universAAL Architecture and The Resource Discovery

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Outline

1. Ambient Intelligence and AAL
2. The universAAL EU Project
3. AAL Spaces as Smart Environments
4. Resource Discovery in AAL Spaces
5. Open issues

Ambient Intelligence and AAL

- A recent discipline that aims at providing **context-aware** environment by adding intelligence to our surroundings

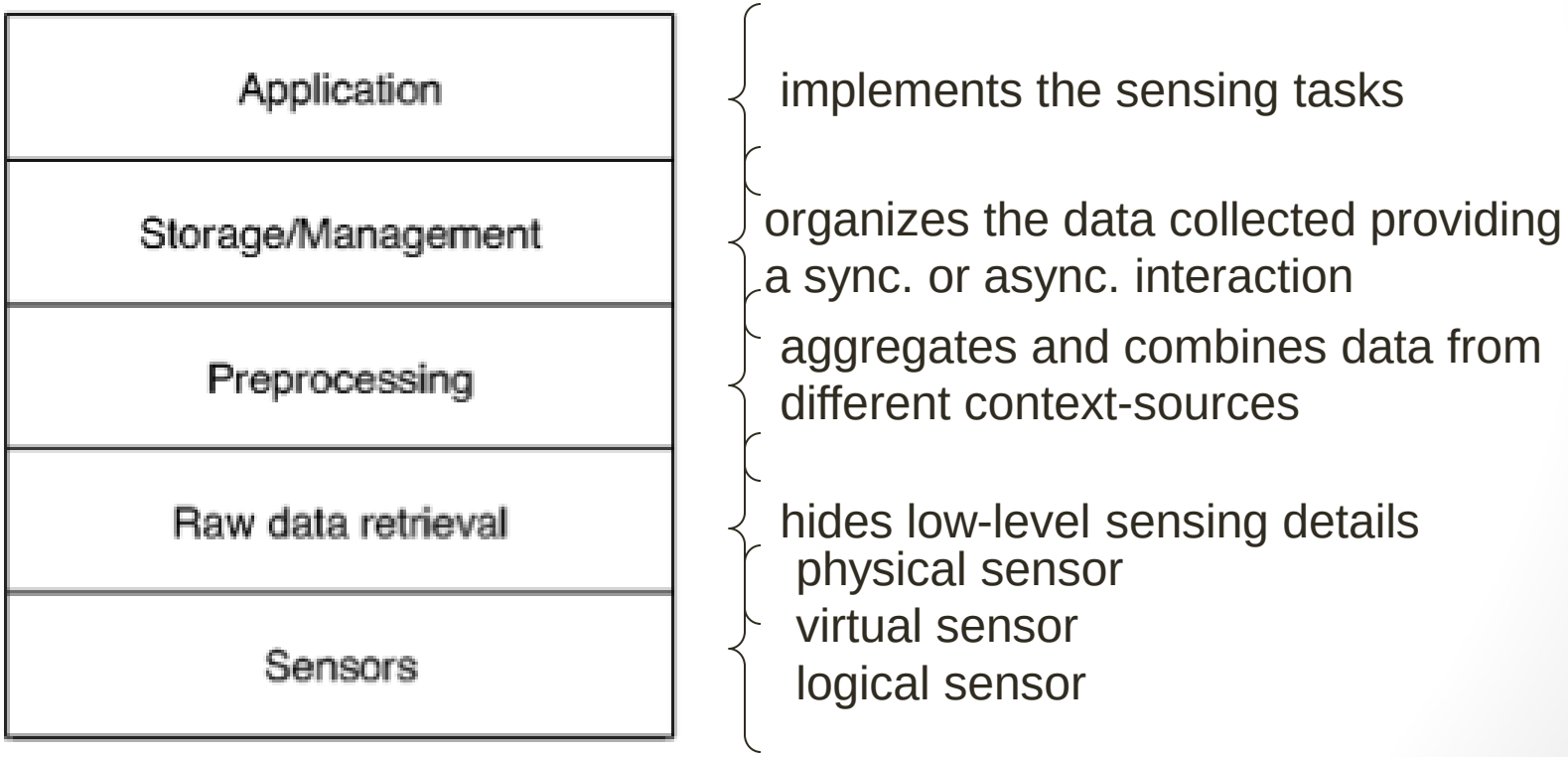
- Context-aware systems
  - Rely on the context-information
  - Context-information is any kind of data describing the env.
  - Context-information is exploited in order to react to the context changes

Ambient Intelligence and AAL

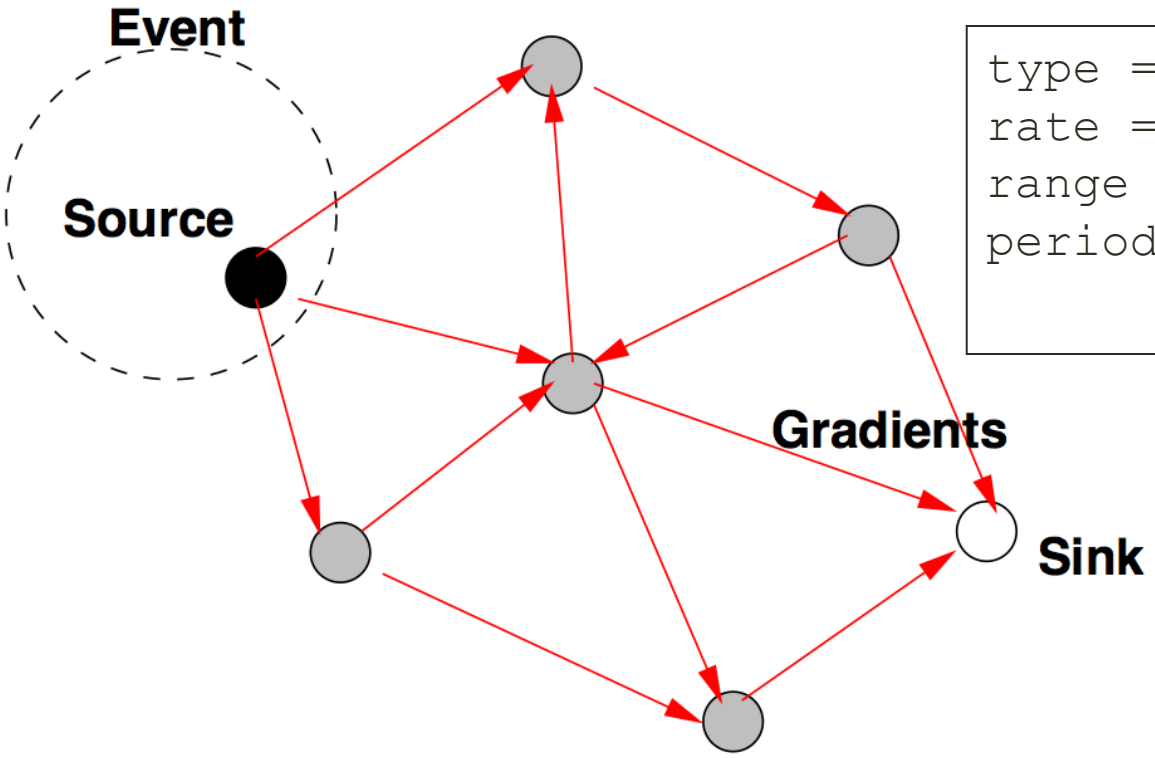
Embedded:	Many invisible dedicated devices throughout the environment.
Personalized:	The devices know who you are.
Adaptive:	Change in response to you and to the environment.
Anticipatory:	Anticipate your desires as far as possible without conscious mediation: PRE-sponsive, not responsive.

Introduction

A conceptual framework for context-aware systems:



Context-awareness




```
type = light
rate = 50ms
range = [x,y,z,w]
period = 100s
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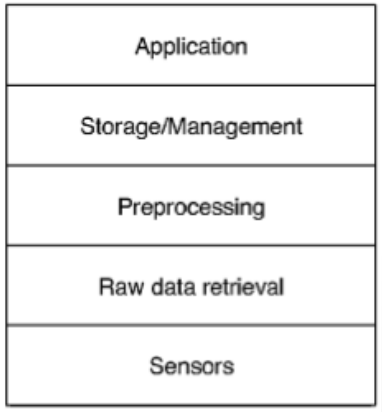


Ambient Intelligence and AAL

The Computer for the 21st Century

Mark Weiser
(1952-1999)

Mark Weiser:
"The Computer for the 21st Century",
Scientific American,
Vol. 265 No.9, pp. 66-75, 1991.

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it"

Ubiquitous Computing (since 1988):
computers massively deployed, calm
"each person is continually interacting with hundreds of nearby interconnected computers without explicitly attending to them"

Augmented Environments (since 1993)
("Back to the Real World", CACM July 1993)
interaction with accustomed physical/tangible environment

- Ubiquitous Computing
  (Mark Weiser, Xerox PARC 1988)
- Calm Computing
  (John Brown, Xerox PARC 1996)
- Universal Computing
  (James Landay, Berkeley 1998)
- Invisible Computing
  (G. Barriello, UoWashington 1999)
