Semantic Web Services

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- DIP
- OWL-S Coalition
- SOA4All
- WSMO Working Group

Outline

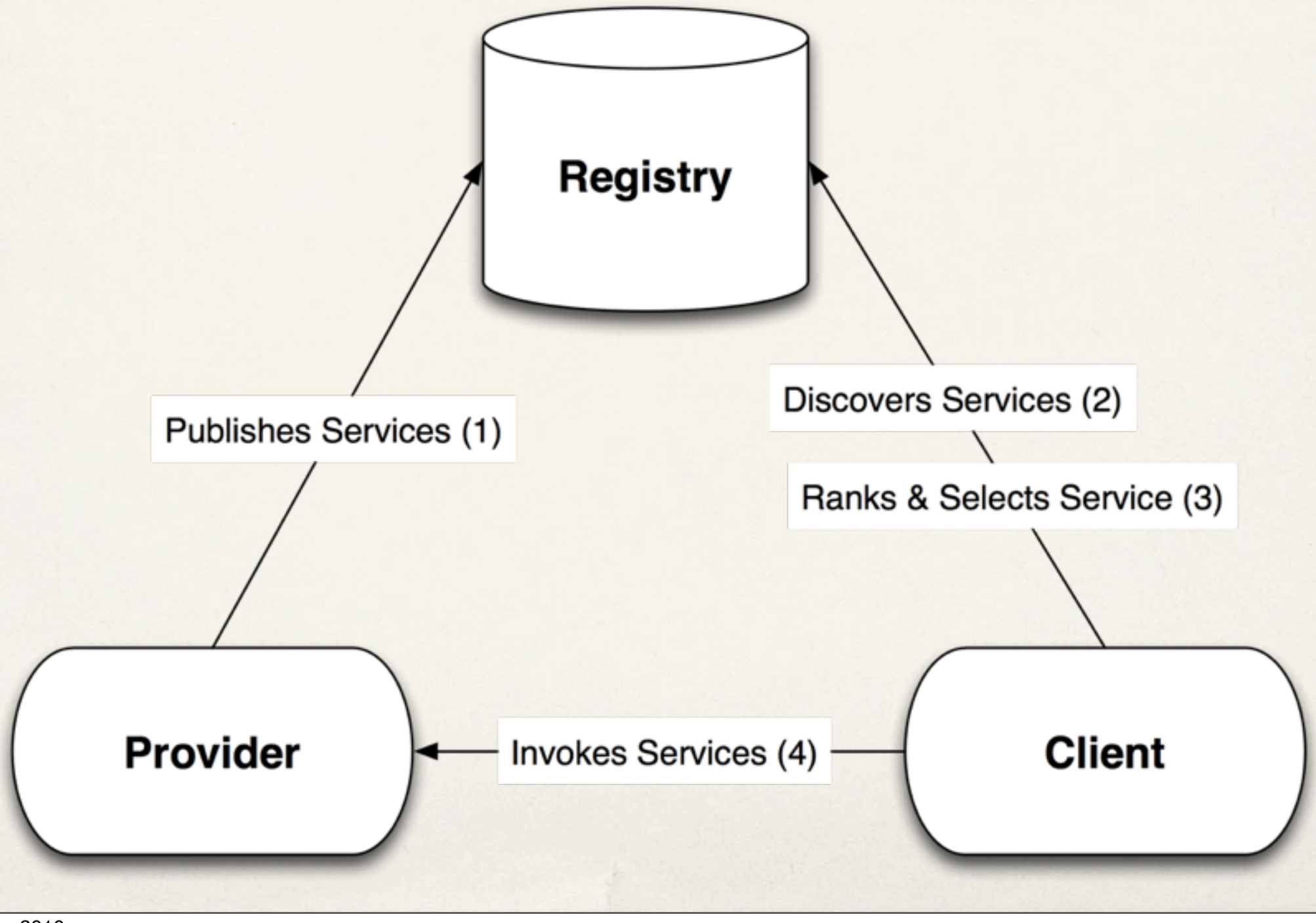
- Service Orientation and Web Services Technologies
- Semantic Web Services Overview and Techniques
- Main Conceptual Frameworks
  - OWL-S, WSMO
  - WSDL-S/SAWSDL, WSMO-Lite
  - SAREST, MicroWSMO
- Applying Semantic Web Services

Service-Oriented Architecture
&
Web Service Technologies

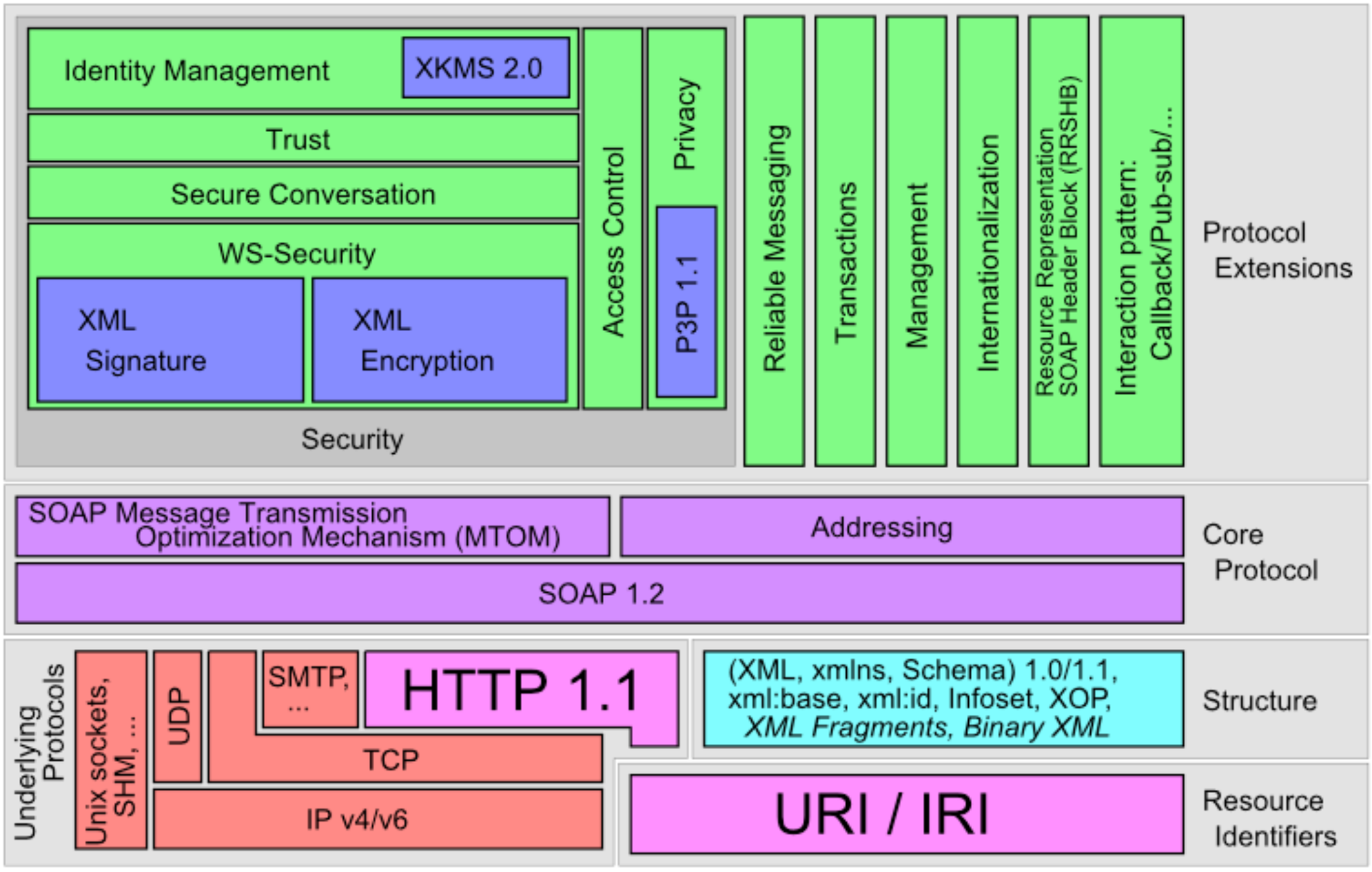
Service Orientation

- A Service is a reusable software component offered through a language independent interface
- Service-orientation regards the development of systems as the composition of loosely coupled services
- Promotes reuse and improves the maintenance and evolution of systems

SOA Approach



Related Technologies



Source: Steve Bratt W3C - http://www.w3.org/2005/Talks/1103-sb-mit-mwi/

Web APIs and RESTful Services

API	Description	Category	Mashups
Google Maps	Mapping services	Mapping	1711
Flickr	Photo sharing service	Photos	446
YouTube	Video sharing and search	Video	378
Amazon eCommerce	Online retailer	Shopping	298
Twitter	Microblogging service	Social	196
Microsoft Virtual Earth	Mapping services	Mapping	171
eBay	Online auction marketplace	Shopping	170
del.icio.us	Social bookmarking	Bookmarks	129
Yahoo Maps	Mapping services	Mapping	129
Google Search	Search services	Search	127
411Sync	SMS, WAP, and email messaging	Messaging	120
Yahoo Search	Search services	Search	120
Last.fm	Online radio service	Music	104
Facebook	Social networking service	Social	91
Google Homepage	Portal gadgets	Widgets	87
Yahoo Geocoding	Geocoding services	Mapping	87
Google Ajax Search	Web search components	Search	78
Technorati	Blog search services	Blog Search	65

Source

Semantic Web Services

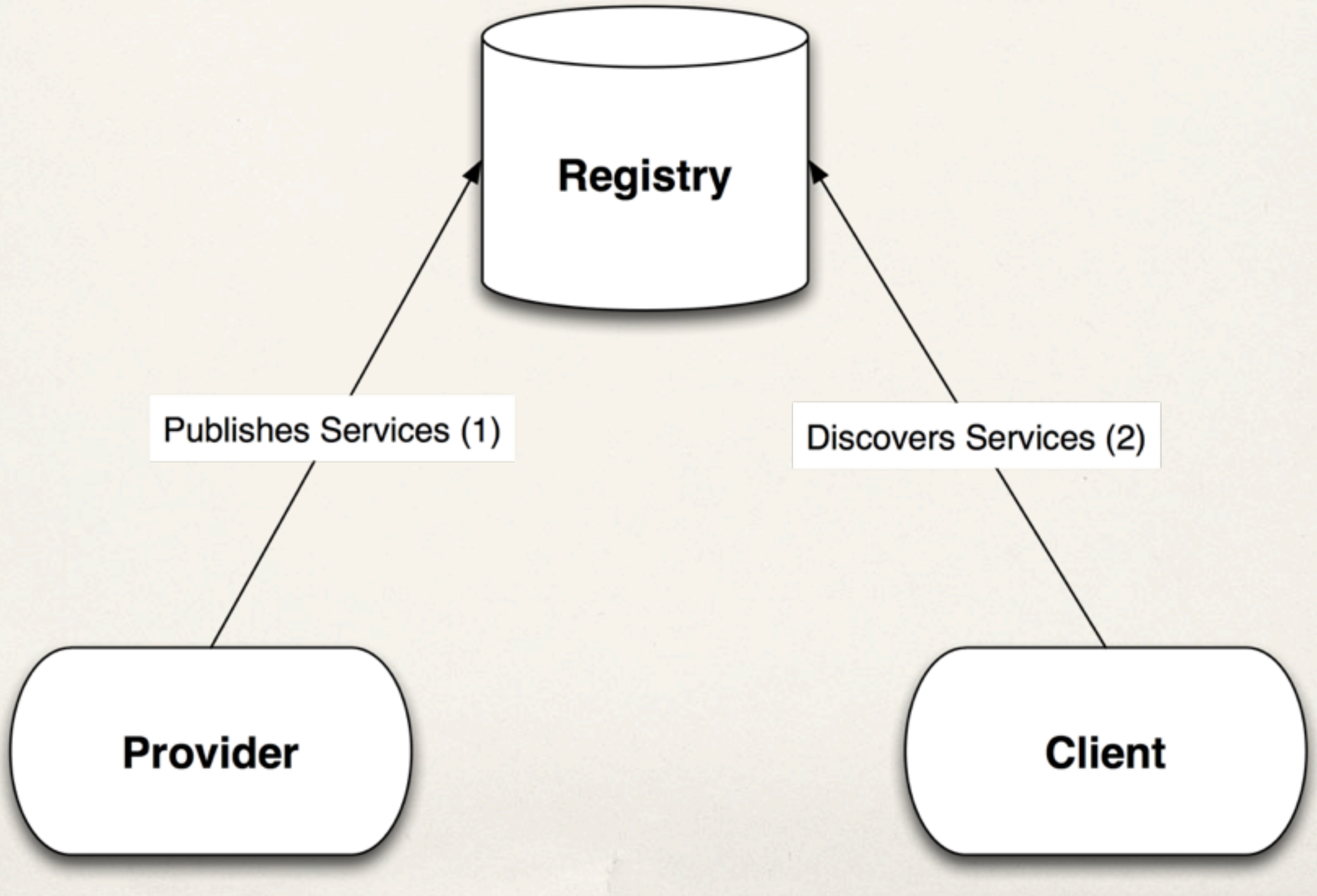
Limitations of WS Technology

- Current technologies allow usage of Web Services but:
  - Only provide syntactical information descriptions
  - Web Service discovery, composition, and invocation need to be done manually
  - Manual labour reduces scalability
  - The situation is considerably worse for Web APIs

