第二届中国**Agent**理论与应用学术会议
（Agent2008）

基于主体的
语义 Web 服务

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INSTITUTE OF COMPUTING TECHNOLOGY

内容提要

- 概述
- **Web** 服务自动发现
- **Web** 服务自动组合
- 语义**Web**服务平台 **SWSBroker**
- 群智能决策支持系统 GIDSDP
- 结束语

多主体系统发展过程

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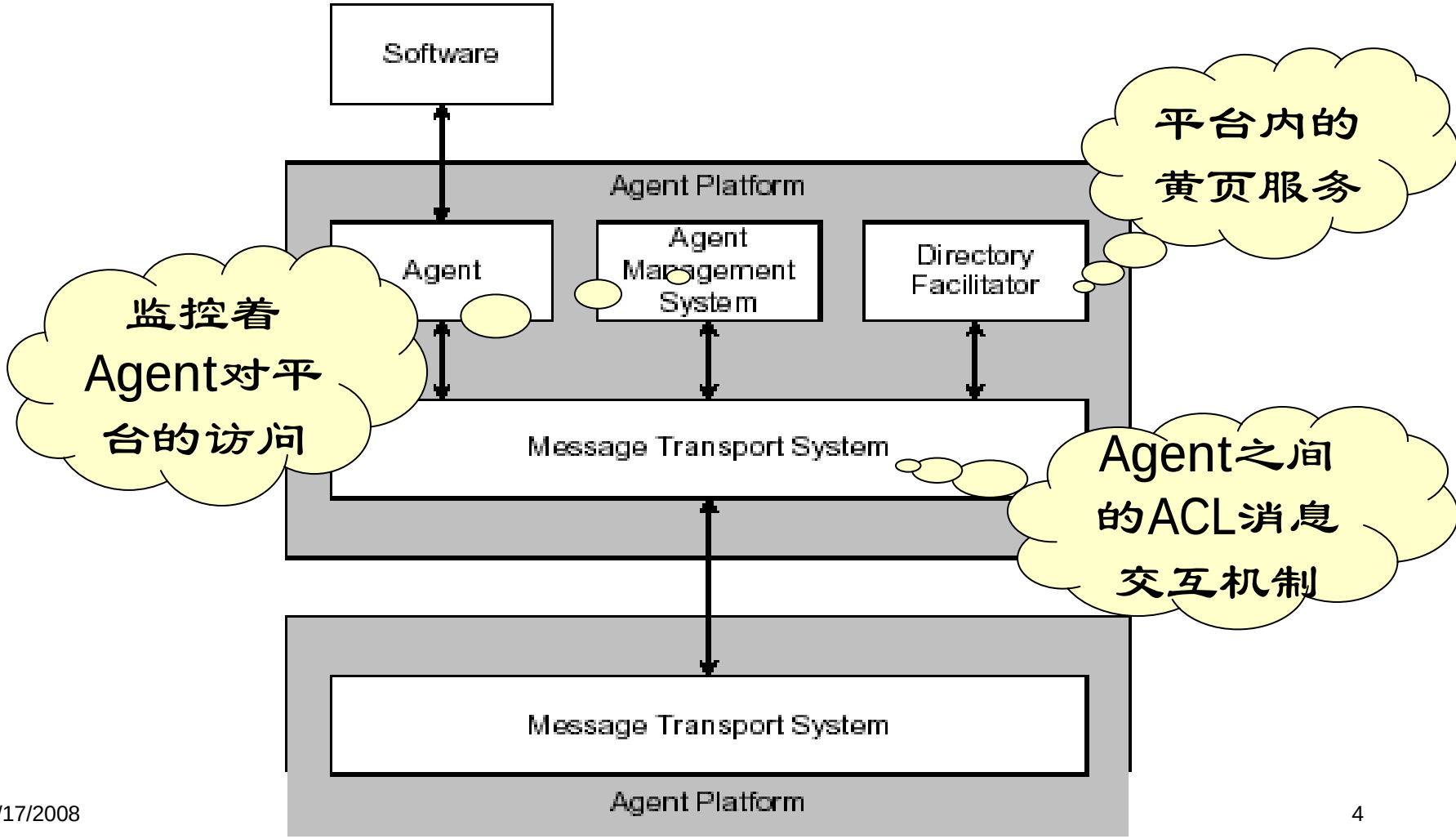
- 1987 Bratman BDI
- 1990 Shoham AOP
- 1991 Rao and Georgeff formalized the BDI model
- 1992 Jennings Hierarchical Architecture (GRATE)
- 1993 ARPA KQML
- 1996 FIPA (Foundation for Intelligent Physical Agents)，是一个非营利组织，建立于瑞士日内瓦。
- 2002 AAMAS (autonomous agents and multi-agent systems)

多主体系统发展过程


Software
Agent Platform
Agent
Agent Management System
Directory Facilitator
Message Transport System
Message Transport System
Agent Platform
平台内的黄页服务
监控着Agent对平台的访问
Agent之间的ACL消息交互机制

多主体系统

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- **IBM公司的AgentBuild**
- **Agent Oriented Software Pty Ltd公司的Jack**
- **英国BT公司Zeus**
- **TILAB and Motorola的JADE**
- **中科院计算所的MAGE等**

多主体系统软件性能比较

	JADE	JACK	Zeus	MAGE
需求分析	常规方法	常规方法	常规方法	面向主体统一建模平台 AUMP
主体结构	支持BDI模型	支持BDI模型	支持BDI模型 支持内部状态机	支持BDI模型
通信语言	FIPA ACL	FIPA ACL	采用规则 支持对话管理	FIPA ACL
开发环境	基于JAVA编程 提供调试工具	基于JAVA编程 提供调试工具	基于JAVA编程 提供调试工具	可视化主体开发环境 VAStudio，具有多种开发工具，行为库、主体库等，支持软件复用
运行平台	JADE运行平台 支持主体移动	JACK运行平台 支持主体移动	Zeus运行平台 不支持主体移动	MAGE运行平台 支持主体移动

AAMAS

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2002 AAMAS (autonomous agents and multi-agent systems)

- 2002 Bologna, Italy
- 2003 Melbourne Australia
- 2004 New York, USA
- 2005 Utrecht, The Netherlands
- 2006 Hakodate, Japan

AAMAS

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- **2007 AAMAS Honolulu, Hawaii, USA**
  Autonomic Computing

- **2008 AAMAS Estoril, Portugal**
  Multi-Robots
  Virtual Agents

主体技术发展

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- **Web Service**
- **Semantic Web**
- **Workflow:**

  WADE is the main evolution of JADE and adds to it the ability to define system logics according to the workflow metaphor.

Web的发展

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Web 1.0 (1993-2003)	Web 2.0 (2004- beyond)	Web 3.0 (2007- beyond)
“Read”	“Write” & Contribute	Semantics
“Page”	“Post / record”	Search engine
“static”	“dynamic”	
Web browser	Browsers, RSS Readers, anything	
“Client Server”	“Web Services”	
Web Coders	Everyone	
“geeks”	“mass amatuerization”	

Web 1.0

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- 静态的网络
- 地窖式的信息
- 单一的沟通

Web Services

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WWW
URI, HTML, HTTP

Web Services
UDDI, WSDL, SOAP

Bringing the computer back as a device for computation

Static

Dynamic

Web 2.0

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- 2004年由O’Riellly开始使用这个名词
- 网络 + 社会计算
- 动态内容
- 高度互动
- 协作的
- 以读者为本
- 以小区为本

Web 2.0 例子

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- RSS 内容发放
  网志 – 网络 + 评论
- Wikis　　维基 – 内容在小区内建立
- 直接的信息, SMS
- 透过IP来传送声音 – Skype
- Podcasting 播客
- Vlogs 视频博客

Web 2.0 支持技术

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- Web 服务
- XML APIs
- AJAX (asynchronous JavaScript and XML)
- Microformats
- 开放式检索 vs SRU/SRW

Web 2.0 的典型网站

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- YouTube
- Facebook
- MySpace
- Flickr

