



Semantic Web Fred

Automated Goal Resolution on the Semantic Web

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Motivation

- Promises of the Semantic Web:
 - semantically enhanced web content processing
 - turn Web into environment for distributed computation
 - automated collaboration of entities over the Internet
- Identified Key Technologies:
 - **Ontologies:** semantic terminology definitions
 - **Web Services:** computational facilities accessible over Web
 - **Agents:** electronic representatives acting on behalf of owner
- Facilitate Automated Collaboration on the Semantic Web
=> **Questions:**
 - What are the building blocks and their functional interplay?
 - How to determine appropriate collaboration partners and resources?
 - Which techniques allow efficient & high-quality collaboration support?

SWF Objectives / Outline

1. Framework for Automated Collaboration

- collaboration model
- building blocks identification
- system components

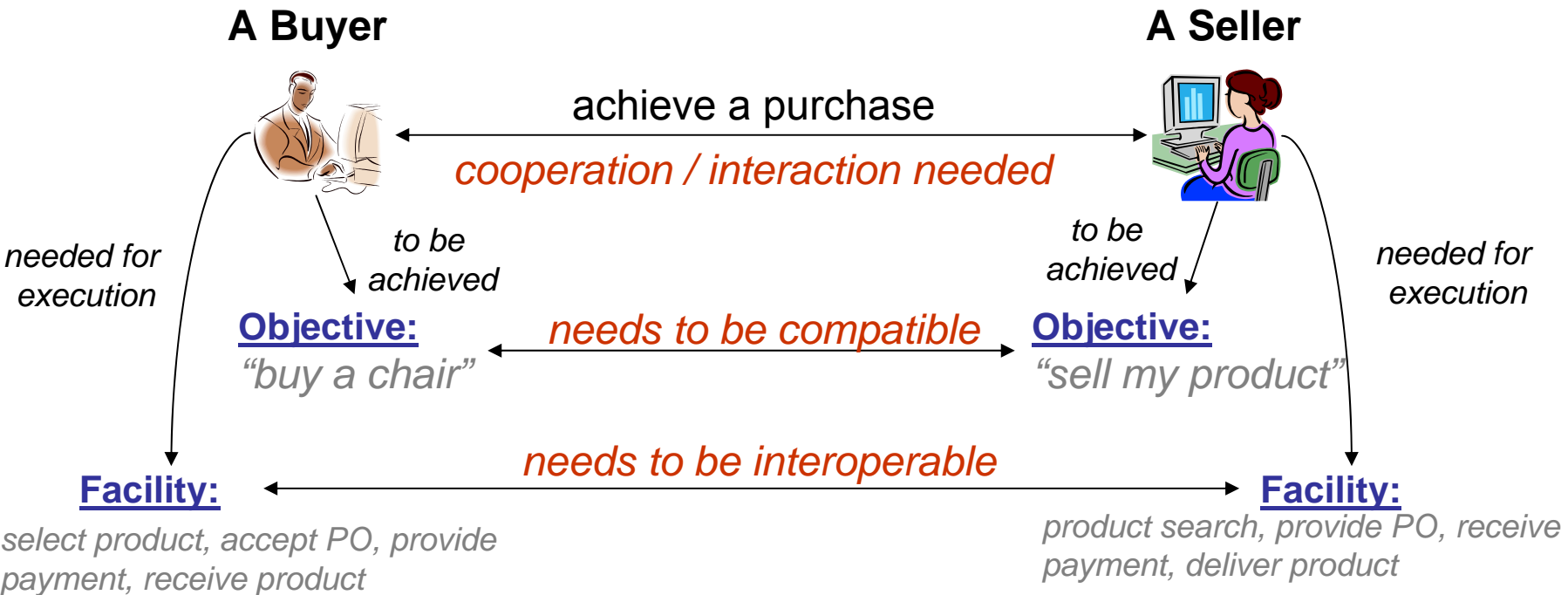
2. Building Blocks Specification

- Freds (agents), Ontologies, Goals, Services, Mediators
- structure, usage, and interplay
- semantic resource description

3. Cooperation Establishment

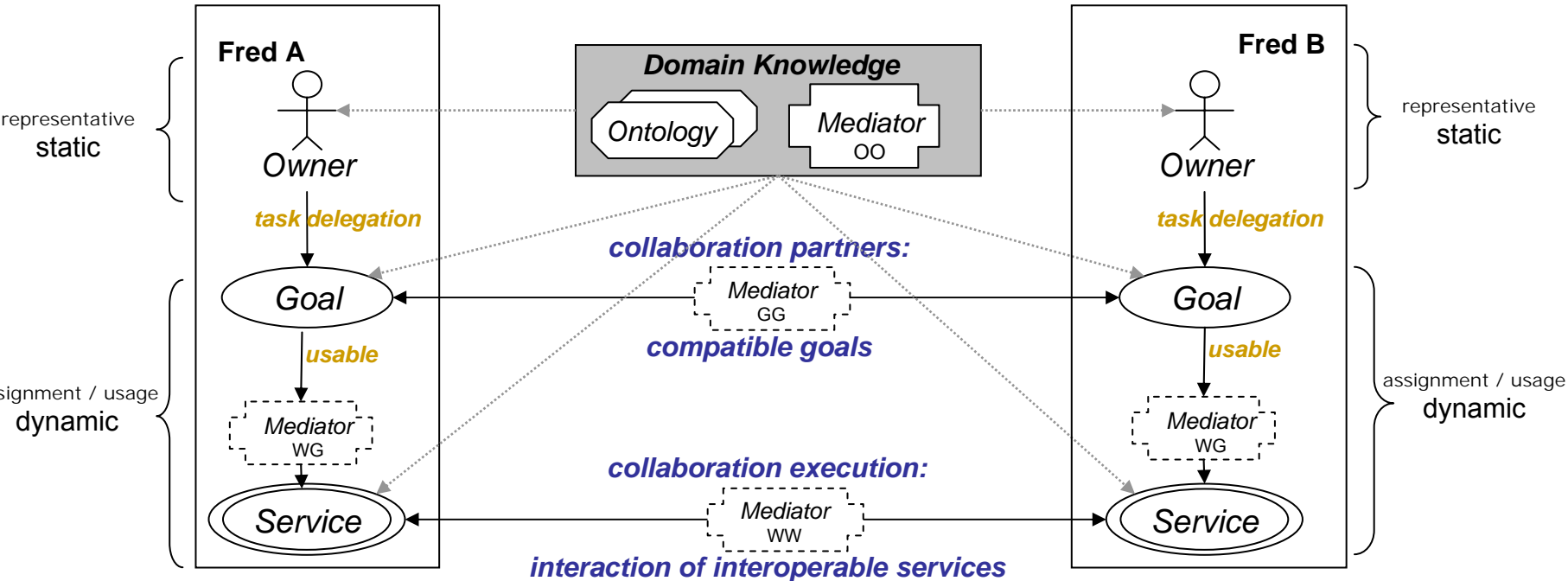
- dynamic cooperation establishment
- approach & techniques for discovery and compatibility determination
- components realization

