Multi-agent and Semantic Web Systems: Web Services: Part 1

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Antecedents

B2B

Previous attempts at distributed computing (CORBA, Distributed Smalltalk, Java RMI) have yielded systems where the coupling between various components in a system is too tight to be effective for low-overhead, ubiquitous B2B e-business over the Internet. These approaches require too much agreement and shared context among business systems from different organizations to be reliable for open, low-overhead B2B e-business.

`http://www-128.ibm.com/developerworks/webservices/library/w-ovr/`

Web Service Architecture

- Tightly coupled, monolithic systems are brittle:
  - changing the output of one subsystem can cause the whole system to break;
  - software collaboration may unintentionally rely on side effects of a specific implementation.
- Web Service architecture is designed to be loosely coupled;
- applications use service discovery to dynamically bind components to concrete network-available services.

Applications in WS Architecture

Application Design

- Describe capabilities of network services needed to perform a function.
- Describe the 'orchestration' of these collaborators.

Application Execution

- Translate collaborator requirements into query to discovery agent.
- Locate service with right capabilities.
- Orchestrate message-passing to invoke services.

- Desired goal: "Just-in-time" integration of applications.

Concepts and Terminology

- Following terminology about Web Services derived from W3C *Web Services Architecture* (WS-Arch: W3C WG Note, 2004–2-11).

- http://www.w3.org/TR/ws-arch/

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WS Standards

WSDL (Web Service Description Language) and SOAP: W3C Recommendations; used widely but not universally.

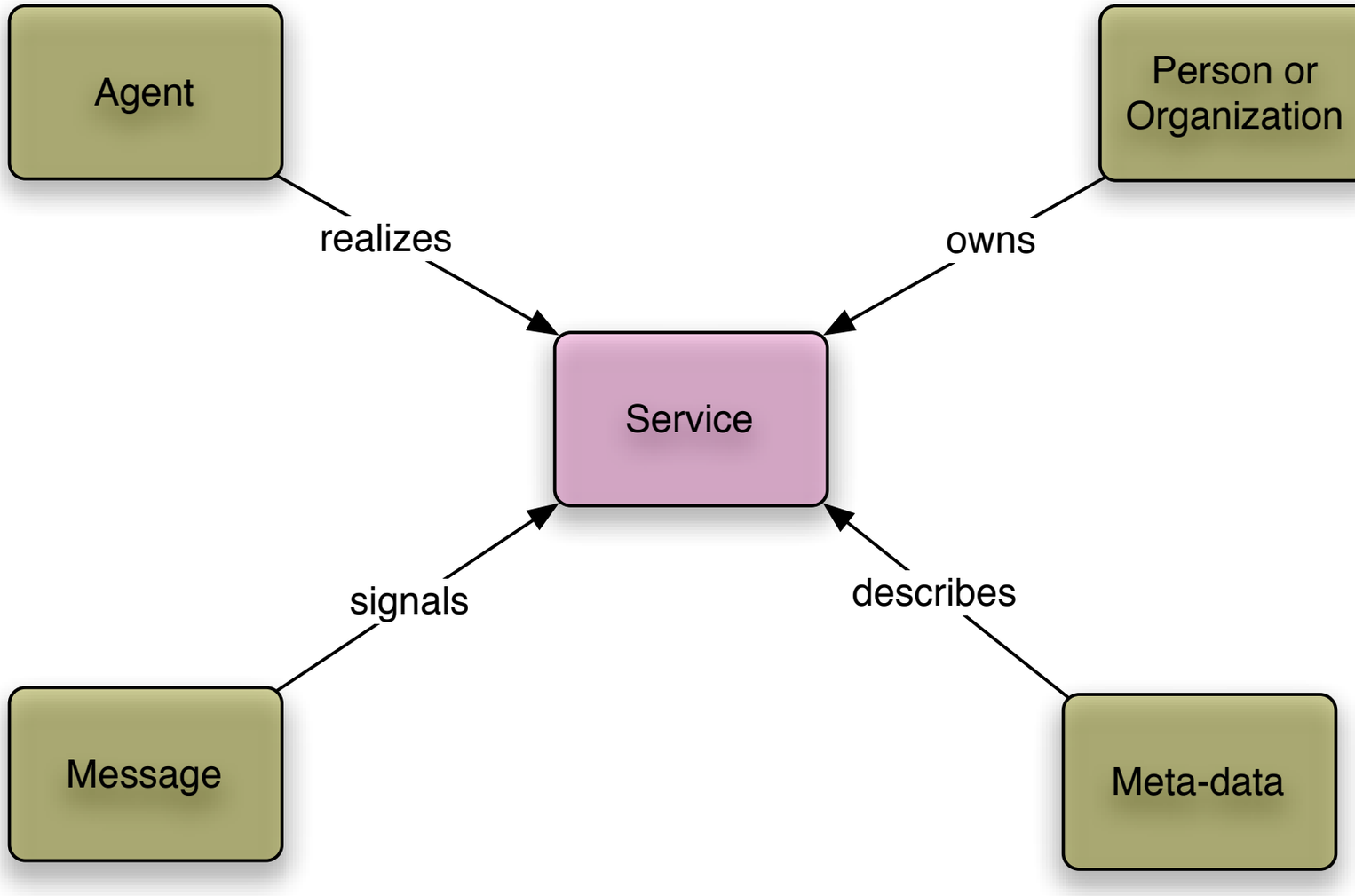
Agents, Entities and Services

- WS is intended to be an abstract notion.

