

Semantic Web Services

Christoph Bussler
Digital Enterprise Research Institute (DERI)
Galway, Ireland
<http://www.deri.ie>

Christoph Bussler
July 27, 2004

ICWE 2004, Munich

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Outline

- The Integration Problem
- Web Services
- The Semantic Web
- Semantic Web Services
- Summary and Conclusions

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The Integration Problem

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Types of Integration

- Database Integration
- User Interface Integration
- Systems Integration

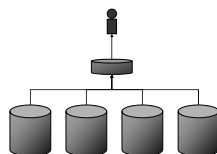
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Database Integration

- Subject of integration: data
- Goal: common and consistent (logical) schema across multiple data sources



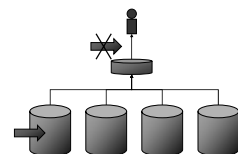
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Database Integration

- Subject of integration: data
- Goal: common and consistent (logical) schema across multiple data sources
- Passive: change in source does not change already obtained results



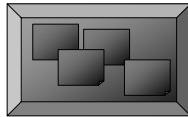
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User Interface Integration

- „Portal Integration“
- Subject of integration: windows
- Goal: common visual presentation (and data?)



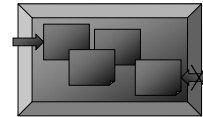
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User Interface Integration

- „Portal Integration“
- Subject of integration: windows
- Goal: common visual presentation (and data?)
- Passive: change in one presentation does not change the others



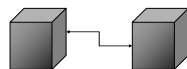
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Systems Integration

- Systems
 - Software systems like applications (e.g., Enterprise Resource Planning System)
 - EAI (Enterprise Application Integration)
 - Enterprises (e.g., buyer and supplier organization)
 - B2B (Business-to-Business Integration)



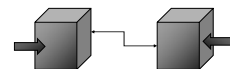
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Systems Integration

- Systems
 - Software systems like applications (e.g., Enterprise Resource Planning System)
 - EAI (Enterprise Application Integration)
 - Enterprises (e.g., buyer and supplier organization)
 - B2B (Business-to-Business Integration)
- Active: change in one system causes other system to change



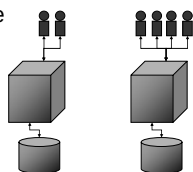
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Systems are HAD

- Heterogeneous
 - Different data models
- Autonomous
 - Independent state change
- Distributed
 - No shared state



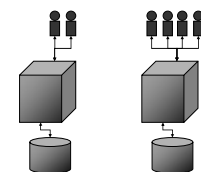
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The Integration Problem

- Synchronization of HAD systems



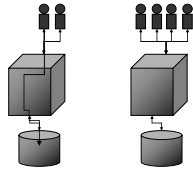
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The Integration Problem

■ Synchronization of HAD systems



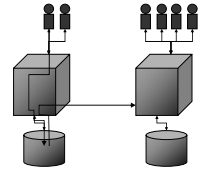
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The Integration Problem

■ Synchronization of HAD systems



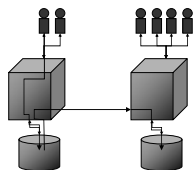
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The Integration Problem

■ Synchronization of HAD systems



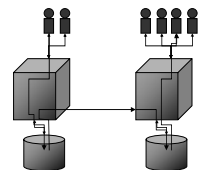
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The Integration Problem

■ Synchronization of HAD systems



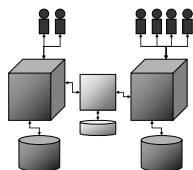
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Integration Systems

■ Systems that integrate systems



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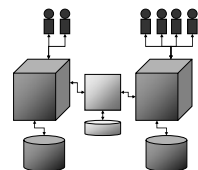
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Integration Systems

■ Systems that integrate systems

- Integration concepts
- Integration architecture



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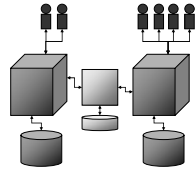
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Integration Systems

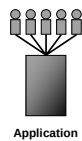
■ Systems that integrate systems

- History
- Current state
- Future

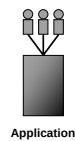


History of Integration Systems

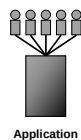
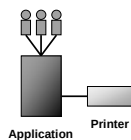
Once upon a time ...



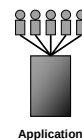
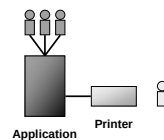
Shocking news!



Integrate? Integrate!



Integrate? Integrate!



Integrate? Integrate!



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Integrate? Integrate!



