Software Agents and Semantic Web – Technologies for Intelligent Wireless Internet

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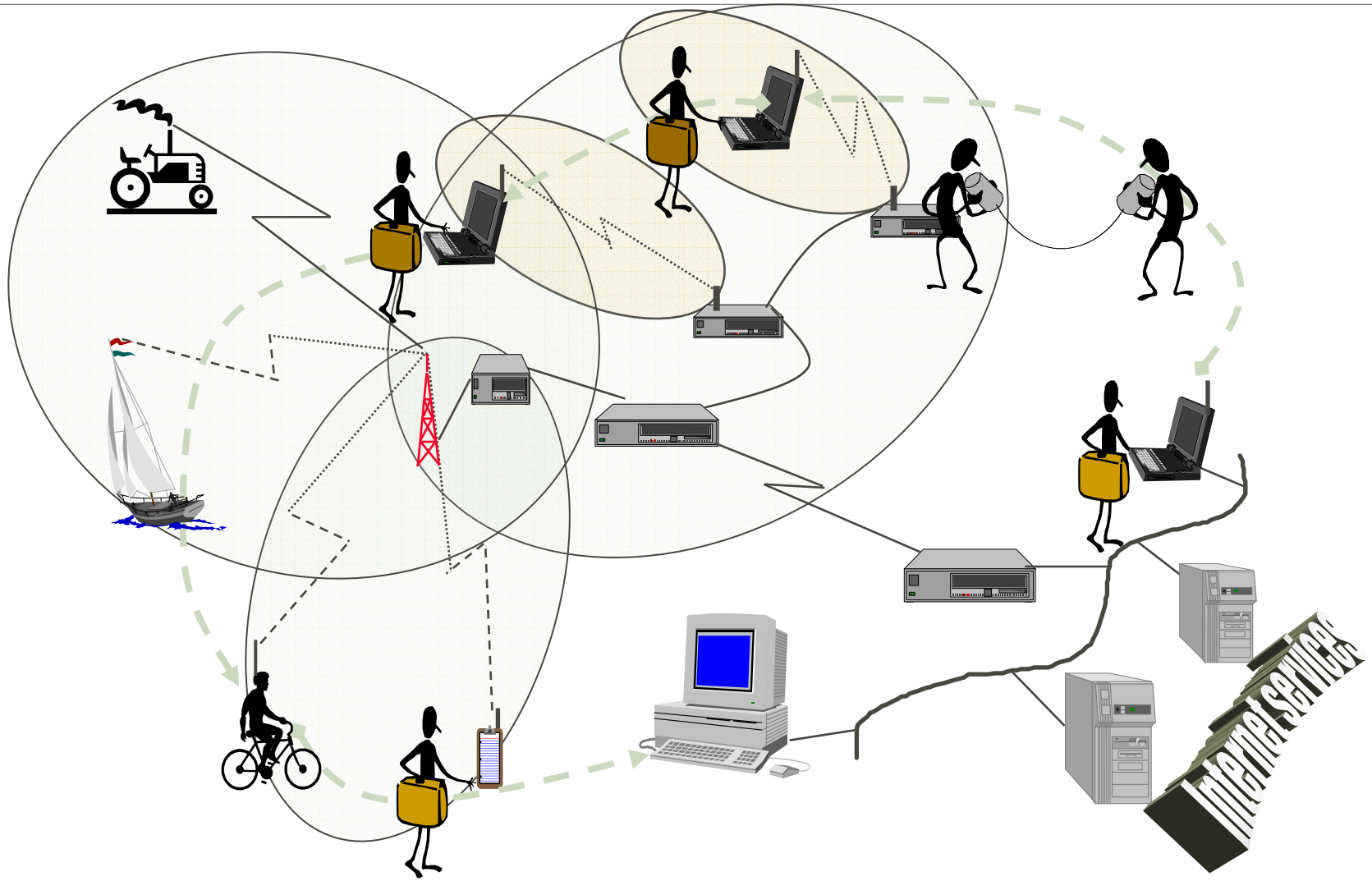
Topics

Software Agents and Semantic Web – Technologies for Intelligent Wireless Internet

- Intelligent Wireless Internet
- Challenges
- Software agents
- Semantic Web
- Research problems
- Conclusions

