

# Middleware and Web Services

## Lecture 6: Service Concepts

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## Service Oriented Architecture



- SOA supports two core business strategies
  - Growing top-line revenue
    - Enterprise reacts quickly to requirements from the market
    - Business processes can be reconfigured rather than reimplemented
  - Improving bottom-line profit
    - Saving development costs by reusing existing services
- Pre-integrated solutions
  - Out-of-the-box applications and integration solutions among them

## Overview

- Integrating Applications
- Web Service Architecture

## Integration and Interoperability

- Integration
  - *A process of connecting applications so that they can exchange and share capabilities, that is — information and functionalities.*
  - *Includes methodological approaches as well as technologies*
- Interoperability
  - *Ability of two or more applications to understand each other*
  - *Interoperability levels*
    - *Data – syntax/structure and semantics*
    - *Functions/Processes – syntax and semantics*
    - *Technical aspects – protocols, network addresses, etc.*

# Integration Approaches Overview



## Data-oriented Integration



- Third-party database access
  - Application D accesses a database of application B directly by using SQL and a knowledge of database B structure and constraints
  - In the past: monolithic and two-tier client/server architectures
  - Today: ETL (Extract, Transform, Load) technologies
- Problems
  - App D must understand complex structures and constraints
    - Data – very complex, includes structure and integrity constraints
    - Functions/processes – hidden in integrity constraints
    - Technical – access mechanisms can vary

## Service-oriented Integration



- Integration at the application layer
  - Application exposes services that other applications consume
  - Services hide implementation details but only define interfaces for integration
- Problems
  - Can become unmanageable if not properly designed
  - Interoperability
    - Data – limited to input and output messages only
    - Functions/processes – limited to semantics of services
    - Technical – access mechanisms can vary

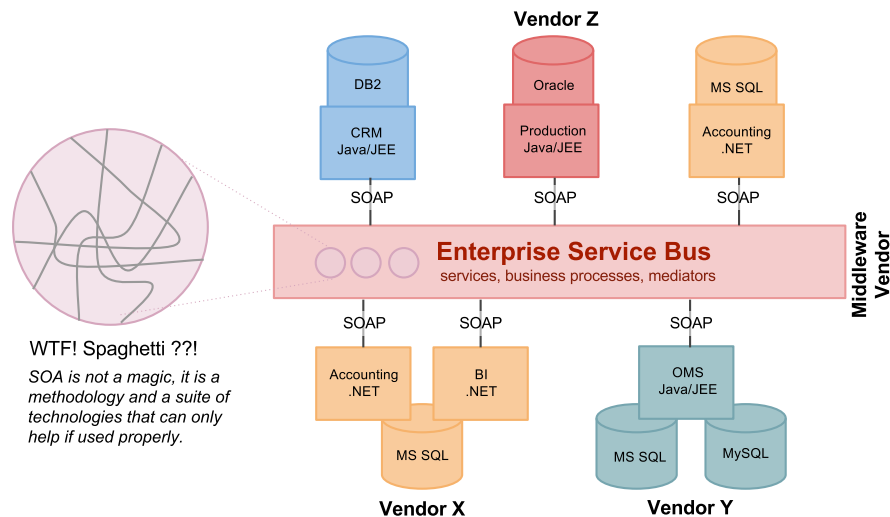
## One-to-One Service Integration

- Direct integration of applications
  - Multiple protocols problem, multiple vendor problem
  - Replication of integration functionalities such as interoperability solutions



## Many-to-Many Service Integration

- Enterprise Service Bus – central integration technology
  - Realizes so called Service Oriented Architecture (SOA)
  - Contains various integration components such as process server, mediators, messaging middleware, identity management, etc.



