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Innovation Norway  
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CWI

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UNIK  
UNIVERSITY GRADUATE  
CENTER

UNIK4250 - Security in Distributed Systems  
March 2012

# Semantics in Mobile Networks

Josef Noll

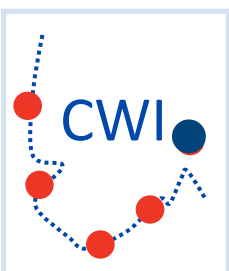
Prof. @UiO/UNIK

[josef@unik.no](mailto:josef@unik.no)

member of CWI Norway

# Overview

- The mobile phone is your representative in the digital world
  - SIM card
  - payment, access (NFC)
  - security agent (store credentials in the SIM card)
  - Location
  - Gateway for the Internet of Things (IoT)
- Security challenges
  - Person: electronic traces, privacy, anonymity
  - Things (IoT): security, privacy, dependability
- Semantics for
  - Context-aware & personalised services
  - attribute-based access control
- Policies
  - User, Company, Service providers
  - Authorities



## Summary

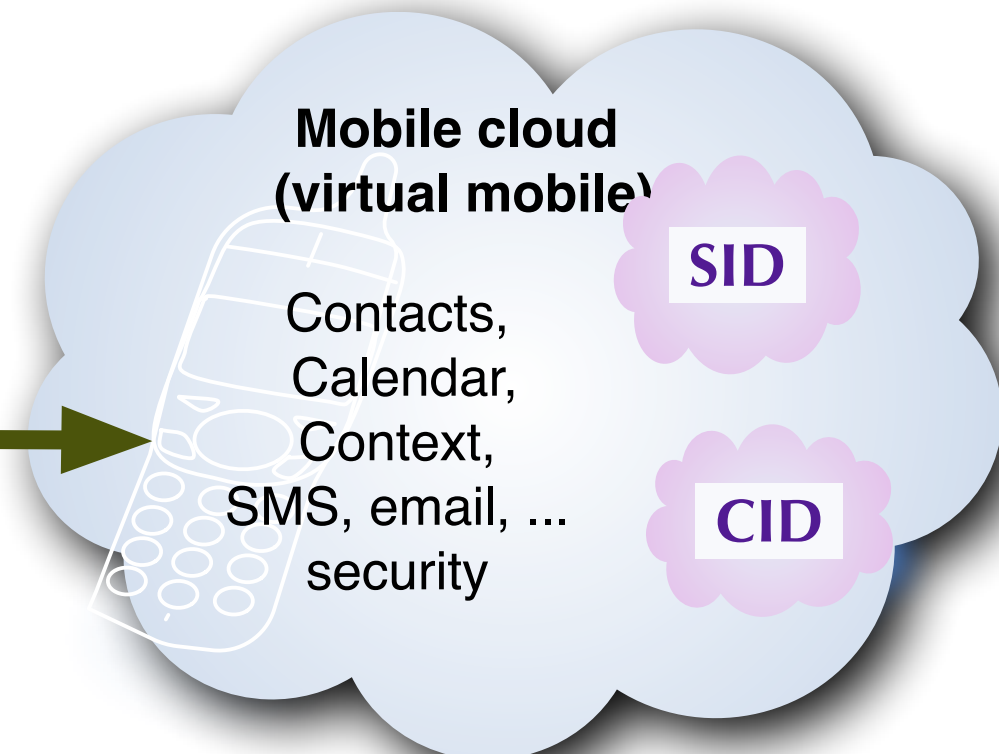
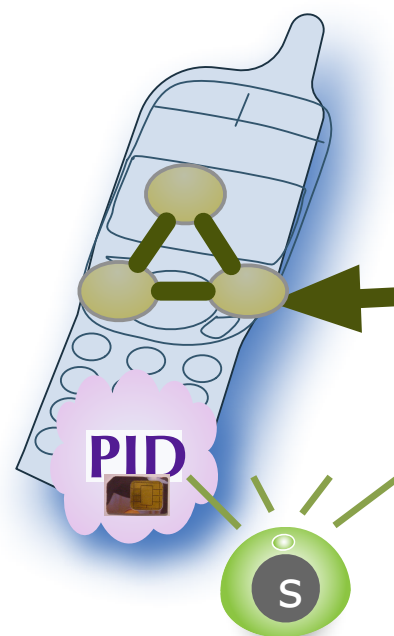
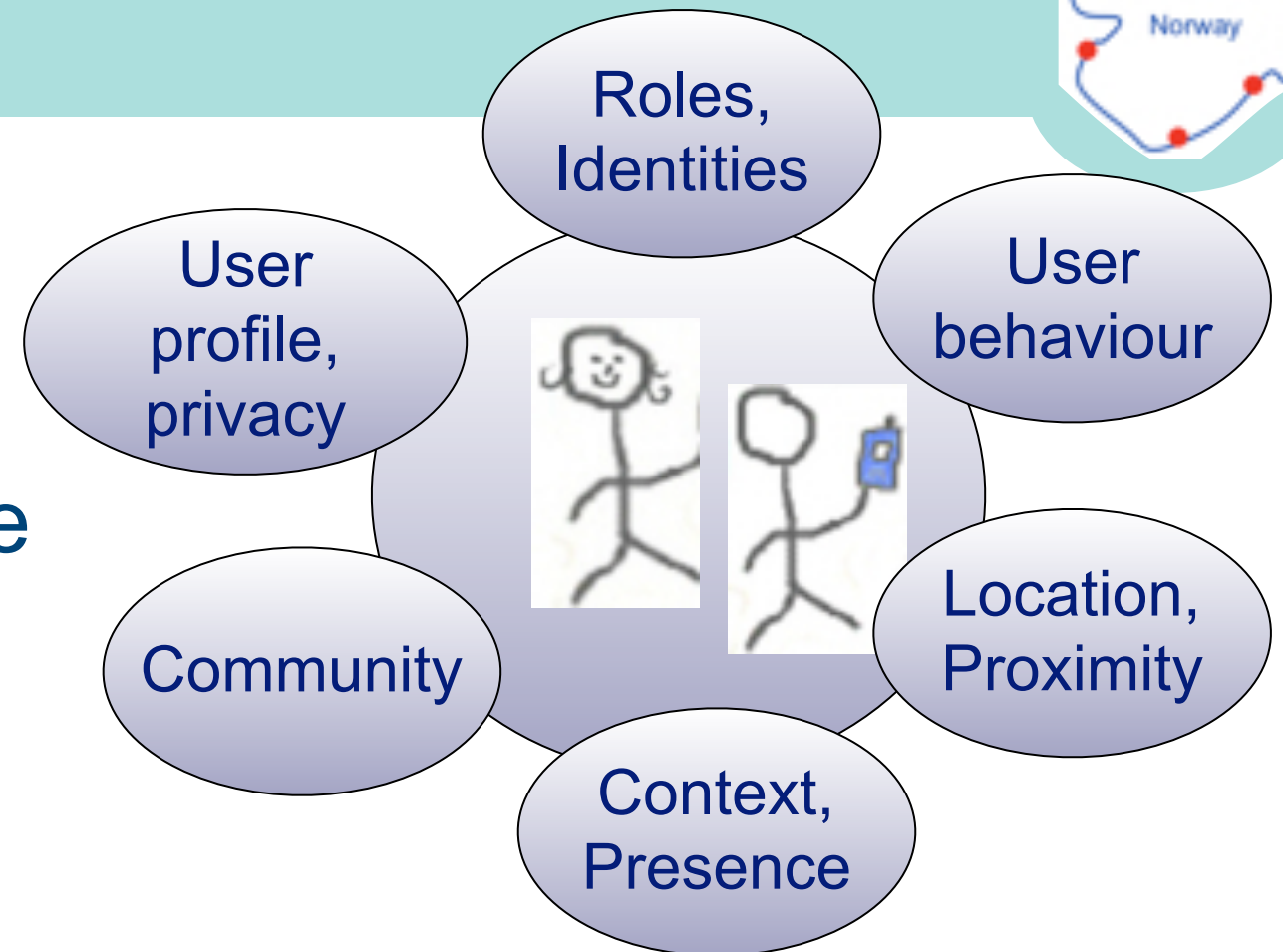
# My phone collects all my security



# User-centric representation in the cloud



- Representation of the user through the mobile - “my digital representative”
- Distributed representation in the cloud - “virtual mobile”
  - Corporate Identity - CID
  - Social Identity - SID
- Privacy in the mobile
  - (Personal) PID
- ensures/enables
  - user-centric
  - privacy
  - cloud reasoning



# Roadmap Beyond 3G (B3G)



B3G vision:

User preferences

Security, QoS, Price  
Appearance, User friendly  
Presence (context aware)  
Community (micro co-ordination connection, services)

It works

Services

Media scaling  
Service discovery, Jini, Mobile Agents  
Management: network, security

It is simple

Technology

Core Network  
Access network  
Terminals  
Supplementary technologies

1-2 Mbit/s everywhere  
200 Mbit/s in hot-spots

It is personalised



2001

2005

2008/2010



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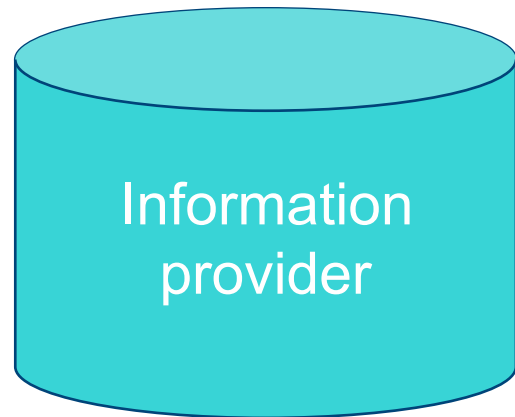


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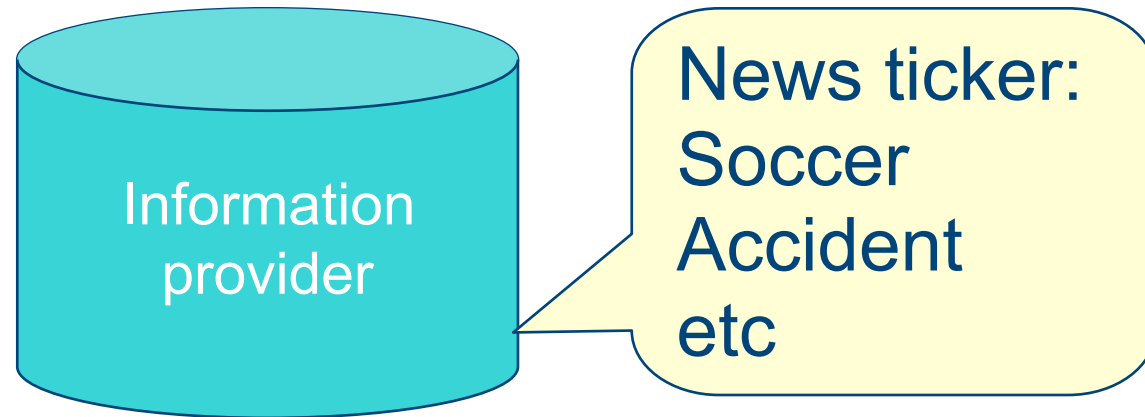
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2008/2010

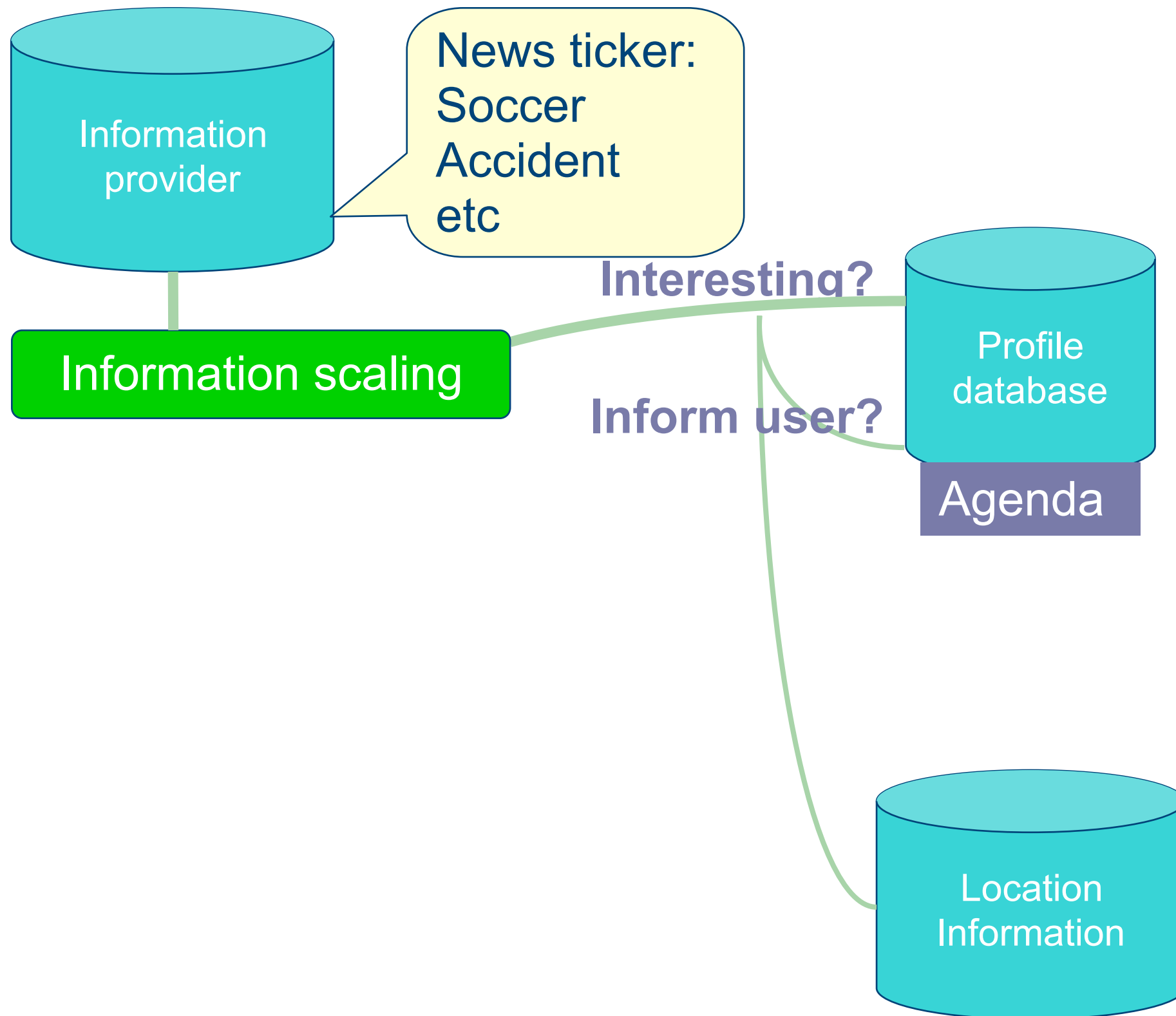
# Example: Personalised Information Provision



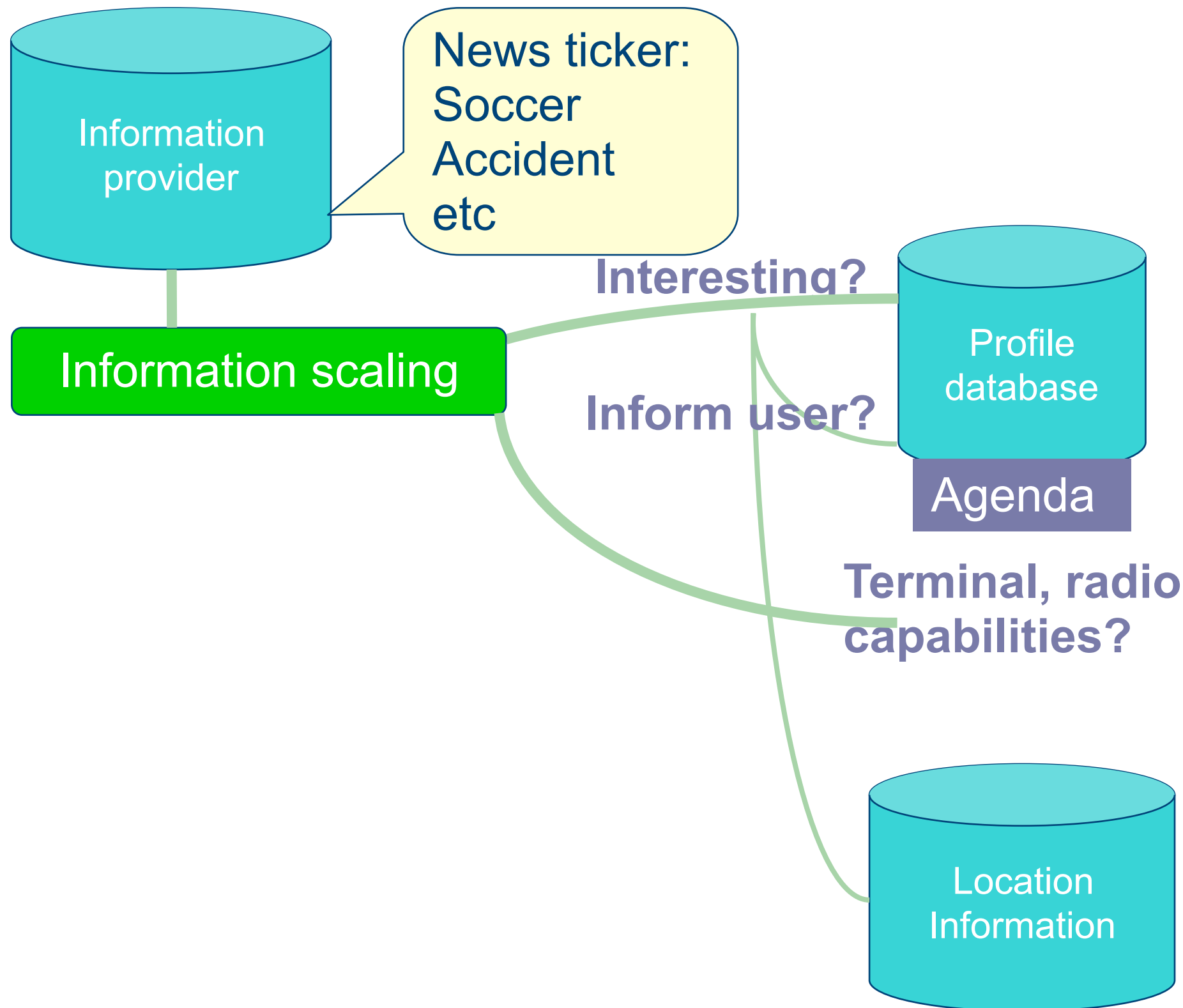
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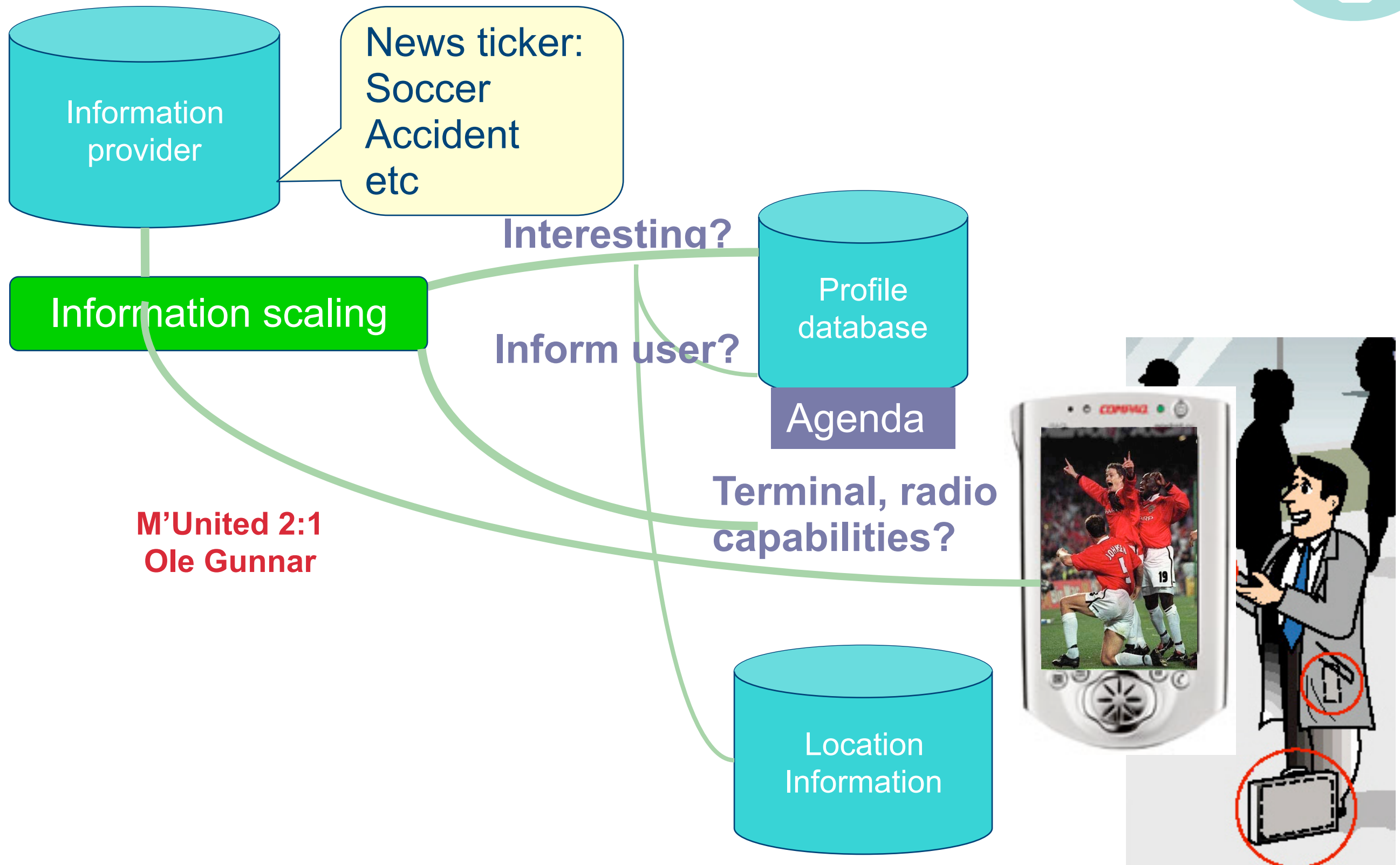
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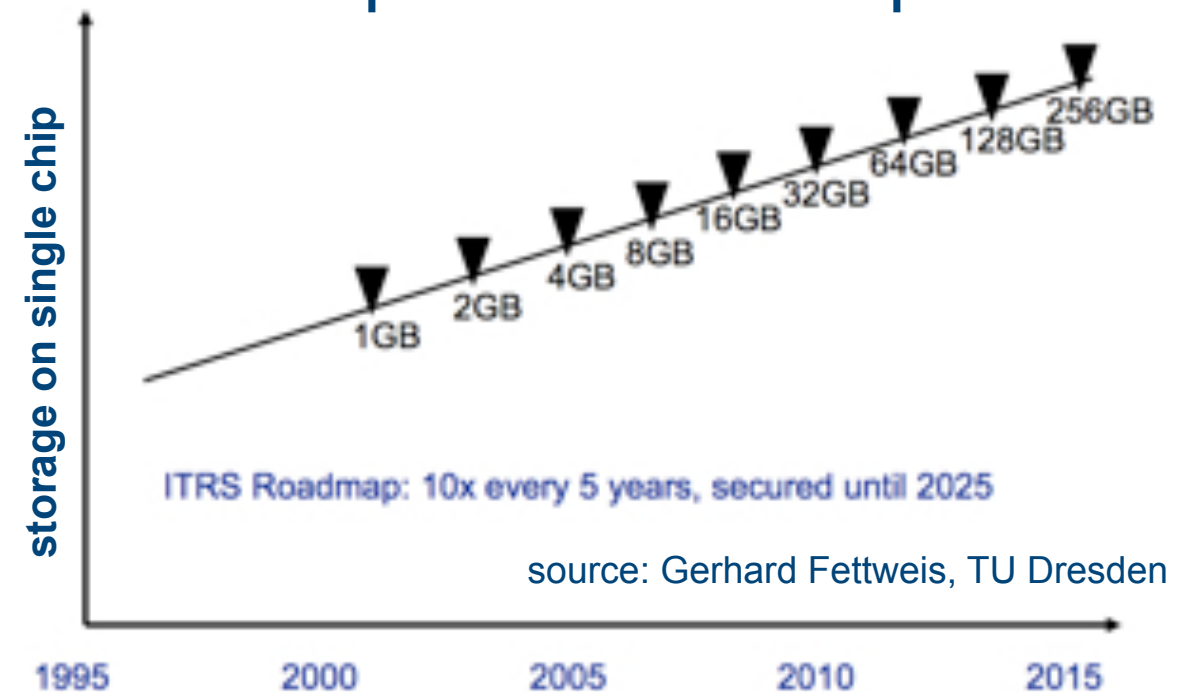