Intelligent Wireless Internet

Intelligent Wireless Internet



Intelligent Wireless Internet

- Future environment for wireless data communications
  - Ubiqutious / pervasive computing
    - *Pervasive computing is the trend towards computing that takes place anywhere, any time connecting different kinds of computing devices using different kinds of data communications.*
  - Multiple, heterogenous networks
    - bluetooth, WLANs (802.11a/b/g), GPRS, UMTS, satellites, etc.
    - separate infrastructures
    - highly varying QoS
  - Multiple, heterogenous terminals
    - intelligent phones, PDAs, tablet PC, laptop PC, ...
    - capable of using simultaneously several different data communication channels



Intelligent Wireless Internet

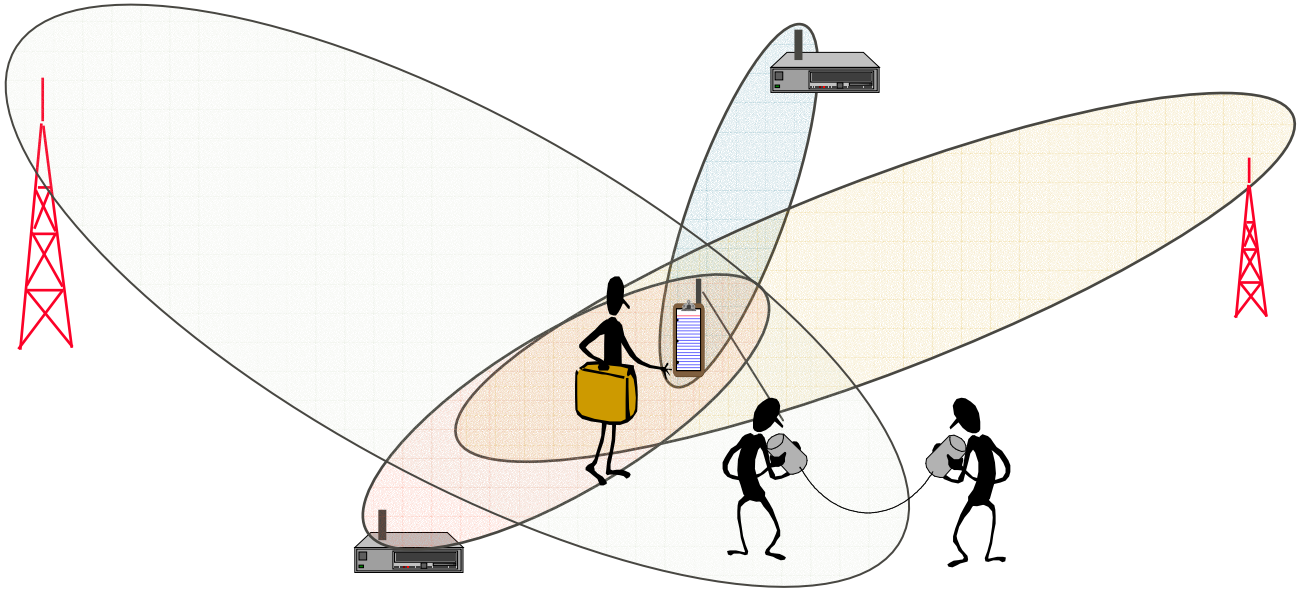
- What do we mean with the term ’intelligent wireless Internet’?
  - adaptive services
  - learning
  - *reactive behaviour*
  - *proactive behaviour*
  - *goal-oriented behaviour*

  Best possible services at each occasion
    - place, time, cost,
    - subscription,
    - terminal,
    - etc.

as transparently as possible to end-users

Intelligent Wireless Internet

Requires reasoning about which communication service to use to transfer data …



Challenges

Challenges

- Adaptive services
  - modelling environment (context) of data communications
  - monitoring the environment
- Learning
  - performance

