT EVENT by FireNode4 (24). Solar fault count: 9. Temp fault count: 3.
15:28:21 - ALARM by FireNode1 (21). Temperature: 155. IR intensity: 2509. Solar faults: 7. Temp faults: 7. Fire
15:28:26 - FAULT EVENT by FireNode3 (23). Solar fault count: 4. Temp fault count: 8.
15:28:32 - ALARM by FireNode3 (23). Temperature: 249. IR intensity: 1105. Solar faults: 1. Temp faults: 1. Fire
15:28:36 - ALERT by FireNode3 (23). Alarm type: 2.
15:28:40 - CRITICAL EVENT by FireNode5 (25). Temperature: 129. IR intensity: 2515.
```

Stop checking for messages

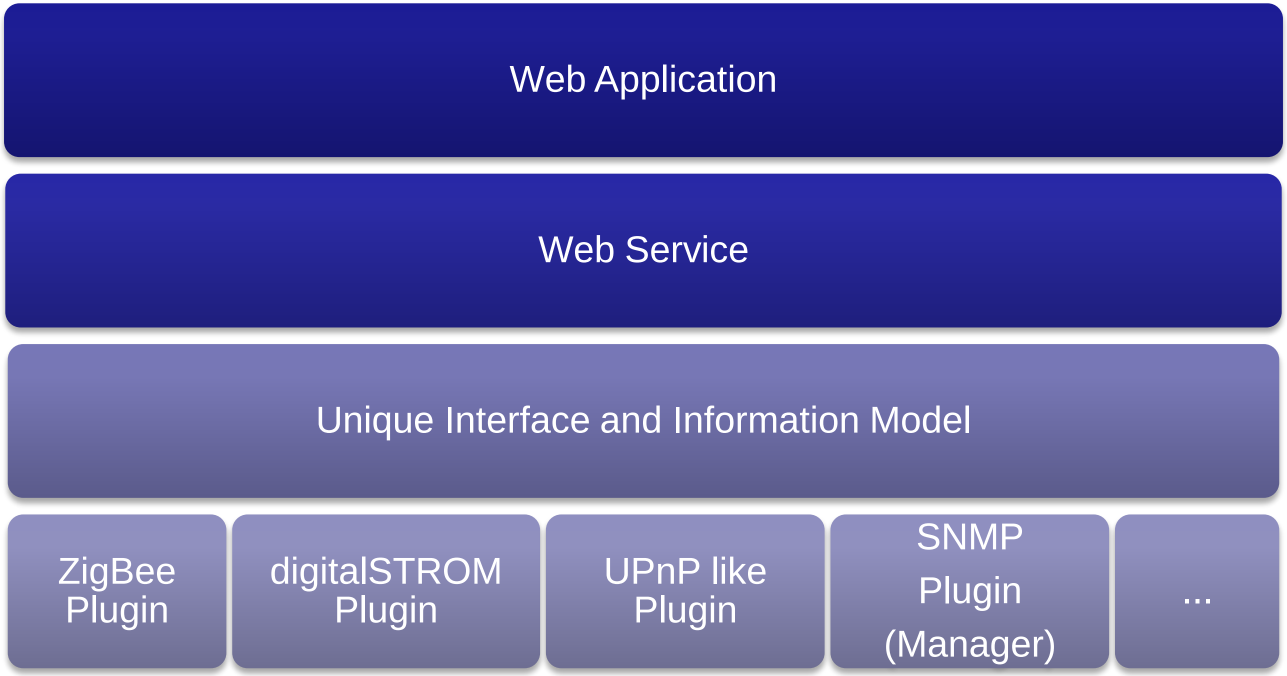
Home Gateway Architecture

- Support for different embedded technologies, IP routing nodes, end devices, and network management tools

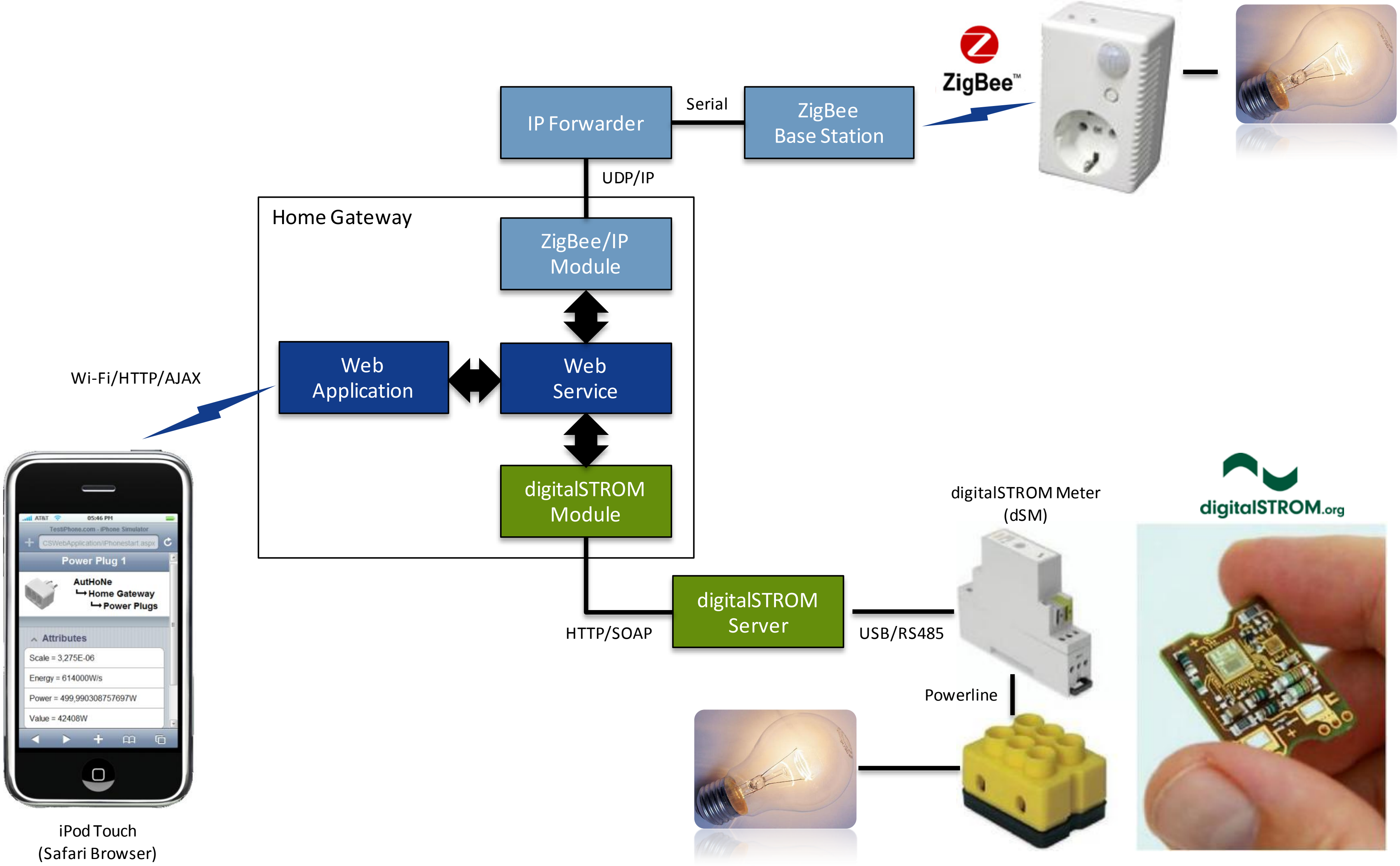