- Pervasive Computing
  (Academia, IBM 1999, SAP 2000)
- Context Based Computing
  (Berkeley/IBM 1999)
- Hidden Computing
  (Toshiba 1999)
- Post PC Computing
  (common sense)
- Ambient Intelligence
  (European Commission, FP5)
- Everyday Computing
  (Georgia Tech, 2000)
- Sentient Computing
  (AT&T, 2002)
- Autonomous Computing
  (IBM, 2002)
- Amorphous Computing
  (DARPA, 2002)

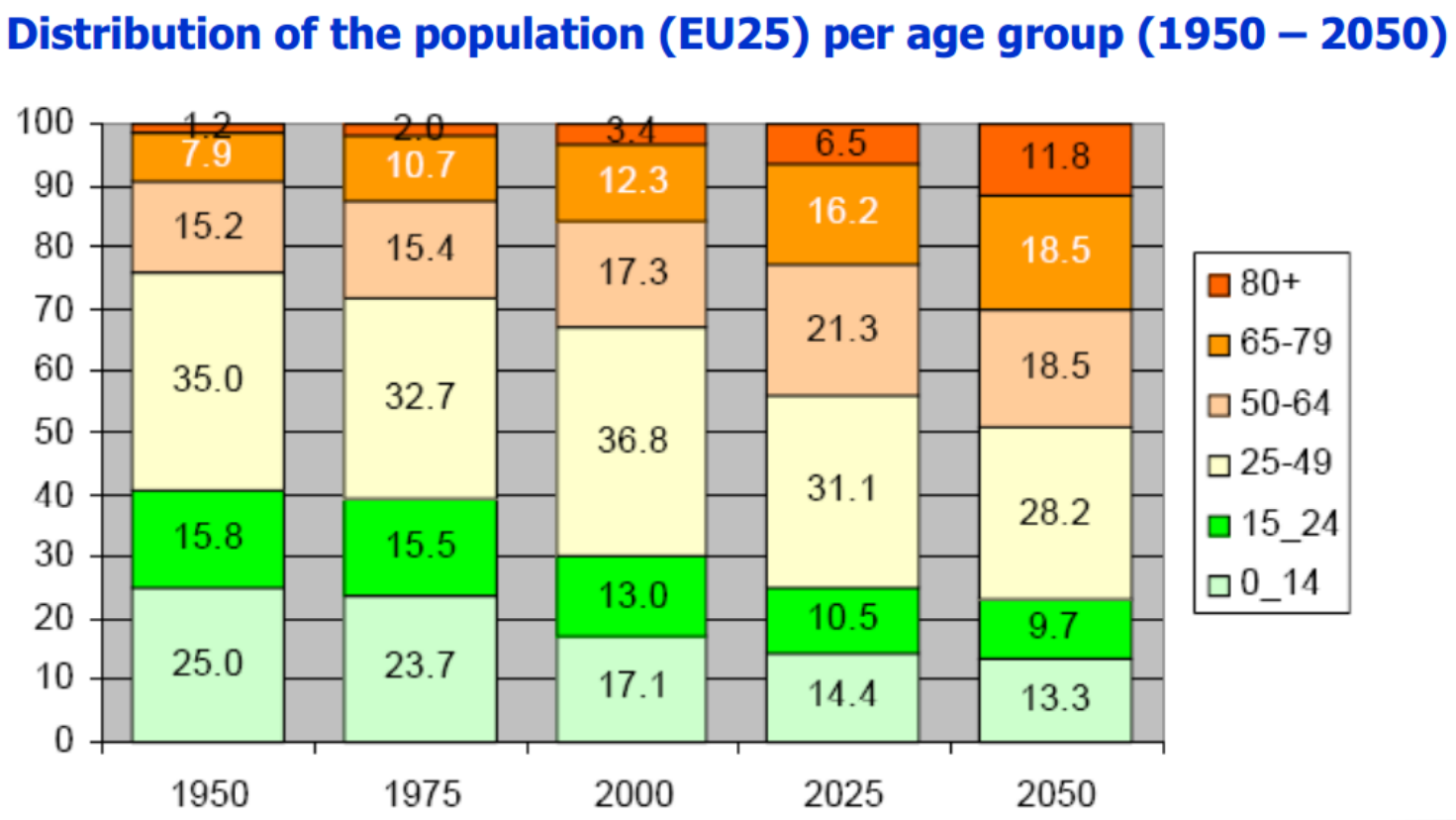
Ambient Intelligence and AAL

- **Ambient Assisted Living** helps individuals to improve their quality of life, to stay healthier and to live longer

- AAL has to be distinguished from more tradition forms of assistive technology by emphasizing the importance of the **Ambient Intelligence** in AAL technologies

- $\rightarrow AAL \in Ambient\ Intelligence$

Ageing in Europe



Enabling technologies

Sensing

- Sensor for environment, safety and security
- Vital sign data and activity sensors
- Sensor networks

Reasoning

- Reasoning for AAL
- Activity recognition

Acting

- Human-oriented actuators
- Neuroscience-based model
- Integration of sensors and actuators in intelligent devices

Communication

- PAN, LAN, PAN
- Advanced communication protocol

universAAL project

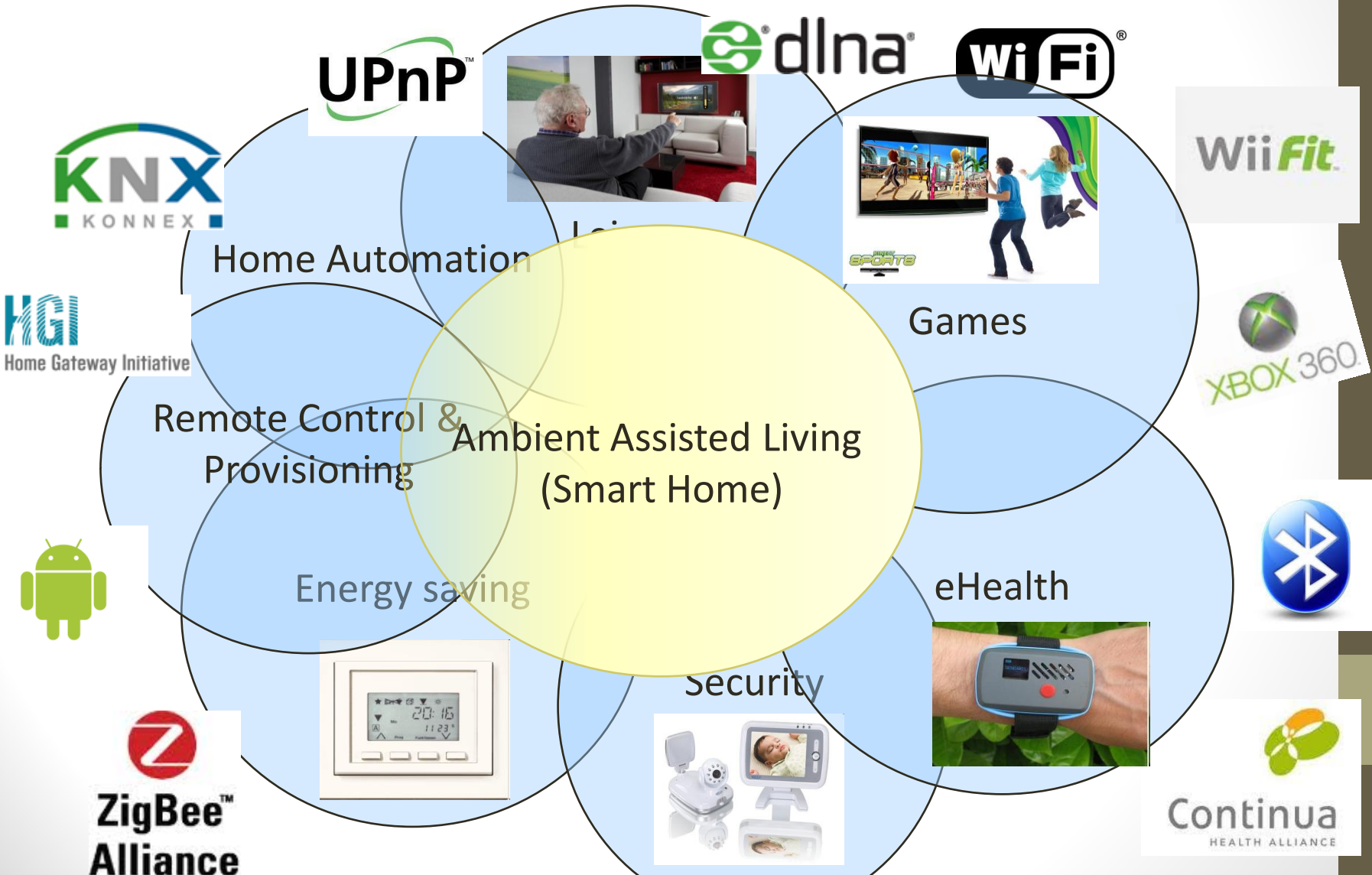
- **universAAL** project is an EU-funded research project
- Large-scale **I**ntegrated **P**roject in EU 7th Framework Programme (Priority 7.1b: ICT & Aging)
- **universAAL** open platform and reference specification for AAL
  http://universAAL.org

universAAL project

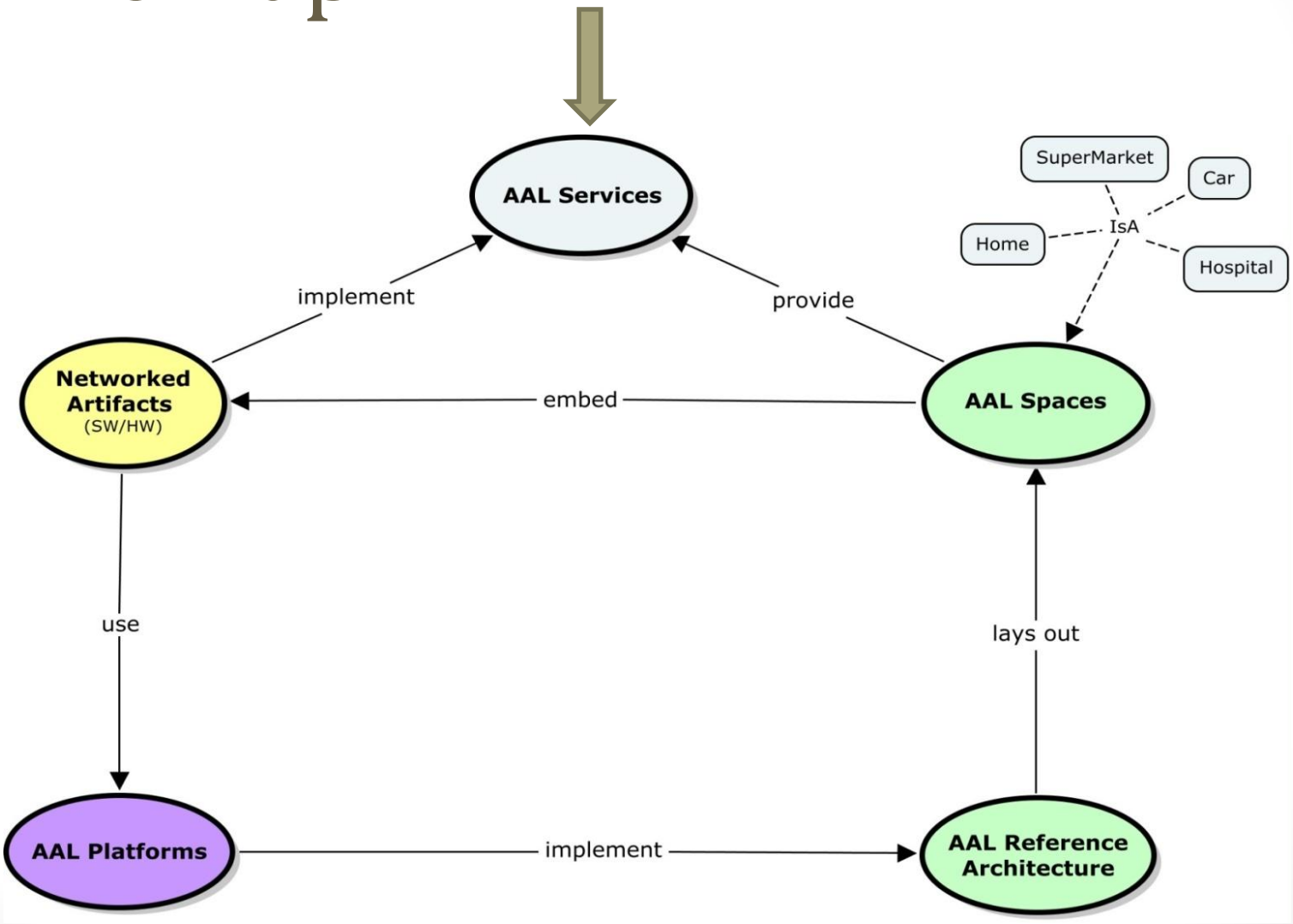
The Consortium

No	Name	Short name	Country
1	STIFTELSEN SINTEF	SINTEF	Norway
2	AIT Austrian Institute of Technology GmbH	AIT	Austria
3	CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	CERTH	Greece
4	CONSIGLIO NAZIONALE DELLE RICERCHE	CNR-ISTI	Italy
5	ERICSSON NIKOLA TESLA D.D.	ENT	Croatia
6	FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V	Fh-IGD	Germany
7	FORSCHUNGSZENTRUM INFORMATIK AN DER UNIVERSITAET KARLSRUHE	FZI	Germany
8	IBM ISRAEL - SCIENCE AND TECHNOLOGY LTD	IBM	Israel