Collaboration Model



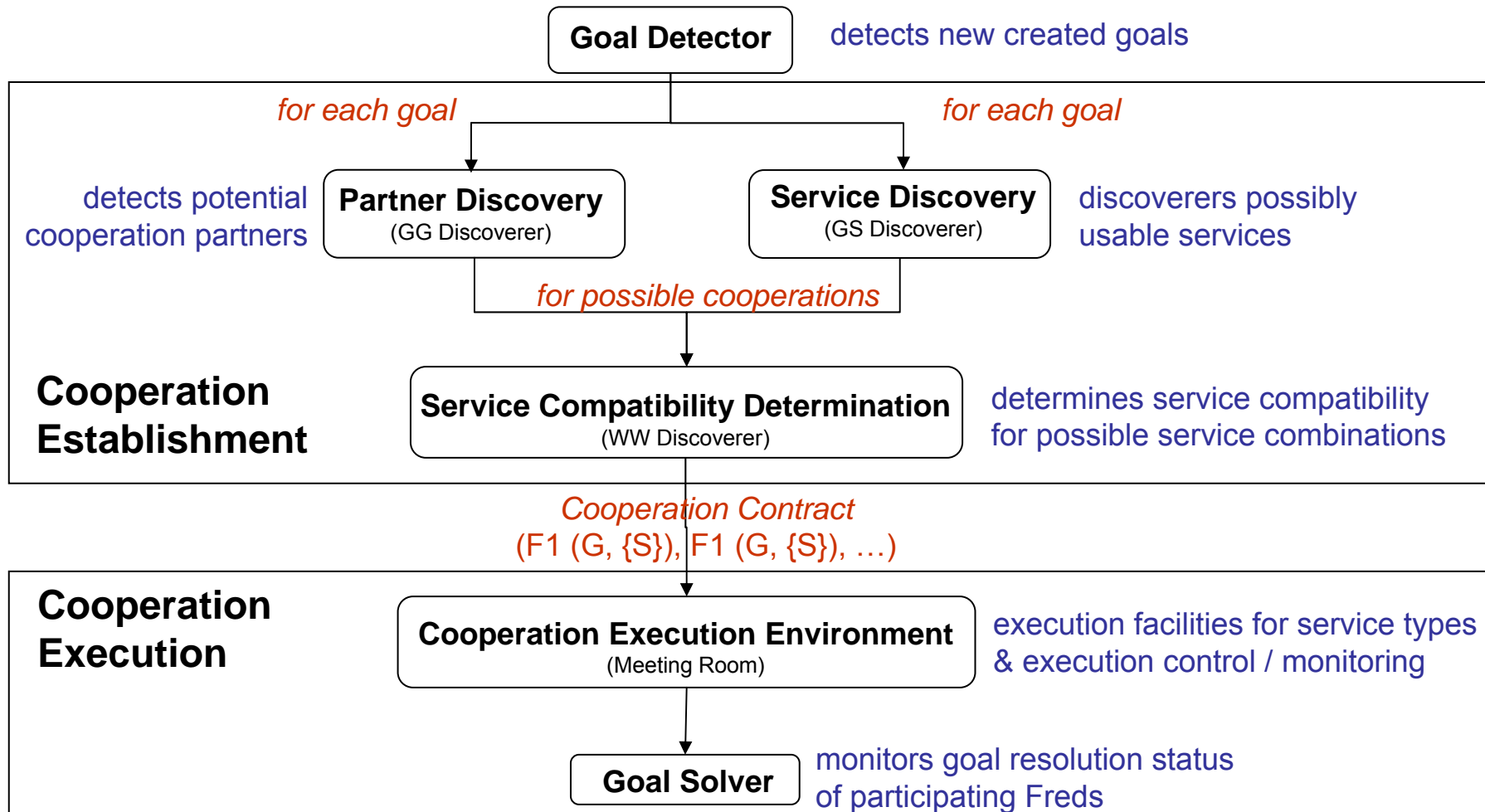
- every entity has objectives and facilities (symmetric partners)
- cooperation only if profitable for each party