# Future Internet and Internet of Things

## Real world statements



- The speed of development



Your mobile phone is the  
representative in the digital  
world  
and the gateway to the  
**world of sensors**

# Future Internet and Internet of Things

## Real world statements



**"Last year (2007) the world produced more transistors than rice corns"**  
– Hans Christian Haugli, CEO, Telenor R&I  
2008

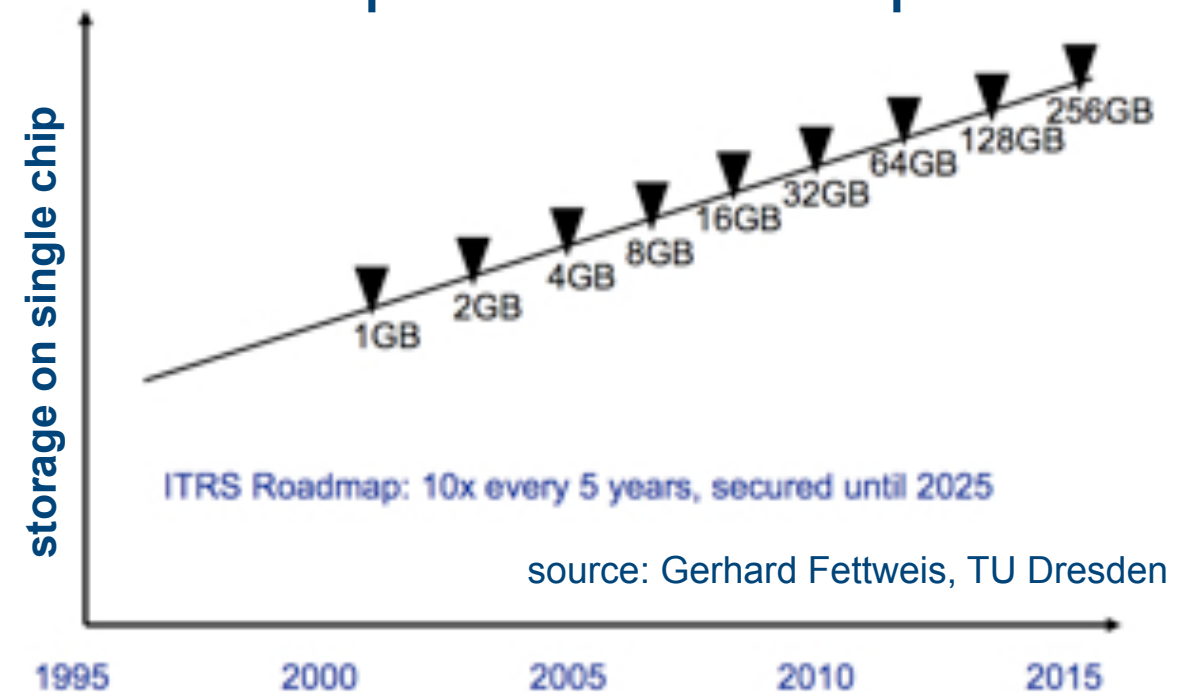
**"By 2012, iPods ... be capable of holding all music you will ever hear in your life (or one year of video)"**

**By 2018 it can hold all videos ever produced"**  
– Nikesh Arora, EMEA manager, Google

**"The privacy you are so fond of is mostly an illusion"**  
– Scott Mc Nealy, Sun Microsystems

**"Now we have roughly 5.2 Mio mobile subscribers. In some year we will have 30...50 Mio devices on the mobile network"**  
– Hans Christian Haugli, CEO, Telenor Objects  
2010

### ● The speed of development



Your mobile phone is the representative in the digital world  
and the gateway to the **world of sensors**

# Mobile Phone and Sensors



- N. Arora, Google Europe Manager [Oslo Innovation Week]:
  - By 2012, iPods ... be capable of holding all music you will ever hear in your life (or one year of video)
  - By 2018 it can hold all videos ever produced
- This speed will continue until 2025 [ITRS Roadmap]

# Mobile Phone and Sensors

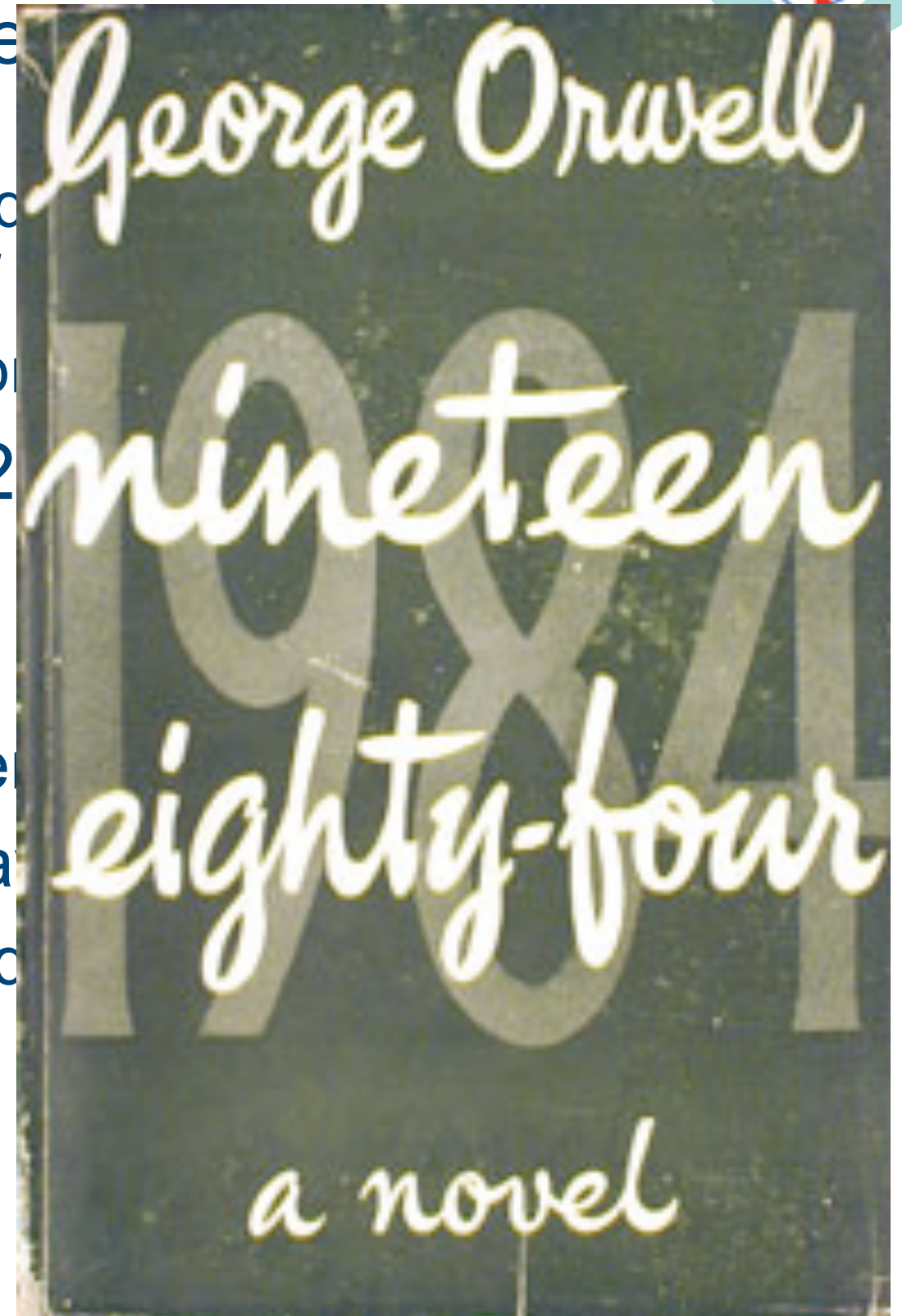


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- Imagine a device, which
  - will save all the conversations you ever had
  - will record all the environments you have ever been in
  - identity all people you have ever talked to and remember what you talked about

# Mobile Phone and Sensors

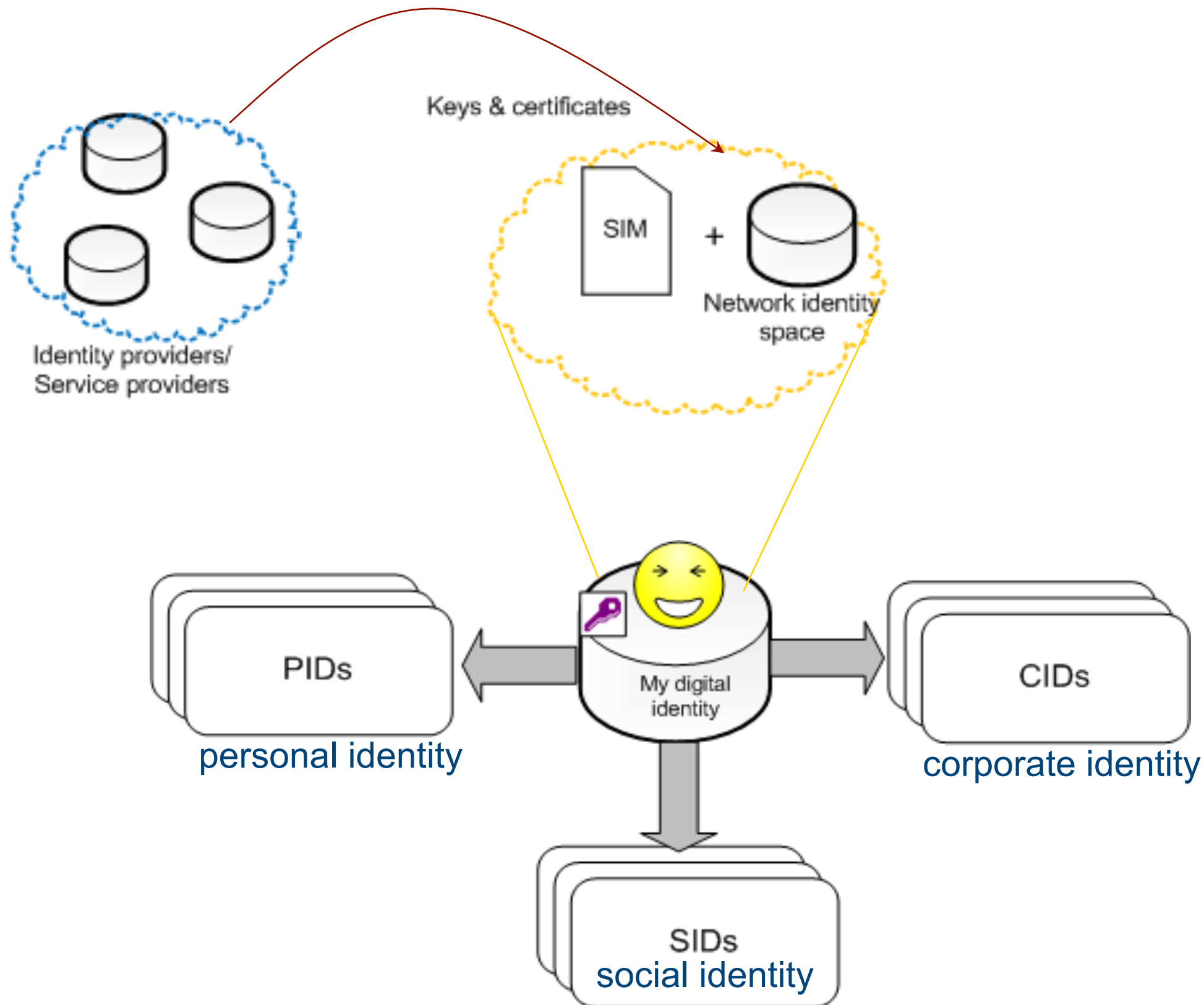


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  - By 2018 it can hold all videos ever produced
- This speed will continue until 2020



- Imagine a device, which
  - will save all the conversations you ever have
  - will record all the environments you have been in
  - identify all people you have ever talked to and all the places you talked about
- “Your Mobile will do”

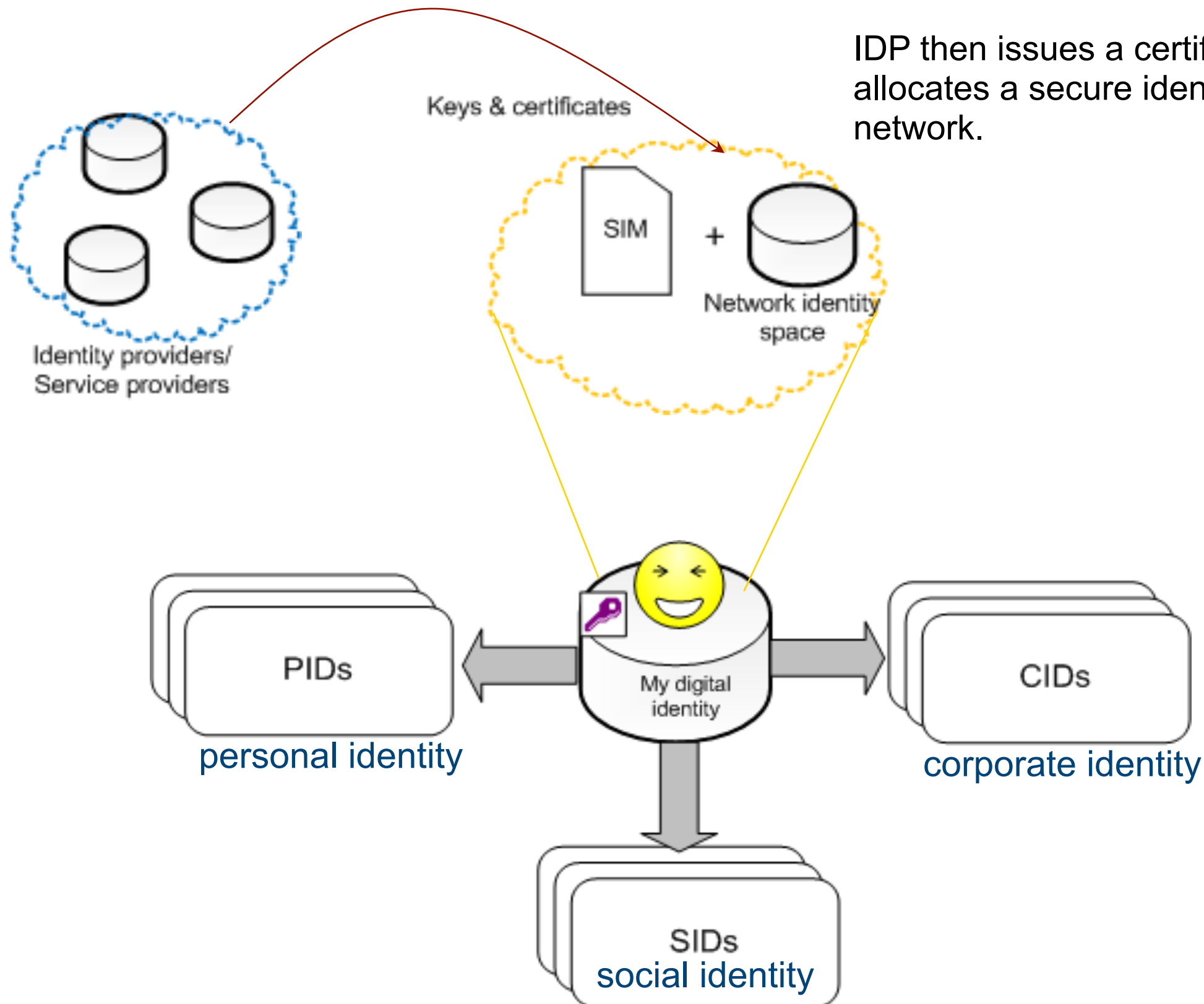
# Distributed Identities and ID Provider



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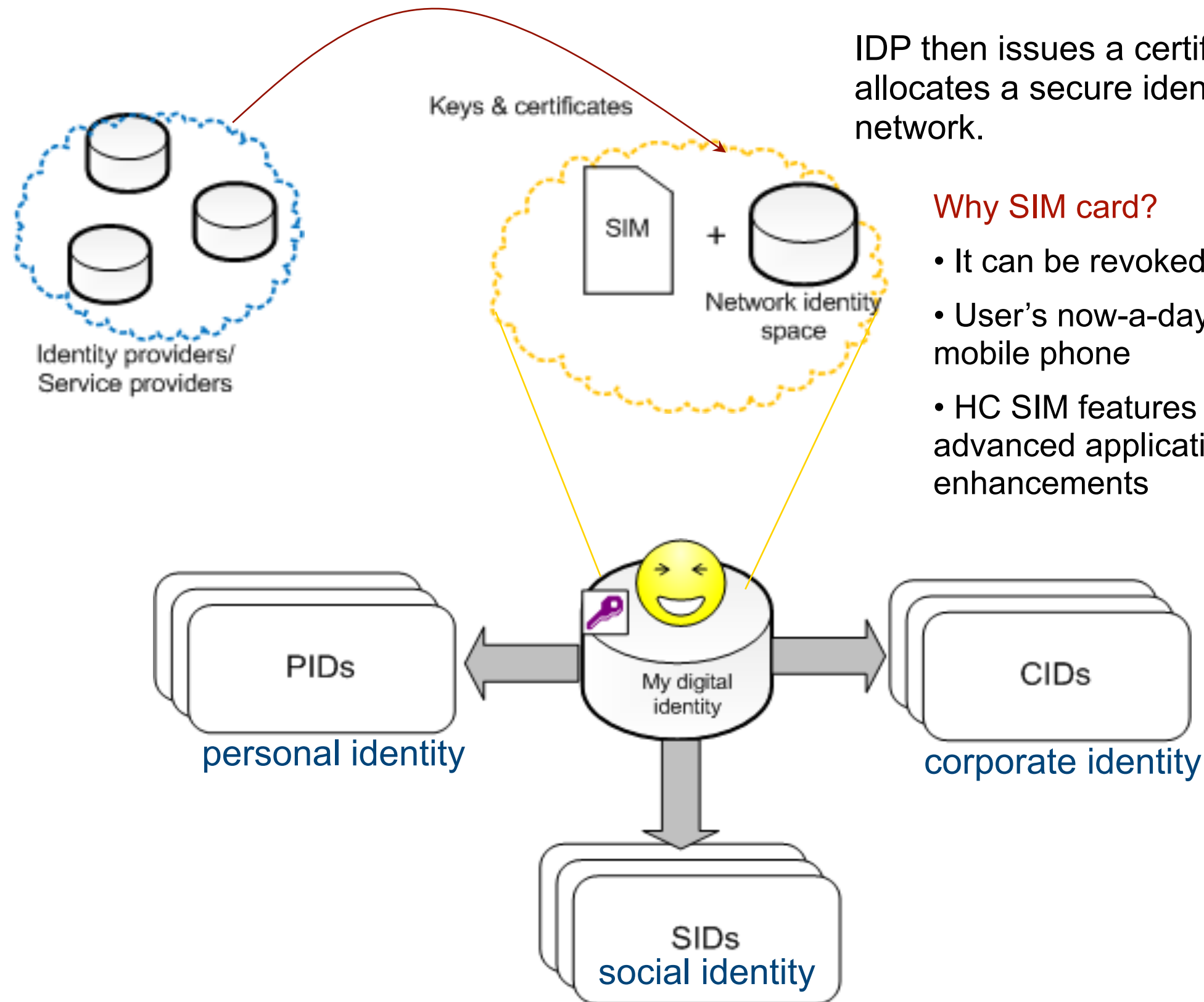


IDP then issues a certificate to the user and allocates a secure identity space in the network.



# Distributed Identities and ID Provider

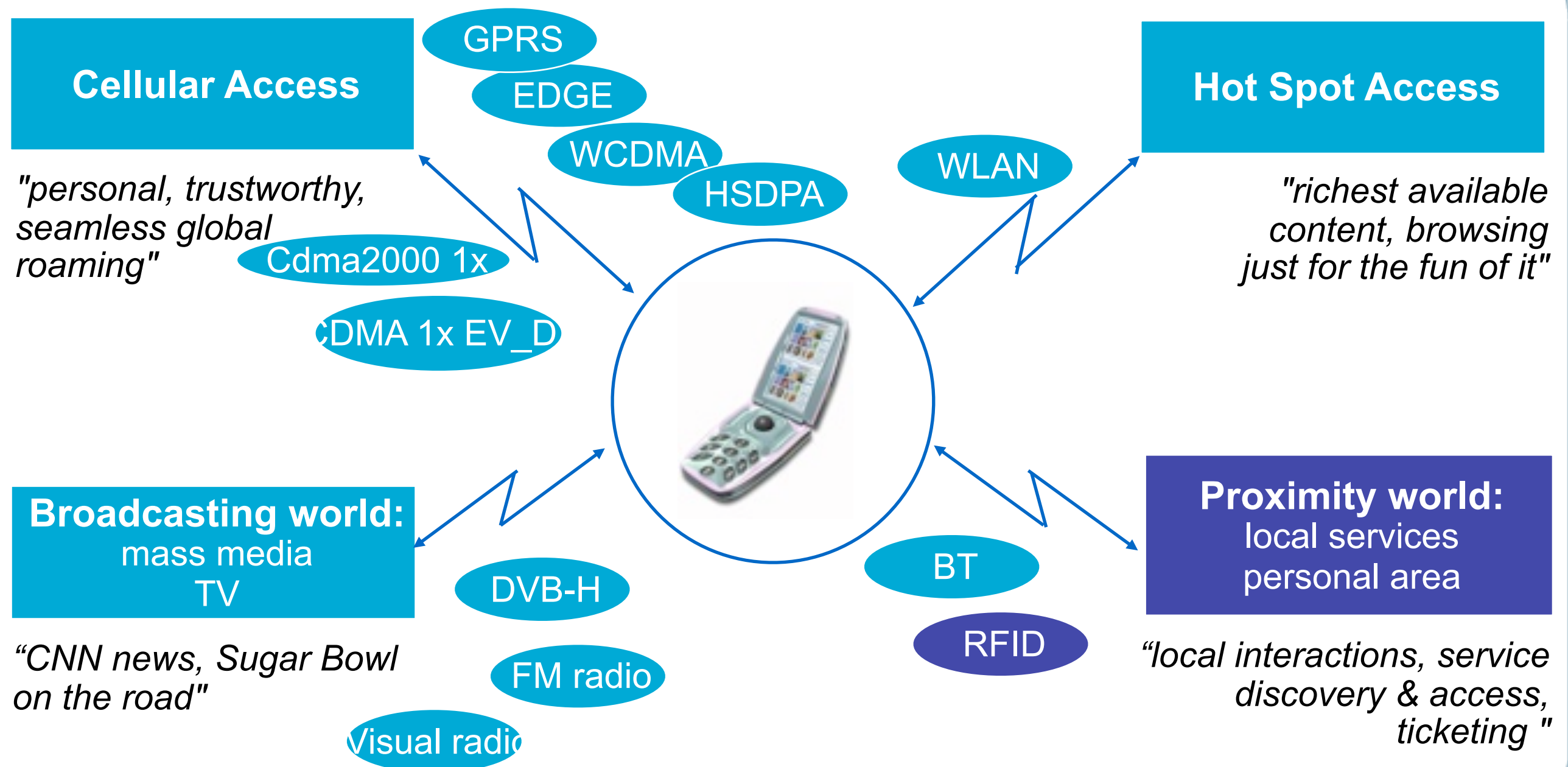
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## Why SIM card?