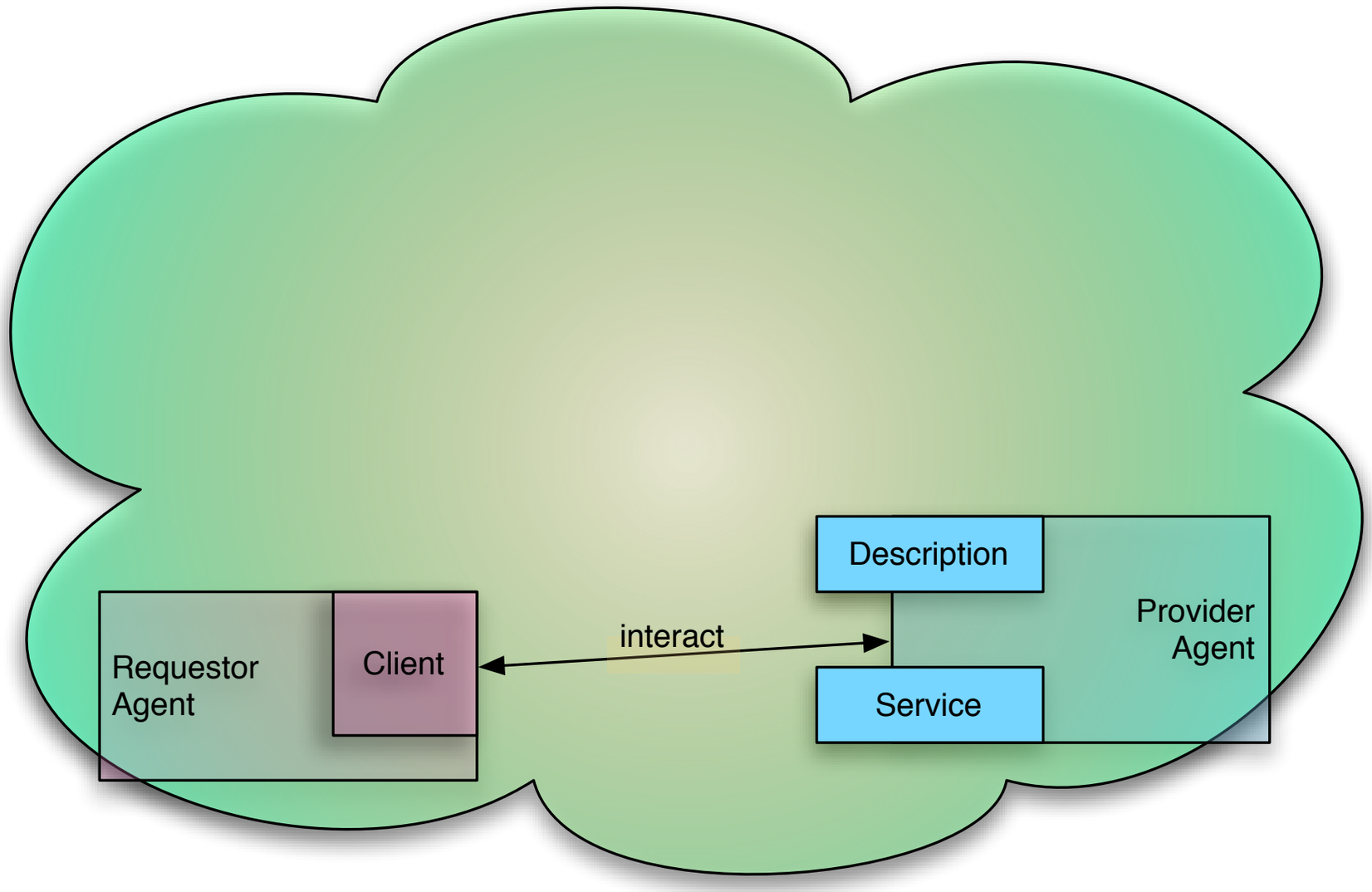
- Must be realised by a concrete piece of software—called an agent by WS-Arch.
  - Agent can send and receive messages.
  - Service is a resource defined by its functionality.
  - Service can stay the same even though agent (i.e., implementation) is changed.

- Entity is individual or organisation that requests or provides a service.