Home Gateway Software Concept

- Layered software architecture design that abstracts from the different technology domains in the network
- Plugins can adapt the technology specific semantic to an unique model provided by an unique interface
- Model is used by Web Service/Web Application for remote access by other services, knowledge entities or end devices



ZigBee and digitalSTROM Support



Power Plug 1

AutHoNe
↳ Home Gateway
↳ Power Plugs

Attributes

Scale = 3,275E-06

Energy = 614000W/s

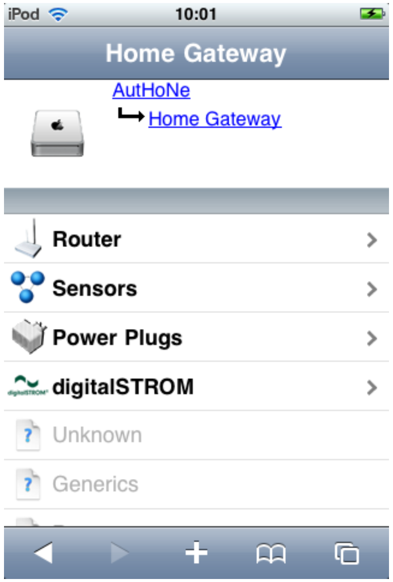
Power = 499,990308757697W

Value = 42408W

AUTHONE

Multi Client Systems

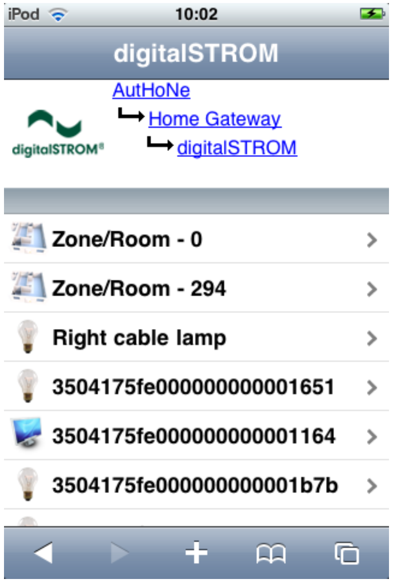
- Remote access to the Home Gateway through iPod/iPhone or other state of the art end devices