Semantic Web Services

- Automate Web Service technologies by using
  - Formal annotation of Web Services
  - Inference-based techniques for (semi) automated discovery, composition, mediation, execution of Web Services
- Integration with the Semantic Web
  - Ontologies as data model

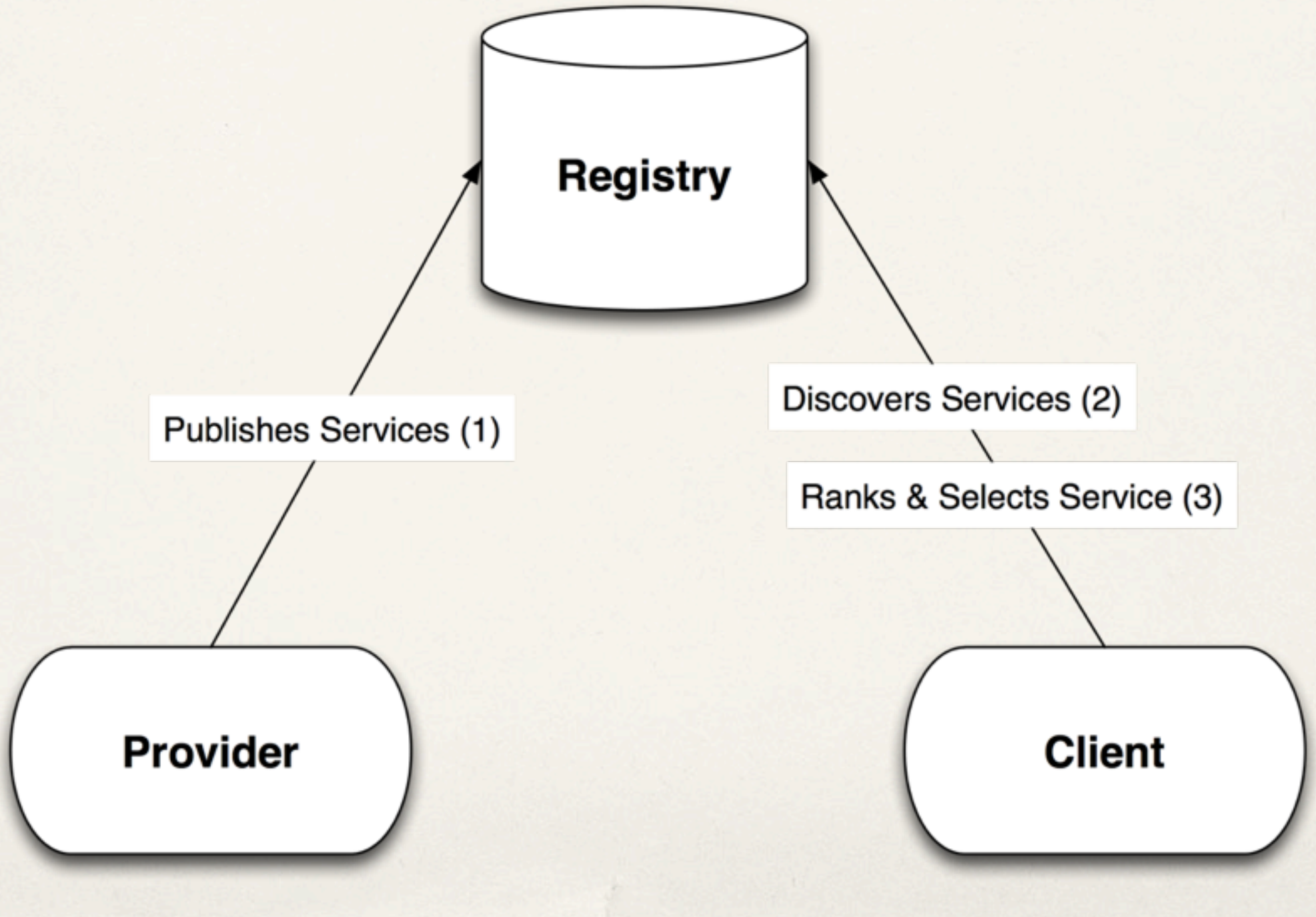
Service Discovery/Matchmaking



Service Discovery/Matchmaking

- Find candidate Web Services that can provide the desired functionality using
  - Structural analysis
  - IR techniques
    - Match natural language keywords in resource descriptions, similarity analysis
  - Semantic Matchmaking
    - Reasoning applied over descriptions, i.e., Inputs/Outputs, Preconditions, Effects, Classifications
- Hybrid IR/semantic solutions perform better

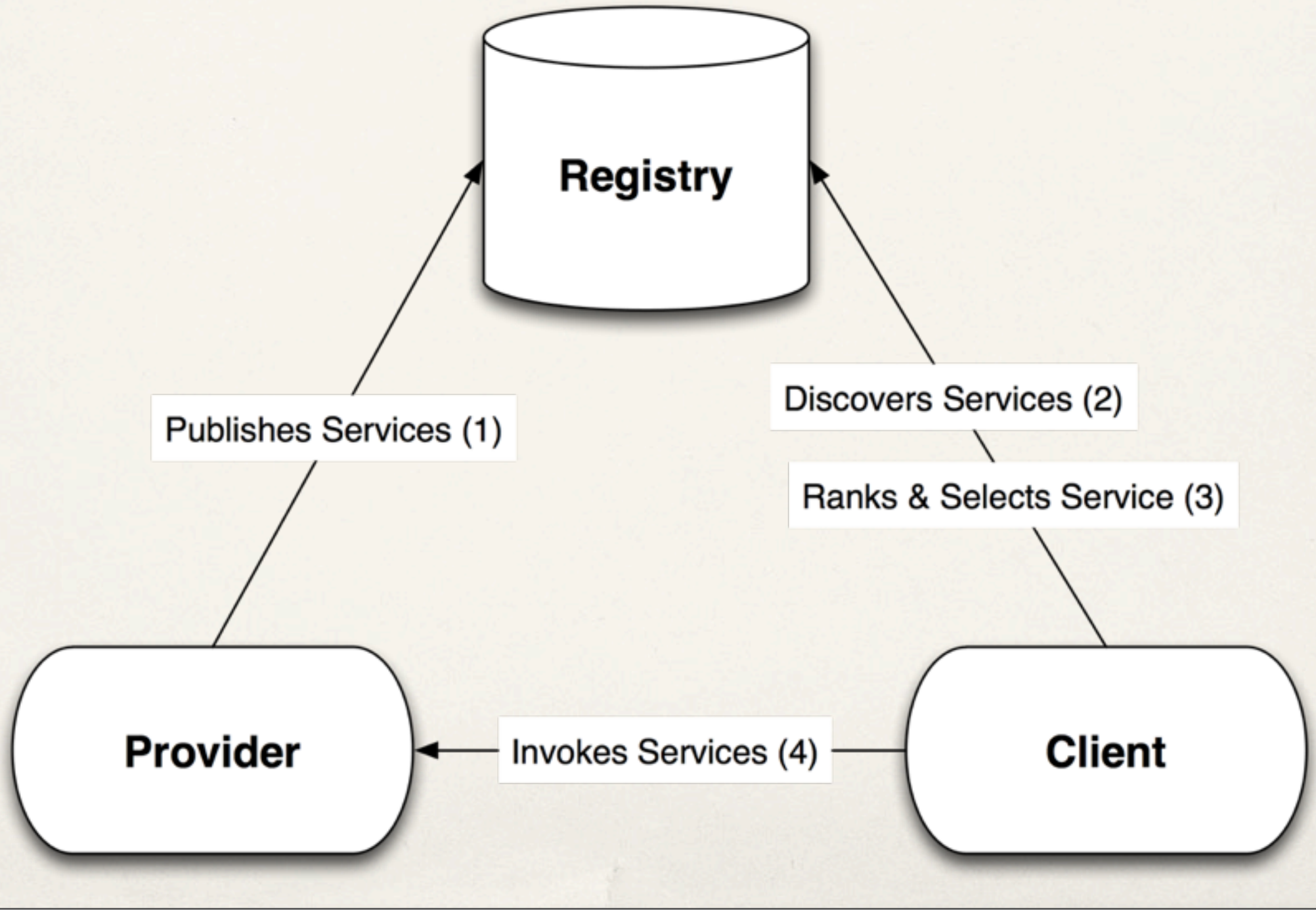
Service Ranking & Selection



Service Ranking & Selection

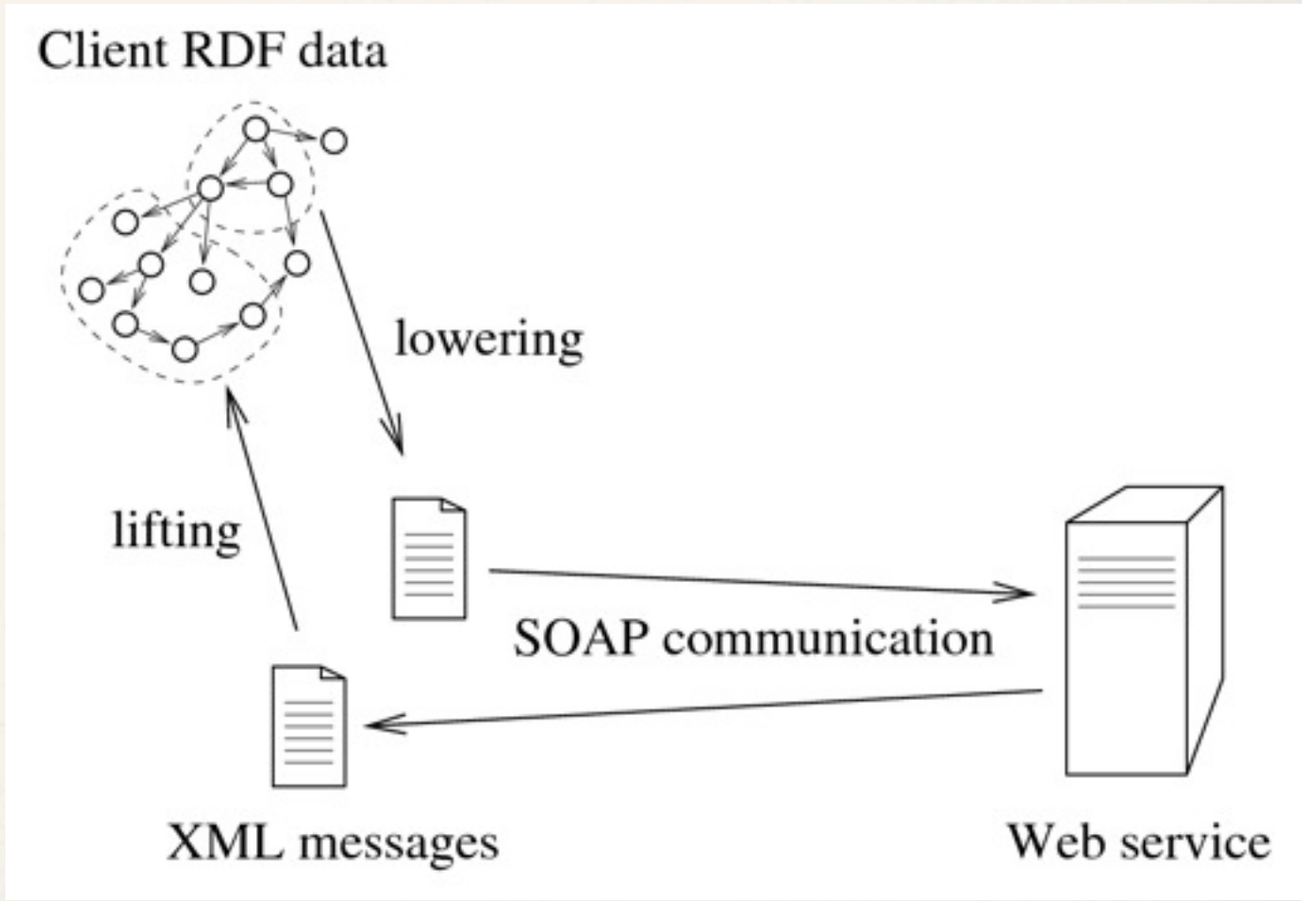
- Rank and eventually select the best service given certain criteria
- Often applied after service matchmaking using
  - Different degrees of match for ranking (exact > plugin, etc)
  - Non-functional properties (QoS, response time, user location, etc)
- Techniques
  - Weighted combination, skyline, fuzzy reasoning

