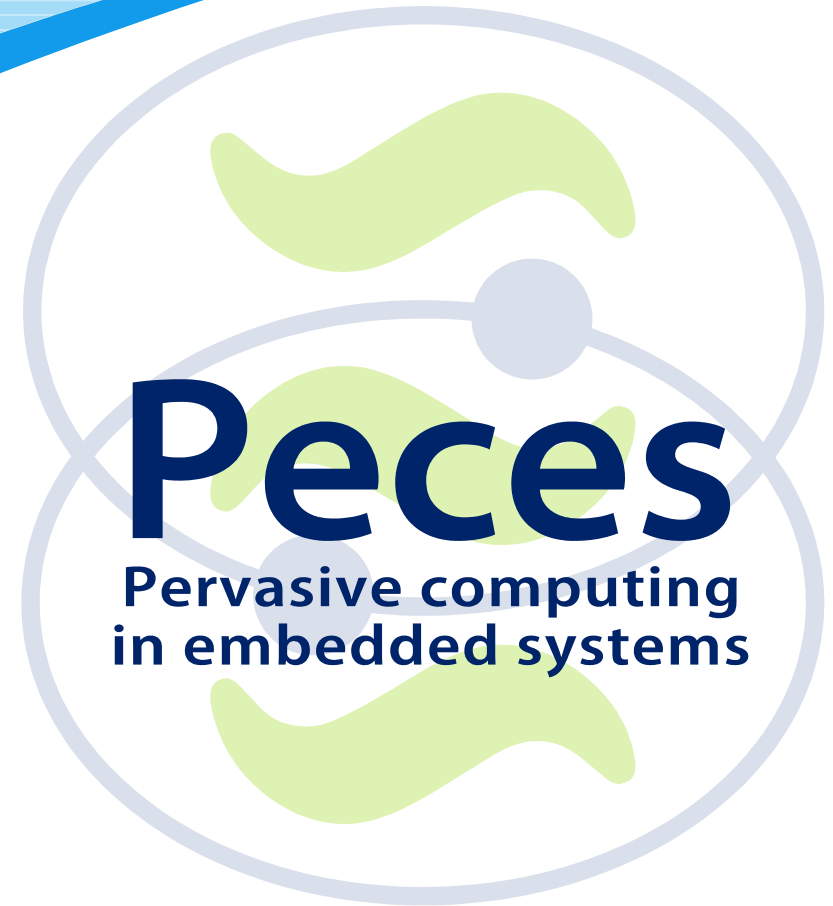EUROPEAN
COMMISSION

Community research

Peces

Pervasive computing in embedded systems

SEVENTH FRAMEWORK
PROGRAMME

ETRA I+D

UNIVERSITY OF DUISBURG-ESSEN

FRAUNHOFER

FRONTENDART

UNIVERSITY OF NEWCASTLE

NATIONAL UNIVERSITY OF IRELAND, GALWAY

Contract:
FP7- 224342-ICT-2007-2

PECES Technology
Outline

- **Goal and Approach**
- **Role Assignment**
  - **Role Specification**
  - **Context Ontology**
  - **Classes of Rules**
  - **Trust and Security**
  - **Automatic Assignment**
  - **Role-based Mechanisms**
- **PECES Middleware**
  - **Architecture**
  - **Interaction**
- **Summary**

PECES
Goal and Approach

- **Goal**
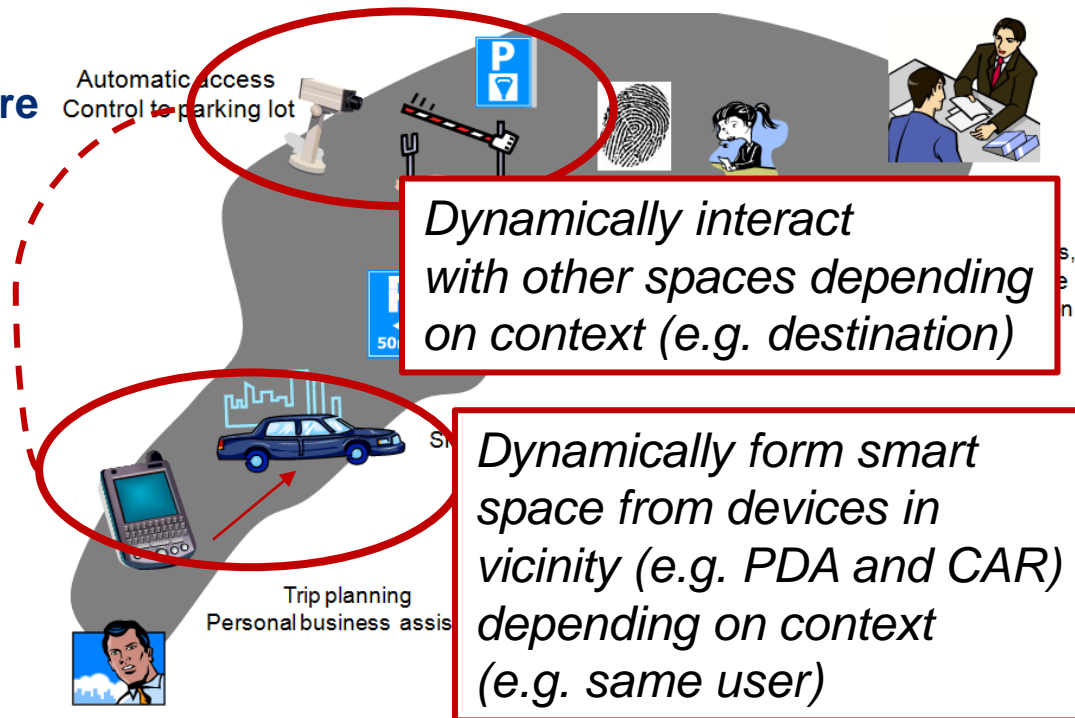 - **Implementation of a middleware to ease development of applications that adapt automatically to their context**
    - Within a single smart space
    - Across smart spaces
- **Validation Applications**
  - **eHealth**
  - **Localization and navigation**
  - **Automated parking system**
- **Approach**
  - **Creation of uniform abstraction for adaptation → role assignment**
  - **Provisioning of middleware mechanisms on top of this abstraction**