Mapping to Technology: Building Blocks

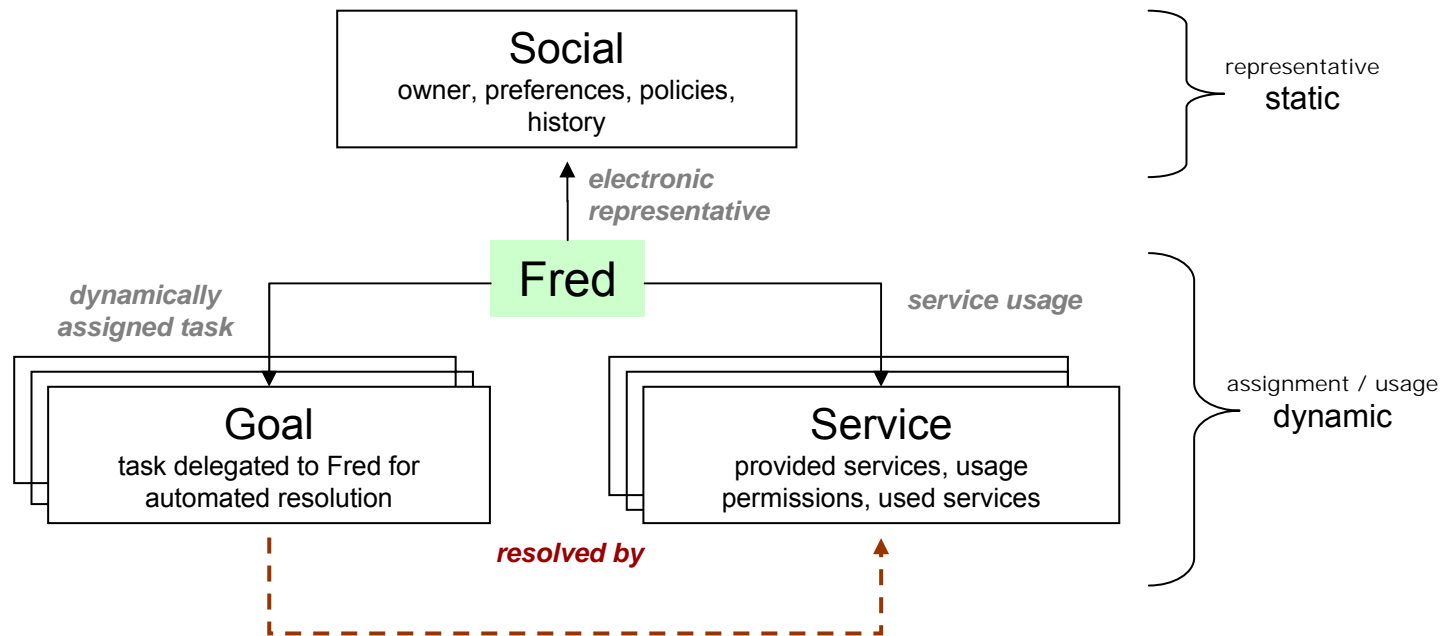


- **ontology-based knowledge and semantic resource descriptions**
- **dynamic goal assignment & service usage**
- **collaboration if compatible goals & interoperable services**
- **collaboration execution = service interaction**

System Components



Freds



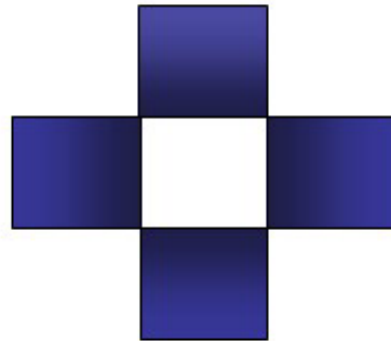
- electronic representative of entities involved in service usage & provision
- cooperative interface agent
- not (pro / re) active: central system control

Web Service Modeling Ontology

WSMO – Top Level Notions

Objectives that a client may have
when consulting a Web Service

Goals



Ontologies

Web Services

Mediators

Connectors between components with
mediation facilities for handling heterogeneities

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

Semantic description of Web
Services:

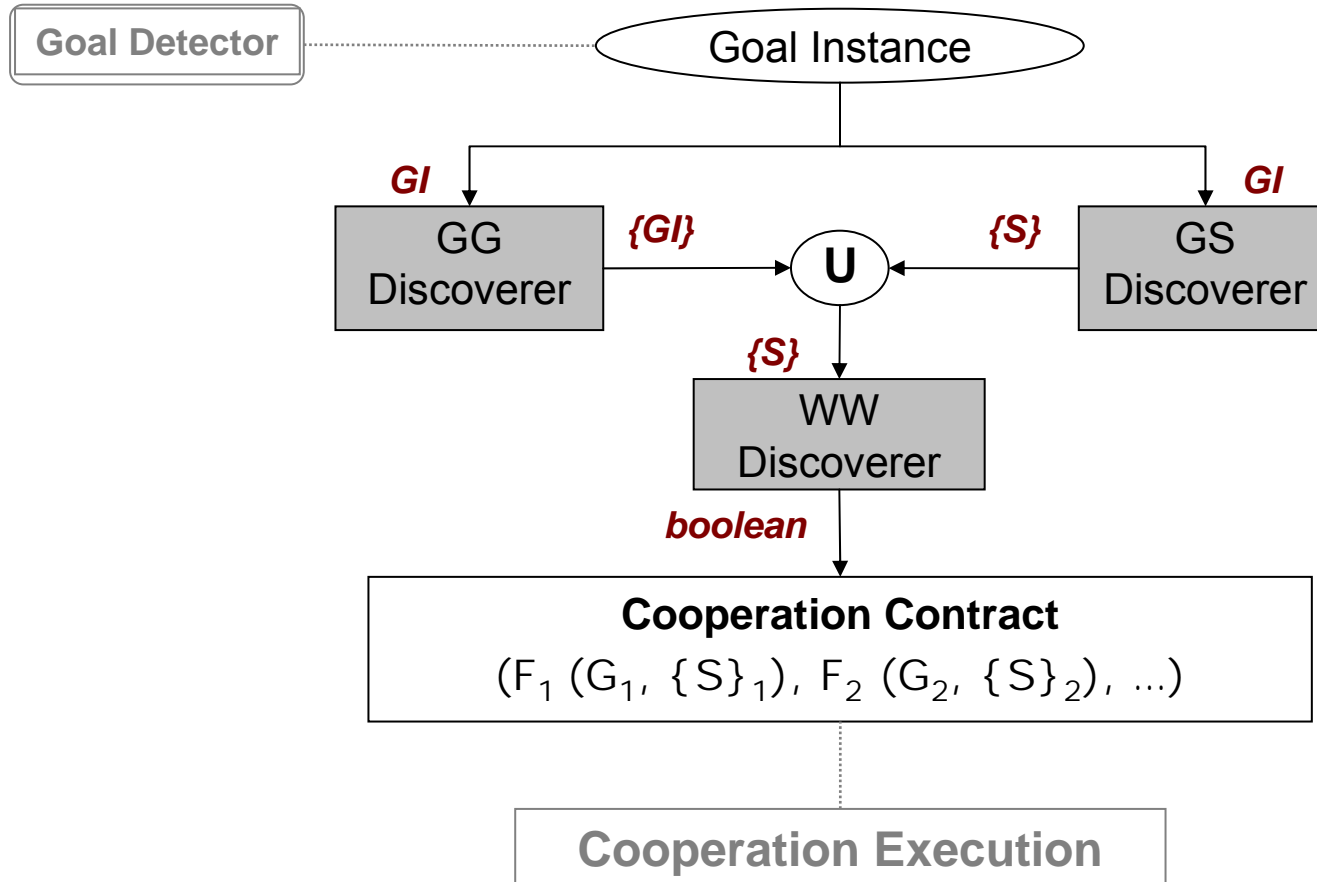
- **Capability** (*functional*)
- **Choreography** (*interaction*)
- **Orchestration** (*composition*)

SWF uses WSMO version 1.0 (www.wsmo.org)

WSMO elements in SWF

- **Ontologies**
semantic terminology definitions used in all other element descriptions
- **Goals**
tasks delegated to Freds for automated resolution
 - Goal Templates and Goal Instances
 - main description notions: submission, postcondition, effect
- **Services**
computational facilities
 - SWF service types
 - description notions: non-functional properties, Capability, Choreography
- **Mediators**
connectors with mediation facilities for resolving heterogeneities
 - mediator types
 - source & target, mediation service

Dynamic Collaboration Establishment



Partner & Service Discovery

- Action and Object Knowledge Distinction

Action defines what is to be done;

*interacting entities need to have **compatible actions***

⇒ **Action-Resource Ontology**

- **Object** defines whereon a action is to be performed;

*interacting entities need **not-contradicting object definitions***

⇒ **Set Theoretic Object Matchmaking**

- set-based resource descriptions
- matchmaking notions
- realization in VAMPIRE (theorem prover)

- **Combination is needed**

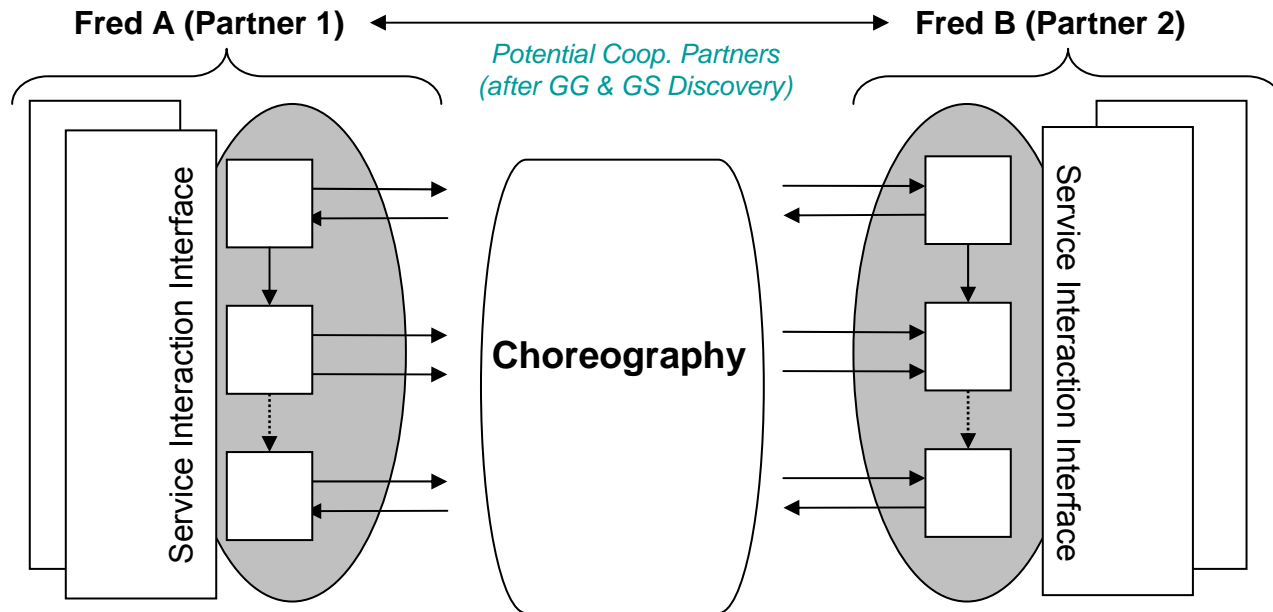
(2 resources might have not contradicting objects but not-compatible actions)

