

# Middleware and Web Services

## Lecture 6: Service Concepts

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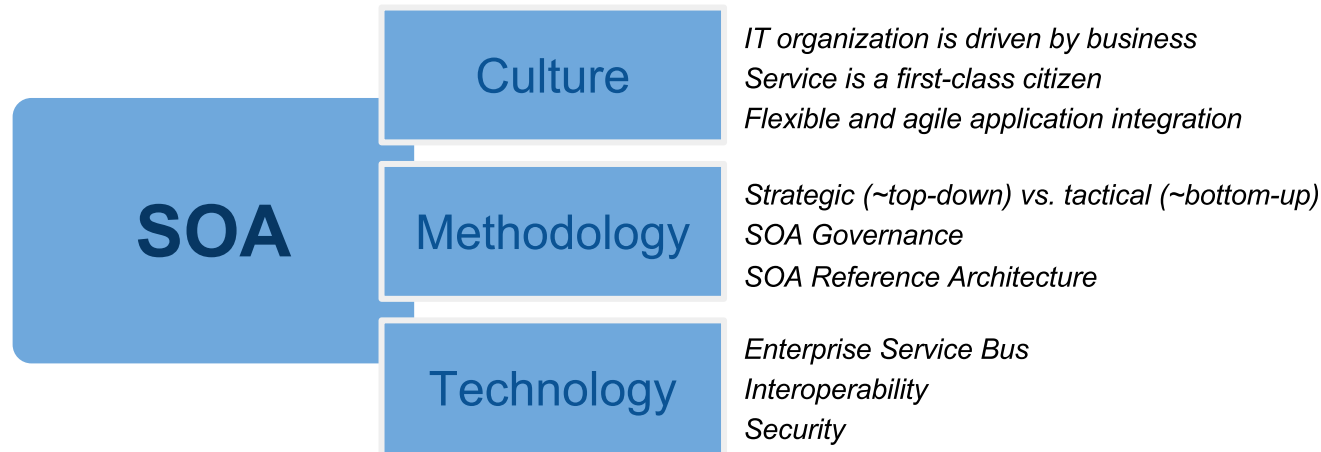
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# Service Oriented Architecture



- 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 resuing existing services*
- Pre-integrated solutions
  - *Out-of-the-box applications and integration solutions among them*

