Ontologies and semantic Business Process Management

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Acknowledgement

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Outline

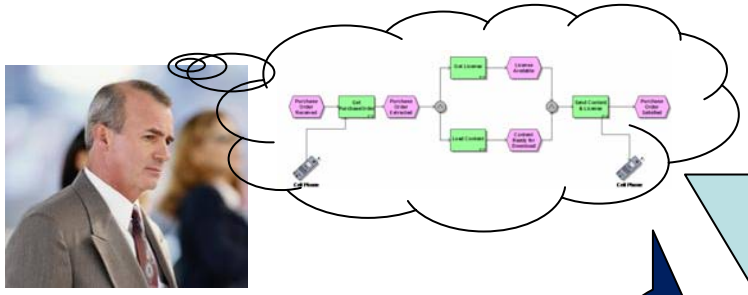
- About Me & DERI
- Business Process Management
- Problems in traditional BPM
- Semantic Business Process Management Business

About Me & DERI

- 5th-year PhD student
- DERI
  - Currently three locations
    - DERI Galway, Ireland
    - DERI Stanford, USA
    - DERI Korea, Seoul
  - ~ 100 members
- Research interests
  - Semantic Web
  - Business Process Management
  - Service-oriented architectures
- Achievements
  - Co-authored W3C Member Submission WSMX
  - Coined Semantic Service Oriented Architecture

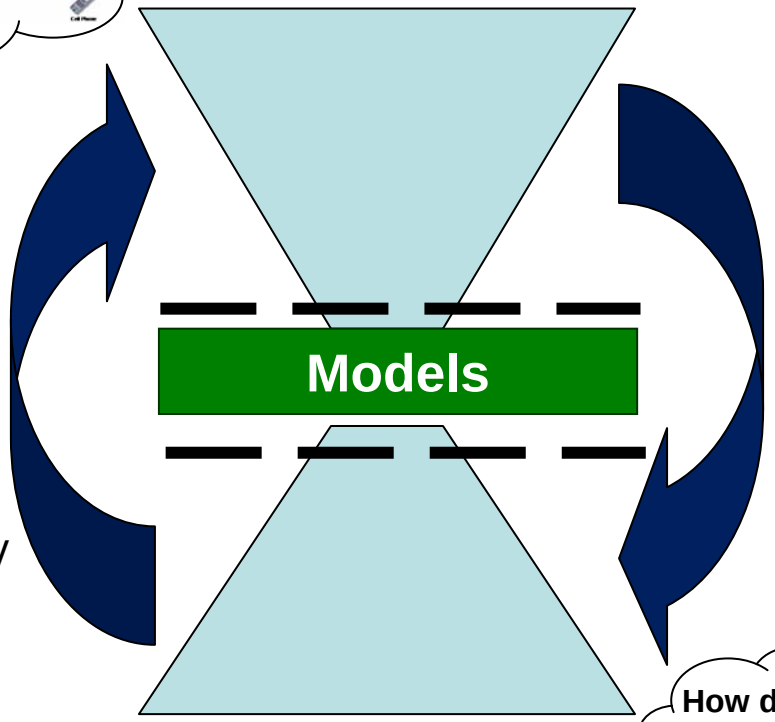
Business Process Management

The Critical Business / IT Divide



Business Experts' Perspective

Querying the Process Space
- reduce costs
- increase product quality
- improve throughput times
- less training
- less support required
- increase forecast accuracy



Bridging Business-IT gap
- reduce implementation costs
- implementing the real requirements
- faster implementation
- less support requests
- align implementation

How do I execute this process in the IT system?

IT Implementer's Perspective

Enterprise Modelling

- Different Models exist with different:
  - Applications
  - Modeling methods
  - Scope
- Possible abstraction layers
  - Requirements definition
  - Design specification
  - Implementation specification
  - Execution and run-time models

Enterprise Modelling

Enterprise Models:

"… a computational representation of the structure, activities, processes, information, resources, people, behavior, goals, and constraints of a business, government, or other enterprises."

	What (Data)	How (Function)	Where (Network)	Who (People)	When	Why
Models	e.g. UML Class Diagram, ER Model	e.g. Function Modeling	e.g. Business Logistics System	e.g. Workflow Model	e.g. Master Schedule	e.g. Business Plan, Strategic Maps

Enterprise Models

- Generic models for enterprise architectures:
  - Zachman Framework (highly structured, spanning all aspects)
  - CIMOSA (European counterpart)
  - ARIS (scientifically designed model now used by IDS Scheer)
  - TOGAF (ANSI/IEEE standard architecture specification)
  - …
- … models with focus on process design & execution:
  - BPMN (comprehensive graphical notation)
  - EPC (graphical notation)
  - UML Activity diagrams (popular standard model maintained by OMG)
  - XPDL (interchange language)
  - BPEL (execution language)
  - …

Business Process Management (BPM)

"Composition of service functionality to achieve a certain goal in the scope of a collaboration."

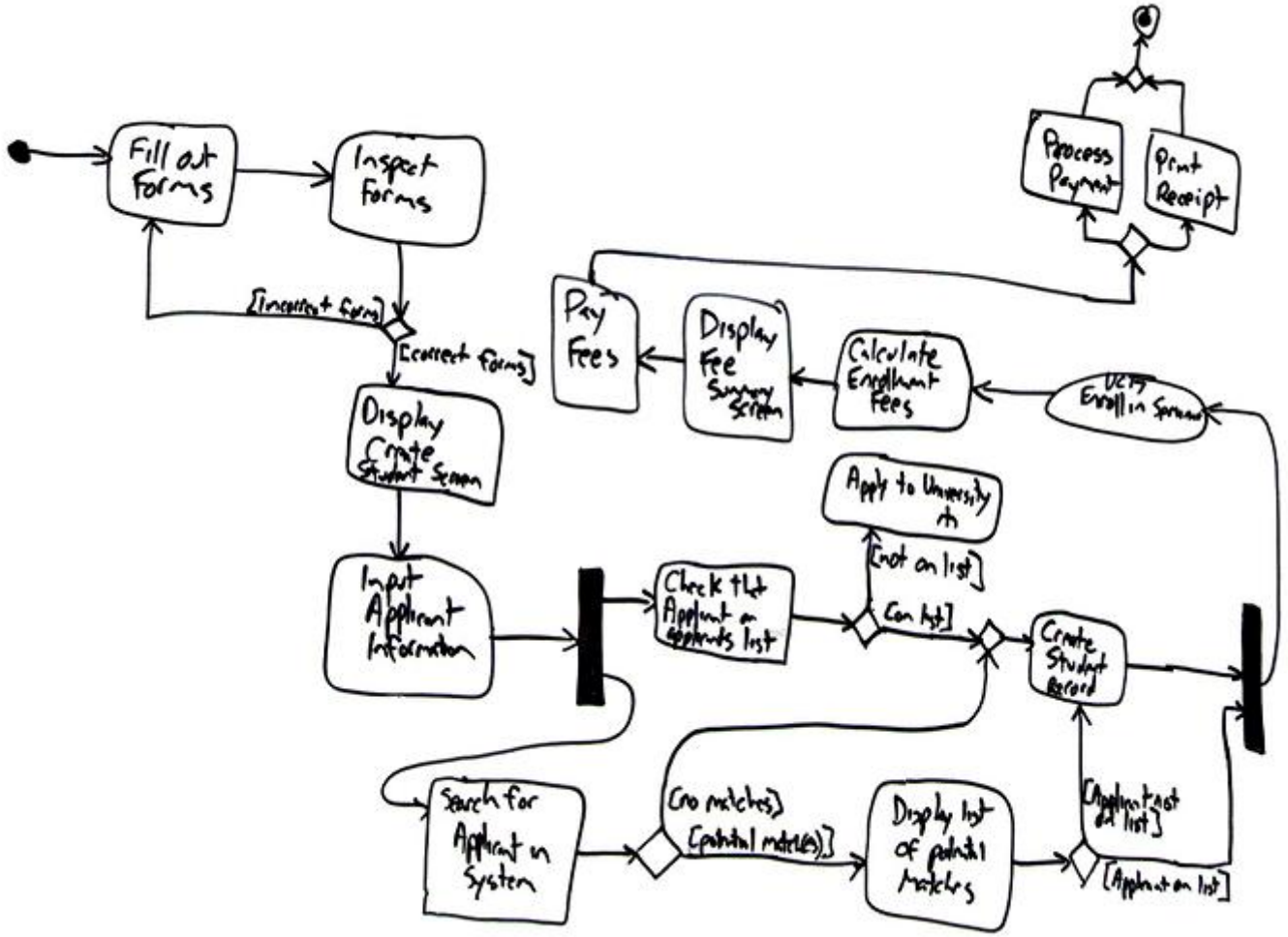
- Business Process Models

… can span multiple enterprises

- Private Process
- Public Process

… separate coordination (choreography) and control (orchestration)

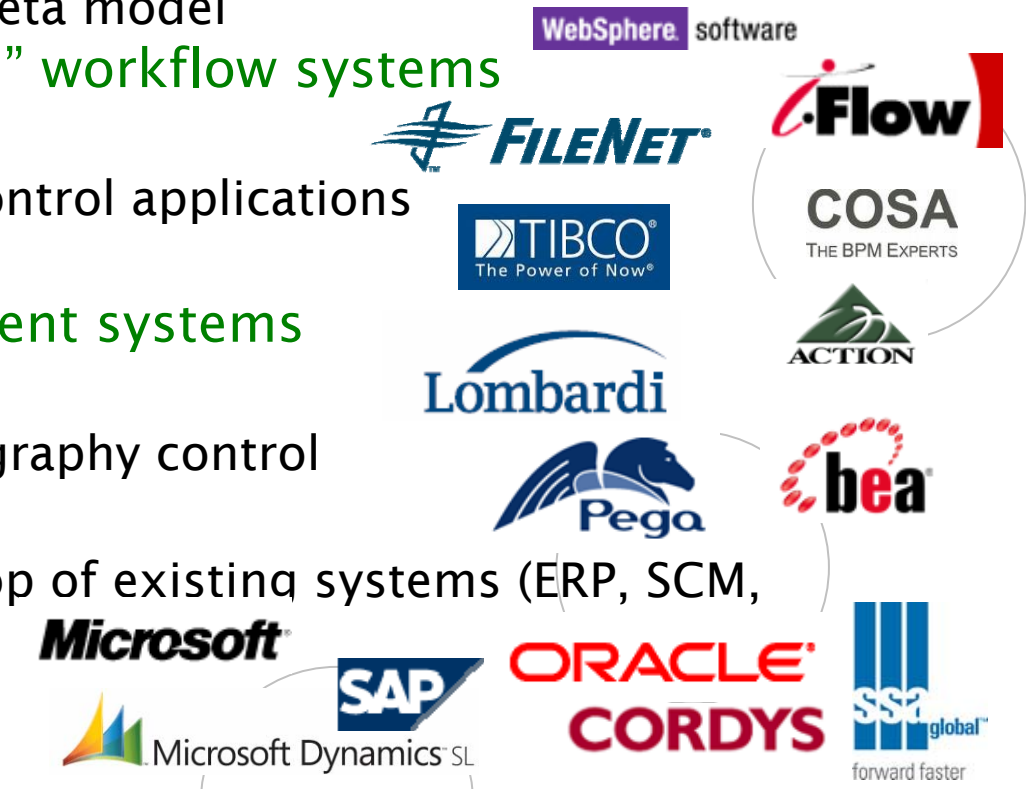
Example



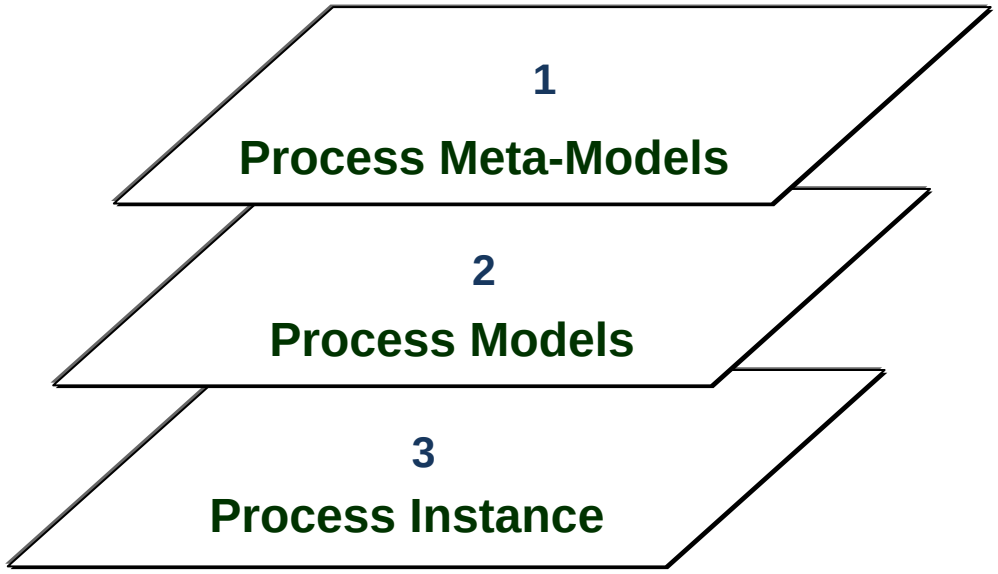
[Amber, S.: http://www.agilemodeling.com/artifacts/activityDiagram.htm]

BPM ancestors - History

- 70's / 80's: Information systems with hard-coded workflows
  - Office automation systems
- late 80's / 90's: Generic workflow systems
  - Generic, but proprietary meta model
- 90's: Generic "standardised" workflow systems
  - Explicit process models
  - Interface architecture to control applications
- Today:
- Business Process Management systems
  - Web Service paradigm
  - Orchestration and Choreography control
- Process Aware Systems
  - Process Management on top of existing systems (ERP, SCM, CRM…)



BPM modelling layers



1. **Languages/Models** defining generic concepts to describe model types (e.g. UML, BPEL).
2. **Instance of a Process Meta-Model.** Defines a model to describe a domain (e.g. Purchase Order Process).
3. **Instance of a Process Model.** Run-time behaviour of a process (e.g. <PO_started_101107>).