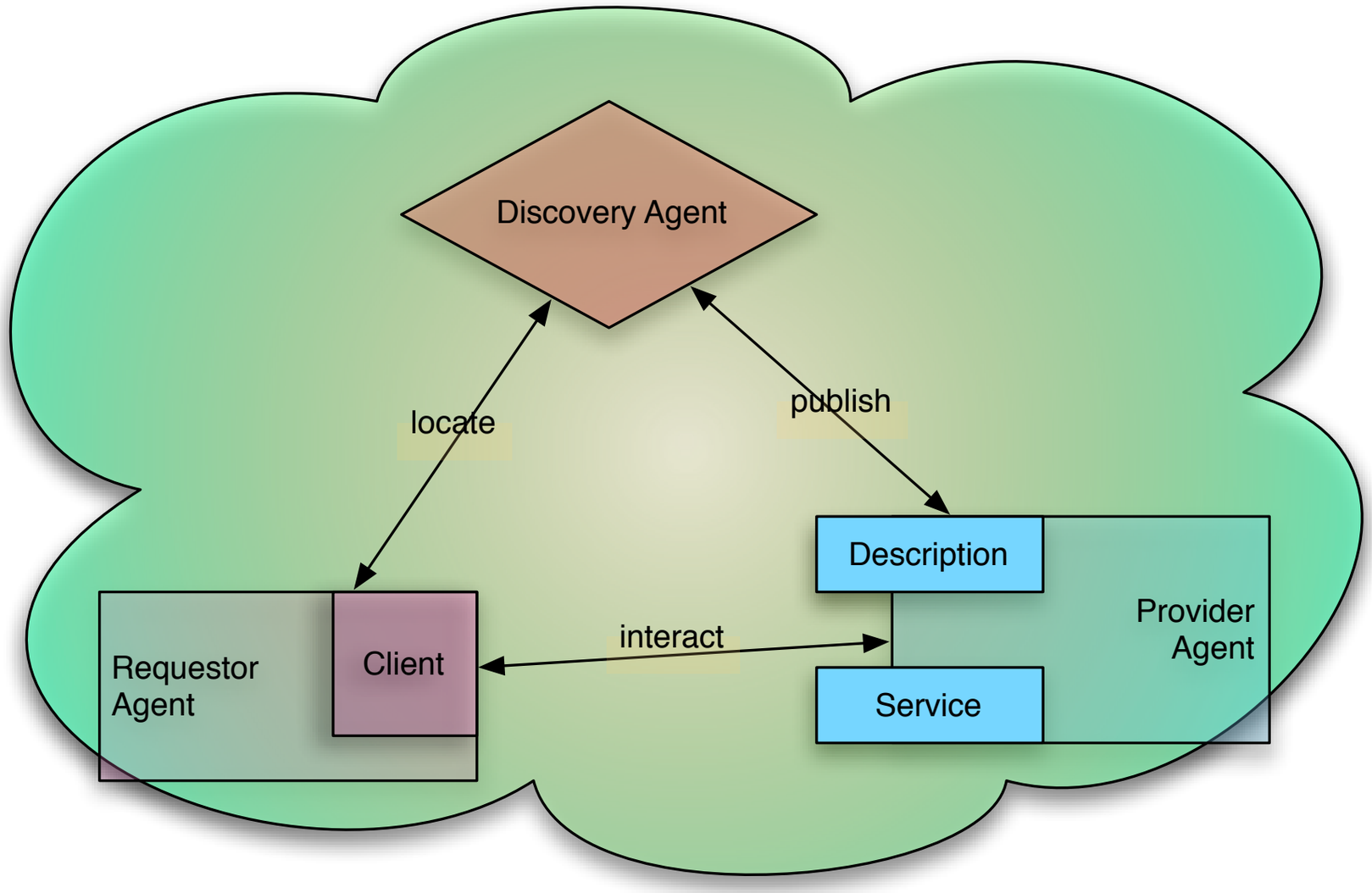
Service Oriented Architecture (WS-Arch)



Service Oriented Architecture: interact



Service Oriented Architecture: interact/publish/locate



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- Assumes that agents share common concepts about Flight, EconomyClass, etc.