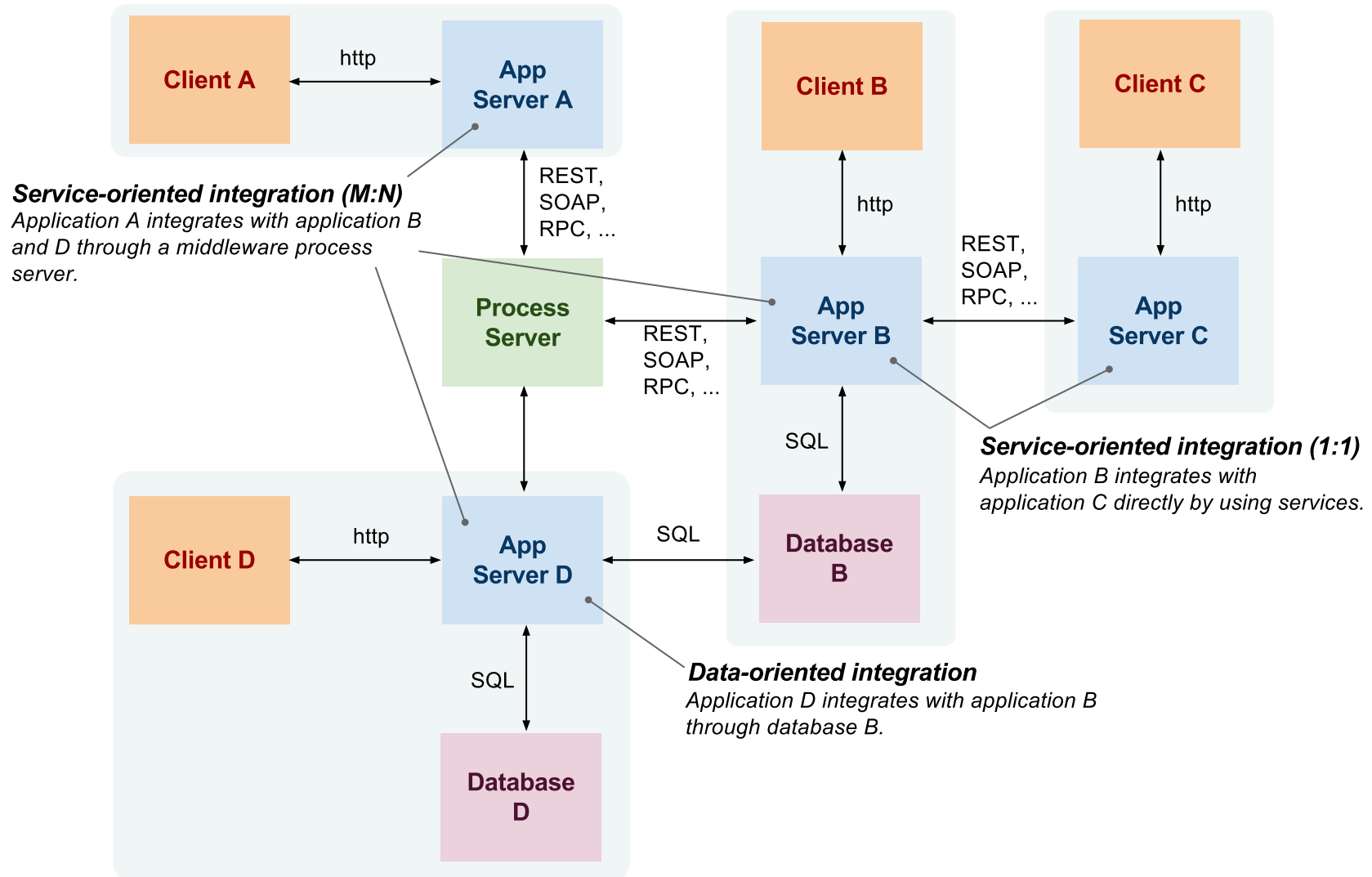
# Overview

- 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

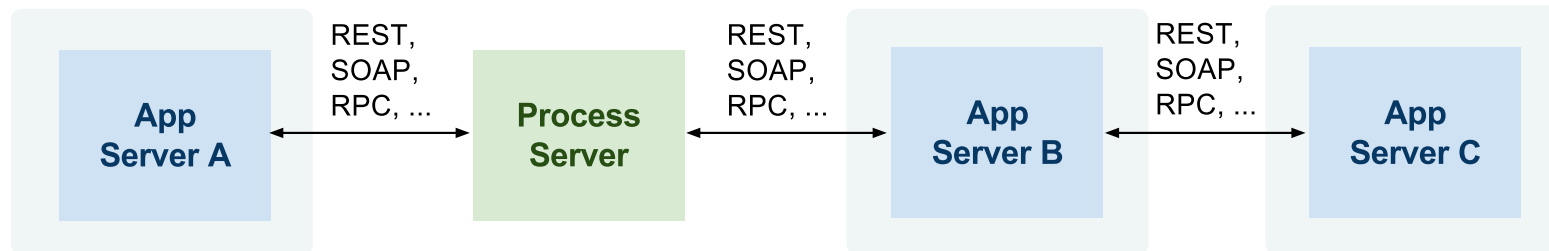


# Data-oriented Integration



- 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