Process Meta-Models

- 1962: Petri Nets. Carl A. Petri (PhD-Thesis): Communication with automata [Petri, 1962]
- 1969: Situation calculus. [McCarthy/Hayes, 1969] Current version of situational calculus introduced in 1991 [Reiter, 1991]
  - is a logic formalism
  - represents changing scenarios as a set of second-order logic formulae
  - basic elements of the calculus are:
    - actions that can be performed in the world
    - fluents that describe the state of the world
    - situations (A situation represents a history of action occurrences)

Process Meta-Models

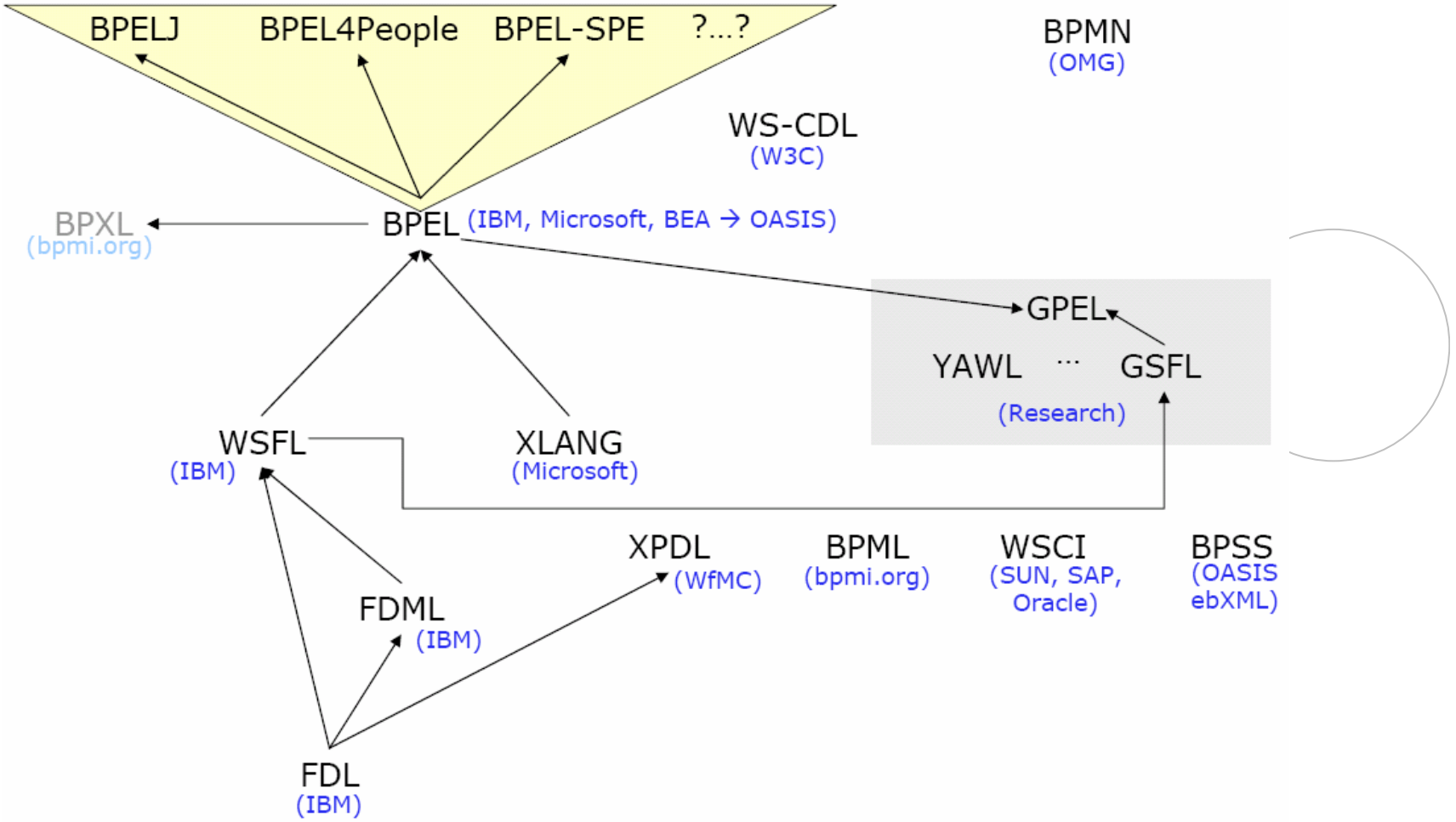
Process Algebras

- 1973-1980: CCS. Calculus of Communicating Systems [Milner, 1980]
- 1978: CSP. Communicating Sequential Processes (CSP) [Hoare, 1978] . Subsequently developed into a fully-fledged process calculus during the early 1980's.
- 1992 – now: π-calculus. [Milner et al., 1992]
- Features that all process algebras have in common:
  - message-passing
  - Describing processes and systems using a small collection of primitives, and operators for combining those primitives
  - Defining algebraic laws for those process operators → equational reasoning

Process Meta-Models

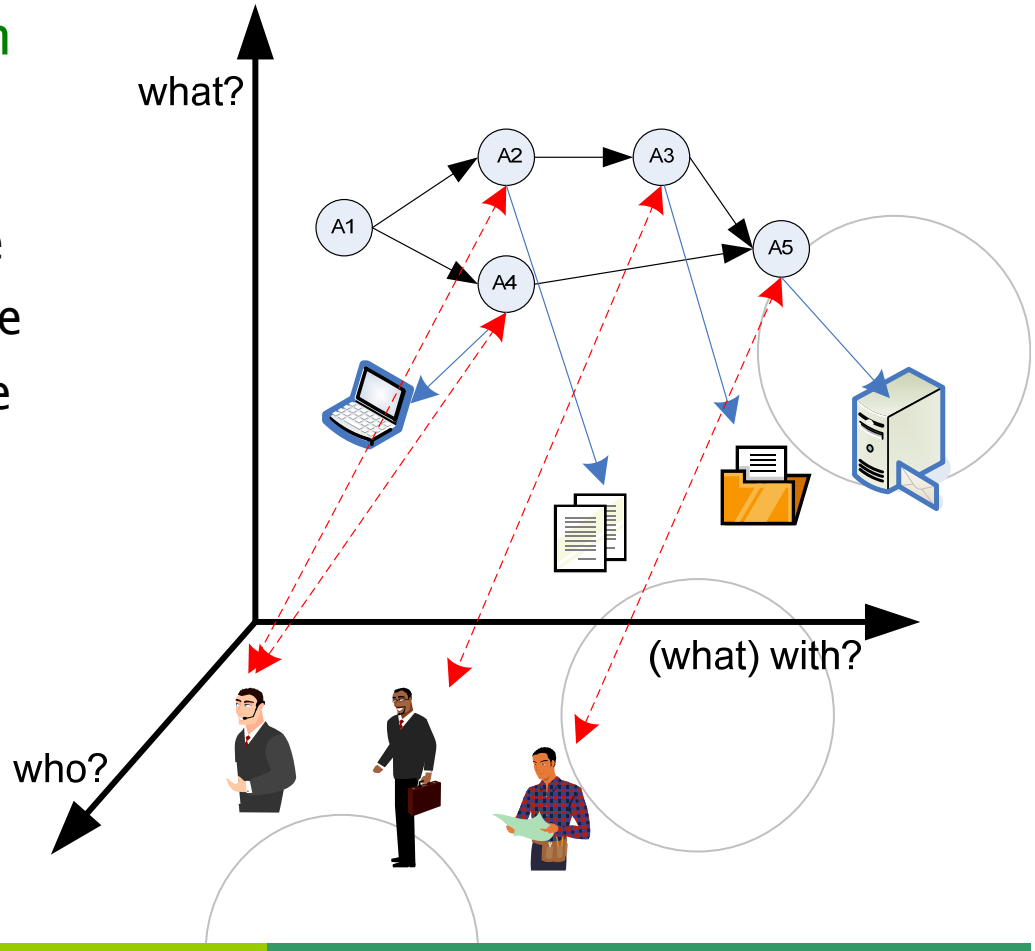
- 1962 – now: Finite State Machines (FSM) [Hopcroft et al., 2001]
  - originates in finite automata. A Finite Automaton is a more formal notion than a FSM
  - Notion of FSMs was introduced to be more usable for computer science. A FSM is defined by the following:
    - a finite non empty set of states
    - an initial state
    - a finite non empty set of distinct input events or their categories
    - state transitions
    - actions