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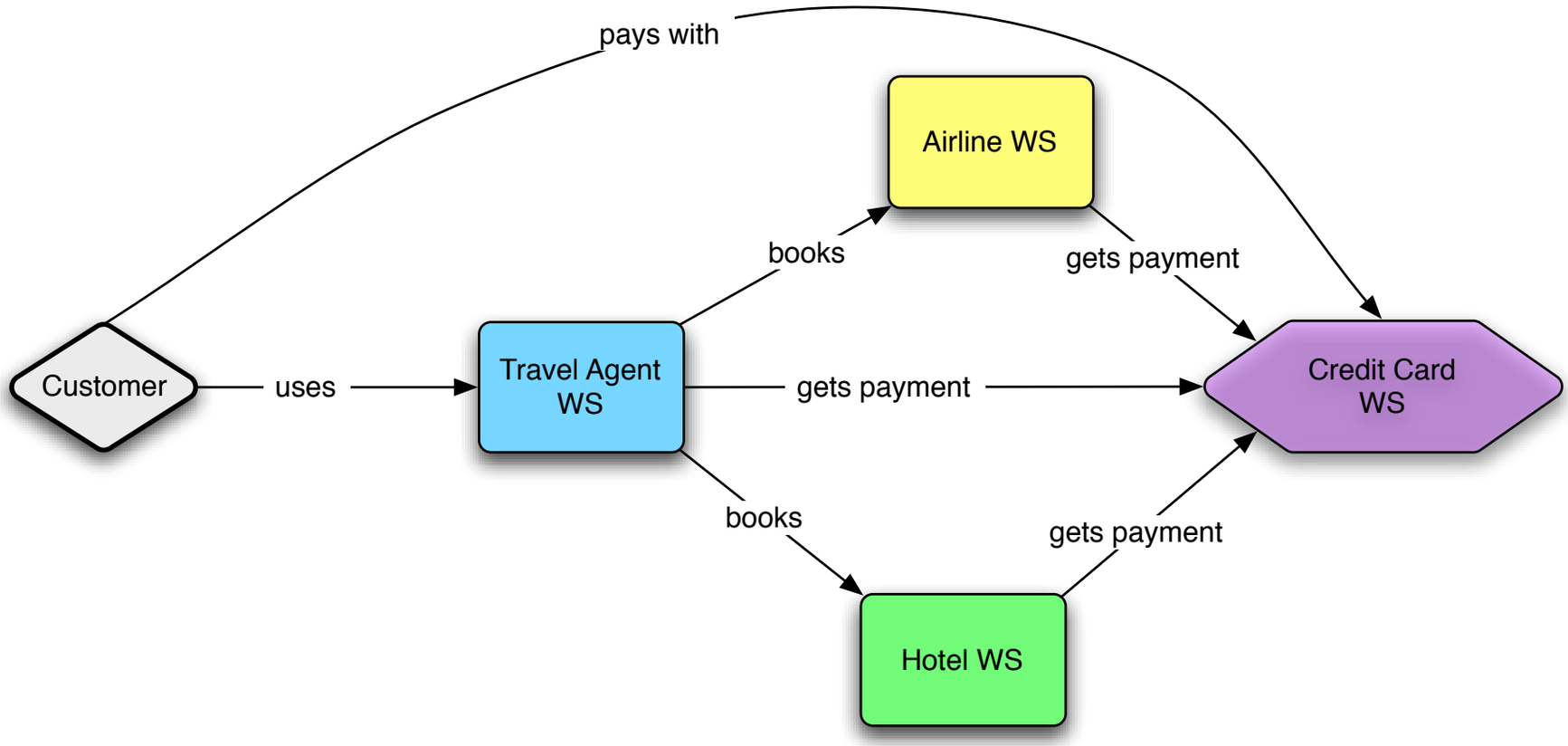
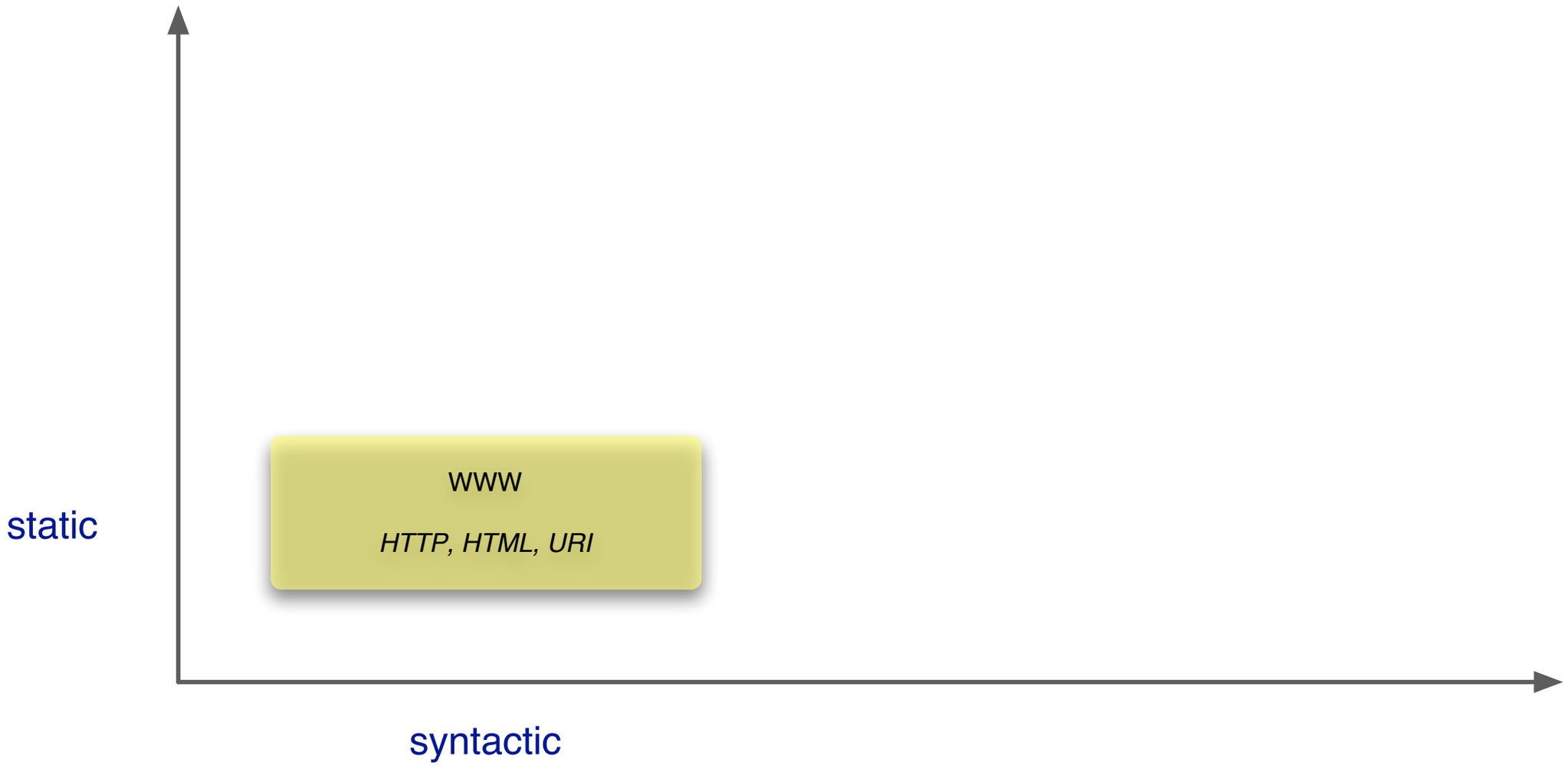