Web 3.0

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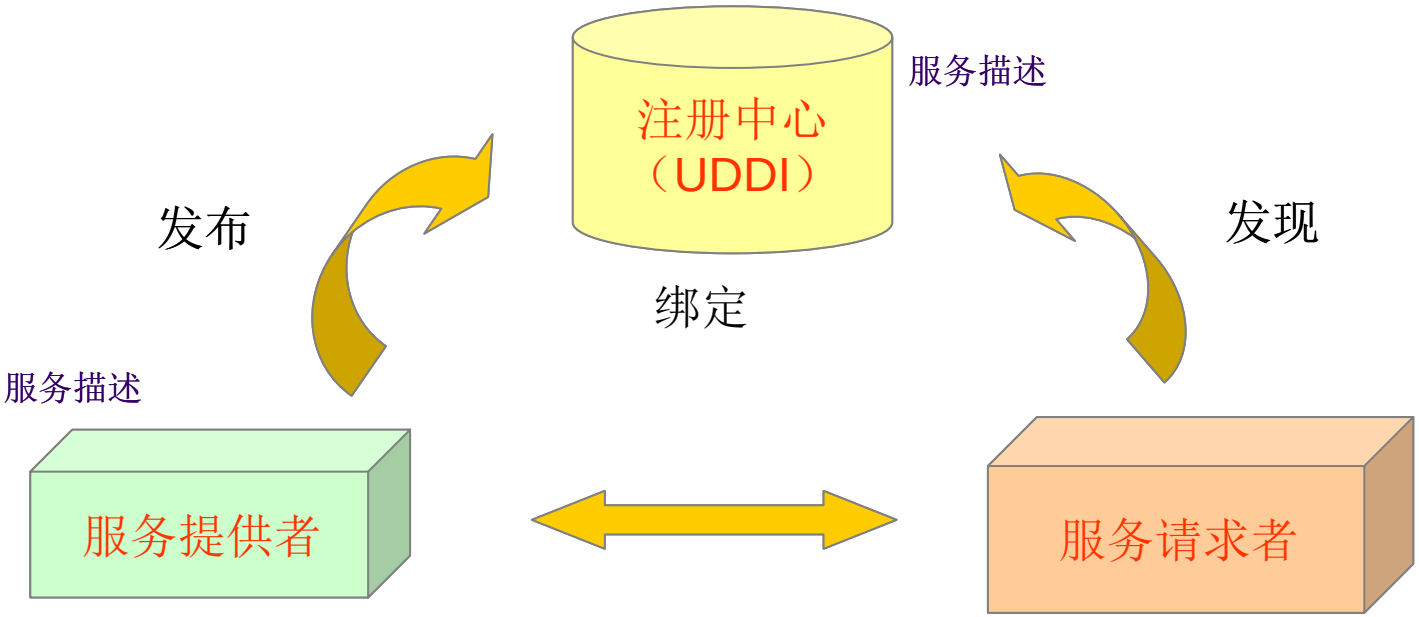
- Web 2.0 + 人工智能
- 语义 Web
- Web 2.0 + 企业计算

Web Services

Web服务

- 服务：服务是被封装好的软件。它用统一的形式描 述，用标准的协议调用。
- 面向服务的计算（SOC）：



Web Services Protocols

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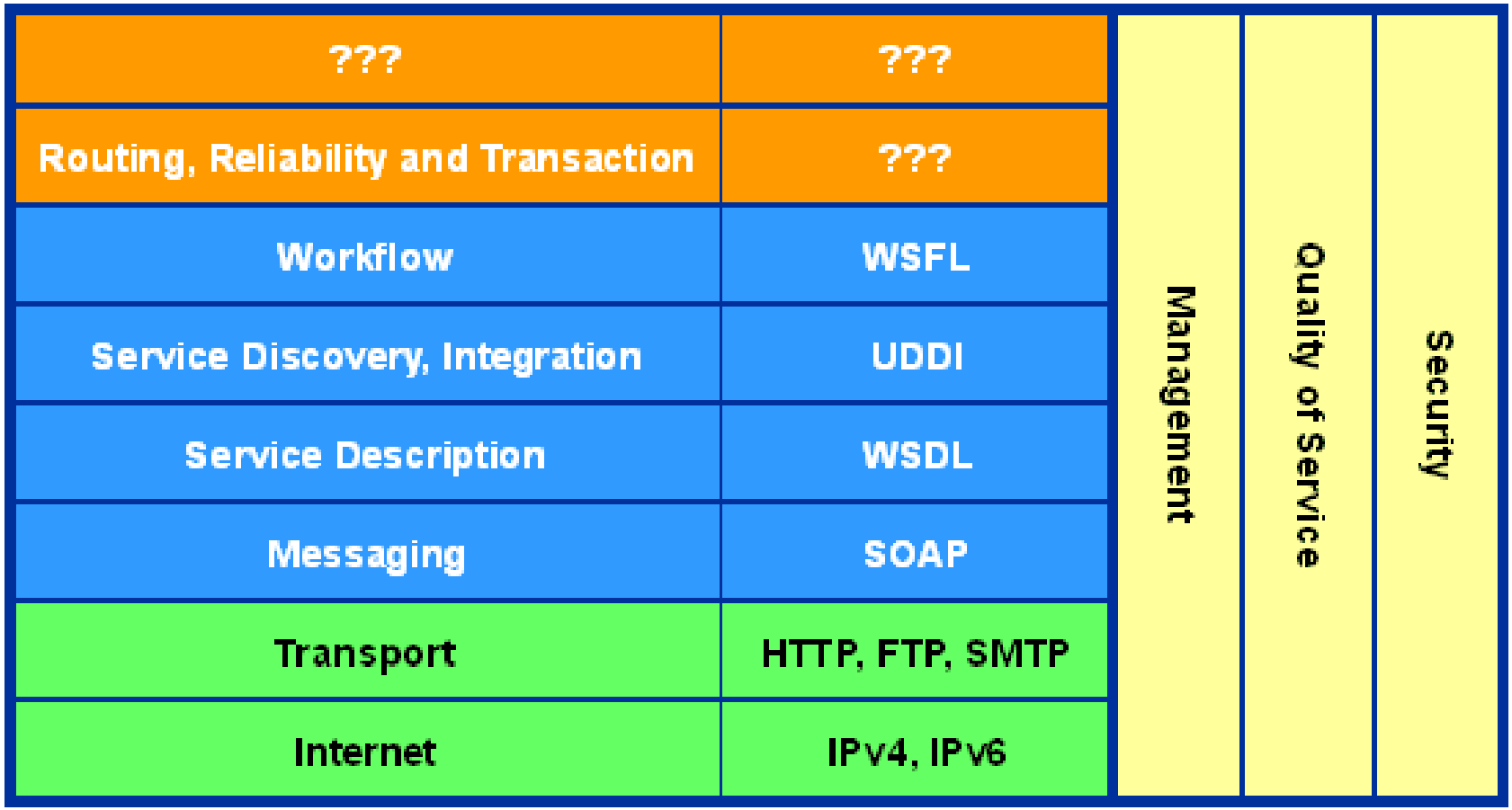
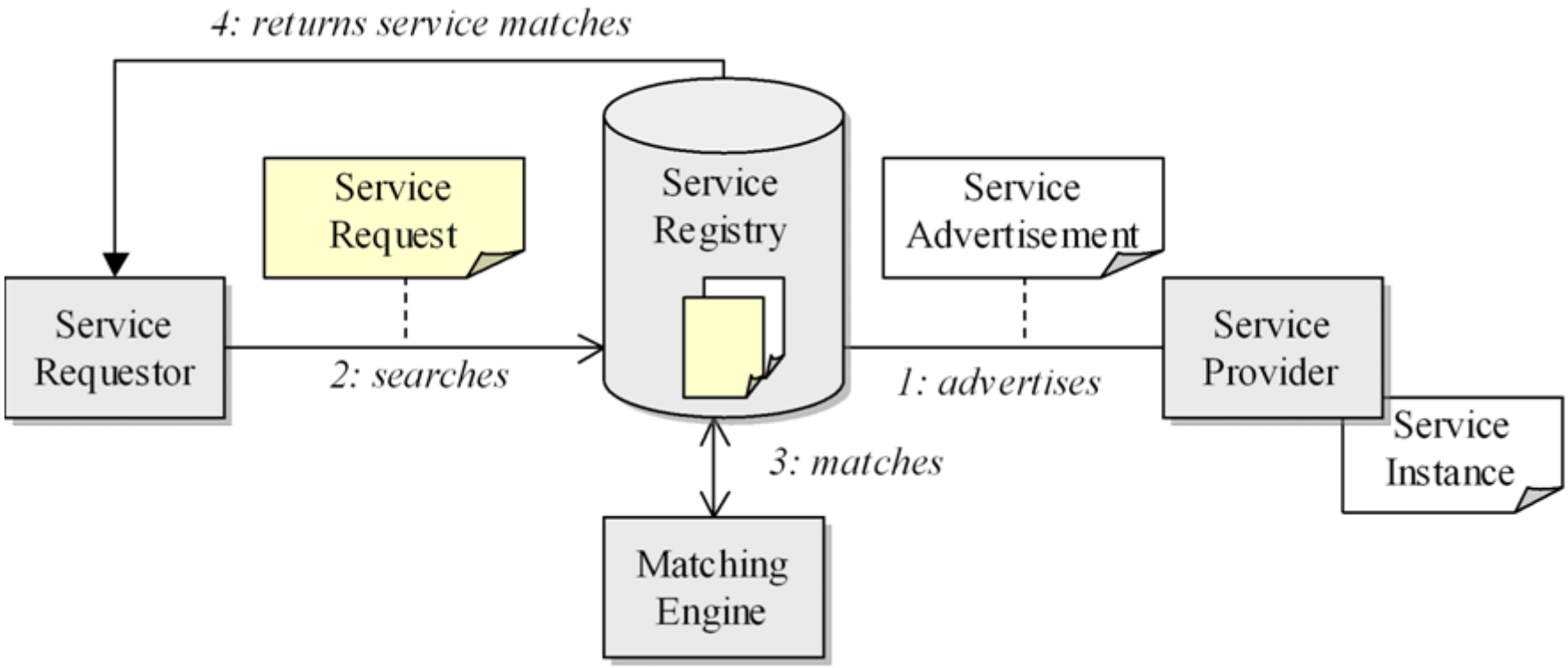
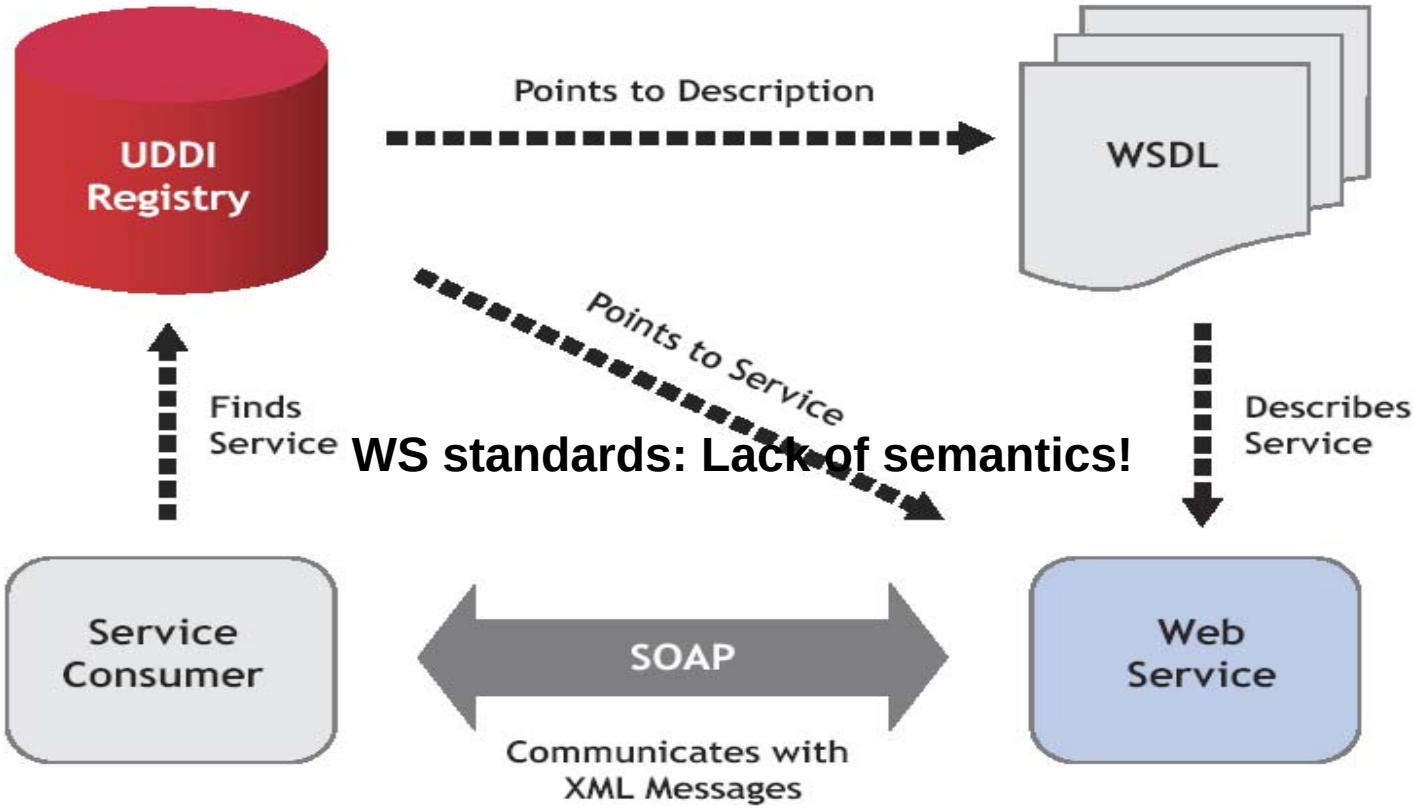