9	IMPLEMENTAL SYSTEMS SL	IS	Spain
10	UNIVERSIDAD POLITECNICA DE VALENCIA	ITACA-UPV	Spain
11	PHILIPS ELECTRONICS NEDERLAND B.V.	Philips	Netherlands
12	PROSYST SOFTWARE GmbH	ProSyst	Germany
13	REGION SYDDANMARK	RSD	Denmark
14	SOLUCIONES TECNOLÓGICAS PARA LA SALUD Y EL BIENESTAR SA	TSB	Spain
15	TECHNISCHE UNIVERSITAET WIEN	TUW	Austria
16	UNIVERSIDAD POLITECNICA DE MADRID	UPM	Spain
17	VDE VERBAND DER ELEKTROTECHNIK ELEKTRONIK INFORMATIONSTECHNIK EV	VDE	Germany

The market fragmentation



The Map


AAL Services
SuperMarket
Car
IsA
Home
Hospital
implement
provide
Networked Artifacts
(SW/HW)
embed
AAL Spaces
use
lays out
AAL Platforms
implement
AAL Reference Architecture

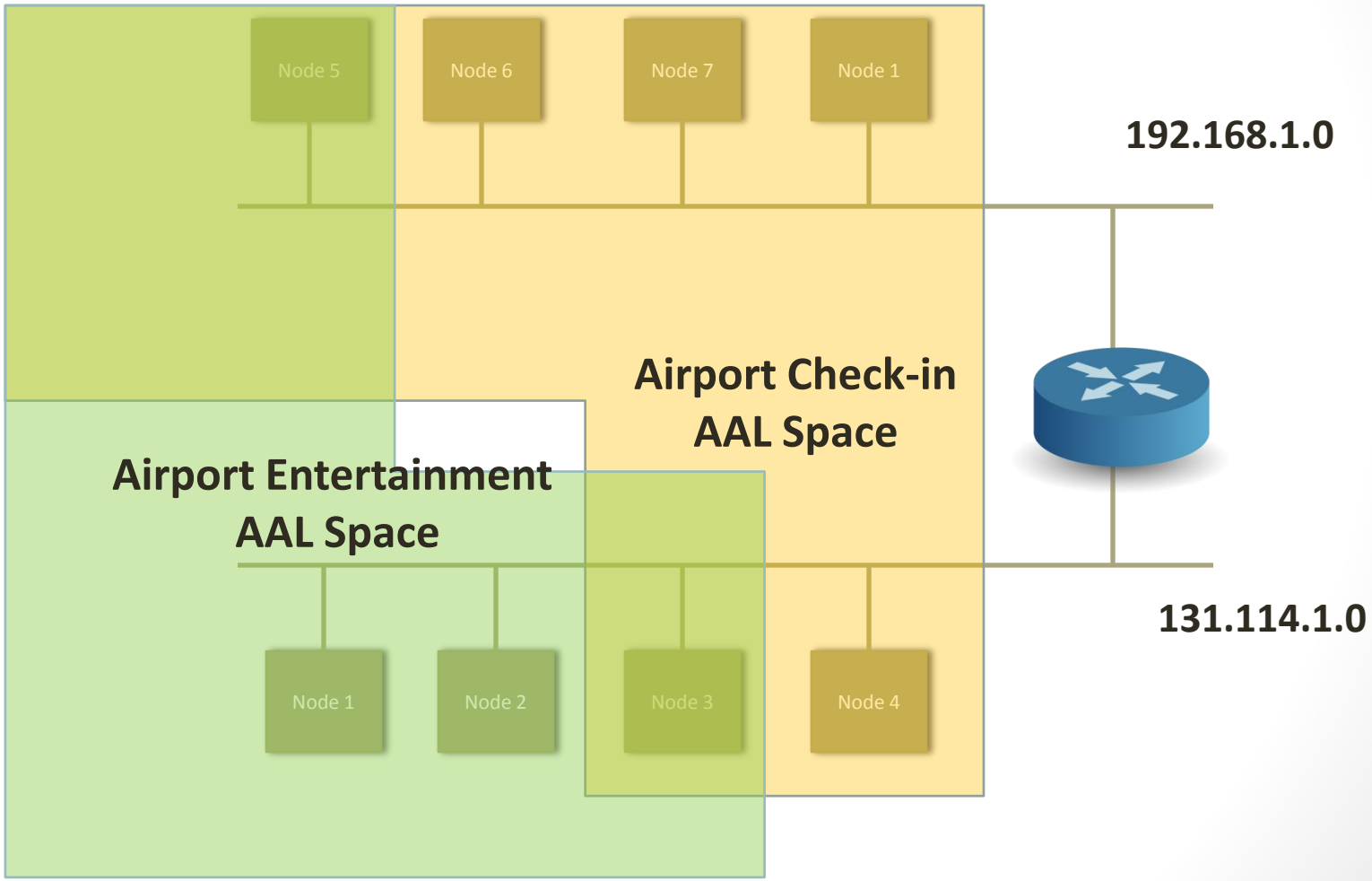
AAL Services

- **AAL For Person:**
  - Home safety and security
  - Rehabilitation and care
  - Remote assistance
  - Personal activity management
- **AAL in the community**
  - Participation in the community activities
  - Creativity
  - Mobility: localization, public transportation
  - Entertainment
- **AAL@Work**
  - Access to working space
  - Tele-work
  - Prevention of dieses and injuries

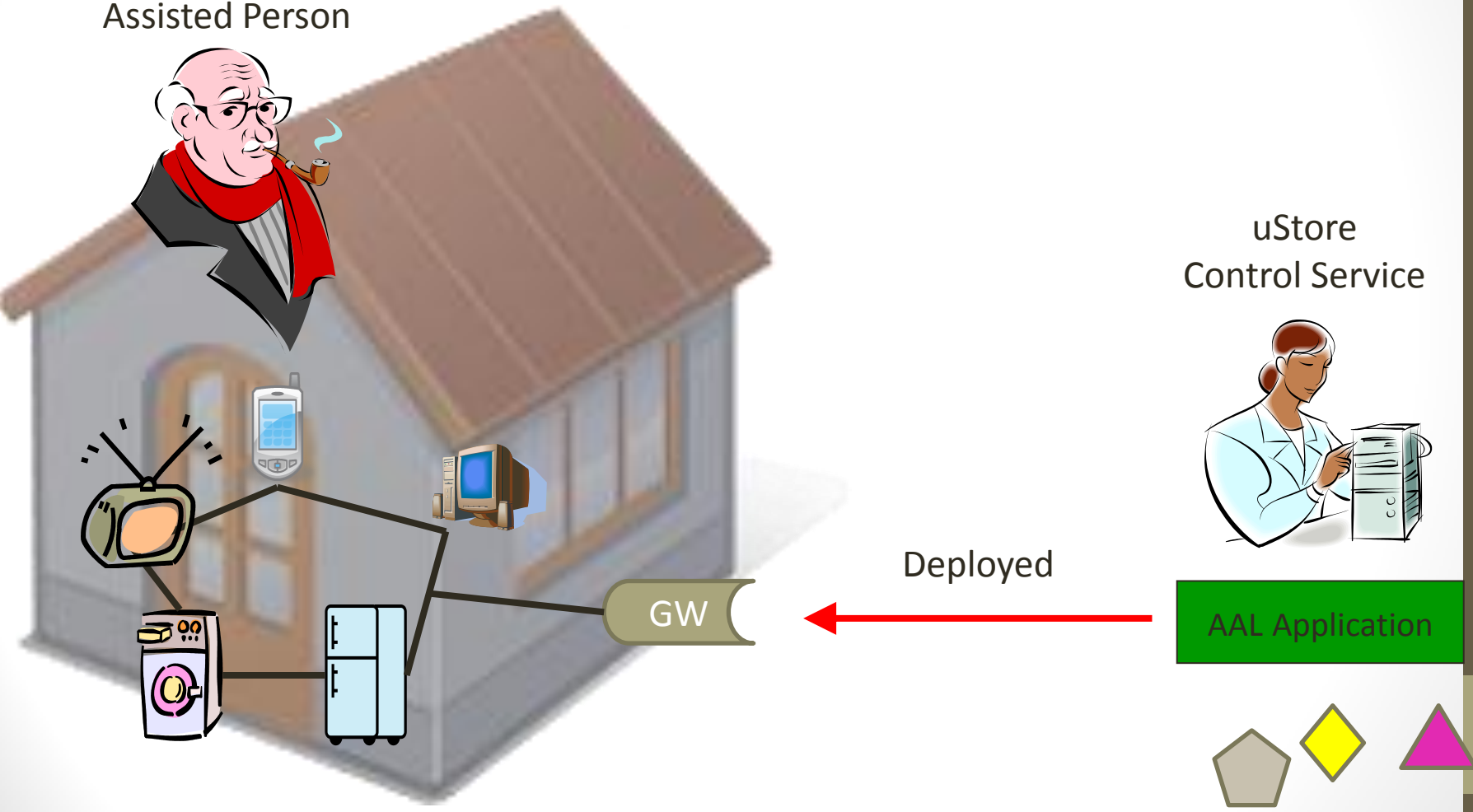
AAL Spaces features

1. Logical and autonomous ensemble of nodes (aka AAL-aware node) sharing some services in a seamless way
2. The AAL Space topology can not coincide with the network topology.
3. The AAL Space must be described in terms of meta-data
   - E.g.: space name, space unique id, space status, space type, space topic, space reference location
4. AAL nodes act with specific roles
   - AAL Space Coordinator
   - AAL Space Gateway
   - AAL Space Registry
   - AAL aware node

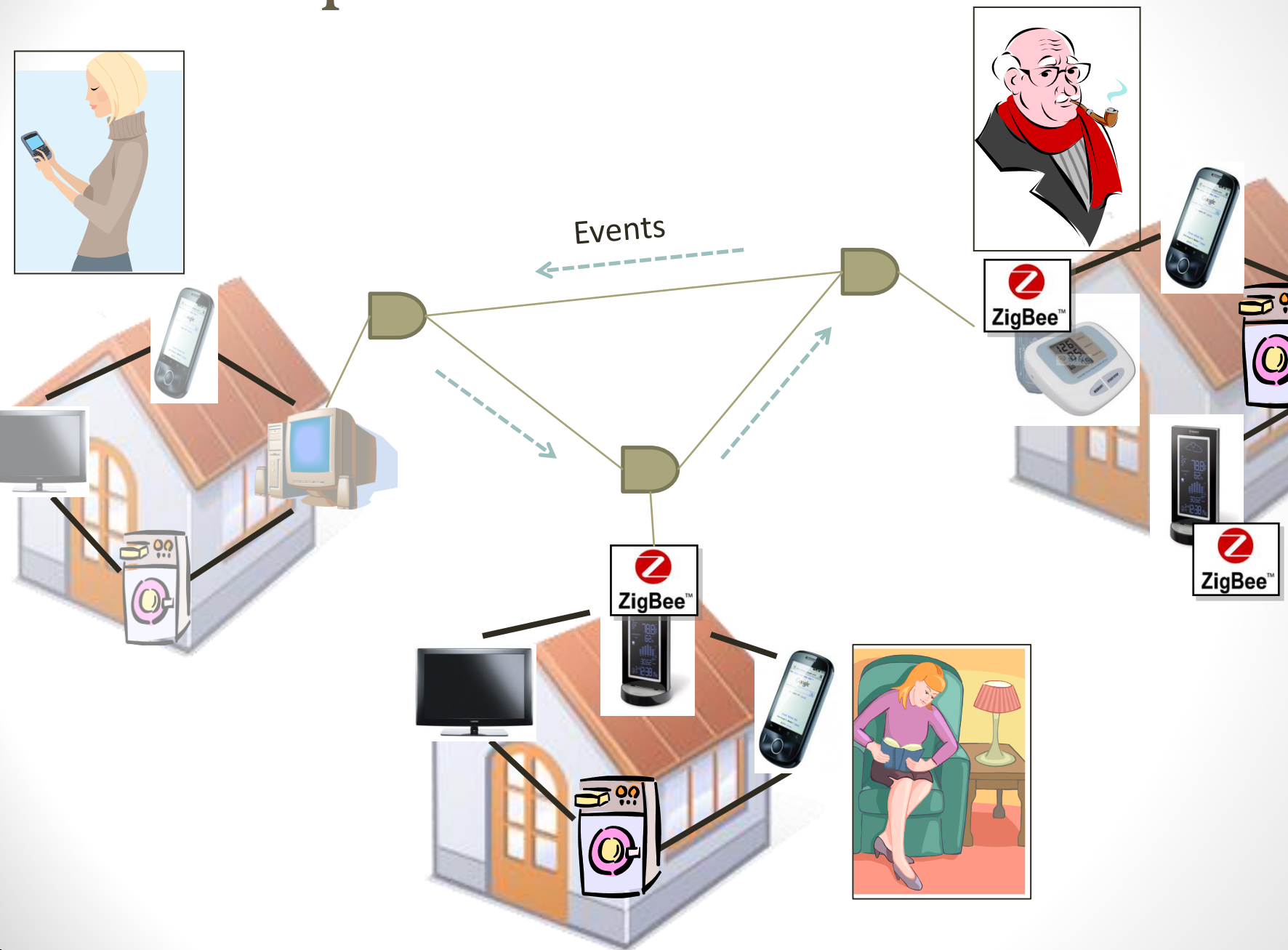
AAL Spaces features



Multipart Application deployment



Home Space I-Home



Home Spaces

Multipart application deployment

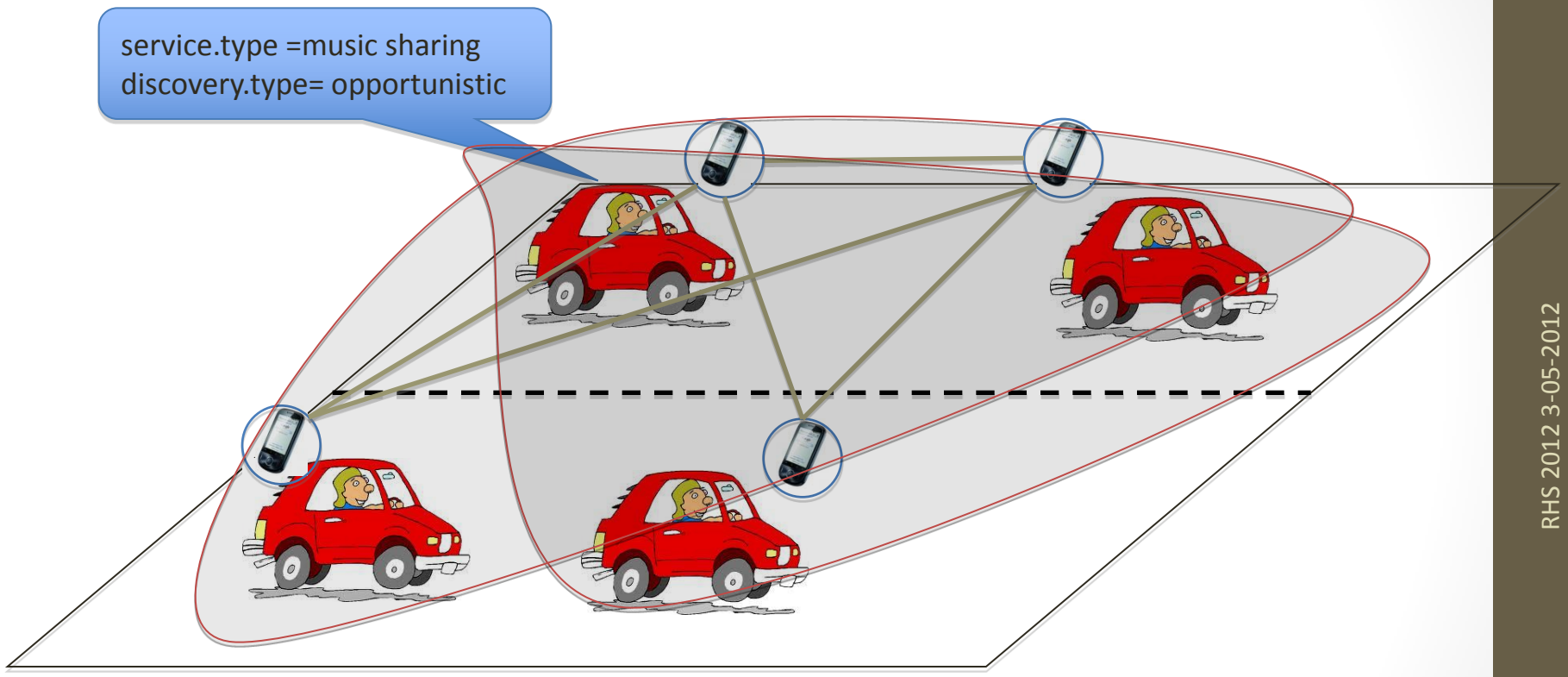
- Peers should know the features of other peers installed at Home
- The **discovery mechanisms** should be able to get all the interesting properties of the rest of the networked devices

Interconnected Home