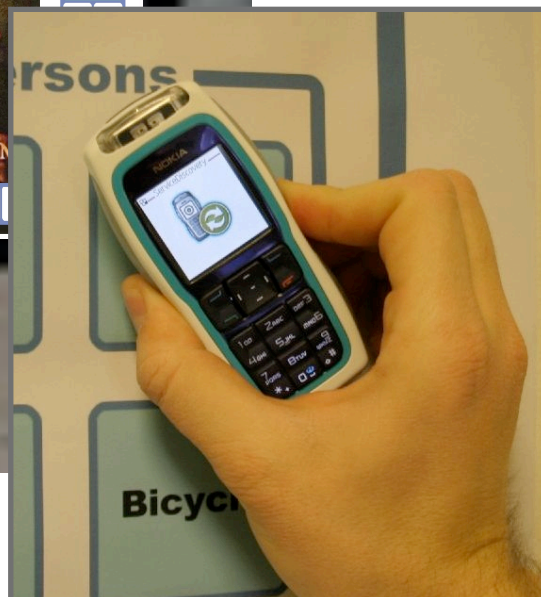
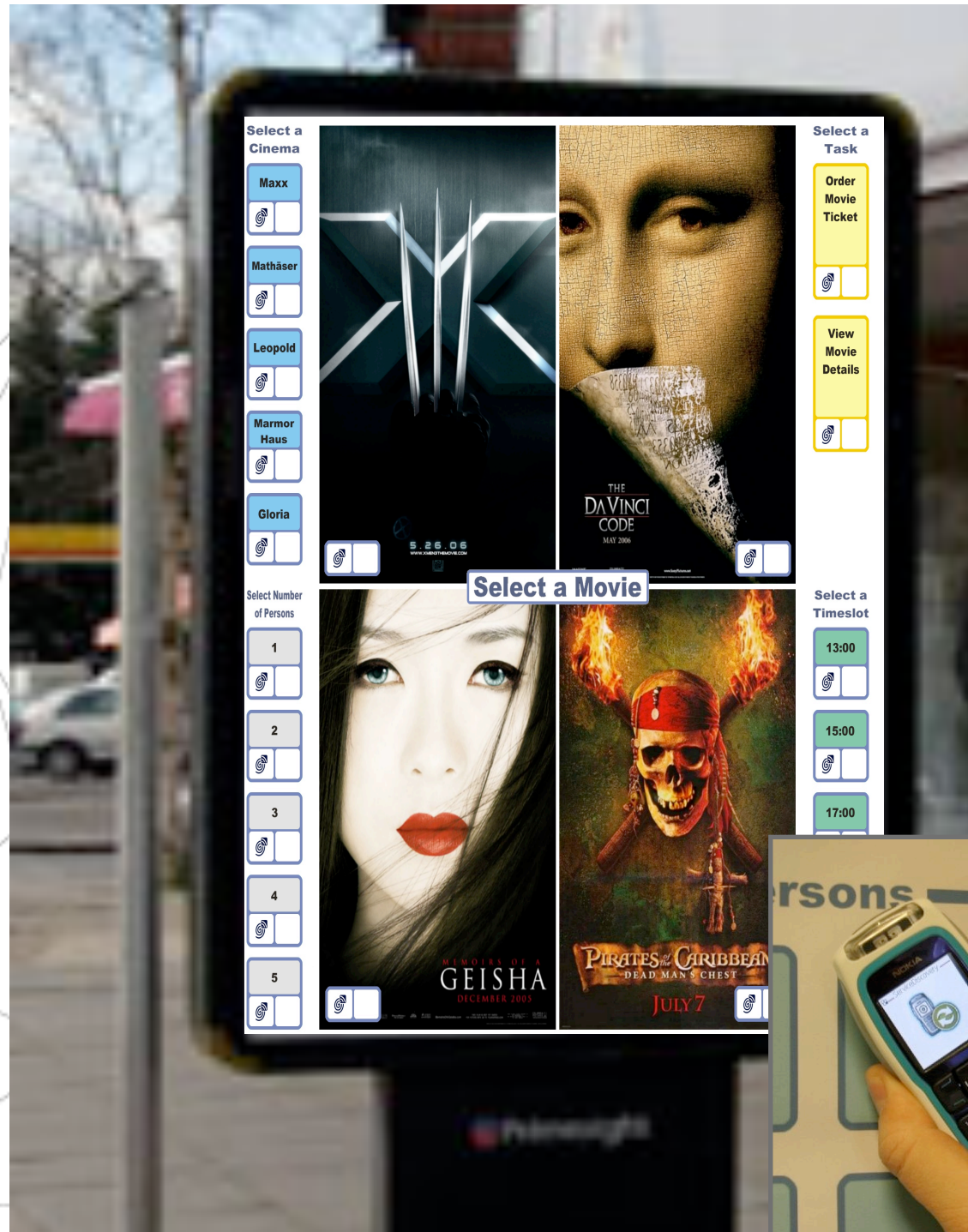
- It can be revoked
- User's now-a-days rarely found without mobile phone
- HC SIM features more storage, advanced applications, further security enhancements

# Local interactions are a natural step toward multi-radio access of complementing radio technologies

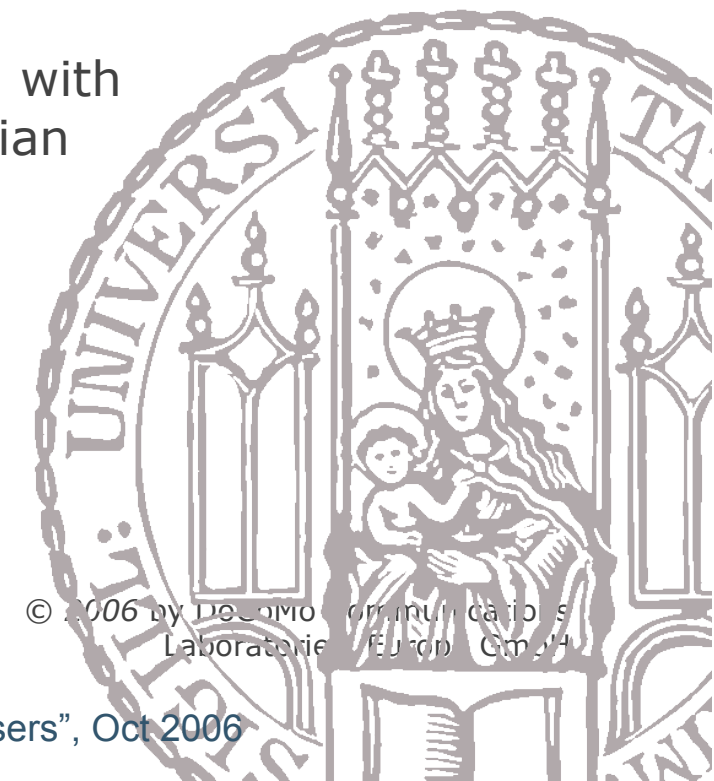


## PERvasive Service Interaction

- Mobile users can interact with **arbitrary** objects tagged with electronic or visual tags
- Through this interaction the mobile user implicitly **interact with a service**
- Mobile user can **purchase goods** such as tickets, music etc; or acquire information about a location, products, transport etc.



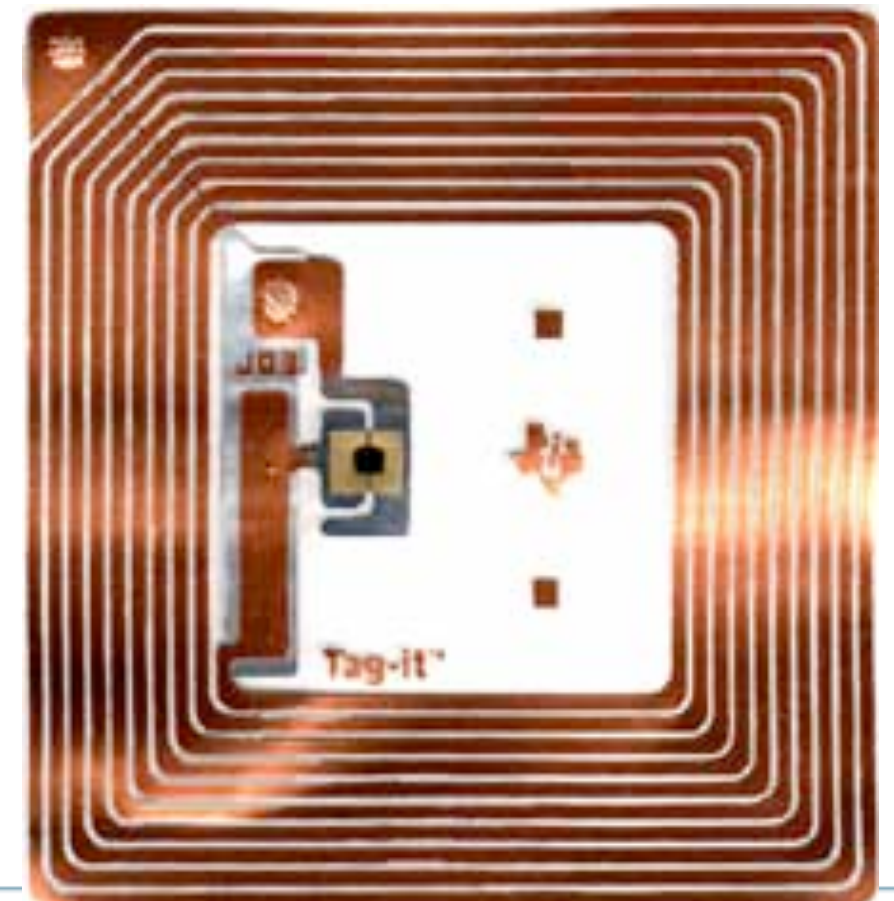
In collaboration with  
Ludwig Maximilian  
Universität  
München



© 2006 by DoCoMo Communications Laboratories Europe GmbH

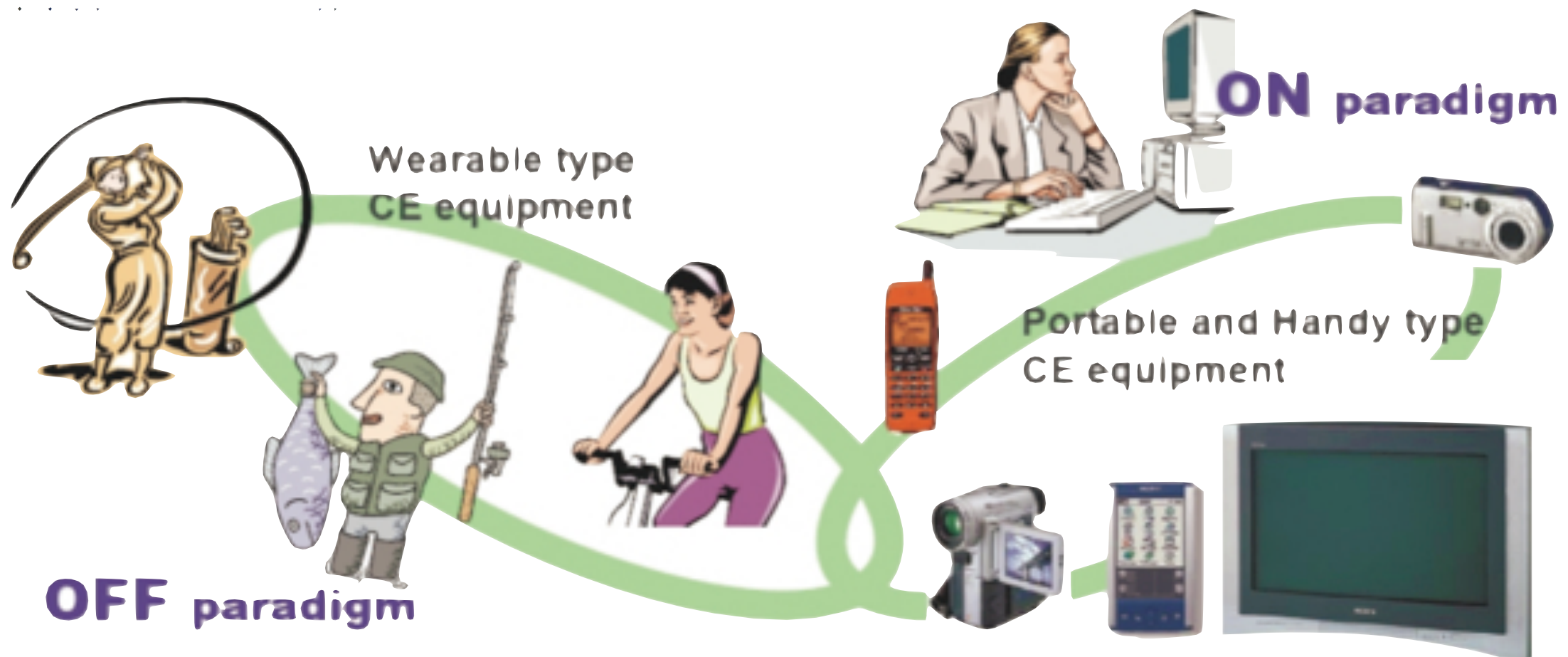
# RFID Tag (Transponder)

- | Consist of microchip that stores data and antenna
- | Active transponders have on-tag battery
- | Passive transponders obtain all power from the interrogation signal of reader
- | Active and passive only communicate when interrogate by transceiver
- | Available in all forms



# NFC technology and use case

- Based on RFID technology at 13.56 MHz
- Typical operating distance 10 cm
- Compatible with RFID
- Data rate today up to 424 kbit/s
- Philips, Sony and Nokia
- ECMA-340, ISO/IEC 18092 & ECMA-352, ...standards
- Powered and non-self powered devices

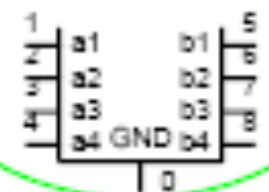


# NFCIP-2 Interface and protocol (ISO/IEC 21481)



Proximity Card  
Reader

Vicinity Card  
Reader

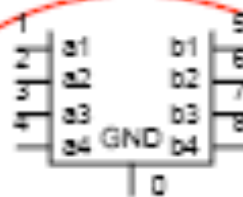


Interface  
Standards

ISO/IEC 18092  
(NFCIP-1)

ISO/IEC 14443  
(Contactless  
Proximity Cards)

ISO/IEC 15693  
(Contactless  
Vicinity Cards)



Proximity Card

Vicinity Card

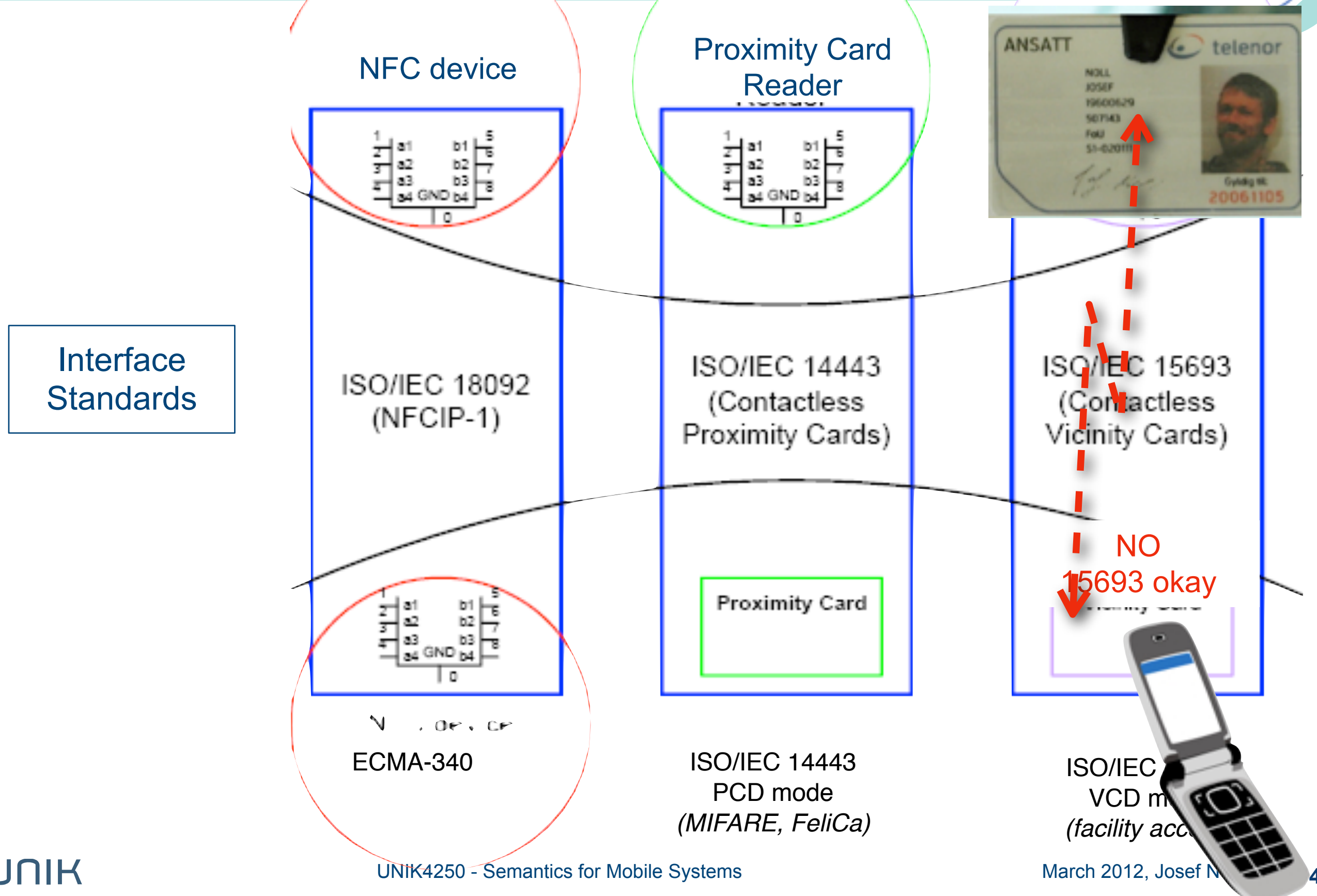
ECMA-340

ISO/IEC 14443  
PCD mode  
(MIFARE, FeliCa)

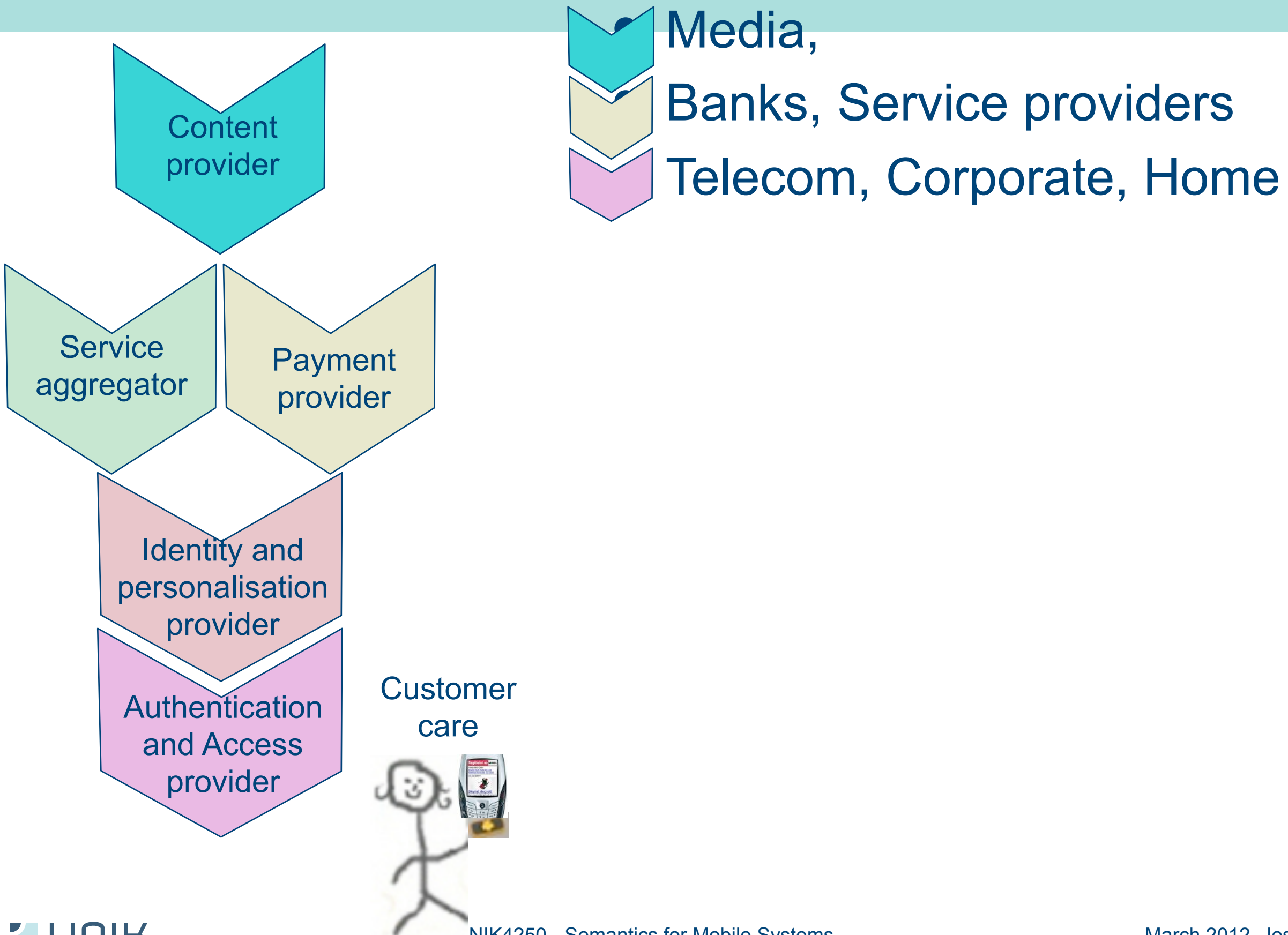
ISO/IEC 15693  
VCD mode  
(facility access)