Process Meta-Languages

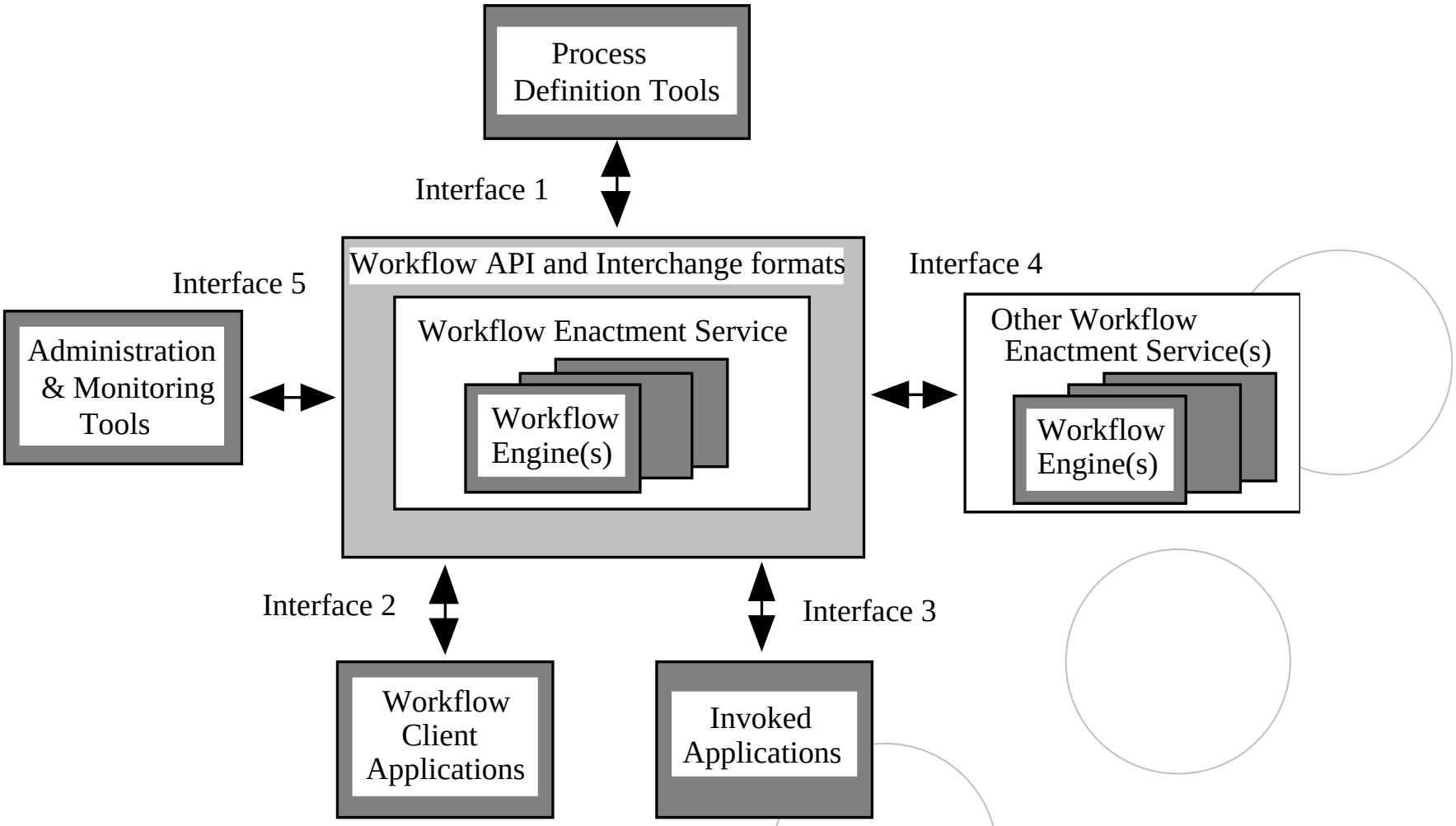


Workflow (Process) Model

- Workflows have multiple perspectives, depending on author the number of core perspectives differ:
  - Control Flow perspective
  - Informational perspective
  - Organization perspective
  - Operational perspective
- Other dimensions exist
  - No agreement on standard model
  - multiple notations and languages

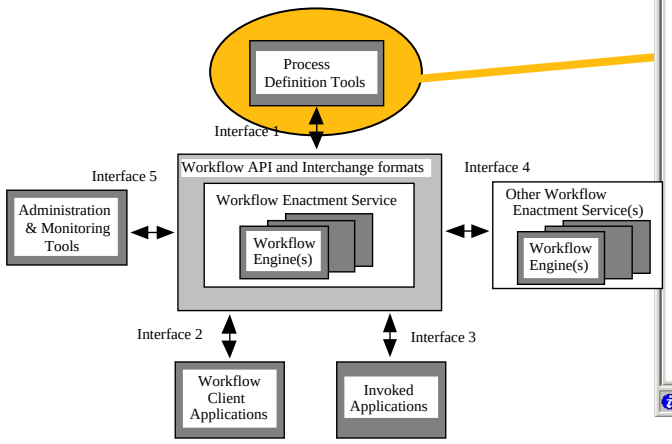


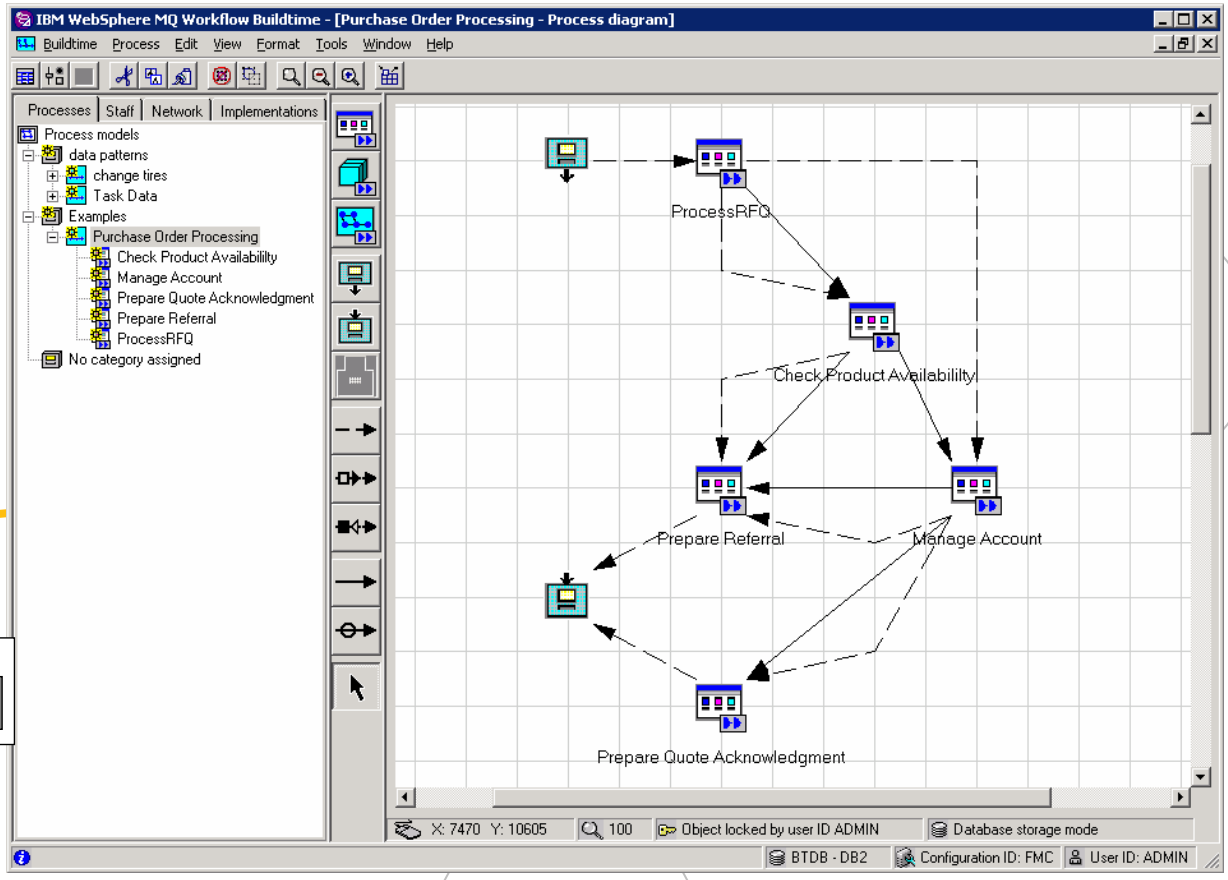
WfMC Reference Model



WfMC Reference Model

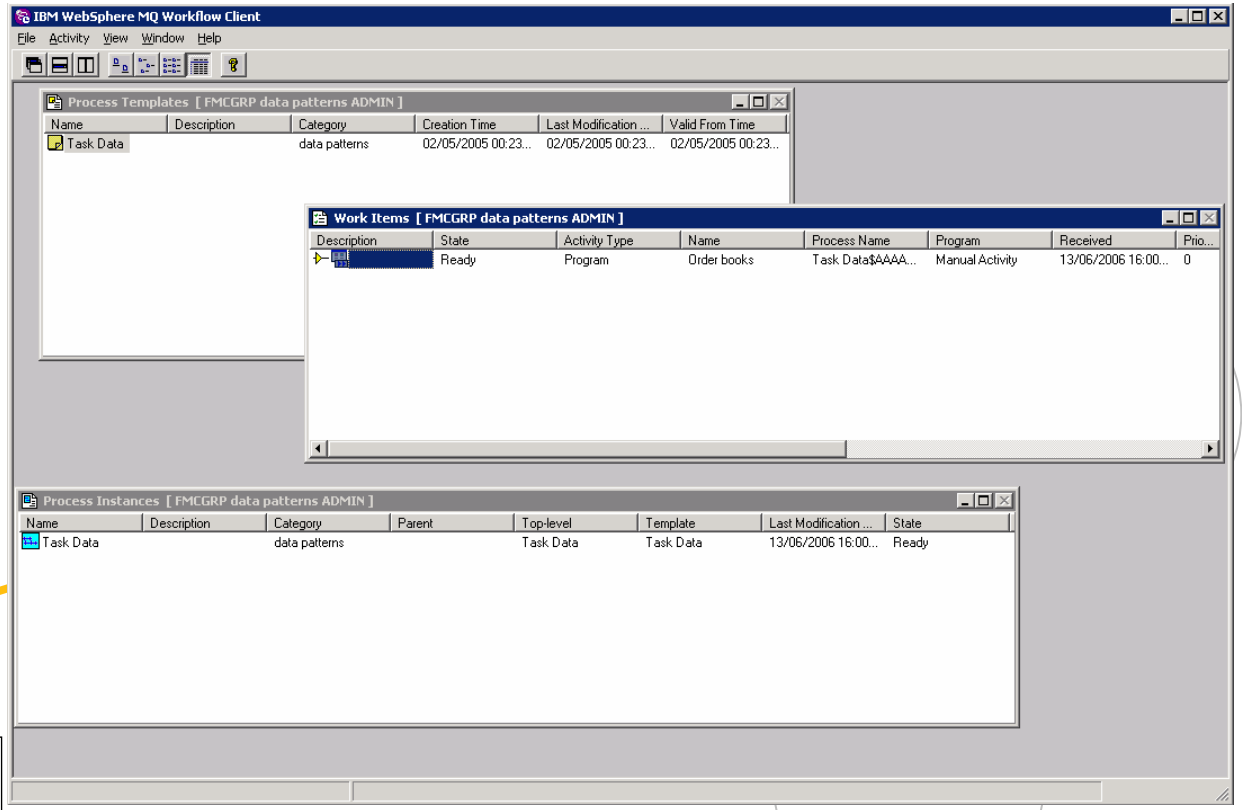
- **Build-time**
  - Defining
  - Modelling

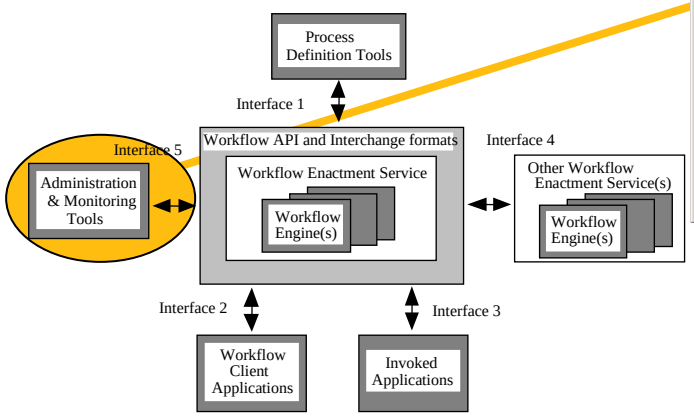




WfMC Reference Model

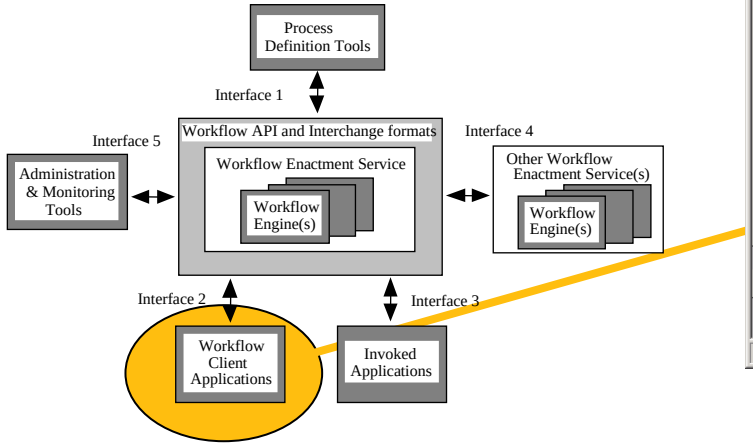
- **Run-time control**
  - Manage instances
  - Sequence activities
- **Run-time interactions**
  - With humans
  - With applications