- The scope of the **discovery mechanisms** should be configurable to allow the discovery in ad hoc network topology

Mobile Space

Opportunistic Spaces

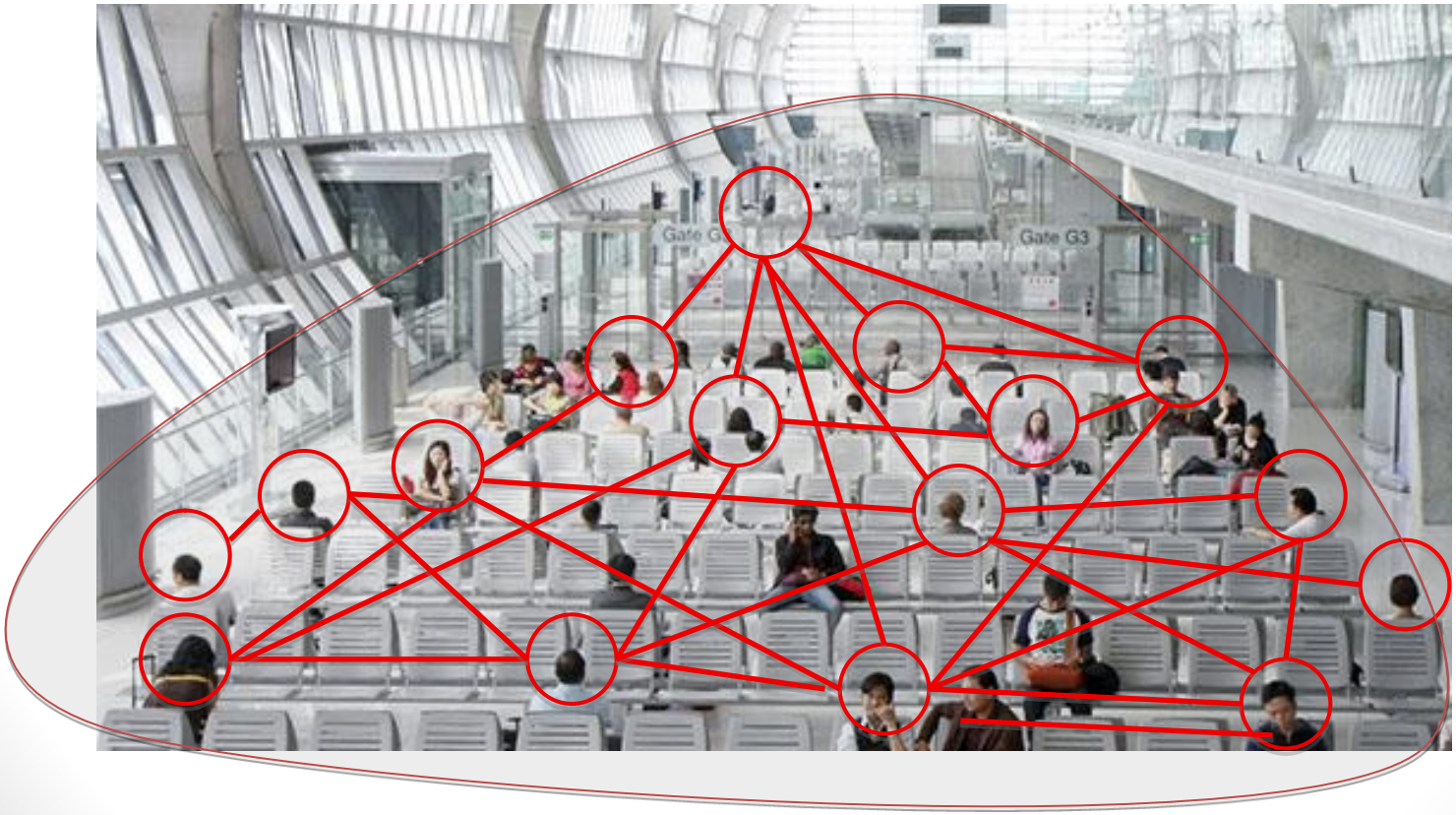


Mobile Space

- The AAL Space is here considered as a group of devices discovered in the interior (cabin) of the car.
  - Devices/Sensors installed in the car (KAN bus) or Mobile phone and game console used by passengers
- The car space can be enlarged by considering the connectivity provided by the next generation of vehicular networks
  - Opportunistic communications,
  - Car-To-Car communication (IEEE 802.11p - WAVE)
  - Smart road signs

Airport Space

Large-scale networks



Airport Space 2
Stationary services

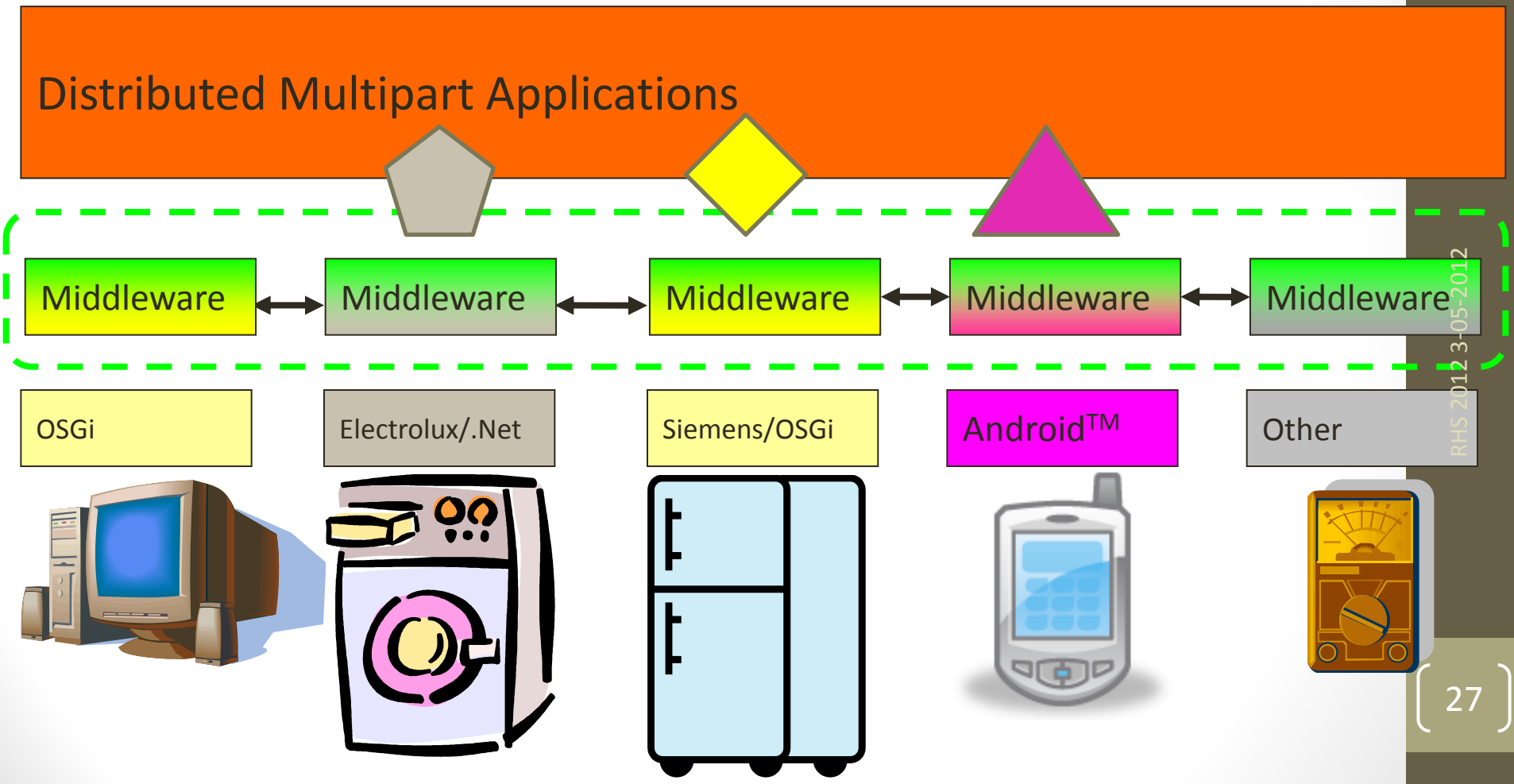
Attribution (CC 2.0) :http://www.flickr.com/photos/ceiling/2374266108/sizes/l/

Airport Space

- **Scalability:** is the main issues in large public spaces
- **Mobility**: the person moves quickly in the airport, and its local area of interest change continuously
  - **Stationary Devices/Services**
    - Check-in desk, Restaurant, Entertainment, Touristic assistance,
  - **Mobile Devices/Services**
    - Thousands of passengers with smart phones
- We need to **filter the thousands of nodes** we can discover locally in the Airport (e.g. Stationary only)
- We should be able to restrict the number of discovered devices to that ones closed to the assisted person (i.e. **location based discovery**)
- We should guaranty the **privacy** of the service requests

universAAL project

MW 2.0



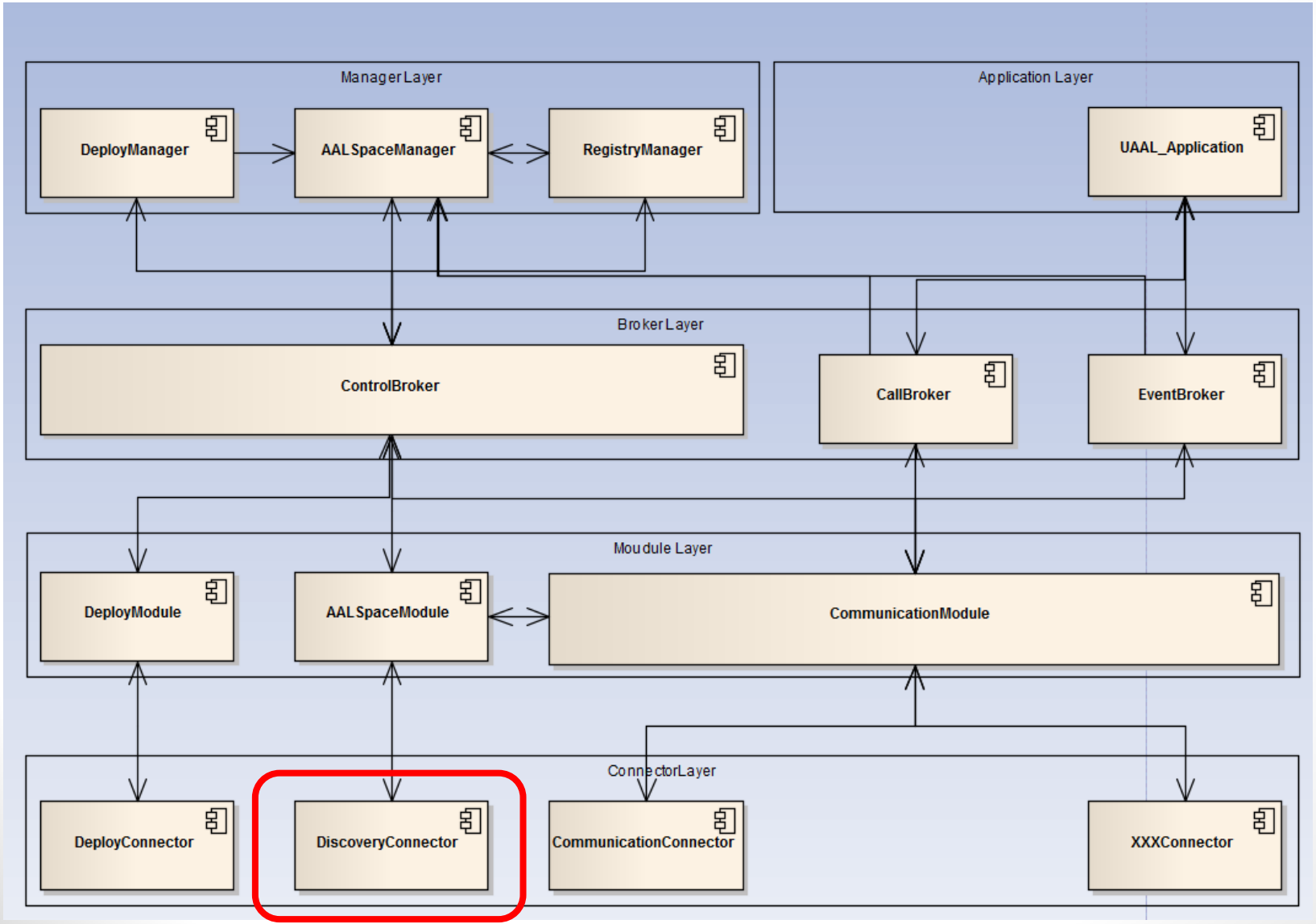
universAAL project

MW 2.0

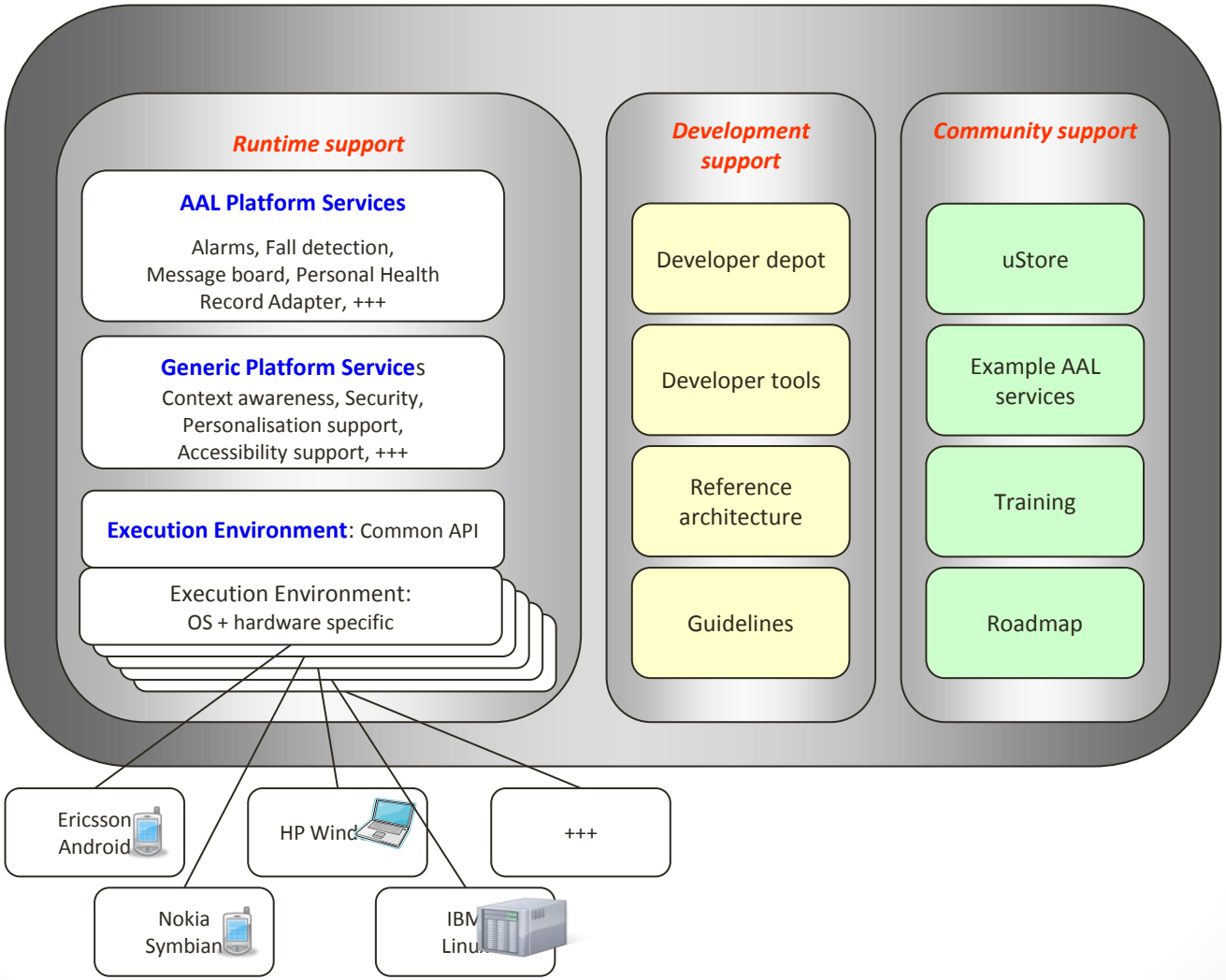
- High-modularized architecture
- Service Oriented Architecture
  - Based on OSGi Felix and Apache Karaf
- Exploits the existing technologies for
  - Advanced communications
  - Discovery framework
  - Distributed deployment of sw artefacts
- Extra features based:
  - Diagnostic module
  - Security module
- AAL Space cantered

universAAL project

MW 2.0



The big-picture



Resource and Service Discovery