WS Reference Architecture



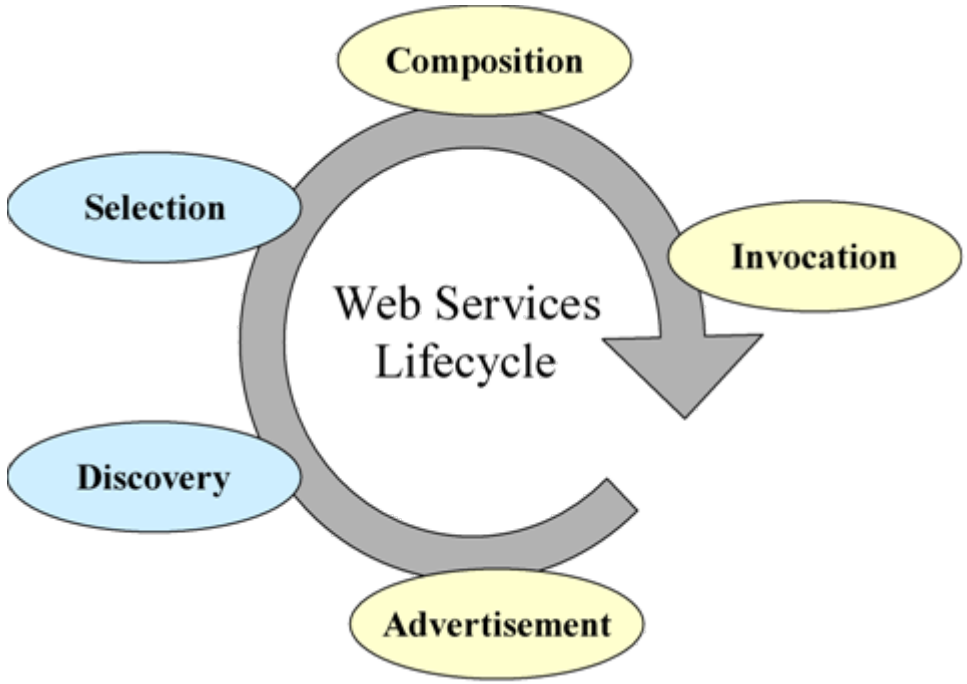
Web Services



Web Service Architecture

Web Services

- *programmatic interfaces for applications (i.e., business logic), available over the WWW infrastructure and developed with XML technologies*.



Motivation for the Semantic Web

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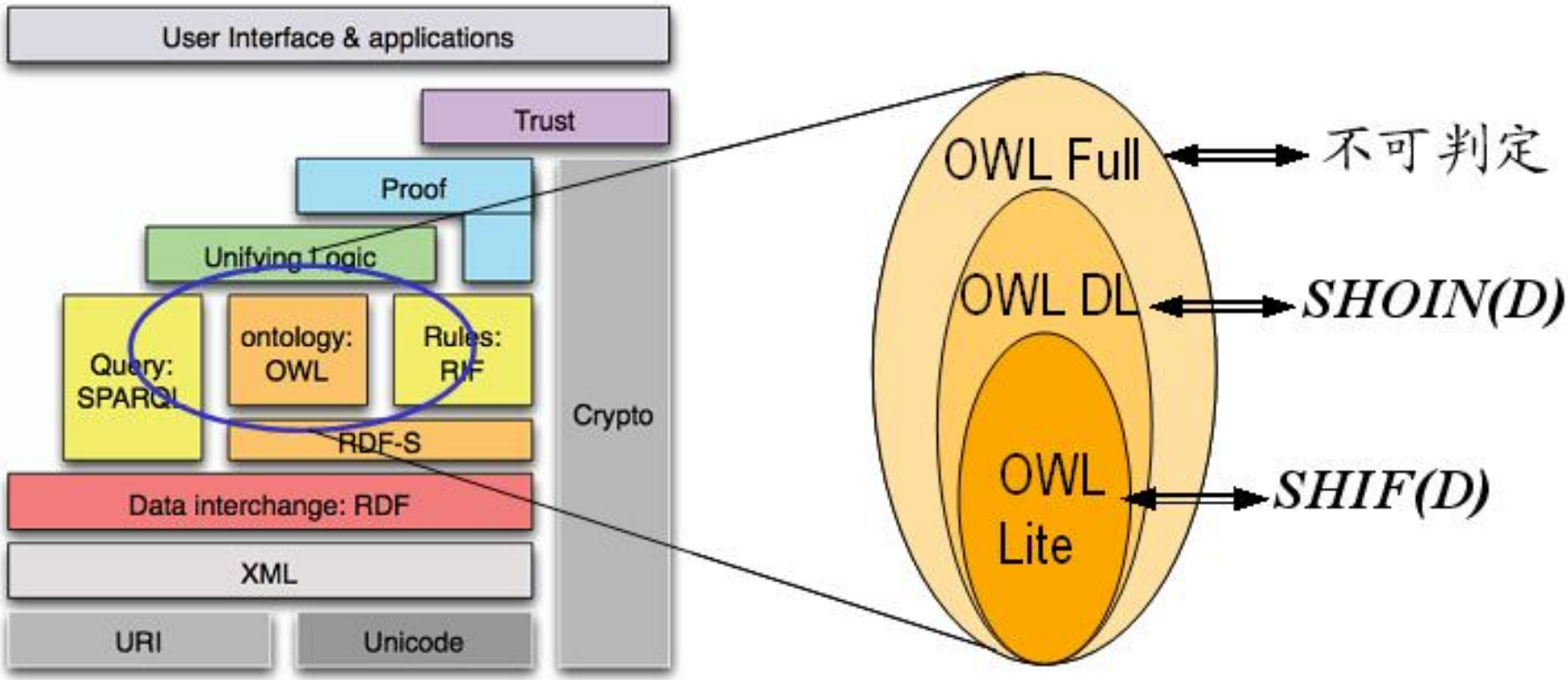
	Static	Dynamic	Syntax	Semantic
Encoding	HTML	+ RDBMS	+ XML	+ RDF/OWL
Creation	Manually	Generated by server-side applications	Generated by applications based on schema	Generated by applications based on models
Users	Humans	Humans	Humans and applications	Humans and applications
Paradigm	Browse	Create/Query/ Update	Integrate	Interoperate
Applications	Browsers	Browsers	Process Integration, EAI, BPMS, Workflows	Intelligent agents, Semantic engines