## Integration and Types of Data

- Transactional data – Web services
  - Service-oriented integration
  - online, realtime communication between a client and a service
  - Usually small amount of data and small amount of service invocation in a process
- Bulk data – ETL
  - Data-oriented integration
  - processing of large amount of data in batches
- **ESB provides both Web service and ETL capabilities**

## Overview

- Integrating Applications
- **Web Service Architecture**
  - *Definition of a Service*
  - *Service Interface Components*

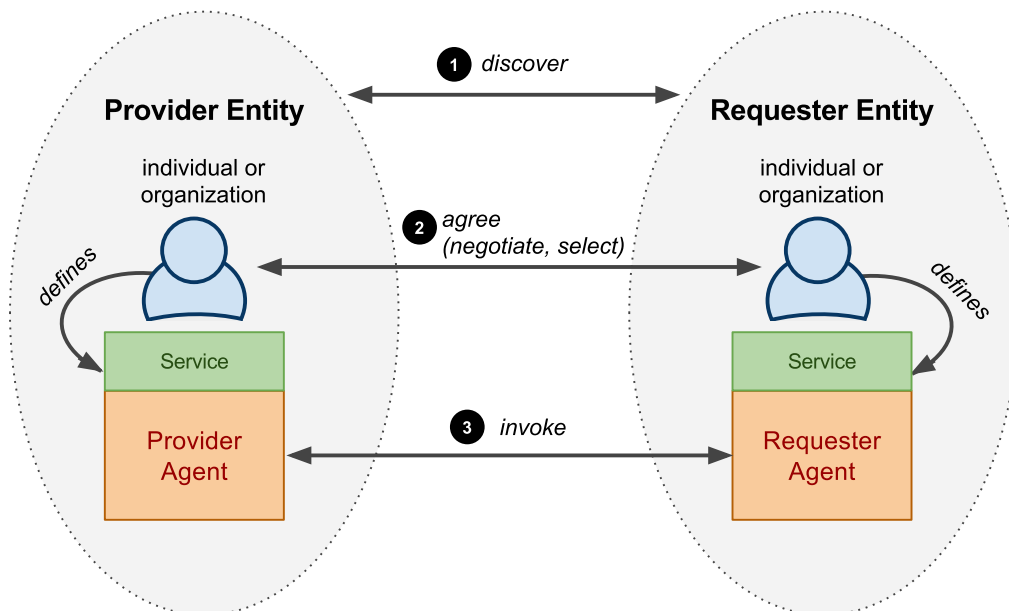
## Web Service Architecture

- Web Service Architecture
  - *Defined by W3C in Web Service Architecture Working Group Note* [🔗](#)
  - *Defines **views***
    - *message-oriented view (WSDL and SOAP)*
    - *resource-oriented view (REST and HTTP)*
  - *Defines **architecture entities** and their **interactions***
    - *Abstraction over underlying technology*
    - *Basis for service usage processes and description languages*
- Service Oriented Architecture
  - *Collection of tools, methods and technologies*
  - *There is some implicit understanding of SOA in the community such as*
    - *SOA is a solution for Enterprise Application Integration*
    - *SOA is realized by using SOAP, WSDL, (and UDDI) technologies*
    - *SOA utilizes Enterprise Service Bus (ESB)*
  - ⇒ *~ a realization of Web Service Architecture message-oriented view*

## Basic Entities

- **Agent**
  - *software or hardware that sends/receives messages*
  - *concrete implementation of a service*
- **Service**
  - *abstract set of functionality and behavior*
  - *two different agents may realize the same service*
- **Provider**
  - *owner (person or organization) that provides an agent realizing a service*
  - *also called a service provider*
- **Requester**
  - *a person or organization that wishes to make use of a provider's service*
  - *uses a requester's agent to exchange messages with provider's agent*

## Interaction of Entities



## Overview

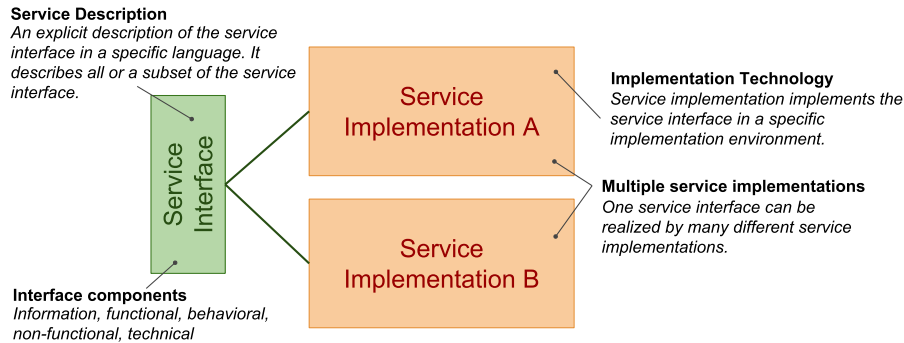
- Integrating Applications
- Web Service Architecture
  - *Definition of a Service*
  - *Service Interface Components*