A **Resource** is any source of supply:

- File-system
- Memory
- CPU-capability
- Communication capability

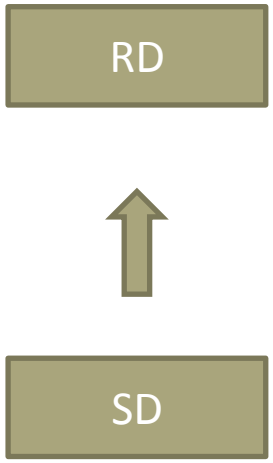
that can be provided as a **Service**

The **Resource Discovery (RD)** is any mechanism that is providing capability to locate a resource in the network

Resource and Service Discovery

Goal of RD is to:

- Advertise resource clients of the availability of a specific resource in the network
- Provide a pointer to the resource (ie. the URL to the resource provider)



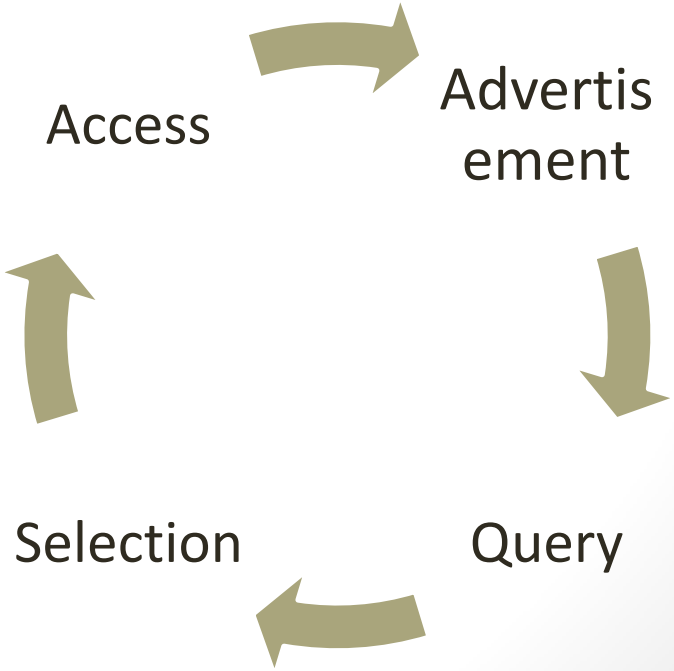
Resource Discovery Design

- To select structured vs non- structured discovery architectures
- To choice a search technique and the query matching strategy
- To provide the resources data representation
- To design the system for a specific network topology (ie. star, tree or mesh topologies)
- To address the scale of the network: internet-scale vs enterprise-scale system vs local-scale systems)

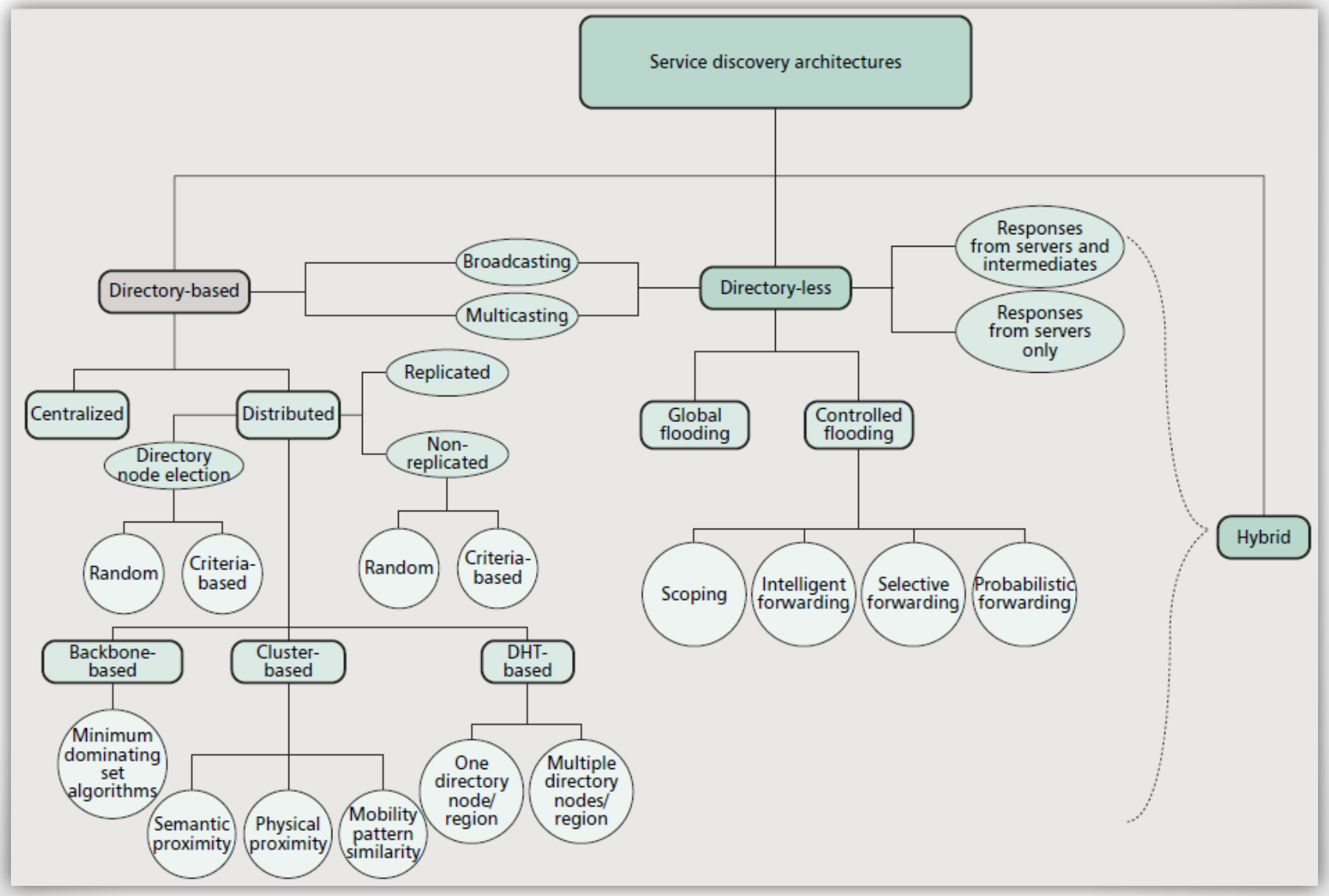
Resource Discovery Process

RD process is mainly composed of the following steps:

1. To advertise the resources
2. To query about the resources provided by the providers
3. To select the most suitable resource
4. To access to the resource



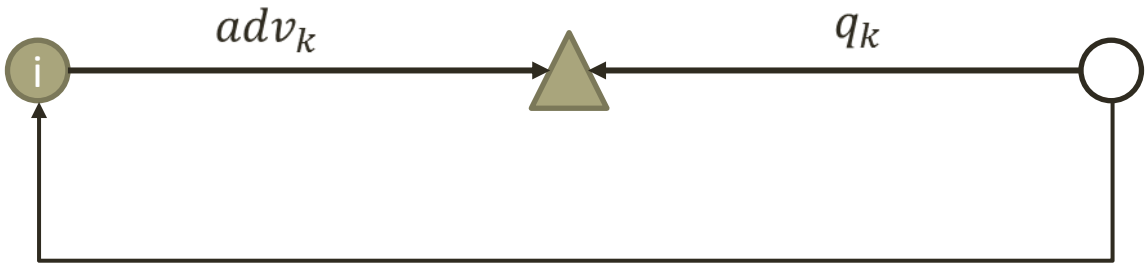
RD Architectures



Centralized Architecture

- Resource Directory: collects the information about the resources available on the network
- Resource Provider: advertises the resource (adv) to the Service Directory
- Resource Client: queries the Service Directory for a specific resource and accesses the Service Provider

Node	*Advertisements*
i	adv_h, adv_k
j	adv_x, adv_y



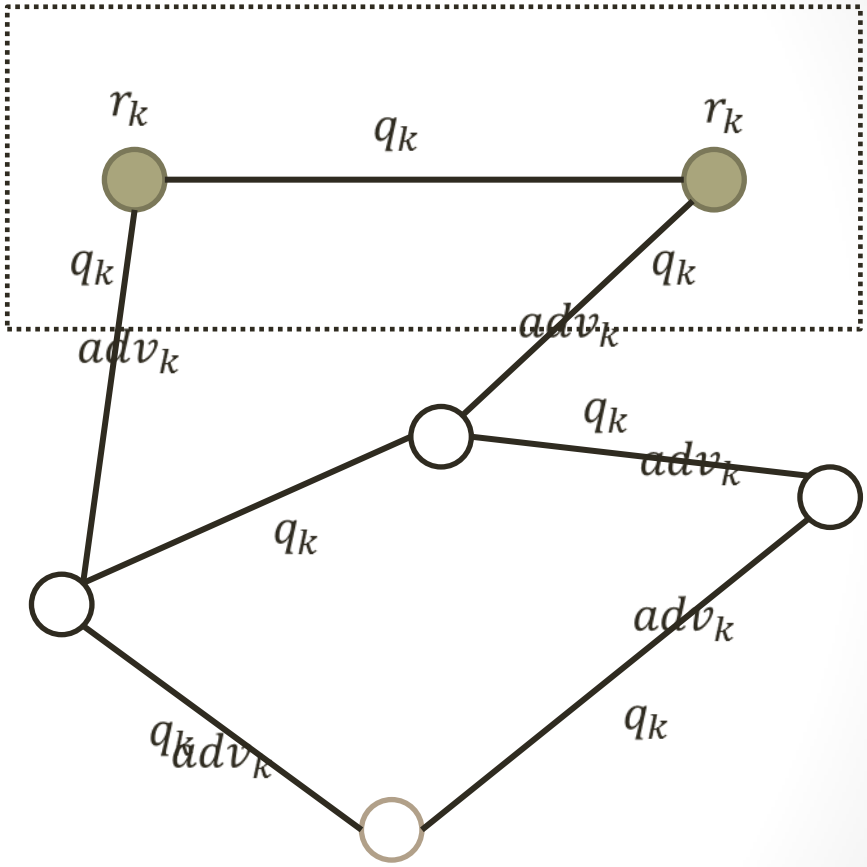
Decentralized Architecture

- Resource Provider: announces the availability of the resources to the whole network or answers to the client queries
- Resource Client: injects the queries into the network waiting for a response

Decentralized Architecture

$$q_k = \begin{cases} type = k \\ access\ cost = c \\ location = [x_1, y_1], [x_2, y_2], \\ [x_3, y_3], [x_4, y] \end{cases}$$

