Comparison of Software Agent Frameworks with the J2EE Framework

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Problem

- What are the synergies, conflicts, and interoperability challenges/potentials between applications developed for software agent frameworks and those of the Web-centric, thin client, n-tier server, component frameworks as exemplified by the Java 2 Enterprise Platform (J2EE)?

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Background

Software Agents

- Intense research activity, beginning transition to commercial applications
- Paradigm for peer-to-peer activity
- Reference: *Multi-Agent Systems*, Weiss, 1999, MIT Press

Java 2 Enterprise Framework (J2EE)

- State-of-the-art enterprise system. Web-centric n-tier component architecture (from Sun Microsystems, Inc.)
- Continued Evolution: Web services, Connector architecture framework enhancement

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Objective

- **Overall**: To elucidate potential synergies and conflicts as well as avenues for interoperability between applications that are developed for the Web-centric client-server n-tier component architecture and those that are developed as multi-agent software agent systems using
  - specifications-based approach
  - selective prototyping
- **Current Fiscal Year Objectives**:
  - Investigate the *"Services Paradigm"* across the J2EE <-> FIPA-compliant agent systems
  - Investigate approaches to integrated security for application(s) spanning J2EE-FIPA-agent system
  - Petri net modeling of the hybrid J2EE-FIPA-agent system implementing Web services

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Activities

- Investigate Services Paradigm across J2EE --- FIPA-compliant agent systems:
  - Software agents offer Web services to (Web) client of J2EE
  - EJB components of J2EE offer composed Web service to software agent via BPEL execution engine
  - Software agents offering Web services register services on FIPA-OS platform and in UDDI Registry
  - Petri net-based modeling explorations of extended system
- Contribute to FIPA services TC specification development
- Explore dynamic use of ontology to find weather services in FIPA-compliant software agent using DAML-based ontology and Jess Knowledge Base
- Investigate end-to-end security approaches applicable to synergistic applications spanning J2EE --- FIPA-compliant agent platforms
- Collaborations: Agent access to EJB: Connection from FIPA-compliant platform to J2EE EJBs.

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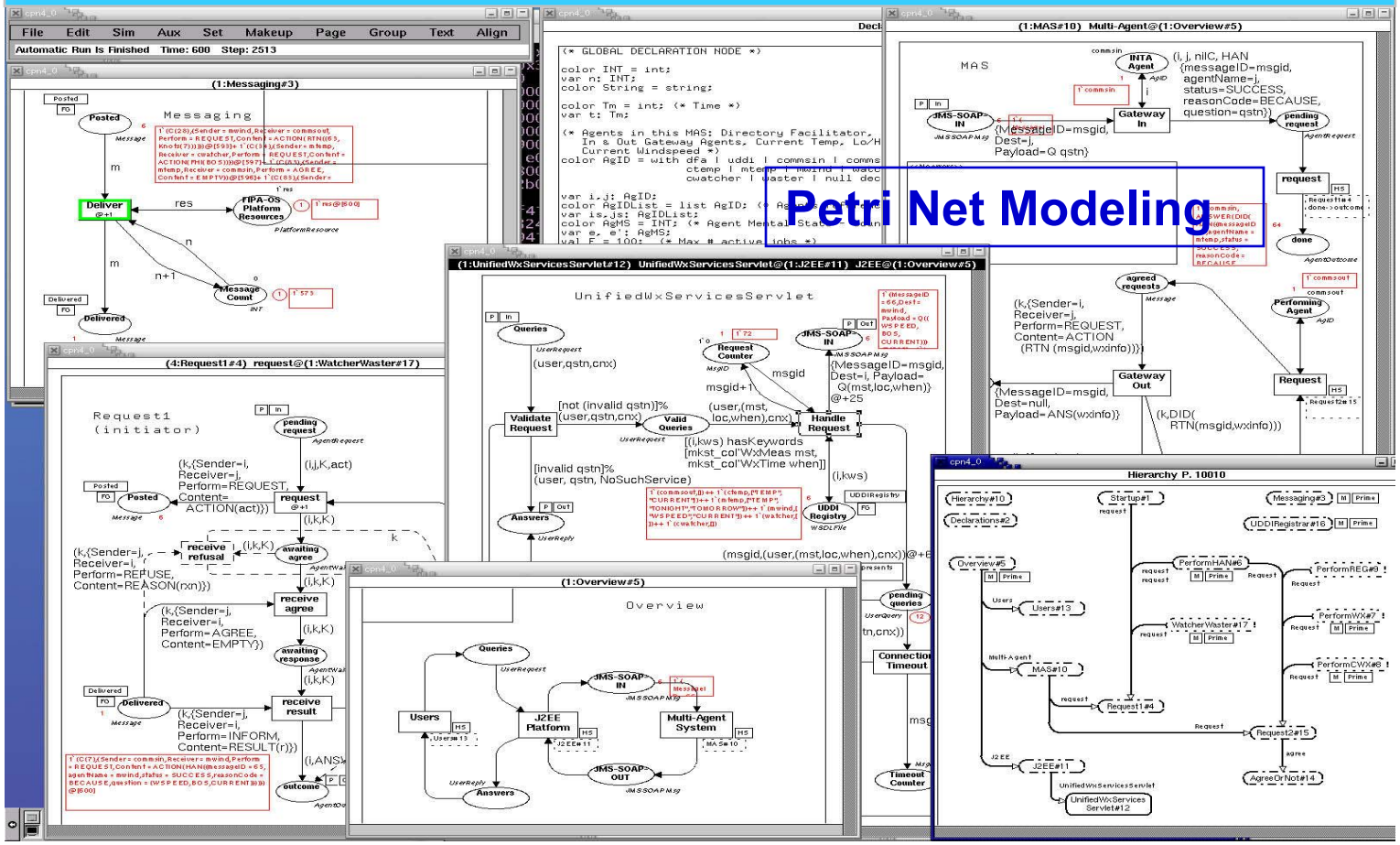
Highlight