■ Early form of EAI

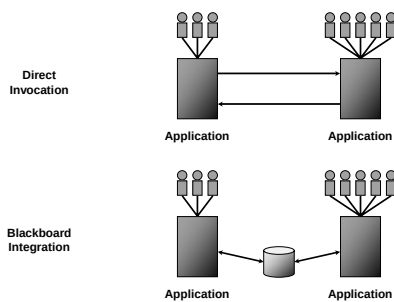
- Enterprise Application Integration (EAI)
- Also called A2A (application-to-application) Integration

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Initial Forms of Automated Integration

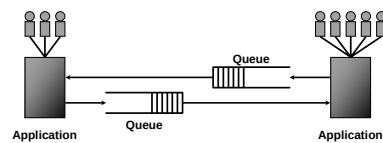


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Message Oriented Middleware



■ Enque / deque from shared queues

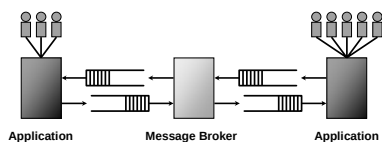
- Direct messages
- Persistent, transactional, reliable queues (best case)

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Message Broker



■ Messages in message broker

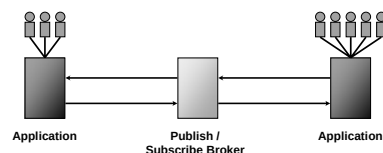
- Indirect messages
- Added functionality in broker

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Publish / Subscribe Broker



■ Data in Publish / Subscribe broker

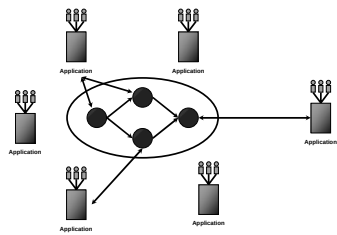
- Indirect addressing, based on content

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Process Integration



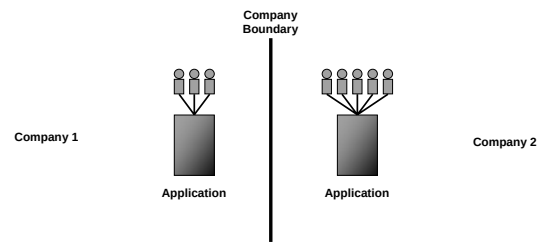
- Multi-step behavior
 - So far only point-to-point integration

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More Shocking News!

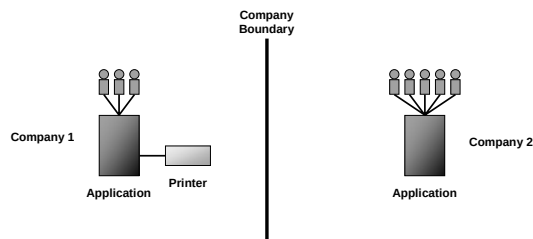


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Integrate? Integrate!

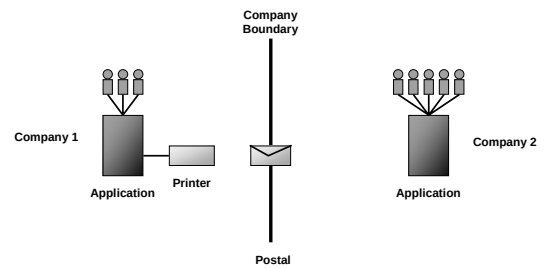


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Integrate? Integrate!

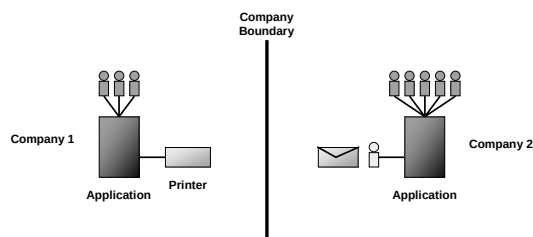


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Integrate? Integrate!



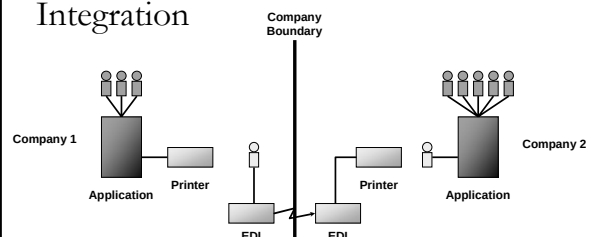
- Early form of B2B
 - Business-to-business (B2B) integration

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The 'first' Steps of Automated Integration



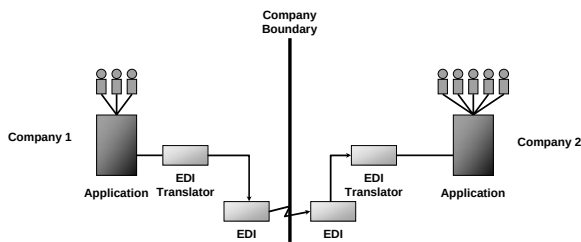
- 'Door-to-door EDI'
 - EDI defines transmission format
 - The applications not any more