- “Multi Client Systems” through different types of Web (2.0) applications in front of the gateway web service
- Enabling rapid development and flexible design to support new device categories


iPod 10:01

Home Gateway

AutHoNe
↳ Home Gateway

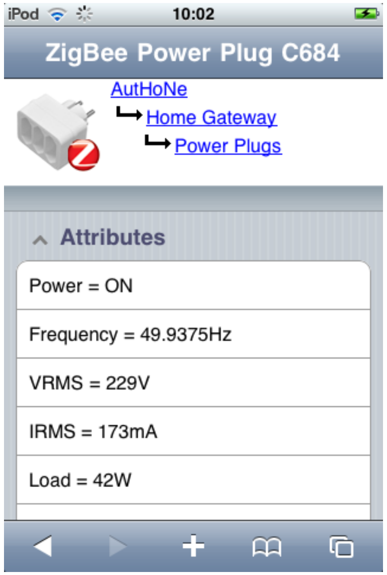
Router ›
Sensors ›
Power Plugs ›
digitalSTROM ›
Unknown
Generics


iPod 10:02

digitalSTROM

AutHoNe
↳ Home Gateway
↳ digitalSTROM

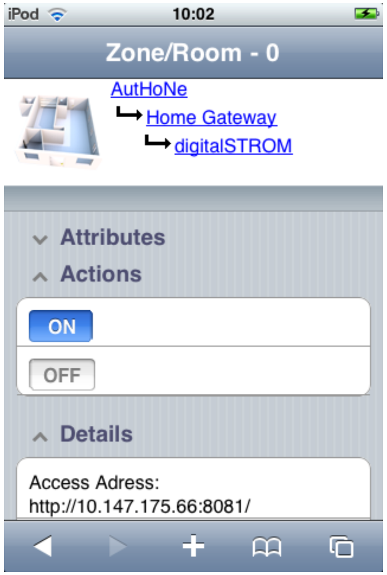
Zone/Room - 0 ›
Zone/Room - 294 ›
Right cable lamp ›
3504175fe000000000001651 ›
3504175fe000000000001164 ›
3504175fe00000000001b7b ›


iPod 10:02

ZigBee Power Plug C684

AutHoNe
↳ Home Gateway
↳ Power Plugs

Attributes
Power = ON
Frequency = 49.9375Hz
VRMS = 229V
IRMS = 173mA
Load = 42W


iPod 10:02

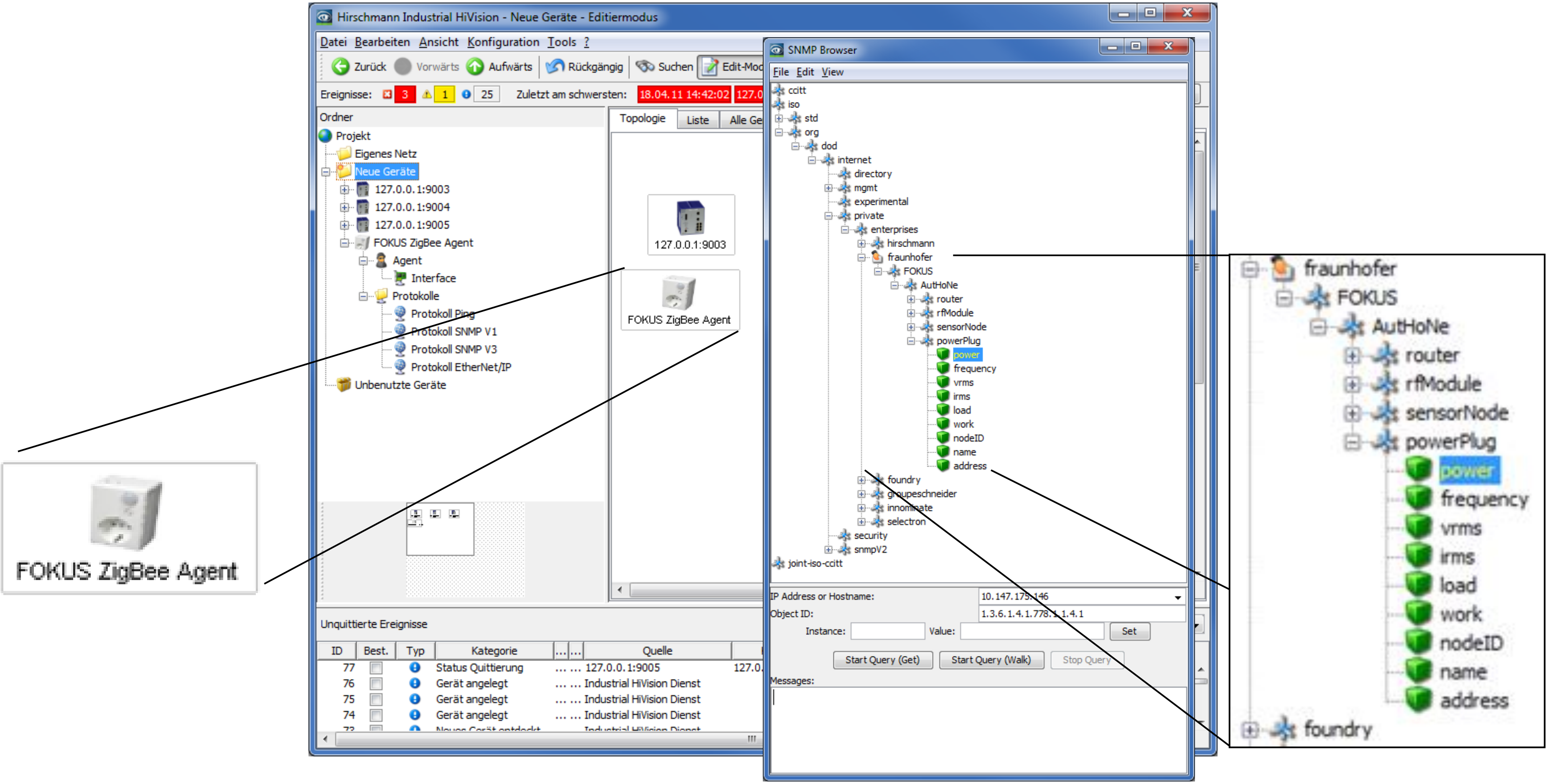
Zone/Room - 0

AutHoNe
↳ Home Gateway
↳ digitalSTROM

Attributes
Actions
ON
OFF
Details
Access Adress:
http://10.147.175.66:8081/

Network Management

- Support of SNMP by a small SNMP-Agent connected to ZigBee
- Hirschmann (former project partner) Industrial HiVision as SNMP Manager that can access ZigBee power plugs with an own MIB



IP Address or Hostname: 10.147.175.146

Object ID: 1.3.6.1.4.1.778.1.1.4.1

Instance:

Value:

Messages:

Unquittierte Ereignisse

ID	Best.	Typ	Kategorie	...	...	Quelle	
77	☐	❶	Status Quittierung	...	...	127.0.0.1:9005	127.0.
76	☐	❶	Gerät angelegt	...	...	Industrial HiVision Dienst	
75	☐	❶	Gerät angelegt	...	...	Industrial HiVision Dienst	
74	☐	❶	Gerät angelegt	...	...	Industrial HiVision Dienst	
73	☐	❶	Neues Gerät entdeckt			Industrial HiVision Dienst	