Enterprise Collaboration & Interoperability

COIN
EU FP7 Integrated Project 216256
Baseline Services and Negotiation Support
Klaus Fischer
Ingo Zinnikus

Summer School, Aachen 19
Oct. 2010
Overview

• Motivation and Background
  – DFKI
  – COIN Vision
  – Basic Concepts of Interoperability
• Negotiation: Basic Concepts
• Application Examples
• Model Driven Design
• Conclusion and Future Work
Motivation and Background
DFKI is Situated at three Sites

Bremen
Virtual Enterprises, e-Business and Supply Chain Management
**COIN VISION:** “By 2020 enterprise collaboration and interoperability services will become an invisible, pervasive and self-adaptive knowledge and business utility at disposal of the European networked enterprises from any industrial sector and domain in order to rapidly set-up, efficiently manage and effectively operate different forms of business collaborations, from the most traditional supply chains to the most advanced and dynamic business ecosystems.”

**COIN MOTTO:** “Enterprise Interoperability and Enterprise Collaboration are the two sides of the same COIN”
Background and motivation

Enterprise Collaboration (EC) and Enterprise Interoperability (EI) have been the two major research catalysts for DG INFSO D4 "Networked Enterprise & Radio Frequency Identification (RFID)", and aggregated tens of projects and hundreds of researchers in their projects clusters initiatives. COIN is rooted in the previous initiatives.

**Enterprise Collaboration** comes from a business perspective and identifies the process of enterprises - mainly SMEs - to set-up and manage cross-enterprise win-win business relations in response to business opportunities.

**Enterprise Interoperability** originates by the ICT world and identifies a capability of enterprise software and applications to exchange information and to mutually understand the information exchanged at the level of data, applications, processes and enterprise models involved.
COIN promoters believe that EC and EI are different concepts which cannot be merged or confused but that they are so interdependent and simultaneously present in every networked enterprise, that they can be really considered as the two sides of the same COIN.

**COIN MOTTO:** “Enterprise Interoperability and Enterprise Collaboration are the two sides of the same COIN”

**The SIDE A of the COIN:** Enterprise Collaboration  
**The SIDE B of the COIN:** Enterprise Interoperability  
**The Metal of the COIN:** Service Platform  
**The Value of the COIN:** Software as a Service Utility  
**The Market of the COIN:** Manufacturing Enterprises
COIN Architecture & GSDP Issues

ENTERPRISE INTEROPERABILITY ENTERPRISE COLLABORATION SERVICES

SERVICE CLOUDS

SERVICE GALAXY

ENTERPRISE COLLABORATIVE PLATFORMS

GENERIC SERVICE PLATFORM

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The COIN Consortium & Funnel Model

Industrial Partners
- TXT e-solutions
- IC FOCUS
- Atos Origin
- ESONET
- Siemens

Academic & Research Partners
- VIT
- SINTEF
- ESI
- European Software Institute
tecnalia
- Jožef Stefan Institute, Ljubljana, Slovenia

User Partners
- IND
- PÖYRY
- ISOIN
- ACS
- Unconventional Business
- Filas
- Finanziaria laziere di sviluppo

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Conceptual Integration: ATHENA Reference Model

Enterprise System A (MDD Abstraction)
- Computational Independent Model (CIM)
- Platform Independent Model (PIM)
- Platform Specific Model (PSM)
- Execution Platform A

Model-Driven Architecture (MDA) & Architecture-Driven Modernisation (ADM)
- Semantic Annotation

Model Transformation (MT)

Enterprise System B (MDD Abstraction)
- Computational Independent Model (CIM)
- Platform Independent Model (PIM)
- Platform Specific Model (PSM)
- Execution Platform B

Model-Driven Architecture (MDA) & Architecture-Driven Modernisation (ADM)
- Semantic Annotation

Model Transformation (MT)

Interoperability Patterns
- Horizontal Integration
- Vertical Integration

Service Aspects
- Process Aspects
- Information Aspects

Model Interoperability (MI)

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Technical Integration: ATHENA Reference Model

Enterprise A
(Technical World)

Users

Business

Enterprise B
(Technical World)

Users

Business

ICT Infrastructure

Service Bus

Software System

Infrastructure Services

Registry/Repository

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COIN Architecture
COIN Service Provisioning Platform

Agent Platform (Jack/Jade)

Semantic Web Service Middleware

Service Requester

Security Gateway

Network

Service Provider X

Security Gateway

Network

Service Provider Y

Security Gateway

Network

P2P Repository/Registry

X Node

Y Node
Semantic Web Service Middleware

Semantic Web Services Middleware (WSMX)

Core Management

Execution Semantics

Discovery
Composition
Selection and Ranking
Data Mediation
Choreography
Grounding
Invoker

Resource Manager Interface

Goals
Services
Ontologies
Mediators

Network

Provider X

Provider Y
Negotiation: Basic Concepts
A negotiation is an iterative communication and decision making process between two or more sides (parties) represented by two or more agents who cannot achieve their objectives through unilateral actions and who search for a consensus decision.