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Initial Forms of Automated Integration

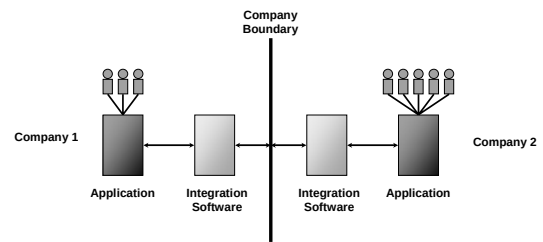


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Integration Systems



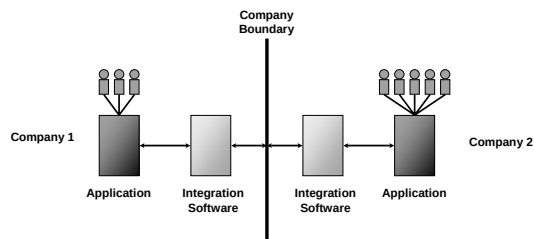
- Business-to-business (B2B) integration software

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Integration Systems



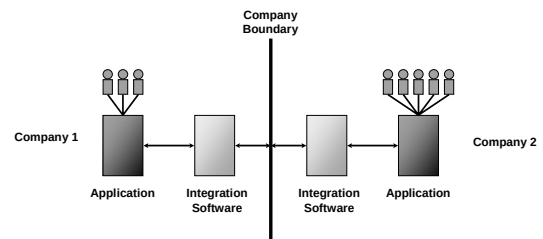
- Business-to-business (B2B) integration software
 - Note: two installations of integration software

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General Integration Scenario

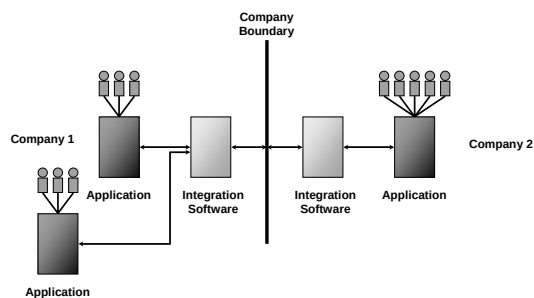


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General Integration Scenario

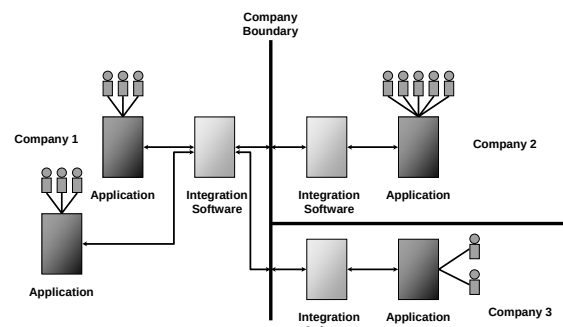


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General Integration Scenario

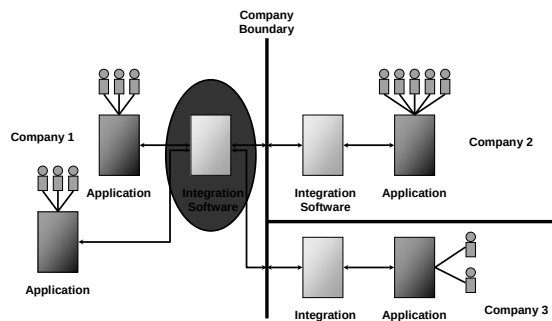


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General Integration Scenario



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Integration Concepts

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Basic Concepts of Integration

- Data
 - Business data in application systems
- Parties
 - Endpoints of integration like application systems
- Events
 - Data sent between parties
- Behavior
 - Exchange order of events
- Processes
 - Business logic to achieve business goals

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Data

- Business data
 - Purchase order
 - Patient record
- Semantics
 - Complete "enough" for business purpose
 - Consistent use of vocabulary referring to concepts (ontologies)
- Managed in application software systems



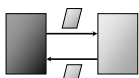
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Events

- Intent of data
 - Create vs. update vs. delete purchase order
 - Create vs. update vs. inquire for patient record
- Events are directed
 - Source party and target party
- Managed by integration software
 - Outside application software systems!