Modeling of Web Service Activity in J2EE - FIPA-agent System



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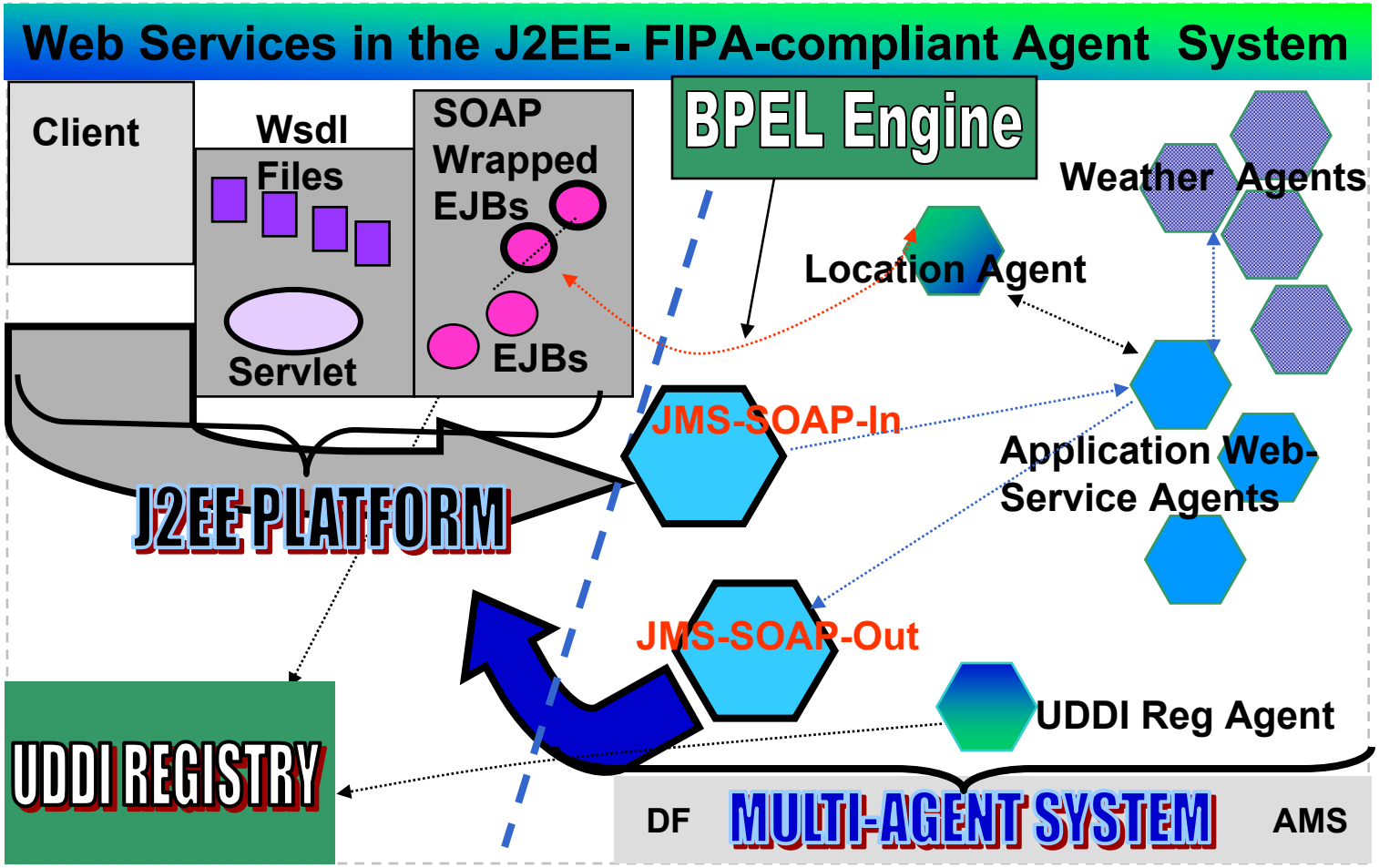
Demonstration