Evolution of the WWW



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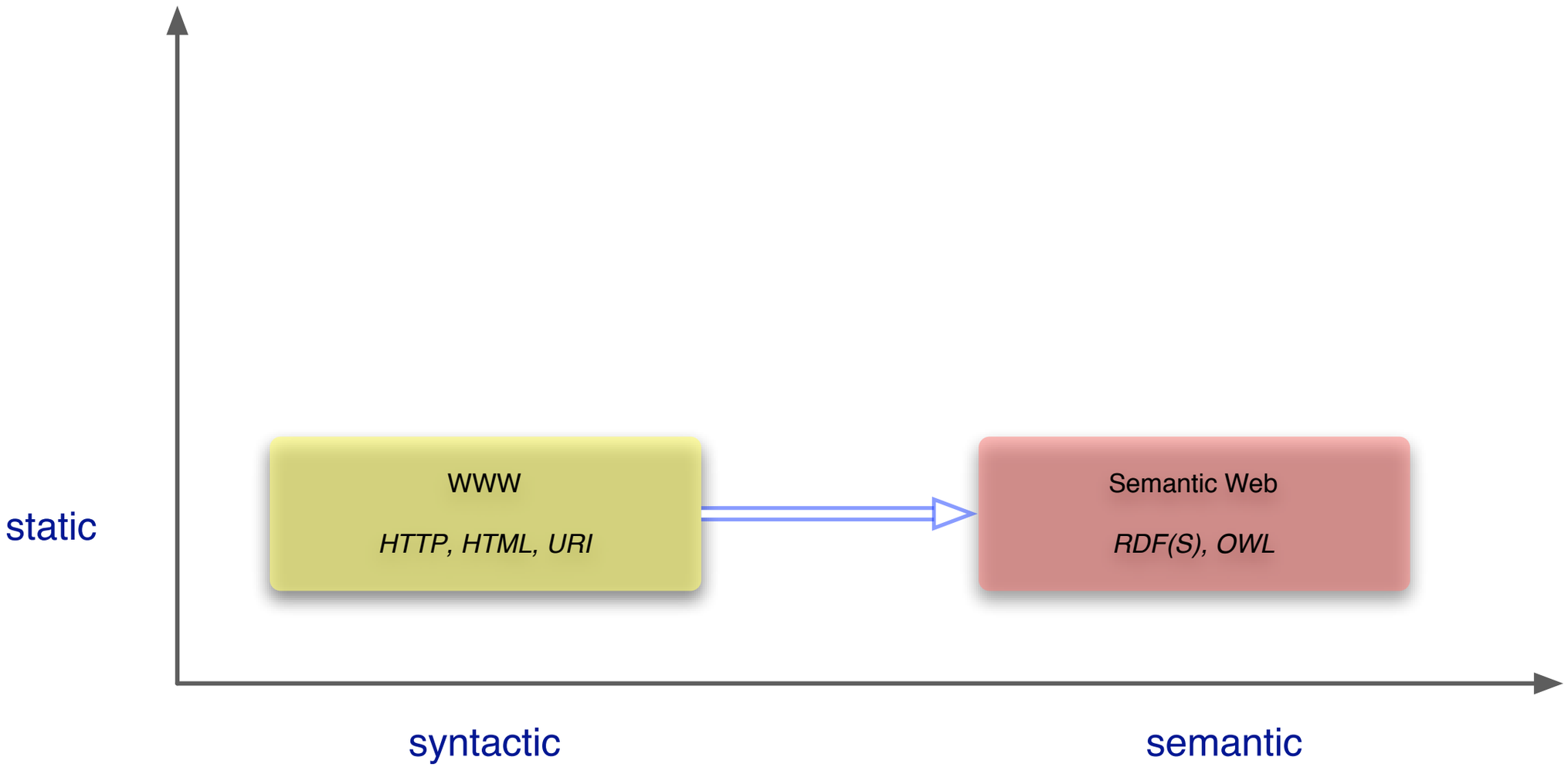

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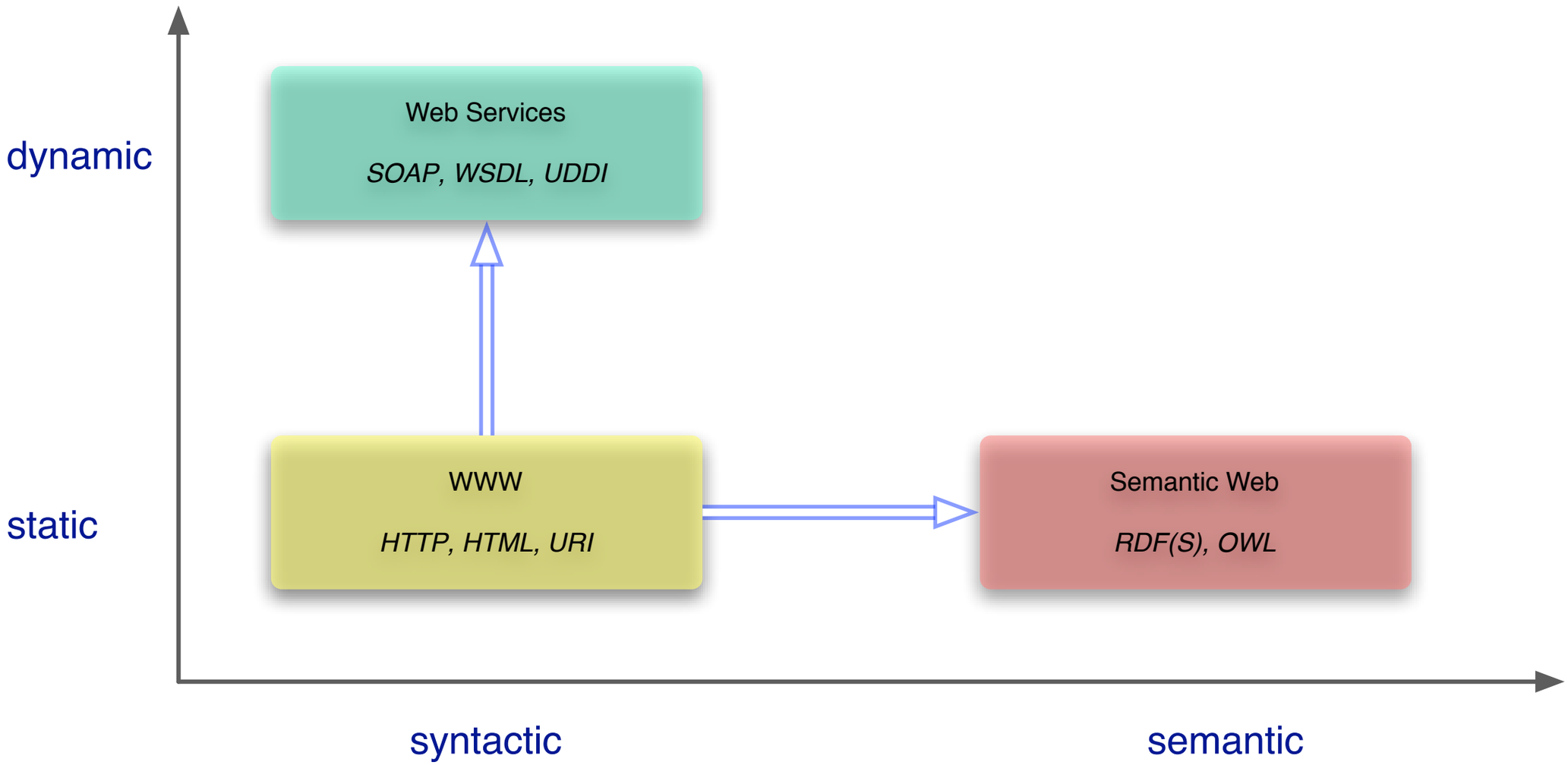

The Appeal of Web Services

- A means of building distributed system across the internet.