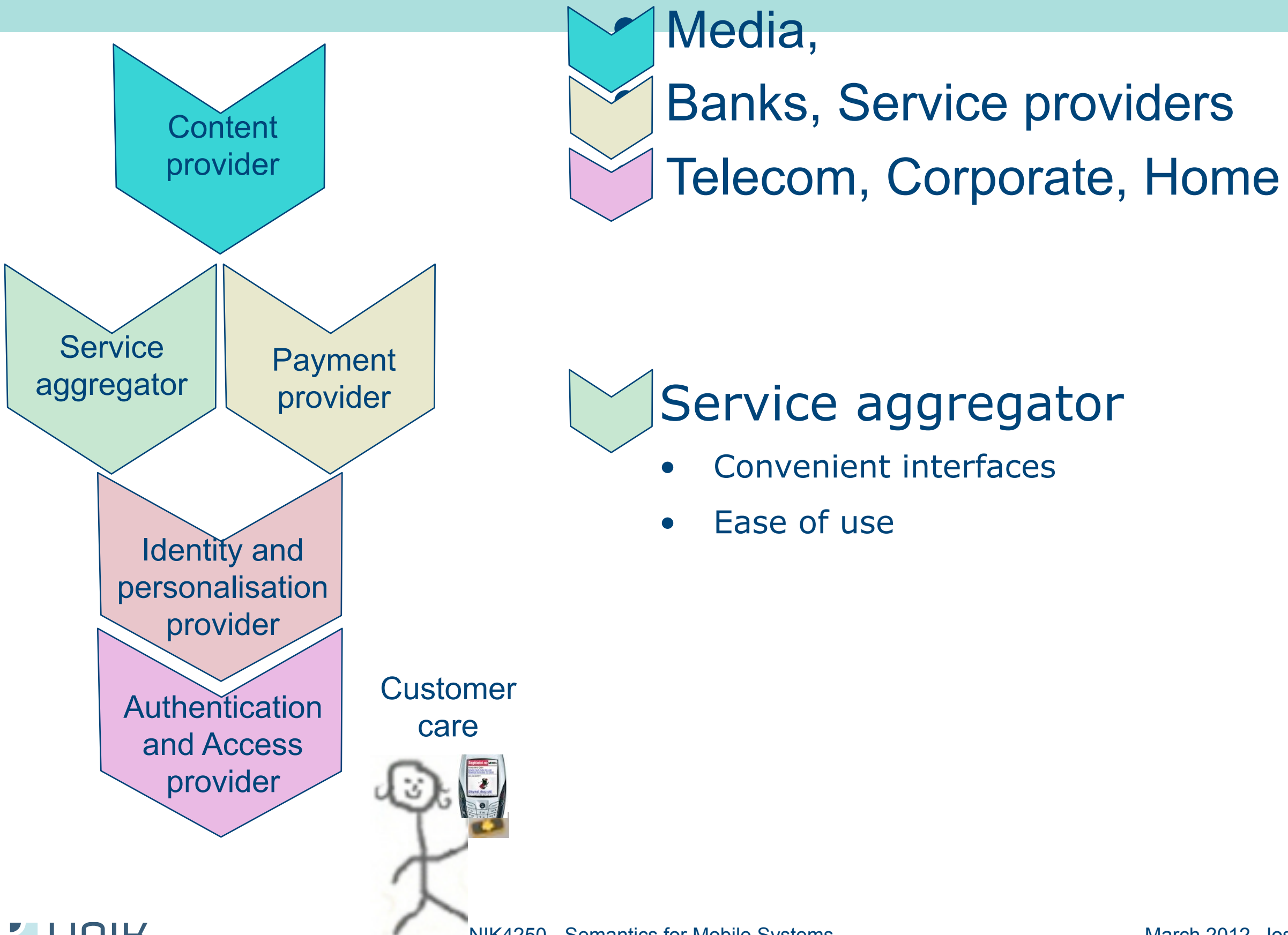
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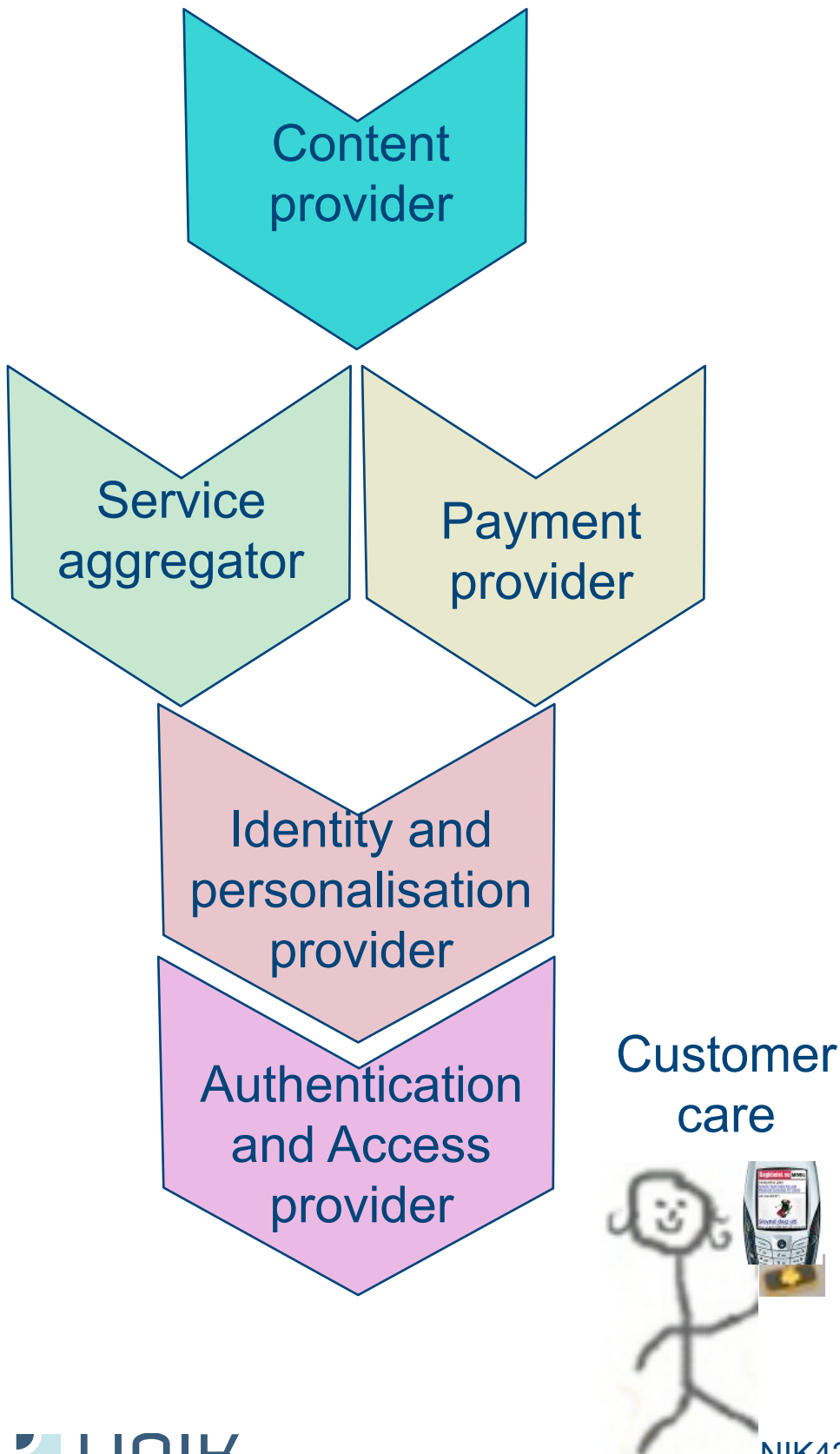
# Third party business model



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# Third party business model



Media,  
Banks, Service providers  
Telecom, Corporate, Home

Service aggregator

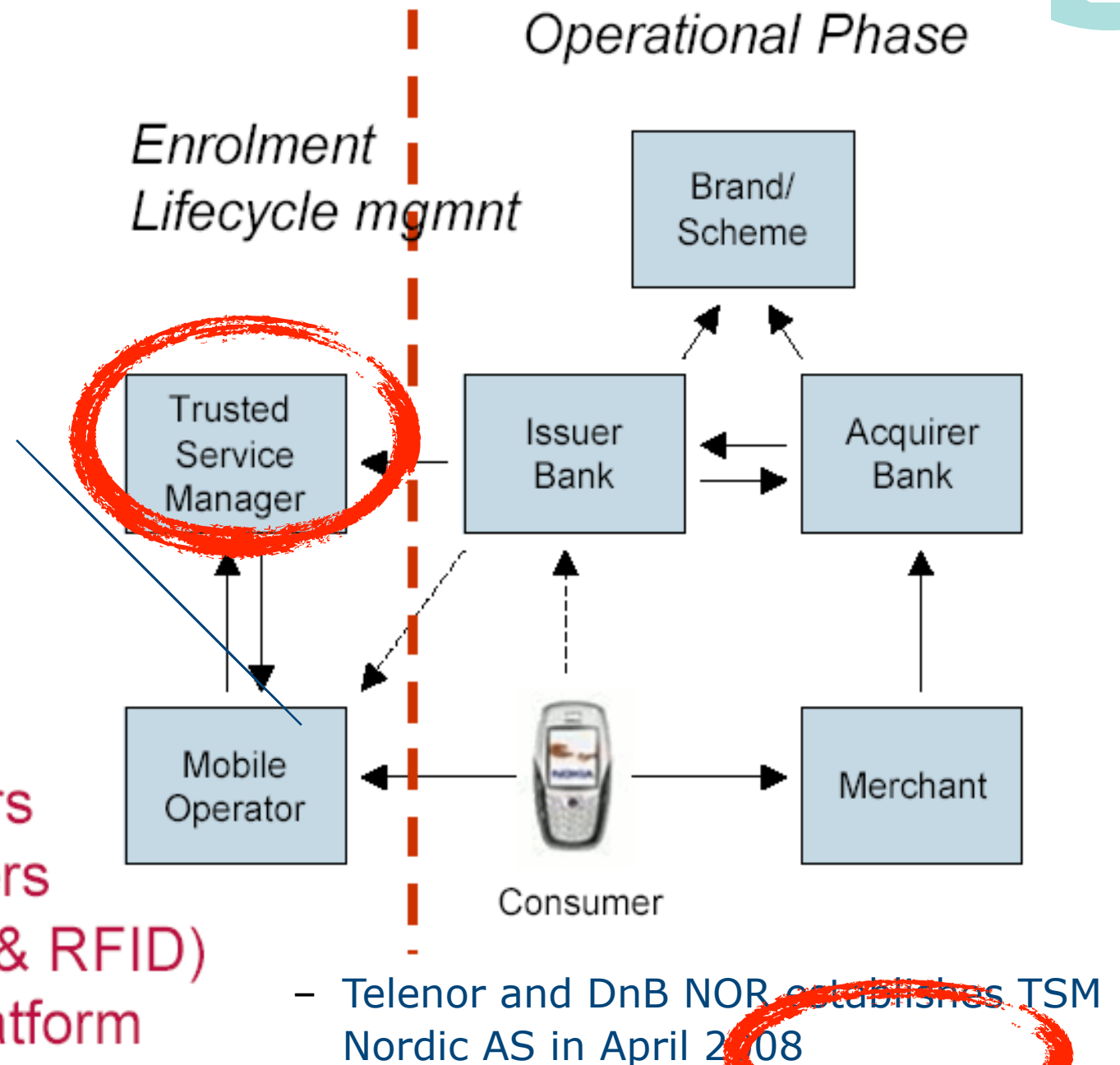
- Convenient interfaces
- Ease of use

Identity and personalisation provider

- Convenience
- Trust

# Ecosystem: for NFC The collaborative business model

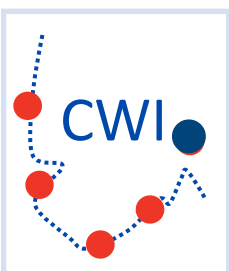
- Principle Stakeholder
    - Consumer
  - Key Stakeholders
    - Banks
    - Mobile Operators
    - Merchants
  - Supporting Stakeholders
    - Card Associations
    - Transaction Service Providers
    - Mobile Handset Manufacturers
    - Technology Providers (NFC & RFID)
    - Third Parties (Application/Platform Providers)
- Source : Mobey Forum Ltd. + Bent Bentsen, 2008



# Intro

- The mobile phone is your representative in the digital world
  - SIM card
  - payment, access (NFC)
  - security agent (store credentials in the SIM card)
  - Location
  - Gateway for the Internet of Things (IoT)
- Security challenges
  - Person: electronic traces, privacy, anonymity
  - Things (IoT): security, privacy, dependability
- Policies
  - User, Company, Service providers
  - Authorities
- Semantics for
  - Context-aware & personalised services
  - attribute-based access control

Summary



# Have you heard these ones?

from Scott Mc Nealy (Sun Microsystems)



**“The privacy you are so fond of is mostly an illusion”**

**“You have no privacy. Get over it.”**

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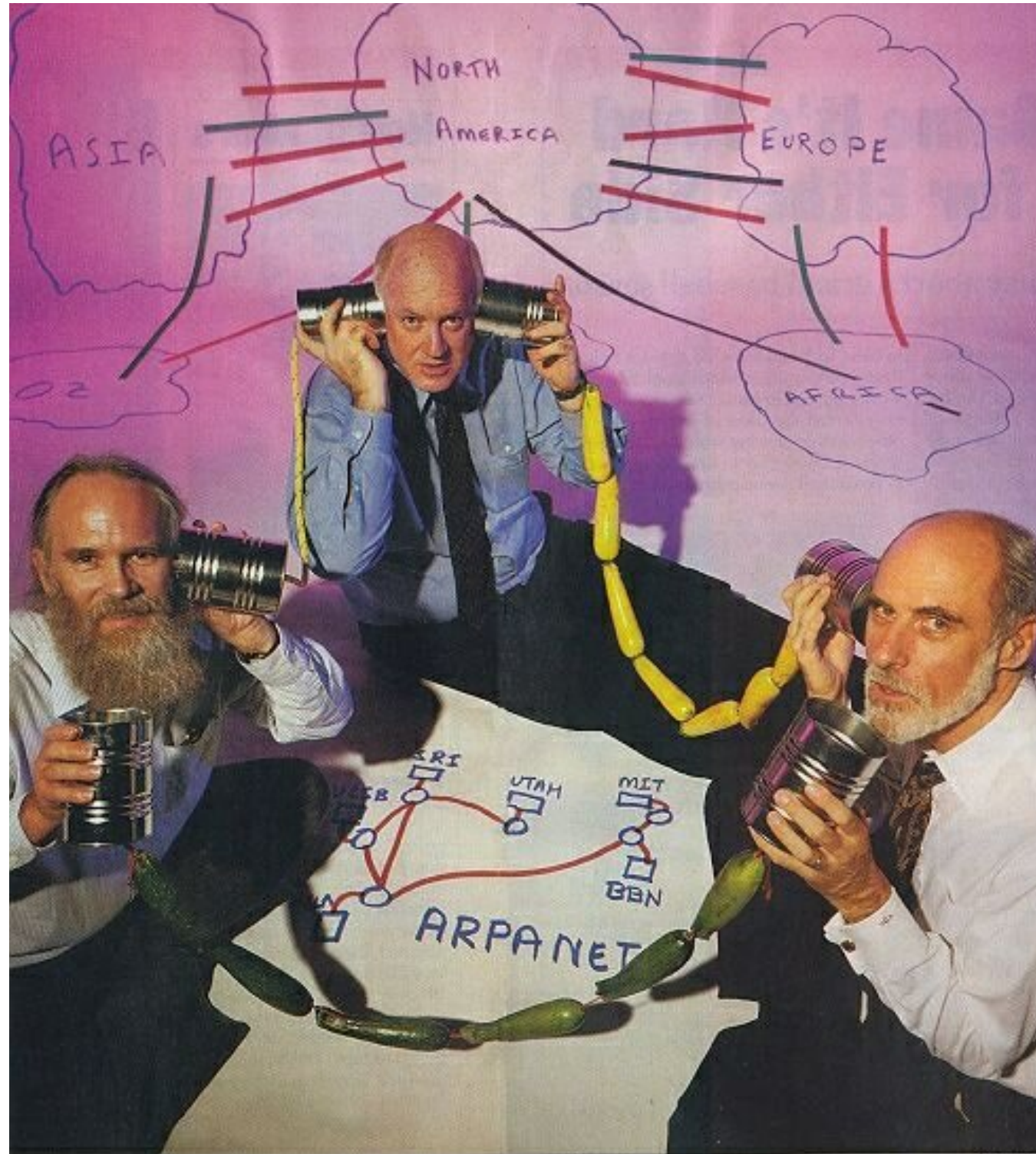


**“The privacy you are so fond of is  
mostly an illusion”**

So, let's go  
home and do  
something useful

**“You have no privacy. Get over it.”**

# How come these guys didn't think of privacy?



Source: <http://www.michaelkaul.de/History/history.html>

# Physical privacy

- don't touch me
- don't kiss me
- don't invade
- don't you dare



# Physical privacy

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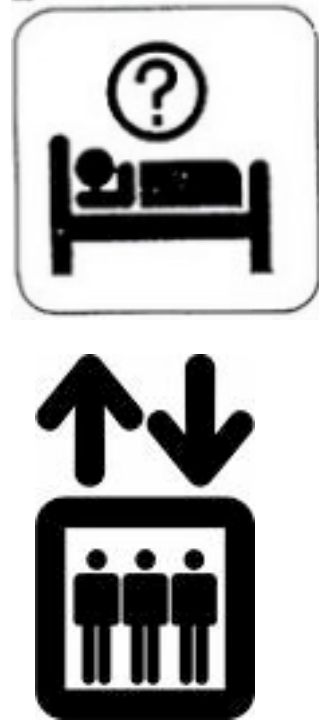


## Factors

- cultural sensitivity
- personal dignity
- shyness
- safety concerns

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## Factors

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## The worst places (for me)



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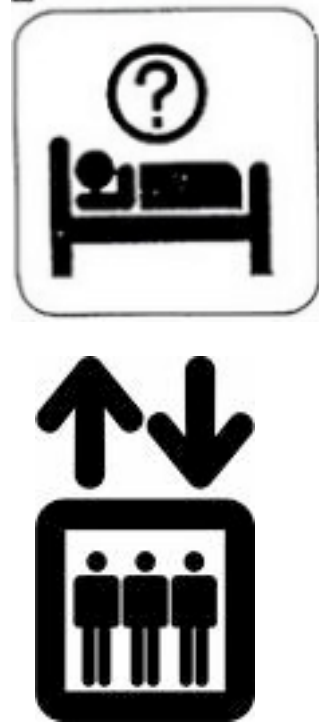
safety concerns

the best places (for me)



# Physical privacy

- don't touch me
- don't kiss me
- don't invade
- don't you dare



## Factors

- culture
- person
- shyness
- safety



## The worst places (for me)



## The best

# Physical privacy



- d
- d
- d
- d



## Factors

- cultural sensitivity
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The  
(for

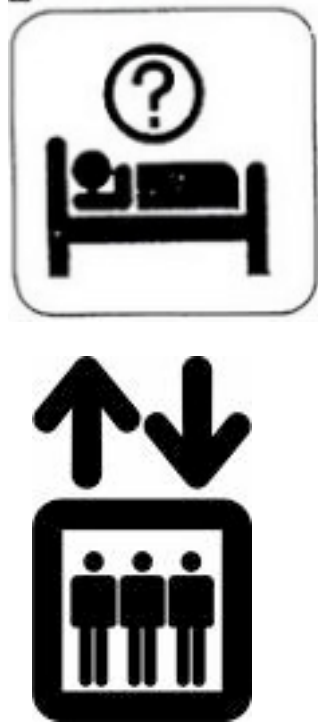


The best places (for me)



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## The worst places (for me)



## The best places (for me)



# Organisational privacy

- What is in Coca Cola?
- When will VW launch the new Golf?



- Access to fingerprints of all people
- 



# Organisational privacy

- What is in Coca Cola?
- When will VW launch the new Golf?



- Access to fingerprints of all people
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## Factors

- Patent (IPR)
- Trade mark
- price of information
- **effect of damage**

## Information about me

- electronic information stored about me
  - religion, sexual orientation, political opinion
  - personal activities
  - family information
- Membership in social networks
- access to accounts
- Medical information
- Political privacy

# Information privacy



## Information about me

- electronic information stored about me
  - religion, sexual orientation, political opinion
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- Membership in social networks
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## Electronic traces

- Mobile phone
  - GSM,
  - Bluetooth
- sensor data
- traffic cameras
- surveillance
- payment card usage
- fingerprint check-in



# Summary

## Factors influencing privacy



- cultural sensitivity
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## My own understanding

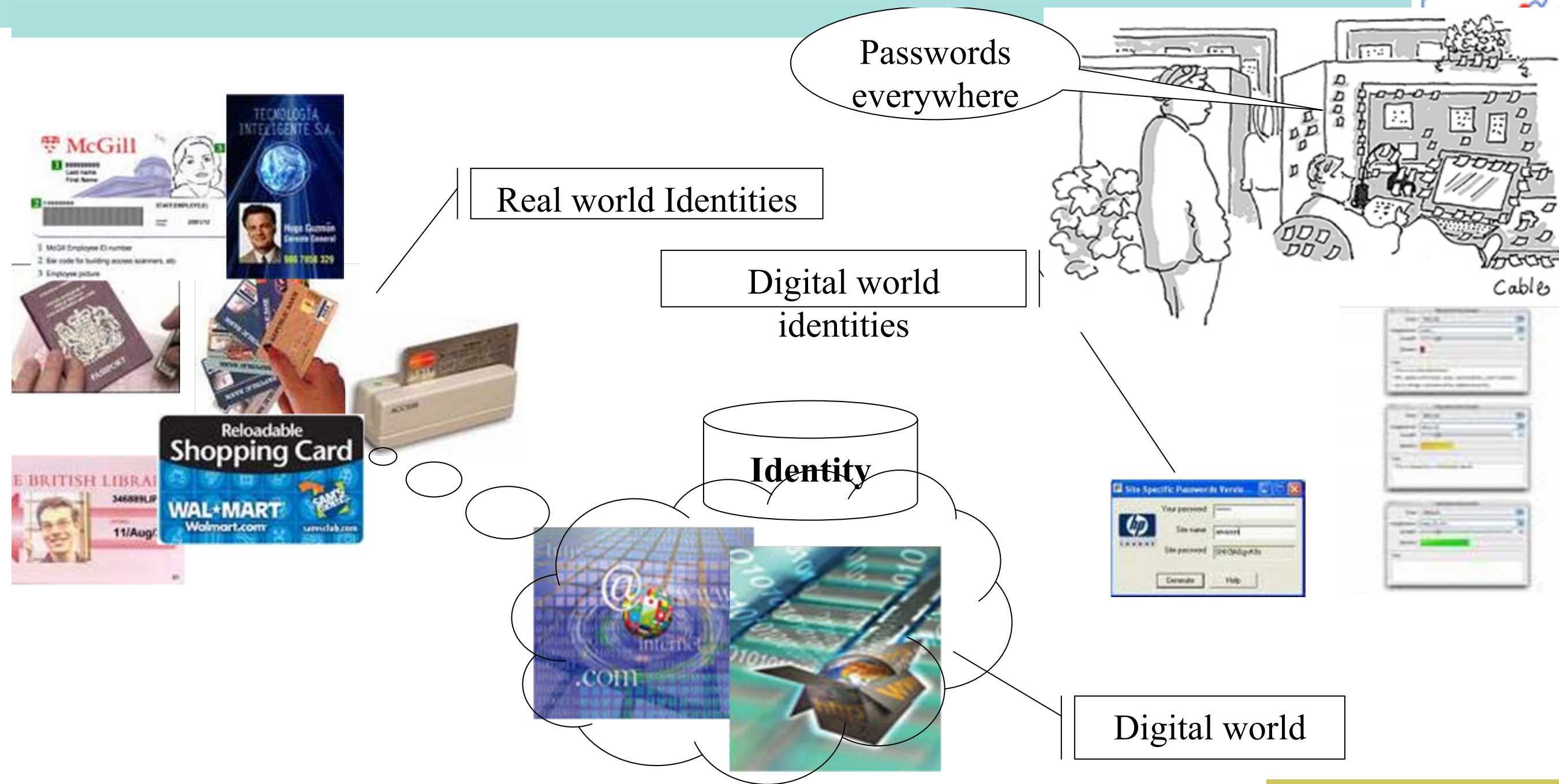
Privacy is about protecting myself such that others can't harm me more than I can tolerate

**others**  
**--> trust, relation**

**harm**  
**--> my roles (identity)**

- In philosophy, **identity** is whatever makes an entity definable and recognizable, in terms of possessing a set of qualities or characteristics.
- **Identity** is an umbrella term used throughout the social sciences for an individual's comprehension of him or herself as a discrete, separate entity.
- **Digital identity** also has another common usage as the digital representation of a set of claims made by one digital subject about itself or another digital subject.
- An **online identity** is a social identity that network users establish in online communities.
- As more more services are accessible in digital world, digital identities and their management will play a vital role in secure service access and privacy .....