Components Architecture

- Design Principles:
 - modular components (according to discovery facility)
 - layered architecture:
 - set-up time & runtime discovery
 - least expensive operations first

⇒ **effective search space narrowing**
- GG Discoverer (Partner Discovery)
 - matches Goal Instances (active objectives assigned to Freds)
 - returns sets of Goal Instances (potential cooperation partners)
- GS Discoverer (Service Discovery)
 - matches Goal Instance and Service Capabilities
 - returns set of Services (usable for cooperation execution by Goal Instance owner)

Choreography and Service Compatibility



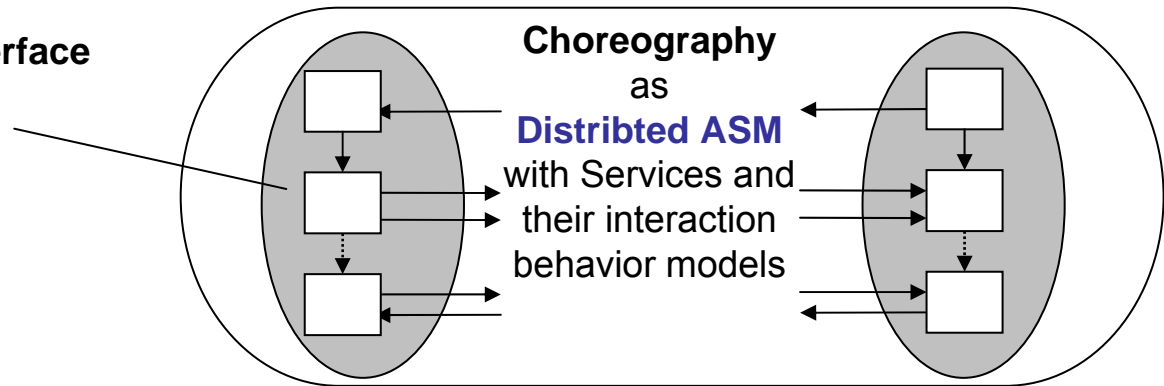
Choreography:

- agreed & valid conversation protocol
- **Service Compatibility is a pre-requisite for valid conversation protocol:**
 - all information to be exchanged are compatible
 - message exchange order allows deadlock-free & terminating interaction

Service Compatibility with ASMs

Service Interaction Interface as **Sequential ASM**:

- States
- State Signature
- Guarded Transitions



Service Compatibility Determination:

1. Information Compatibility:

- service descriptions use **same / interoperable ontologies**
- **message content is compatible** (Object Matchmaking)
- **direction of messages is inverse / compatible**

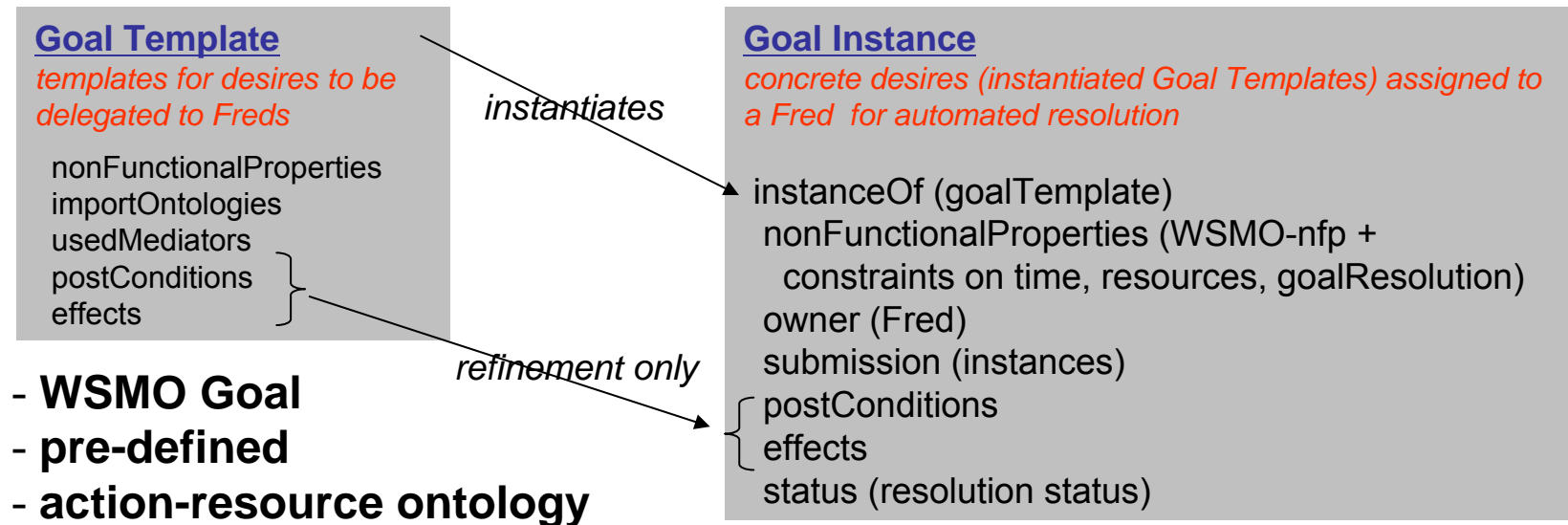
2. Communication Compatibility:

- Choreography (i.e. composed global conversation protocol) is **weak sound**:
start and termination state, deadlock-free, terminating without additional input