- *Reactive behaviour*
- *Proactive behaviour*
- *Goal-oriented behaviour*

- Solutions should be based on standards

Possible Technology for Solutions

Semantic Web

Knowledge representation

Actors

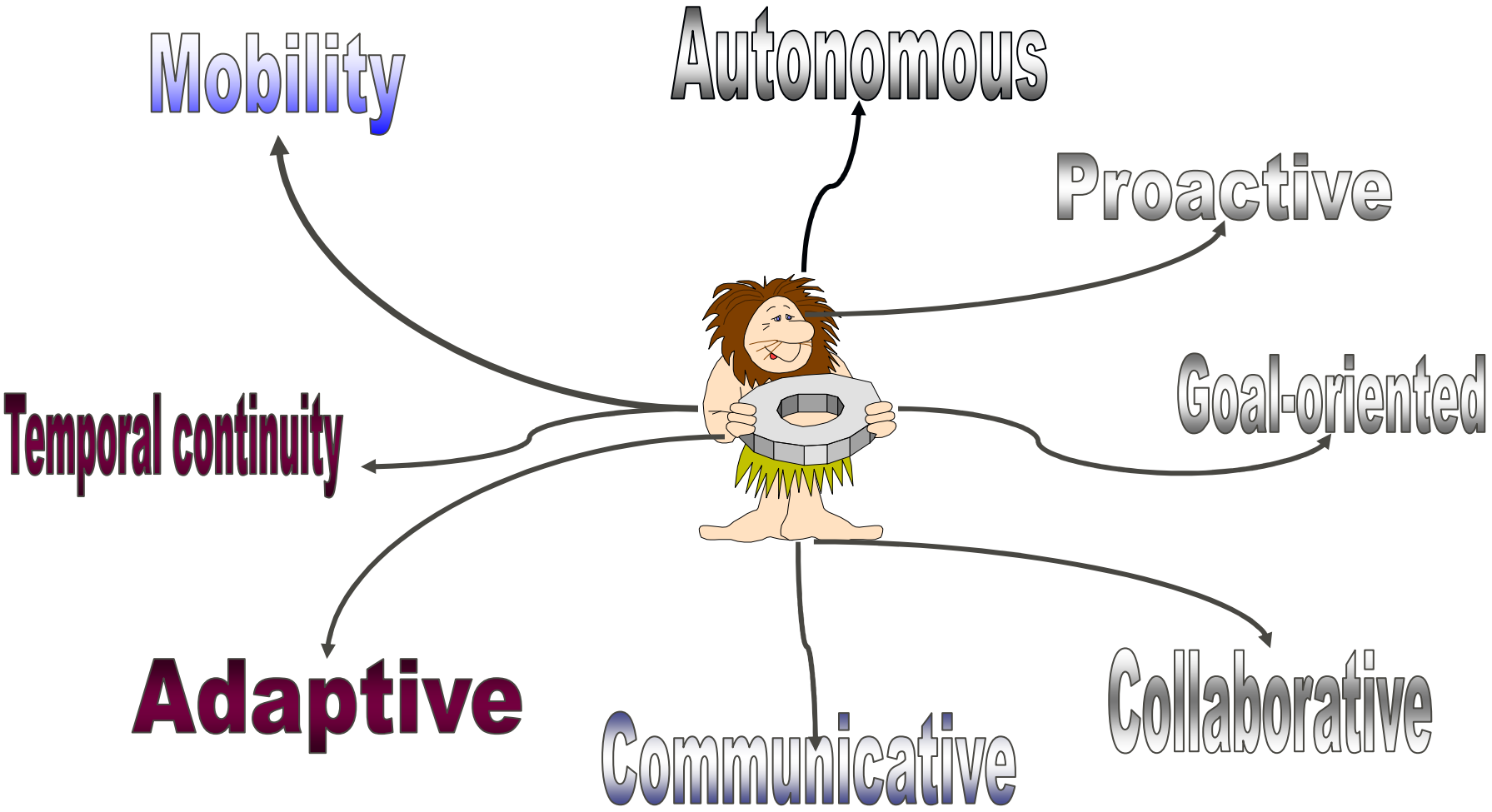
Software Agent

Software Agents

Software Agents

- What is a software agent?
  - ***No single, generally accepted definition.***
  - “An autonomous agent is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future.”
  - “Intelligent agent is one that is capable of autonomous actions in order to achieve its goals, which are defined in their design objectives.”
  - At least following features:
    - 1) Reactivity: intelligent agents are able to perceive their environment, and respond in a timely fashion to changes that occur in their environment in order to achieve their goals;
    - 2) Pro-activeness: intelligent agents are able to exhibit goal-directed behaviour by taking an initiative in order to achieve their goals;
    - 3) Social ability: intelligent agents are capable of interacting with other agents in order to achieve their goals.