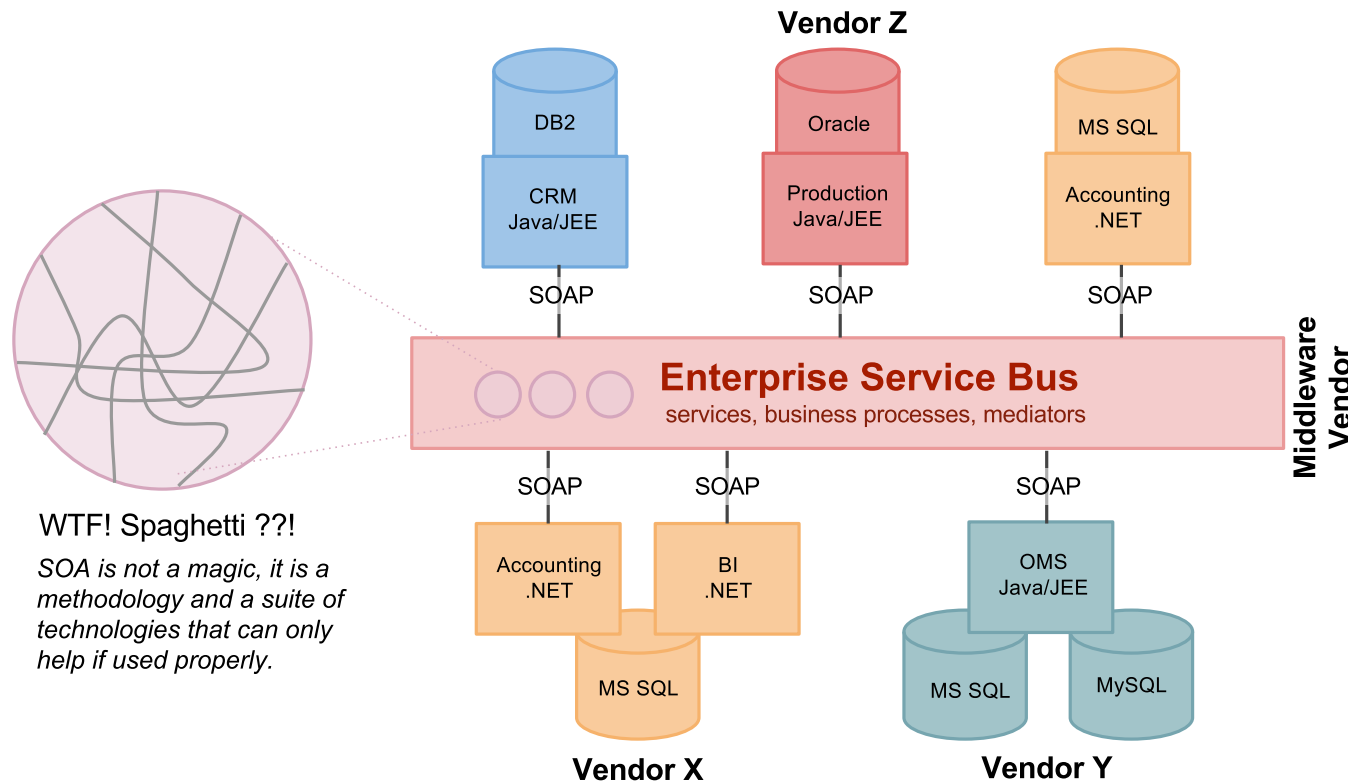
- Direct integration of applications
  - *Multiple protocols problem, multiple vendor problem*
  - *Replication of integration functionalities such as interoperability solutions*