Automatic access Control to parking lot

Dynamically interact with other spaces depending on context (e.g. destination)

Dynamically form smart space from devices in vicinity (e.g. PDA and CAR) depending on context (e.g. same user)

Trip planning Personal business assis
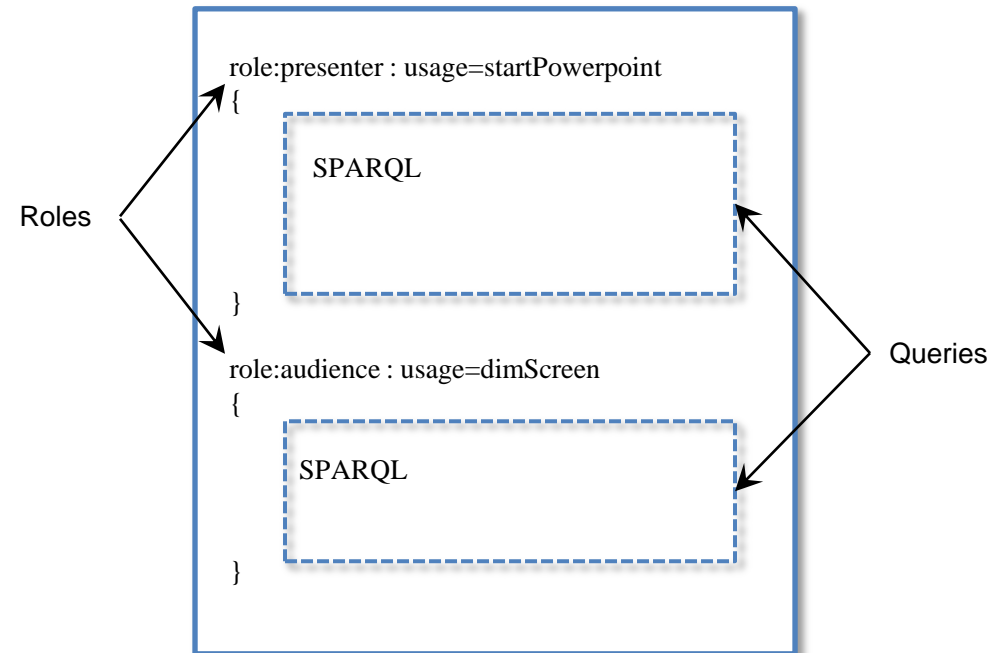
Role Assignment
Overview

- **Devices know parts of their context (e.g. location, equipment, etc.) and make it accessible to other devices**

- **Applications can „address" a set of devices based on constraints on their context (e.g. devices with big screen or devices belonging to John) → specified within a role specification**

- **Generic middleware service computes the sets of devices that match the specified constraints → and assigns so-called roles**

- **Constraints can reference each other hierarchically to improve efficiency and to increase the flexibility → by referring to a role within another role specification**

➢ **Both, applications and middleware services can use assigned roles to interact with a set of devices**

