Challenges of Ubiquitous Semantic Web Services

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Workshop on Semantic Web Services:
Preparing to Meet the World of Business Applications
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Scenario

Vision: Software over the Web

Technology: Status of Web Services

Engineering: Web Services Engineering

Example: Value-Added Service Broker

Research Challenges
Vision: Software over the Web
Two Faces of Web

“Program = Algorithm + Data Structure”
Semantic Web Services
To Bridge the Semantic Gap of Web Services

Semantics
Web Services/ SOC
Information/Data
Semantic Web

SOC: Service-Oriented Computing

Web
Grid/P2P/Mobile

Web Services

Semantics
Web Services

SOC: Service-Oriented Computing

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Vision: Software over the Web
Two Directions of Computing

3rd Wave of IT Evolution?
- From PC (0.1B Unit/Year) to Ubiquitous Network (10B+ Unit/Year)
- Dense Software Connected Everywhere: Diversity & Interactions

Shifting of User Expectations
- Computing is Commodity, Collaboration Creates Value

Network [Enterprise, Public Services]
Ubiquitous, Embedded, Mobile

Web

Ubiquitous Network Era (2000~) [10B Unit/Year]

Mainframe Era (’60~’70) [10K Unit/Year]

PC Era (’80~’90) [0.1B Unit/Year]
Vision: Software over the Web
Evolution of Information Systems

From Enterprise to Networked Enterprises
From Information Stock to Information Flow

Business Unit
Ex: Sales, Warehouse Mgmt

Enterprise (Integration)
Ex: ERP

Information Stock

A-Corp ERP

Information

Sales

Manufacturing

B-Corp ERP

Networked Enterprise
(Integration)
Ex: SCM, CRM

Information Flow

Customer

A-Corp Sales

B-Corp Distributor

C-Corp Supplier

Task
Ex: Data Entry
Vision: Software over the Web
Collaboration Creates Synergy Effect

Airline Computer Reservation System (CRS)
Collaboration is the Essential Requirements

Other Airlines (SABRE)
Reservation of Other Airlines
Schedule/Availability
Reservation
Availability Mgmt
Yield Mgmt
Customer Mgmt (FFP)
Check-in
Flight Info
Passenger Mgmt
Baggage Mgmt
Airport Operation
Ticketing
Sales Mgmt
Accounting

Services Provided to Travel Agency

Vision: Software over the Web
Collaboration Maximizes End-to-End Value Added

 Collaboration along with End-to-End Process

- Cost Cutting: Optimization over the End-to-End Process
- Value-Added: Better Customer Satisfaction: Aggregation, Agility

 Different Aspects of Two Ends: User and Business

B2C, P2P
- Direct Connection
- Service Integration
  (One Stop Service)
  [Buy, Maintenance, Finance]

B2B, B2M2B
- Business Process Collaboration
- New Business Model/Market
  [SCM, e-Marketplace]

End-to-End e-Business Process

Diverse Customers

Global Market

CRM

SCM

Sales

Distribution

Manufacturing
Vision: Software over the Web
Challenges of Networked Enterprise Software

Evolution onto Open and Decentralized Network

- Web is Boundary-less, Center-less
- Evolution is Dynamic, and (Locally) Autonomic

From System to System-of-Systems

- End-to-End within/across Different Organizations with Different Platforms and Architectures
- Integration Nightmare of Spaghetti Systems
- Interoperability/Collaboration
  - Program Interface: OS, Languages, Middleware
  - Semantics of Data: Ontology (Vocabulary, Relationship), Data Structure, Languages, Encoding
Emerging Ubiquitous/Embedded Systems: ITS

“ITS Revolution”: ITS, Telematic, VRM
- Safety, Environment, Convenience, Entertainment

“Mobile” Collaboration of Automobile with
- Ground System, Manufacturer, Service Providers

On-Board System
- 50+ CPUs & 120+ Sensors Connected via LAN

Services for Driving
- Driving Assistance, Navigation, Diagnostics, Entertainment

Services at Rest Area
- Area Guide (Restaurants, Parking)

Services at Garage
- CRM (Maintenance), Information (Recall)