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EDI Example

```

GS~P0~ERPTEST~IMPEXP~20000512~1352~142~X~004010
ST~850~0001
BEG~00~NE~616000000096~~20000420
PER~BD~JACKSON, DEBBIE
FOB~DF~ZZ~Road Freight
N1~SU~SUPPLIER NAME INC~92~999888
N2~SUPPLIER REP
P01~0001~2~EA~~~PN~BOEING PART NUMBER 19
CTP~~~0~2~EA
PID~F~~~Burns Part
TD5~~GA~RD
TXI~LS~~100~CD~46020106~~~~178 000 010
SCH~2~EA~~~002~20000420
N9~55~0000
    
```

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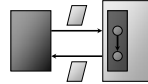
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RosettaNet Example

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE DeliveryHeader SYSTEM "DeliveryHeader_MS_B02_00.dtd">
<DeliveryHeader>
  <isSecureTransportRequired>
    <AffirmationIndicator>yes</AffirmationIndicator>
  </isSecureTransportRequired>
  <messageDateTime>
    <DateTimeStamp>20001121T145200.000Z</DateTimeStamp>
  </messageDateTime>
  <messageReceiverIdentification>
    <PartnerIdentification>
      <domain>
        <FreeFormText>DUNS</FreeFormText>
      </domain>
      </domain>
      <GlobalBusinessIdentifier>123456789
      </GlobalBusinessIdentifier>
      <locationID>
        <FreeFormText>Santa Clara</FreeFormText>
      </locationID>
    </PartnerIdentification>
  </messageReceiverIdentification>
</DeliveryHeader>
```

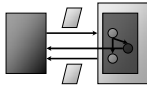
Behavior

- Exchange sequence of events like
 - Send purchase order
 - Receive purchase order acknowledgment
- Defines externally visible behavior of party
 - "Public process"



Behavior

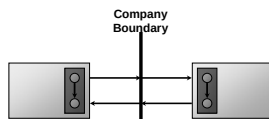
- Error events like
 - "I don't understand"
 - Data inconsistency
 - No business agreement
 - Out of sequence according to behavior
- Defines externally visible error behavior of party



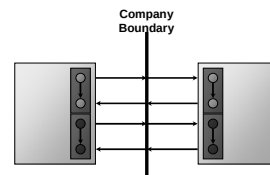
Behavior: P2P vs. C/S

- Peer-to-peer (P2P)
 - Coordinated behavior of involved parties
 - Both control and supervise communication of events
 - Both send and receive events as per behavior
- Client / Server (C/S)
 - Server defines behavior, client has to follow it
 - Client is in control of communication
 - Server responds to invocation, but does not initiate any sending

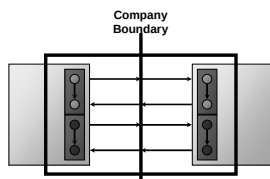
Behavior: P2P in Detail



Behavior: P2P in Detail



Behavior: P2P in Detail



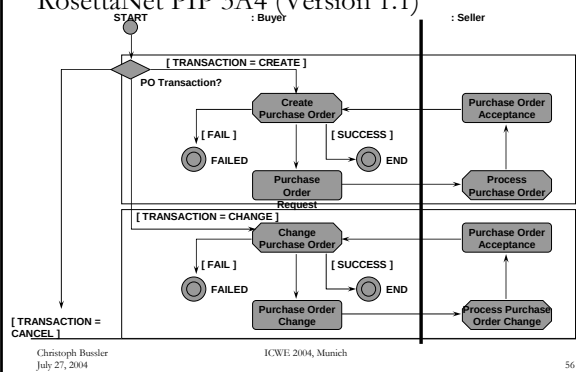
- Behavior of both parties matches
- Control moves back and forth between parties

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B2B Protocol Example: RosettaNet PIP 3A4 (Version 1.1)



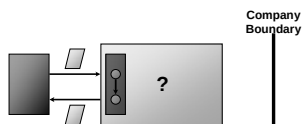
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Processes

- Processing of events (business logic)
 - Purchasing process
 - Patient admission process
- Defines party internal process
 - "Private process"



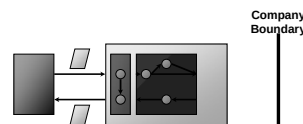
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Processes

- Processing of events (business logic)
 - Purchasing process
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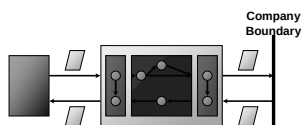
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Processes

- Processing of events (business logic)
 - Purchasing process
 - Patient admission process
- Defines party internal process
 - "Private process"



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Flashback: Systems are HAD Systems

- Homogeneous
- Autonomous
- Distributed

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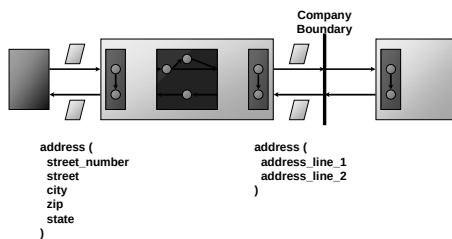
Flashback: Systems are HAD Systems

- ~~Homogeneous~~ Heterogeneous
- Autonomous
- Distributed

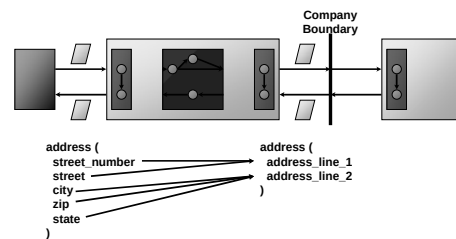
Heterogeneity requires Mediation

