# Middleware and Web Services

## Lecture 6: Service Concepts

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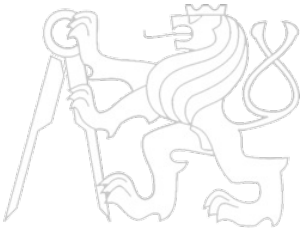

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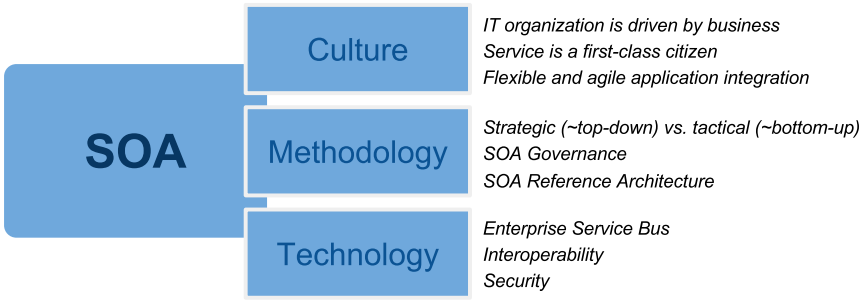
## Service Oriented Architecture




- 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

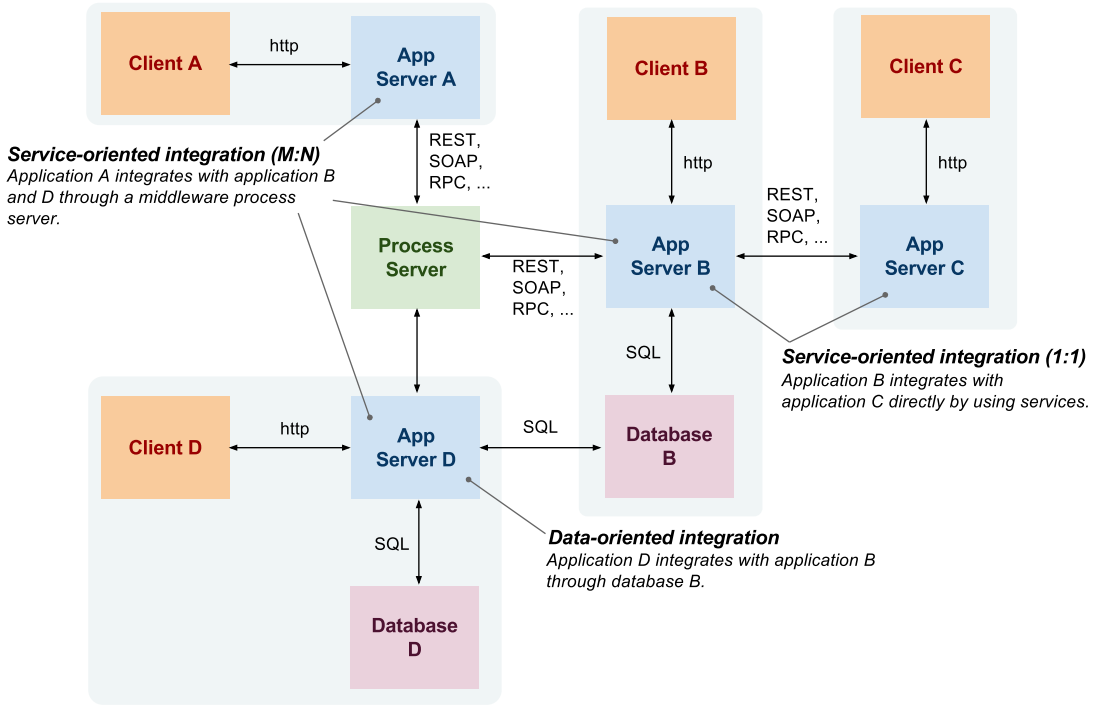
- Integrating Applications
- Web Service Architecture