# 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*

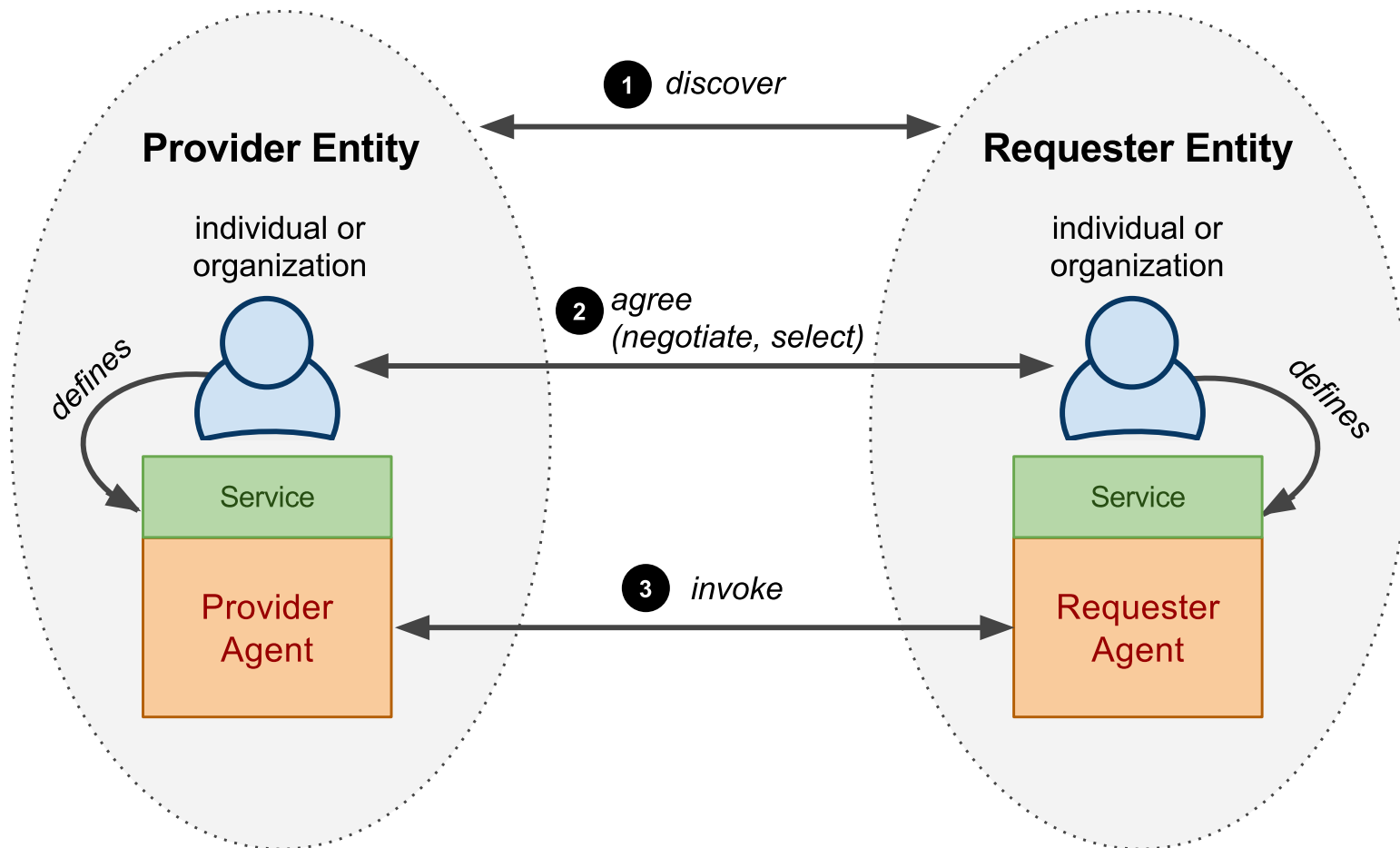
# Web Service Architecture

- 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*



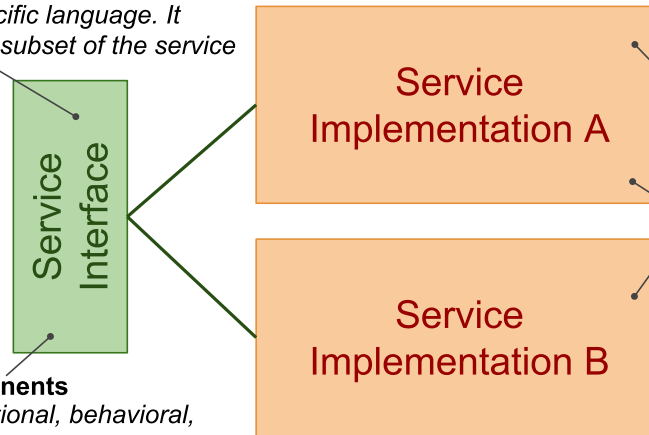
# Interface, Description and Implementation

## Service Description

An explicit description of the service interface in a specific language. It describes all or a subset of the service interface.