- Events
 - Different parties use different data models (semantics)
 - Event mediation
- Behavior
 - Different parties use different event exchange sequences
 - Behavior mediation

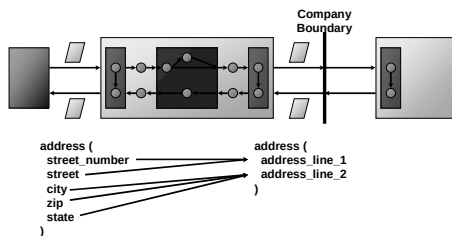
Event Mediation



Event Mediation



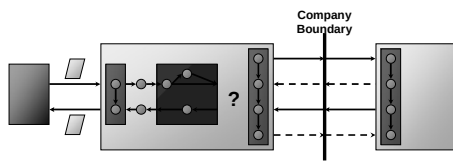
Event Mediation



Experience Note

- Event mediation is THE biggest problem in integration today
 - 60 - 80% of effort are spent on data mediation
 - Projects have failed because of impossible data mediation

Behavior Mediation

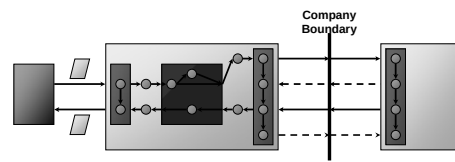


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Behavior Mediation

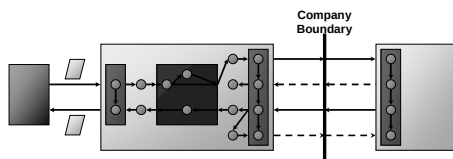


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Behavior Mediation



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Situation

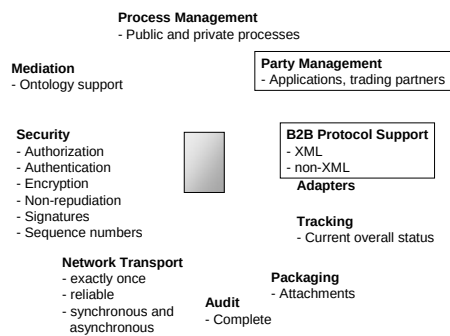
- Many existing and new application systems
 - I. e. many ontologies
- Many B2B protocol standards
 - I. e. many more ontologies
- Existing and new standards and technologies
 - EDI, Swift, ACORD
 - OASIS, RosettaNet
 - ...
- One enterprise has to integrate many of them AT THE SAME TIME!

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Summary



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Web Services

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Web Services

■ Definition 1. Web Services as a Software Architecture

- "Web services are a new breed of Web application. They are self-contained, self-describing, modular applications that can be published, located, and invoked across the Web. Web services perform functions, which can be anything from simple requests to complicated business processes. ...
Once a Web service is deployed, other applications (and other Web services) can discover and invoke the deployed service."

IBM web service tutorial

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Web Services

■ Definition 2. Web Services as a new Concept for eWork and eCommerce

- „Web Services, are Services accessible via the web“

Numerous white papers

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Web Services

■ Definition 3. Web Services as a programming technology

- „Web Services are Remote Procedure Calls (RPC) over HTTP“

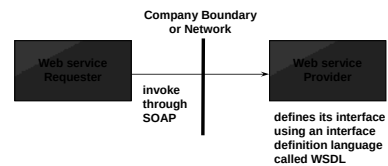
Current state of the art

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State-of-the-Art in Web Services



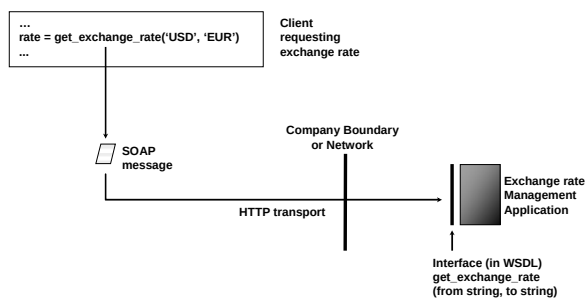
- SOAP: Simple Object Access Protocol
- WSDL: Web Service Description Language

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State-of-the-Art in Web Services



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SOAP (Simple Object Access Protocol)

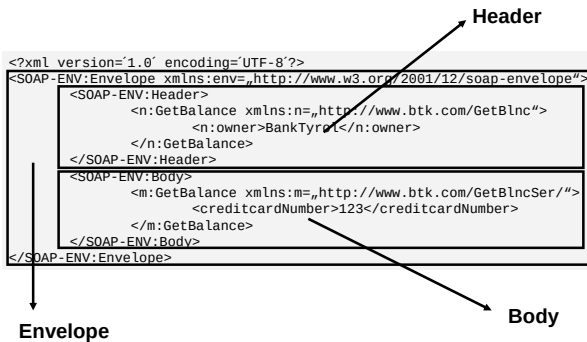
- XML Messaging Protocol that
 - Allows software running on disparate operating systems, and environments to make RPC
 - Stateless, one-way message exchange paradigm
- Elements:
 - **Envelope**: container where main end-to-end information conveyed in a SOAP message must be carried
 - **Header**: optional extension mechanism that provides a way to pass information in SOAP messages that is not application payload
 - **Body**: mandatory element where the main end-to-end information conveyed in a SOAP message must be carried

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SOAP elements



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State-of-the-Art in Web Services

- WSDL concepts
 - Message
 - XML Schema definition
 - Operation
 - Input and output message
 - One way invocation
 - Request / response invocation
 - Port type
 - Port
- Example



Acrobat Document

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State-of-the-Art in Web Services