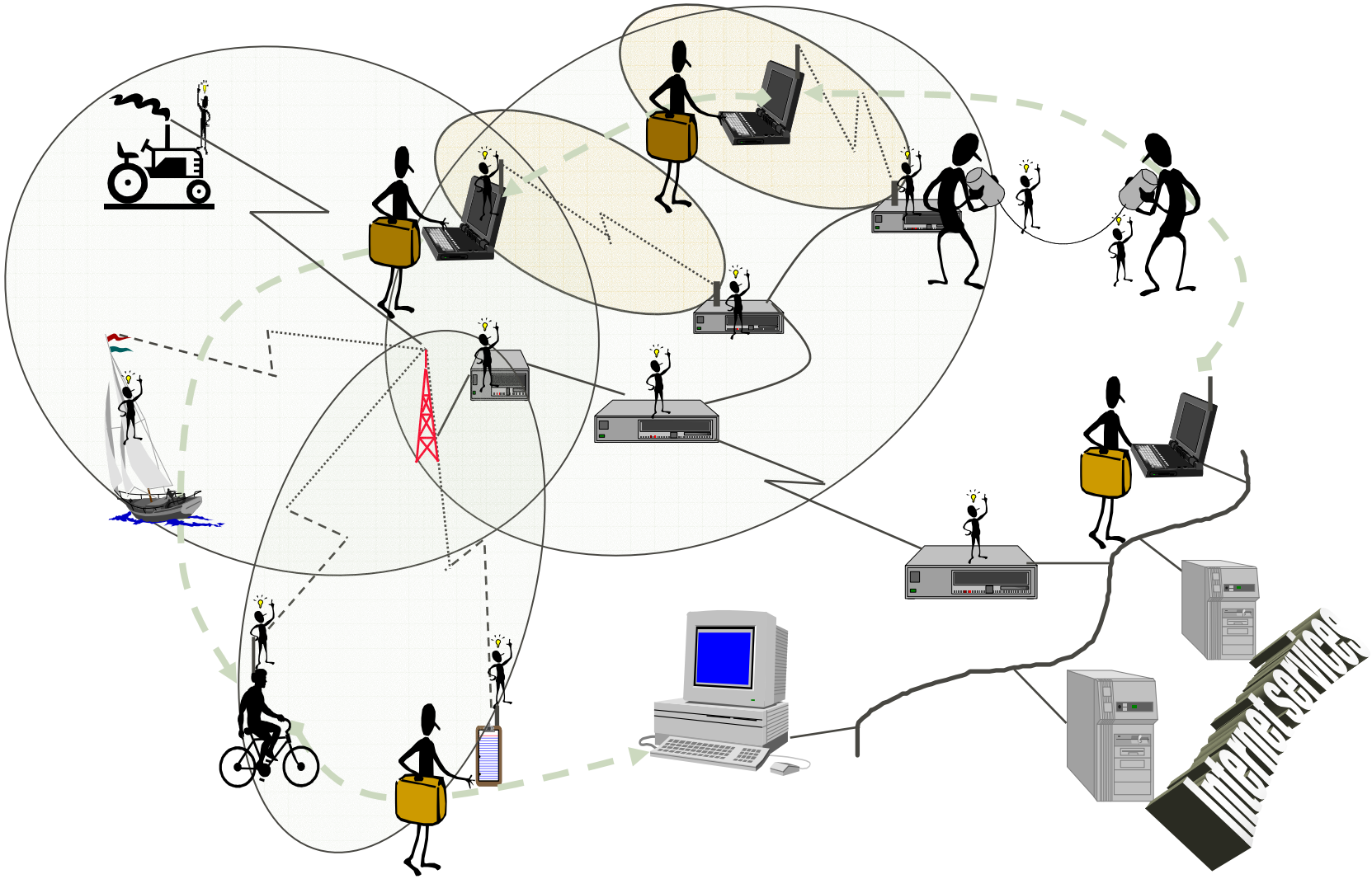
Software Agents



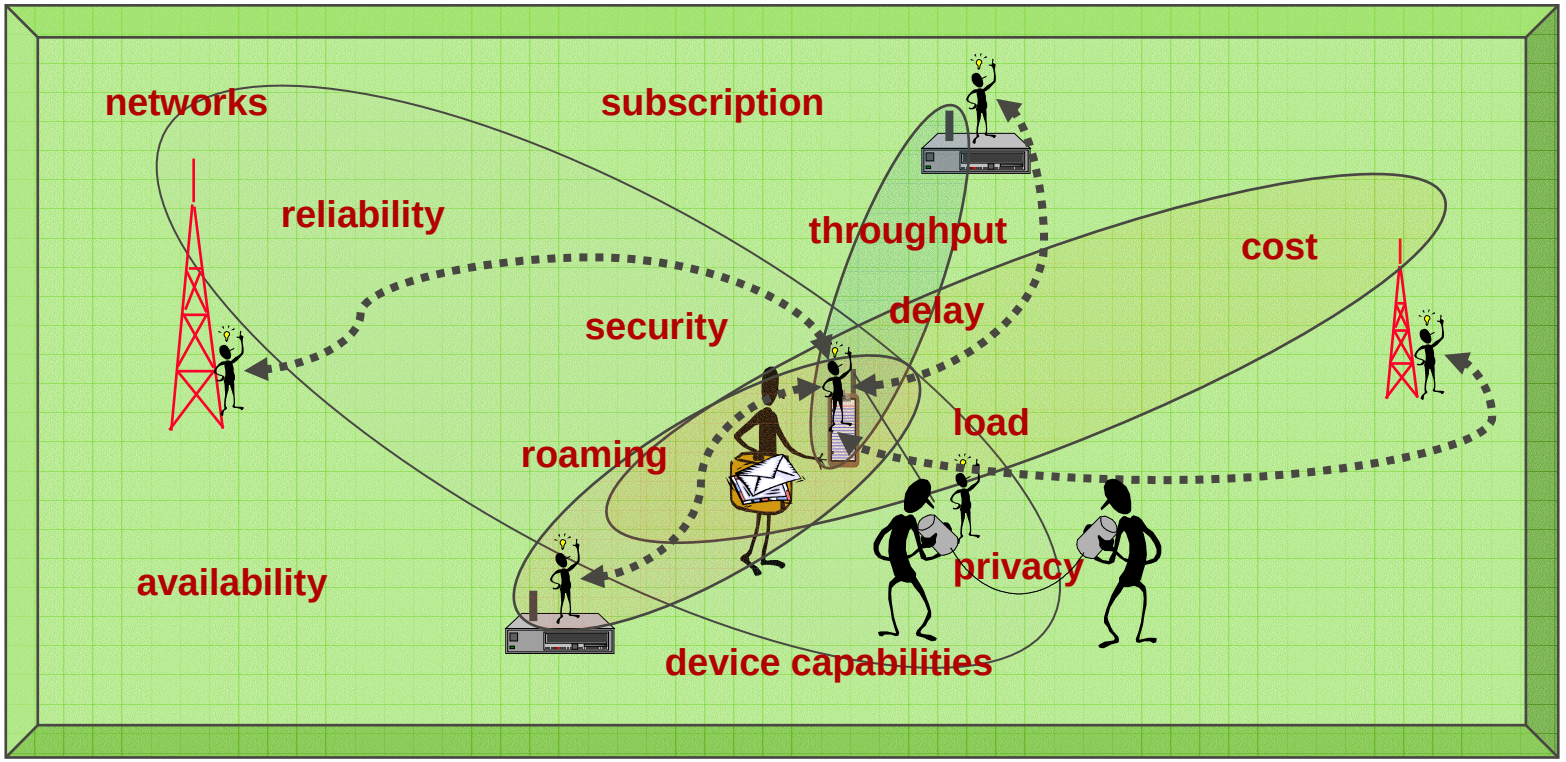
Software Agents

- New paradigm for developing distributed systems
  - Services are offered by autonomous agents doing cooperation (MAS).
    - agent-to-agent communication
      - FIPA (Foundation for Intelligent Physical Agents)
        - Message Transport Service, FIPA ACL, FIPA SL, etc.
        - Nomadic application support.
  - Devices are represented by agents
    - *Ontology of devices*
  - Networks are represented by agents
    - *Ontology of data communications*
  - Users are represented by agents
    - *Ontology of users' context*