# Digital identity



- Recommendation: Dick Hardt@OSCON, Identity 2.0

# The dilemma of computer science

## Identity - “*same as*” and “*not*”



- **Identity** is an umbrella term used throughout the social sciences for an individual's comprehension of him or herself as a **discrete, separate entity**.

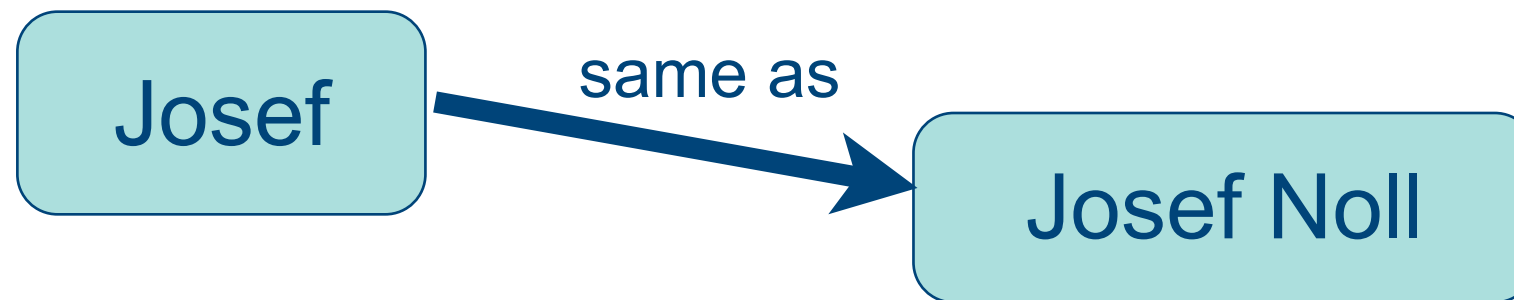


# The dilemma of computer science

## Identity - “*same as*” and “*not*”



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- **Computer science:** use of ontologies, binary strings ‘xFxkeyil9e4’

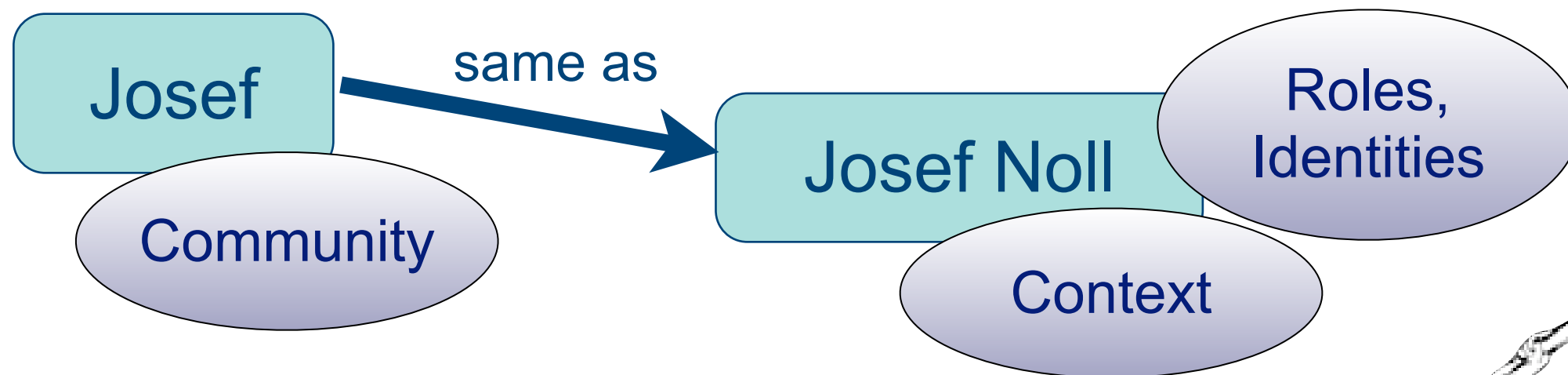


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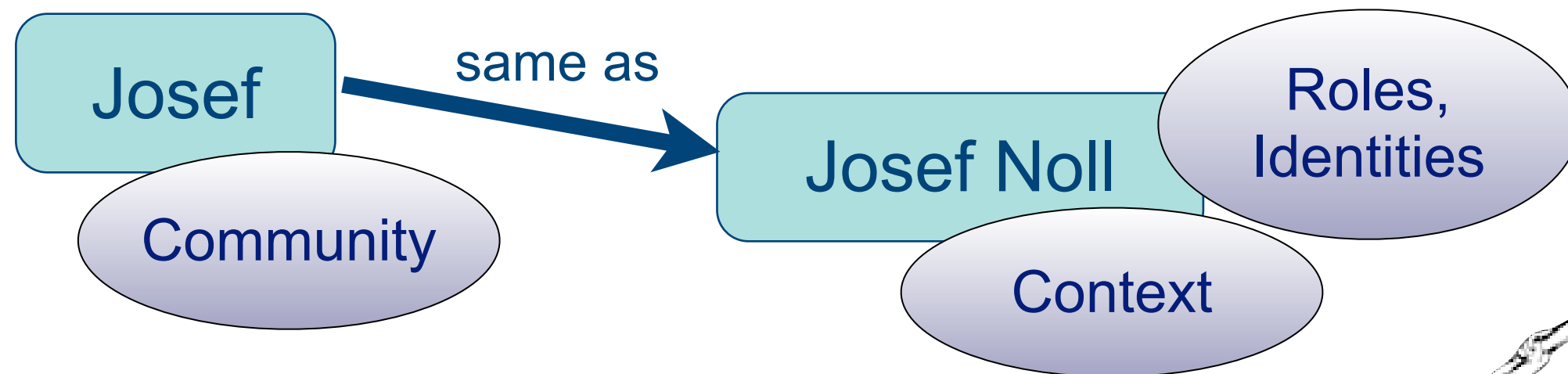


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- **Are we in computer science in the Middle Ages?**

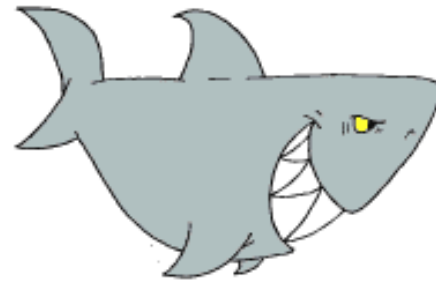


- G. W. Leibniz (1646): if  $a=b$  and  $b=c$ , then  $a=c$

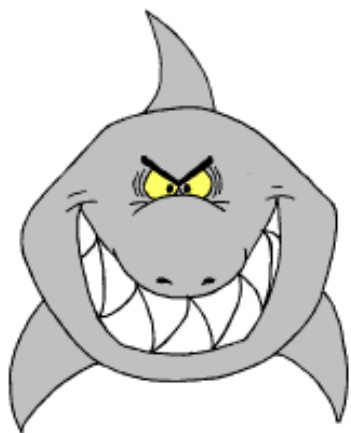


# Challenge

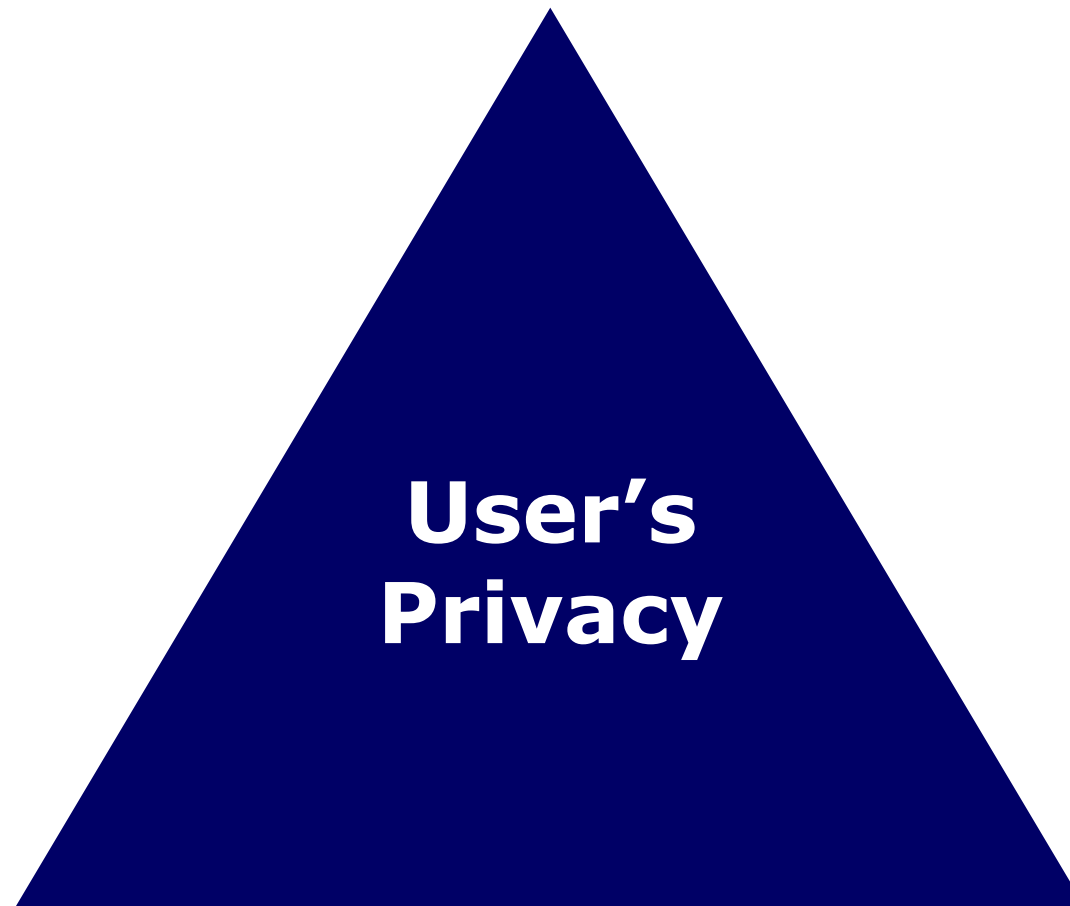
## Manage the Privacy 2.0 Bermuda Triangle



Data is  
everywhere



High value of  
personal data



User's  
Privacy



Vulnerable  
technology

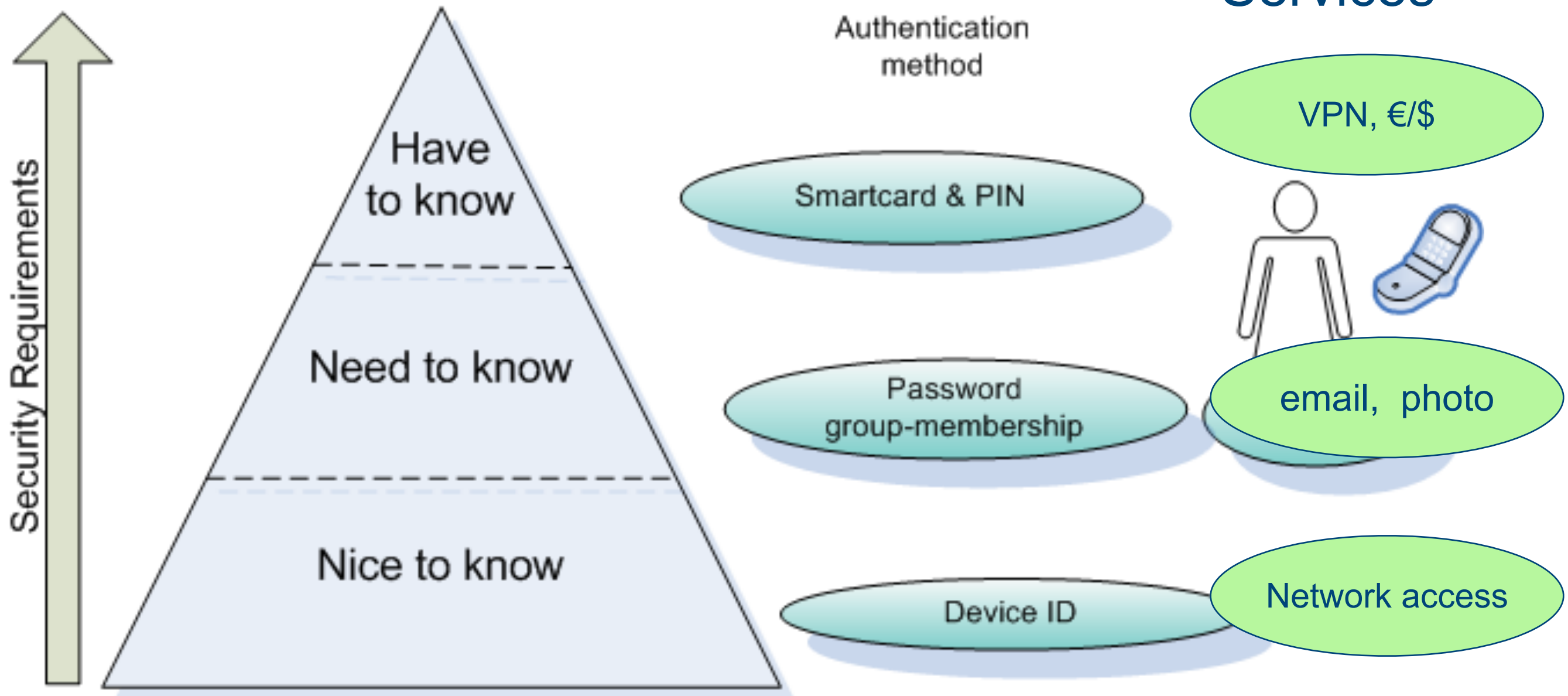
Source: Stefan Weiss, Deloitte & Touche, 2007

# Privacy Requirements

*“How much will it cost me if my privacy gets compromised?”*

- see: lost mobile phone, security of your house
- take appropriate measures

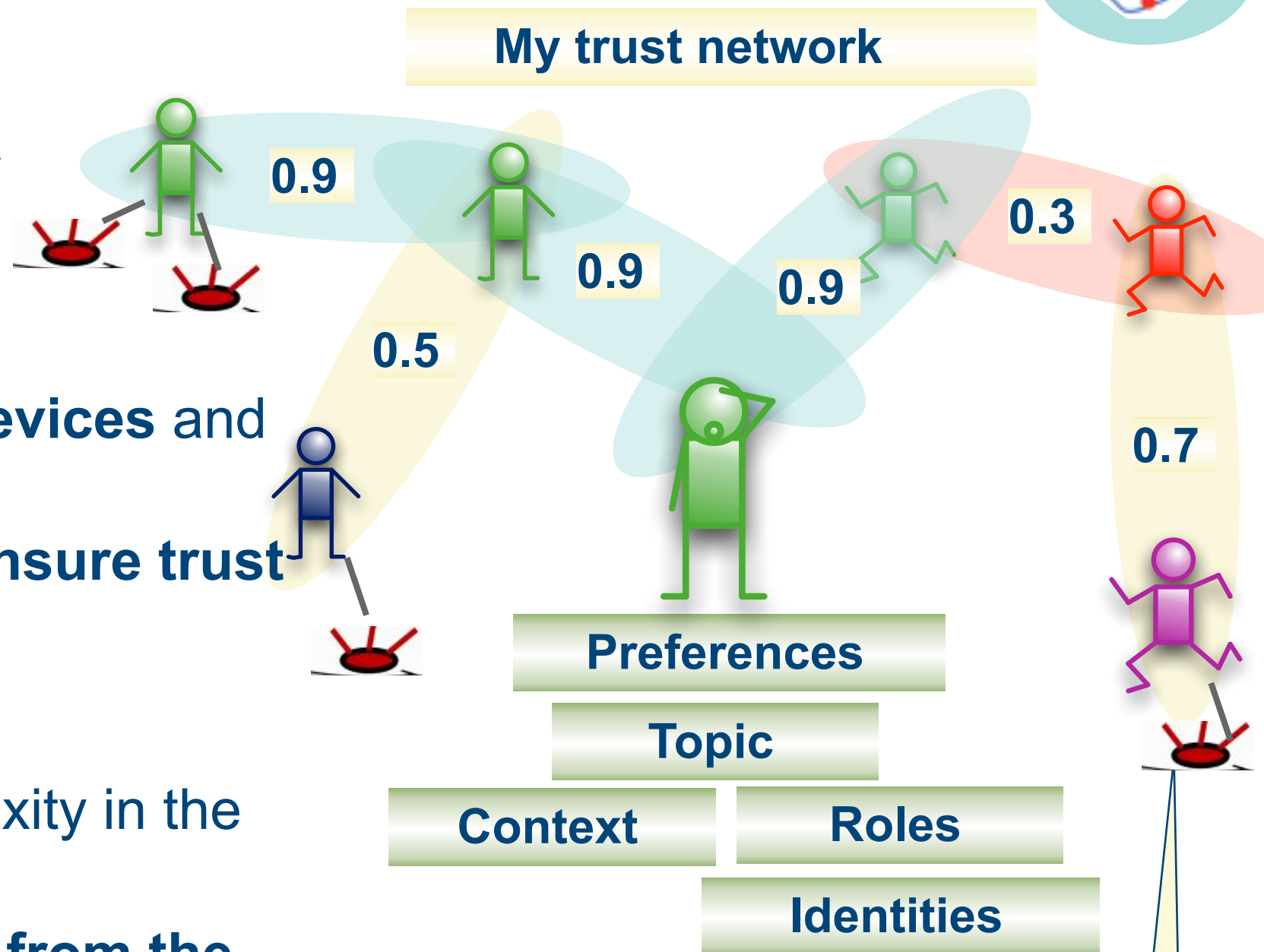
## Examples of Services



# Paradigm change for The Internet of the Real World and IoT



- Trust related privacy  
-> **Representing the user adequately**
- Connecting to **sensors, devices and services**  
-> **Provide privacy and ensure trust relations**
- An ever increasing complexity in the digital environment  
-> **Hiding the complexity from the use**

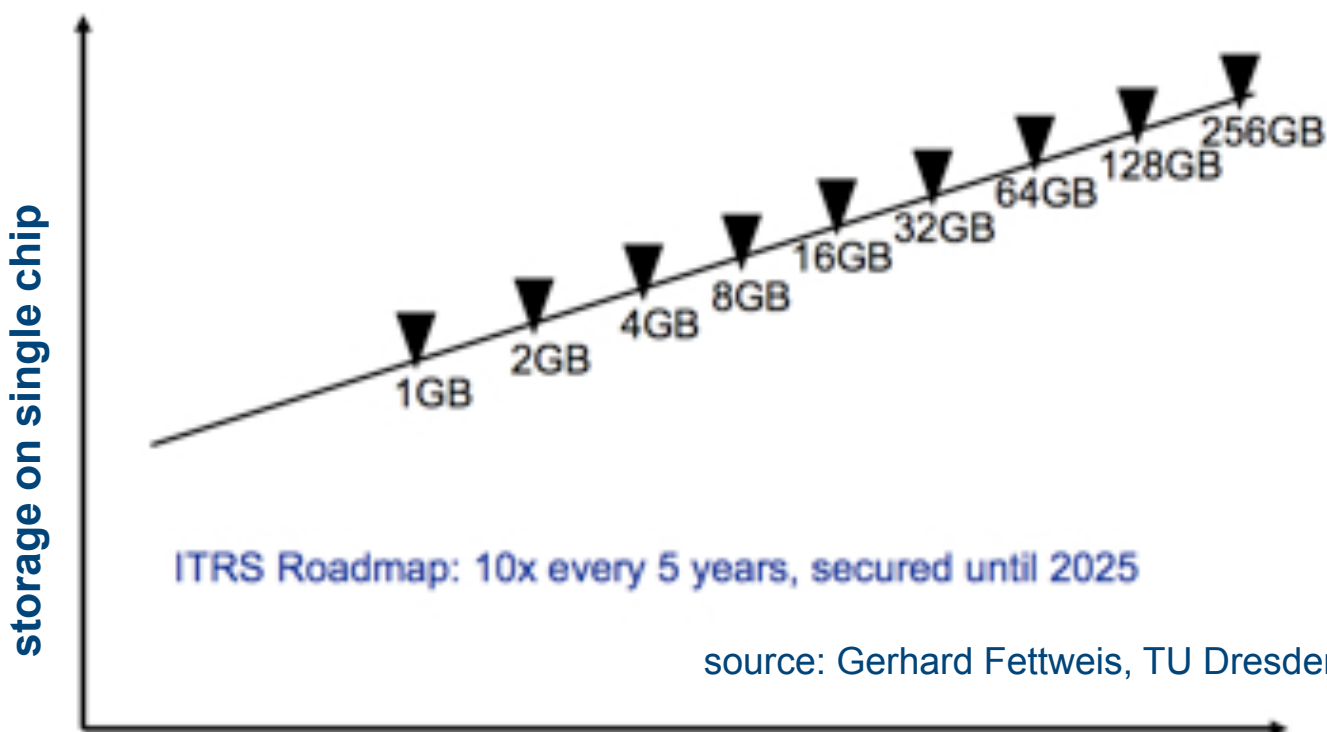


Thanks to Vladimir Oleshchuk for ideas and discussions

# Internet of Things (IoT)

- The present "Internet of PCs" will move towards an "Internet of Things" in which 50 to 100 billion devices will be connected to the Internet by 2020. [CERP-IoT, 03.2010]
- "We are entering a new paradigm where things have their own identity and enter into dialogue with both other things and humans mediated through processes that are being formed today. [IoT Europe 2010 conf., 06.2010]