(Bichler et al., 2003)
Negotiation: Research Areas (Bichler et al. 2003)

**Computer Science**
- Computational linguistics
- Data mining and KDD
- Artificial Intelligence
- Distributed AI
- Automated negotiations
- Autonomous negotiation agents
- Distributed negotiations
- Negotiation software platforms

**Economic Sciences and Management**
- Econometrics
- Experimental economics
- Management science
- Decision science
- Bargaining theory
- Auction theory
- Game theory
- Negotiation analysis

**Information Systems**
- Decision support
- Group and negotiation support
- Workflow models
- Electronic commerce
- Decision support systems
- Negotiation support systems
- Electronic negotiation tables
- Negotiation support agents
- Electronic markets
- Electronic auctions

**Negotiation media and Systems: tools, agents, and platforms**

**Negotiation procedures and models: strategies, tactics and techniques**

**Law and Social Sciences**
- Law
- Psychology
- Sociology
- Linguistics
- Political sciences
- Mediation and facilitation
- Models of attitude and perception
- Process models
- Cultural influences
- Cognitive models
e-Negotiation Systems (selected)

• WebNS (Yuan et al., 1999)
• Negoisst (Schoop et al., 2001)
• SilkRoad (Ströbel 2003)
• SimpleNS (http://mis.concordia.ca/simplens)
• Inspire (http://interneg.org/inspire)
• SmartSettle (http://smartsettle.com)
• NegotiAuction (Teich et al., 2001)
• Aspire (Kersten, Lo, 2003)
Three Types of Negotiation Support Systems (NSS)

- Negotiation support systems assist users with communication and decision-making activities
- Negotiation software agents replace users in their communication and decision-making activities
- E-negotiation media provide a platform that implements a negotiation protocol.
The goal of an agreement process is to come to a mutual agreement between agents regarding the specification of one or more future deals.
Intention Phase

For the intention phase the following tasks related to the offer exchange in electronic negotiations can be identified:

- **Offer Specification**: The agents have to specify offers indicating their constraints towards the transaction object. This specification may also include the provision of signatures or the definition of timestamps (to express offer validity).
- **Offer Submission**: Submitting an offer can range from the active task of sending an offer to a specific agent or group of agents to the notification of completion of the offer specification and its provision in an accessible manner.
- **Offer Analysis**: Upon reception, offers are usually not only stored and processed but also checked for compliance with certain conditions or rules.
Agreement Phase

- **Offer Matching:** The goal for this task is to find pairs of offers that firstly classify as potential candidates for a transaction execution (e.g. by fulfilling mutual constraints defined in the offers). The scoring of candidates may also be part of the offer matching task. The extended goal for scoring is to find the "best" pair of offers among the set of candidates, taking into account criteria such as agent preferences for the comparison of a candidate pair towards competing pairs. Finally, a selection or resolution of conflict among the potential candidates might be necessary.

- **Offer Allocation:** Using the results of the offer matching and scoring, this task has to determine the result of the process execution ("who gets what") and thereby defines the duties of the agents involved in the manifested deal. If the selected offer still features value ranges or options, a final configuration is also part of the offer allocation task.

- **Offer Acceptance:** In this final task, buyers or sellers have the chance to accept or sign one or more offers in order to execute the transaction within the agreed-upon deal.

(Ströbel, M. & Weinhardt, C., 2003)
<table>
<thead>
<tr>
<th></th>
<th>Exogenous Criteria</th>
<th>Endogenous Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explicit Criteria</strong></td>
<td>Rules or quantifiable knowledge about the business context, e.g. laws or statistical data for agent behavior or object transactions</td>
<td>Choices made by the scenario designer, e.g. the termination of the negotiation process or a certain matchmaking algorithm</td>
</tr>
<tr>
<td><strong>Implicit Criteria</strong></td>
<td>Domain knowledge which cannot be directly determined or represented in a formal way, e.g. ethical standards</td>
<td>Facts determined through assessing the negotiation process execution, e.g. the fairness or efficiency achieved.</td>
</tr>
</tbody>
</table>

(Ströbel, M. & Weinhardt, C., 2003)
Endogeneous, Implicit Criteria

- Pareto-Efficiency
- Social welfare maximisation
- Fairness
- Convergence
- Stability
- Truth revelation
- Nature of gains