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Impacts

- **Paper** "Interoperability, Standards, and Software Agent Systems," in *Proc. 23 Army Science Conference*, December 2002
- **Paper** "Comparison of Two Component Frameworks: The FIPA-compliant Multi-Agent System and the J2EE Platform," accepted for Intl. Conf. Software Engineering, May 2003. **Participation** in **FIPA Standards** activities as Vice-chair of FIPA Services TC
- **Tech Transfer** of JMS Comms Agent to open source FIPA-OS developer community; hosted on Source Forge at http://fipa-os.sourceforge.net/contributions.htm
- **Collaboration** with "High Confidence Software Containers" MOIE project (G. Vecellio, PI) ; agents access to EJBs in J2EE system

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Future Plans

- **Bring Research Project to a Close with**
  - Completion of research threads
  - Additional tech transfer to FIPA-OS developer community
  - Development of specifications for FIPA *Service* Abstract Architecture
  - Knowledge Management Efforts
    - Internal:
      - Project Web-site http://rcf.mitre.org/~mlyell , mailing list, MITRE Technical Report documents, final reports
      - MITRE Institute course on "Introduction to Software Agents"
      - Potential "Convergence" TEM / Symposium in collaboration with JABA and eJBI MOIEs
    - External: Presentation of papers at appropriate conference venues

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Focus on "Services across J2EE --- FIPA-compliant Agent System"

- *Petri Net Modeling in System*
- *Details of Web Services in System*

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Petri Net Modeling in System

- Petri Net Models of 'Web Service Activity in the J2EE --- FIPA-compliant Multi-agent System'
  - Base Model
    - Modeling effort connected to a prototyped MAS: 1 J2EE platform and 1 FIPA-OS platform
    - Development of abstractions of conversation protocols can be re-used
    - To yield Basic performance results
  - Extensions to Base Model: Additional agents involved in answering questions
    - Still 1 FIPA-OS platform (and 1 J2EE platform)
    - Deep vs. Shallow Jobs investigation
  - Extensions to Base Model to include multiple J2EE and FIPA-OS platforms

Modeling Allows Investigations Beyond the Scope of the Basic Prototype.