Aspects for Discussion

- Collaboration: Agents and Semantic Web Services
- Freds & Collaboration Model
- WSMO
- Goals and Services
- Discovery Realization
- Service Compatibility Determination

SWF Goals



- extended WSMO 1.0 Goal definition
- Goal Instance Creation / Task Assignment to Freds
 - o by user via SWF user interface
 - o dynamically during cooperation establishment

WSMO Web Service Description

- complete item description
- quality aspects
- Web Service Management

Non-functional Properties

Core + WS-specific

- Advertising of Web Service
- Support for WS Discovery

Capability

functional description

Interaction Interface for consuming WS

- Messages
- External Visible Behavior
- 'Grounding'



Realization of WS by using other Web Services

- Functional decomposition
- WS Composition

Choreography --- Interfaces --- Orchestration

SWF Service Model

○ SWF Service Types

1. Plans = internal service implemented in Java
2. Process = multiple-step / nested service
3. external Web Services (invoked via WSDL description)

Services

a computational resource available in the system, described as WSMO Web Services

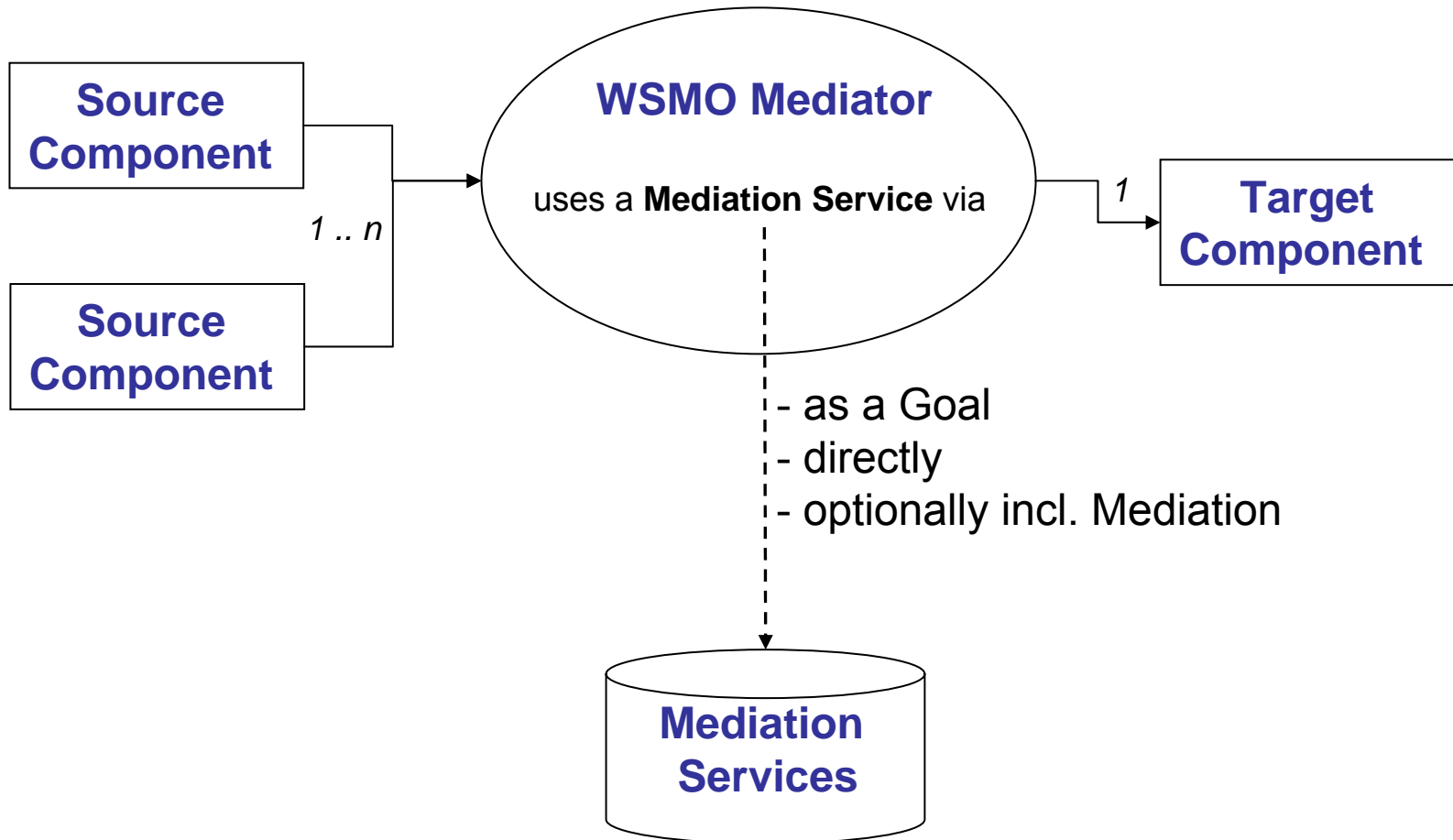
nonFunctionalProperties **ofType** nonFunctionalProperties
importOntologies **ofTypeSet** ontology
usedMediators **ofTypeSet** {ooMediator, wgMediator}
capability **ofType** capability
 preconditions **ofTypeSet** axiom
 assumptions **ofTypeSet** axiom
 postconditions **ofTypeSet** axiom
 effects **ofTypeSet** axiom
choreography **ofType** choreography