Service Invocation



Service Invocation

- Invocation of selected service
- Typically involves lifting and lowering
- Often requires mediation



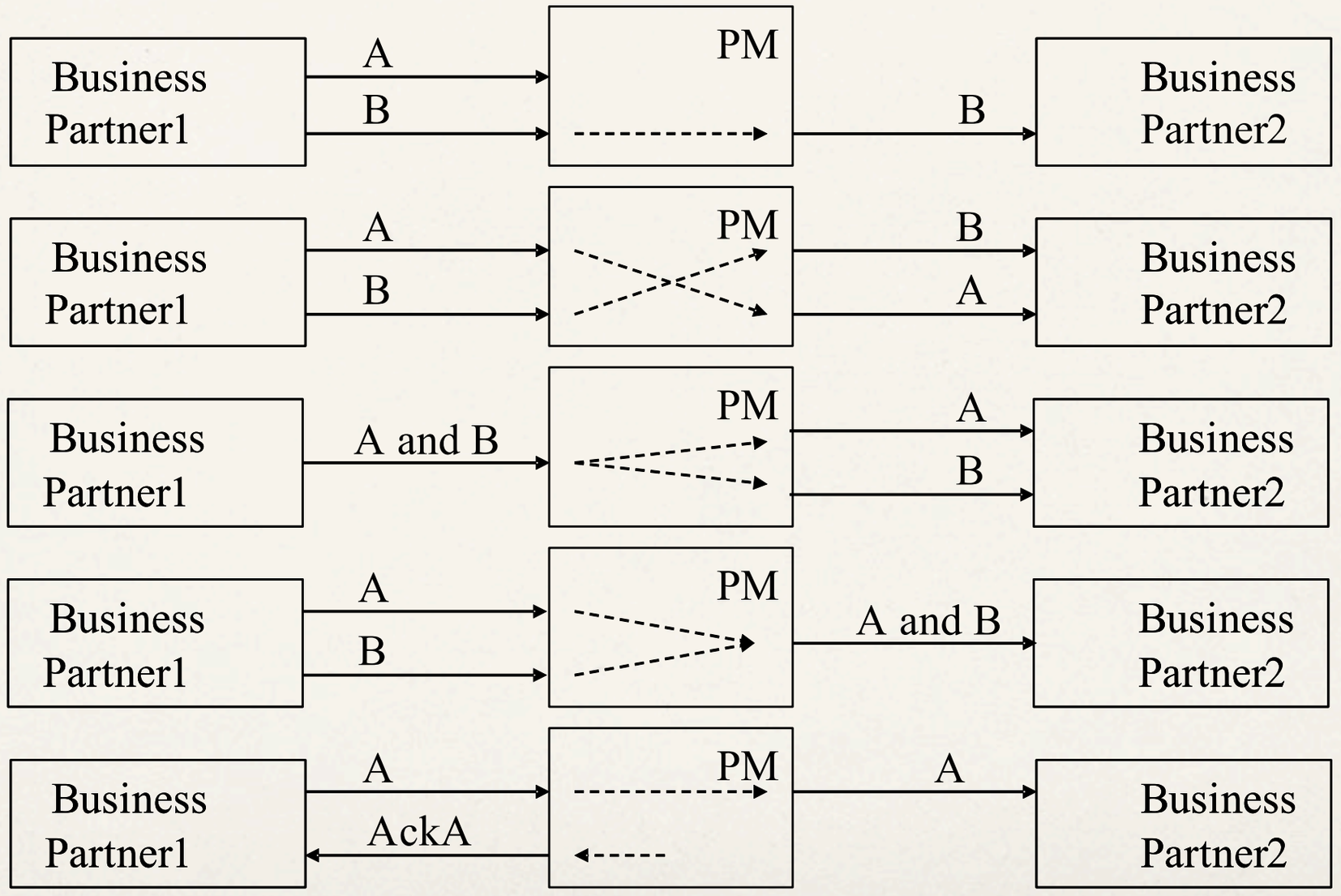
Mediation

- Heterogeneity as inherent characteristic of the Web:
  - Heterogeneous terminology, formalisms, functionalities, communication protocols and business processes
- Often approached by means of a generic mismatch resolution machinery
  - Mediation definition language & mediation patterns
  - Execution environment for mediation definition

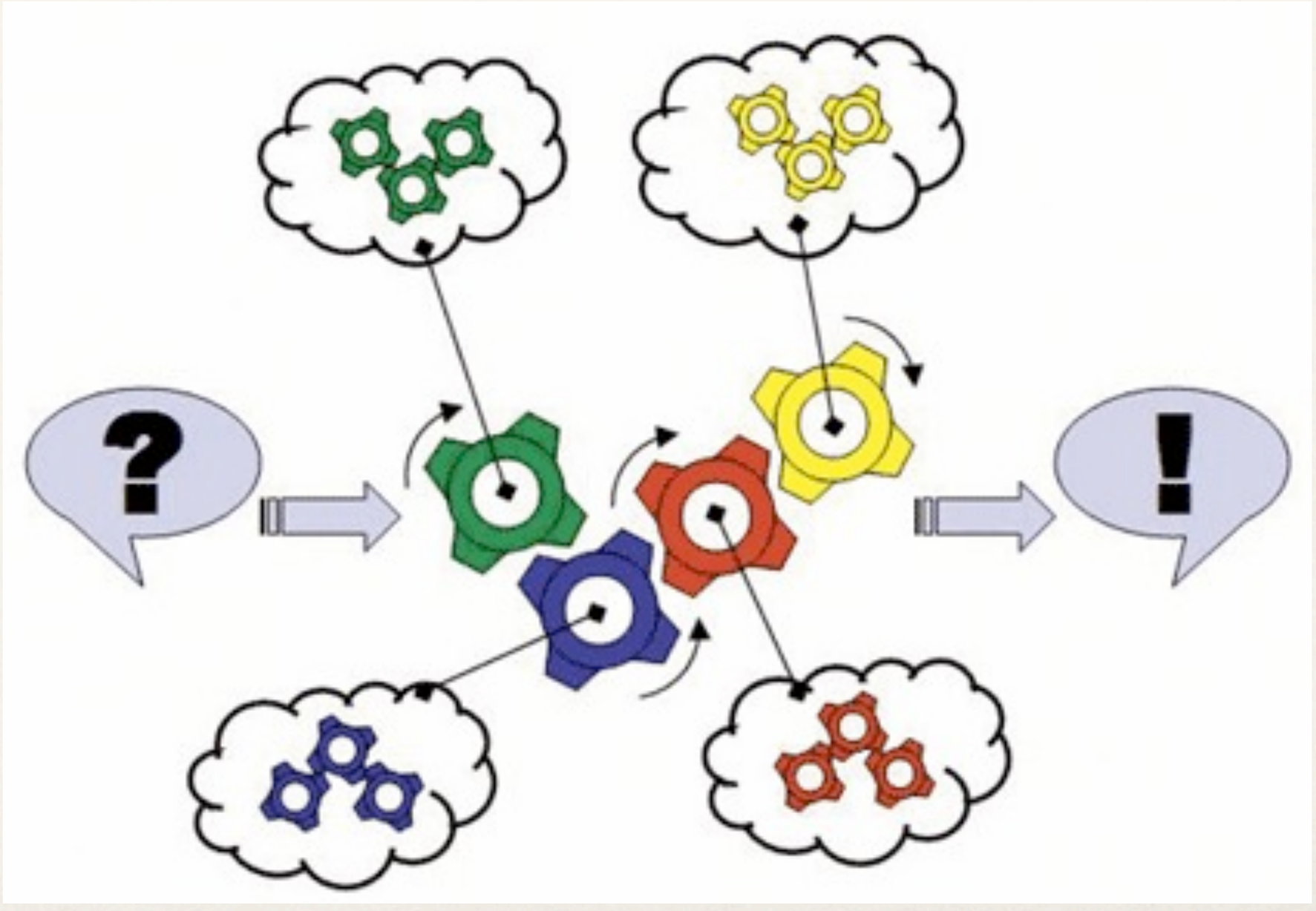
Data Mediation Techniques

Ontology **Mapping**	Ontology **Alignment**	Ontology **Merging**
 Mapping Rules	 Ontology A is made compatible to ontology B	

Process Mediation



Service Composition



Source: Matthew Zager - http://soa.sys-con.com/node/155631

Service Composition

- Combine several Web services for solving a request
- Applied if no directly usable Web service exists to solve the goal of a client
- Often approached as
  - Planning, i.e., devise a set of actions that will take us from the current state to the state requested
  - Parametric Design, i.e., given a skeleton, find the right configuration of parameters that can achieve our goal

Main Conceptual Frameworks

Main Approaches

- Web Services
  - Top-down: OWL-S, WSMO
  - Bottom-up: WSDL-S/SAWSDL, WSMO-Lite
- Web APIs
  - SAREST
  - hRESTS/MicroWSMO

Types of Service Semantics

- *Information model semantics*: semantics of the data used and exposed by the service