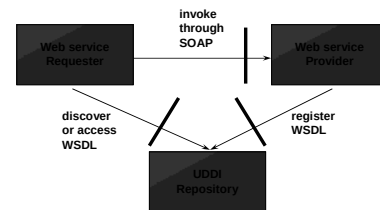
- Idea and vision
 - Self-composing web services
 - Mechanism 'web service discovery'
 - Discovery location: directory

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State-of-the-Art in Web Services



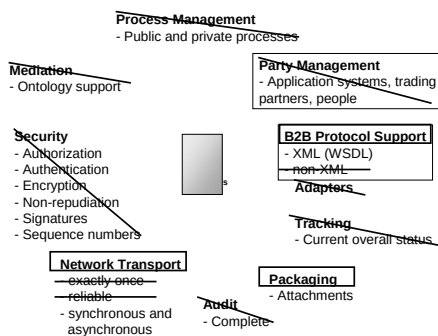
- SOAP: Simple Object Access Protocol
- WSDL: Web Service Description Language
- UDDI: Universal Description, Discovery and Integration

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Web Service Support for Integration



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Bridging the Gap

- Base web service specifications
 - WSDL
 - SOAP
 - UDDI
- Additional web services specifications for
 - Processes
 - Ontology
 - Security
 - Party management
 - Adapters
 - Reliability and transactions
 - Addressing
 - Documents
 - ...

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Further important ongoing Efforts

- Behavior
 - BPEL4WS, BPML, WSCI, WSCL, ebXML, ...
- Ontology
 - RDF/S, OWL, ...
- Security
 - SAML, XKMS, ...
- Party management
 - CPA, CPP
- Adapter
 - J2EE connector architecture

Further important ongoing Efforts

- Reliability and transactions
 - WS-C
 - WS-T
- Addressing
 - WS-Addressing
- Documents
 - FIX
 - OASIS
 - RosettaNet
- ...

The Real Problem

- www.zapthink.com 

Experience Note

- There is **NO** proposal for the data mediation problem!
 - Remember: the biggest problem in integration

Experience Note

- There is **NO** accepted conceptual model for integration

The Semantic Web

The Semantic Web

■ Coined by Tim Berners-Lee (1997)

- "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."

• T. Berners-Lee, J. Hendler, O. Lassila,
"The Semantic Web", *Scientific American*, May 2001

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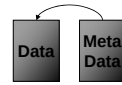
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The Semantic Web

■ Meta data

- Data about data
- Meta data describes data



■ Augmentation of data with explicit meta data

- Defines terminology (definitions)
- Defines vocabulary (instances)

■ Web pages consist of augmented data

- Data is unit of augmentation, not web page

■ Technology: Ontologies

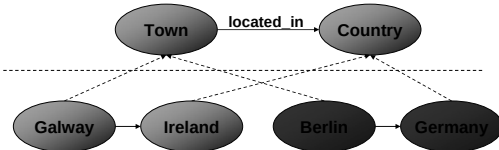
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The Semantic Web: Ontologies

Definition



Values

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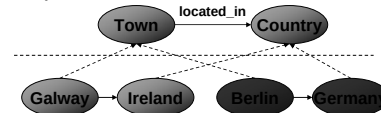
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The Semantic Web: Ontologies

Al Gore to speak in Galway

galway.net, 28 Apr 2004

Al Gore, 45th. Vice President of The United States will be visiting Ireland to deliver a keynote address at the Forum to debate the Constitution for Europe, a major event announced today and being held in Galway, Ireland on Thursday the 27th and Friday the 28th of May during the term of Ireland's Presidency of the EU.



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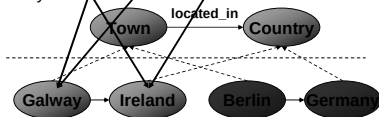
The Semantic Web: Ontologies

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Meta data annotation



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What is an ontology?

- "An ontology is an explicit and formal specification of a conceptualization."

T.R. Gruber

■ Ontologies are shared between

- Web sites
- Agents
- Humans
- Software systems

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Ontology Languages

- Resource Description Framework (RDF)
 - www.w3.org/RDF/
- RDF Schema (RDFS)
 - www.w3.org/RDF/
- Web Ontology Language (OWL)
 - www.w3.org/2001/sw/WebOnt/
- Others
 - DAML (www.daml.org/)
 - DAML+OIL (www.daml.org/language/)