Semantic Web Architecture



Semantic Web

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Dynamic

Web Services

UDDI, WSDL, SOAP

Bringing the computer back as a device for computation

Static

WWW

URI, HTML, HTTP

Semantic Web

RDF, RDF(S), OWL

Serious Problems in

- information finding,
- information extracting,
- information representing,
- information interpreting and
- and information maintaining.

Bringing the web to its full potential

Semantic Web Services

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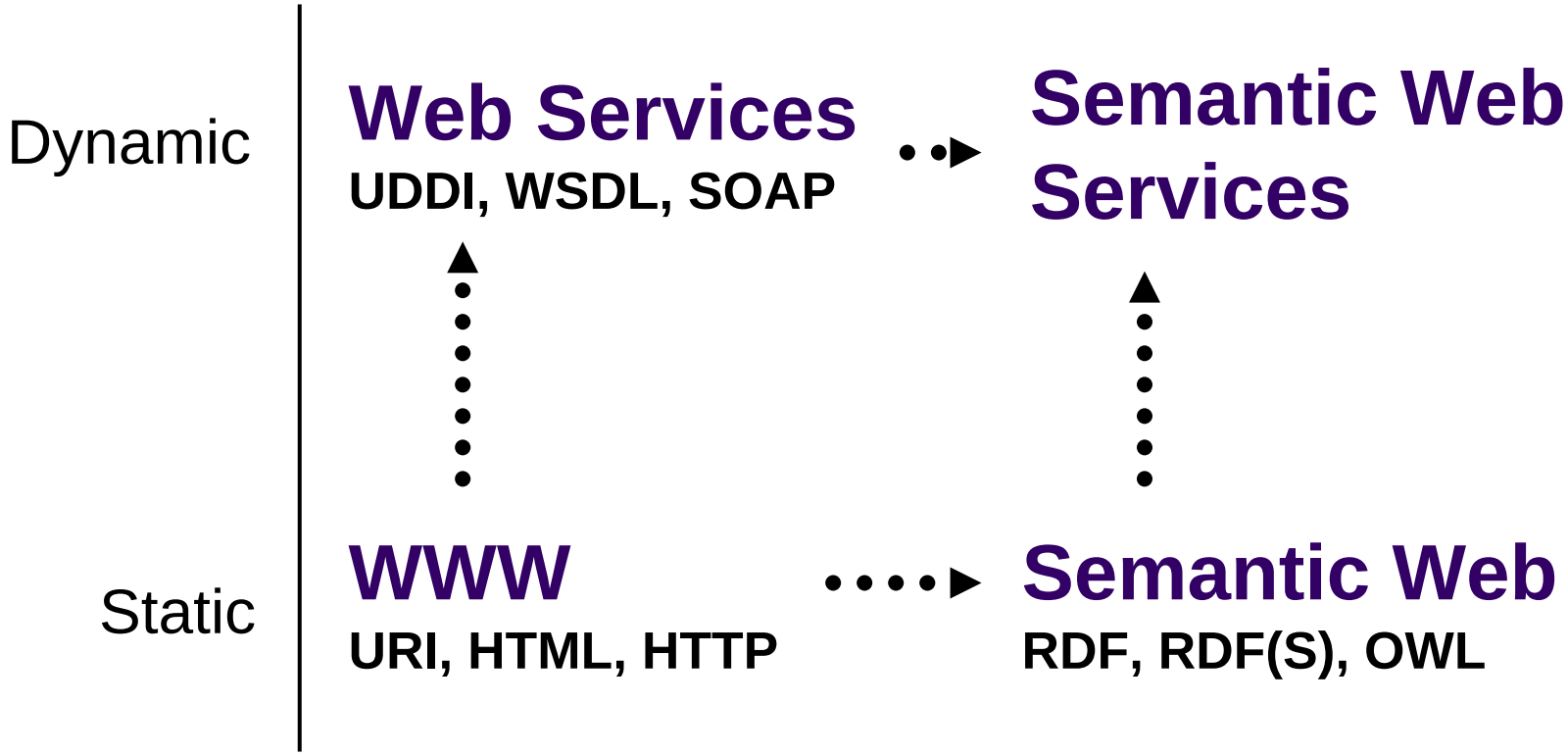

Semantic Web Services

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Semantic Web Services

=

Semantic Web Technology

+

Web Service Technology

Semantic Web Services

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- Define exhaustive description frameworks for describing Web Services and related aspects **(Web Service Description Ontologies)**
- Support ontologies as underlying data model to allow machine supported data interpretation **(Semantic Web aspect)**
- Define semantically driven technologies for automation of the Web Service usage process **(Web Service aspect)**

Semantic Web Services

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- What should S+WS ontologies provide?

  (Mainly) Automation of the Usage Process:

  - Publication
  - Discovery
  - Selection
  - Composition
  - Execution
  - Monitoring

内容提要

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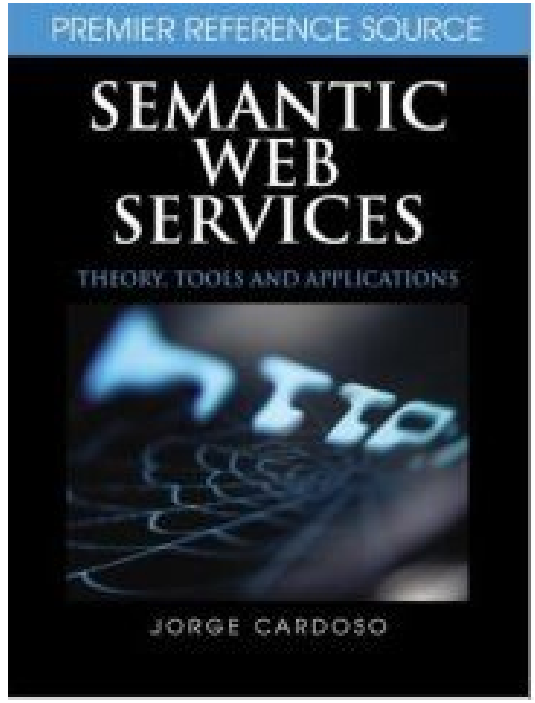
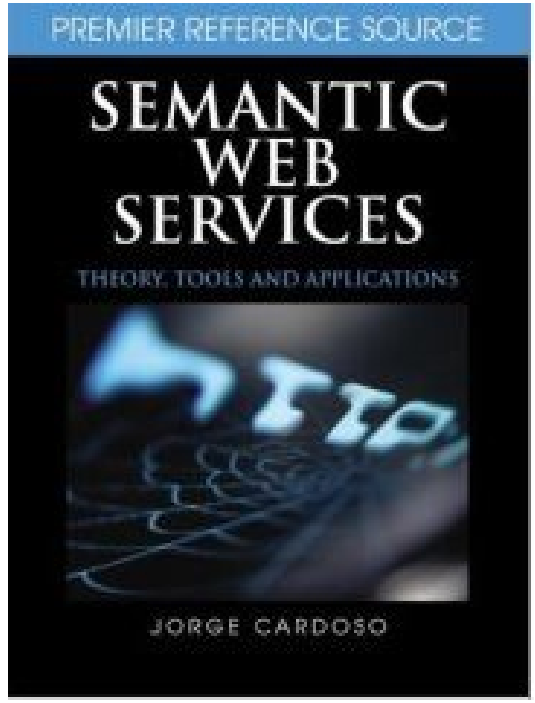
Degree of Match (DoM)

- *A value that expresses how similar two entities are, with respect to some similarity metric(s)*
- Important feature of most SWS matchmaking approaches
- Allows for ranking of discovered services
- Example DoM set: exact, plugin, subsumes, subsumed-by, fail



Variety of Matchmaking Approaches

- Direct
  - Return only single services that match the request
- Indirect
  - Compute service compositions (or “chains” in the simplest case)
- Logic-based
  - Description Logics and First Order Logic reasoning
- Similarity-based (IR techniques)
  - Linguistic similarity, term frequency, …
- Graph matching