- Virtualisation: independent of programming language, OS, development environment.

- Based on well-understood underlying transport mechanisms (e.g., HTTP).

- Components can be developed and upgraded independently.

- Fairly decentralised (though issues about discovery, composition).

- Probably not appropriate where a high level of fine-grained interaction is required.

Perspectives

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  - remote procedure call (RPC)
  - business process within a workflow
  - dialogue in multi-agent system

RPC Concepts

- RPC is a protocol to allow agent on one host to cause execution of code on remote host.

- Uses client-server model of distributed computation:
  - Client sends message to server
    - [execute] procedure *P* with arguments $a1, \ldots, an$
  - Server executes *P*, and sends message back to client
    - result [of executing $P(a1, \ldots, an)$]

Protocols and Endpoints

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Convention that govern syntax, semantics, and synchronization of communication between two computing 'endpoints'. Enables/controls connection, communication, data transfer.

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Endpoint Reference

Conveys the information needed to address an endpoint.
Interactions may create new service instances, hence a need to dynamically create new endpoint references.
(cf. `http://www.w3.org/TR/ws-addr-core`)

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Example Function

```
public float checkAvailability(Date checkinDate,
                               Date checkoutDate,
                               String roomType) {
    if (roomAvailable) {
       return roomRateInUSD;
    } else {
       return 0.0;
    }
}
```

WS Metadata

Two kinds of metadata about services:

Non-operational

- service category (e.g., hotel room booking)
- informal description
- information about provider entity (name, contact details)

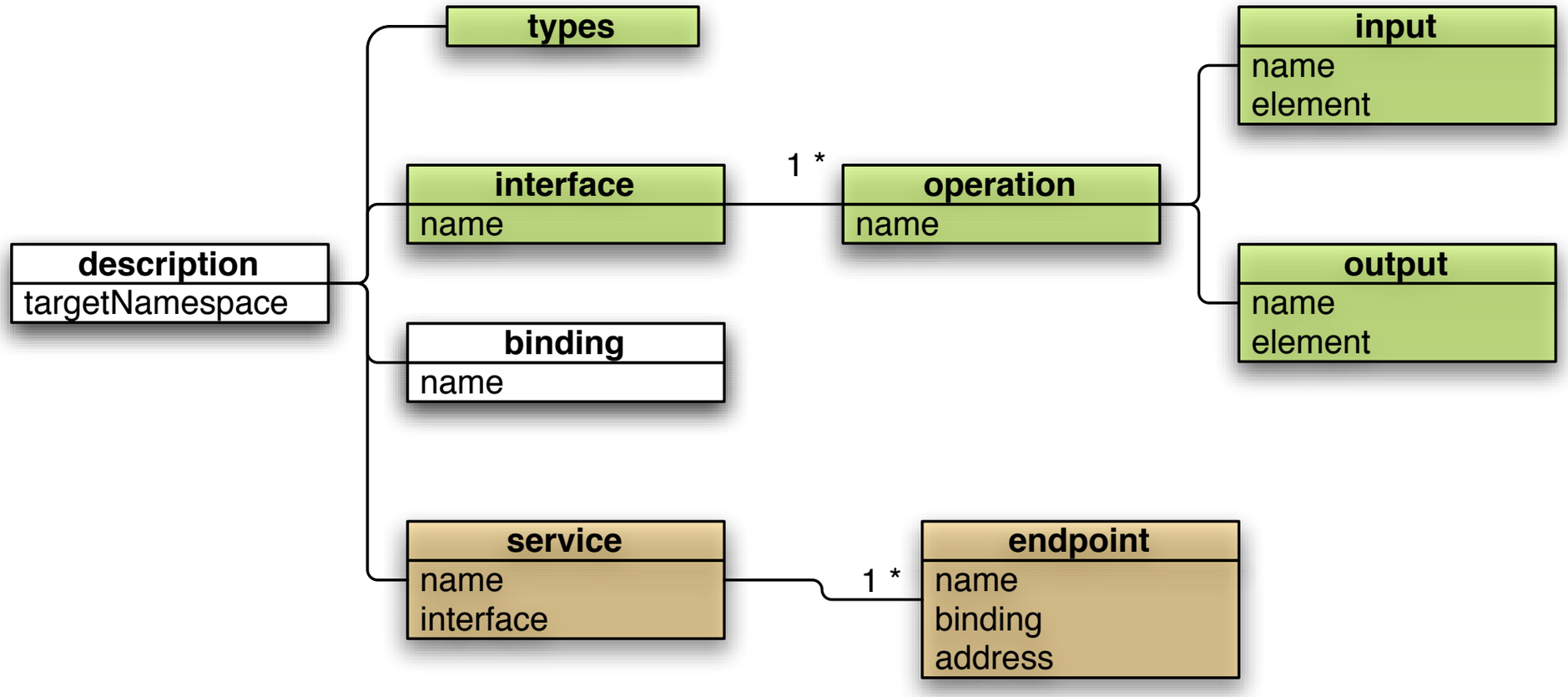
Operational

- service interface
- communication protocol
- service endpoint

- Operational metadata is standardly expressed using Web Service Description Language (WSDL)