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Ontology Languages

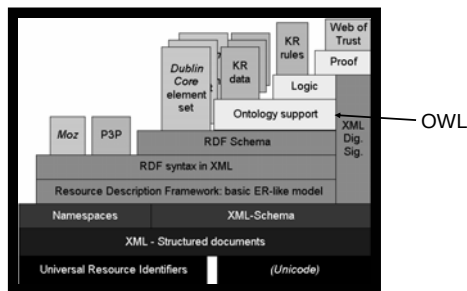
- RDF
 - Model for instances, objects, resources
- RDFS
 - Vocabulary description language for property and classes as well as generalization hierarchies
- OWL
 - Richer vocabulary description language, including relations, cardinality and equality

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Semantic Web Languages



Tim Berners-Lee. Semantic Web Languages cake

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Semantic Web Services

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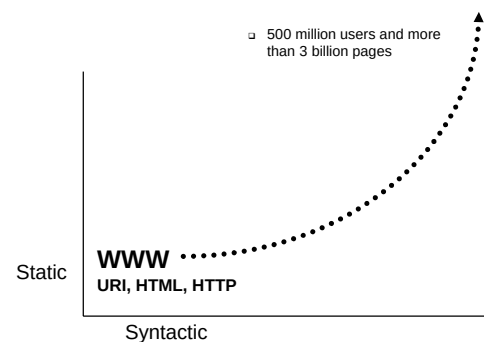
Semantic (Web Services)

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General Vision

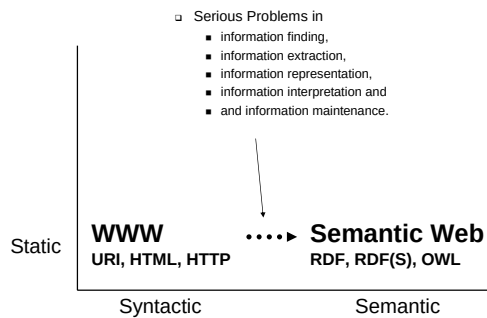


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General Vision

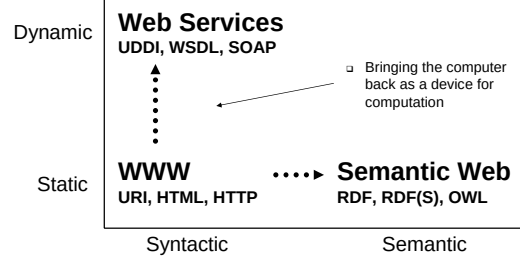


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General Vision

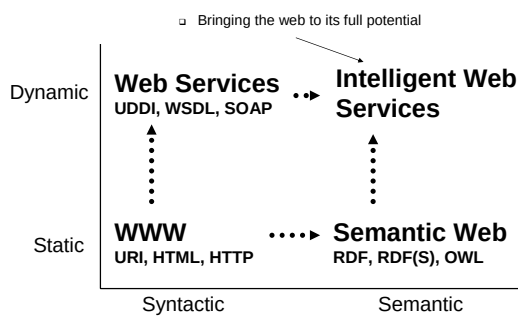


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General Vision



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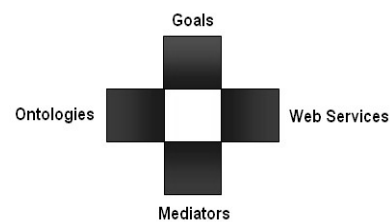
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Semantic Web Services

■ Web Service Modeling Ontology (WSMO)

- www.wsmo.org, www.wsmx.org



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Web Service Modelling Ontology

- WSMO is a conceptual model for the description Semantic Web Services
- Grounded on the Web Service Modeling Framework (WSMF)
- It represents the backbone for the development of:
 - Web Service Modelling Language (WSML)
 - Web Service Modelling Execution Environment (WSMX)

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Web Service Modelling Language

- Web Service Modelling Language (WSML)
 - F-logic based language, for the description of Semantic Web Services based on WSMO
 - Three different species
 - WSML-Full, a full First-Order Logic
 - WSML-DL, a description Logic subset of FOL
 - WSML-HL, a Horn Logic subset of FOL

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Web Service Modelling Execution Environment

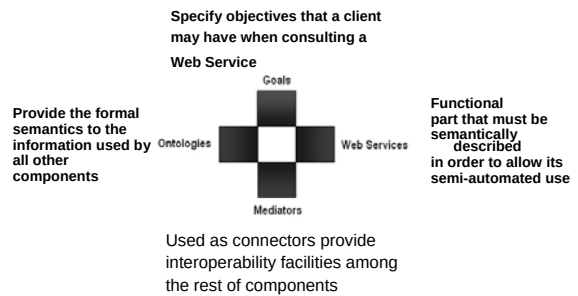
- Web Service Modelling Execution Environment (WSMX)
 - A reference implementation of an execution environment for WSMO
 - Test-bed for WSMO to demonstrate the viability of using WSMO for dynamic interoperation of Semantic Web Services

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WSMO Elements



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Ontologies

- Provide the formal semantics to the information used by all other components
 - Non functional properties
 - Used mediators
 - Allow to import ontologies. By importing other ontologies, one can make use of concepts and relations defined elsewhere
 - Permit to align, merge and transform imported ontologies
 - Axioms
 - Set of axioms that belong to the represented ontology
 - Concepts
 - Set of concepts that belong to the represented ontology
 - Relations
 - Set of relations that belong to the represented ontology
 - Instances
 - Set of instances that belong to the represented ontology

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Mediators

- Used as connectors, provide interoperability facilities among the rest of components
 - Non functional properties
 - Source component
 - Defines one of the two logically connected entities
 - Target component
 - Defines one of the two logically connected entities
 - Mediation Service
 - Points to
 - A goal that declarative describes the mapping or
 - A wwMediator that links to a web service that implements the mapping
 - Reduction