## Service

- Difficult to agree on one definition
- Business definition
  - *A service realizes an effect that brings a business value to a service consumer*
  - *for example, to pay for and deliver a book*
- Conceptual definition
  - *service characteristics*
  - *encapsulation, reusability, loose coupling, contracting, abstraction, discoverability, composability*
- Logical definition
  - *service interface, description and implementation*
  - *service usage process*
  - *service use tasks, service types*

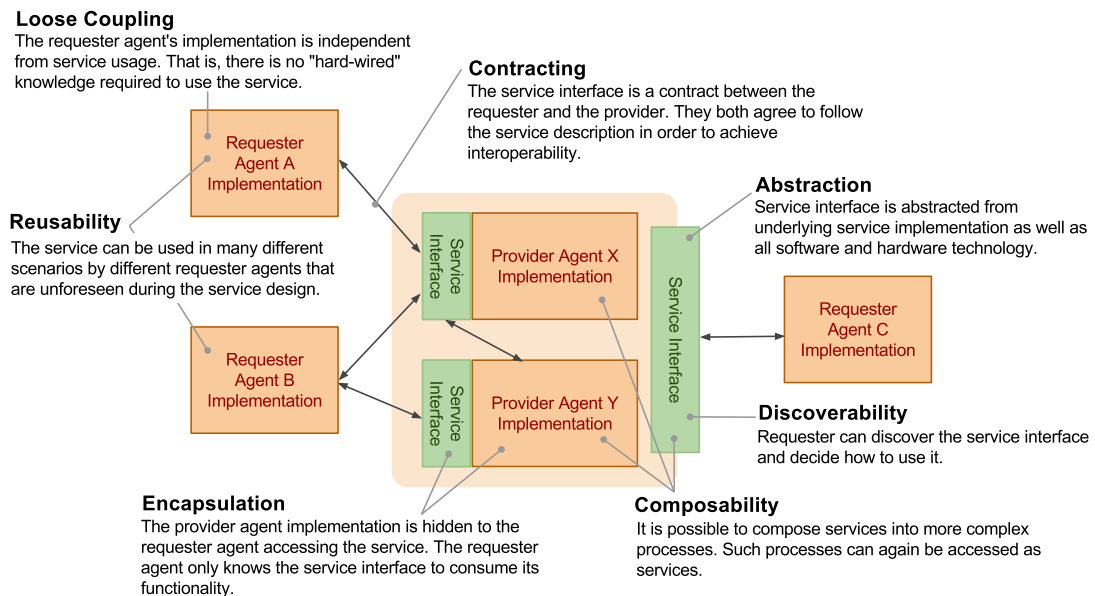


# Interface, Description and Implementation



- Terminology clarification
  - *service ~ service interface + service implementation*
  - *WSDL service ~ service description in WSDL language*
  - *SOAP service ~ a service interface is possible to access through SOAP protocol; there is a WSDL description usually available too.*
  - *REST/RESTful service ~ service interface that conforms to REST architectural style and HTTP protocol*

## Service Characteristics



## Service Description

- Standards-driven
  - *Standards that define service description*
  - *They give a space for variability*
    - *too much – big flexibility but increases complexity (~WSDL)*
    - *limited – enforce agreement and interoperability (~REST)*  
(as long as parties correctly implement the standard)
- Languages to describe service interfaces
  - *formal – machine processable*
  - *textual – natural text description*
- Comparison of WSDL and REST models for service interfaces

| Model | Standards-driven  | Languages   |
|-------|---|---|
| WSDL  | XML-based WSDL, XML Schema for input/output/fault messages; big space for variations (operations, exchange patterns, protocols) | WSDL+XML, textual description for rules of public processes |
| REST  | Web Architecture, HTTP, XML Schema, JSON; little space for variations (uniform interface, statelessness, etc.)                  | HTML – mostly textual description, AtomPub, WADL            |

## Overview

- Integrating Applications
- Web Service Architecture
  - *Definition of a Service*
  - *Service Interface Components*