The speed of development



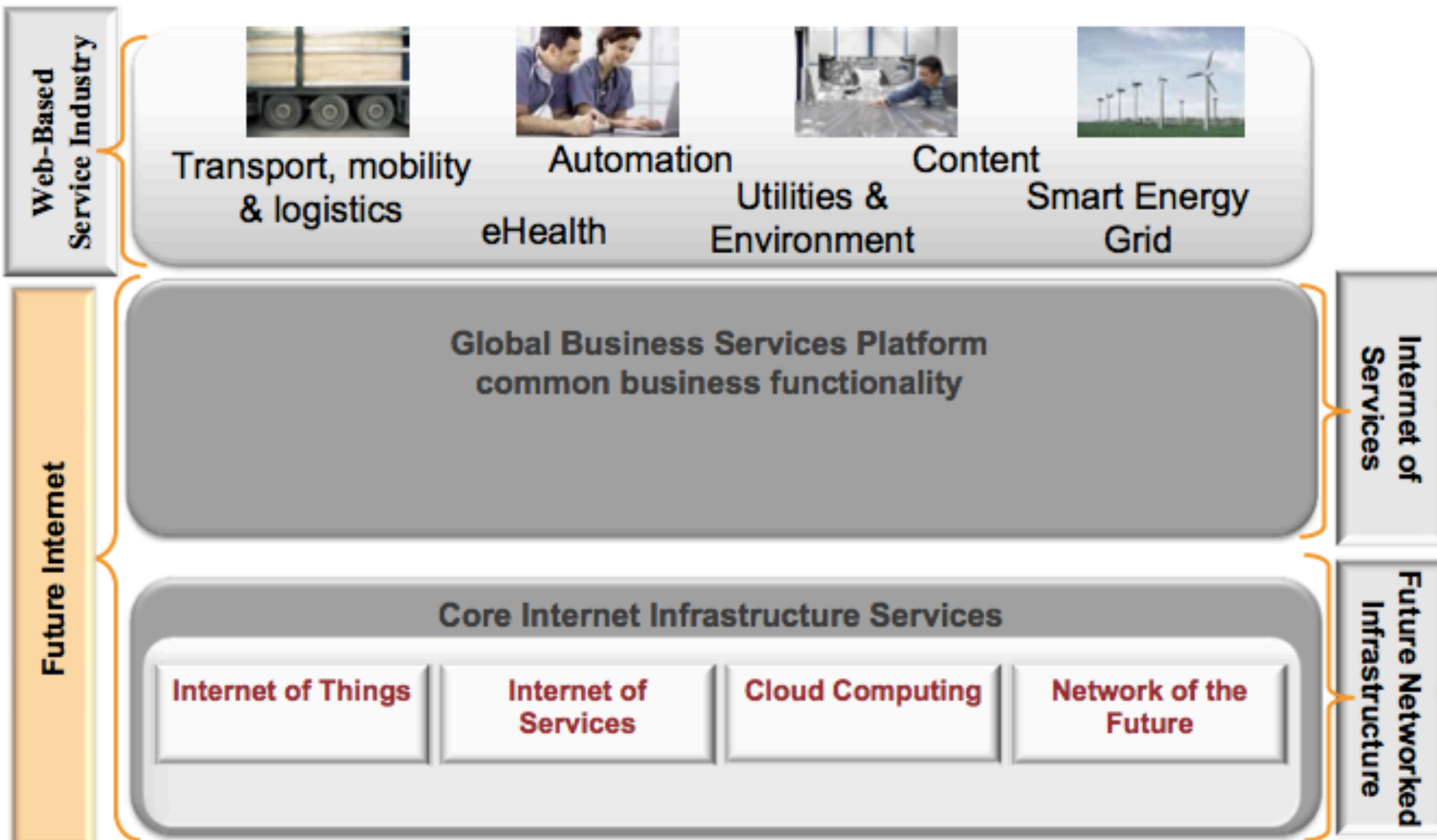
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source: Gerhard Fettweis, TU Dresden

Mobile Systems

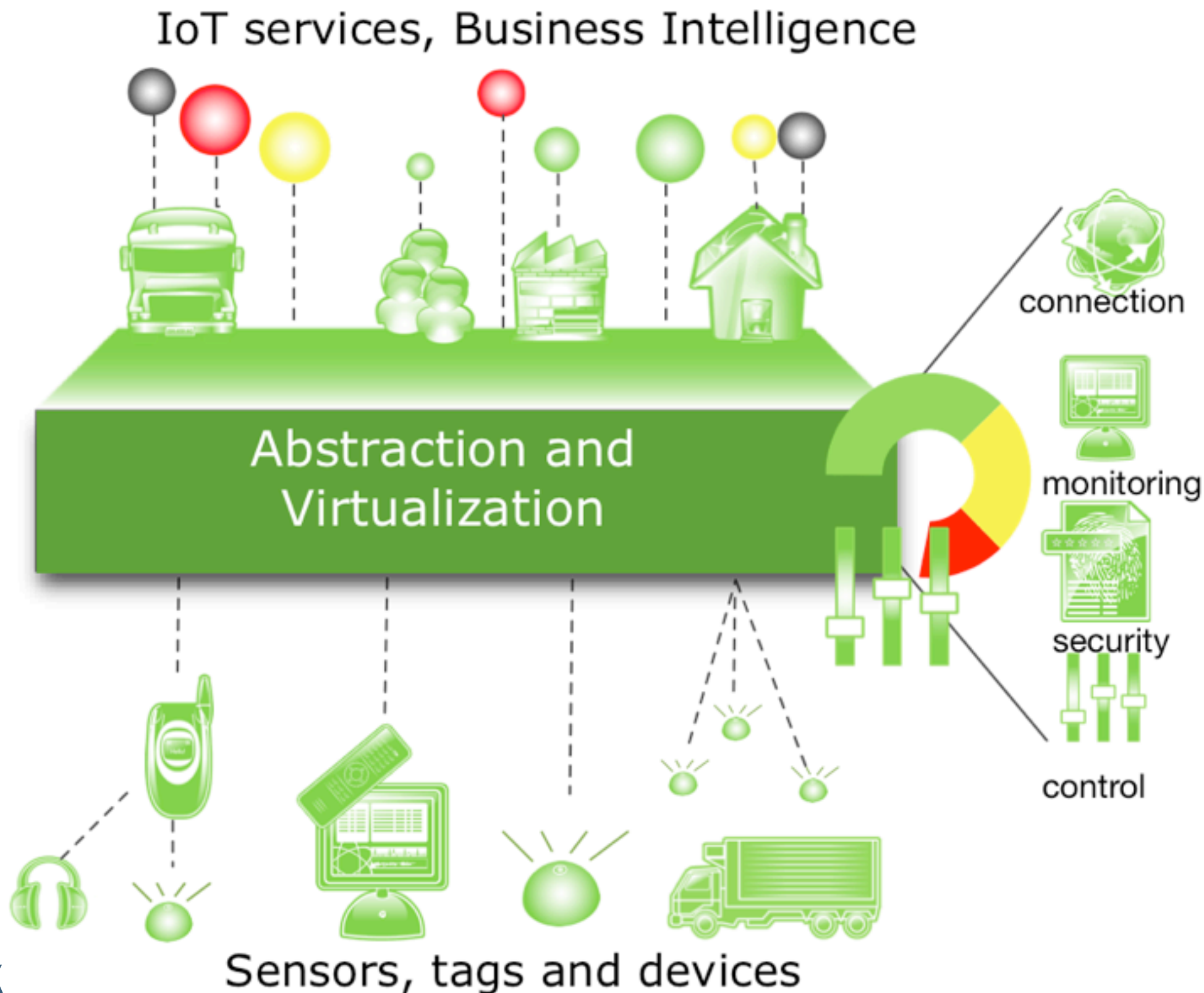
March 2012, Josef Noll

# Principal Objective of the FI PPP - A Holistic Global Service Delivery Platform



[Source: J. Schaper, FI PPP Constituency Event Nice, March 2010]

# IoT: From sensors to business



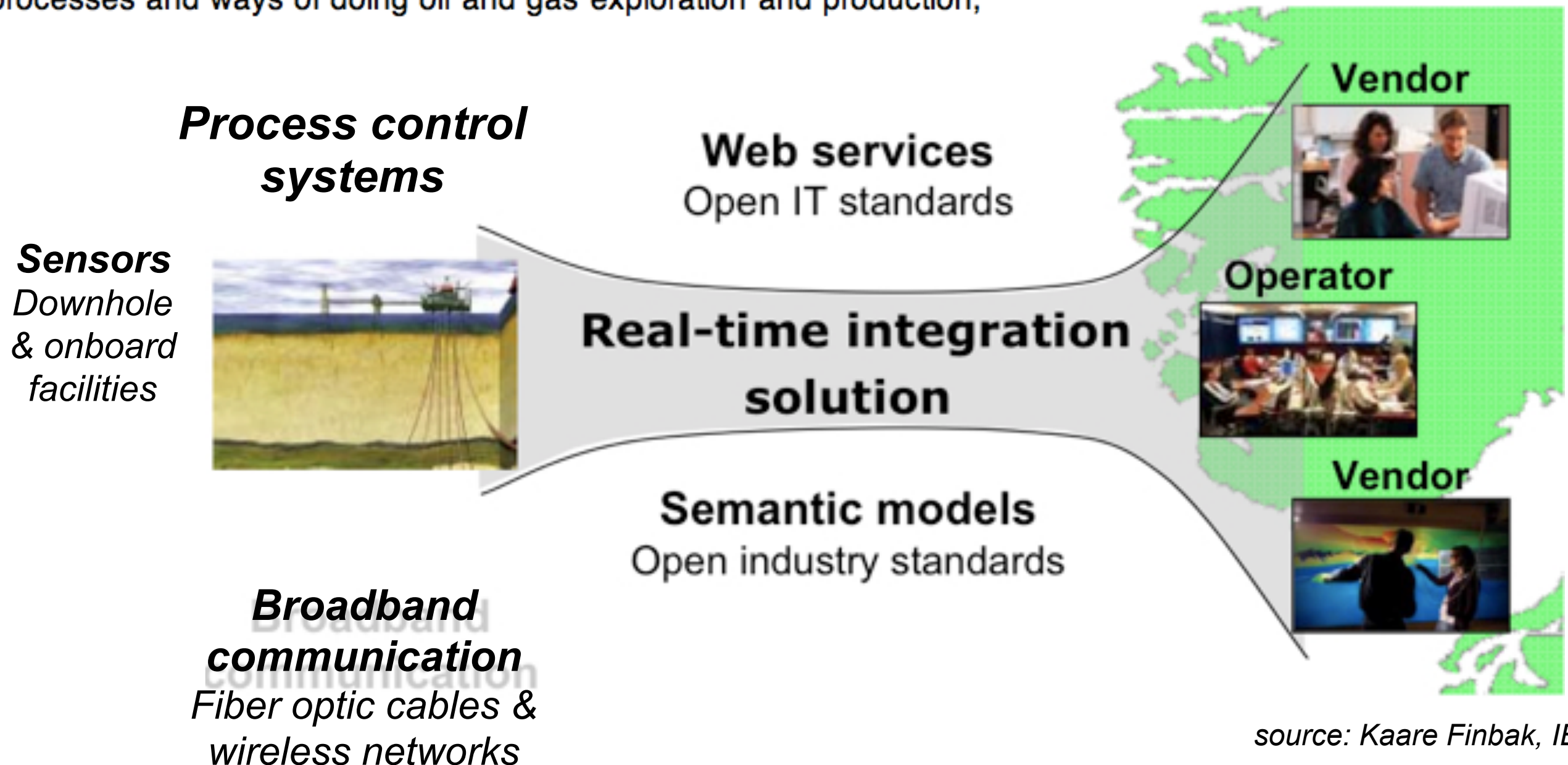
- *Integrated operations*: from oil and gas industry into the business of every sector
- Aspects of Integrated Operations
  - trust-based security
  - content-awareness (and context-awareness)
- Challenges in ICT security for the Internet of Things (IoT)
  - Security, privacy and dependability in sensor systems
  - Heterogeneous infrastructures
  - security metrics
- Example: Artemis pSHIELD project
  - Use case: Railway data through Telenor Objects Shepherd platform

# Focus: Security in Integrated Operations

## Integrated operations

From Wikipedia, the free encyclopedia

In the [Petroleum industry](#), **Integrated operations** (IO) refers to new work processes and ways of doing oil and gas exploration and production,



source: Kaare Finbak, IBM

# Focus: Security in Integrated Operations



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## Integrated operations

From Wikipedia, the free encyclopedia

In the [Petroleum industry](#), **Integrated operations** (IO) refers to new work processes and ways of doing oil and gas exploration and production,

**Process control systems**

**Sensors**  
Downhole  
& onboard  
facilities



**Web services**  
Open IT standards

*40 bill US\$ added economic value (2007-2015)  
Integrated Operations on the NCS - OLF numbers*

**Real-time integration solution**

**Semantic models**  
Open industry standards

**Broadband communication**  
Fiber optic cables &  
wireless networks

**Vendor**



**Operator**



**Vendor**



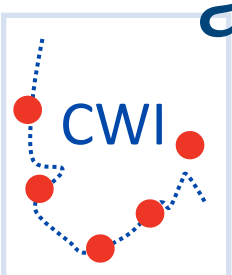
source: Kaare Finbak, IBM

# Challenges for security

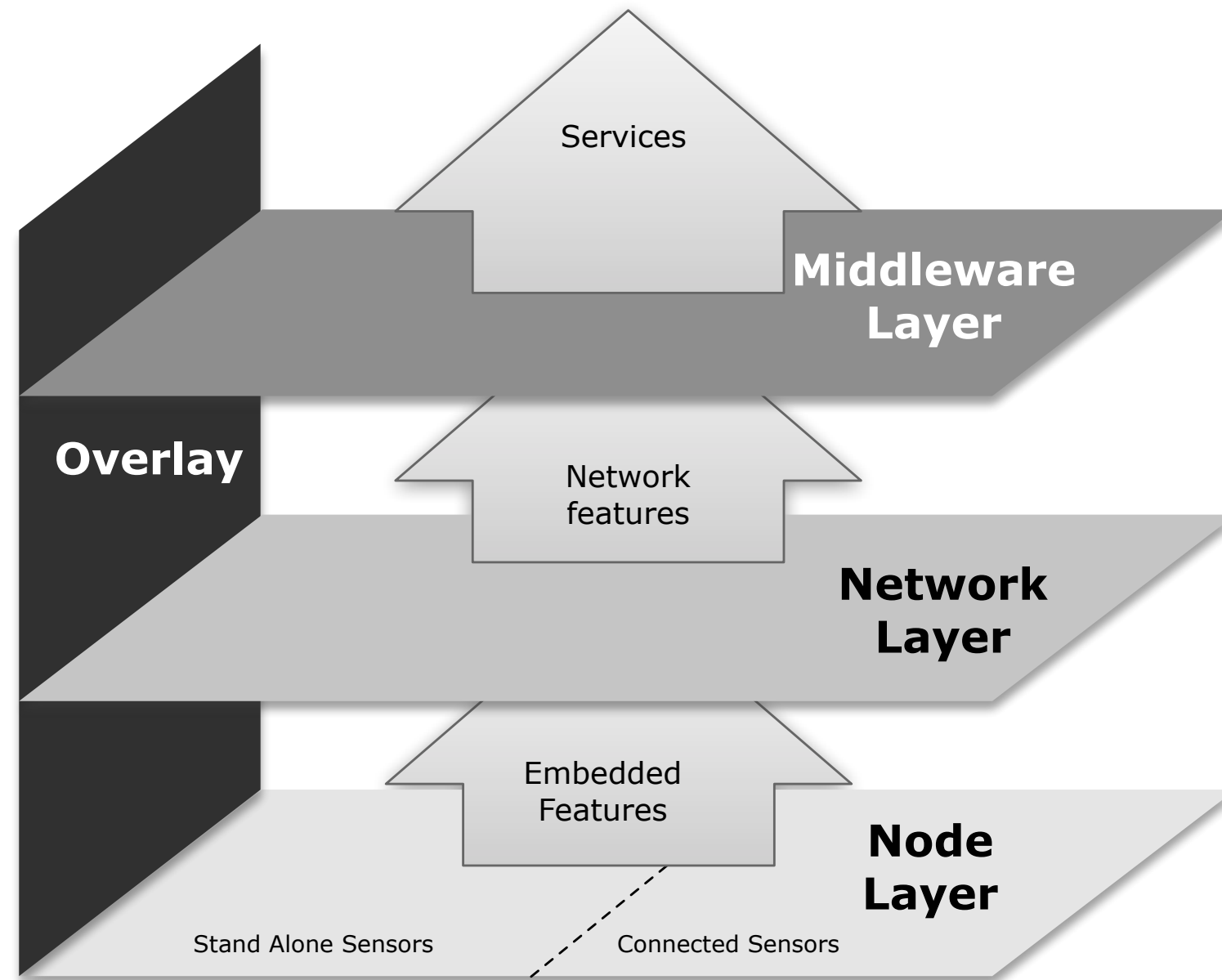
- to define the characteristics of a component and of the system
- to quantify security, privacy and dependability (SPD) through a metrics
- to compose SPD technologies according to the selected metric (composability)
- to provide modularity and expandability
- to provide enriched services and applications



The Artemis pSHIELD project



- Security, here
  - security (S)
  - privacy (P)
  - dependability (D)
- across the value chain
  - from sensors to services
- measurable security?
  - metrics for systems
  - metrics for attacks

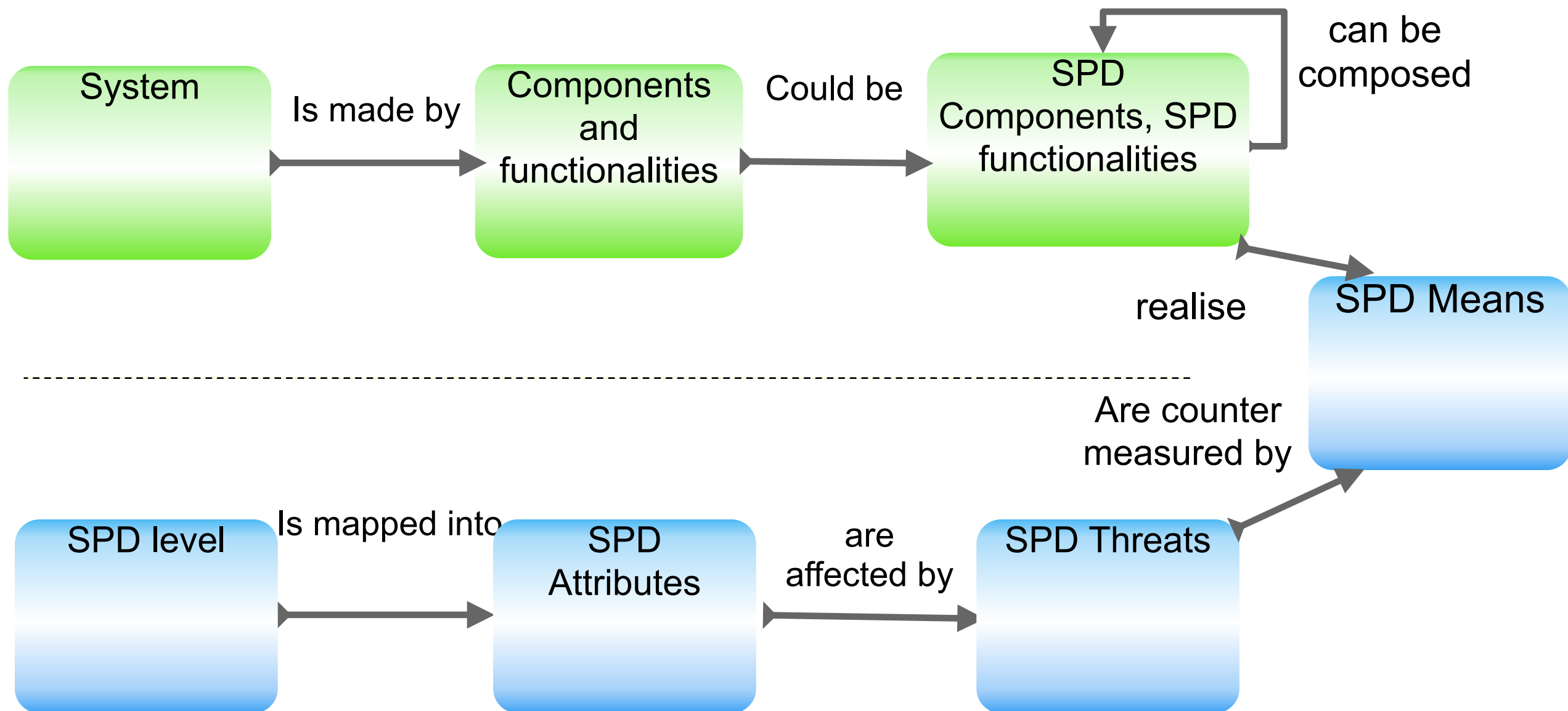


# Security, Privacy and Dependability (SPD) in the IoT



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Ontology logical representation: each concept is modeled and the relations are identified in order to have the logical chains that enables the SPD-aware composability



# SPD Metrics specification

Minimum attack potential value  
to exploit a vulnerability  
**= SPD value**

Calculated attack  
potential

Attack scenarios

SPD  
level

SPD  
attributes

SPD  
threats

Base of knowledge

System

Function  
ality

SPD  
system

*Factors to be  
considered*

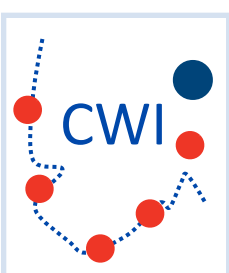
- Elapsed Time
- Expertise
- Knowledge of functionality
- Window of opportunity
- Equipment

| Factor                            | Value                |
|-----------------------------------|----------------------|
| <b>Elapsed Time</b>               |                      |
| <= one day                        | 0                    |
| <= one week                       | 1                    |
| <= one month                      | 4                    |
| <= two months                     | 7                    |
| <= three months                   | 10                   |
| <= four months                    | 13                   |
| <= five months                    | 15                   |
| <= six months                     | 17                   |
| > six months                      | 19                   |
| <b>Expertise</b>                  |                      |
| Layman                            | 0                    |
| Proficient                        | 3 <sup>*(1)</sup>    |
| Expert                            | 6                    |
| Multiple experts                  | 8                    |
| <b>Knowledge of functionality</b> |                      |
| Public                            | 0                    |
| Restricted                        | 3                    |
| Sensitive                         | 7                    |
| Critical                          | 11                   |
| <b>Window of</b>                  |                      |
| Unnecessary / unlimited access    | 0                    |
| Easy                              | 1                    |
| Moderate                          | 4                    |
| Difficult                         | 10                   |
| Unfeasible                        | 25 <sup>** (2)</sup> |
| <b>Equipment</b>                  |                      |
| Standard                          | 0                    |
| Specialised                       | 4 <sup>(3)</sup>     |
| Bespoke                           | 7                    |
| Multiple bespoke                  | 9                    |