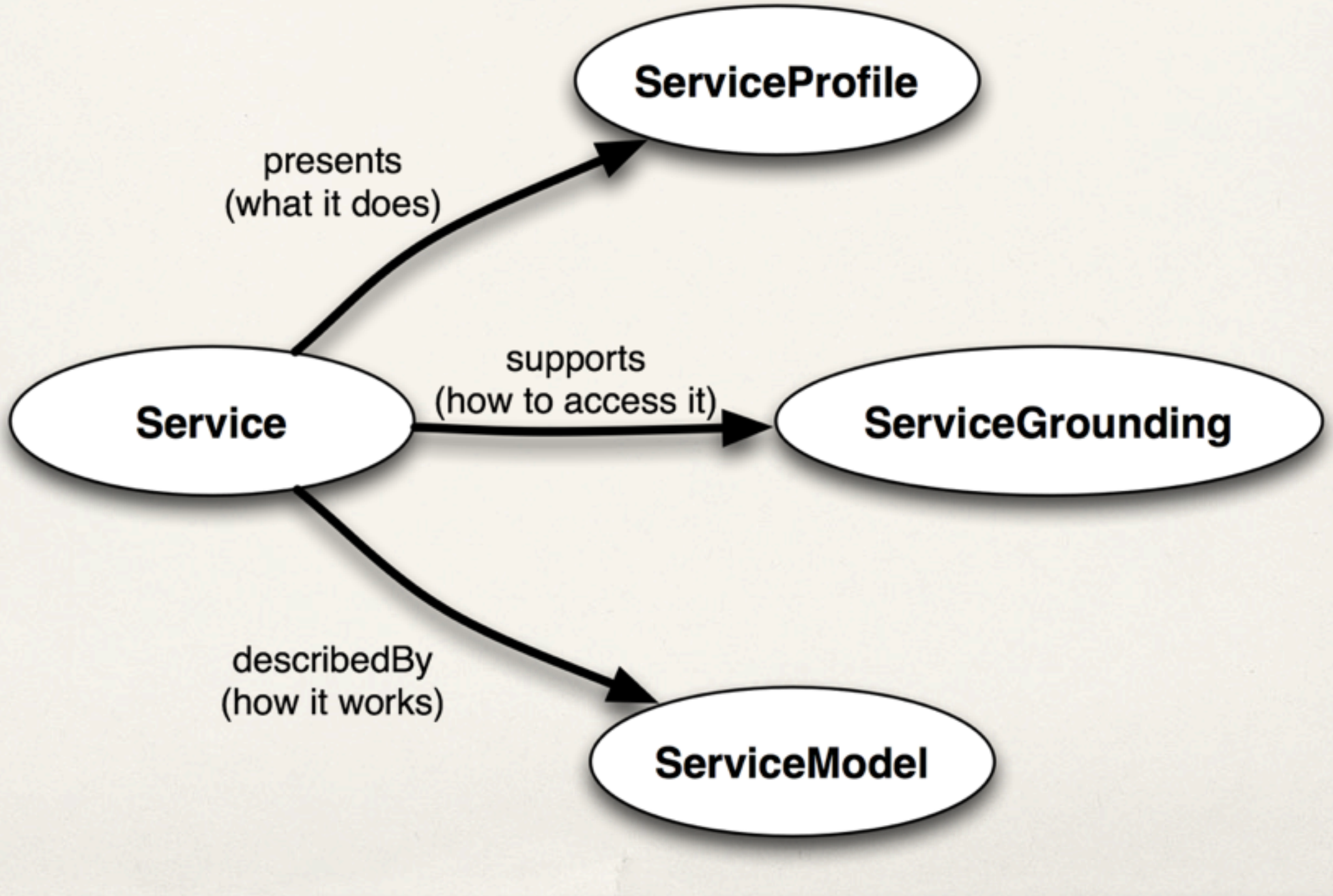
- *Functional semantics*: what the service does, e.g., categorisation, capability

- *Non-Functional semantics*: semantics related to the non-functional aspects of the service, e.g., Quality of Service (QoS), security, etc.

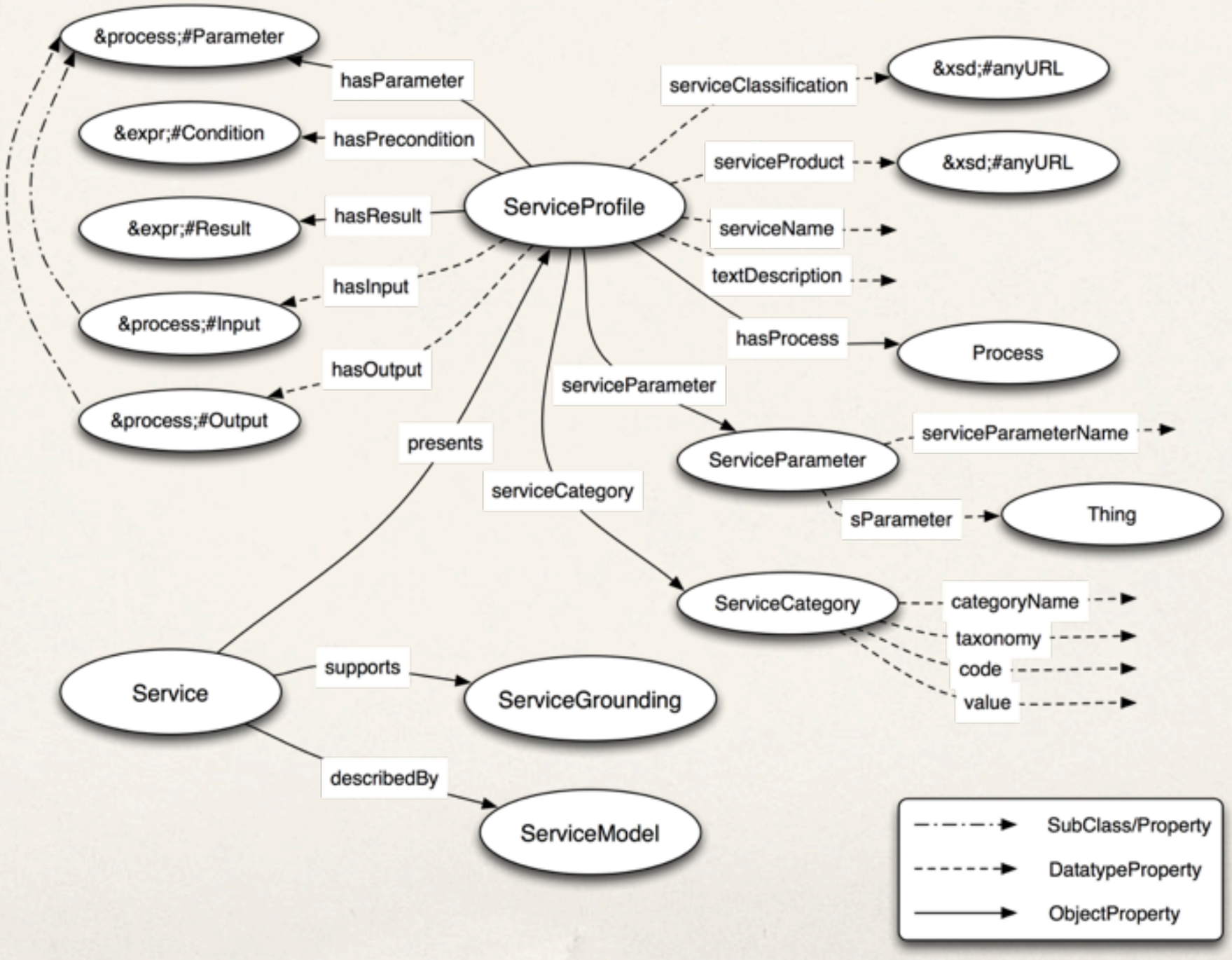
- *Behavioural semantics*: semantics related to the behaviours, e.g., choreography, faults, etc

Web Service-centric Models

OWL-S


ServiceProfile
presents
(what it does)
Service
supports
(how to access it)
ServiceGrounding
describedBy
(how it works)
ServiceModel

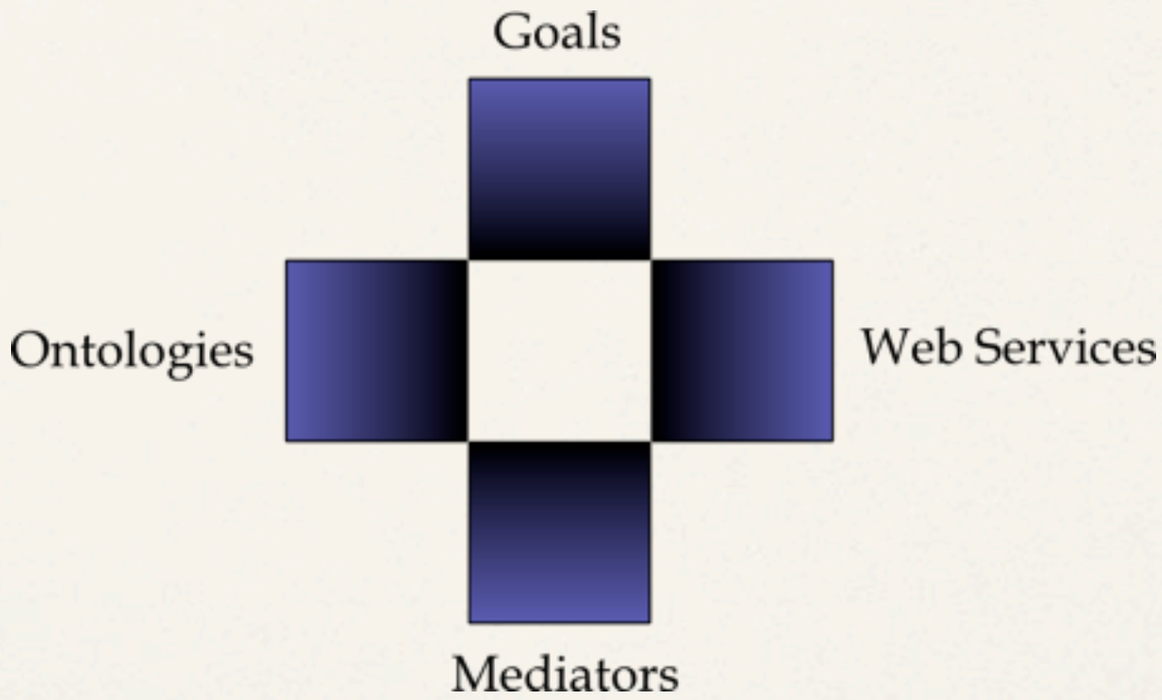
OWL-S


&process;#Parameter
hasParameter
&expr;#Condition
hasPrecondition
&expr;#Result
hasResult
&process;#Input
hasInput
&process;#Output
hasOutput
ServiceProfile
presents
serviceClassification
&xsd;#anyURL
serviceProduct
&xsd;#anyURL
serviceName
textDescription
hasProcess
Process
serviceParameter
ServiceParameter
serviceParameterName
sParameter
Thing
serviceCategory
ServiceCategory
categoryName
taxonomy
code
value
Service
supports
ServiceGrounding
describedBy
ServiceModel
SubClass/Property
DatatypeProperty
ObjectProperty

WSMO

Objectives that a client may have
when consulting a Web Service

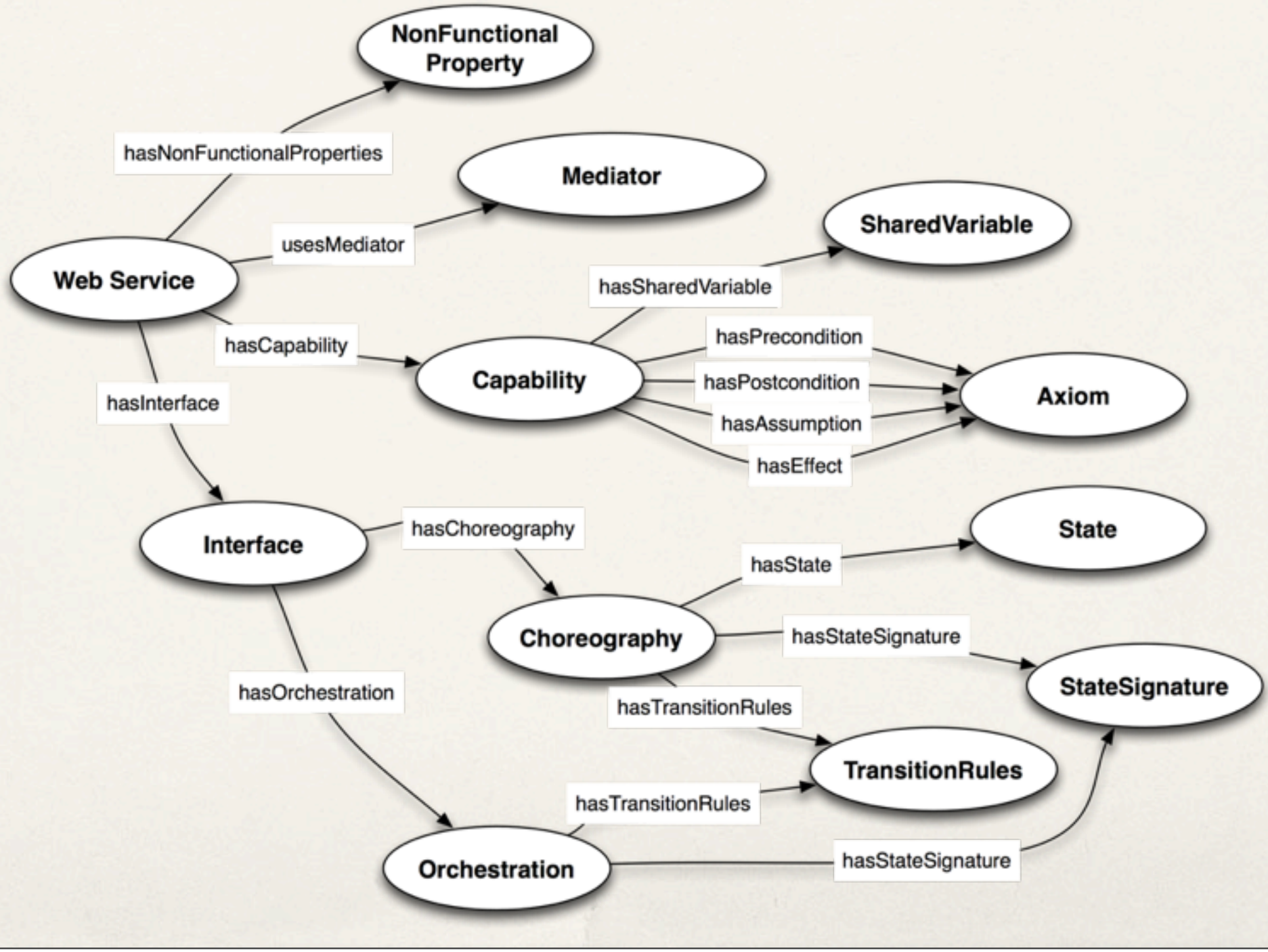
Provide the formally specified terminology of the information used by all other components