Software Agents & Intelligent Wireless Internet



Context of data communications



Software Agents & Intelligent Wireless Internet

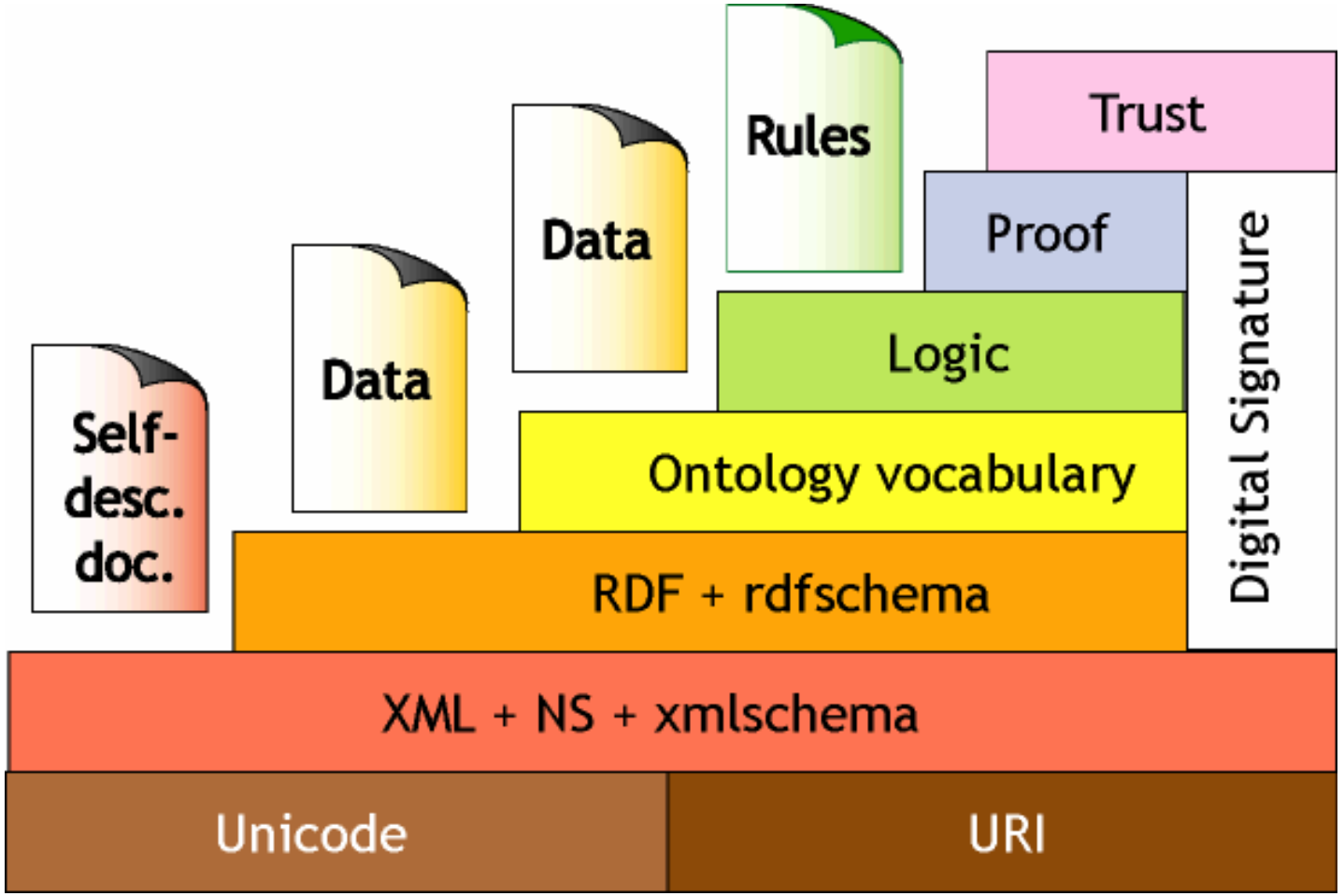
- Reasoning and deciding about which communication service to use to transfer data requires
  - Ontology of data communications
    - FIPA (simple ontology)
  - Ontology of terminals
    - W3C and FIPA
      - ---> *profiles of terminals*
  - Negotiation protocols
    - FIPA
  - Content languages
    - FIPA, KIF, ….
  - Agent communication language
    - FIPA-ACL, KQML, …
  - *Missing: standard-based ontologies for data communications that do enable adequate reasoning*.