Role Assignment
Role Specification

- **Roles are used to create a higher abstraction from context**
- **Roles are defined in a role specification which contains**
  - ○ **queries to define constraints on context**
  - ○ **usage tags to indicate a meaning**
- **Usage of web standards for portability of context information**
  - ○ **Context represented using RDF statements**
  - ○ **Selected subset of SPARQL to implement queries**
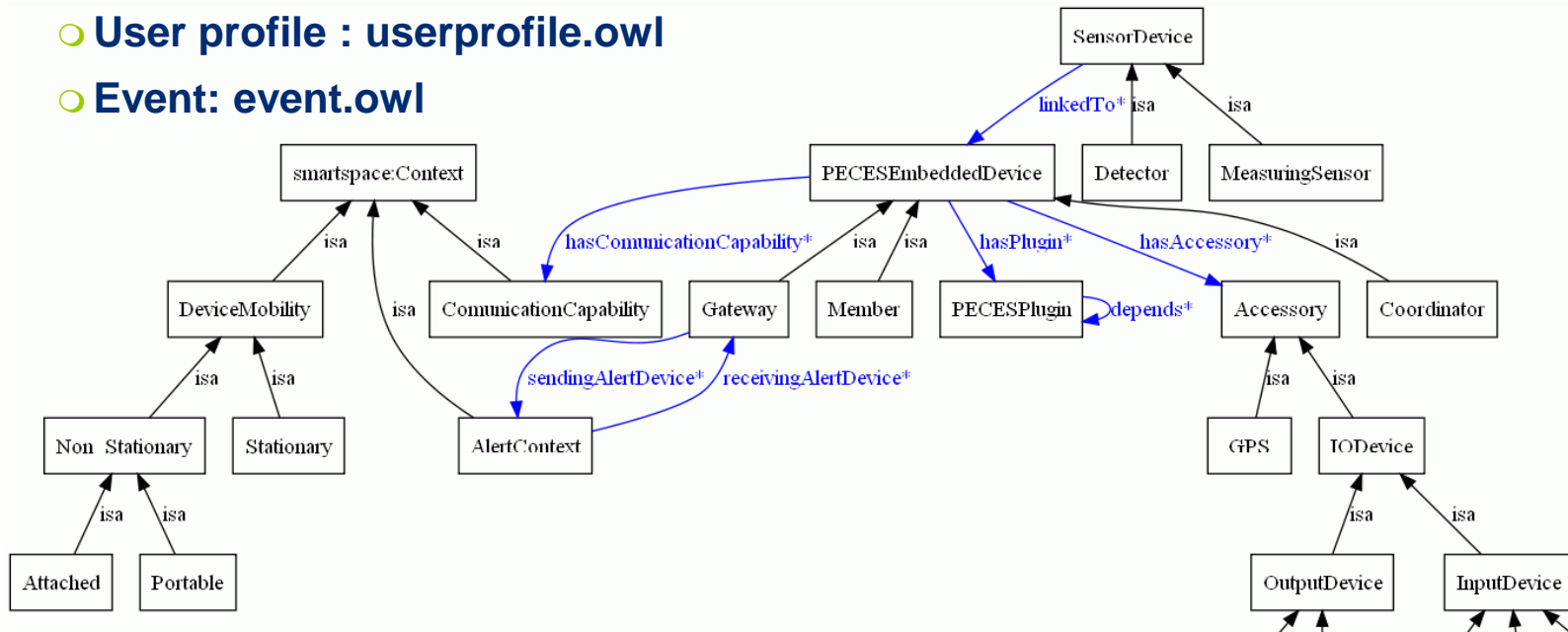 - ○ **Context ontology (OWL subset) to provide data model with support for reasoning**

Roles

role:presenter : usage=startPowerpoint
{

SPARQL

}

role:audience : usage=dimScreen
{

SPARQL

}

Queries

Role Assignment
Context Ontologies

- **PECES context ontology artefacts (http://www.ict-peces.eu/ont/{xyz})**
  - ○ **Smart space ontology : smartspace.owl**
  - ○ **Device ontology profile :device.owl**
  - ○ **Measurement ontology :measurement.owl**
  - ○ **User profile : userprofile.owl**
  - ○ **Event: event.owl**

Role Assignment
Sparql Queries

- **Query language : SPARQL-SELECT**
- **Basic graph pattern (BGP)**
  - **PREFIX rdf: http://xmlns.com/foaf/0.1/**
  - **PREFIX device: http://www.ict-peces.eu/ont/device.owl#**
  - **SELECT   ?accessory**
  - **WHERE {   ?accessory rdf:type device:Accessory }**
- **Conjunctive query form**
  - **SELECT ?accessory ?property ?value**
  - **WHERE {   ?device smartspace:carriedBy <:john>.**
  - **?device device:has_Accessory ?access**
  - **?accessory ?property ?value.**
  - **}**
- **Query patterns can be extended and combined on d scenarios basis**

> list all property and value pairs associated with the PDA carried by John

> A "machine" can determine the specification of the device, and then tailor its service to that device.