- 1 common service description language
- Orchestration not of interest

Mediation

- **Heterogeneity ...**
 - Mismatches on structural / semantic / conceptual / level
 - Occur between different components that shall interoperate
 - Especially in distributed & open environments like the Internet
- **Concept of Mediation** (Wiederhold, 94):
 - *Mediators* as components that resolve mismatches
 - Declarative Approach:
 - Semantic description of resources
 - ‘Intelligent’ mechanisms that resolve mismatches independent of content
 - Mediation cannot be fully automated (integration decision)
- **Levels of Mediation within Semantic Web Services (WSMF):**
 - (1) **Data Level:** mediate heterogeneous Data Sources
 - (2) **Protocol Level:** mediate heterogeneous Communication Patterns
 - (3) **Process Level:** mediate heterogeneous Business Processes

Mediator Structure



Action-Resource Ontology

```
concept action
  compatibleAction ofType set action
concept buy subConceptOf action
  compatibleAction ofType set sell
concept sell subConceptOf action
  compatibleAction ofType set buy
```

**Action
Taxonomy**

**Resource
Taxonomy**

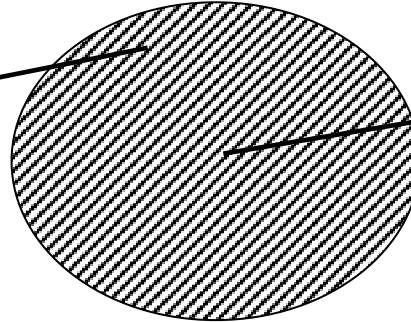
```
concept resource
  hasAction ofType set action
concept goal subConceptOf resource
concept service subConceptOf resource

concept buyergoal subConceptOf goal
  hasAction ofType set buy
concept sellerservice subConceptOf service
  hasAction ofType set sell
```

all resources are defined as instances of resource types

Set-Based Resource Descriptions

Information Space
all possible instances
of used ontologies



Description Notion
all possible instances that
satisfy restricted information space

postcondition

definedBy

```
exists ?PurchaseItem(?PurchaseItem[  
  item hasValue ?PurchaseFurniture  
] memberOf swfmo:product) and  
exists ?PurchaseFurniture(?PurchaseFurniture[  
  material hasValues {wood},  
] memberOf furn:chair) and  
?X[  
  purchaseItem hasValue ?PurchaseItem,  
  buyer hasValue kb:MichaelStollberg,  
  purchasePayment hasValue kb:MSCreditCard  
] memberOf swfmo:purchaseContract .
```

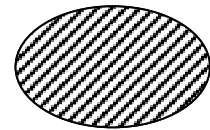
Goal Instance Postcondition

- Objective: receive a purchase contract for a wooden chair for Michael Stollberg payment with credit card
- meta-varibale X (dynamically quantified by matchmaking notion)
- restrictions on several ontology notions
- WSML syntax

Set Theoretic Matchmaking Notions

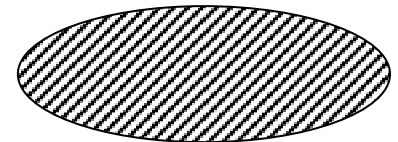
1. Exact Match:

$$R_Q, R_R, O, M \models \forall x. (R_Q \iff R_R)$$



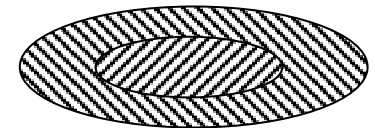
2. PlugIn Match:

$$R_Q, R_R, O, M \models \forall x. (R_Q \implies R_R)$$



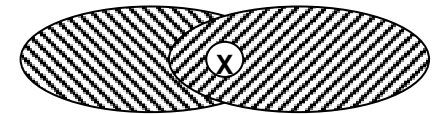
3. Subsumption Match:

$$R_Q, R_R, O, M \models \forall x. (R_Q \leq R_R)$$



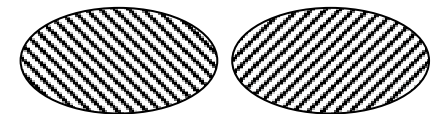
4. Intersection Match:

$$R_Q, R_R, O, M \models \exists x. (R_Q \wedge R_R)$$



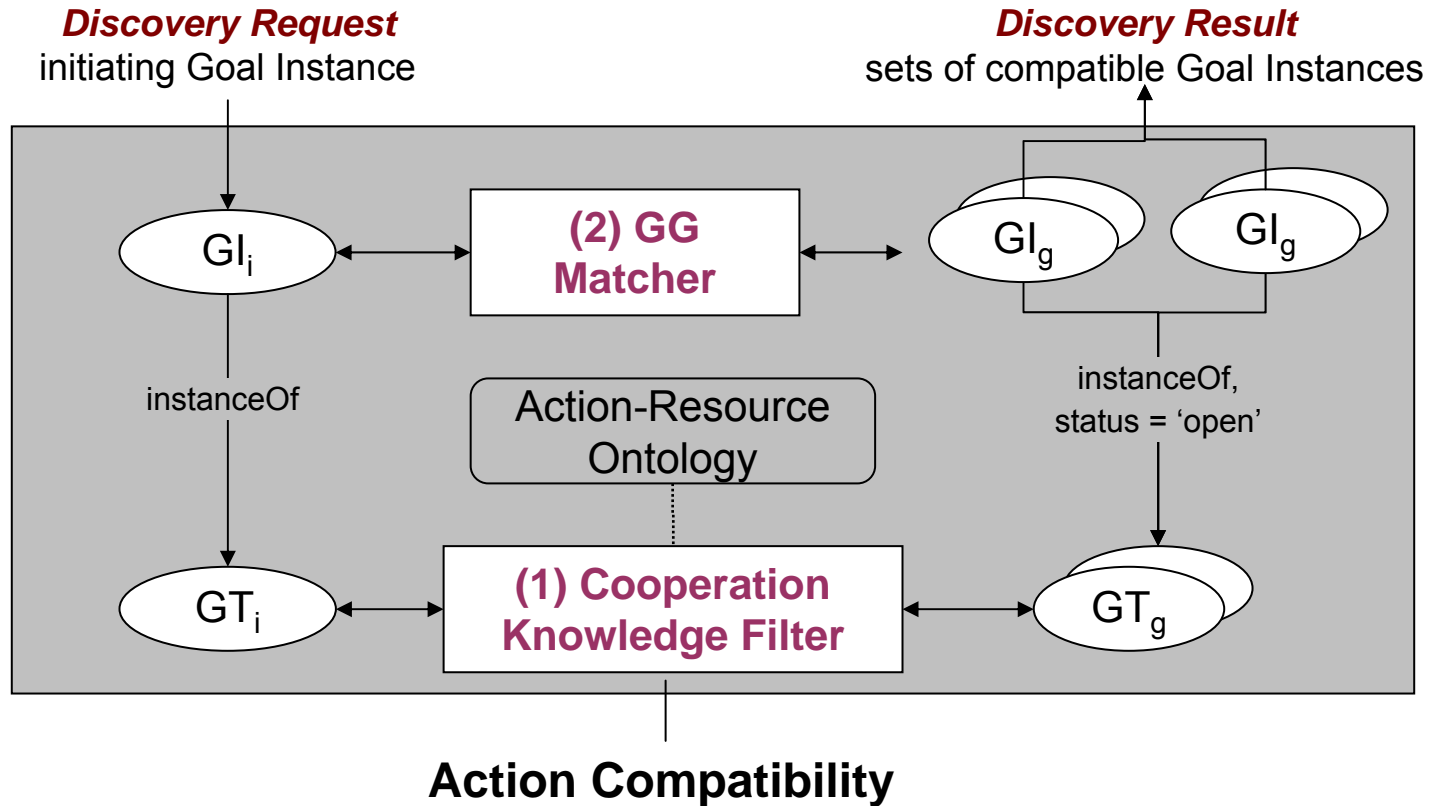
5. Non Match:

$$R_Q, R_R, O, M \models \neg \exists x. (R_Q \wedge R_R)$$



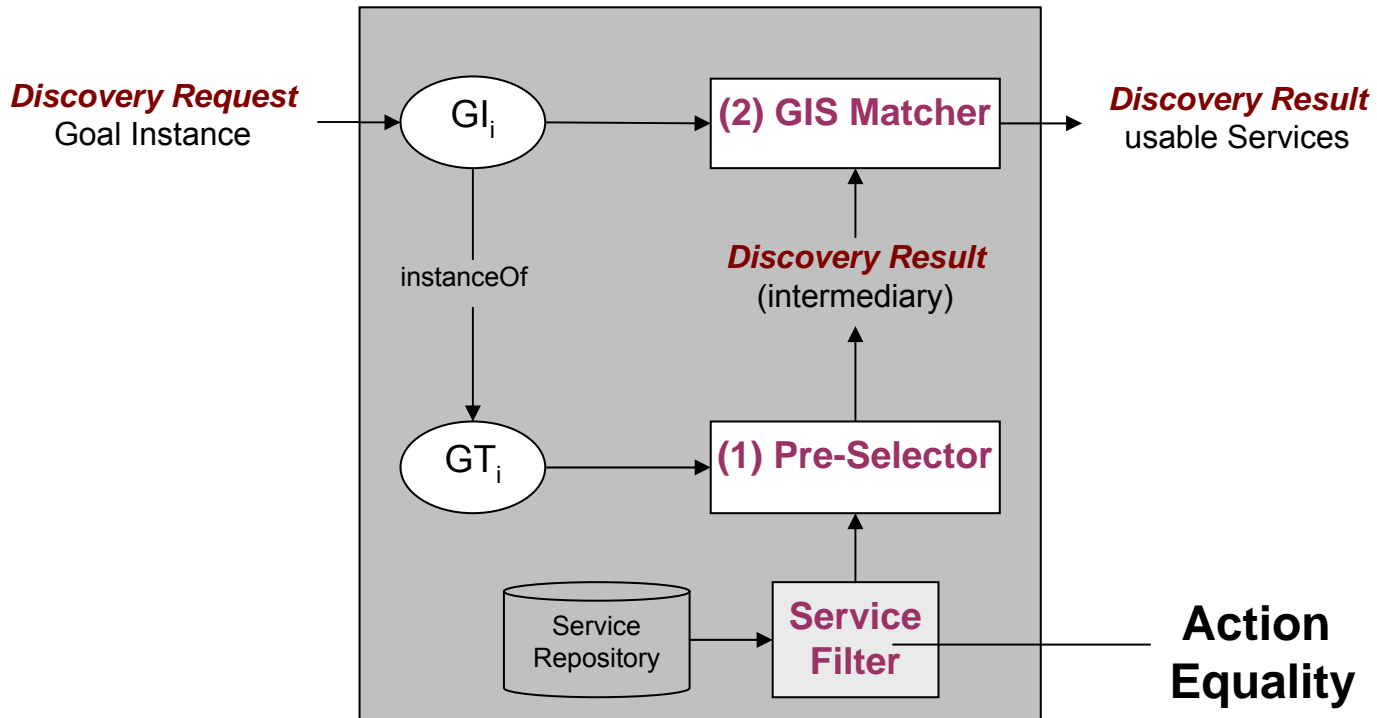
Partner Discovery

(GG Discoverer)



Service Discovery

(GS Discoverer)



Service Compatibility Determination (WW Discoverer)