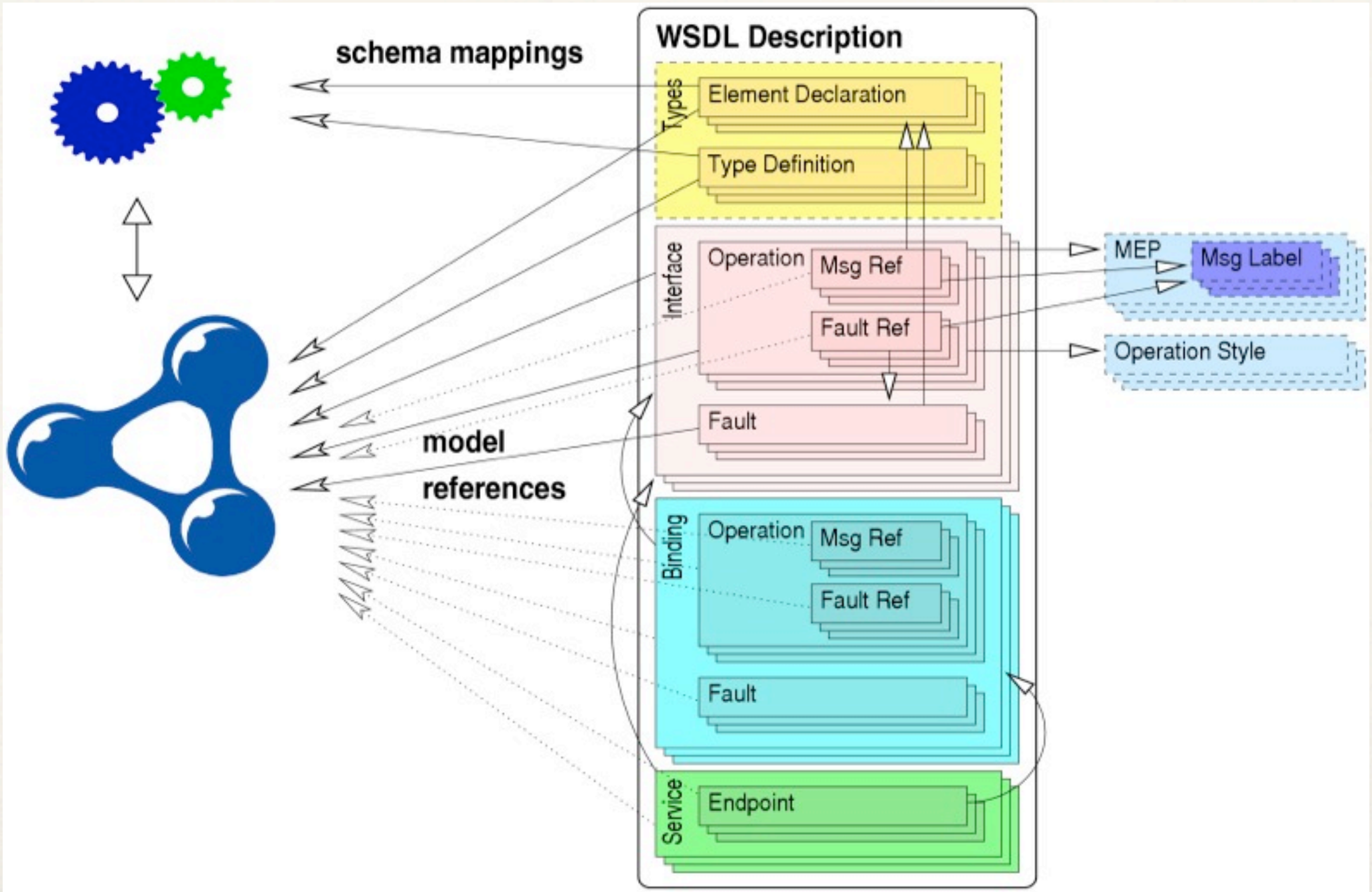
Semantic description of Web Services:
- Capability (functional)
- Interfaces (usage)

Connectors between components with mediation facilities for handling heterogeneities

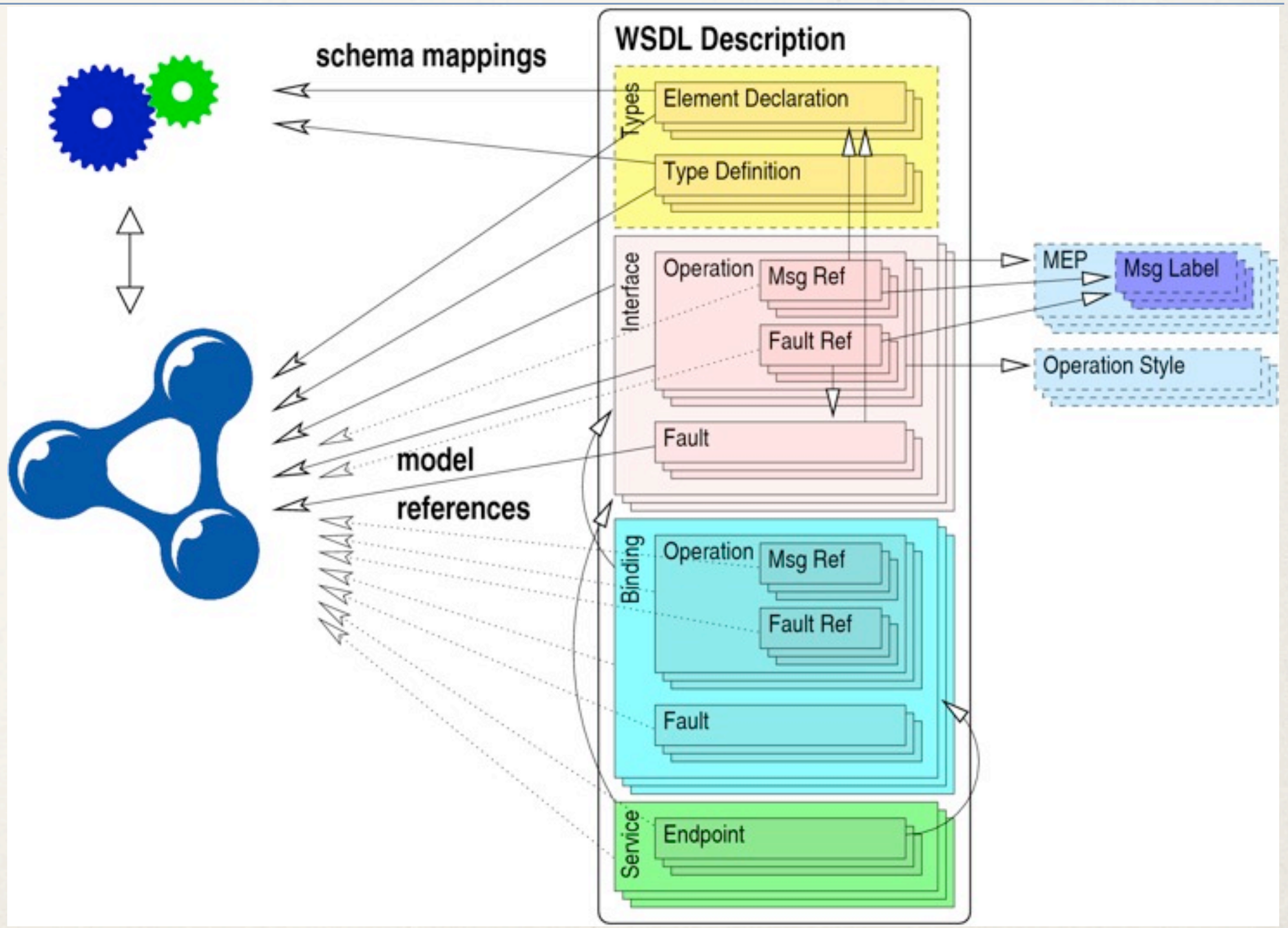
WSMO


NonFunctional Property
hasNonFunctionalProperties
Mediator
SharedVariable
usesMediator
Web Service
hasSharedVariable
hasCapability
hasPrecondition
Capability
hasPostcondition
Axiom
hasInterface
hasAssumption
hasEffect
Interface
hasChoreography
State
hasState
Choreography
hasStateSignature
StateSignature
hasOrchestration
hasTransitionRules
TransitionRules
hasTransitionRules
Orchestration
hasStateSignature