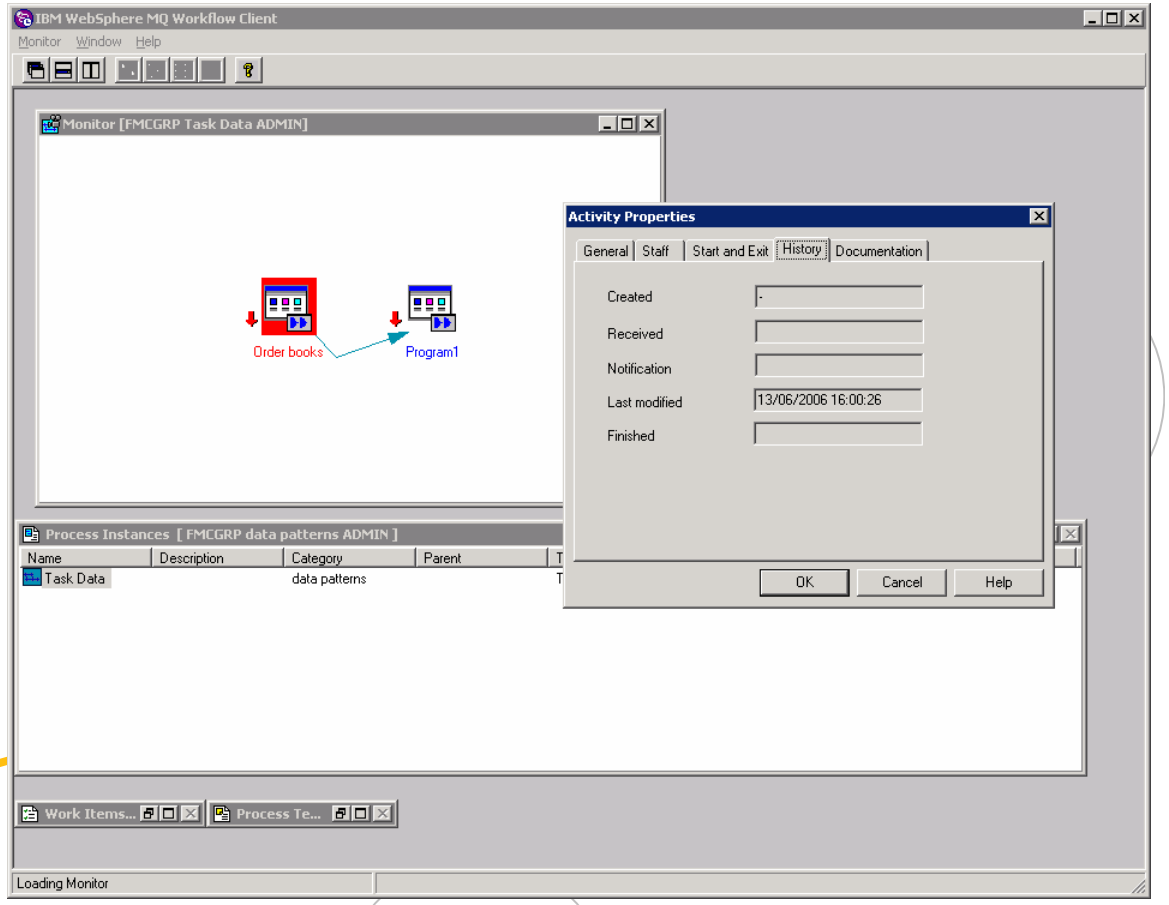




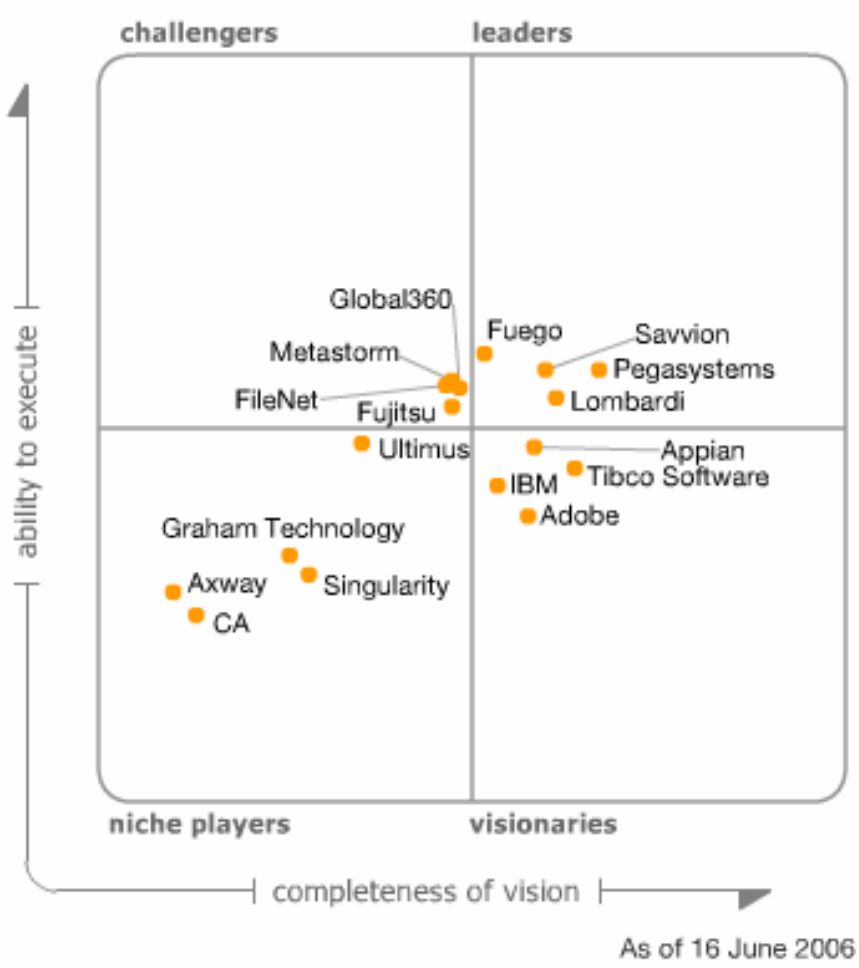
WfMC Reference Model

- **Run-time monitoring**
  - Display status of running or completed workflow instances
  - View task lists for users or roles
  - Display system workload



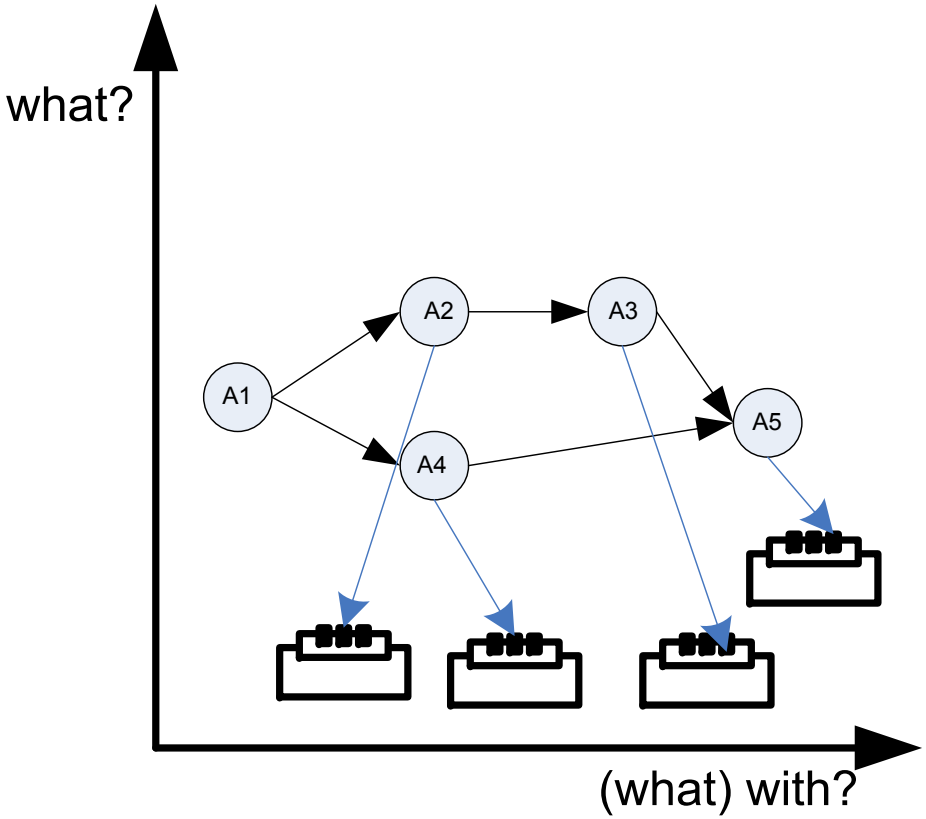


BPM Market Space



Hill, J. B., Sinur, J.: Magic Quadrant for Business Process Management Suites. 2006

Dimensions in Web Service Flows



- BPM only incorporates three dimensions
  - Control Flow
  - Informational
  - Operational
- Web services are the only operational entity
- Drawback: no organisational dimension
  - But efforts exist: BPEL4People

BPEL

- BPM language/model
- Language to specify behaviour of business processes
- Executable and Abstract processes
  - Executable processes
    - Executed within a compliant environment (portability)
  - Abstract processes
    - Specify constraints of message exchange
    - Provide “views” on internal processes
- Combination of graph-based language (IBM WSFL) and calculus-based language (Microsoft XLANG)

Problems in traditional BPM

Problems in traditional BPM

- Business Process Management (BPM)
  - management, implementation, and monitoring of processes in enterprises
  - many BPM technologies exists
  - SOA as new principle
- BUT: several insufficiencies
  - Business – IT – Divide (different worlds)
  - incompatible modelling languages
  - Business Process Modeling & Execution
    - syntactic process specification languages
    - hard-wired Web Service Execution (inflexible)
- Aim of Semantic BPM:
  - "ontologise" the BPM Life Cycle
  - enhance BPEL with Semantic Web Services

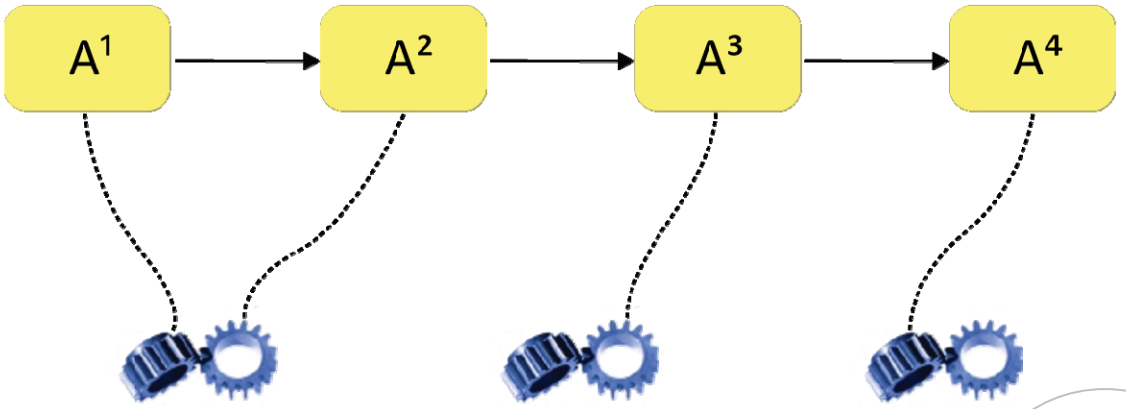
Problem Setting

Here is my business process!
I think this solves my business problem nicely…

Nice try, but it won't run…
You need to specify the services that perform each step!