Ground System
- Remote Sensors, Monitor System

Manufacturer Center
- Service Providers

GPS

ITS: Intelligent Transport System
VRM: Vehicle Relationship Management
Vision: Software over the Web
Software over the Web Forms an Society

Key to E-Business/Software Society: Collaboration of Software Systems across Organizational Boundaries

Human Society: Collaboration of People
Scenario

Vision: Software over the Web
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Research Challenges
Technology: Evolution of Web Services
(My) Vision of Web Services

Business-Service-Computing Model

- Platform Independence: Productivity, Interoperability
- Business-Model Independence: Reuse, Evolution/Agile

Abstraction
Search
Profile
Negotiation
Authorization
Cataloguing
Computing Space (Components, etc)

Business Space

Service System

Vision of Web Services

Architecture
Business System

Service Space

Computing System
Technology: Evolution of Web Services
From Object/Component to Web Services

Service = Encapsulation of Components

Service Provision
- ASP (Application Service Provider)
- Service Requester
- Web Services Service Broker
- Service Provider

Application
- EDI, EC (SCM, eMP), EAI/B2BI

Computing Platform
- Component-Based System
  - Component Architecture
  - Integration (Middleware)

Object
Technology: Evolution of Web Services
Business/Social Rationale

Single Common Ground

IBM, Microsoft, Sun, Oracle, …
Technology: Evolution of Web Services
Web Services Platform Reaching a Maturity

Web Services Platform: 3 Major Technology Stacks

Description, Publish & Search, Binding & Execution

Current Issues: Business Process Orchestration

W3C WG
Architecture

Composition
Definition
Message
Transportation

Reference Architecture
Usage Scenarios
Service Description

Coordination

WSIL ➔ WSDL

BPEL (WSFL/XLANG) ➔ ebXML

BPSS

SOAP/XMLP

XML

HTTP/SMTP

BPSS

dbXML Registry

UDDI

XML Schema

XML Namespace

Meta-Data

Business Ontology

Publish & Search

WOL
Technology: Evolution of Web Services

Web Services Technology Stack

Orchestration/Choreography Interactions
- BPEL4WS
- WS-Coordination
- WS-Transaction
- WSCI

Registry
- UDDI
- ebXML RR

Security
- XKMS
- XRML
- XML Encryption
- XML Signature
- SAML
- WS-Secure Conversation
- WS-Federation
- WS-Authorization
- WS-Policy
- WS-Trust
- WS-Privacy
- WS-Security

Management
- WSDM
- WSMF

Description
- WS-Inspection
- WSDL

Inter-mediatory
- WS-Routing
- WS-Referral
- WS-License
- DIME
- BXXP
- ebXML TRP

Encapsulation
- WS-Reliability
- WS-ReliableMessaging

Reliability
- WS-Reliability
- WS-ReliableMessaging

Messaging
- SOAP v1.1
- SOAP w/Attachment
SOA: Architecture for Dynamic Collaboration

- Architecture: From Client/Server to Publish/Subscribe
- Program/Service Discovery: From Design-Time to Run-Time based on Semantic/Contents
- From Ownership to Usage

Dynamic Discovery/Binding of Components/Services

- Component-Based: Run-Time Binding
  - Ex: DLL (Dynamic Link Library) on Windows
- Service-Oriented: Dynamic Discovery and Binding of Services
Technology: Evolution of Web Services

Implication of Publish/Subscribe Architecture

- **Publish-Find-Bind Pattern**
  - Decoupling: No Direct Interactions between Requester and Provider
  - Discovery at Run-Time (when Buying) rather than Design-Time (Plan)

- **Analogy to Social Architecture**
  - Consumer
  - Service Registry (UDDI)
  - Provider

  - **Find/Discovery**
  - **Publish**
  - **Bind**

  - Producer
  - Service Requester
  - Service Provider
Web Services Form an Ecosystem

Diverse Services Emerging on the Web
Amazon, Google, Microsoft Office 2003 Research Service

Application = Binding Services for Business

Unlike Physical Ecosystems, Web Services are:

Almost Free from Physical Constraints: Diversity, Scope
Dynamic Changing at Real-Time
Technology: Evolution of Web Services

Broker Architecture on SOA

**Broker/Intermediary Architecture**

- Decoupling between Requester and Provider
- Better Binding between Requester and Provider