SAWSDL in a Picture



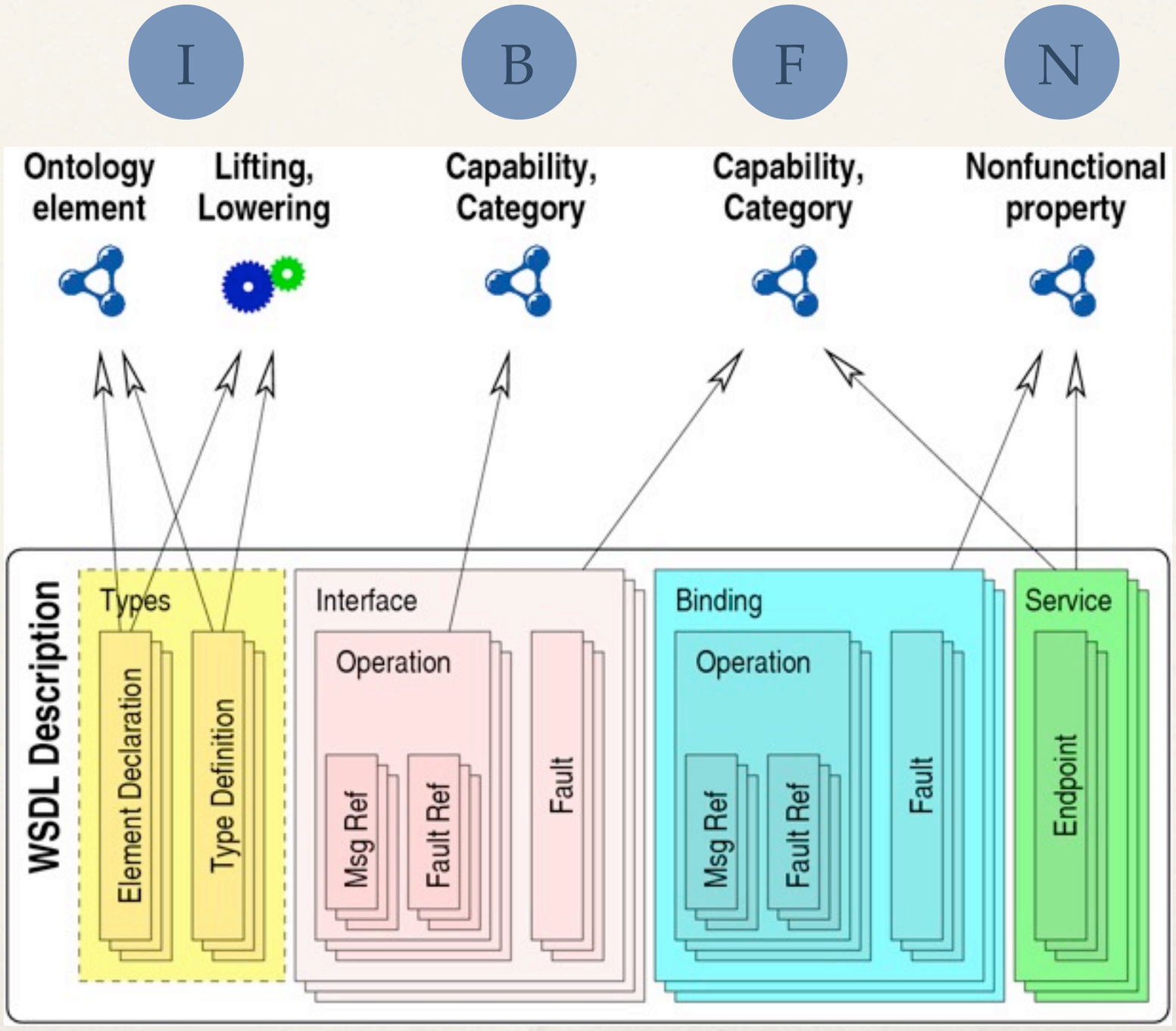
SAWSDL is Purposely Underspecified



No predefined semantics

No fixed formalism

WSMO-Lite in SAWSDL



Web API-centric Models

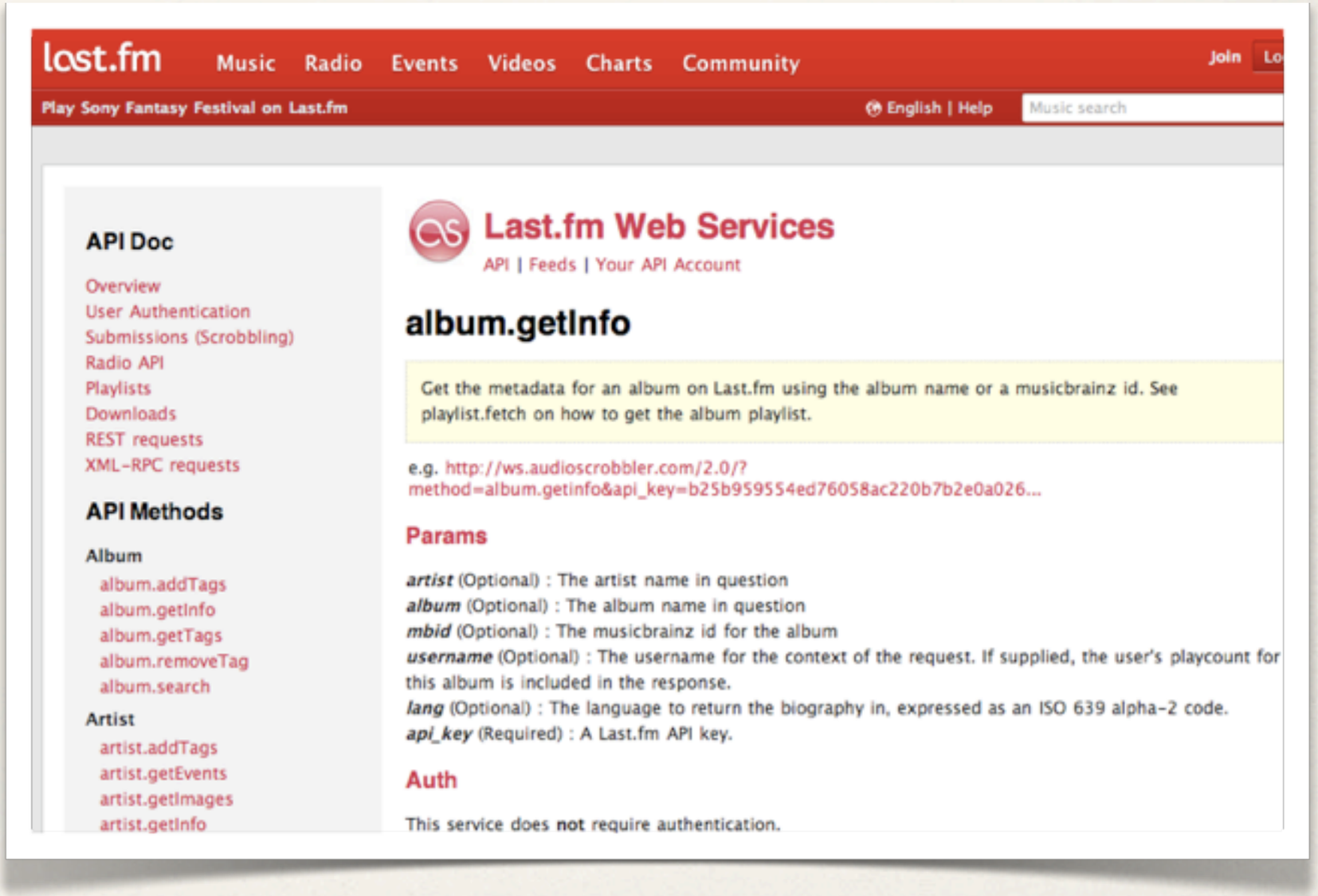
Web APIs Descriptions

Most often described via plain HTML pages

Unstructured

Highly heterogeneous descriptions

Often incomplete descriptions



SAREST

- SAREST is a microformat (poshformat) for RESTful services
- Currently uses RDFa to annotate Web pages
- Basic SAREST properties
  - domain-rel: domain information of a resource
  - sem-rel: captures the semantics of a link
  - sem-class: annotation of a single entity within a resource
- Includes a non-normative minimal service model

hRESTS/MicroWSMO

- hRESTS is a microformat (poshformat) for Web APIs
  - Service, its operations
    - Resource address, HTTP method
    - Input/output data format
- MicroWSMO extends hRESTS with SAWSDL-like hooks for pointing to semantic descriptions
- Proposes as normative the minimal service model

Processing Web API Annotations

- Web API annotations are usually extracted from the Web page (e.g., GRDDL)

- The resulting annotations are used as the basis for manipulation

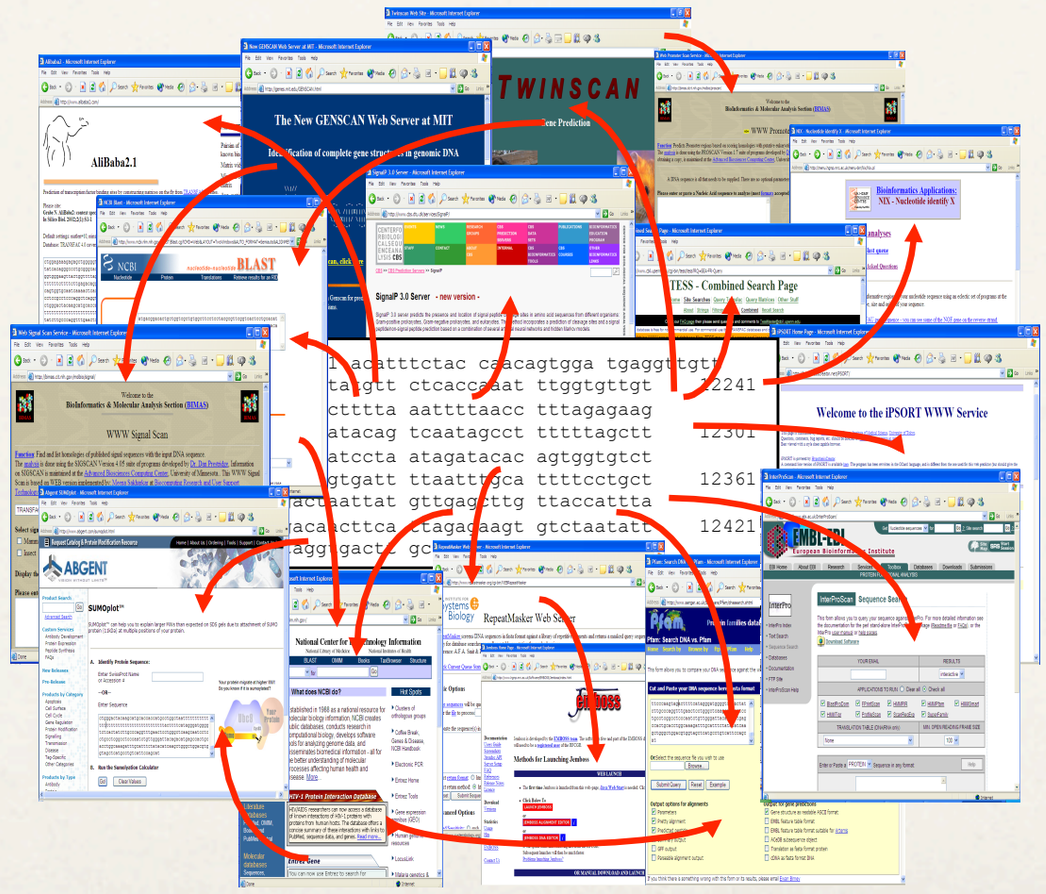
- Processing of Web API annotations builds upon existing work on Semantic Web Services by applying the same or slightly adapted algorithms

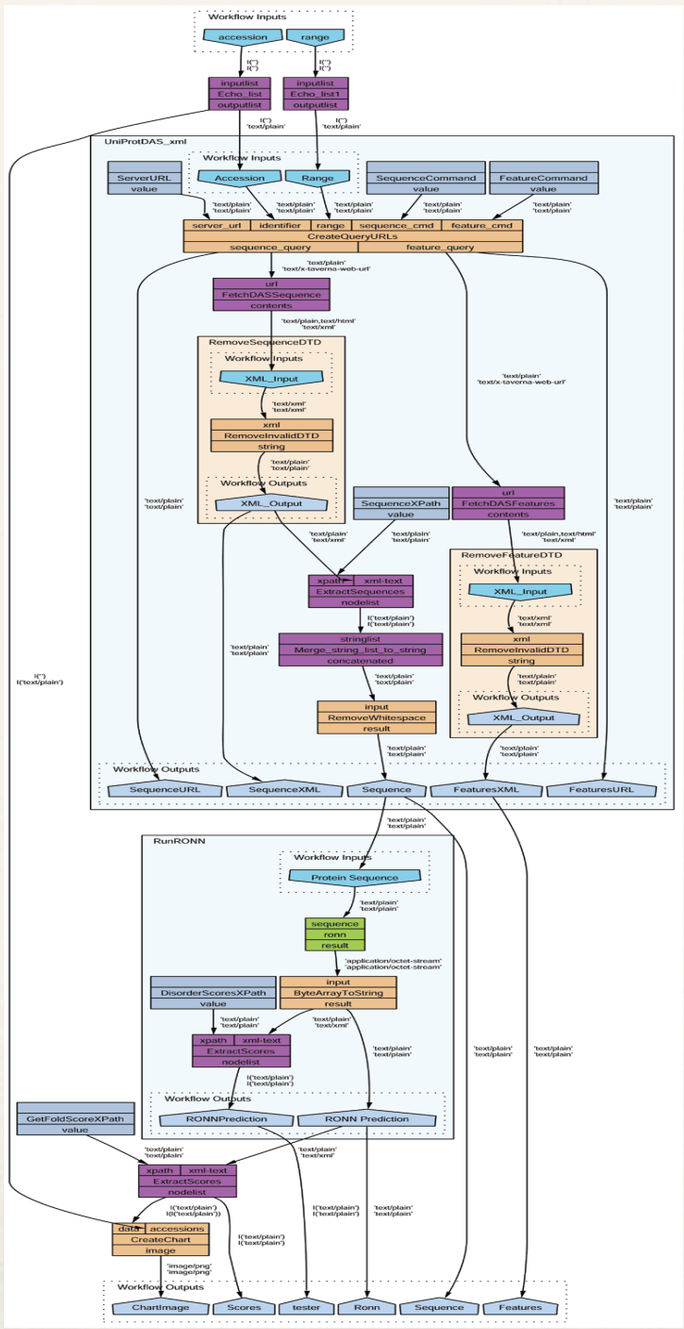
- Invocation is however a significantly different task