## Interface components

Information, functional, behavioral, non-functional, technical



## Implementation Technology

Service implementation implements the service interface in a specific implementation environment.

## Multiple service implementations

One service interface can be realized by many different service implementations.

- 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

## Loose Coupling

The requester agent's implementation is independent from service usage. That is, there is no "hard-wired" knowledge required to use the service.

## Reusability

The service can be used in many different scenarios by different requester agents that are unforeseen during the service design.

## Contracting

The service interface is a contract between the requester and the provider. They both agree to follow the service description in order to achieve interoperability.

## Abstraction

Service interface is abstracted from underlying service implementation as well as all software and hardware technology.

## Discoverability

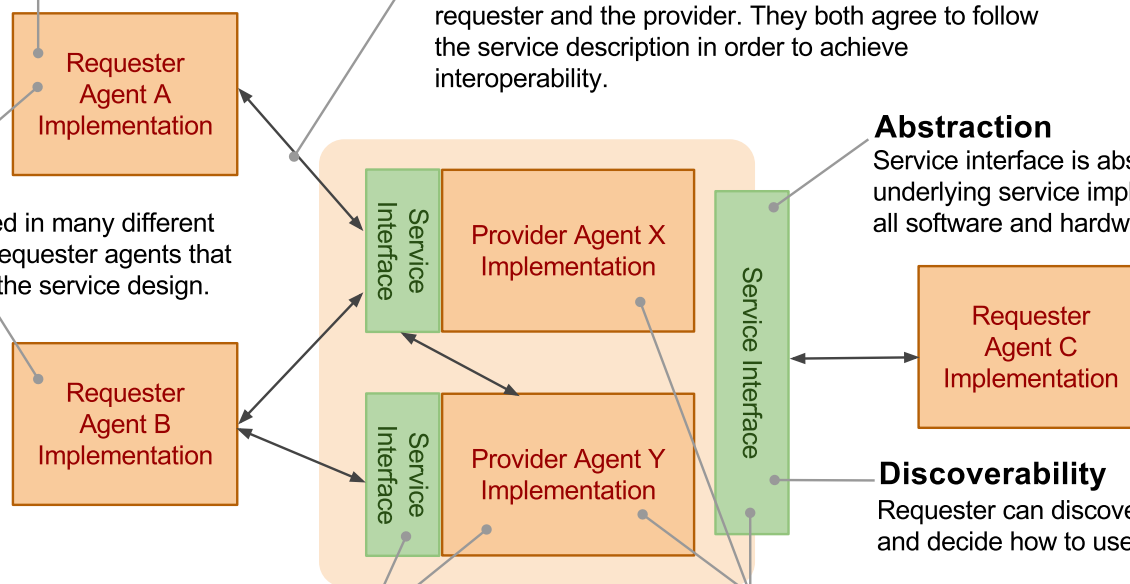
Requester can discover the service interface and decide how to use it.

## Encapsulation

The provider agent implementation is hidden to the requester agent accessing the service. The requester agent only knows the service interface to consume its functionality.

## Composability

It is possible to compose services into more complex processes. Such processes can again be accessed as services.