## Service Interface

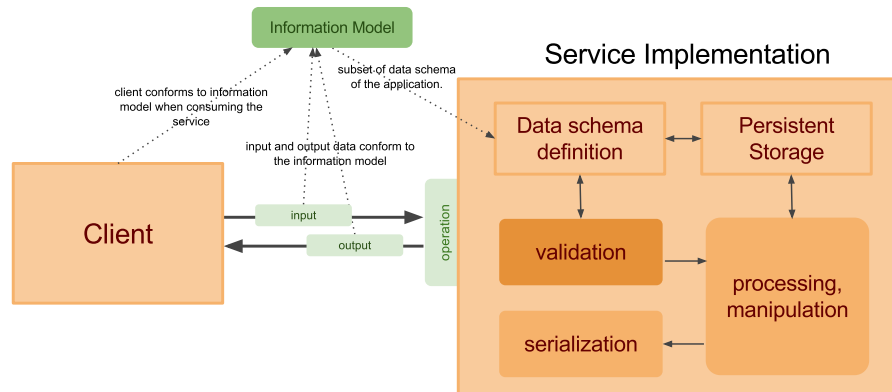
- They correspond to interface definition
- Service interface components
  - *Information*
    - data used by the service
    - for example, input and output messages, resource representations
  - *Functional*
    - capability: operations, preconditions, effects
    - pointer to a classification hierarchy
  - *Behavioral*
    - public process: how to consume the service's functionality
    - orchestration: realization of service's functionality
  - *Non-Functional*
    - security, financial, descriptive info (author, date)
  - *Technical*
    - technical details such as IP addresses, ports, protocols, etc.

## Running Example

- Textual service description
  - *Service name: Order Book Service*

```
1  * the service provides three operations: 'open', 'add', 'close'
2  * operation 'open' opens the order
3    - input: none
4    - output: text informing that the order was opened
5
6  * operation 'add' adds an item to the order
7    - input: an item name, the syntax is [0-9A-Za-z\-\-]+
8    - output: text informing that the item was added to the order
9
10 * operation 'close' closes the order and returns all items in the order
11   - input: none
12   - output: list of all items previously added to the order
13
14 * the public process is: S0--open--S1, S1--add--S1, S1--close--S0, where
15   S0, S1 are states such that S0 = order is closed, and S1 = order is opene
16
17 * protocol is HTTP, method POST for all operations,
18   running locally, tcp/8080, stateful server
```
- Service implementation
  - Will go through the code in Java
  - Will use the *session object* (see Lecture 3) for the state management

# Information Component



- Information Component
  - Defines models for all data used by the service as input/output messages, states
  - Data in formats mostly XML and JSON or plain text (our example)
  - Languages: XML Schema, or other—regular grammars or plain text.
- Tasks
  - Validation – check the syntax and validates the data against rules
  - Processing and manipulation – process and manipulates the data
  - Serialization – transforms the data to transportation formats (XML, JSON, text)

## Example

- Description

```
1 | ...
2 | * operation 'add' adds an item to the order
3 |   - input: an item name, the syntax is [0-9A-Za-z\-\-]+
4 |   - output: text informing that the item was added to the order
5 | ...
```

- Service implementation

- Validation – syntax checking

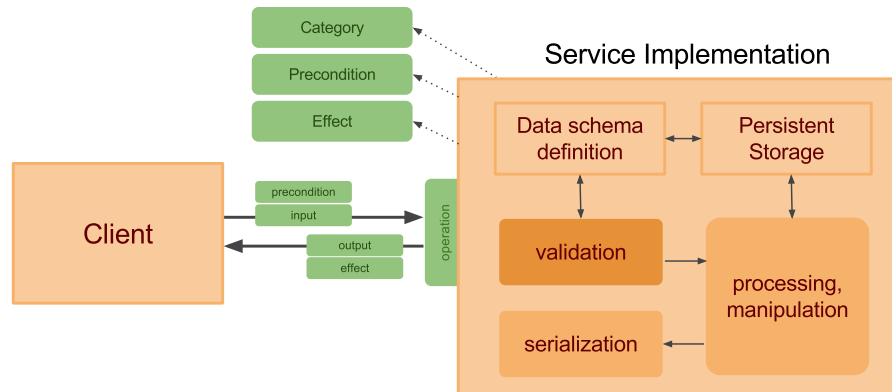
```
1 | // check the syntax of the item name
2 | if (item.matches("[a-zA-Z0-9\\-]+"))
3 |     // ... process operation
4 |     return "Item added.";
5 | else
6 |     throw new Exception("Invalid item name.");
```



### Tasks

- Describe a complex item using XML Schema and learn how to validate it in Java.