Semantic Web

Semantic Web

- “The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation. ”
  - Tim Berners-Lee, James Hendler, Ora Lassila, The Semantic Web , Scientific American, May 2001.
- The Semantic Web is the representation of data on the World Wide Web. It is a collaborative effort led by W3C with participation from a large number of researchers and industrial partners. It is based on the Resource Description Framework (RDF), which integrates a variety of applications using XML for syntax and URIs for naming.
  - W3C

Semantic Web



Tim Berners-Lee's *XML2000 address*

Semantic Web

- Structure of data (XML and XSD)
  - XML provides a surface syntax for structured documents, but imposes no semantic constraints on the meaning of these documents.
  - XML Schema is a language for restricting the structure of XML documents.
- Semantics of data (RDF and RDF(S))
  - RDF is a datamodel for objects ("resources") and relations between them, provides a simple semantics for this datamodel, and these datamodels can be represented in an XML syntax.
  - RDF Schema is a vocabulary for describing properties and classes of RDF resources, with a semantics for generalization-hierarchies of such properties and classes.
- Ontologies (OWL)
  - OWL adds more vocabulary for describing properties and classes: among others, relations between classes (e.g. disjointness), cardinality (e.g. "exactly one"), equality, richer typing of properties, characteristics of properties (e.g. symmetry), and enumerated classes.

Semantic Web

- RDF & RDF(S)
  - Resource Description Framework is a framework for describing and interchanging metadata.
  - A Resource is anything that can have a URI; for example, a data communication channel.
    - TeliaSonera/GPRS/channel
  - A Property is a Resource that has a name and can be used as a property; for example, Linerate.
  - A Statement consists of the combination of a Resource, a Property, and a value. These parts are known as the 'subject', 'predicate' and 'object' of a Statement.
    - An example Statement is “The Linerate of the TeliaSonera/GPRS/channel is 48 Kbits/s”.
  - There is a simple method for expressing these abstract Properties in XML, for example:

```
<rdf:Description about=‘TeliaSonera/GPRS/channel’>
<Linerate>48</Linerate>
<Unit>Kbits/s</Unit>
</rdf:Description>
```

Semantic Web

- OWL (Web Ontology Language)
  - Further developed from DAML+OIL
  - OWL is a language for defining and instantiating Web ontologies.
  - An OWL ontology may include definitions of classes, properties and their instances.
  - An ontology differs from an XML schema in that it is a knowledge representation.
  - Three sublanguages
    - OWL Lite
      - classification hierarchy and simple contraints
    - OWL DL
    - OWL Full

Semantic Web

- OWL (Web Ontology Language)
  - OWL Lite

RDF Schema Features
Class
rdf:Property
rdfs:subClassOf
rdfs:subPropertyOf
rdfs:domain
rdfs:range
Individual

(In)Equality:
equivalentClass
equivalentProperty
sameIndividualAs
differentFrom
allDifferent

Property Characteristics
inverseOf
TransitiveProperty
SymmetricProperty
FunctionalProperty
InverseFunctionalProperty

Property Type Restrictions
allValuesFrom
someValuesFrom

Restricted Cardinality
minCardinality (only 0 or 1)
maxCardinality (only 0 or 1)
cardinality (only 0 or 1)

Header Information:
imports
priorVersion
backwardCompatibleWith
incompatibleWith

Semantic Web

- OWL example

```
<owl:Class rdf:ID=”WirelessDataCommunication” />

<owl:Class rdf:ID=”GPRS”>
   <rdfs:subClassOf rdf:resource=”#WirelessDataCommunication” />
   ...
</owl:Class>
<owl:Thing rdf:ID=”Channel” />
<owl:Thing rdf:about=”#Channel”>
   <rdf:type rdf:resource=”#GPRS”/>
</owl:Thing>
<owl:Class rdf:ID=”UMTS”>
   <rdfs:subClassOf rdf:resource=”#WirelessDataCommunication” />
 ...
</owl: Class>
```

Research Problems

Research Problems

Software agent technology and Semantic Web technology form a promising base to develop Intelligent Wireless Internet.

- A model of the context of (wireless) data communications
  - what is really needed to enable adequate reasoning and decision-making?

- Ontologies based on OWL for
  - data communications,
  - mobile equipment, and
  - services.

- *Bit-efficient transfer of knowledge.*

Conclusions

Conclusions

- Future Intelligent Wireless Internet
  - Ubiqutious / pervasive computing
  - Multiple, heterogenous networks
  - Multiple, heterogenous terminals
  - adaptive services, learning, *reactive behaviour, proactive behaviour, goal-oriented behaviour*

- Requires reasoning about and decision-making which communication service to use to transfer data …
- Good candidates:
  - software agent technology & Semantic Web technology
- Many research challenges are involved
  - ontologies for different domains

Thank you for your attention