# 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   |
|-------------|---|---|
| <b>WSDL</b> | 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 |
| <b>REST</b> | 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

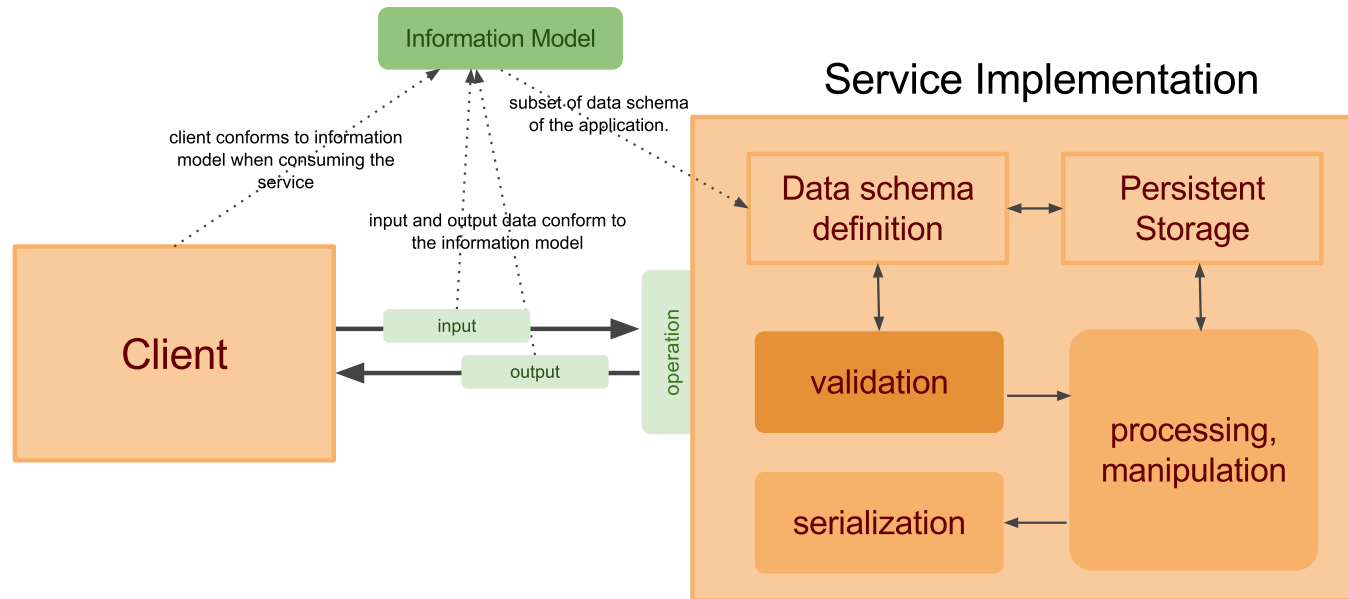
- *Service name: Order Book Service*

```
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 opened.
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.");
```