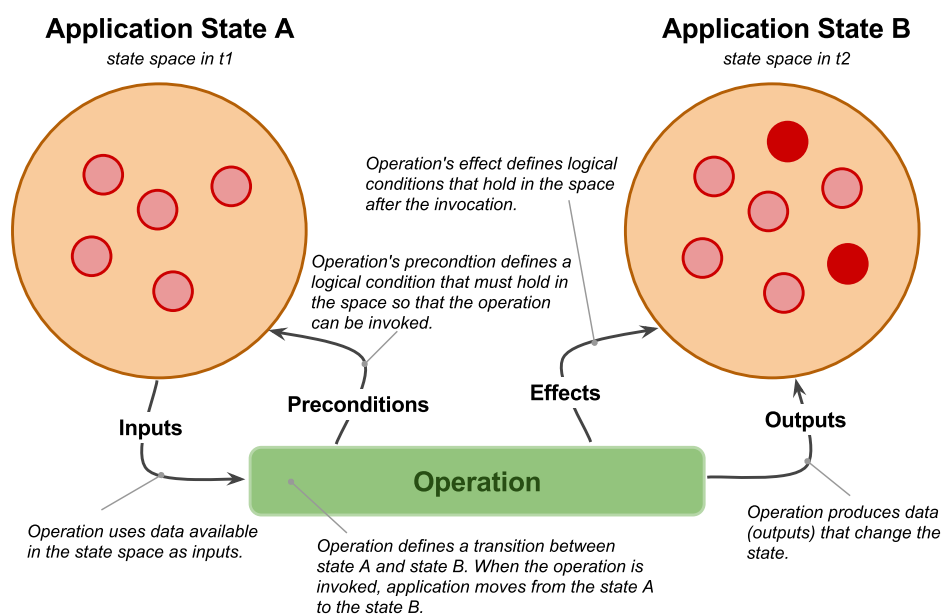
# Functional Component



- **Functional component**
  - Service has a set of operations
    - each operation has input and output data from the information model
    - each operation has a capability (a precondition and an effect)
  - Service has a functional category – pointer to a classification hierarchy
  - Service has a capability (a precondition and an effect)
- **Tasks**
  - Validation – checks a precondition holds in a state before processing

# Preconditions and Effects

- **Preconditions and effects on an operation**  
*(Note that preconditions and effects on a service are analogical)*



## Example

- Description

```
1 * the service provides three operations: 'open', 'add', 'close'
2 ...
3 * the public process is: S0--open--S1, S1--add--S1, S1--close--S0, where
4 S0, S1 are states such that S0 = order is closed, and S1 = order is opened.
5 ...
```

⇒ *There is an order of operations such that*  
→ before invoking **add**, the client must invoke **open**  
⇒ *operation add has*  
→ precondition **order.isOpen()==true**  
→ effect **item in order.items**

```
1 if (order.isOpen()) {
2     // ...
3     order.getItems().add(item);
4     return "Item added.";
5 } else
6     throw new Exception("An order must be opened before adding the item!");
```

## Functional Category Example

- Classification schema

- Describes taxonomy of services (outside of service interface)
- Functional category points to a term in the taxonomy