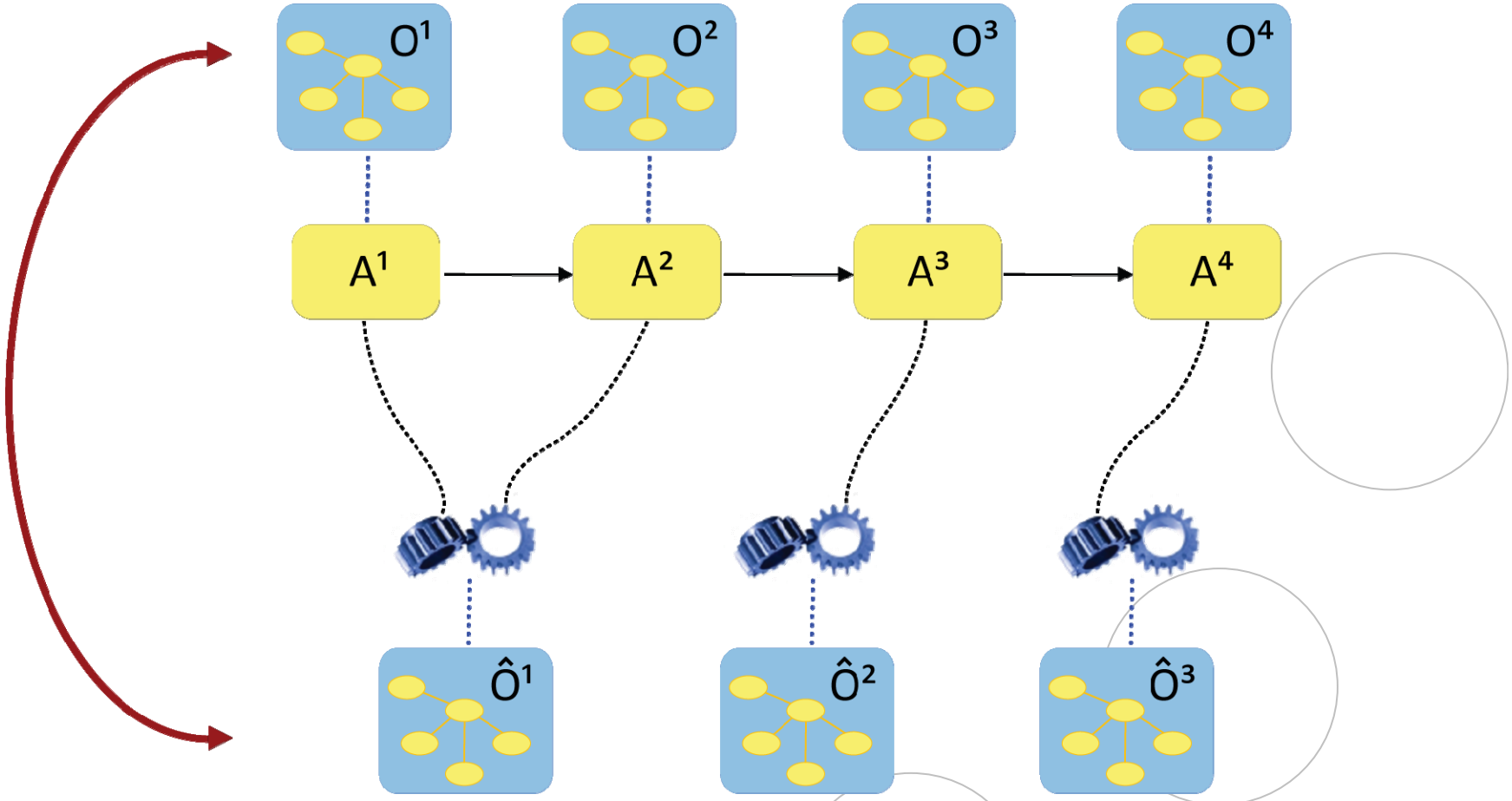
Problem Setting

I don't understand about these technical details!
This is my view on the process...



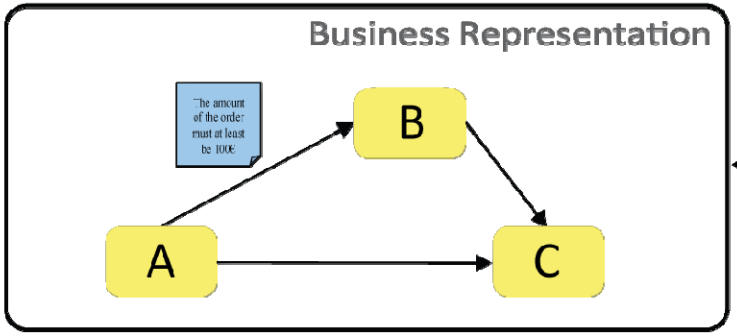
o.k. no problem, I will help you...

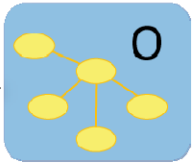
Semantic Matching of Activities and Services



Matching Model Representations & Semantics

Here is my business process!





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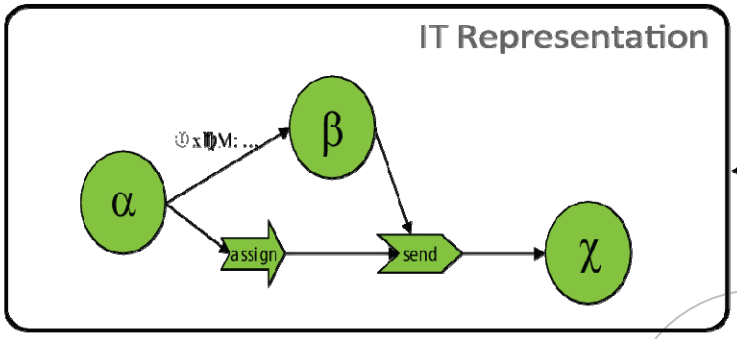
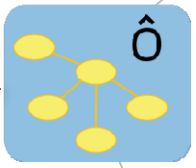
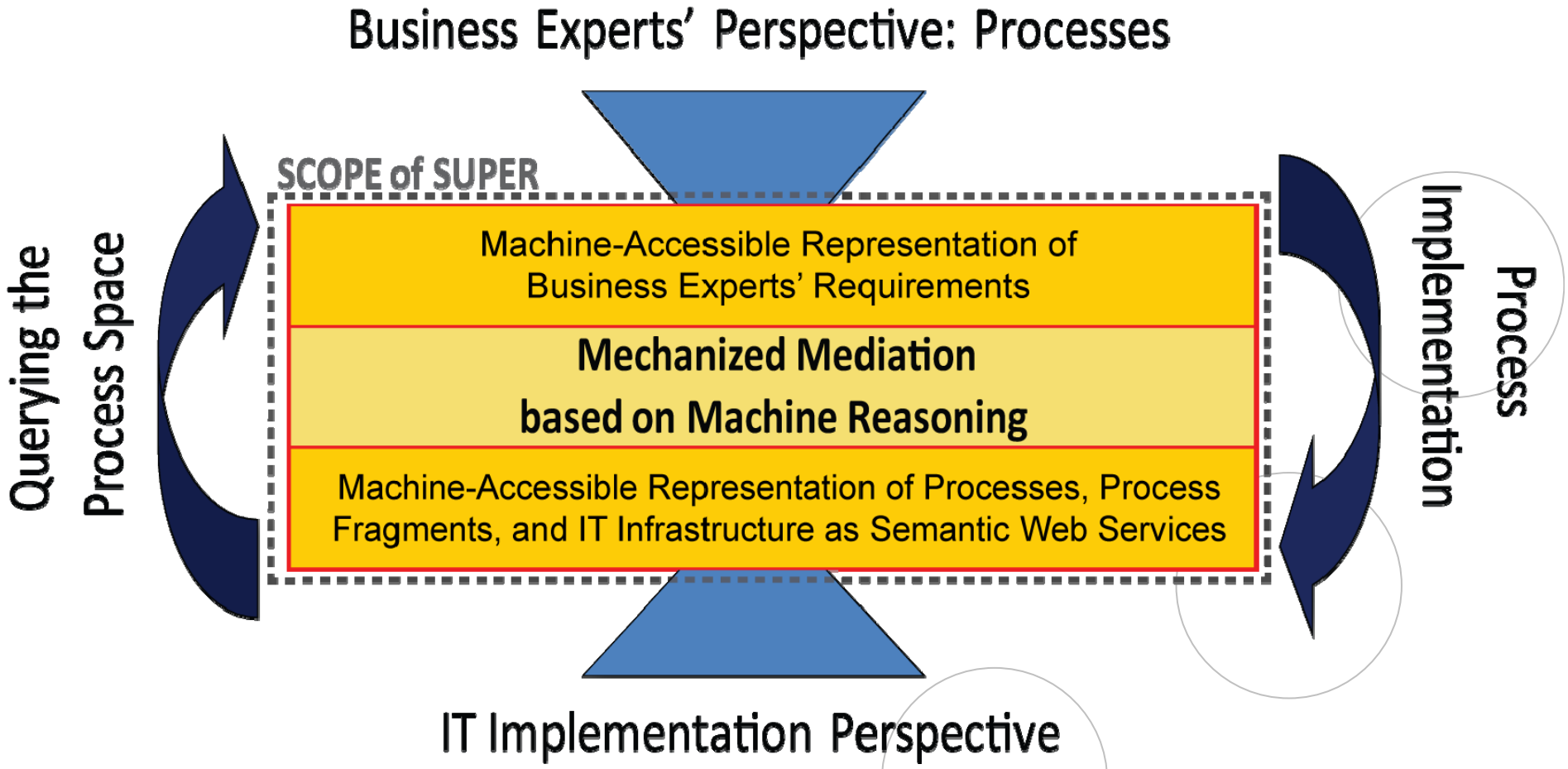




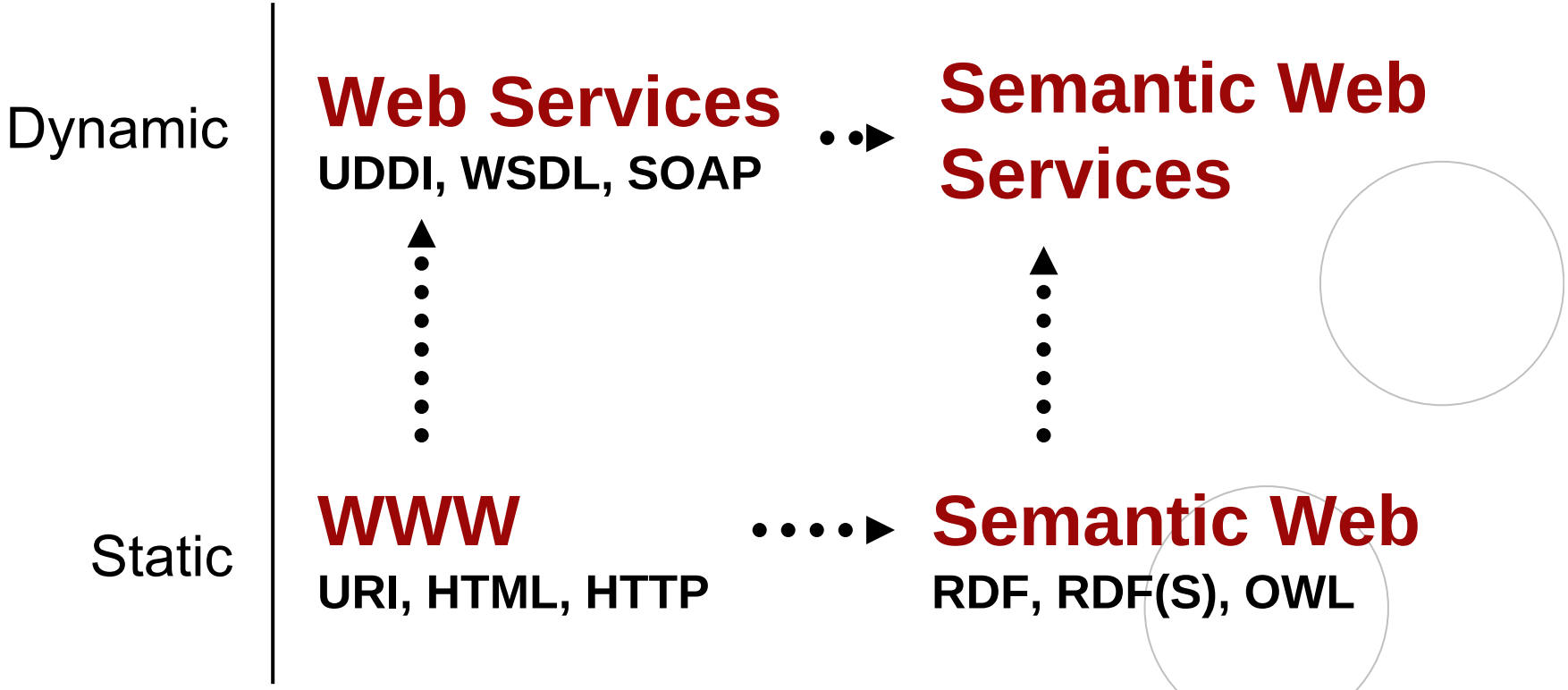
Wow! This is perfect – nothing left to do for me!