## Integration and Interoperability

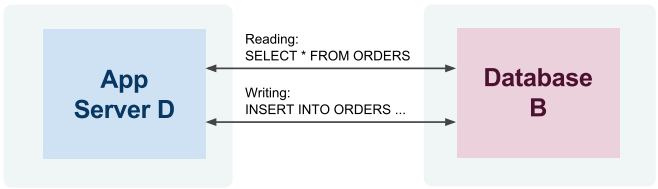
- Integration
  - *A process of connecting applications so that they can exchange and share capabilities, that is — information and functionalities.*
  - *Includes methodological approaches as well as technologies*
- Interoperability
  - *Ability of two or more applications to understand each other*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

# Integration Approaches Overview



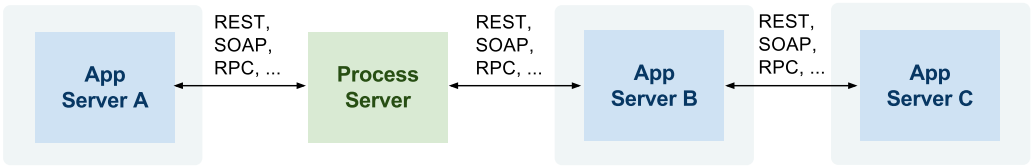



# Data-oriented Integration




- 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

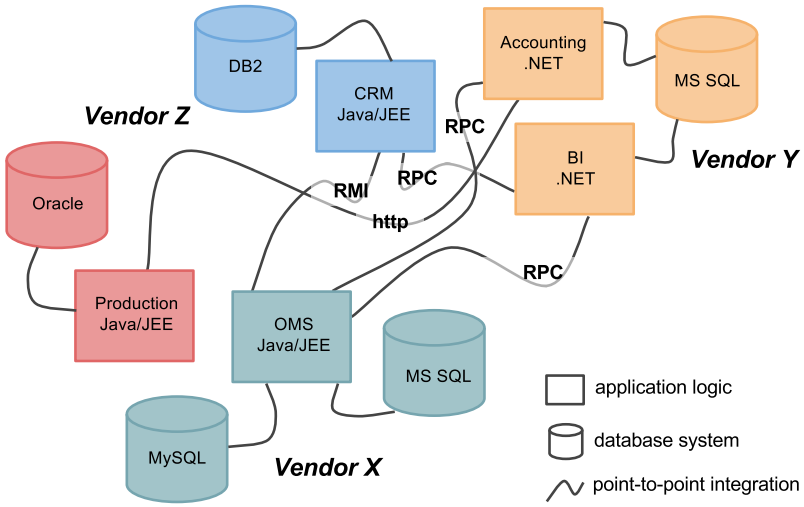



- Integration at the application layer
  - *Application exposes services that other applications consume*
  - *Services hide implementation details but only define interfaces for integration*
- Problems
  - *Can become unmanageable if not properly designed*
  - *Interoperability*
    - → *Data – limited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



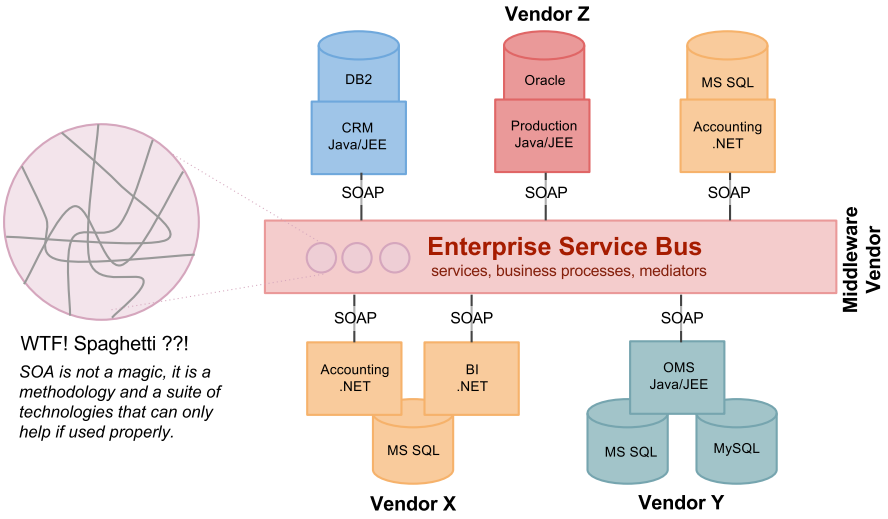
# One-to-One Service Integration

- 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.*




WTF! Spaghetti ??!