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Details of Web Services /1

- Software Agents Offer Services to Web Clients of J2EE Platform
  - Agent services registered in UDDI Registry and FIPA-OS DF
  - Agents offering services fill out *agentized* WSDL files
  - Communication across systems ---> Develop SOAP - JMS binding
  - Each agent does not need to know the SOAP protocol; use a Gateway architecture
    - Gateway Elements: Servlet to process, JMS provider support, JMS Gateway agents (with JMS capability)
    - Current Gateway *cannot* participate in BPEL engine to allow composition of SOAP services

- EJBs in J2EE System are SOAP- wrapped
  - Client agent "knows" SOAP protocol
  - EJBs participate in offering a *composed* service via BPEL engine

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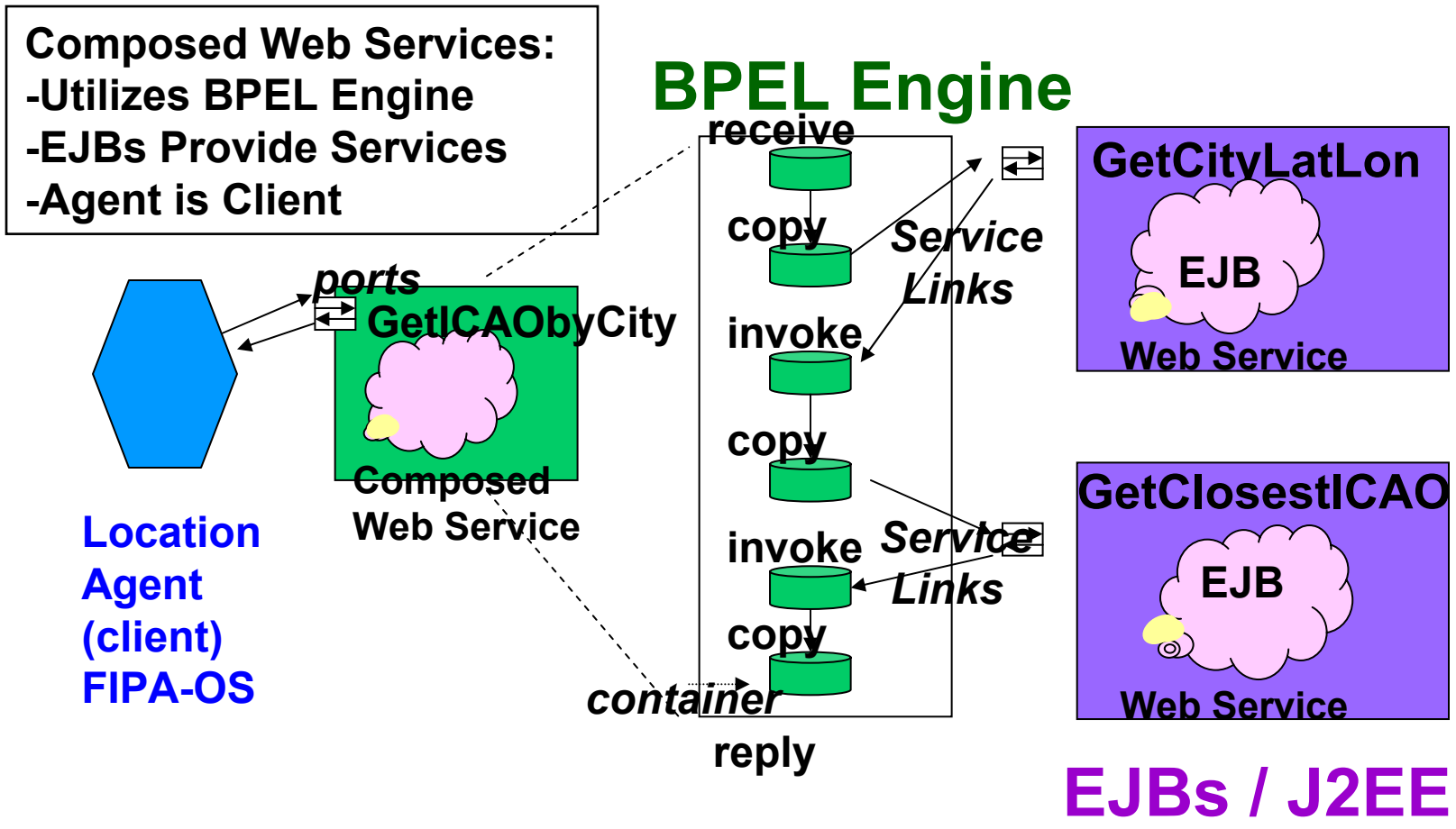
Details of Web Services /2