Discovery of Web Services

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- Keyword based
  - UDDI – Universal Description, Discovery, and Integration
  - WSMX (WSMF)
- Semantic discovery
  - Matchmaking – compares advertised and requested service capabilities
  - Subsumption of classes, properties as well as equivalence can be considered
  - The process can be domain ontology dependent

Semantic discovery implementations

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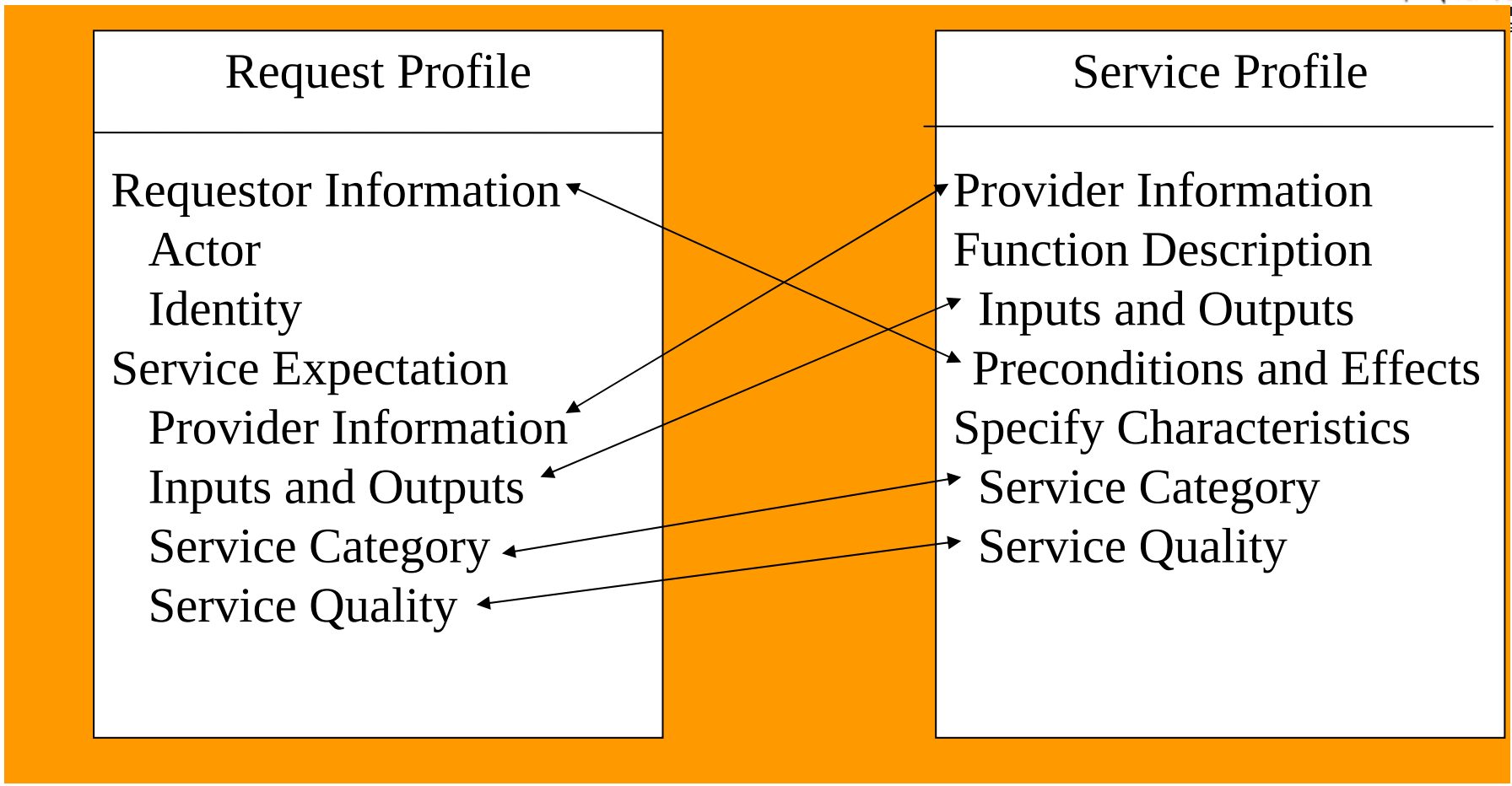
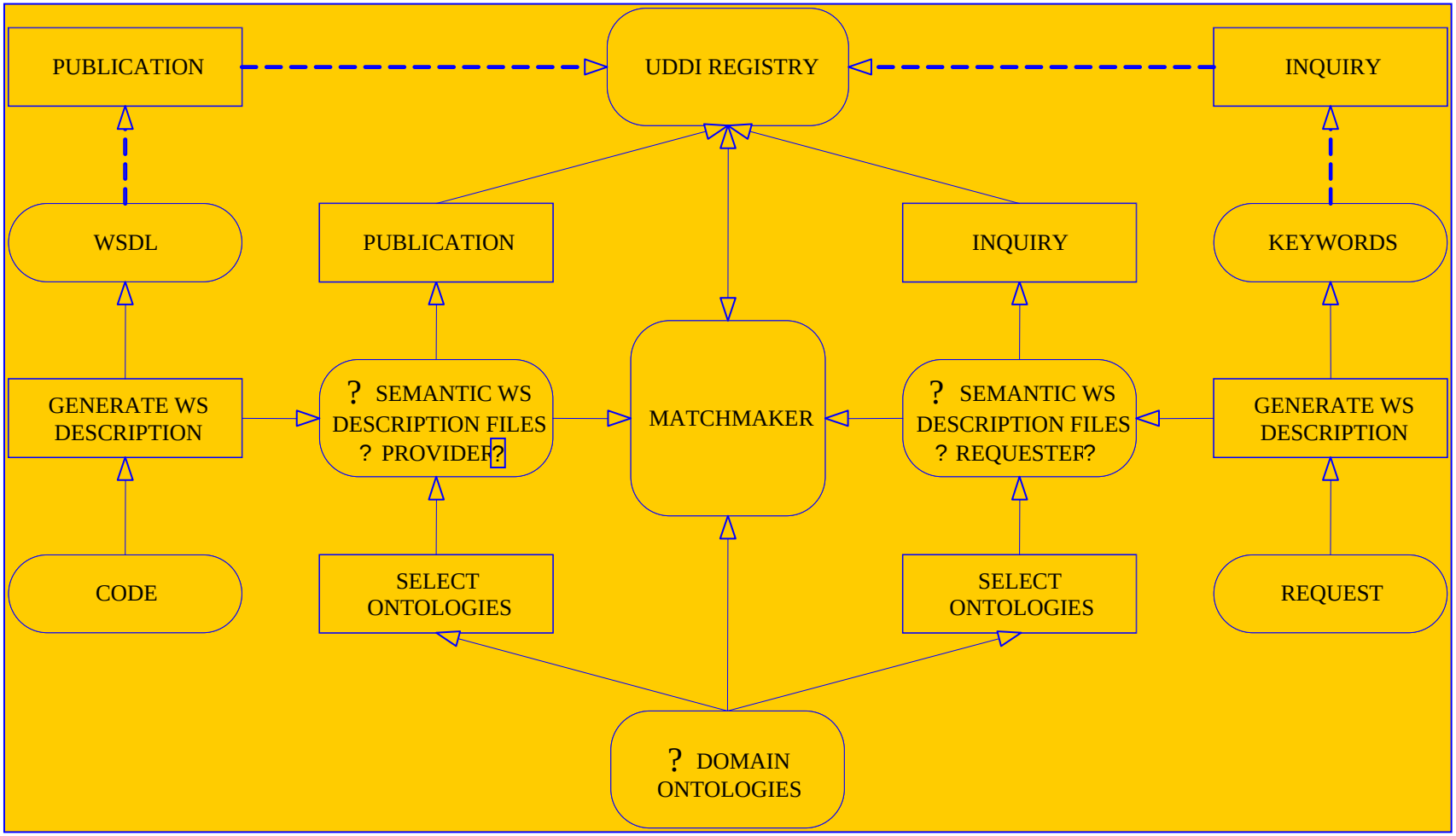
- MINDSWAP, Univ. of Maryland
  - Composer – demo only;
  - Matchmaker and planner licensed to FujitsuLabs (no sources)
- Carnegie Mellon, Atlas project
  - Matchmaker, OWL-S -> UDDI
  - No sources
- IBM Emerging Technologies Toolkit (Alpha)
  - Demo available; no sources
- TU Berlin Matchmaker
  - Open source; demo, based on transformation to Prolog