$$adv_k = \begin{cases} type = k \\ access\ cost = d \\ location = [x, y] \\ URL \end{cases}$$

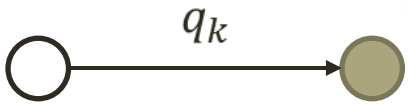


Discovery Modes

- How the clients learn about the resources the network provide
- The choice of the best discovery modes depends on:
  - Network density
  - Number of available resources
  - Popularity of the resources

Discovery Modes

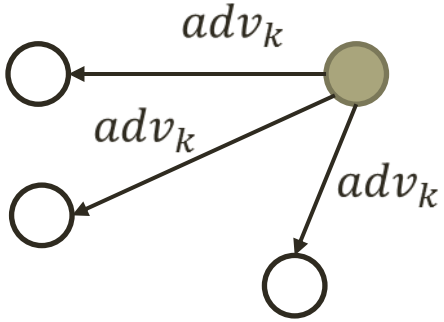
Reactive



- *Clients explicitly send a query to the directory agent(s) or to a set of providers*

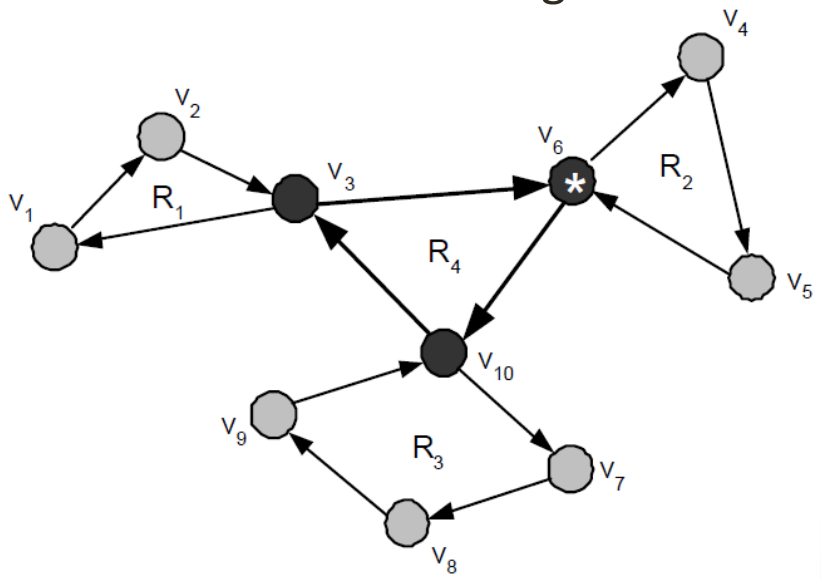
Proactive

- *Clients receive resource advertisements without asking for them*
- *Providers announce/refresh the resources as soon as they are available*

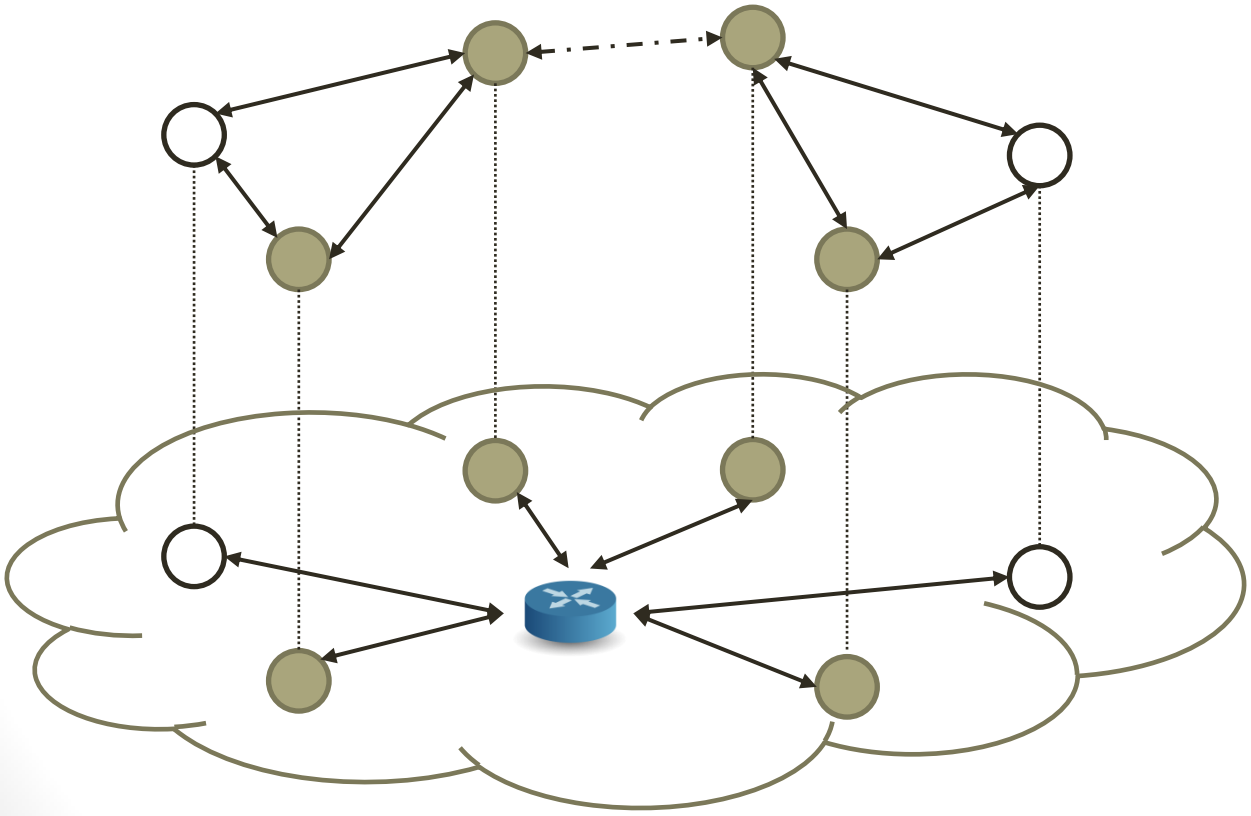


Clustering and Overlay networks

- The centralized architectures force to send the queries to the resource directories
- With the decentralized architectures it is possible to build a network of overlay without any structural change
  - Nodes are organized in clusters sharing common properties
  - Queries and service advertisements are managed in an efficient way by the cluster



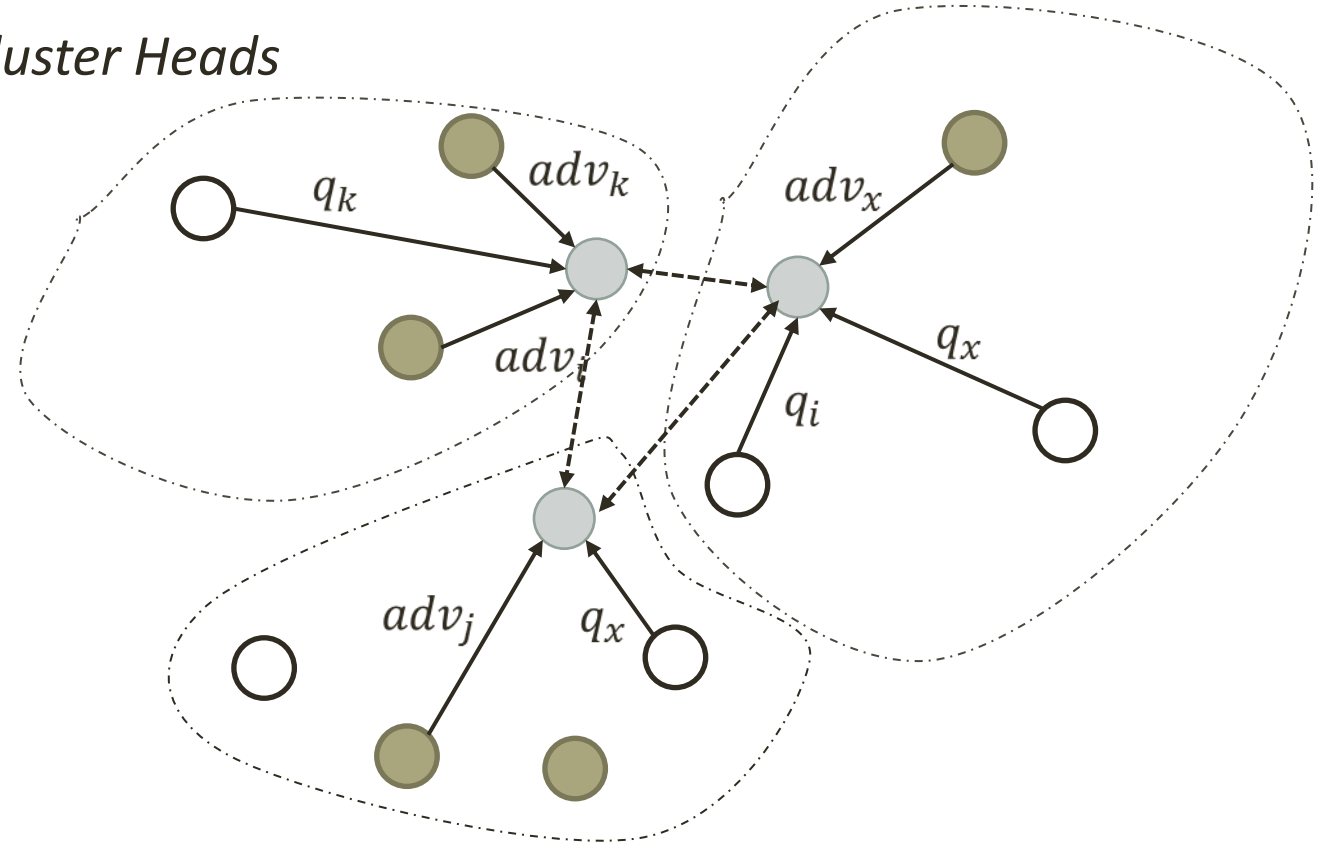
Clustering and Overlay networks



The Overlay Network

Network topology

Clustering and Overlay networks



adv_k = advertisement of resource k
q_k = query for resource k

Service Discovery frameworks

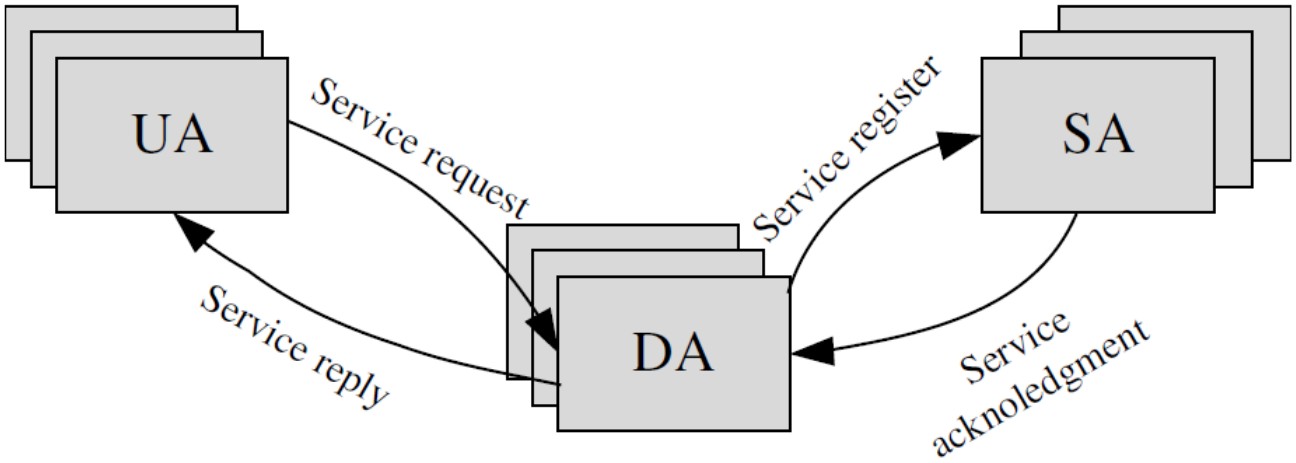
- Review of widely used service discovery frameworks
- Designed for administrated networks (hence not for p2p)
- Centralized and decentralized architectures

1. SLP Service Location Protocol
2. UPnP Universal Plug and Play
3. Bluetooth Service Discovery
4. Bonjour

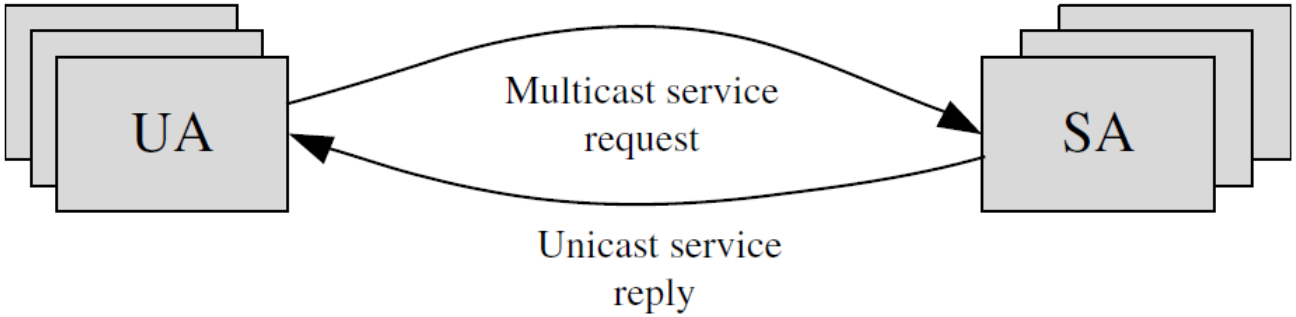
SLP

- SLP is an IETF standard
- Defined by a number of RFCs (2165, 2608, 2609 and 2914)
- SLP relies on a centralized architecture suitable for
  - Large-Enterprise networks
  - LAN
- Supports 2 modes:
  - Centralized mode with Directory Agents (DAs)
  - Distributed mode without DAs

SLP