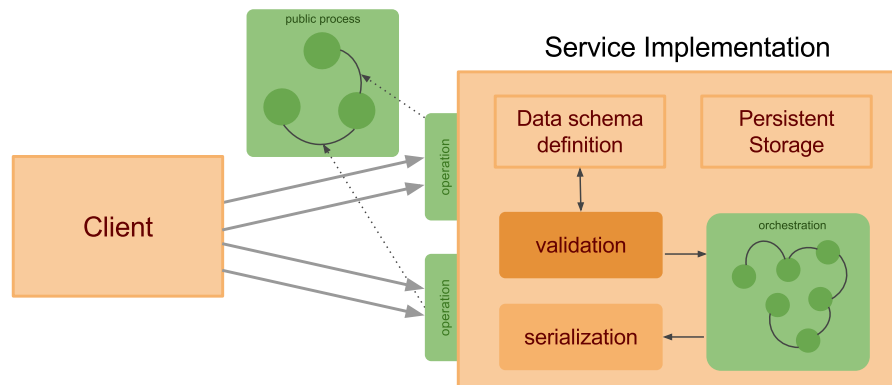
- Example

- Classification schema in XML

```
1 <?xml version="1.0" encoding="utf-8"?>
2 <root xmlns="http://example.org/service-classification-schema">
3     <order>
4         <book>
5             <adventure/>
6             <travel/>
7         </book>
8         <electronics>
9             <TV/>
10            <computer/>
11        </electronics>
12    </order>
13    <shipment><!-- shipment services -->
14 </root>
```

- functional category as XPath expression: **/root/order/book**
- implicit assumption: XML hierarchy is a **sub-class-of** hierarchy

# Behavioral Component



- Behavioral component
  - *public process*
    - *order of operations for the correct functionality consumption*
    - *can be derived from preconditions of service operations*
      - *Note that not all operations must participate in the public process*
      - *A service can have more than one public processes*
  - *orchestration*
    - *How service's functionality is composed out of other services*

## Example

- **processOrder** method implements a public process

```
1 public String processOrder(String op, String item, SessionData sessionData) throws Except
2     if (op.equals("open")) {
3         if (sessionData.isOpen())
4             throw new Exception("Order was already open");
5         else {
6             sessionData.open();
7             return "The new order has been opened";
8         }
9     }
10    if (op.equals("add")) {
11        if (sessionData.isOpen()) {
12            if (item.matches("[a-zA-Z0-9\\-]+"))
13                sessionData.getItems().add(item);
14            else throw new Exception("Invalid item name.");
15            return "Item added.";
16        } else
17            throw new Exception("An order must be opened before adding the item!");
18    }
19    if (op.equals("close")) {
20        if (sessionData.isOpen()) {
21            String response = "The order has been closed, the ordered items are:\n";
22            for (String i : sessionData.getItems())
23                response += " " + i + "\n";
24            return response;
25        } else
26            throw new Exception("Cannot close an order that has not been opened!");
27    }
28    throw new Exception("Invalid operation: " + op);
29 }
```

## Example (Cont.)

- **RequestHandler** implementation

```
1 public void handleRequest(HttpServletRequest request,
2     HttpServletResponse response) throws IOException, ServletException {
3     // get the session id and create the new session data if none exist
4     String sid = sessions.getSessionID(request);
5     SessionData sessionData = sessions.getData(sid);
6     if (sessionData == null) {
7         sessionData = new SessionData();
8         sessions.setData(sid, sessionData);
9     }
10
11     try {
12         if (request.getMethod().equals("POST")) {
13             String responseText = processOrder(request.getParameter("op"),
14                 request.getParameter("item"), sessionData);
15             response.setStatus(200);
16             response.setHeader("cookie", "session-id="+sid);
17             response.setContentType("text/plain");
18             response.getWriter().write(responseText);
19         } else {
20             response.setStatus(405); // Method not allowed
21             response.setHeader("Allow", "POST");
22         }
23     } catch (Exception e) {
24         response.setStatus(400); // client-side error
25         response.setContentType("text/plain");
26         response.getWriter().write(e.getMessage());
27     }
28     response.flushBuffer();
29 }
```

## Evaluation

- How "good" is our Order service?
  - *Analysis of the service by service characteristics.*

| Principle                       | +/- | Comment  |
|---------------------------------|-----|--|
| Loose Coupling                  | +   | Uses standard response codes.  |
|                                 | –   | Unforeseen clients will have to know the service's public process to work with it.                             |
|                                 | –   | Uses operation names that clients must understand.   |
| Reusability                     | –   | Can be reused but is subject to loose coupling issues.   |
| Contracting and Discoverability | –   | Textual description is informal, it is hard to agree on the service interface.                                 |
| Composability                   |     | N/A  |
| Abstraction                     | +   | Service description can be implemented by various implementation technologies.                                 |
| Encapsulation                   | +   | Distinguishes interface from implementation, processing logic is not exposed to clients through the interface. |