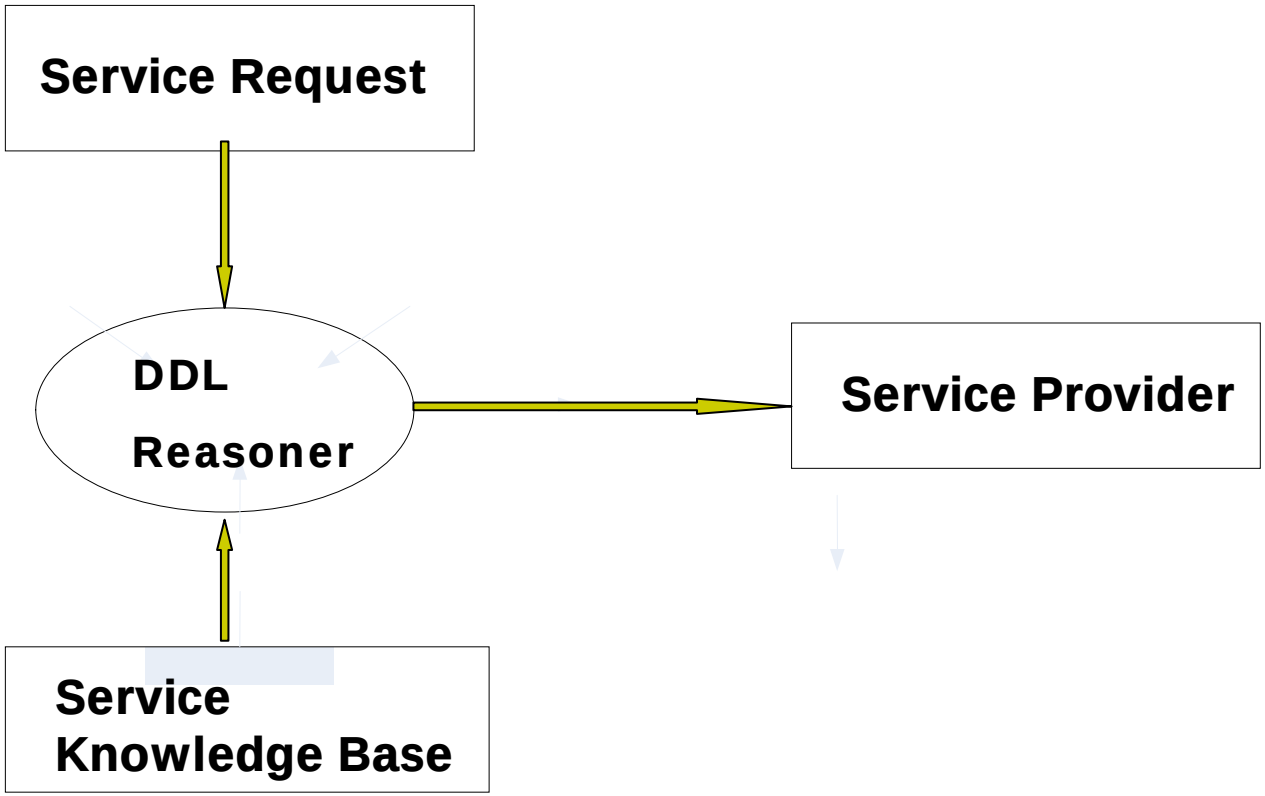
Match Making



Matchmaking Workflow



Matchmaking by DDL Reasoning



KMSphere Layers

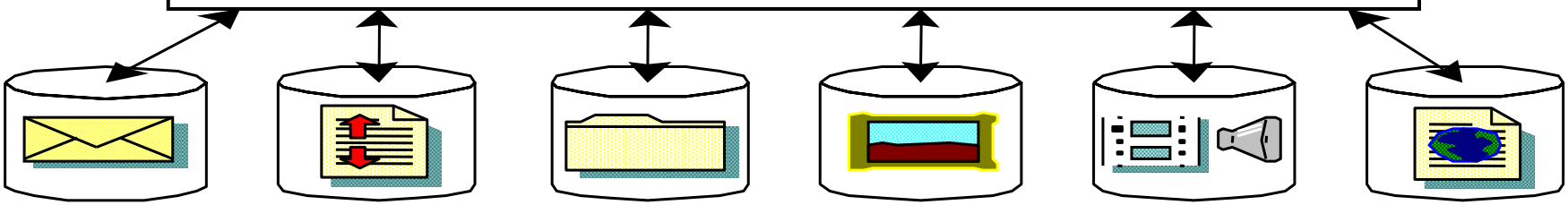


Knowledge Application

Knowledge Distribution

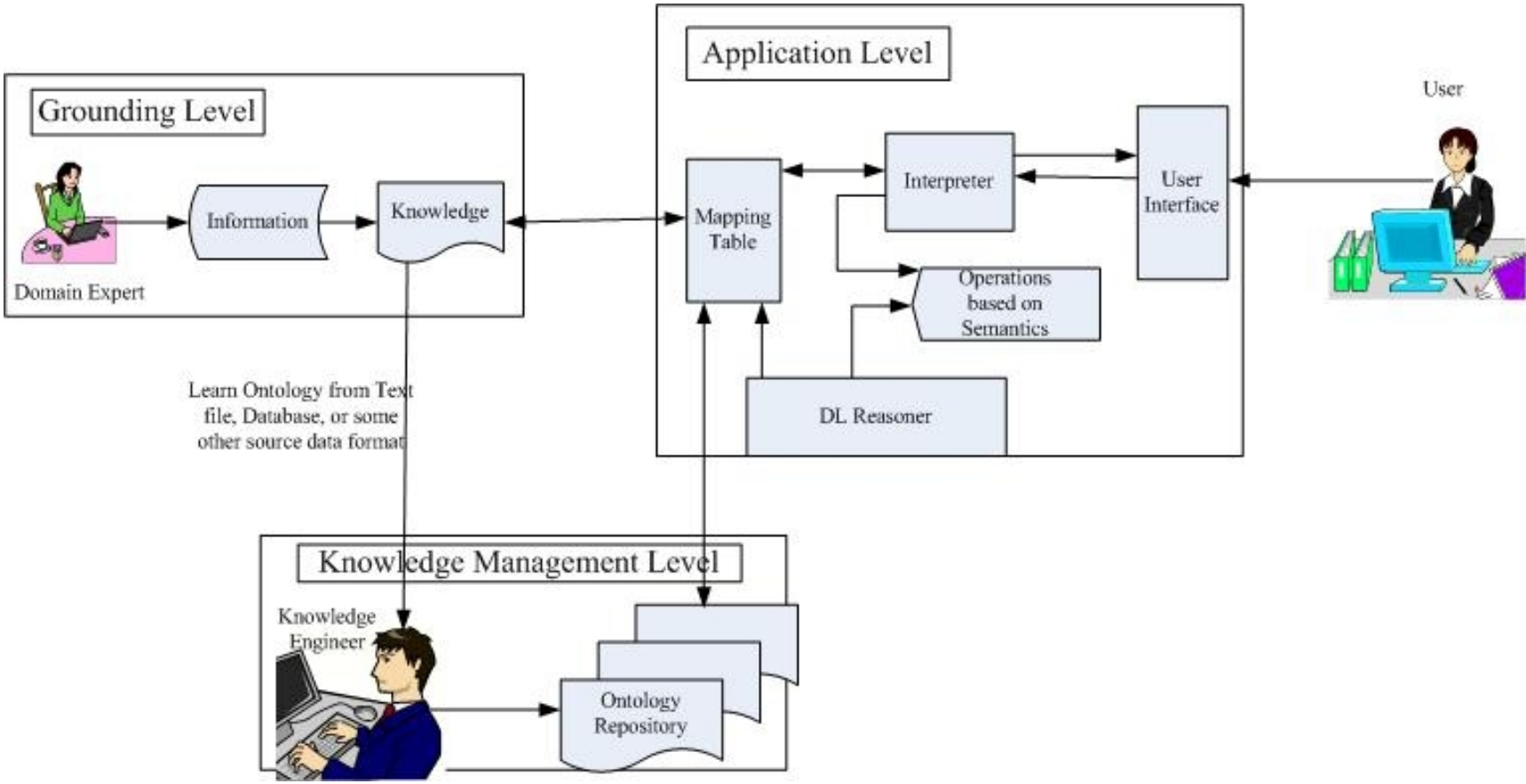
Knowledge organization

Ontology Acquisition