Applying Semantic Web Services

E-Science

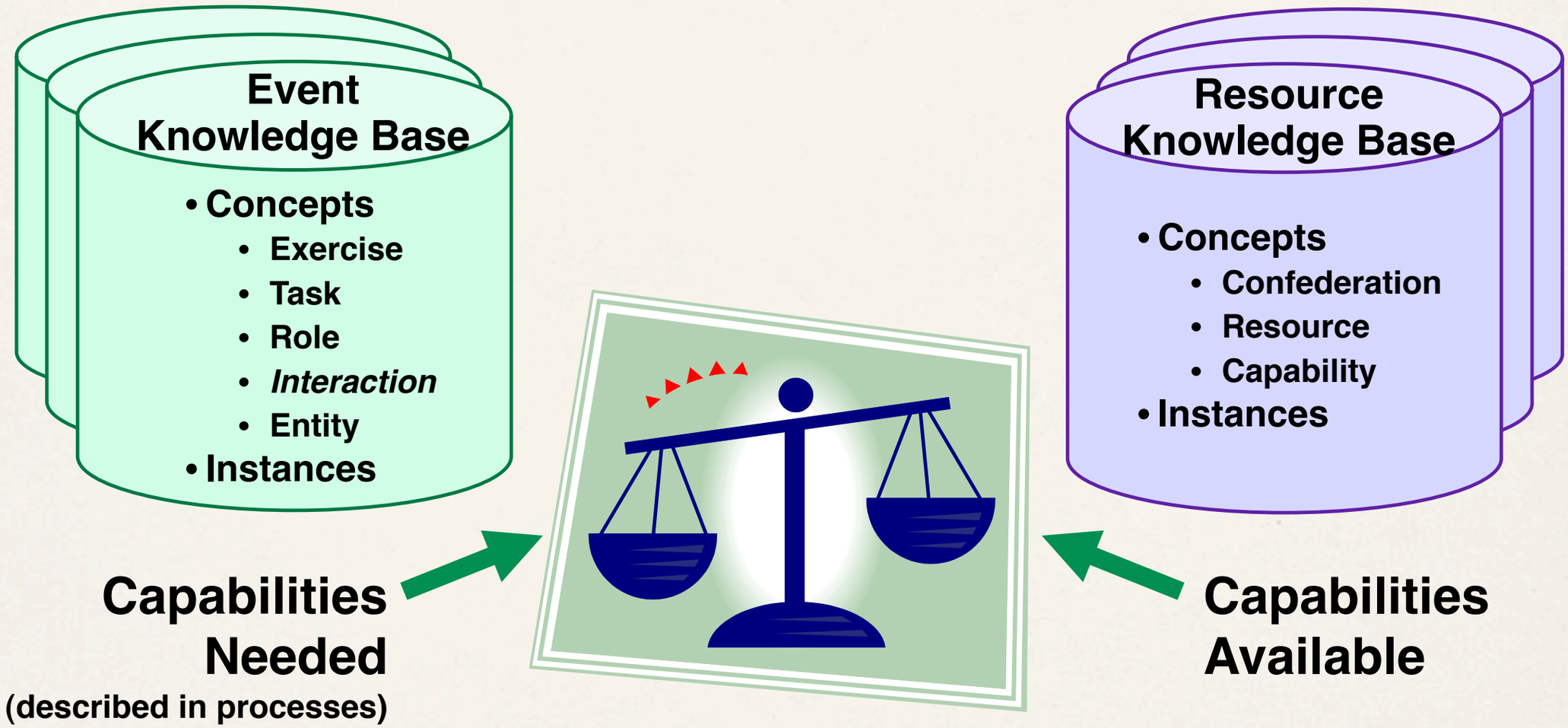
myGrid





Courtesy of Carole Goble

Software Interoperability



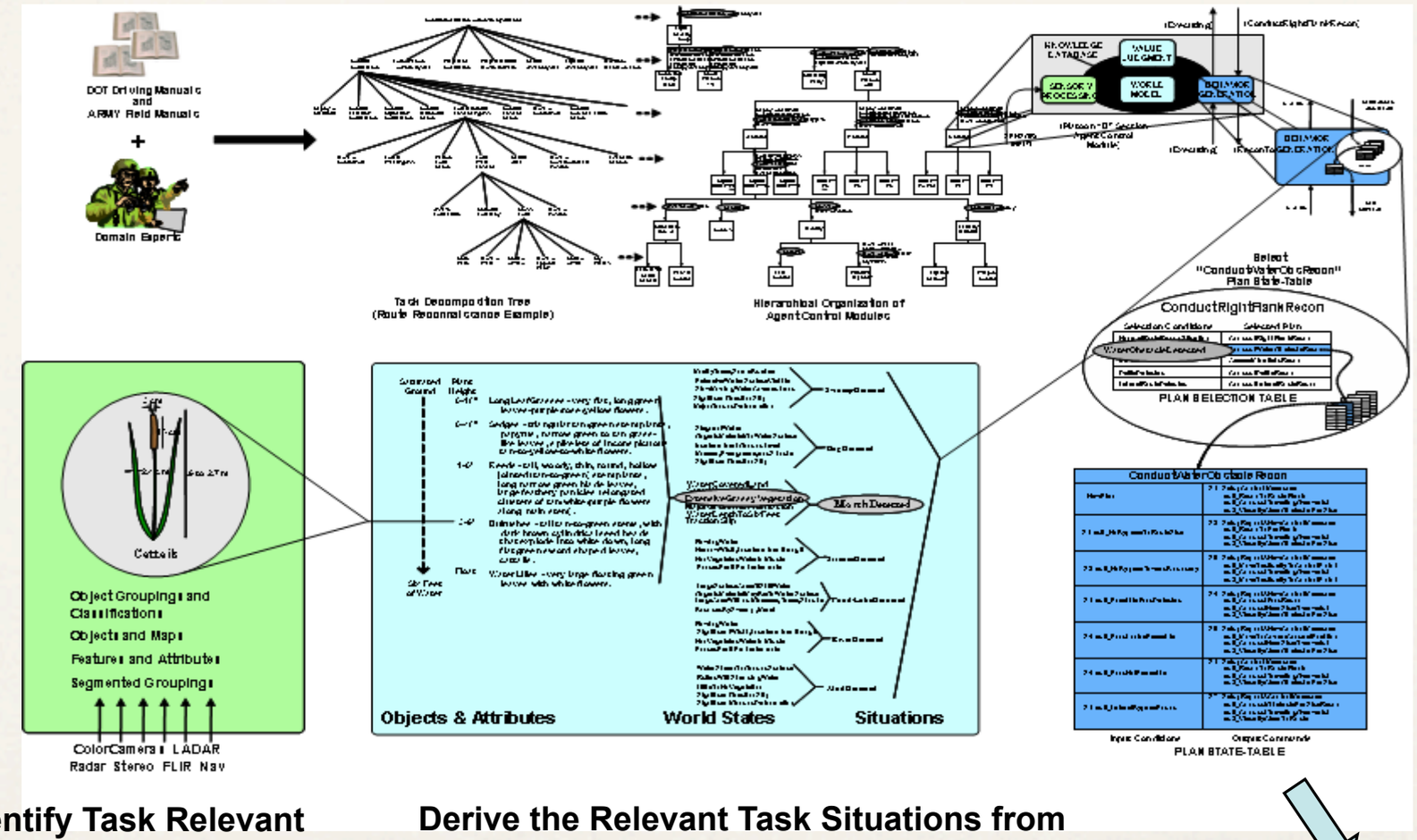
If the Capabilities Available provide a "reasonable match" to the Capabilities Needed, Interoperability may be achieved

Otherwise ➔ No Interoperability

Autonomous Vehicles

Services **Roles**

Decompose Tasks **Map Tasks to Agent Architecture** **Map Task Decisions To State-Tables**



Identify Task Relevant Entities and Objects

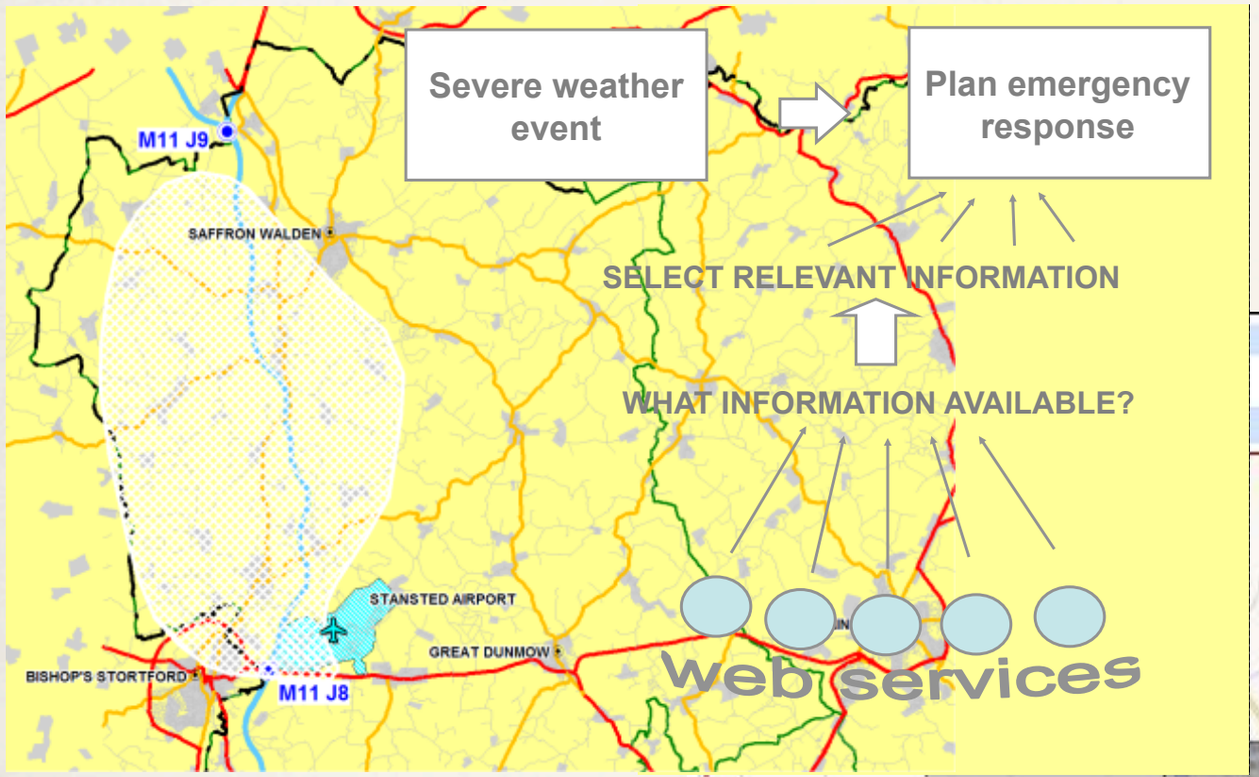
Derive the Relevant Task Situations from World States and Object Parameters