**Analogy to Human Society**

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![Diagram of Broker/Intermediary Architecture](attachment:diagram.png)

- **UDDI Server**
- **UDDI Registry**
- **Service Broker**
- **Requester**
- **Service Provider**
- **Web Server for SOAP**
- **Interface Description with WSDL**

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1. **Request**
2. **Find**
3. **Get**
4. **Request**
5. **Invoke**
6. **Reply**
7. **Response**
8. **Response**

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Example: Value-Added Service Broker
Research Challenges
Engineering: Web Services Engineering
User-Driven and Business-Driven

Two Ends

- **User-Driven**: Diverse Requirements, Context-Awareness by Use Case/Scenario
- **Business-Driven**: Business Goals and Quality by Business Modeling (e.g. EA: Enterprise Architecture)

**User-Driven** (B2C, G2C)
Diverse Requirements, Context-Awareness
Use Case/Scenario
Customer Behavior

**Business-Driven** (B2B, G2B, etc.)
Business Goals and Quality
Business Models
Choreography

One User
(Profile, Behavior, etc.)
Personal Profile, Customer Preference

Enterprise/Organization
[Business Profile, etc.]
Corporate Profile, Business Strategy/Rule/Policy

Broker
Engineering: Web Services Engineering
Broker is the Key Player

2 Roles of Broker

- (On Demand) Design: Find and Composition
  - Find Qualified Web Services
  - Composition and Evaluation
- (On Demand) Execution
  - Execution, Control of Scope, Protocol Binding
Engineering: Web Services Engineering
Business Models on Broker Architecture

Common Broker Pattern of Multiple Business Models

1. Join
   - Buy
   - Broker
   - Sell

2. Cataloguing
   - Forward Auction
   - Reverse Auction
   - Exchange (Double Auction)

3. Bidding
   - Forward Aggregator [MRO Hub/Catalogue Hub]
   - Reverse Aggregator [MRO Hub/Catalogue Hub]

4. Selection
   - Supply Chain [SCM]
Engineering: Web Services Engineering Requirements to Dynamic Brokerage

Brokerage is *Essentially* Dynamic and Complex

- **(Dynamic) Positioning**
  - Sell, Buy

- **(Dynamic) Change of Scope**
  - Scope of Call-for-Bid: Open, Close, etc.

- **Negotiation**
  - Dynamic Pricing, Changing Conditions

- **(Dynamic) Change of Business Protocols**
  - One-to-One (for MRO), One-to-Many (for Auction), Many-to-Many (for Double Auction/Exchange)

Support of Non-Functional Properties

- Performance, Reliability, Security and Trust
e-Business Value Chain on the Web

- Dynamic Composition and Routing of Web Services
- Value Network: Collaborate Web Services to Augment Business Value
  - Ex. Web Services Network: “Business Dial Tone”

e-Business by Collaborating Brokers [Broker Network]
- Dynamics by Changing Collaboration Patterns
- Need Navigation Method for Value
Concept: Business/Trade is a Drama

Modeling with an Extension of Use Cases

- Introduction of Role and Scene to Use Cases to Enabling Dynamic Collaboration across Business Scenarios
  - Brokerage could be a Role
  - A Scene Defines a Business Context and a Scope
- Service could be a High-Level Use Case

Mapping to Web Services Platform

**Drama(tic) Model for Collaborating Brokers**

- **Actor**: An Active Entity
- **Role (Personality)**: Played by an Actor in a Scene
- **Service**: Task Performed by an Actor with a Role
- **Scene**: Context of Plays of Actors
- **Scenario**: A Sequence of Plays in a Scenario

**Business Scenario S**

1. **Join**
2. **Cataloguing**
3. **Bidding**
4. **Selection**

**Actors and Roles**

- **Actor a**: Role (Buy)
- **Actor b**: Role (Buy), Role (Broker)
- **Actor c**: Role (Sell)
- **Actor d**: Role (Sell)