(Ströbel, M. & Weinhardt, C., 2003)
### Characteristics of negotiations and auctions (Bichler et al. 2003)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Traditional Actions</th>
<th>Traditional Negotiations</th>
<th>Online Auctions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Number of participants</td>
<td>Multi-bilateral, single or double-sided</td>
<td>Bilateral, multi-lateral, or multibilateral; any number of sides</td>
<td>Multi-bilateral, single or double-sided</td>
</tr>
<tr>
<td>2. Participants</td>
<td>Open or restricted</td>
<td>Restricted</td>
<td>Open, restricted, or rule-defined</td>
</tr>
<tr>
<td>3. Consensus required</td>
<td>Bid-taker and selected bidder</td>
<td>Selected or for all participants</td>
<td>Selected participants</td>
</tr>
<tr>
<td>4. Number of objects</td>
<td>Single homogeneous</td>
<td>Single or multiple, homo- or heterogeneous</td>
<td>Single or multiple, homo- or heterogeneous</td>
</tr>
<tr>
<td>5. Number of issues</td>
<td>Single</td>
<td>Single or multiple</td>
<td>Single or multiple</td>
</tr>
<tr>
<td>6. Issues structure</td>
<td>Well-defined</td>
<td>Well-defined, partially, or ill-defined</td>
<td>Well-defined</td>
</tr>
<tr>
<td>7. Offer space</td>
<td>Fixed</td>
<td>Maybe unknown and modified</td>
<td>Fixed</td>
</tr>
<tr>
<td>8. Exchange and knowledge of offer and concession making</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### Characteristics of negotiations and auctions (cont.)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Traditional Actions</th>
<th>Traditional Negotiations</th>
<th>Online Auctions</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Logrolling (conditional concessions)</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>10. Knowledge of offers and concessions</td>
<td>Private or public</td>
<td>Private (rarely public)</td>
<td>Private or public</td>
</tr>
<tr>
<td>11. Exchange of opinions, arguments, threads</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>12. Interdependence</td>
<td>Between bid-taker and bidder (single-sided) or between but not within sides (double-sided)</td>
<td>Full interdependence except multi-bilateral negotiations</td>
<td>Between bid-taker and bidder (single-sided) or between but not within sides (double-sided)</td>
</tr>
<tr>
<td>13. Protocol</td>
<td>A priori defined, explicit and fixed</td>
<td>Well or partially defined; explicit or implicit</td>
<td>A priori defined, explicit and fixed</td>
</tr>
<tr>
<td>14. Competition versus cooperation</td>
<td>Competition among bidders on at least one of the possibly two sides; cooperation prohibited</td>
<td>Competition or cooperation among the agents</td>
<td>Competition among bidders on at least one of the possibly two sides; cooperation prohibited</td>
</tr>
<tr>
<td>15. Process control</td>
<td>Defined a priori</td>
<td>Ill-defined, modifiable by participants</td>
<td>Defined a priori</td>
</tr>
</tbody>
</table>
Classification of Classical Auction Types

- FPSB, Vickrey
- Dutch
- English
- Call Market
- CDA
# Game Theoretic Negotiation Protocol Design

<table>
<thead>
<tr>
<th>Assumptions / Properties</th>
<th>Non-cooperative</th>
<th>Cooperative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No direct communication or binding agreements</td>
<td>Direct communication and binding agreements</td>
</tr>
<tr>
<td></td>
<td>Perfect rationality</td>
<td>Individual rationality</td>
</tr>
<tr>
<td></td>
<td>Self-interest</td>
<td>Self-interest and group rationality are compromised in most solution concepts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Applicable to e.g.</th>
<th>Non-cooperative</th>
<th>Cooperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auctions</td>
<td>Individual rounds of Strategic Bargaining</td>
<td>Coalition Formation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Typical protocol design goals</th>
<th>Non-cooperative</th>
<th>Cooperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximize profits for either seller or buyer</td>
<td>Incentive compatibility, budget balance, etc.</td>
<td>Maximize social welfare and/or individual profits</td>
</tr>
<tr>
<td>Minimize communication</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reservation Prices

Deal = \frac{R'_S + R_B}{2} \quad \text{if} \quad R_S \leq R_B

\begin{align*}
R_S & \quad R'_S & \quad D & \quad D' & \quad R'_B & \quad R_B
\end{align*}
Alternating Concession Protocol

Seller

Buyer

RS
SB
SS
RB
Automated Negotiation: Advantages of agents as proxies

- Negotiation protocols and strategies are often complex: computing best decision requires time and knowledge.
- Agents act more "rational" (rule-based), reducing "irrational" human behavior (→ "auction-fever")
Application Examples
Business Eco System (BES) Negotiation Scenarios