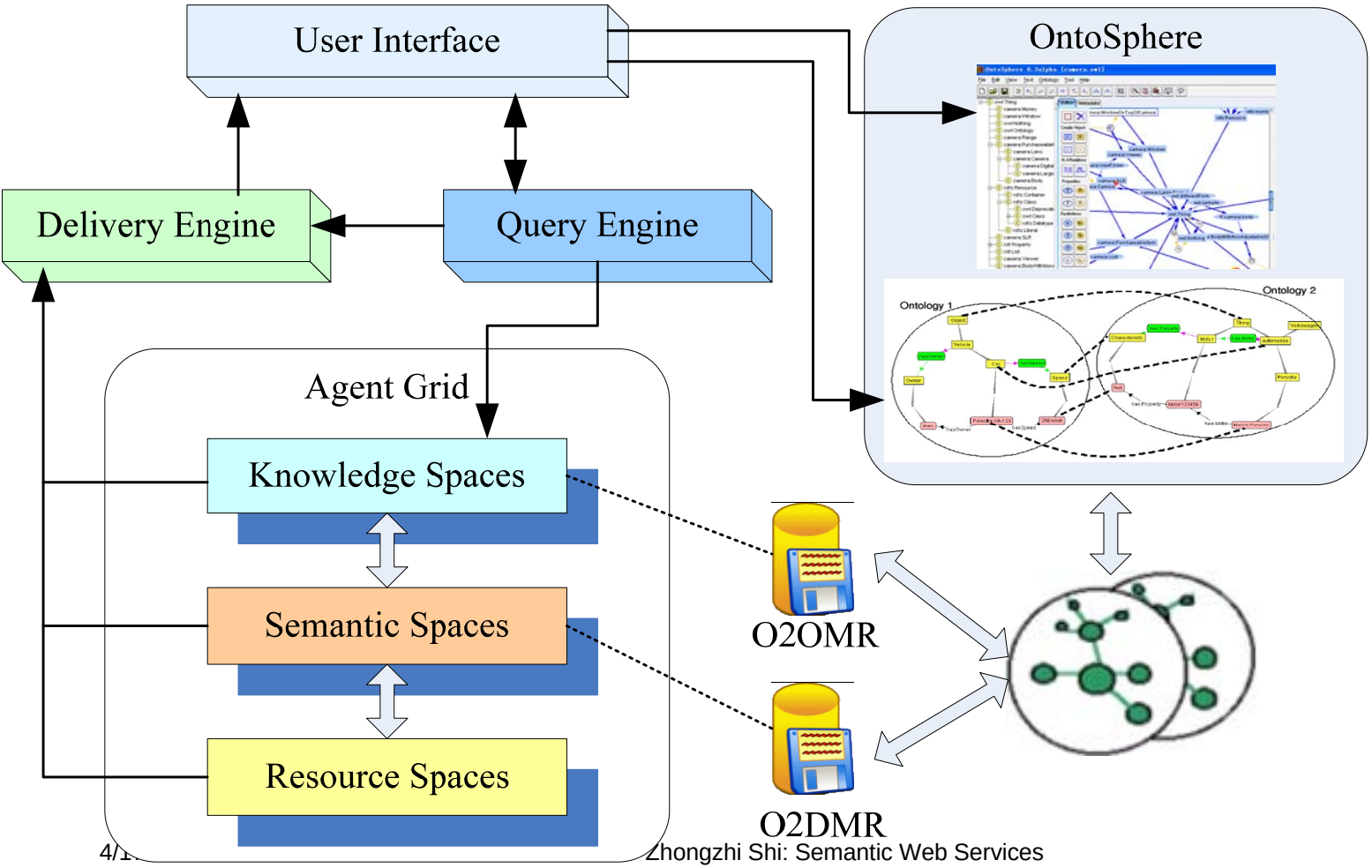


Email Document File Image Video Web

KMSphere Architecture



KMSphere Workflow



KMSphere Demo

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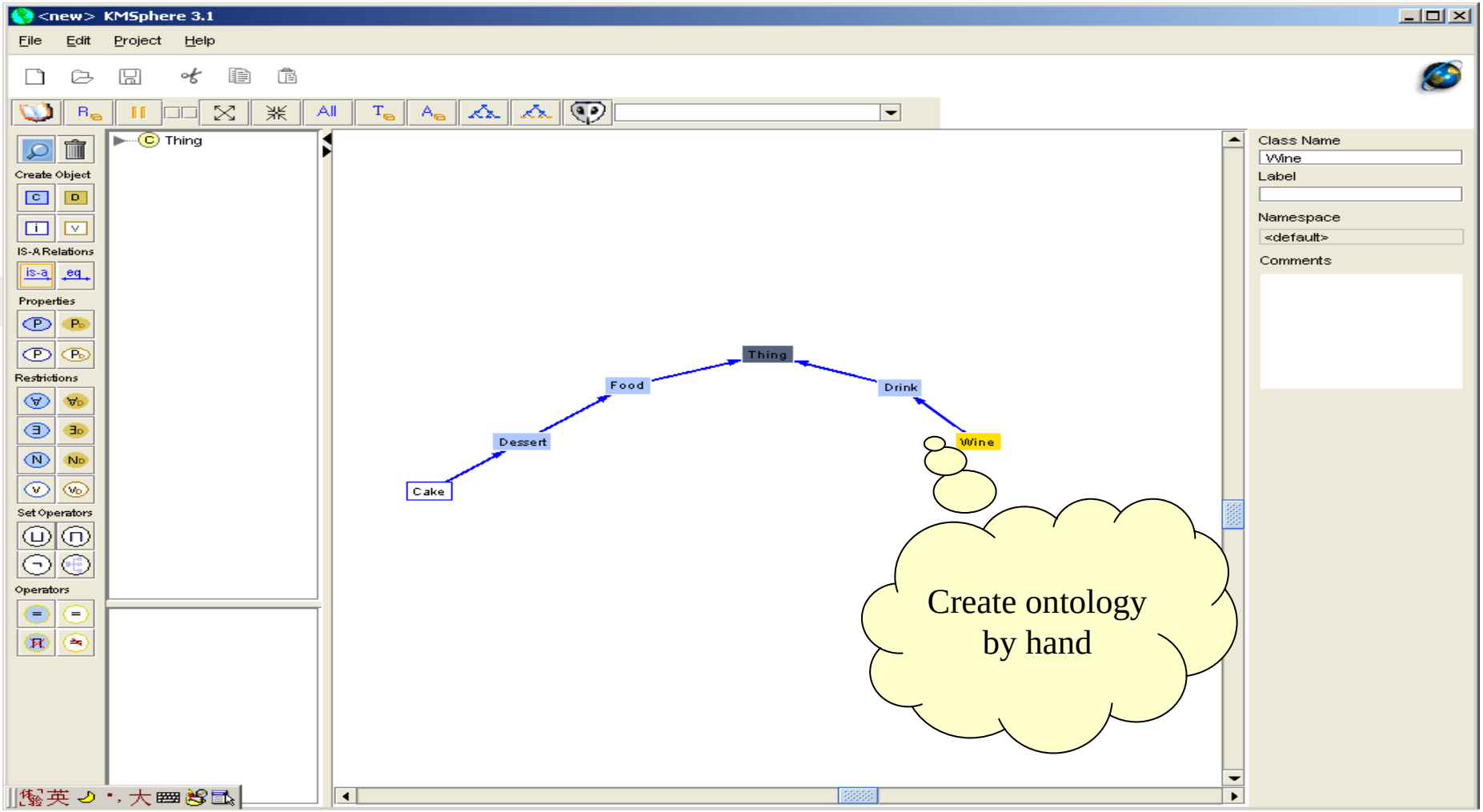

KMSphere Demo

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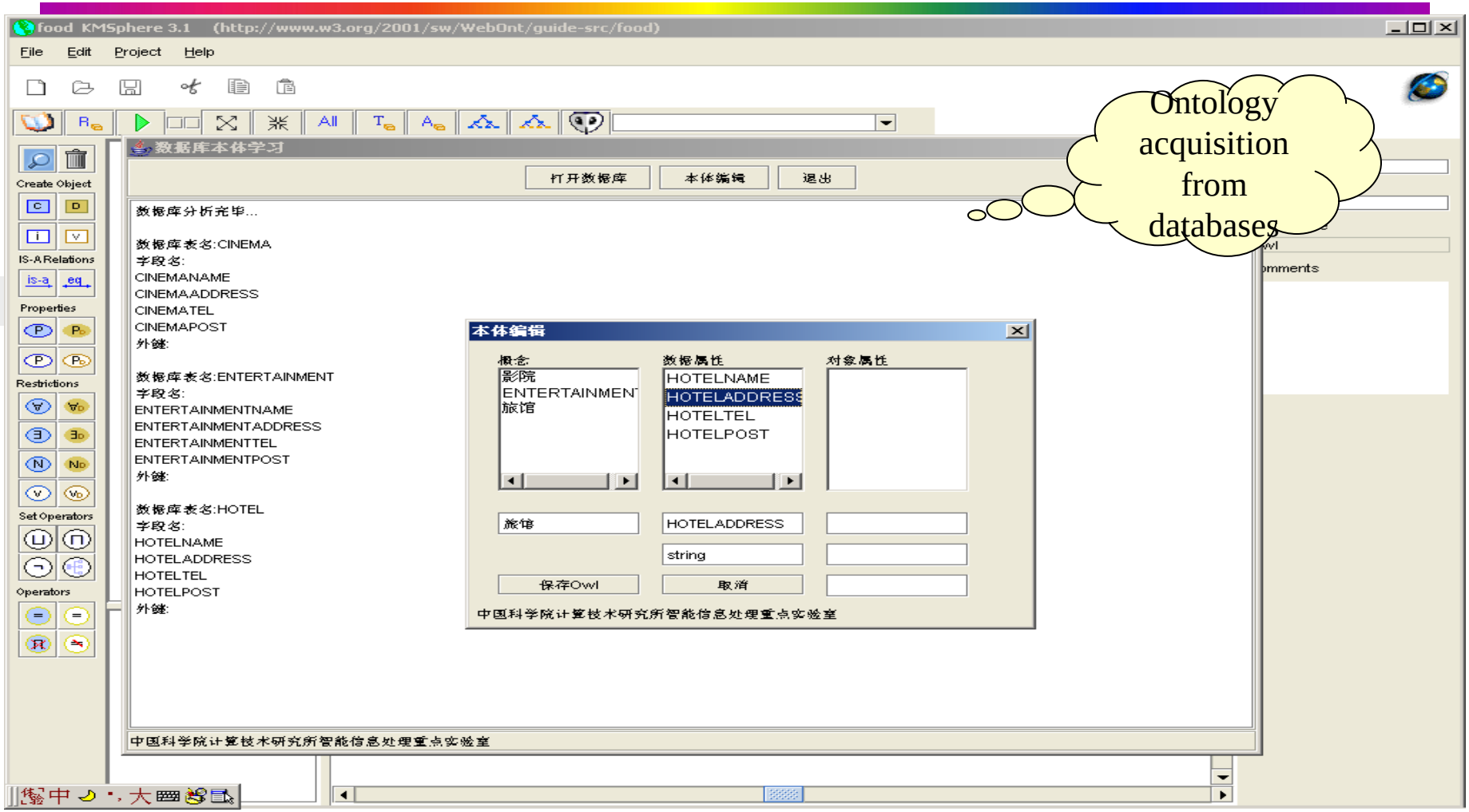