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Role Assignment
Further Usage of Context

relatedToMySmartAccessControl

relatedSmartSpace

mySmartAccessControl

participatingDevice

mySmartAccess

service:provides

accessCon
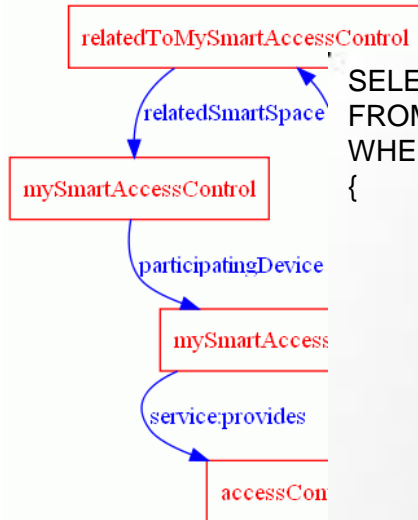
```
SELECT ?device
FROM <useCaseETRA.owl>
WHERE
{
    {
        ?device <http://www.daml.org/services/owl-s/1.1/Service.owl#provides>
                <http://www.ict-peces.eu/ont/smartspace.owl#roadNavigationService>.
        ?vehicle  <http://www.ict-peces.eu/ont/smartspace.owl#participatingDevice> ?device.
        ?vehicle <http://www.ict-peces.eu/ont/smartspace.owl#isOwnedBy>
                <http://www.ict-peces.eu/ont/smartspace.owl#JohnSmith>
    }
    UNION
    {
        ?smartspace <http://www.ict-peces.eu/ont/smartspace.owl#locatedAt> ?location.
        ?location <http://www.w3.org/2003/01/geo/wgs84_pos#location> ?address.
        ?address <http://www.ict-peces.eu/ont/smartspace.owl#country> 'Spain'.
        ?address <http://www.ict-peces.eu/ont/smartspace.owl#city> 'Valencia'.
        ?address <http://www.ict-peces.eu/ont/smartspace.owl#street> 'Tres Forques'.
        ?smartspace <http://www.ict-peces.eu/ont/smartspace.owl#participatingDevice> ?device.
        ?device <http://www.daml.org/services/owl-s/1.1/Service.owl#provides>
                <http://www.ict-peces.eu/ont/smartspace.owl#accessControlRegService>
    }
}
```

- **Besides f**
  - ○ **Context**
  - ○ **Example**

Role Assignment
Classes of Assignment Rules

- **Three classes to support a wide range of applications**

- **Filter Rules**
  - ○ **Constraint over context**
  - ○ **Defined using SPARQL**
  - ○ **Allows restriction to** specific set of devices

- **Reference Rules**
  - ○ **Constraints over roles, e.g. "must have role X from specification Y"**
  - ○ **Allows hierarchical composition of specifications**

- **Authentication Rules**
  - ○ **Constraints over meta information, e.g. "context must have been gathered by sensor X", "context must not be older than 1 hour"**
  - ○ **Allows usage of roles in security critical applications**
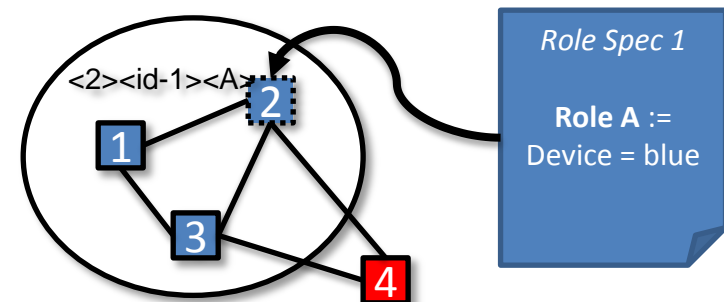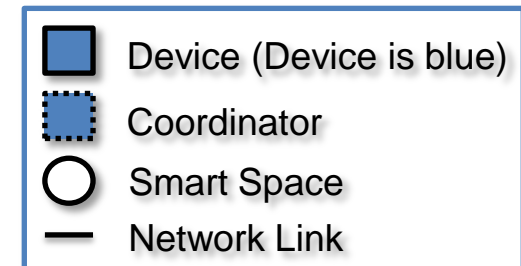
```
SELECT ?device
WHERE
{
  ?device hasUser Alice
  ?device attached Projector
  ?device attached ?screen
  ?screen isA Screen
  ?screen hasWidth ?width
  FILTER(?width > 1000)
}
```