 - It describes in a logical formula the differences between the functionality described in the goal and the functionality of the web service (if any) or another goal
 - A reduction only exists in a wgMediator or a ggMediator

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Mediators

- Refiner
 - Allow to define a component as a refinement of an existing one
- Bridge
 - Provide support for re-use, by enabling two heterogeneous components to interact with each other



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Mediators

- ooMediator
 - Link 2 ontologies, i.e. import of an ontology by another ontology, or use of an ontology by a component
- ggMediator
 - Link 2 goals, i.e. definition of sub-goal hierarchies
- wgMediator
 - link between the
 - Capability of a Web Service
 - And a goal
- wwMediator
 - Link 2 Web Services



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Goals

- Specify objectives that a client may have when consulting a Web Service.
- Goals provide the means to express high level description of a concrete task.
 - Non functional properties
 - Used mediators
 - A goal can import ontologies using ontology mediators
 - A goal may be defined by reusing an already existing goal. This is achieved by using goal mediators
 - Post-conditions
 - Post-conditions in WSMO describe the state of the information space that is desired
 - Effects
 - Describe the desired state of the world after the execution of the Web Service

Web Services

- Represent the functional part which must be semantically de-scribed in order to allow its semi-automated use.
 - Non functional properties
 - Used mediators
 - By importing ontologies, a web service can make use of concepts and relations defined elsewhere
 - Capability
 - Use pre and post-conditions, assumptions and effects to define the functionality
 - Interfaces
 - Describe the communication pattern (choreography, and/or orchestration)

Capability

- Non functional properties
- Used mediators
 - ooMediators: to import ontologies
 - wgMediator: to link capabilities and goals
- Pre-conditions
 - Describe what a web service expects for enabling it to provide its service. They define conditions over the input
- Post-conditions
- Assumptions
 - Assumptions are similar to pre-conditions, however, also reference aspects of the state of the world beyond the actual input
- Effects

Interface

- Describes how the functionality of the service can be achieved (i.e. how to fulfill the capability of the service)
 - Non functional properties
 - Used mediators
 - Choreography
 - Defines how to communicate with the web service in order to consume its functionality
 - Orchestration
 - An orchestration describes a service makes use of other web service or goals in order to achieve it's capability
 - It defines how the overall functionality is achieved by the cooperation of more elementary services
- This distinction reflects the difference between communication and cooperation

WSMO Summary

- WSMO provides a conceptual model for Web Service description and interoperation
- WSML provides a formal language for the description of Web Services based on WSMO
- WSMX provides a reference implementation of an execution environment and test-bed for WSMO in order to demonstrate its viability

Summary and Conclusions

System Integration is Hard

- Systems are
 - Heterogeneous
 - Autonomous
 - Distributed
- For solving the integration problem ...

Explicit Semantics is Key

- Semantic representation of
 - Data
 - Behavior
 - Processes
- Don't focus on infrastructure, focus on semantics!
- www.wsmo.org and www.wsmx.org are current efforts implementing this approach

Contact

- Chris.Bussler@DERI.org
and
- www.deri.ie