A. Centralized approach. SLP with device agents.



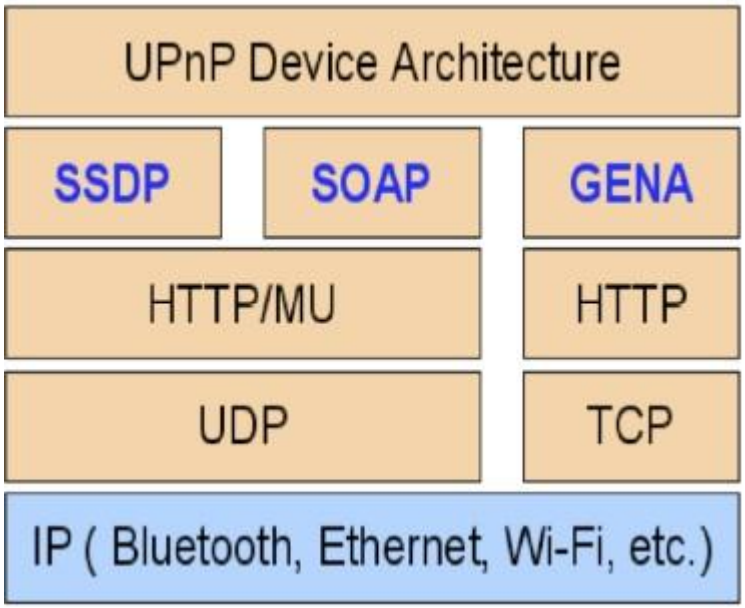
B. Distributed approach. SLP without device agents.

SLP

- The service replies contain:
  - URL: **service:servicename:protocolname://hostname**
  - Attributes: **<key, value>**
  - Scope: string classifying the services
- UAs query the DA or SAs by specifying
  - The type of the service
  - A list of attributes
  - The scope of the service

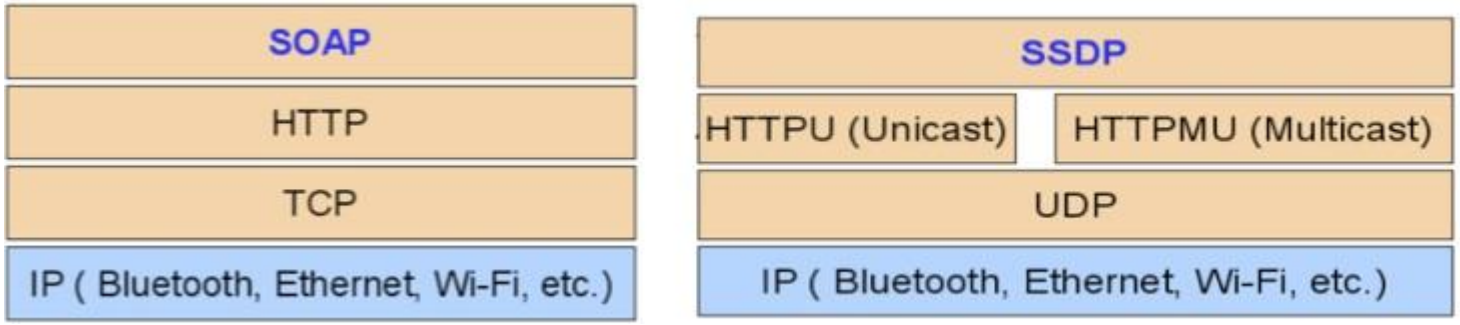
UPnP

- Universal Plug and Play FW defines a protocol stack for:
  - Addressing
  - **Discovery**
  - Description
  - Control
  - Eventing
  - Presentation



UPnP

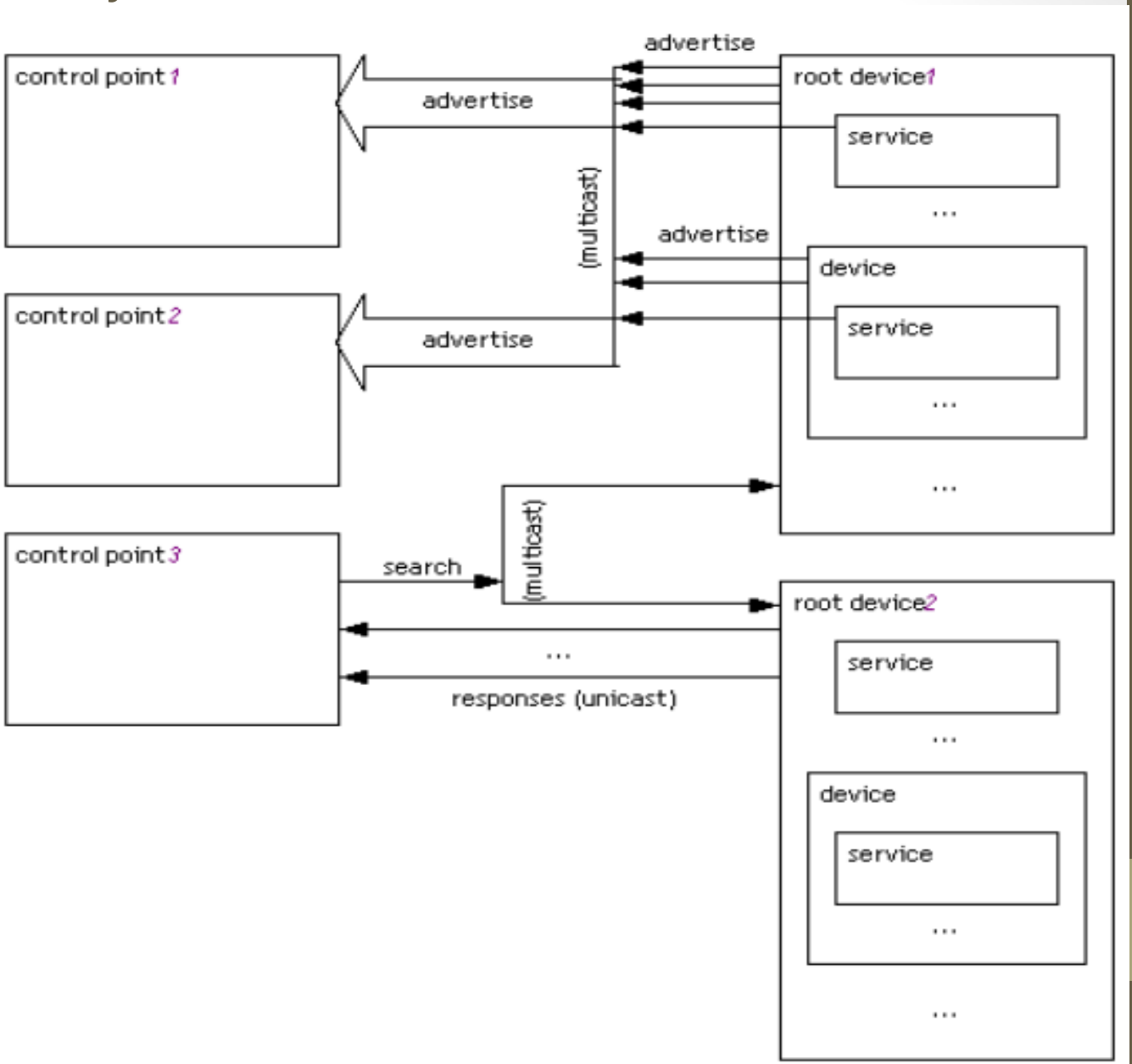
- UPnP relies on the SSDP protocol for the discovery



- Completely distributed query-based
- Roles of nodes:
  - Control Points ($\cong$ *resource clients*)
  - Controlled Devices ($\cong$ *resource providers*)

Resource Discovery

UPnP



Resource Discovery

UPnP

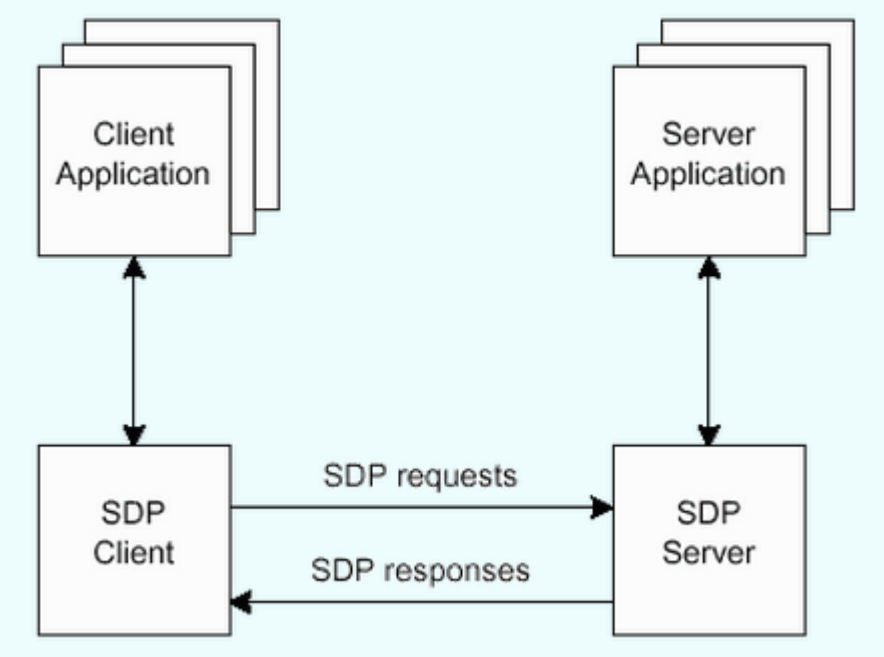
- Control Devices receive an XML URL describing the Controlled Device
  - Every controlled device runs a HTTP server
  - XML document provides a tree-based description of the device
- UPnP also defines:
  - how to access to the service
    - To invoke remote procedures through SOAP messages
  - how to be notified by the service
    - To register to the control variables and to receive asynchronous HTTP messages

Bluetooth Service Discovery

- Bluetooth allows multiple devices to cooperate in a master-slave relationship
  - Piconet composed of
    - *1* master device
    - *n* slaves
- Designed for resource-constrained environments and to spend minimal bandwidth
- Bluetooth is not designed for IP-based networks
- Service Discovery in Bluetooth is powered by SDP

Bluetooth Service Discovery

- Each device can act as SDP client or server
  - Client discovers services provided by other devices
  - Service provides services
- Every service is described by a *service record (*set of service attributes)
- Every service belongs to a *se*
  - Type of the service
  - Set of attributes describing t
- Services and attributes are u
  defined IDs



Bluetooth Service Discovery

- SDP defines 3 search modes
  - Service Search: to search for a specific service identified by an ID. The client will receive a bunch of service records
  - Attribute Search: to search for a set of attributes with respect to a specific service
  - Service and Attribute Search: to search for a service and to fetch a list of relevant attributes

Bonjour

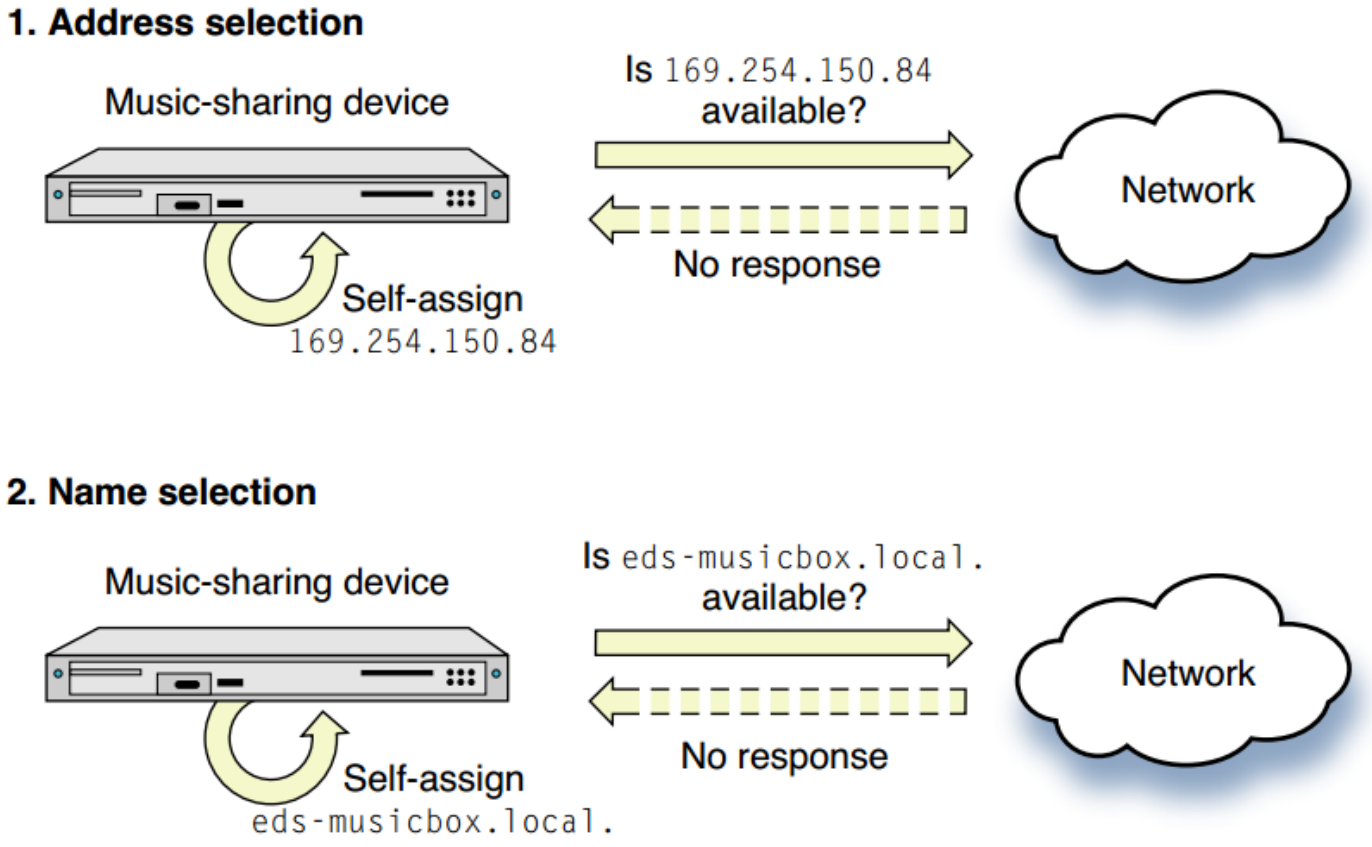
- Bonjour protocol is promoted and supported by Apple
  - Successor of Appletalk
  - Implementation of Zeroconf IETF protocol
- Bonjour is designed for local and ad-hoc IP-based networks
  - Decentralized architecture
  - Relies on multicast and DNS technologies
- Bonjour covers 3 areas:
  - Addressing
  - Naming
  - Service Discovery