Role Assignment
Automatic Assignment

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- **Roles are tags that are automatically assigned to matching devices**
  - **Multiple devices might have the same role (i.e. several group members)**
  - **One device might have multiple roles (i.e. member of several groups)**
- **To automate role assignment PECES introduces some assumptions**
  - **All smart spaces have a limited physical size**
  - **Size does not exceed k-hop neighborhood (k~3)**
  - **A smart space is represented by one device**
    - Device is acting as coordinator
    - Periodically (re-)assigns the roles in the smart space
- **A role assignment can be exported to a central registry on the Internet**
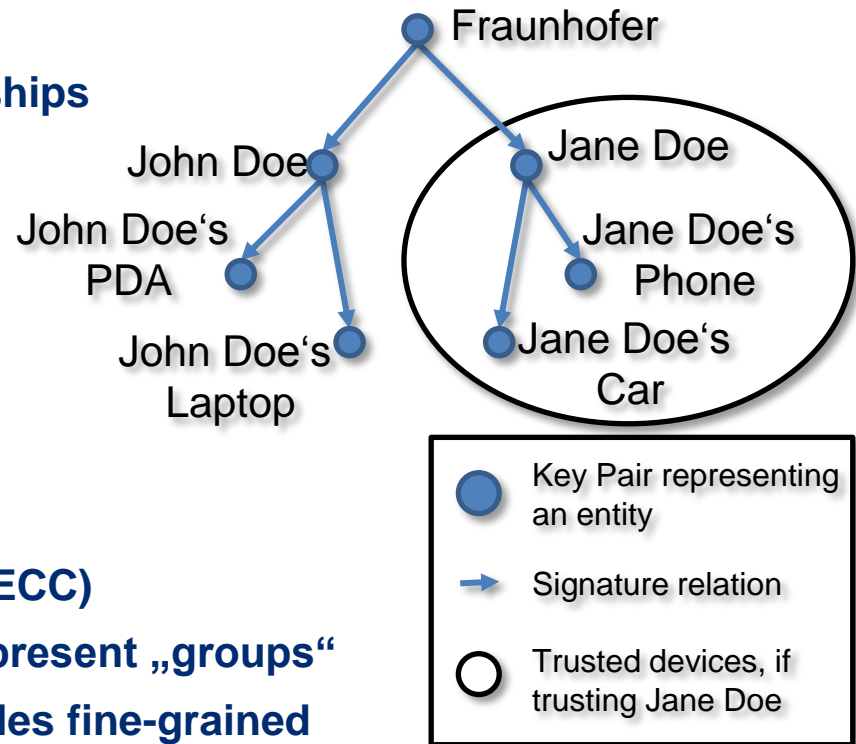 - **Registry can be queried to enable hierarchical role assignment**

Device (Device is blue)
Coordinator
Smart Space
Network Link

<2><id-1><A>

Role Spec 1

Role A := Device = blue

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Role Assignment
Trust and Security

- **Use of certificates to model trust**
  - **Flexible: supports asymmetric relationships**
  - **Distributed: no central point of trust**
- **Use of certificates to bootstrap keys**
  - **Fast: high performance due to caching**
- **Different key distribution schemes**
  - **One-to-one and group communication**
- **Approach**
  - **Devices equipped with asym. key pair (ECC)**
  - **Key pairs signed by other entities to represent „groups"**
  - **Resulting hierarchy of certificates enables fine-grained trust-definition**
  - **Categorization of certificates in different levels of trust**
 - **Trust levels are used to restrict data sharing and role assignment**

Fraunhofer

Jane Doe

John Doe

John Doe's PDA

John Doe's Laptop

Jane Doe's Phone

Jane Doe's Car

Key Pair representing an entity

Signature relation

Trusted devices, if trusting Jane Doe

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Role Assignment
Role-based Mechanisms