Aim of Semantic BPM



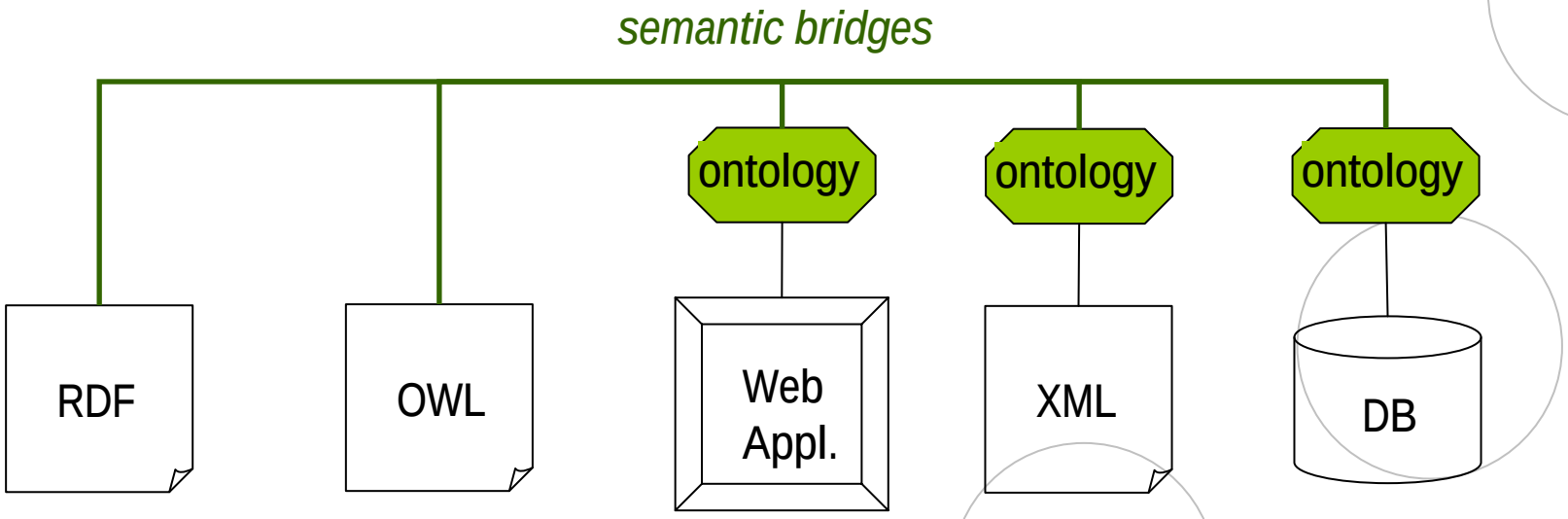
Semantic Business Process Management

Semantics for the WWW

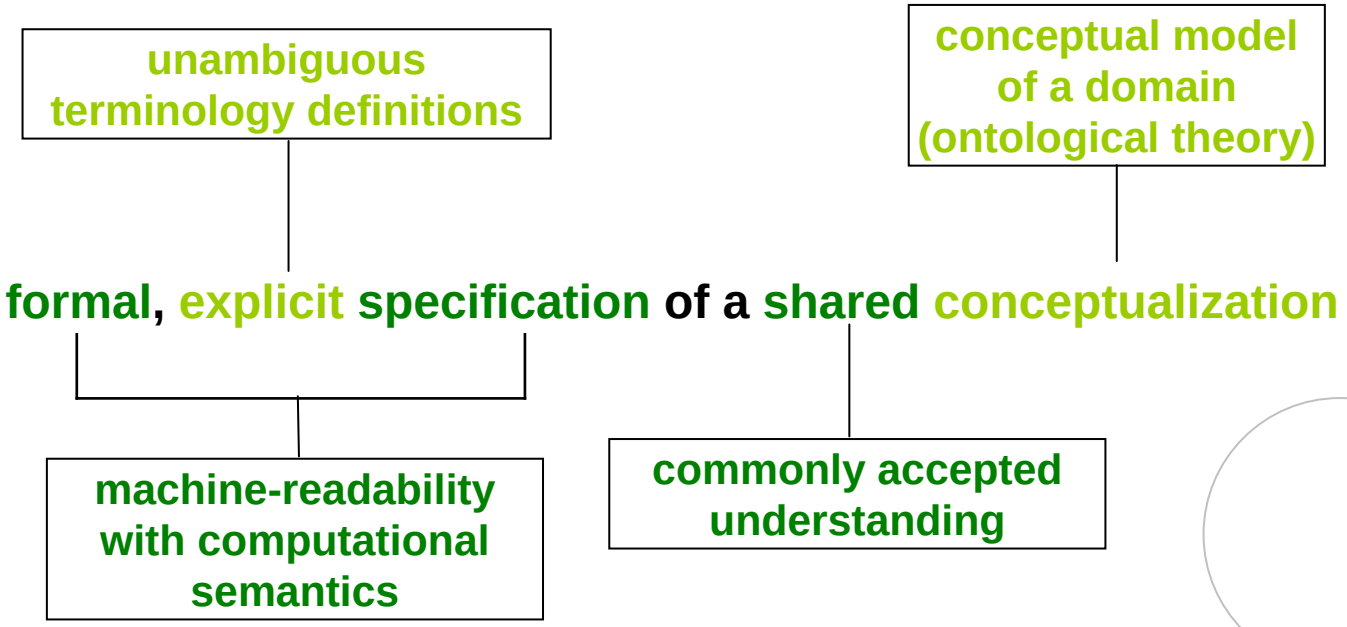


The Semantic Web

- next generation of the Internet (augmentation of the WWW)
- information has machine-processable and machine-understandable semantics
- ontologies as base technology for semantic interoperability

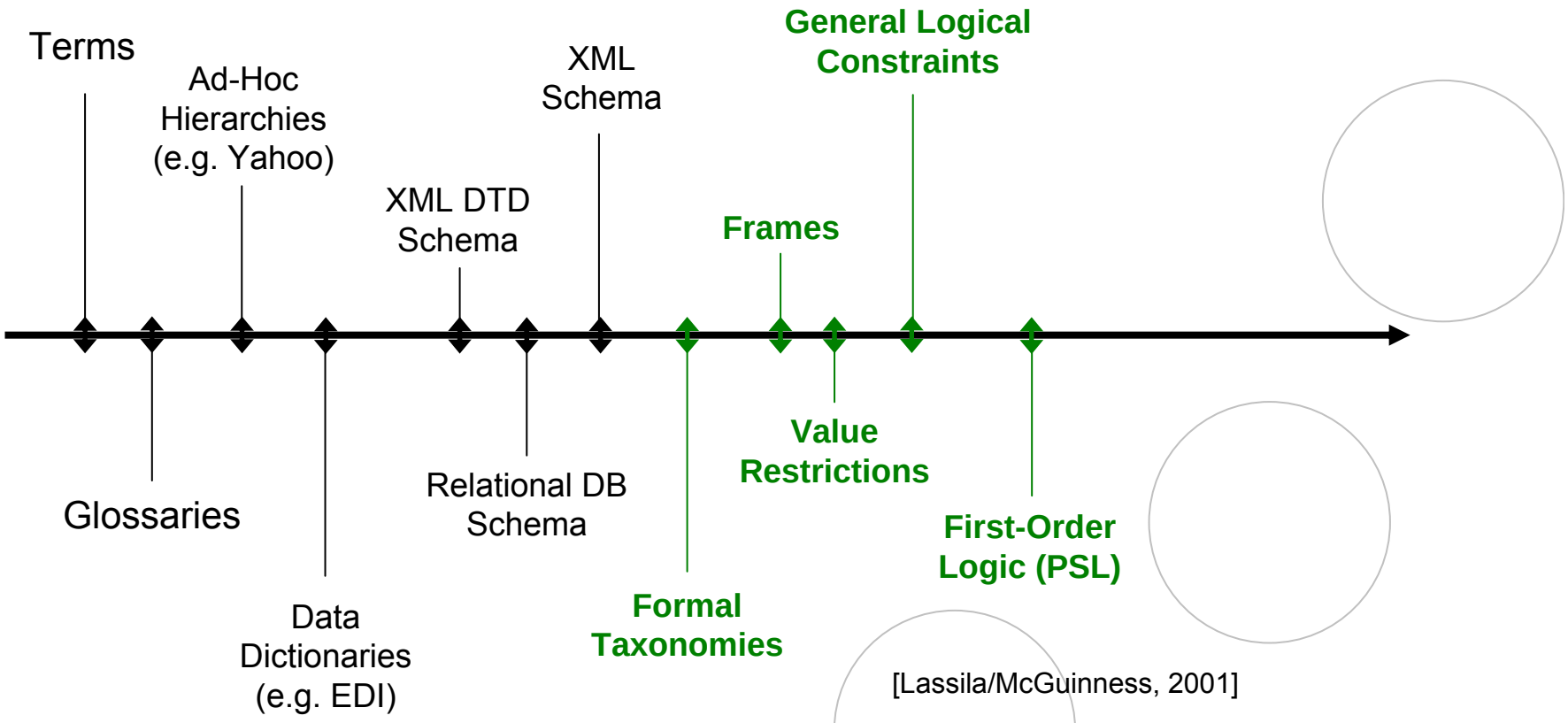


Definition:


unambiguous terminology definitions
conceptual model of a domain (ontological theory)
formal, explicit specification of a shared conceptualization
machine-readability with computational semantics
commonly accepted understanding

Ontologies

- Types of Ontologies

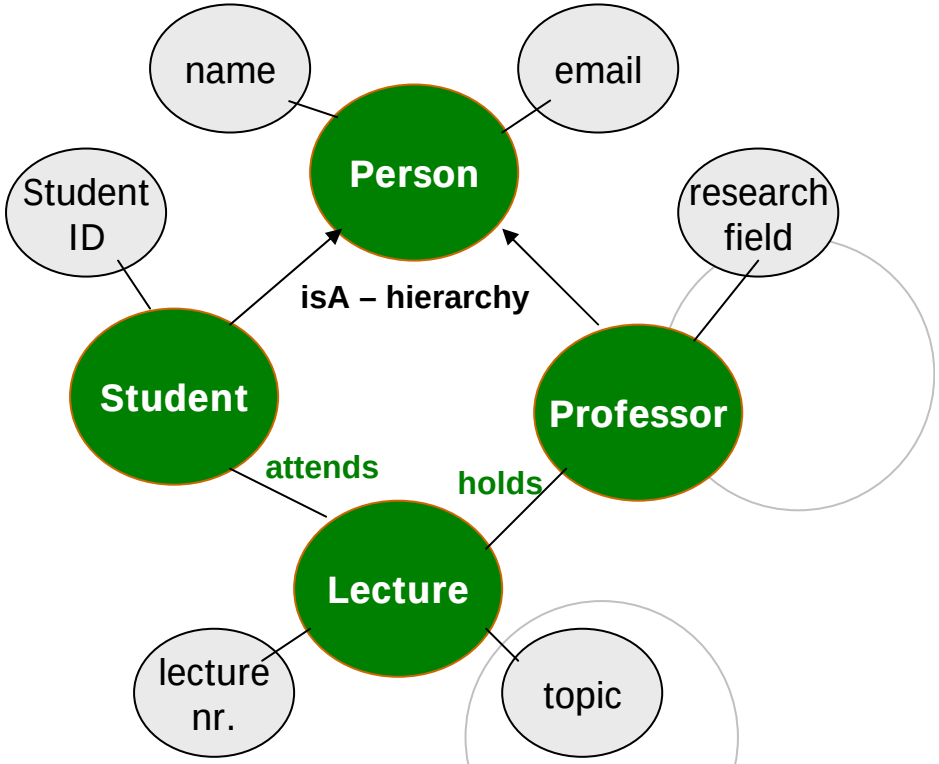


[Lassila/McGuinness, 2001]