**Scene**

- **Join**
- **Cataloguing**
- **Selection**

**Roles**

- **Buy**
- **Sell**
- **Broker**
**Scenario 1&2: Service Aggregation**

- Composing MRO with Spot Procurement for Varying Demands

**Scenario 3: Reduction**

- SCM: Actor b plays both Buyer and Broker

### Business Scenario 1
- [MRO by Aggregation for Domain x]

### Business Scenario 2
- [Spot Procurement by Auction for Domain x]

### Business Scenario 3
- [SCM for Domain y]
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Example: Value-Added Service Broker
Research Challenges
Value-Added Service Broker
Binding Services by Value

- Dynamic (Context-based) Composition by Value
- Spaces in Web Services Ecosystem
  - Local “Semantic” Space to Provide a Specific Value
  - Provide Service Attributes: QoS, SL (Service Level), etc
  - Composing the Services Based on the Value

Web Services Ecosystem

Value Space X (Reliability)

Broker X

Provider A

Provider B

Provider C

Provider D

Provider E

Value Space Y (Precision)

Broker Y

Requester 1

Requester 2

Requester 3
Value-Added Service Broker
Prototype of Value-Added Service Broker

- Value-Added Service Composition by Brokerage
  - Service Composer: Navigation of Composition Patterns by Value
    - Meta-model: Simple Ontology of Value
  - Content-Based Service Routing with WS-Routing
    - Extending SOAP Message and Rerouting by Broker

Value-Added Service Broker
Example: Dynamic Dictionary System

Navigated Collaboration of 3 Dictionary Systems

- ICD Service by @IT: Dictionary Specific to IT
  - Rich in IT Domain, but Narrow
- NetDicV06 Service by Sanseido (Dictionary Publisher):
  - Qualified General Dictionary by Japanese Publisher
  - Highly Reliable, Very Wide but Shallow
- SimpleWordBook: Developed by Students in our Laboratory
  - Specific to Software Engineering
  - Rich in Very Narrow Domain and Possible Incorrectness
Value-Added Service Broker
Example: Dynamic Dictionary System

Increase the Value (Reliability) of Information

- Enrich the Information by Multiple Dictionary
- ICD Service and SimpleWordBook: Possible to Search Technical Terms: e.g. “Apple Computer”
- ICD Service: Provide Rich Information: Company History
- NetDicV06 Service: “Apple” and its Associated Idioms

Example: Search of Words Including “apple”

“apple” is a fruit
Apple is a company
“Apple Computer”
Value-Added Service Broker
Example: Calculation System

**Precision-Guaranteed Calculation System**

- **Combining Different Computing Services**
  - **Ex. Specific Math Package**

- **Guarantee the Precision across End-to-End Processing**
  - **Ex. Data Type Conversion: Integer and Double**

![Diagram](Image)
Scenario

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Research Challenges
Research Challenges
Platform Technology

“2nd Generation”: From Web Services to SOC

- Extension of Platform Computing Architectures
  - Peer Services and Service Grid: Symmetric Web Services
  - Mobile Services
- Overcome Vulnerability and Cost of Decentralization
  - Security, Safety and Trust
  - (Long-Life) Transactions and Performance
- Migration of Legacy Applications and Components to SOC
  - Wrapping
Research Challenges
Development Technology: WebSE

New Frontier in Software Engineering

Process and Methodology

New Process for Development and Delivery

SOD (Service-On-Demand)?

Mapping Real-World (Business) to Web Services

Design and V&V of Dynamic Behavior

Modeling Networked Enterprises/Businesses

BPM Language and Methodology

Visual Modeling Language: UML 2 ++ ?
New Frontier in Software Engineering

- SOA
  - Broker Architecture
- Design for Non-Functional Requirements
  - SLA (Service Level Agreement) and SLM
  - AOSD (Aspect-Oriented Software Development)
  - Security, Safety and Truth
- Better Integration of Semantics: Ontology and Semantic Web
  - (Business) Ontology, Domain Engineering
Summary

Web = New Computing Model

- Creating a New Layer of “Computing” = Service/SOC
- Collaboration is the Key

Web Services Technology

- Rapid Advancement of Platform Technology
- Business Orchestration is the Issue

Need of Web Services Engineering

- Engineering on SOA and Broker Architecture

Semantic Web Services

- Integration of SOC/SOA and Semantic Web
Sense of Beauty in Design
Diversity and Balance/Collaboration
Thank You

Questions ?