Supporting Nomadic Agent-based Applications in the FIPA Agent Architecture

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Introduction

• Multi-agent system implementing a middleware providing (agent-based) applications with tools for adaptation in a nomadic environment

• Nomadic environments enable new ways to access services
  → anywhere, at any time, and using any device

• Challenges that need to be addressed:
  - Varying QoS of the wireless networks
  - Limitations of mobile devices
  - Contextual variability (location, time, user preferences, …)

• Adaptation to the environment is the key issue
Presentation Outline

• Agent Architecture for Wireless World
  - Based on FIPA’s architecture

• Ontologies for Wireless World
  - What kind of ontologies are needed
  - Examples

• Agent Communication for Wireless World
  - Layered model & optimization techniques
Agents?

**Never send a man to do a machine’s job**
- *agent Smith, Matrix*
Wireless/Nomadic Environment

- Typical characteristics
  - Low throughput, long delays, unreliable, ...
  - *Variability*
  - Disconnected mode of operation is the most common state

- Different kind of (wireless) networks
  - Seamless roaming will be important in the future

- Currently we consider long thin networks
  - GSM, HSCSD, GPRS, UMTS, ...
Agents in Nomadic Environments?

- Suitable for complex environments
  - Internet is a complex environment...
  - Wireless Internet is even more complex...
  - Invisible Internet...

Semantic Web

Ambient networks

QoS

Peer-to-peer

Intelligent P2P

Pervasive Computing

Ubiquitous Computing

Ontologies

Ad hoc networks

Distributed Artificial Intelligence
Agent Architecture in Wireless World
FIPA Agent Platform

DF = Directory Facilitator
AMS = Agent Management System
ACC = Agent Communication Channel
FIPA Agent Platform
FIPA Agent Platform

Mobile Device

Fixed Network Host

(Wireless) Connection
FIPA Nomadic Application Support

Knowledge Sharing

Controlling & monitoring

Mobile Device

Fixed Network Host

(Wireless) Connection
FIPA Nomadic Application Support
Ontologies in Wireless World
An ontology is an explicit description of a domain:
- Concepts
  - “Wireless network”, “GSM”, “GPRS”, ...
- Properties and attributes of concepts
  - Each “Network” will have “Operator”, “Location”, “Properties”, ...
  - Every “IEEE802.11a” is a “WLAN”
- Constraints on properties and attributes
  - The name of a network operator is a string
  - GSM network identifier consist of CountryCode and NetworkID
- Individuals (often, but not always)

An ontology defines
- a common vocabulary
- a shared understanding
Ontologies in Wireless world
Example Ontology - Quality of Service
Example Instance

<dam1:Class rdf:ID="GSM">
  <dam1:subClassOf rdf:resource="#WirelessNetwork" />
</dam1:Class>

<Operator rdf:ID="Sonera" />

<GSM rdf:ID="SoneraGSM">
  <operatedBy rdf:resource="#Sonera" />
  <qosProperties>
    <LineRate rdf:resource="#GSMLineRate" />
    <Delay />
  </qosProperties>
  <hasService> ... </hasService>
  <availableAt> ... </availableAt>
</GSM>
Agent Communication in Wireless World
Agent Communication

- Objects use telepathic communication
  - Direct manipulation of each other’s knowledge base

- Agents use more “human-like” communication
  - Speech act theory
  - Agent communication languages
    - e.g., FIPA-ACL, KQML, ...
  - Ontologies for knowledge sharing
Layered Model of Agent Communication

1. **Bearer Networks**
2. **Transport and Signalling**
3. **Message Transport Protocol**
4. **Message Envelope**
5. **Agent Communication Language**
6. **Content Language**
7. **Conversation**

**Protocols and Standards**
- TCP/UDP
- IIOP
- HTTP
- RMI
- FIPA Message Envelope
- FIPA-ACL
- KQML
- SL
- KIF
- CCL
Message Transport

• How messages are transferred between agents
• Desiderata
  - Reliability
  - Efficiency
  - Dynamic adaptation
• Issues
  - Performance problems
  - Terminal mobility
  - Thin clients
Message Envelope

- FIPA "specific" layer

- Defines how messages are delivered
  - independent of message transport protocols

- Different encoding options
  - XML, Bit-efficient, IIOP/IDL

- Bit-efficient encoding similar to bit-efficient ACL
ACL Encoding

• Options
  - String (s-expression), XML, Bit-efficient

• Space-efficient
  - ...by definition

• Time-efficient
  - much faster
    • nice for every application; not only for wireless
    • necessity for
      - high performance applications
      - highly utilized servers
  - simple parser → appropriate for thin clients
Content Languages

- **FIPA-SL**
  - All-purpose content language
  - S-expression (w/ deflate), XML, Binary-XML (w/ special tokens)

- **FIPA-CCL**
  - Language for constraint satisfaction problems
  - XML & Binary-XML

- Results similar to those of message envelope and ACL
Conversation Layer

- Optimizing/modifying existing conversation protocols?
- Developing new conversation protocols?
- Selecting conversation protocol based on current environment
  - low bandwidth $\rightarrow$ simple protocol $\rightarrow$ not so good end result
  - more bandwidth $\rightarrow$ more complicated protocol $\rightarrow$ better end result
Possible Applications

• **Wireless Web Browsing**
  - Intelligent adaptation to changing communication environments
  - Basis for many applications

• **Location-aware applications**
  - Seamless roaming between different network technologies
  - Many other possibilities

• **Mobile Auction scenario**
  - (Intelligent) management of bid timeouts
Conclusions

- **Middleware architecture**
  - Several applications implemented on top of that
  - Extensions by 3rd parties
  - Standardized by FIPA (informative)

- **Wireless Network/QoS Ontology**
  - Minimal, but usable
  - Standardized by FIPA

- **Efficient communication**
  - Optimizations/tailoring needed at all layers
  - Not only works, but
    - Mostly standardized by FIPA
    - Implemented by major FIPA platforms
Thank you

Questions?