Ontologies

Formal Ontology

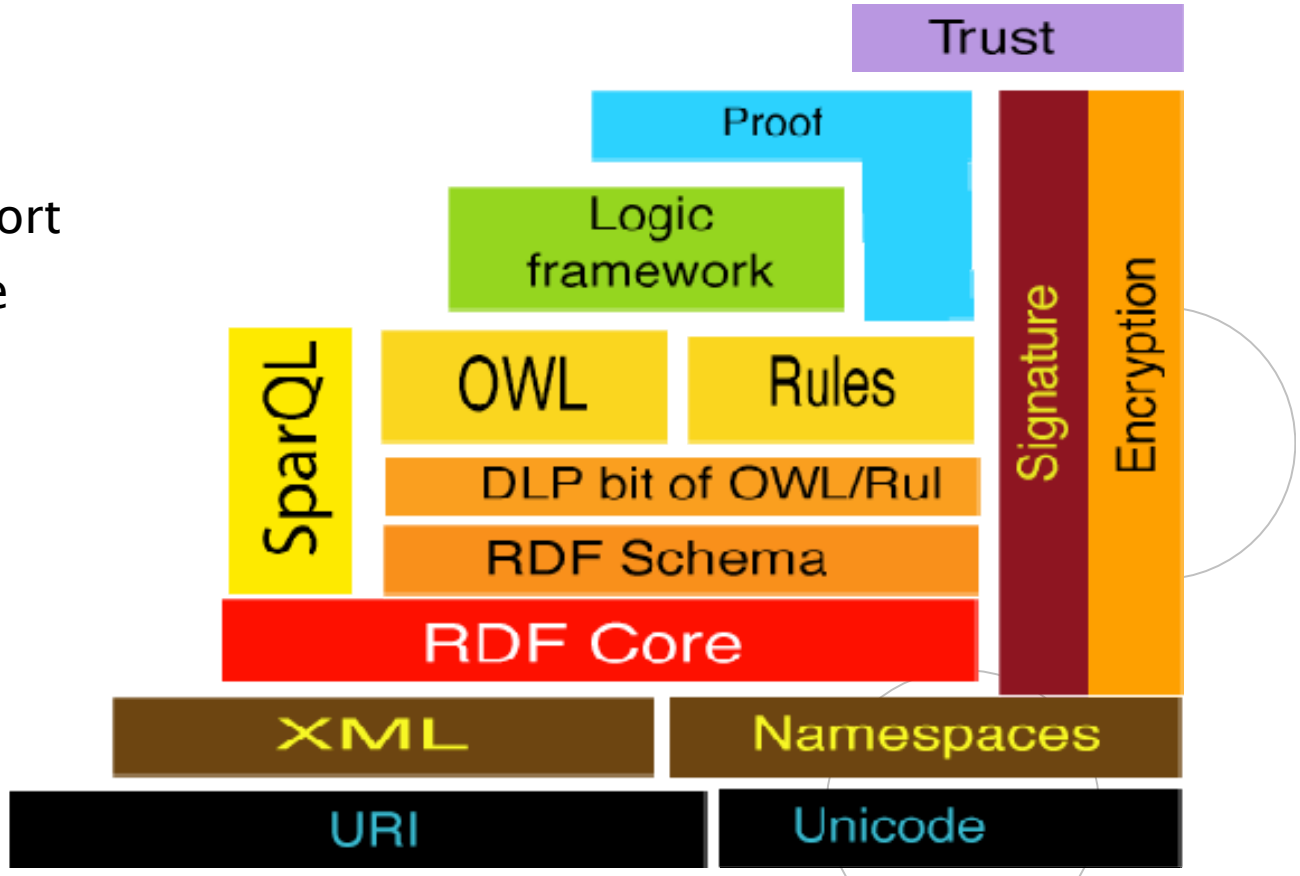
- Concept
  - conceptual entity of domain
- Property
  - attribute describing a concept
- Relation
  - relationship between concepts or properties
- Axiom
  - coherency description between Concepts / Properties / Relations via logical expressions



holds(Professor, Lecture) =>
Lecture.topic = Professor.researchField

Ontology Languages

- Requirements
  - expressivity
  - reasoning support
  - web compliance

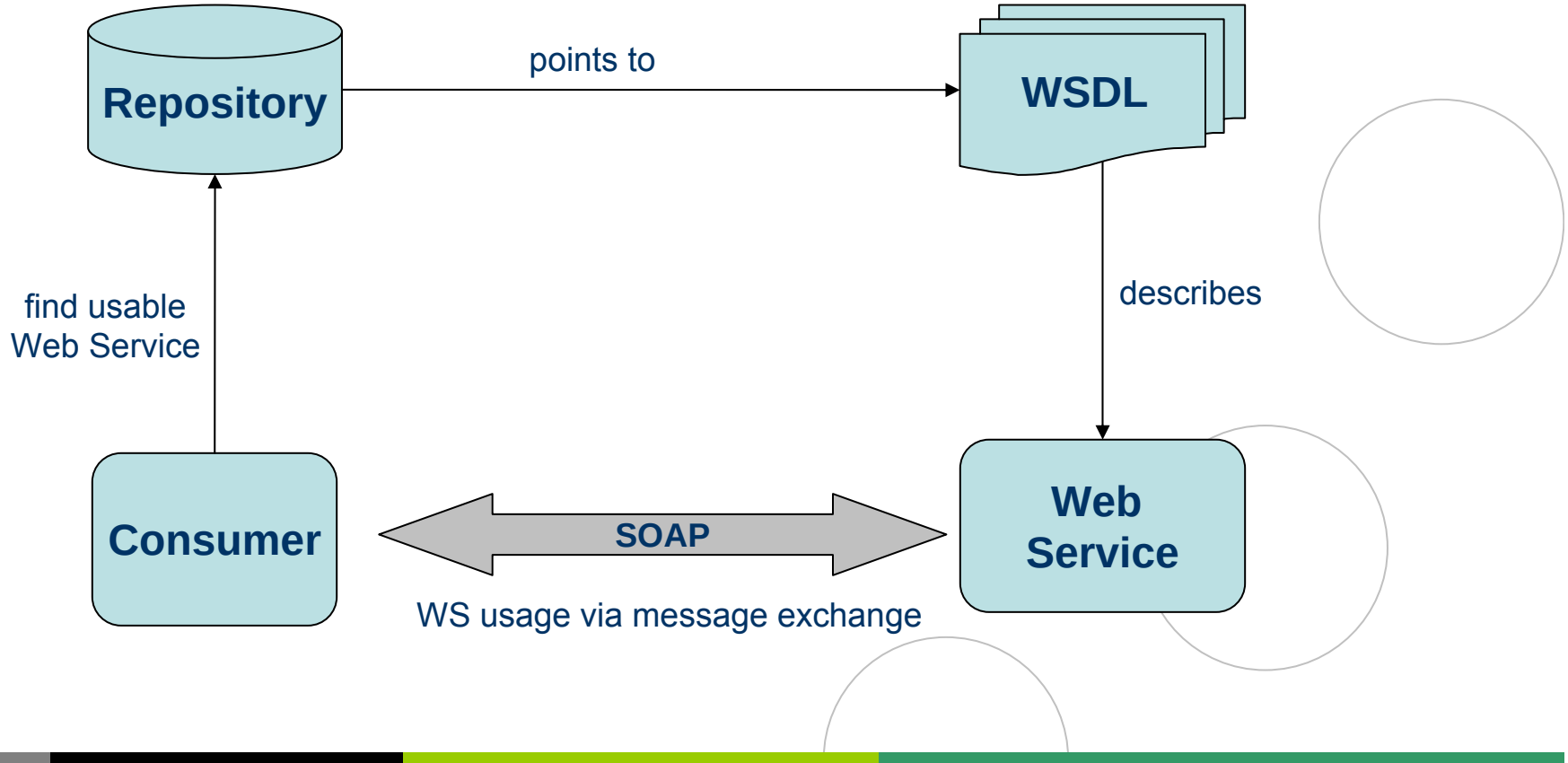


W3C Semantic Web Language Layer Cake
revised version, Tim-Berners-Lee 2005

Web Services & SOA

- Web Service = program accessible over the Web
- Service-Oriented Architecture (SOA):
  - use Web services as basic building blocks
  - dynamically find & invoke those Web services
  - that allow to solve a particular request
- Web Service Technologies:
  - WSDL Web Service Description Language
  - SOAP XML data exchange protocol for the Web
  - UDDI registry for Web Services

The Web Service Usage Process



Deficiencies of WS Technology

- current technologies allow usage of Web Services but:
  - only syntactical information descriptions
  - syntactic support for discovery, composition and execution
  - => Web Service usability, usage, and integration needs to be inspected manually
  - no semantically marked up content / services
  - no support for the Semantic Web

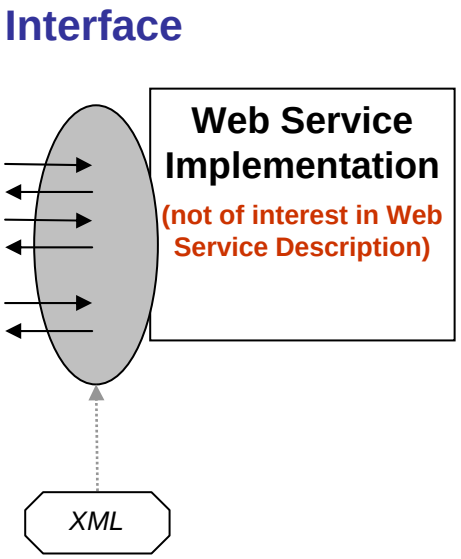
=> initial Web Service Technology Stack failed to realize the SOA Vision

Semantic Web Services

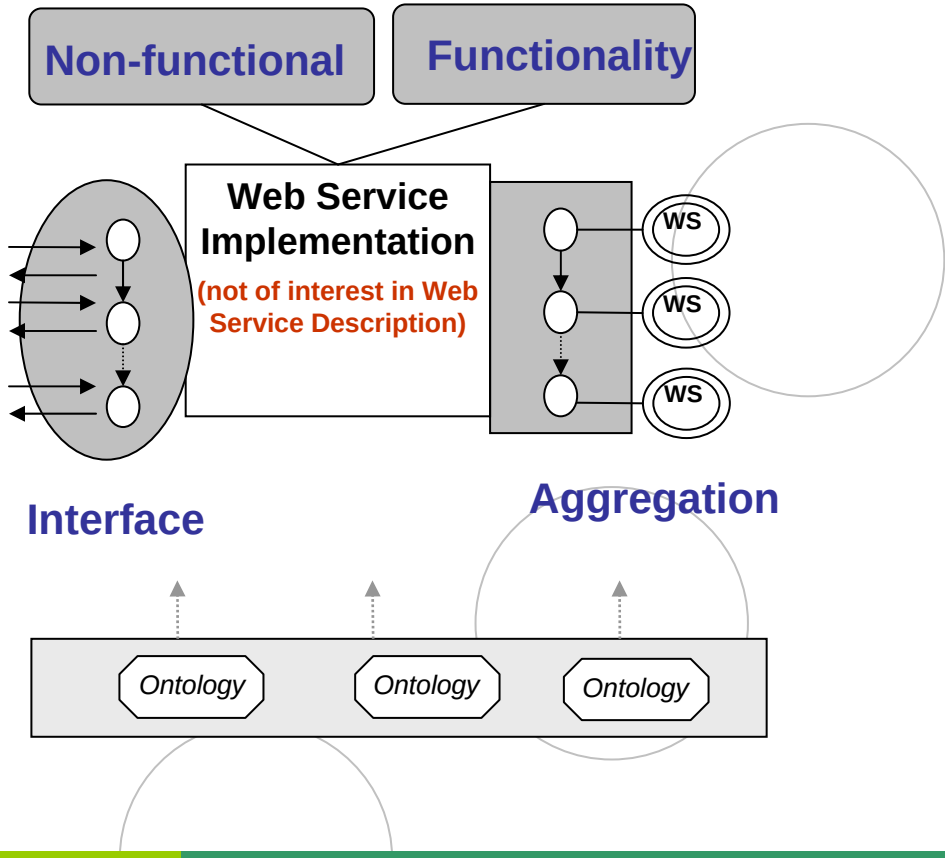
- automate Web Service technologies by
  1. rich, formal annotation of Web Services
  2. automated detection and execution of Web services
- integration with the Semantic Web
  - ontologies as data model
  - Web Services as integral part of the WWW
- inference-based techniques for automated discovery, composition, mediation, execution of Web Services