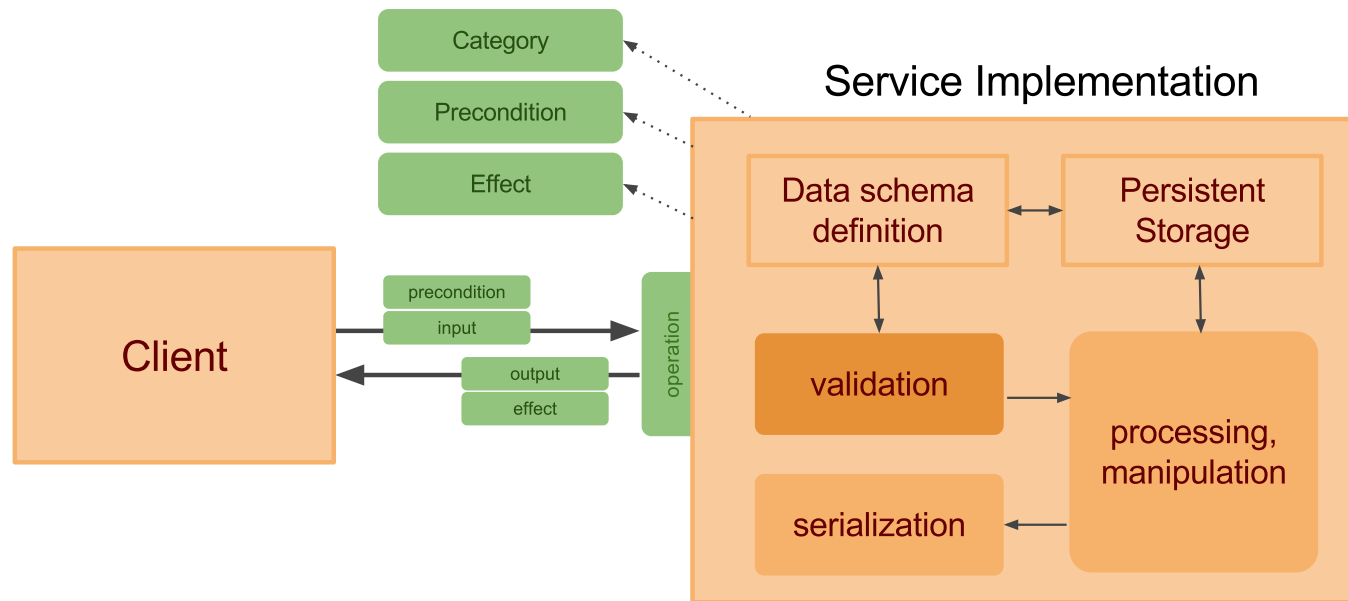


## Tasks

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



# Functional Component

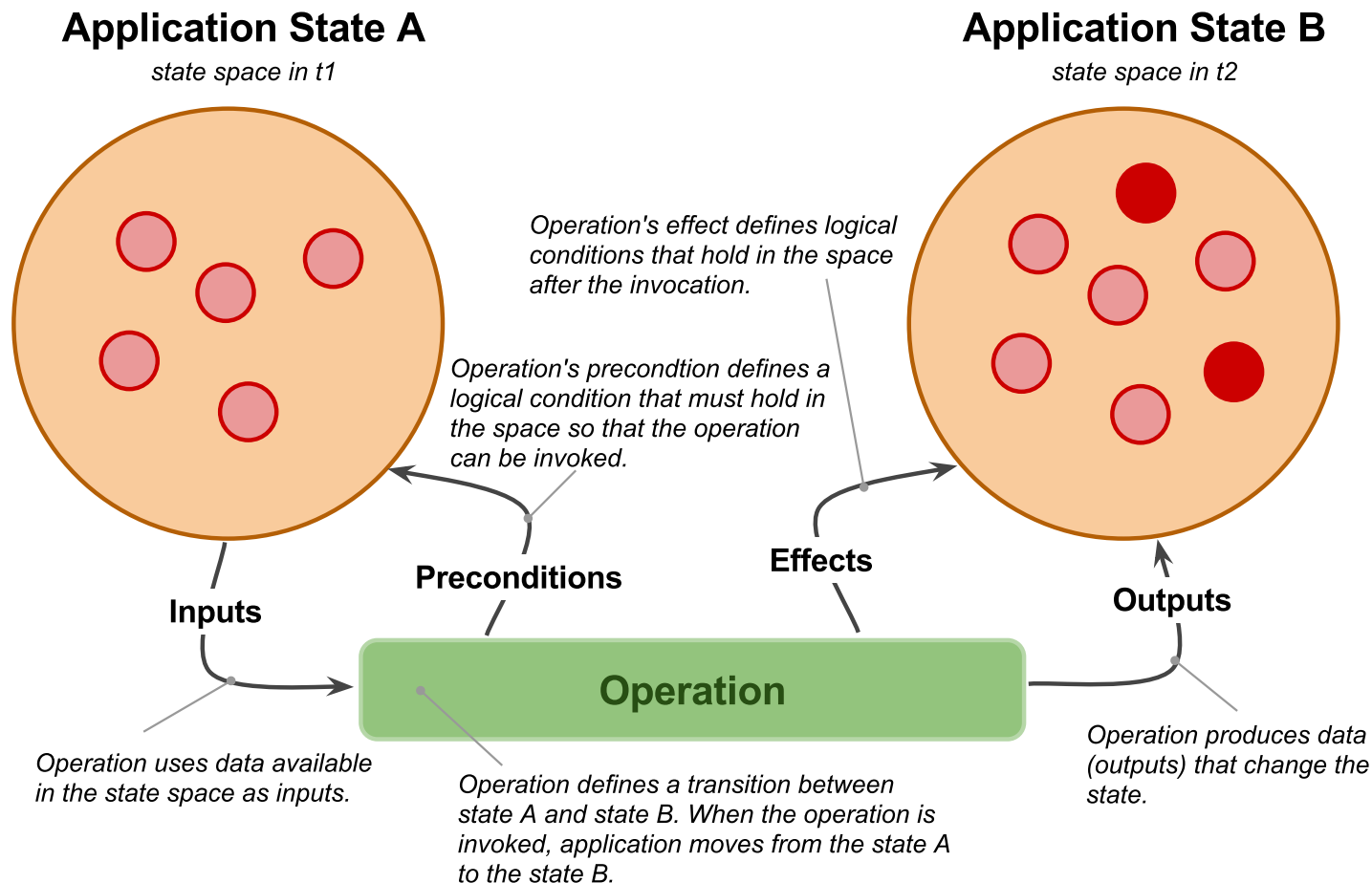


- Functional component
  - Service has a set of operations
    - each operation has input and output data from the information model
    - each operation has a capability (a precondition and an effect)