- http://www.w3.org/TR/wsdl20-primer

WSDL 2.0 Structure



WSDL Interface

Example of WSDL Interface

```
<interface name = "reservationInterface" >
  <operation name="checkAvailability"">
    <input messageLabel="In"
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- element=”CheckAvailability” specifies the message type.
- Where does this get defined?
- In the types section of the WSDL document.

WSDL Types

- Use XML Schema to define types; should be supported by all WSDL 2.0 processors.

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Example of WSDL Type Definition

```
<types>
 <xs:element name="checkAvailability" type="tCheckAvailability"/>
 <xs:complexType name="tCheckAvailability">
   <xs:sequence>
     <xs:element  name="checkInDate" type="xs:date"/>
     <xs:element  name="checkOutDate" type="xs:date"/>
     <xs:element  name="roomType" type="xs:string"/>
   </xs:sequence>
 </xs:complexType>
 <xs:element name="checkAvailabilityResponse" type="xs:double"/>
</types>
```

Service Discovery

- The 'standard' solution uses UDDI Repositories (supported by OASIS)
- UDDI = Universal Description, Discovery, and Integration
- Original vision was a universal yellow pages for e-Business services.
- Services are categorised using a flattish taxonomy; search is by category and keyword.
- But take-up has been low, and focus has moved to supporting private registries.

UDDI.org White Paper: The Evolution of UDDI

... most of today's web service applications are not intended for public use, but rather inside organizations or among existing, trusted business partners.

Composition

- Recall just-in-time integration of applications.

- Automatic composition of service-based applications is more vision than reality.

- Some tool support for manual or semi-manual composition.

- Composition raises issues about discovery and description.

- Next slides: manual composition using a scientific workflow tool.

myGrid, I (http://www.mygrid.org.uk/)

- Large scale, multi-site project in UK e-Science framework
- Concerned with building Grid oriented middleware for molecular biology research;
- *in silico* discovery by combining results and data from local and remote sources.