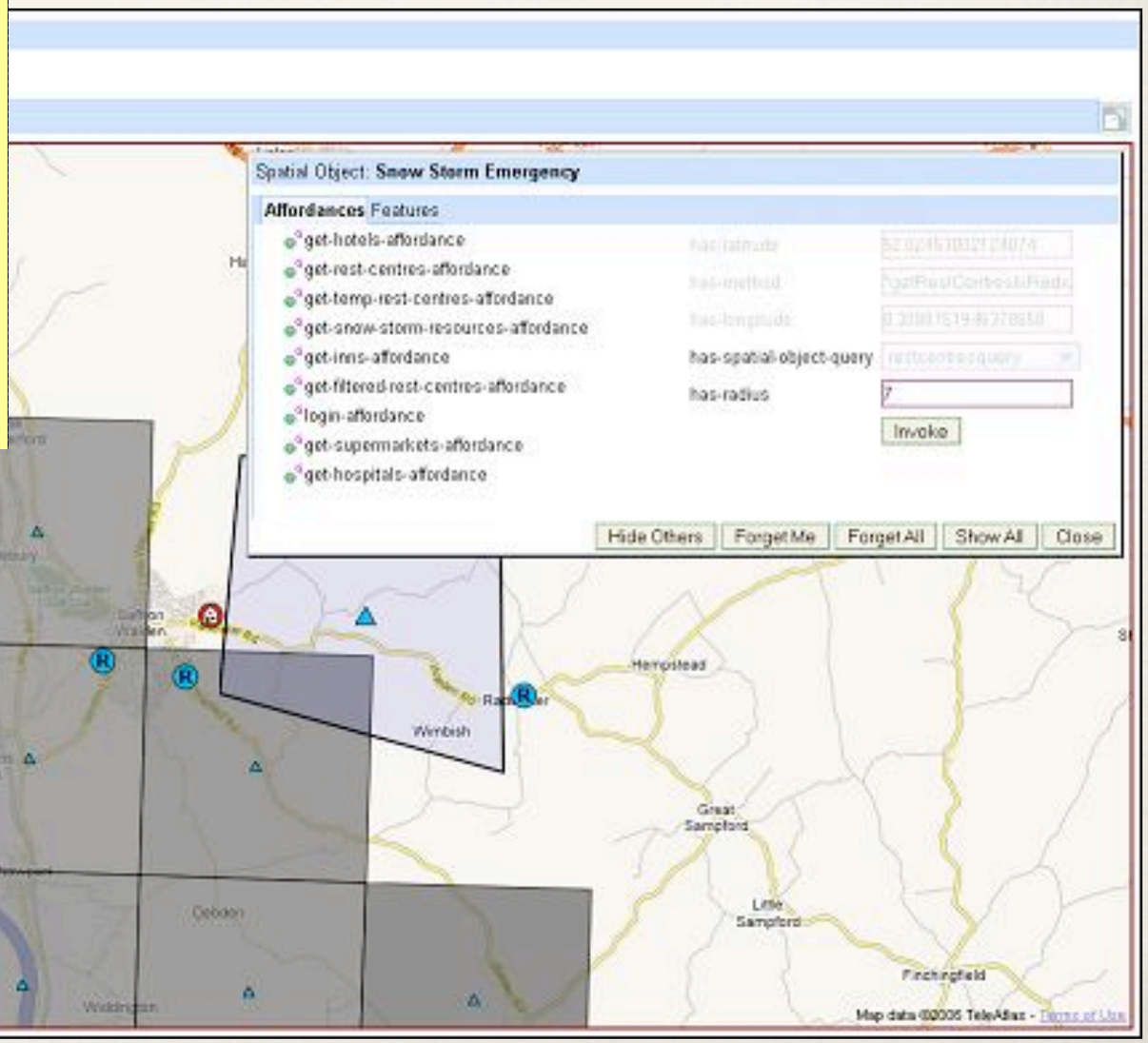
Processes

Parameters

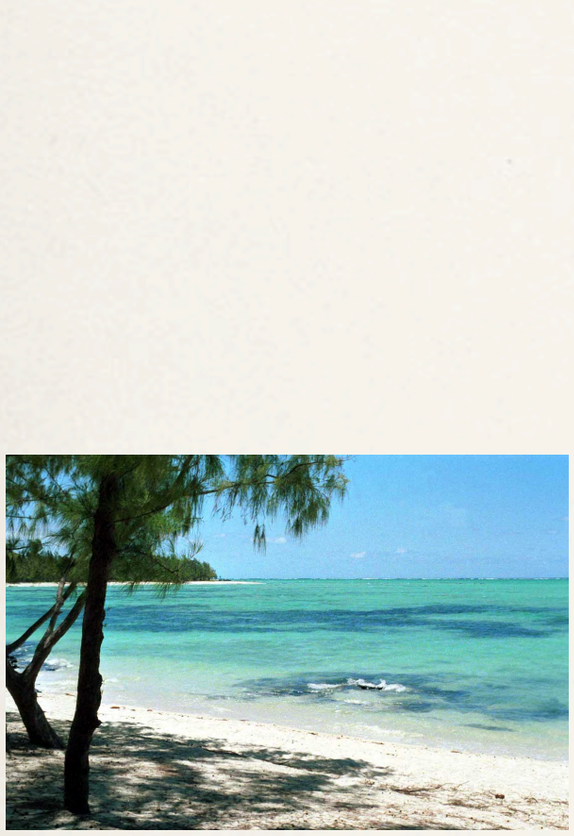
Conditions

Emergency Planning



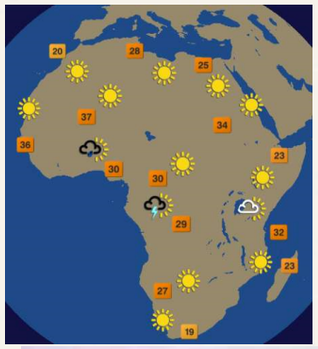


General Broker-based Approach

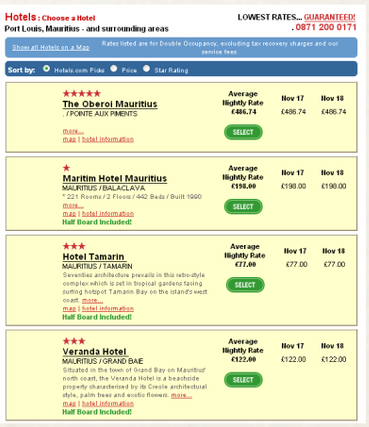


Client

SWS Broker

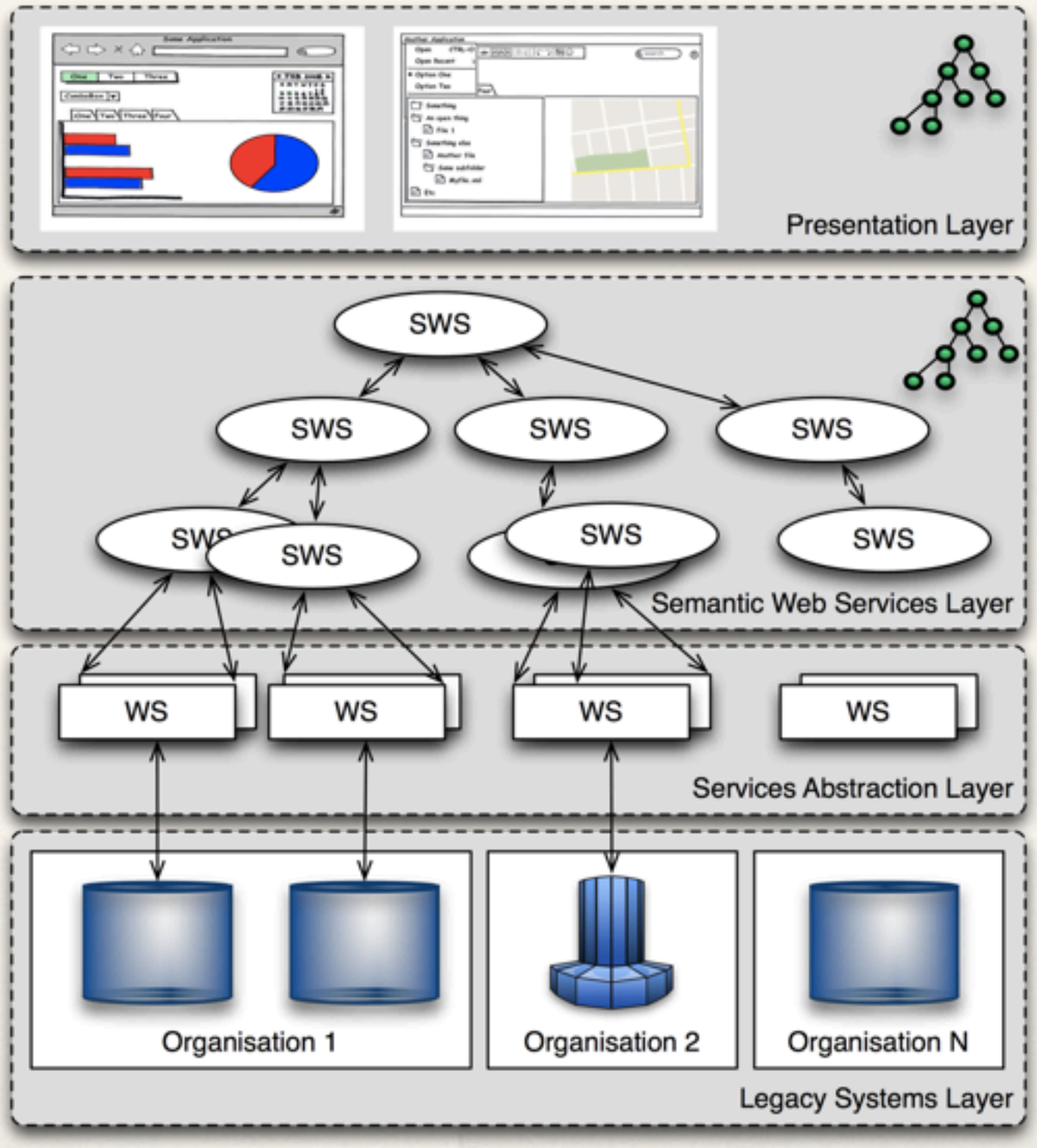


Airline	Departure Time	Arrival Time	Total Travel Time	Roundtrip Price (includes taxes and fees)
British Airways Flight 123	3:45pm London, Great Britain (LHR)	7:25am - Thu, Dec 1 Next day arrival Mauritius, Mauritius (MRU)	11hrs 40min - Nonstop	$1,236 per person Select
Air France Flight 1371 / 966	11:15am London, Great Britain (LHR)	5:55am - Thu, Dec 1 Next day arrival Mauritius, Mauritius (MRU)	14hrs 40min - 1 Stop Change planes in Charles de Gaulle, France (CDG)	$1,297 per person Select
Air France Flight 1371 Air Mauritius Flight 51 operated by AIR FRANCE	11:15am London, Great Britain (LHR)	5:55am - Thu, Dec 1 Next day arrival Mauritius, Mauritius (MRU)	14hrs 40min - 1 Stop Change planes in Charles de Gaulle, France (CDG)	$1,369 per person Select
Air France Flight 5021 operated by CITY JET Air Mauritius Flight 51 operated by AIR FRANCE	9:05am London, Great Britain (LCY)	5:55am - Thu, Dec 1 Next day arrival Mauritius, Mauritius (MRU)	16hrs 50min - 1 Stop Change planes in Charles de Gaulle, France (CDG)	$1,380 per person Select



Services

General Broker-based Approach



Conclusions

- Services provide means for effective reuse of functionality and the creation of added value solutions (businesses) through composition
- The core Web Service technologies require the use of semantics for a greater level of automation
- There are a number of conceptual models that have been proposed for annotating and reasoning over Web Services and Web APIs
- Alongside many engines, frameworks and algorithms have been devised that support discovery, composition, invocation, etc
- Further details and pointers at the end of your handouts

Thank you for your attention

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- C. Pedrinaci, J. Domingue, and A. Sheth. Handbook on Semantic Web Technologies, volume Semantic Web Applications, chapter Semantic Web Services. Springer, 2010.

Useful Links

- SOAP: http://w3.org/TR/soap12
- WSDL: http://w3.org/TR/wsdl20
- WS-Addressing: http://w3.org/TR/ws-addr-core
- WS-Policy: http://w3.org/TR/ws-policy
- UDDI: http://uddi.xml.org/
- W3C: http://w3.org/
- OASIS: http://oasis-open.org/

Useful Links

- OWL-S: http://www.daml.org/services/owl-s/
- WSMO: http://www.wsmo.org and http://cms-wg.sti2.org
- WSDL-S: http://www.w3.org/Submission/WSDL-S/
- SAWSDL: http://www.w3.org/2002/ws/sawsdl/
- SWSF & FLOWS: http://www.w3.org/Submission/SWSF/

Useful Links

- WSMO-Lite: http://cms-wg.sti2.org/TR/d11/v0.2/
- hRESTS/MicroWSMO: http://cms-wg.sti2.org/TR/d12
- SAREST: http://www.w3.org/Submission/SA-REST/
- REST & RESTful Web services: http://en.wikipedia.org/wiki/REST
- Microformats: http://microformats.org/

Useful Links

- WSMX: http://www.wsmx.org/
- IRS-III: http://technologies.kmi.open.ac.uk/irs/
- METEOR-S: http://lsdis.cs.uga.edu/projects/meteor-s/
- Glue: http://glue.cefriel.it/
- OWL-S VM: http://projects.semwebcentral.org/projects/owl-s-vm/