*SOA is not a magic, it is a methodology and a suite of technologies that can only help if used properly.*



# 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

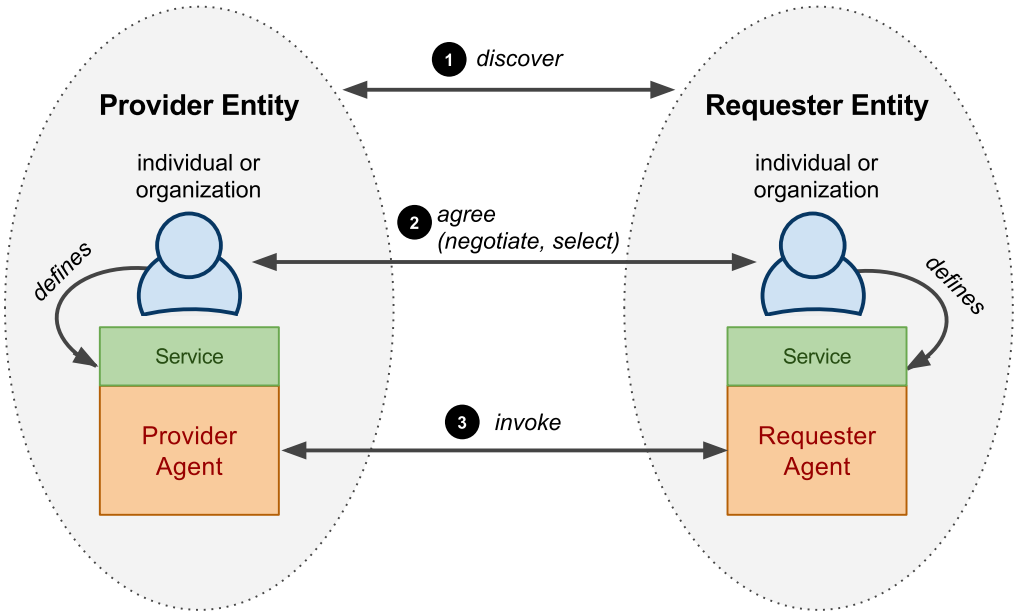
- Web Service Architecture
  - *Defined by W3C in Web Service Architecture Working Group Note*
  - *Defines **views***
    - → *message-oriented view (WSDL and SOAP)*
    - → *resource-oriented view (REST and HTTP)*
  - *Defines **architecture entities** and their **interactions***
    - → *Abstraction 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 provides advances over 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

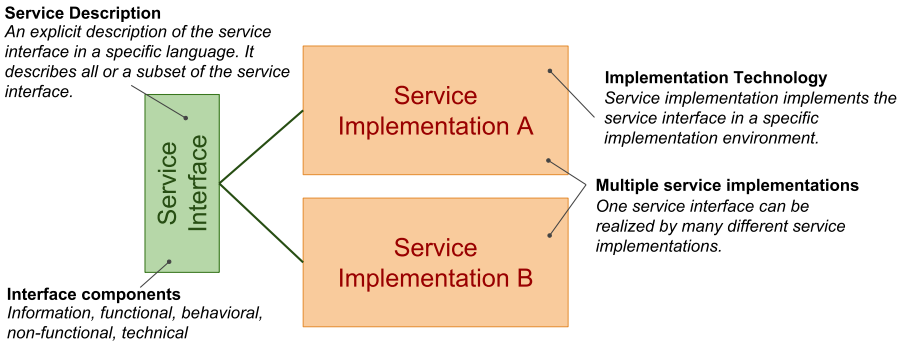
- Integrating Applications
- Web Service Architecture
  - *Definition of a Service*
  - *Service Interface Components*