- Started in 2001 prior to establishment of BPEL, and developed own tools for service composition:
  - Taverna 'workflow' workbench,
  - Scufl language (composition operators).
  - Freefluo enactment engine.
- Specifically designed for use by biologist and bio-informatics users.

myGrid, 2

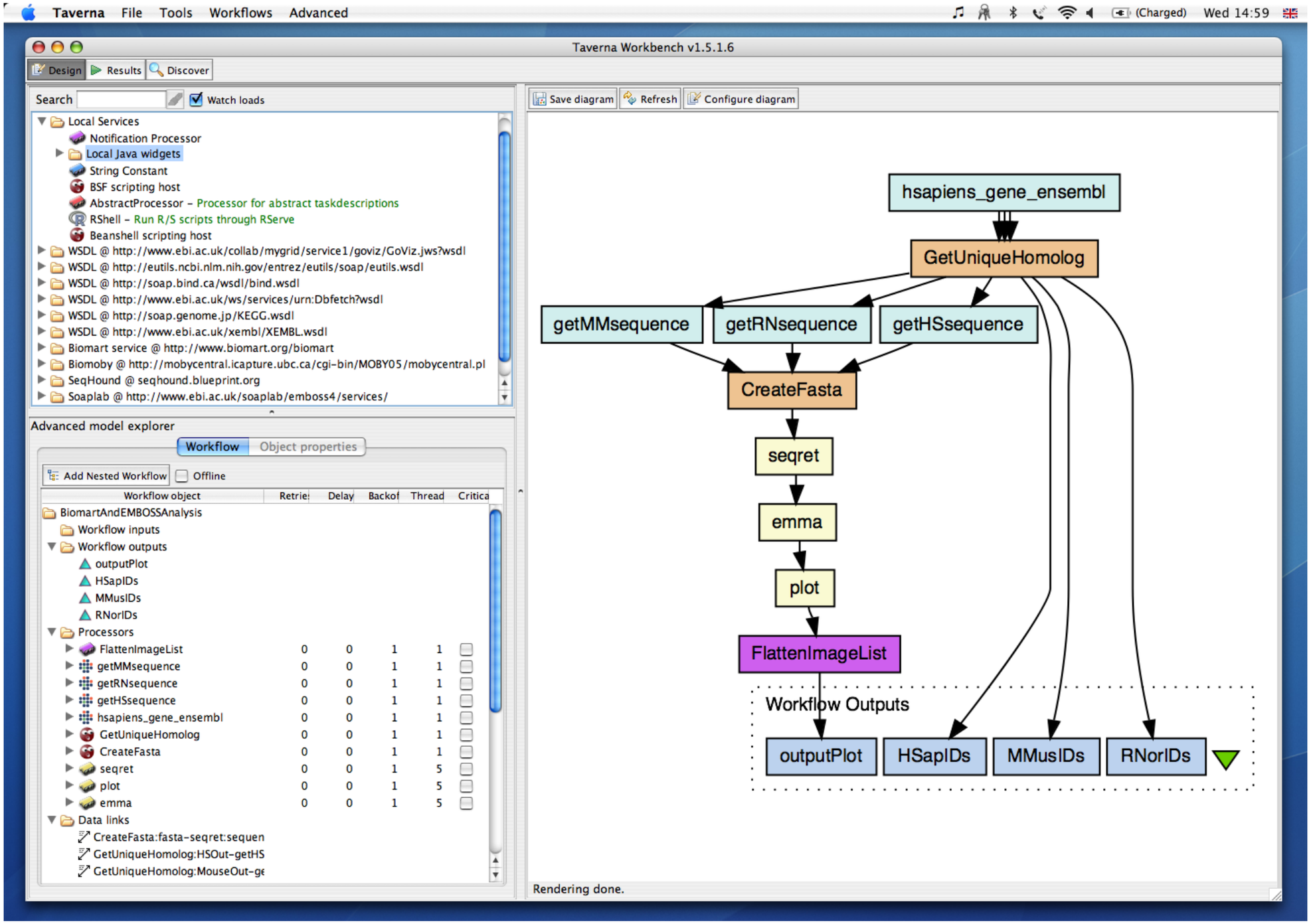
- Intended to provide uniform access to wide variety (> 1000) of services:
  - sequence comparison, protein databases, protein visualization tools, model simulations, etc.

- These are increasingly available as Web Services.

- Workflows need to be easy to create for one-off experiments, but also available for re-use, adaptation, and incorporation in other workflows.

- Tries to be non-prescriptive about data formats.

Taverna Workflow



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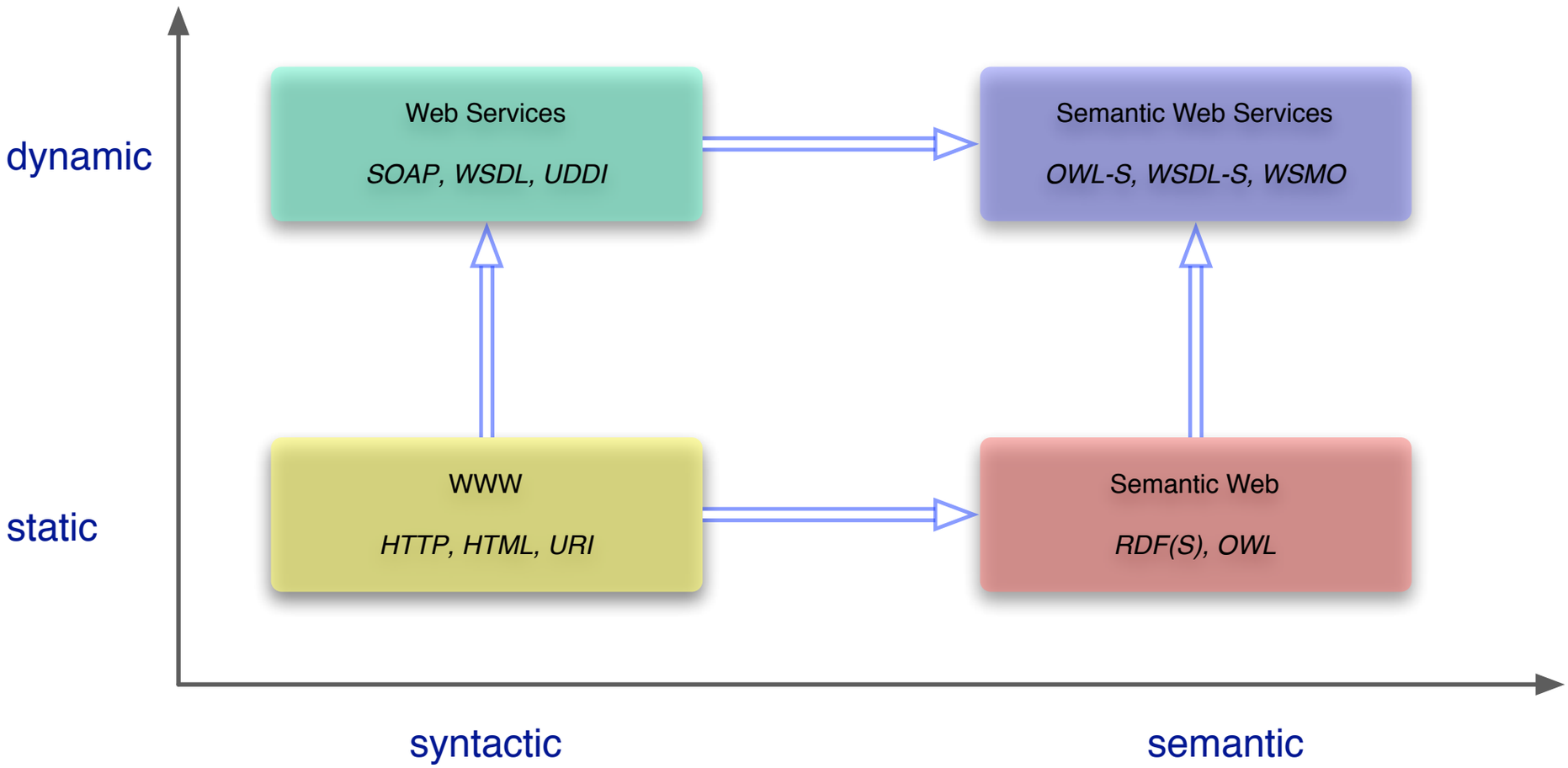

Key idea: use richer RDFS / OWL classes instead of XML Schema types.

Conclusion, 1

- SOA can be seen as evolution of Object Oriented approach.

- Web Services are 'big business': lots of commercial involvement, lots of standardisation activity.

- But little deployment to date of SOA across the Internet. WS are primarily used within organisations:
  - Commercial organisations (maybe with trusted partners)
  - Virtual organisations for Grid computing and e-Science / e-Research.

- Other WS tend to be 'one-shot'; cf. Amazon, Google, etc.

Conclusion, 2

- WSDL has been promoted as standard for describing services:
  - `interface` and associated `operations` give an abstract specification of the service;
  - `binding` and `service endpoint` show how to invoke the concrete service.
- WSDL adopts an RPC view of service, in terms of input and output types of the constituent operations.

DIY

- Many WS are not WSDL/SOAP based.
- You've already accessed Last.fm as a WS.
- Even with SOAP-based services, there are easy-to-use client libraries.
- Writing WSDL interfaces and publishing WS is harder.

Reading

- Read Chapter 8 of Passin (but talks about WSDL 1.0 — some syntactic differences with WSDL 2.0).

- Online tutorial: `http://www.w3schools.com/WSDL/`

- `http://www.xmethods.net/` lists some publicly available WS.