# Examples of Security challenges in the IoT

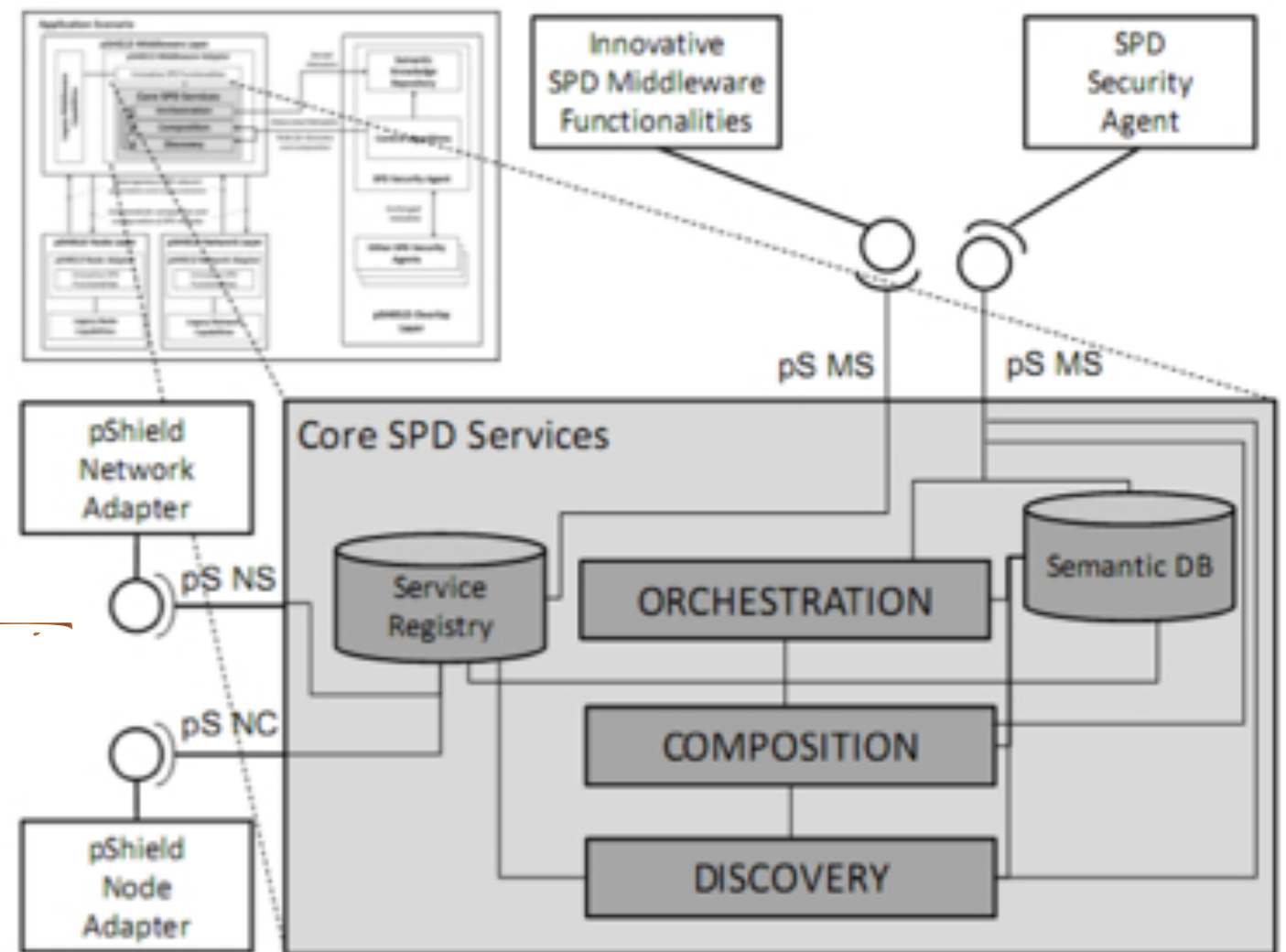
- **System:** Intrusion awareness, fault-tolerance, data redundancy and diversity
- **Platform:** Auto start up on power failure, Auto reconfigurable on software failure, Auto synchronization on software failure, End-to-end secure communication, Mal-user detection, Access control for accessing sensor data
- **Middleware:** SPD Audit, Cryptographic Support, Identification and Authentication, Protection of the SPD functionalities, Security Management
- **Hardware:** SPD metrics, Self-recovery from hardware transient faults (through fault-injection), Auto-reconfiguration, Data encryption, Provision of security and privacy services, data encryption/decryption
- **Radio:** Threats tolerant transmission



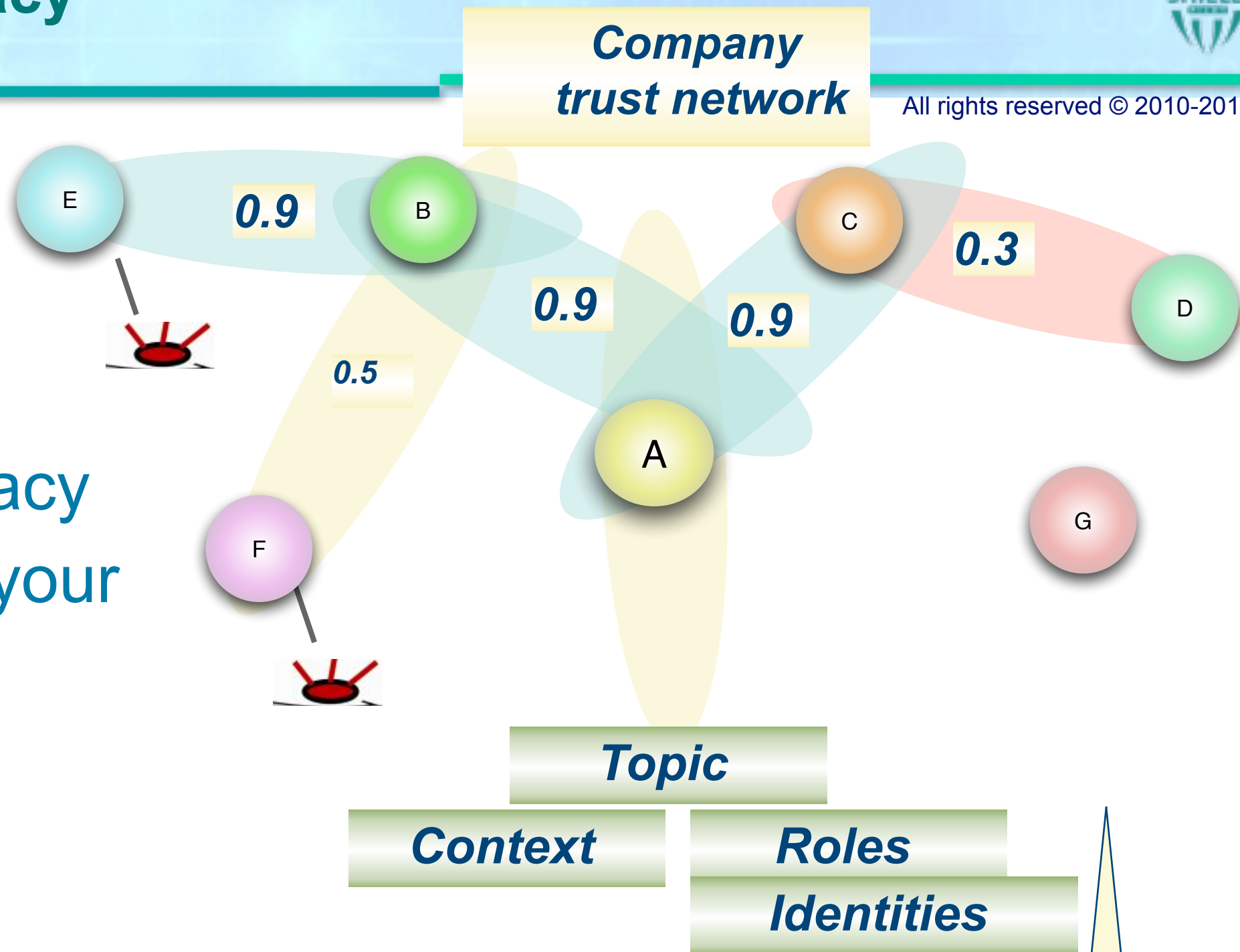
# Pilot: Middleware prototype for composability

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- SPD levels are achieved through specific configurations by the overlay
  - demonstrating the behaviour of the pSHIELD middleware
  - demonstrating SPD-driven composability
  - using metrics-formulation from WP2



- “With whom to collaborate?”
- Share data?
- Trust-based privacy
- Information and your social life

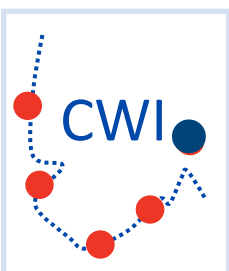


- *Measurable trust? Transient Trust?*
- *Value chains: from sensors to systems*

Thanks to Vladimir Oleshchuk for ideas and discussions

# Overview

- The mobile phone is your representative in the digital world
  - SIM card
  - payment, access (NFC)
  - security agent (store credentials in the SIM card)
  - Location
  - Gateway for the Internet of Things (IoT)
- Security challenges
  - Person: electronic traces, privacy, anonymity
  - Things (IoT): security, privacy, dependability
- Semantics for
  - Context-aware & personalised services
  - attribute-based access control
- Policies
  - User, Company, Service providers
  - Authorities



## Summary

# Industry requirements



## Web services

- Fixed service set, Static service composition, Low degree of automation
- Poor reliability
- Fixed Service Level Agreement

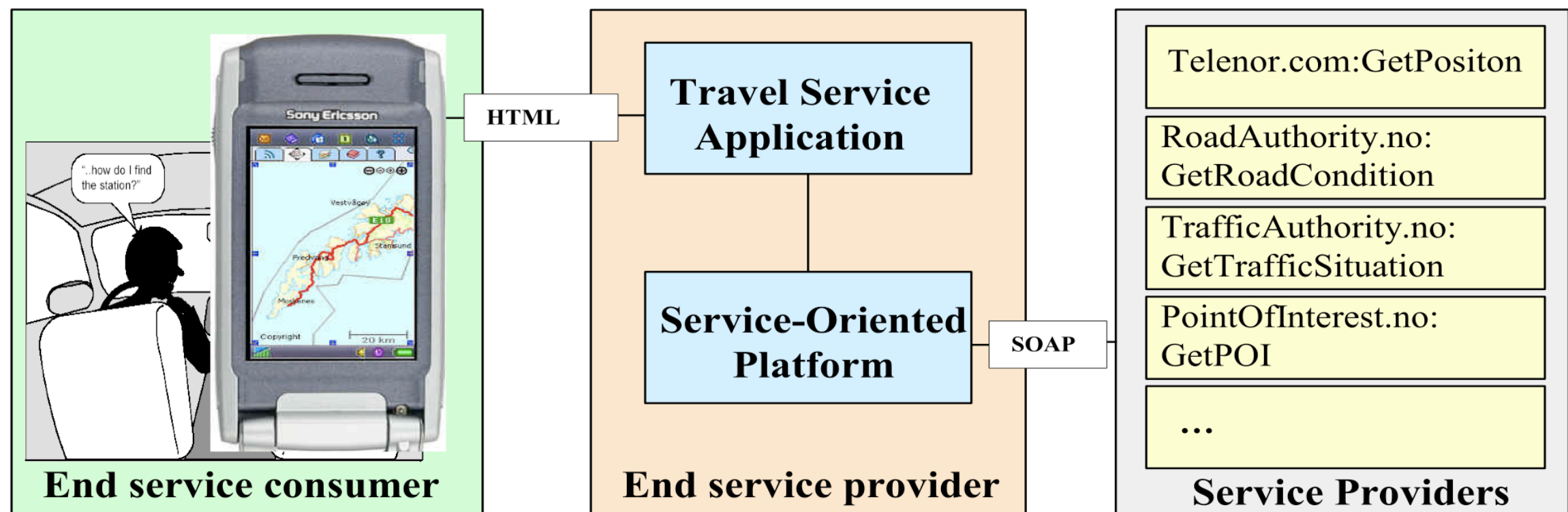
## Semantic Web Services

- Flexible services, easy new services
- Alternative service provision
- Global, dynamic services

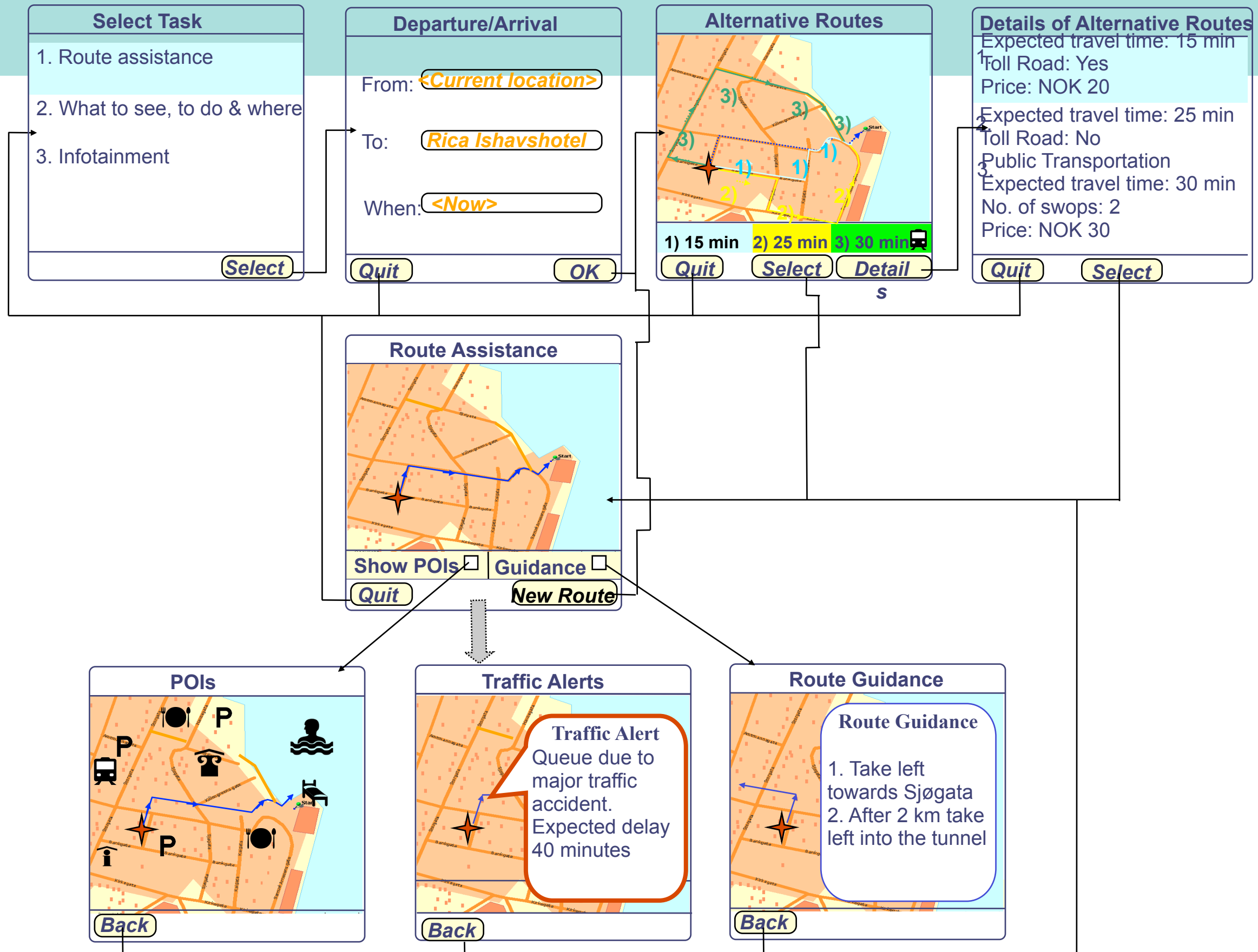
# Scenario: Telematics Service



- Goal of the end service consumer:  
Acquire any information that might be of interest while commuting by car to work or visiting an unfamiliar area, for example as a tourist
- The service is to be run on a mobile phone
- Implementation today is scattered and varying
  - Internet, broadcast, car navigation systems, mobile platforms
  - Manual and automatic call centres, integrated services



# Telematics Application Flow



# Summary: Mobile Service Delivery



- What are the elements for Service Delivery to “Beyond 3G” users?

# Summary: Mobile Service Delivery

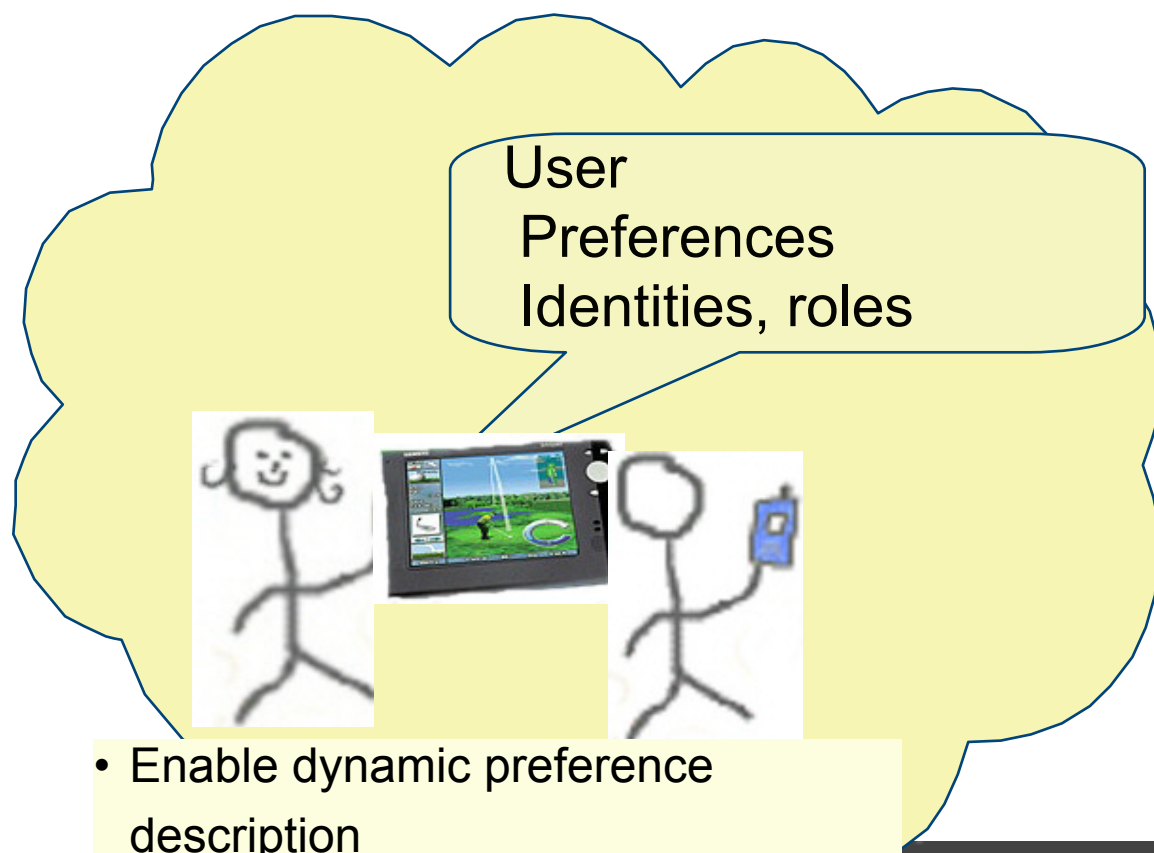


- What are the elements for Service Delivery to “Beyond 3G” users?
- Do we have technologies in place to perform the challenges?

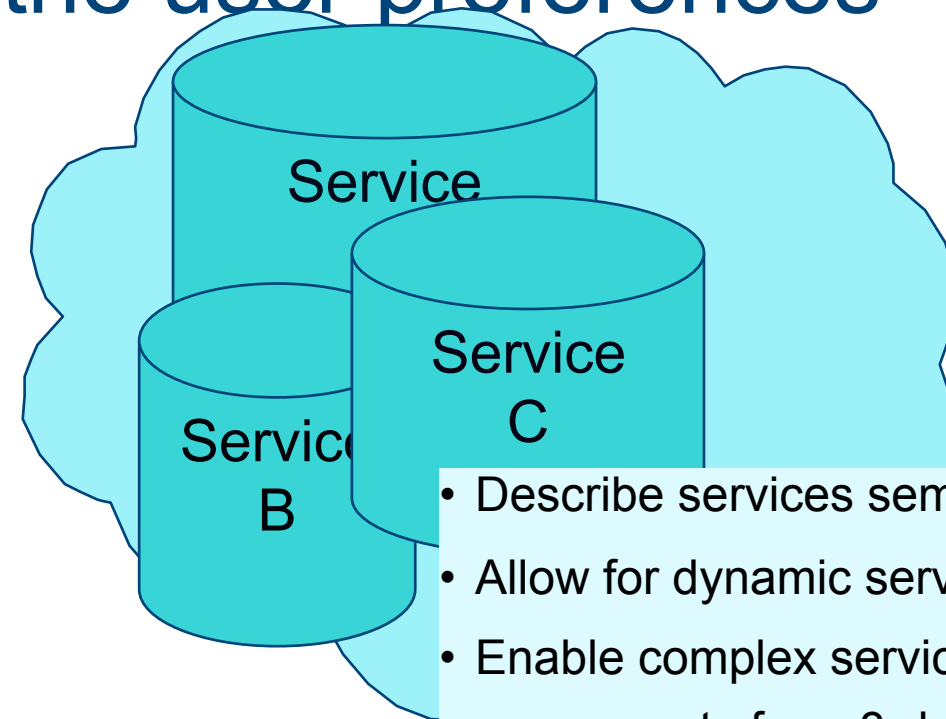
# Wireless World Research Forum (WWRF): Role of Semantics



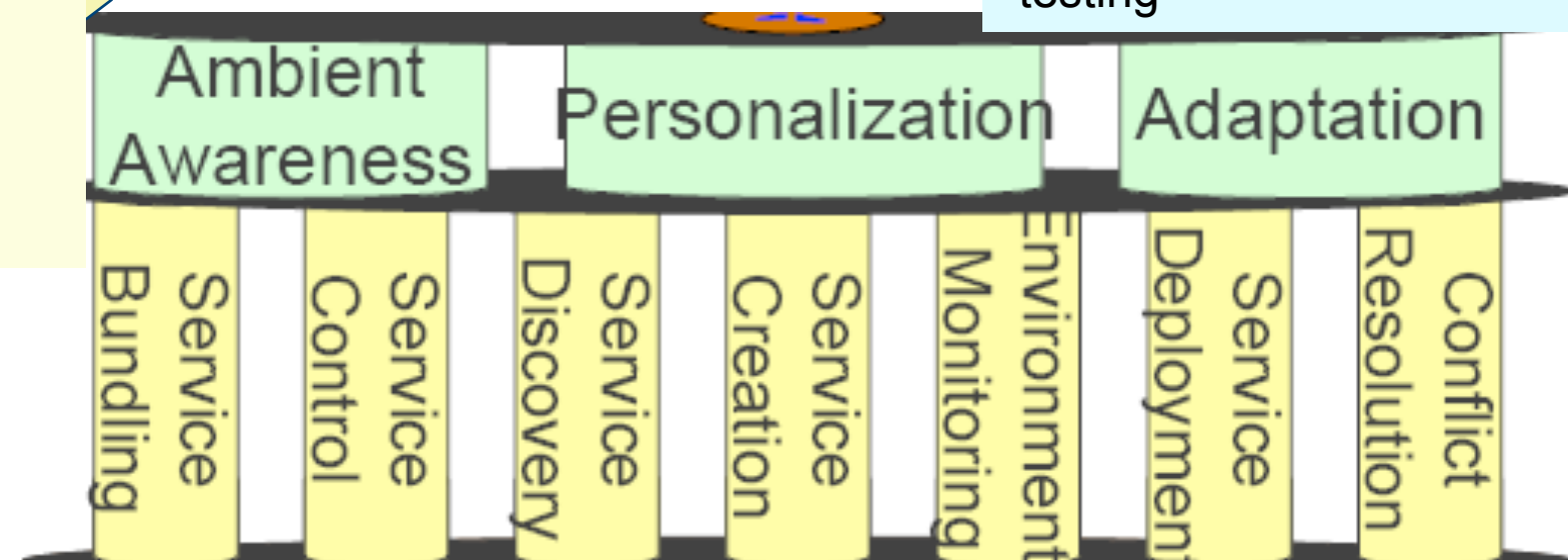
- Linking the service world to the user preferences



- Enable dynamic preference description
- Supporting personalisation and context awareness
- Supports adaptation to interests