## 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*

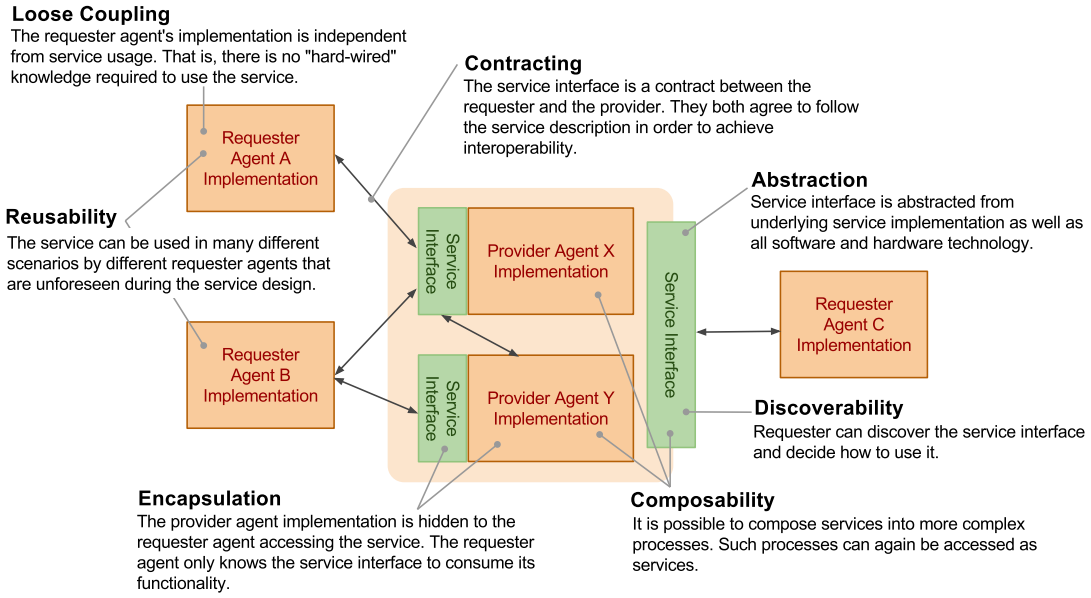
# Interface, Description and Implementation




- 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.*



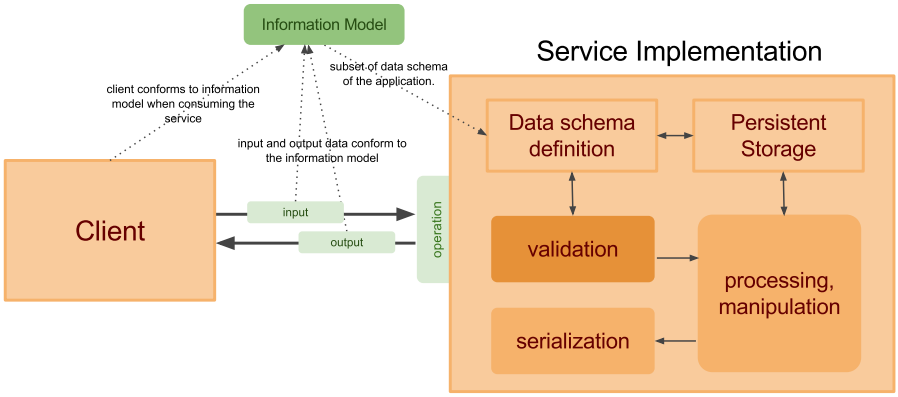
# Running Example

- 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 localy, 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

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

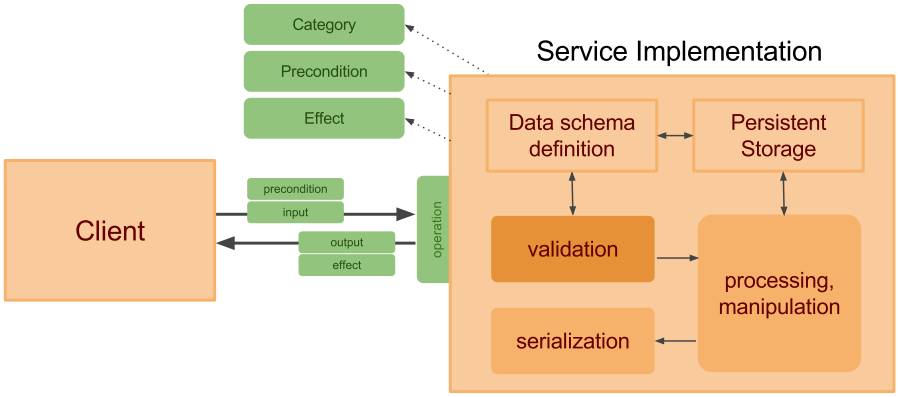
- Service implementation
  - *Validation – syntax checking*