- **Group Communication**
  - ○ **A role is used to identify group members**

- **Smart Space Formation**
  - ○ **Roles identify members of the smart space**
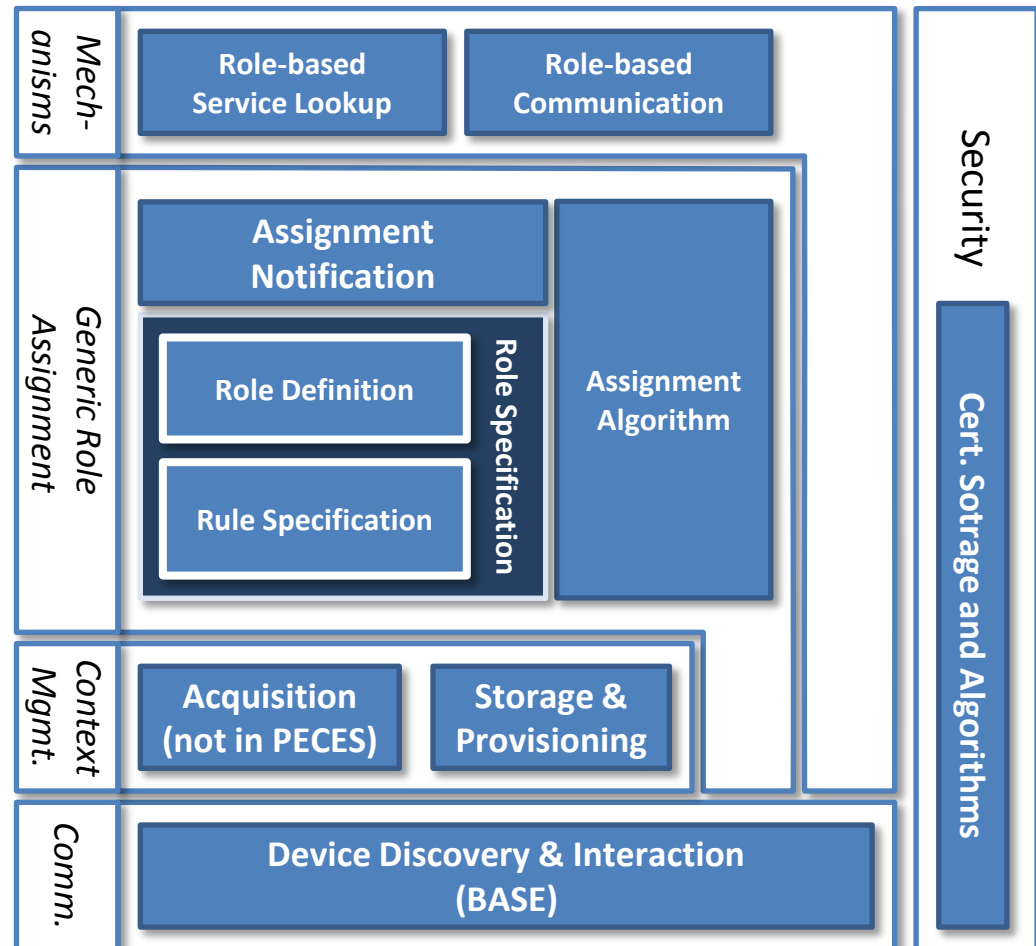 - ○ **Roles identify devices with special abilities (e.g. gateways)**

- **Smart Space Interaction**
  - ○ **Smart spaces are exported to a registry on the Internet**
  - ○ **Roles are used to combine smart spaces hierarchically**

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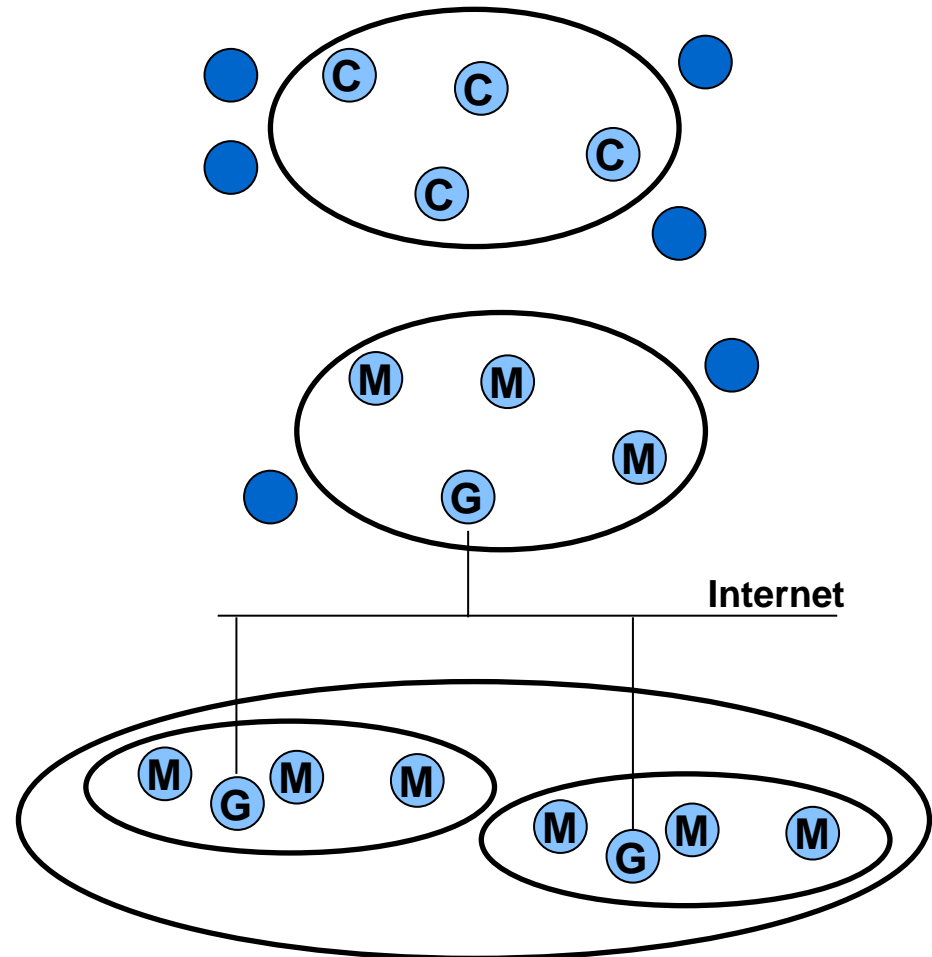
PECES Middleware
Architecture