Bonjour

- Addressing allows to obtain an IP address via self-assigned link-local addressing
  - If DHCP is enabled an IP address is assigned
  - If DHCP is disabled the device randomly select an IP address and verifies if it is free
- Naming allows to map name-to-address via mDNS protocol
  - DNS queries are sent in multicast in the local network
  - Every computer must have assigned a local name (only valid inside the local network)
- Service Discovery allows to discover all the instances of a service a to maintain a named service
  - Via mDNS advertisement using a multicast address
  - Via mDNS query
  - Services are named with human-readable strings

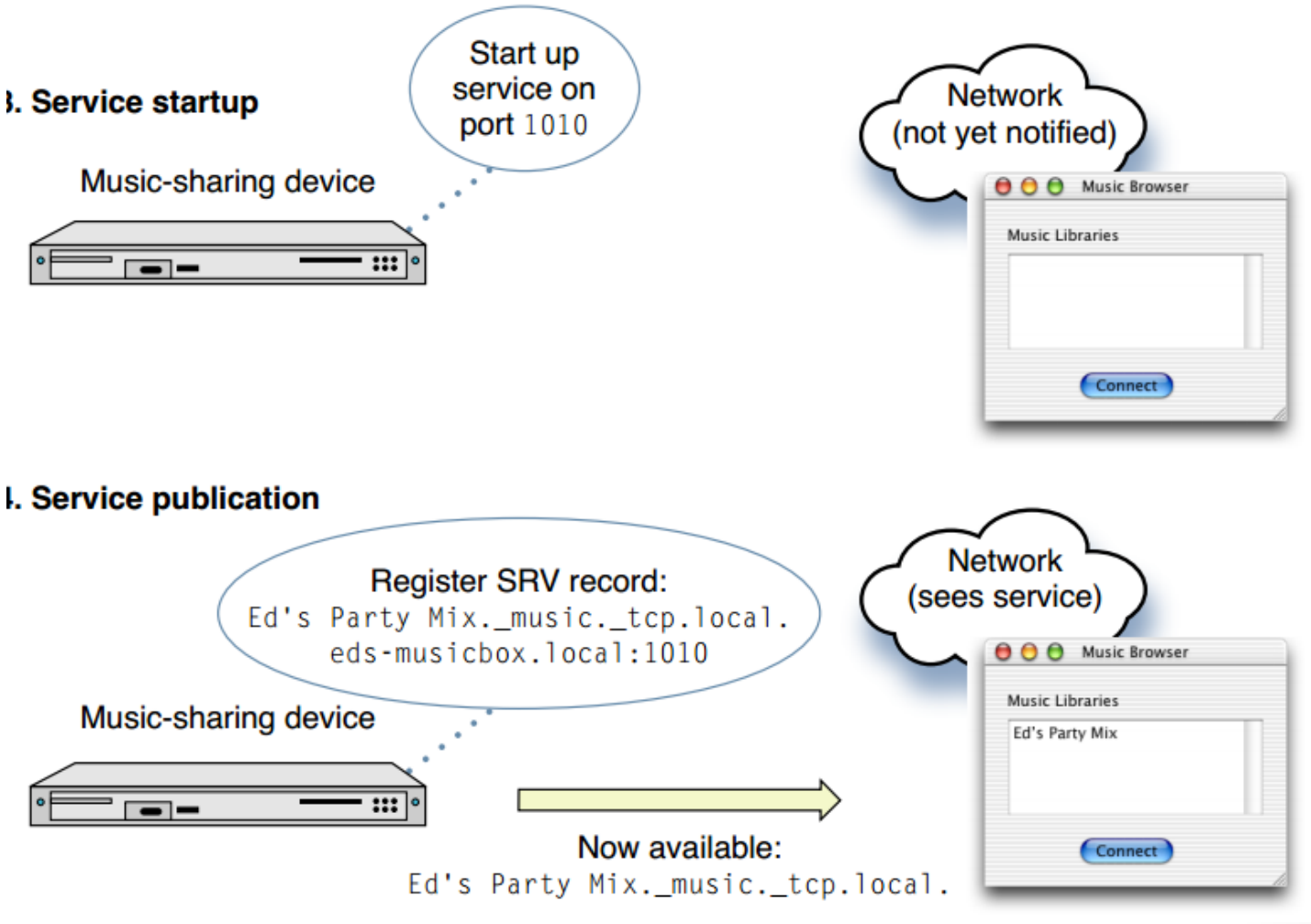
Resource Discovery

Bonjour



https://developer.apple.com/library/mac/documentation/Cocoa/Conceptual/NetServices/NetServices.pdf

Bonjour



https://developer.apple.com/library/mac/documentation/Cocoa/Conceptual/NetServices/NetServices.pdf

Open Issues and Challenges

Ad-hoc and Mesh Wireless Network

- Decentralized infrastructure
- Network size spans from sparse to dense network
- Heterogeneous devices
- Multicast and Broadcast are not suitable for dense network

Wireless Sensor Networks

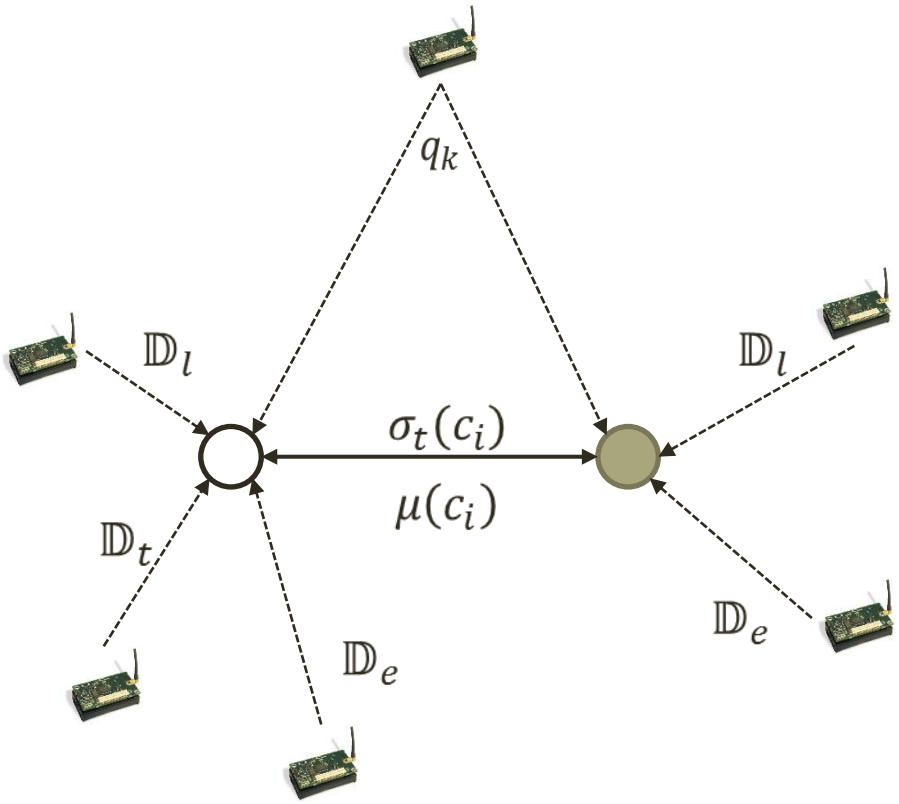
- Communication media with low bandwidth
- Devices with limited memory
- The description of the service must be as compact as possible
  - No XML parsing allows

Open Issues and Challenges

RD in AAL Spaces

- To exploit the context-information to refine the search
- To push to the clients all the **needed** services instead of the **discovered** ones
  - $\mathbb{D} = context$
  - $C = \{\mathbb{D}_0, \ldots, \mathbb{D}_{n-1}\}, \mathbb{D}_i \in \mathbb{D} = i - th\ dimension\ of\ the\ context$
    - $\mathbb{D}_{location}, \mathbb{D}_{time}, \mathbb{D}_{environment}, \mathbb{D}_{physical\ status}, \mathbb{D}_{device\ status}$
  - $\sigma_t(c_i) = v \in \mathbb{R}^n, v = (d_0, .., d_{n-1})$
  - $\mu(c_i) = s, s = \{adv_i, \ldots, adv_k\}_{\sigma_t(c_i)}$

Open Issues and Challenges



Open Issues and Challenges

RD in AAL Spaces (AKA Smart Environment)

- To exploit the context-information to refine the search
- To push to the clients all the **needed** services instead of the **discovered** ones
- To exploit semantic matching techniques in order to match status of the client with the available resources

Open Issues and Challenges

Enabling techniques

- Resource Discovery and routing are similar problems
  - To announce a resource vs to announce a route
  - To query for a service vs to query for a destination
- Cross-layer protocols allow to
  - Piggyback information about the services with the routing protocol
  - Routing messages are filled with service discovery information
- PROS:
  - To reduce overhead of the RD
  - To exploit an existing protocol
- CONS:
  - To increase the message size
  - To modify an existing protocol (ie. AODV)