Negotiation of:
- Entrance
- Exit
- Policies
Agents

- Specify goals they would like to achieve
- Propose contributions to goals
- Problem solving has to combine proposed contributions to achieve the goals
BES Service Centric View

Agents

- Publish service descriptions of services they can offer
- Specify queries for services they are looking for

Match making

- has to match service proposals with the queries (service requests)
BES Resource Centric View

**Agents**
- Publish tasks that should be executed on available resources
- Bid for tasks to execute them on local resources

**Match making**
- Contract net protocol for task assignment
- Simulated trading for task re-distribution

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**Negotiation**

- Provided Resources
- Request Resources
Use Case: Collaborative production planning

- Negotiation in *virtual room* about collaborative production schedule
- Basic decision support
- Negotiation as a service
Use Case: Negotiation of Details

- Interaction protocol modeled with extended DSML4MAS
- Decision services provided as web services
- Protocol execution by agent platform
Model Driven Design
Conceptual Model (Schoop & Quix 2001)
Negotiation Protocols as Petri Nets (Hung & Mao 2002)

Offer(s) and Counter-Offer(s)  Evaluation
UML Activity Diagram for Making Offers and Counter-offers in a Negotiation Session (Chiu et al. 2005)
MDD represents a business-driven approach to software systems development that starts with a computation independent model (CIM) describing the business context and business requirements. The CIM is refined to a platform independent model (PIM) which specifies services and interfaces that the software systems must provide to the business, independent of software technology platforms. The PIM is further refined to a platform specific model (PSM) which describes the realisation of the software systems with respect to the chosen software technology platforms. In addition to the business-driven approach, a model-driven framework should also address how to integrate and modernise existing legacy systems according to new business needs. This approach is known as architecture-driven modernisation (ADM) in the OMG.
These dimensions can be used to analyse software systems or help to structure the system modelling process and to catalyse design decisions. Each of these dimensions may support interoperability achievements or could represent a challenge to interoperability.
Tomorrow’s MDD: UML Programming

Abstraction

UML + Natural Language Application Requirements

UML Model

Source Code
Virtual Machine Code
Binary Code

Business ← IT gap

Executability

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PIM4Agents to Agent Execution Transformation

- Ecore
  - conforms to
  - PIM4Agents meta-model
  - conforms to
  - ATL
  - conforms to
  - Agent meta-model
  - conforms to
  - PIM4Agents-to-AgentMM
  - PIM4Agents model
  - conforms to
  - is transformed into
  - Agent Model
Specification of Domain Specific Modeling Languages (DSML)

\[ L = \langle C, A, S, M_S, M_C \rangle \]

- **Concrete Syntax** \( C \)
- **Abstract Syntax** \( A \)
- **Semantic Domain** \( S \)
- **Mathematical abstraction for specifying the meaning of models**
- **Notation for representing models**

Concepts, Relations, Well formed-ness rules

\[ M_S \]

\[ M_C \]
PIM4Agents Overview

- multiagentsystem
- agent
- organization
- interaction
- deployment
- behavior
- task
- role
- goal
- informationmodel
Multiagent System
Agent

[Diagram showing relationships between Knowledge, DomainRole, Goal, Capability, and Behavior]
Organization
Behavior
Task
Goals
Deployment
• Graphical editor is based on the Graphical Modeling Framework (GMF) of Eclipse
• GMF is based on Ecore
• Abstracts syntax is mapped to concrete syntax
• Semantics defined with Object-Z is transformed to OCL constraints
Contract Net Protocoll (CNP): Organization/Agent View
CNP: Protocol View
CNP: Collaboration View with Role Bindings
CNP: Initiator Behavior View

[Diagram showing a process with nodes and edges labeled with actions like 'participate', 'propose', 'accept', 'refuse', 'reject', 'result', 'failure', and states like 'CollectResponses', 'ParallelOp', 'SendCFP', 'ContractNet', 'Deadline']
PIM4Agents Models

Transformation of PIM4Agents models to execution platform models

Description of existing services (WSDL)

Transformation of service descriptions to execution platform models
Summary

• Interoperability concepts of the projects COIN and ATHENA
• Introduction to
  – Negotiation theory
  – Model driven system development
  – PIM4Agents
• Illustrating examples
Future Work

• Further development of COIN baseline and innovative services with the focus on negotiation services
• Further development of PIM4Agents and transformations to target platforms
• Dedicated metamodels for specific platforms (e.g. JADEX) derived from PIM4Agents
• Development of a „View Framework“ for DMSL4MAS
### Contact Information

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Details</th>
</tr>
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References