  - Service has a functional category – pointer to a classification hierarchy
  - Service has a capability (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!");
```

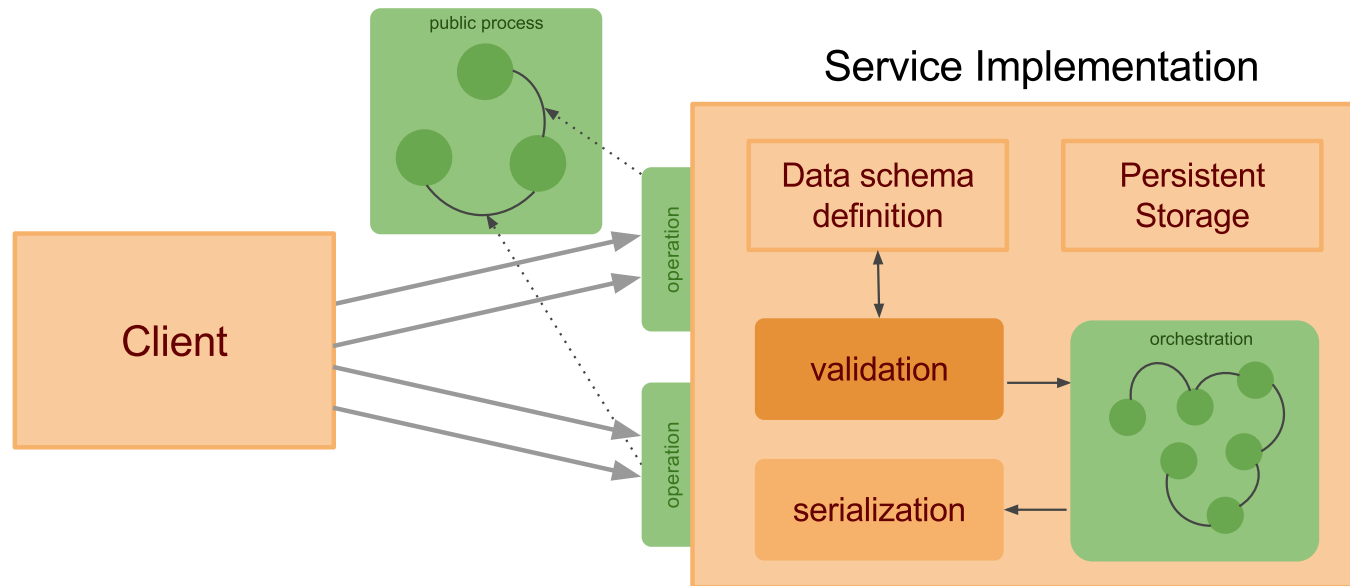
# Functional Category Example

- 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 thas 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. |