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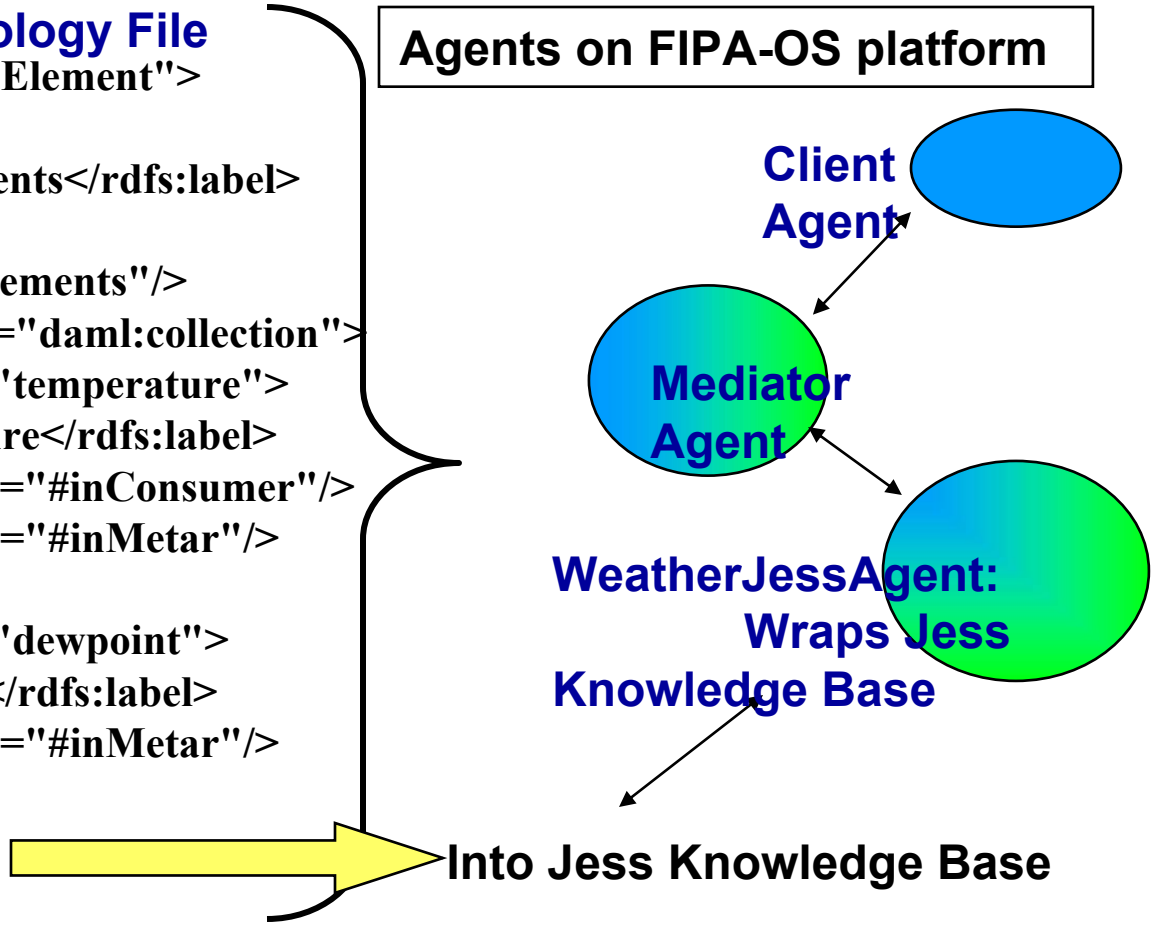
Focus on "Dynamic Use of Ontology to Identify Services in Agent System" /1