- **BASE Middleware**
  - **Device Discovery**
  - **Device Interaction**
  - **Service Abstraction**
    - System Services
    - Application Services

- **PECES Extensions**
  - **Context Management**
  - **Security Mechanisms**
  - **Role Assignment**
  - **Role-based Mechanisms**

Mech-anisms

| Role-based Service Lookup | Role-based Communication |

Generic Role Assignment

Assignment Notification

Role Specification
- Role Definition
- Rule Specification

Assignment Algorithm

Context Mgmt.

| Acquisition (not in PECES) | Storage & Provisioning |

Comm.

Device Discovery & Interaction (BASE)

Security

Cert. Sotrage and Algorithms

PECES Middleware
Interaction (Space Formation)

- **Role assignment layer is implemented as a number of generic system services**

  - **ContextStorage: enables execution of context queries**

  - **Coordinator: issues queries and computes assignments**

  - **Notification: signals changes to role assignment**

- **Further services can be used to provide mechanisms**

  - **Member: manages smart space membership**
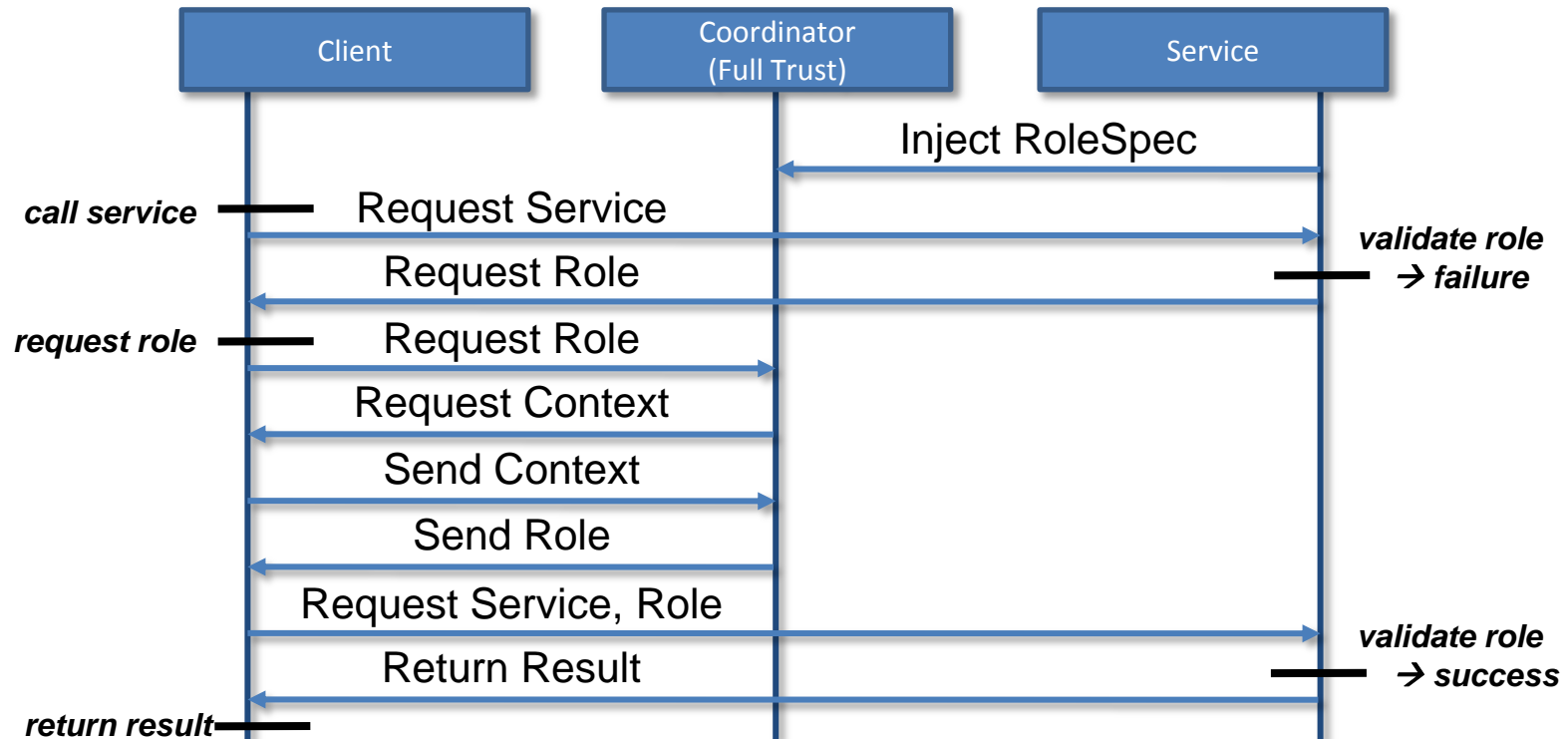
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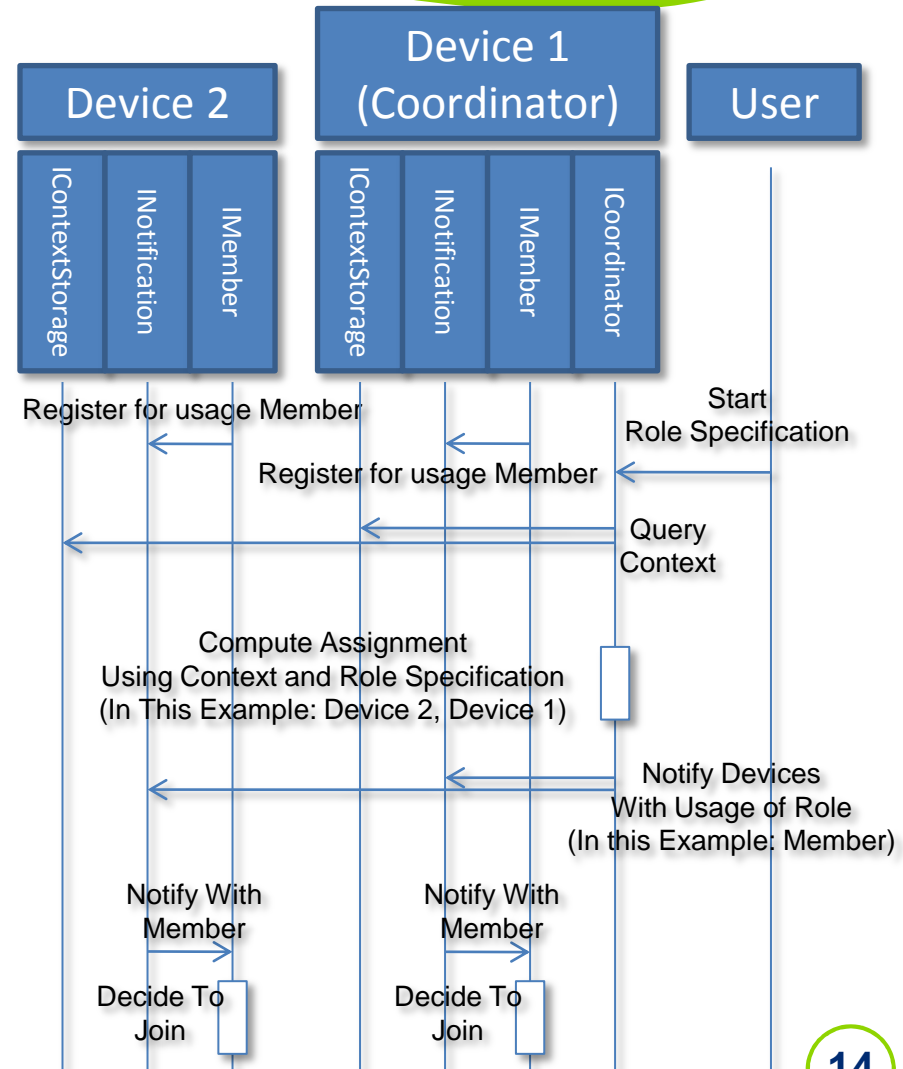
PECES Middleware
Interaction (Access Control)