Semantic Web Services

a) Web Service Description Structure



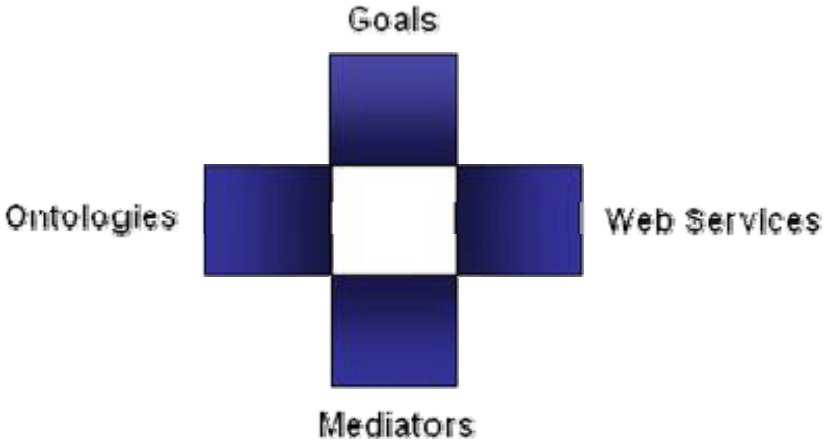
b) Semantic Web Service Description Structure



Web Service Modeling Ontology

(http://www.wsmo.org)

Objectives that a client may have when consulting a Web Service



Provide the formally specified terminology of the information used by all other components

Semantic description of Web Services:
- Capability *(functional)*
- Interfaces *(usage)*

Connectors between components with mediation facilities for handling heterogeneities

WSMO Web Service Description

- complete item description
- quality aspects
- Web Service Management

Non-functional Properties

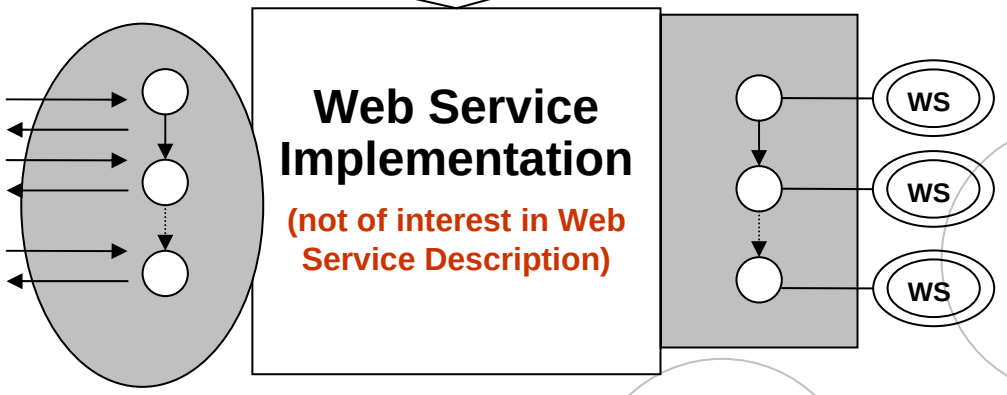
DC + QoS + Version + financial

- Advertising of Web Service
- Support for WS Discovery

Capability

functional description

client-service interaction interface for consuming WS
- external visible behavior
- communication structure
- 'grounding'



realization of functionality by aggregation
- functional decomposition
- WS composition

Interface

Orchestration

WSMO – Modelling Examples

Concept example

concept phoneNumber
  nonFunctionalProperties
    dc#description hasValue "concept of a phone number"
  endNonFunctionalProperties
  countryCode **ofType** _string
  areaCode **ofType** _string
  number **ofType** _string

Sub-concept example

concept mobilePhoneNumber **subConceptOf** phoneNumber
  nonFunctionalProperties
    dc#description hasValue "concept of a mobile phone number"
  endNonFunctionalProperties
  mobileProvider **ofType** Provider

Relation example

relation hasRoute(**ofType** routeDescription, **ofType** route)
  nonFunctionalProperties
    dc#description hasValue "Relation that holds between a route description and a route"
  endNonFunctionalProperties

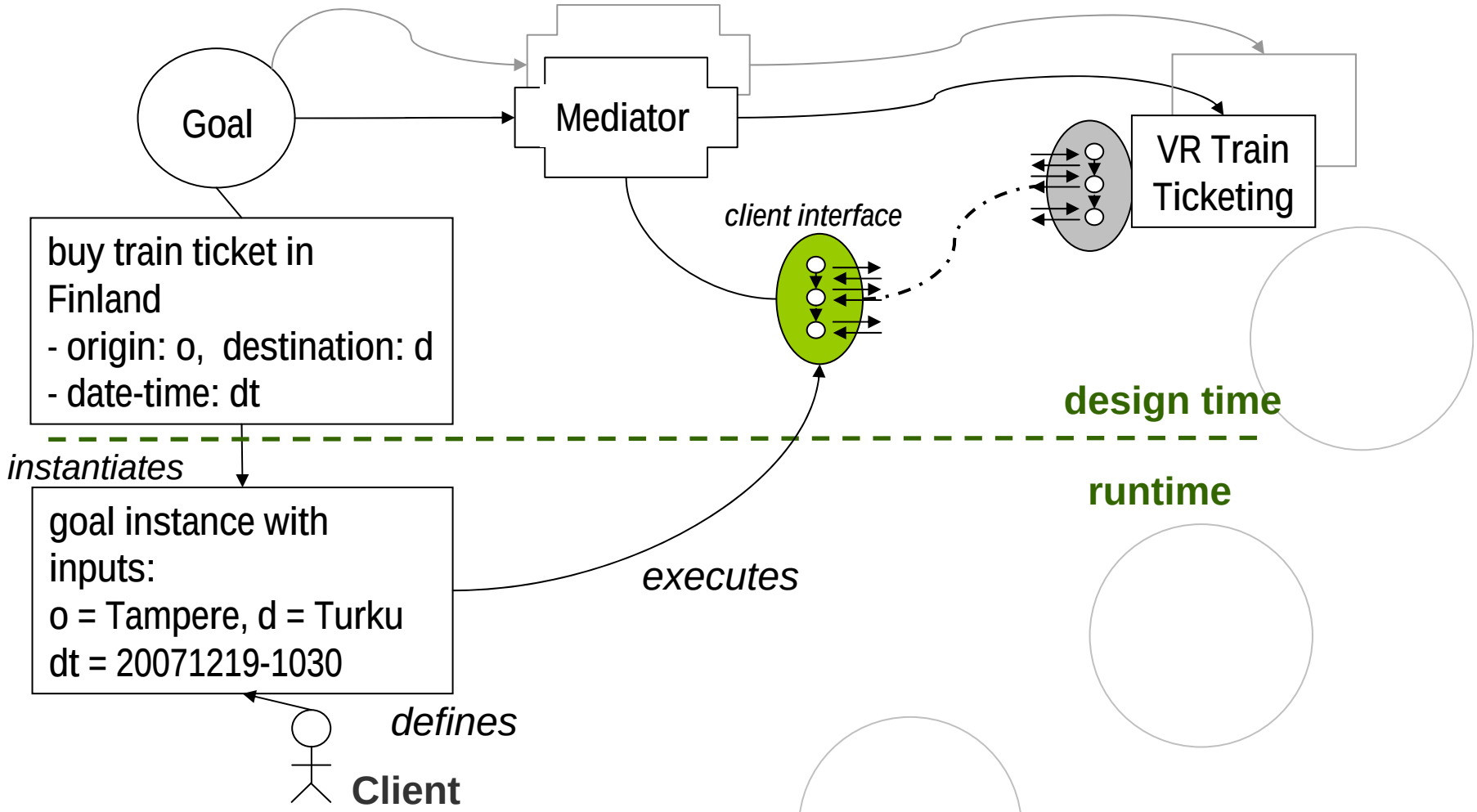
Instance example

instance myPhoneNumber **memberOf** phoneNumber
  countryCode **hasValue** “43“
  areaCode **hasValue** “664“
  number **hasValue** “49322607“

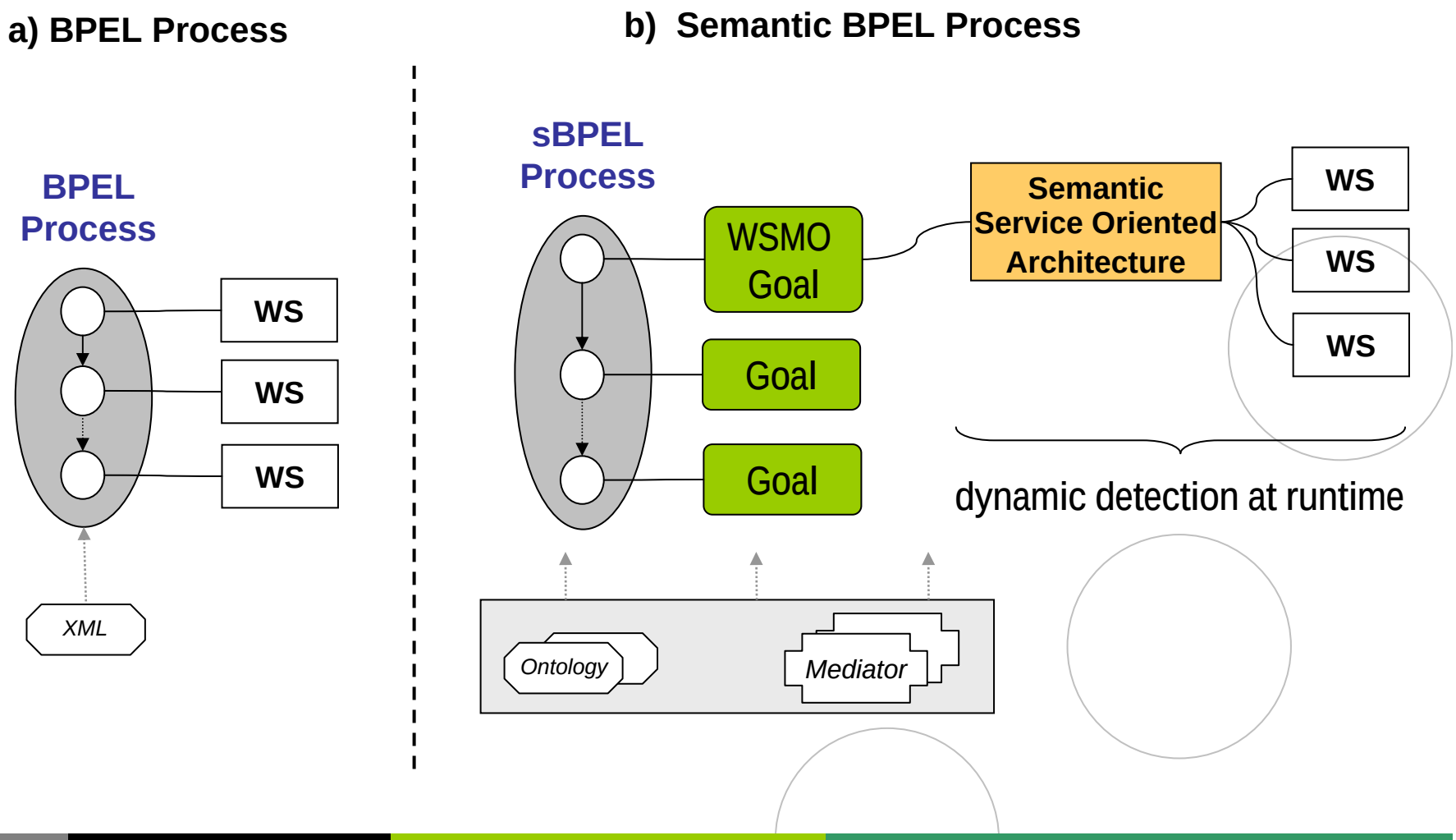
Axiom example

axiom ValidInformationQuality
  definedBy
    forall {?x} (
      ?x **memberOf** informationQualityType
    implies
      ?x[value **hasValue** “low“] **or**
      ?x[value **hasValue** “high“]).

Automated Web Service Usage



From Syntactic to Semantic BPEL



Concluding Remarks

- After 25 years still no standard Process Model established yet → trend towards BPEL for execution standard
- Ontologies in BPM give one:
  - Higher Flexibility for Web service usage
  - Formal Semantics of Data (messages exchanged)
  - Automated Handling of potential heterogeneities
  - better understandable for humans (different abstraction layers)

- Important for you – Take Home Message:
  - Understand the terminology (Process Model, WfM, BPM, Meta Model, Process Model, Instance, Abstraction levels, etc.)
  - Know BPEL and understand its meta model
  - Try one of the Open Source BPEL Engines available on http://sourceforge.net/

Questions?

Interested in doing research on BPM, SOA and ontological frameworks? Please, drop an email to me armin.haller@deri.org or hr@deri.org to get information how to apply at our institute

- Openings relevant for you:
  - intern for up to 6 months
  - Master thesis as visiting researcher
  - Master or Ph.D. student

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