Snippet of DAML Ontology File

```
<daml:Class rdf:ID="tempElement">
   <rdfs:label
xml:lang="en">tempElements</rdfs:label>
   <rdfs:subClassOf
rdf:resource="#reportedElements"/>
   <daml:oneOf parseType="daml:collection">
    <tempElement rdf:ID="temperature">
     <rdfs:label>temperature</rdfs:label>
     <rdf:type rdf:resource="#inConsumer"/>
     <rdf:type rdf:resource="#inMetar"/>
    </tempElement>
    <tempElement rdf:ID="dewpoint">
     <rdfs:label>dewpoint</rdfs:label>
     <rdf:type rdf:resource="#inMetar"/>
    </tempElement>
   </daml:oneOf>
 </daml:Class>
```



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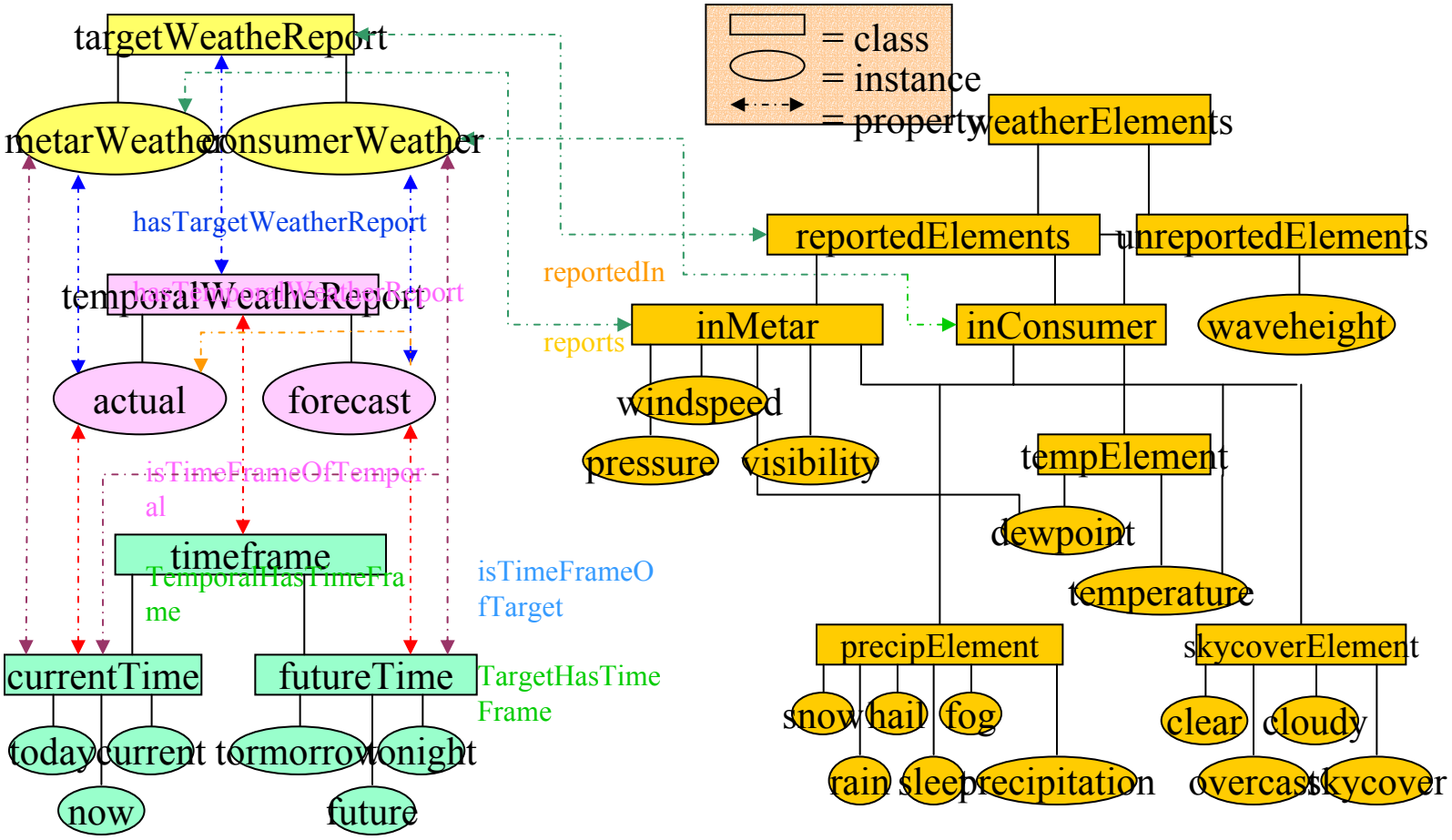
Focus on "Dynamic Use of Ontology to Identify Services in Agent System" /2