- Describe services semantically
- Allow for dynamic service composition
- Enable complex service provision with components from 3rd party providers
- Enable effective service upgrade and testing



Semantic Services are a potential glue for complex service composition

# Why Semantics?

## ■ Syntax vs. Semantics

Arabic



لهنسة فى علم التطور : الاسم  
أسنسيون غومز-برز : المولفون  
السعر : \$74.95  
الكتاب : المنتاج

<Title>لهنسة فى علم التطور </Title>  
<Author>أسنسيون غومز-برز </Author>  
<Price>\$74.95</Price>  
<Product>كتاب </Product>

English



**Title:** Ontological Engineering  
**Authors:** Asunción Gómez-Pérez...  
**Price:** \$74.95  
**Product:** Book

<Title>Ontological Engineering</Title>  
<Author>Asunción Gómez-Pérez...</Author>  
<Price>\$74.95</Price>  
<Product>Book</Product>

## What do the tags **mean** for the machine?

# Why Semantics?

## ■ Conceptual Level

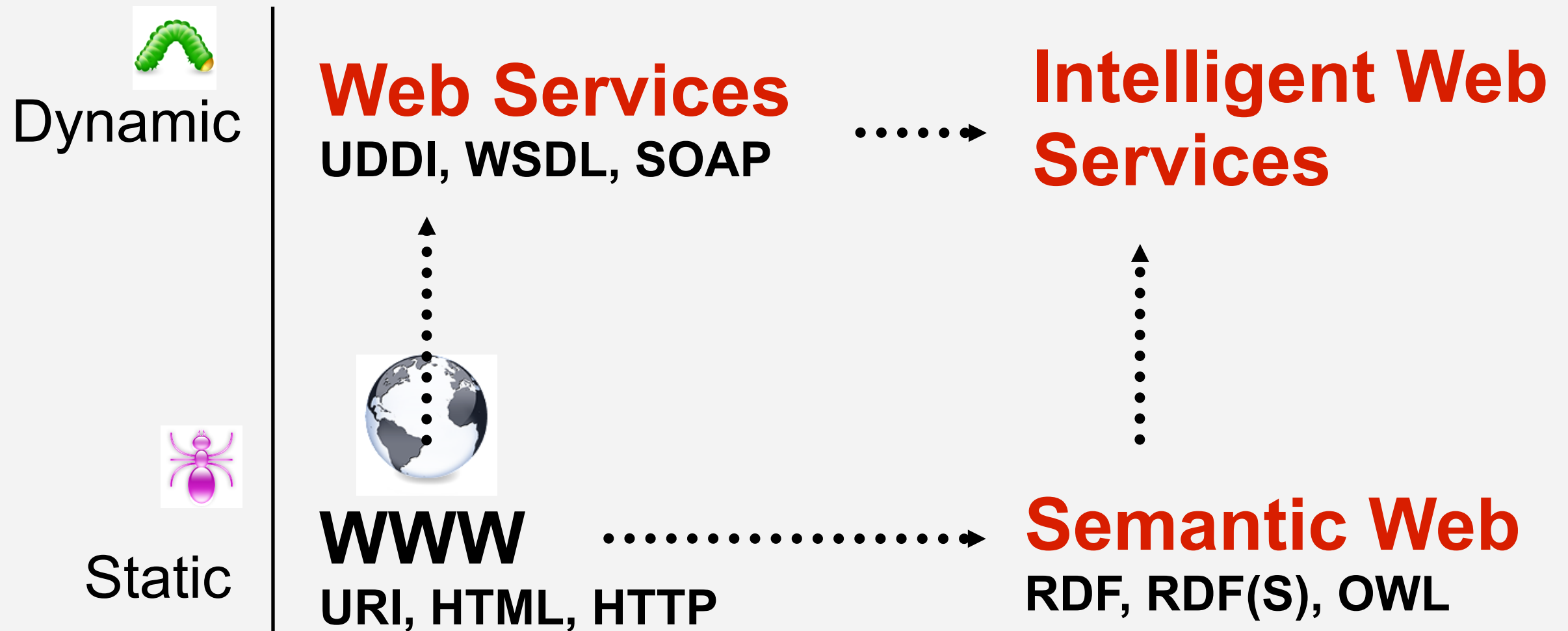


lunch (.no)

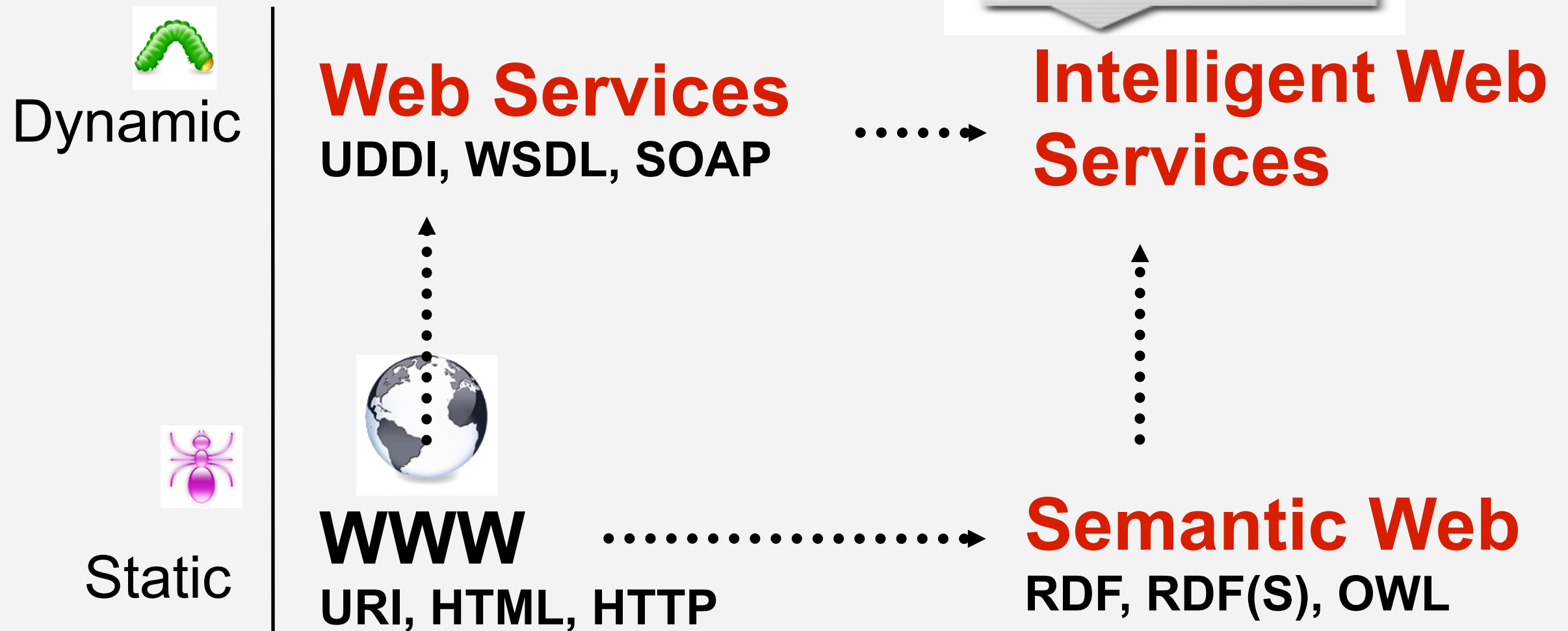


lunch (.es)

# Semantic Web Services



# Semantic Web Services



# Semantics in Business: Knowledge Management

---

- Enable a paradigm switch in searching information
- From
  - Information Retrieval
- To
  - Question Answering
- This presentation illustrates an application in this line for one particular domain



# Semantics in Business: Knowledge Management

- Enable a paradigm switch in searching information
- From
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- To
  - Question Answering

Google: "Josef Noll"

- This presentation illustrates an application in this line for one particular domain



# Semantics in Business: Knowledge Management

- Enable a paradigm switch in searching information

- From

Information Retrieval

- To

Question Answering

Google: "Josef Noll"

Where has Josef Noll introduced Semantic Identity for the first time?

Who is? which media?...

- This presentation illustrates an application in this line for one particular domain



## Requirements for Service Representation

OWL-S

- Represent **capabilities of the service**
  - The function that the service computes
  - Features of the service provided
- **Decidable** (& Effectively Computable) logics: OWL DL

What we need

- Represent **service requirements**
  - Resources requirements
    - CPU, Screen size, Memory size, Network type and bandwidth
    - CC/PP, UAProf
  - Policies and Privacy requirements
  - Cost models
  - Communication Channel
  - Contextual information:
    - where/when can the service be used

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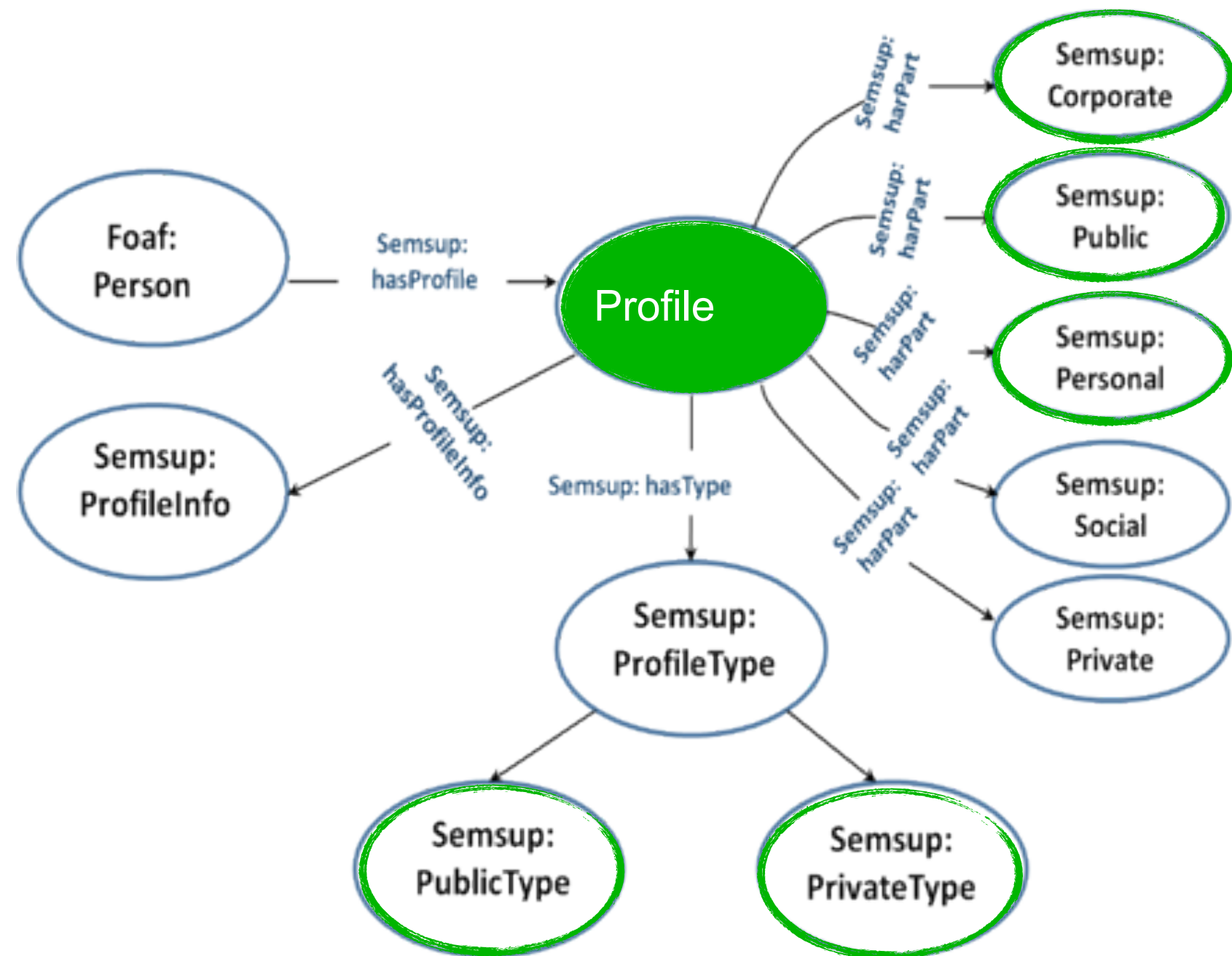
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Challenges

# User profile ontology



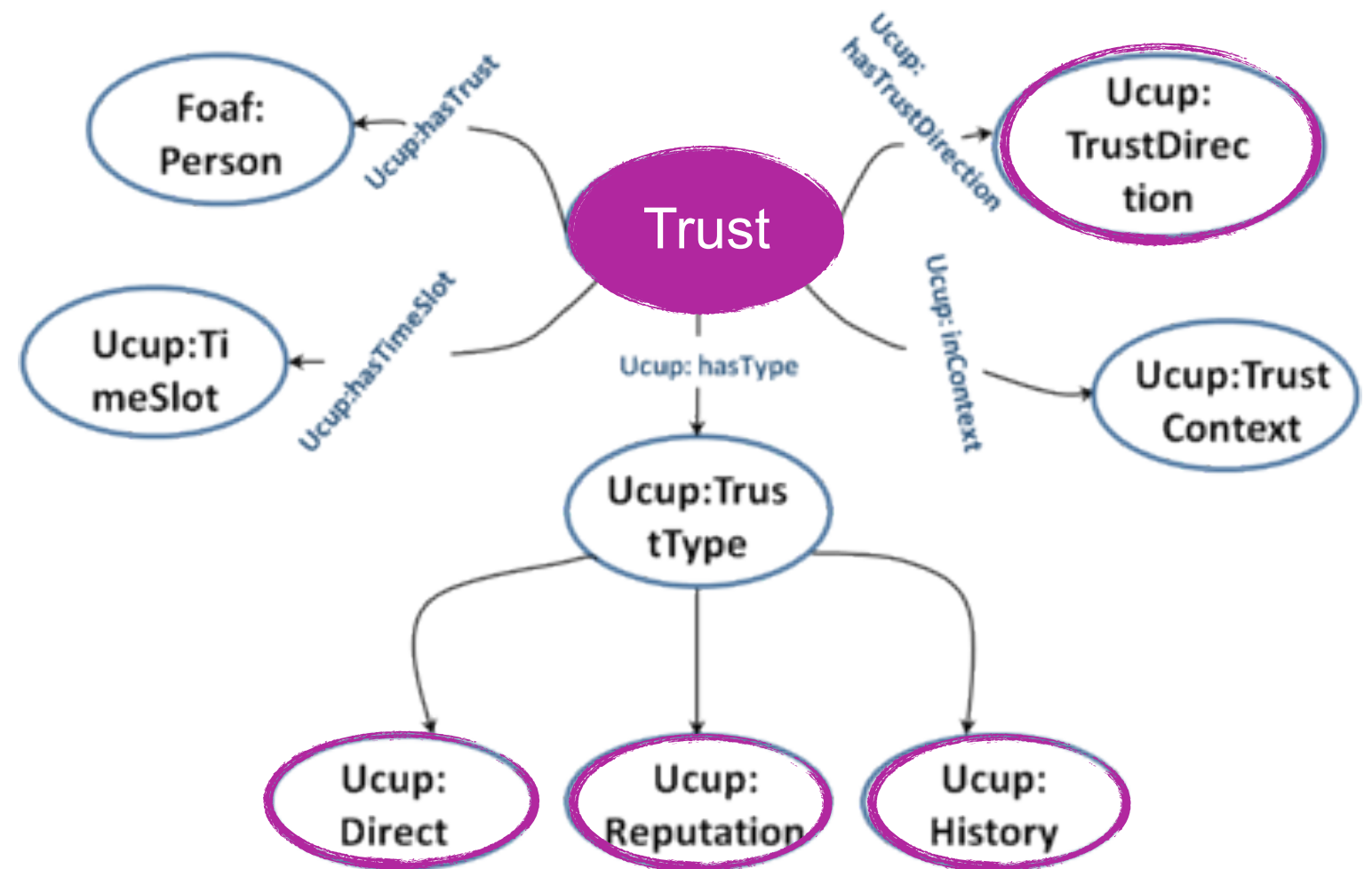
- User profile ontology
  - individual interests
  - distributed for areas “multiple roles”
- Profile access
  - coarse distribution



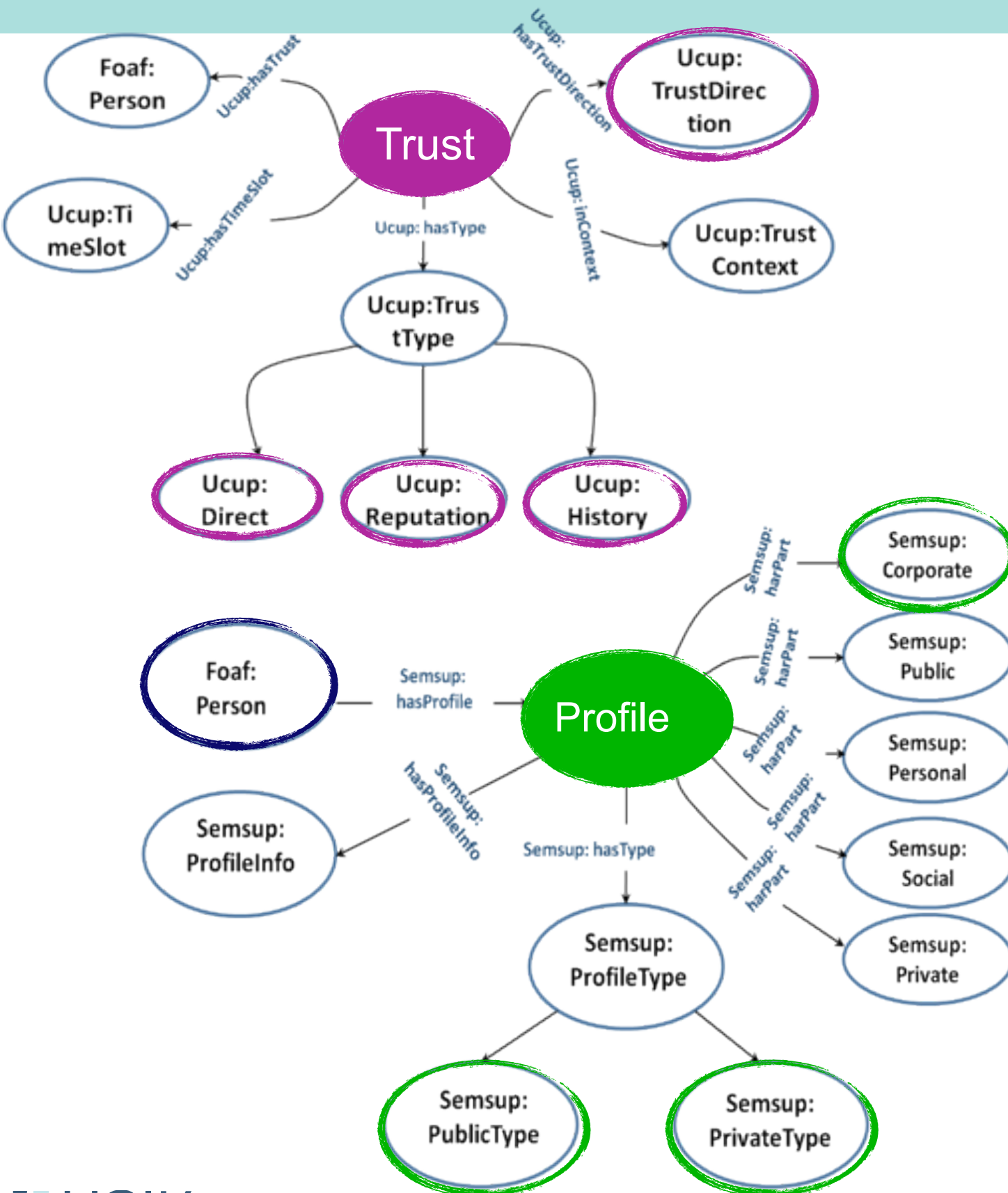
# Trust ontology



- Trust based on
  - direction
  - context
  - topic
- Trust types
  - direct (announced)
  - reputation
  - history



# Merging Ontologies



SKOS Simple Knowledge Organization System RDF Schema

# Idea Ontology (some classes)



- Definition of idea with OWL Restrictions

$$\begin{aligned} Idea &\sqsubset skos:Concept \\ \cap hasAbstract &\exists Abstract \\ \cap &= hasAbstract\ 1 \\ \cap hasTitle &\exists Title \\ \cap hasScore &\exists Score \\ \cap hasOwner &\exists Owner \end{aligned}$$

- Definition of ExcellentIdea, helps reasoner to classify any idea as excellent.

$$\begin{aligned} ExcellentIdea &\sqsubset Idea \\ \cap hasAbstract &\exists Abstract \\ \cap hasTitle &\exists Title \\ \cap hasOwner &\exists Owner \\ \cap hasScore &\exists (Score \cap hasValue \\ &\exists Excellent) \end{aligned}$$

# Screen Shots of the Access Control



# Screen Shots of the Access Control



## Faceted filter

You can add restrictions to your filter. Here you could see the whole filter criteria and delete any or all the restrictions if you want.

Your filter contains 1 restriction:

- Group: Rel9 Project ([delete](#))

Empty filter

## 3 matched individuals

### Gyorgy Kalman

Gyorgy Kalman is a Visiting Professor at the Computer Science Department in the Carlos III University. He holds a PhD in Computer Science from the Digital Enterprise Research Institute at Ireland, Galway.

### Josef Noll

Josef Noll is the Head of the SofLab Group at the Computer Science Department in the Carlos III University and the Head of the Institute for promotion of Innovation Pedro Juan de Lastanosa, Madrid.

### Erik Swansson

## Session

User: administrator

Date: 2007.06.04

## Filter the results with facets

Use the faceted filter to add restrictions to the listed results.

### Properties and values:

- Properties:
  - [has group](#)
  - [has role](#)
  - [has policy](#)

Available values for Group:

- ☒ Telenor RnI
- ☐ Rel9 Project
- ☐ Ericsson
- ☐ Telenor Pakistan

Add

## Resources attached to Erik Swansson

### Document: Management.doc

Policy: Read and write  
Open the document

### Document: Detailed\_design.doc

Policy: Read  
Open the document

### Session

User: eswansson  
Date: 2007.06.04

### Description of the identity in this group

- Project leader:
  - Policy: Final decision
  - Policy: Read and write
- Other Groups:
  - Rel9 Project (current)
  - Ericsson

```
<Role rdf:ID="Project_Leader">
  <hasVisibilityOfGroup rdf:resource="#Rel9_Project"/>
  <hasPolicy rdf:resource="#Administrator"/>
  <hasPolicy rdf:resource="#FinalDecision"/>
  <hasPolicy rdf:resource="#ReadWrite"/>
</Role>
<Role rdf:ID="Project_Member">
  <hasVisibilityOfGroup rdf:resource="#Rel9_Project"/>
  <hasPolicy rdf:resource="#ReadWrite"/>
</Role>
<Role rdf:ID="Visitor">
  <hasVisibilityOfGroup rdf:resource="#Empty"/>
  <hasPolicy rdf:resource="#Read"/>
</Role>
```

# Conclusions



- My Mobile is my digital representative
  - payment, access
  - location (privacy), anonymity
- Security in the Internet of Things is a real challenge
- Privacy and Trust for people
- Collaborative enterprise computing (= Integrated Operations)
- Semantics may help for complexity
- Ontologies for user profiles, trust, context and content
- Description Logic for Reasoning
- Challenges
  - real-world complexity - can we represent?
  - topic specific trust-metrics
  - “measurable security” (security metrics)