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

## Tasks

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

# Functional Component

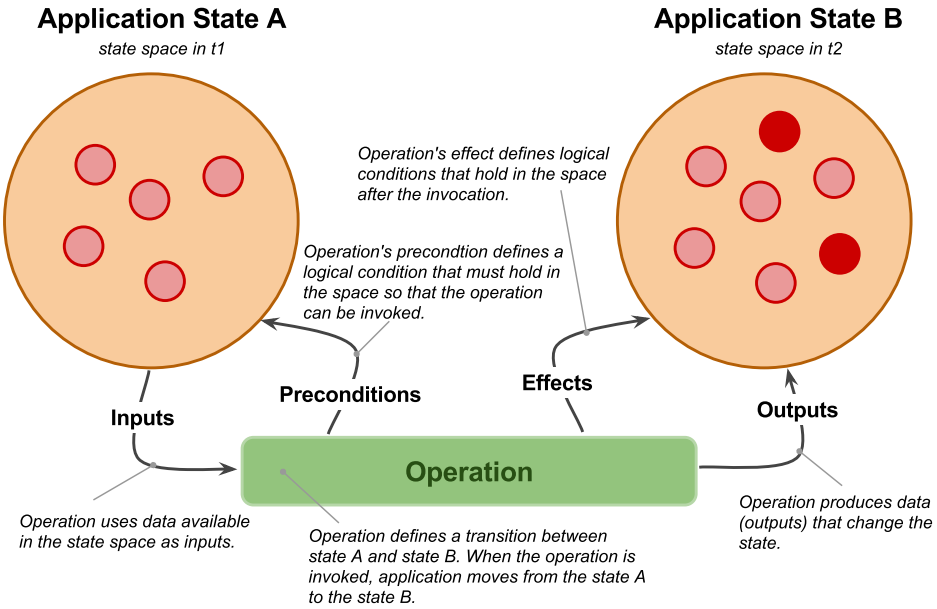



- Functional component
  - *Service has a set of operations*
    - *→ each operation has input and output data from the information model*
    - *→ each operation has a capability (a precondition and an effect)*
  - *Service has a functional category – pointer to a classification hierarchy*
  - *Service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

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

⇒ *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`

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



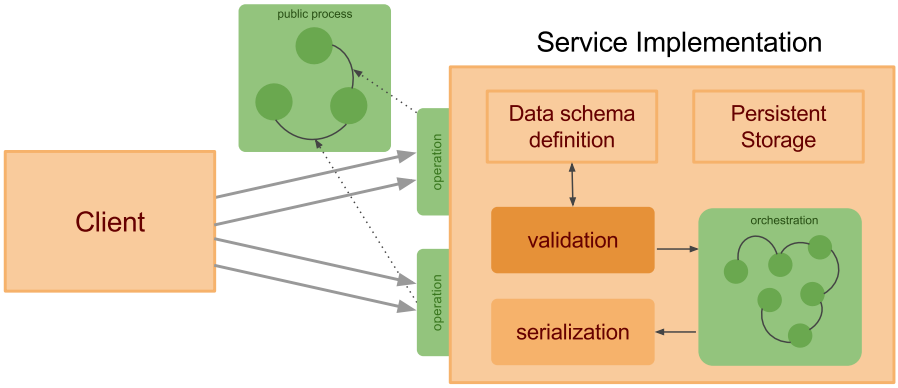
# Functional Category Example

- Classification schema
  - *Describes taxonomy of services (outside of service interface)*
  - *Functional category points to a term in the taxonomy*
- Example
  - *Classification schema in XML*

```
<?xml version="1.0" encoding="utf-8"?>
<root xmlns="http://example.org/service-classification-schema">
    <order>
        <book>
            <adventure/>
            <travel/>
        </book>
        <electronics>
            <TV/>
            <computer/>
        </electronics>
    </order>
    <shipment><!-- shipment services -->
</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 Excep
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 openned 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 openned!");
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 throught the interface. |