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Focus on "Dynamic Use of Ontology to Identify Services in Agent System" /3

- Exemplar Question in English
  - "Get weather report that gives current weather"
- Exemplar Question in FIPA-SL
  - ((any ?x (isTimeFrameOfTarget current ?x)))
- FIPA-SL Question encoded in XML
  - <sl>
  - <any variable="?x">
  - <predicate predsym="isTimeFrameOfTarget">
  - <term> current </term>
  - <term> ?x </term>
  - </predicate>
  - </any>
  - </sl>

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Focus on "Security across the J2EE --- FIPA-compliant Agent System" /1

- Currently no FIPA specifications regarding software agent or agent platform security
  - Certain agent platforms offering security provisions
- Security and Software Agents
  - Current state-of-the-art views:
    - agents have identities
    - utilize trust and delegation,
    - use of policies permits modification of access rights
- Security and J2EE Platform
  - Mature relative to agent systems
  - Features:
    - Middleware controls basic security: Containers and Java Connector Architecture
    - Authentication and Authorization features

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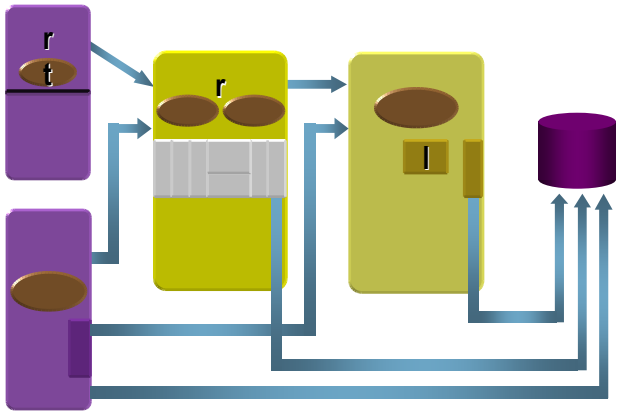
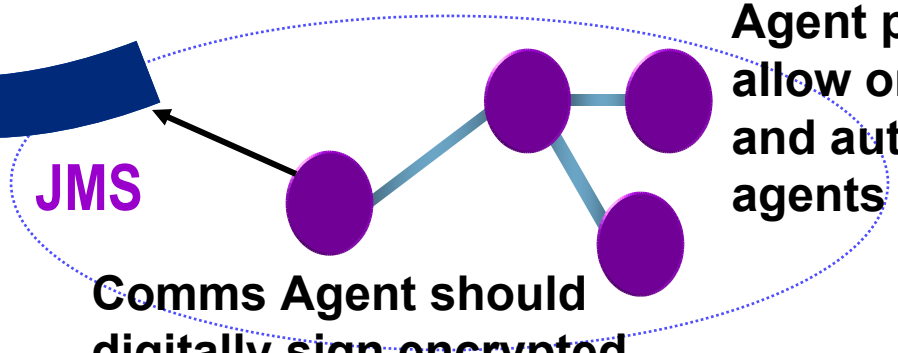
Focus on "Security across the J2EE --- FIPA-compliant Agent System" /2

Elucidate Security Issues via Scenarios:
J2EE Clients Subscribe to Agent-System Information Product



Client must be authorized to access JMS channel

JMS and secure communications



Agent platform should allow only authorized and authenticated agents to register

Comms Agent should digitally sign encrypted JMS payload

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