- **For access control, role assignment is done reactively but basic concepts are identical → reuse of generic abstraction to facilitate device interaction**

Summary

○ **Goal**

- PECES middleware to ease development of adaptive applications
  - –Support for interaction within a single smart space
  - –Support for interaction across different smart spaces

○ **Approach**

- Creation of uniform abstraction for adaptation → role assignment
- Flexible context model based on Web standards to ensure data portability
- Security and trust mechanisms to enable trustworthy interaction
- Provisioning of middleware mechanisms built on top of role assignment
  - –Smart space formation and interaction
  - –Role-based communication and service interaction
  - –Role-based Access Control

PECES Technology
Availability

○ **Open Source**

- All middleware components are available at peces.googlecode.com
  - Device-specific interoperable communication, role assignment, context storage, ontologies, security, …
- BSD license to facilitate pickup in academic and commercial projects
- Apache Maven to enable simple yet modular reuse on heterogeneous devices

○ **Documentation**

- Detailed specifications available at PECES project website
- Walk-throughs and (simple) example applications at Googlecode website

○ **Development Tools**

- Comprehensive suite of tools implemented on top of Eclipse
  - Point-and-click device and security configuration
  - Context and query specification and compilation
  - Scenario emulation and testing

○ **Test it yourself, it is all freely available !**

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- **Questions?**

Título general de la presentación

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