KMSphere Demo

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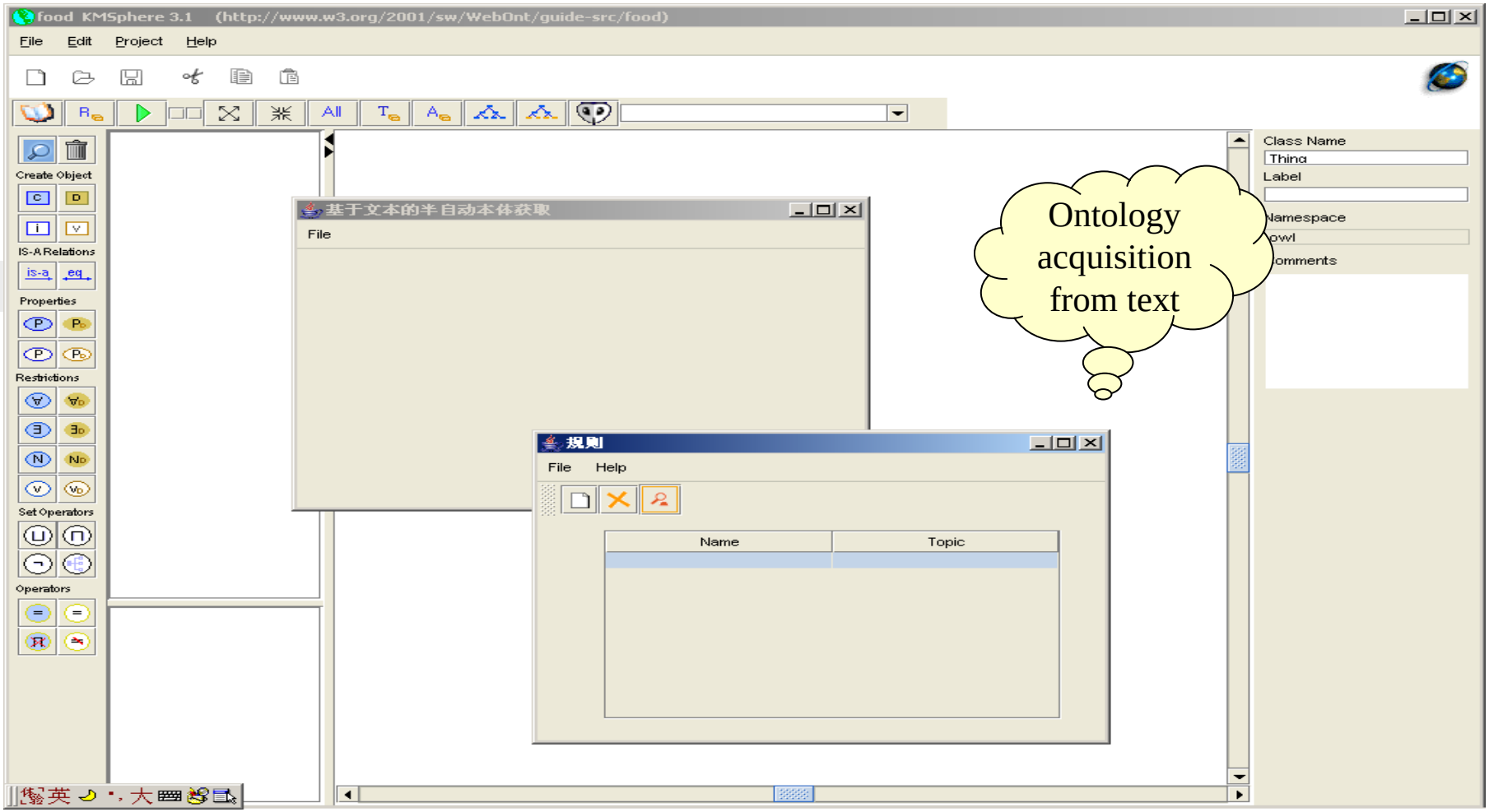

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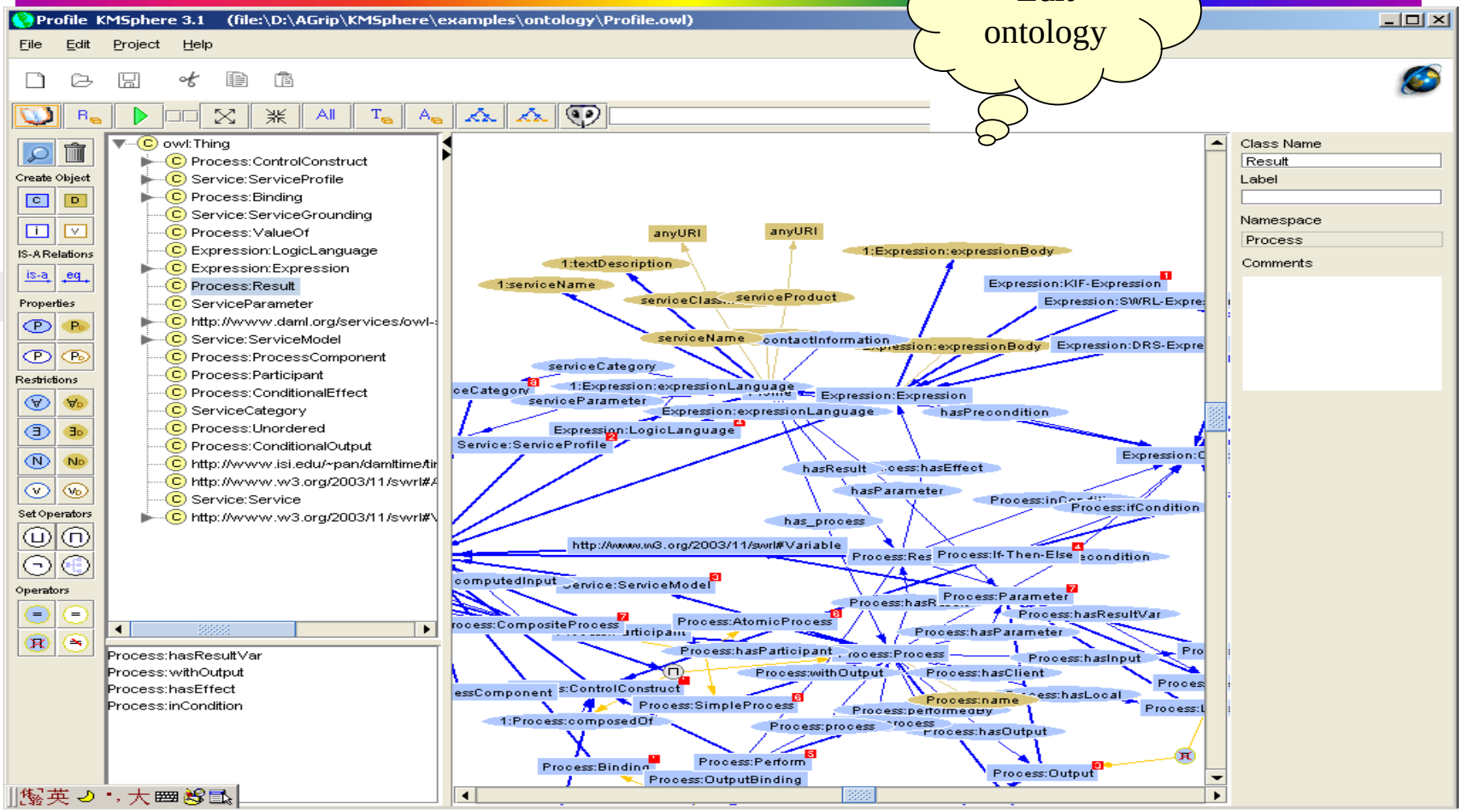

KMSphere Demo

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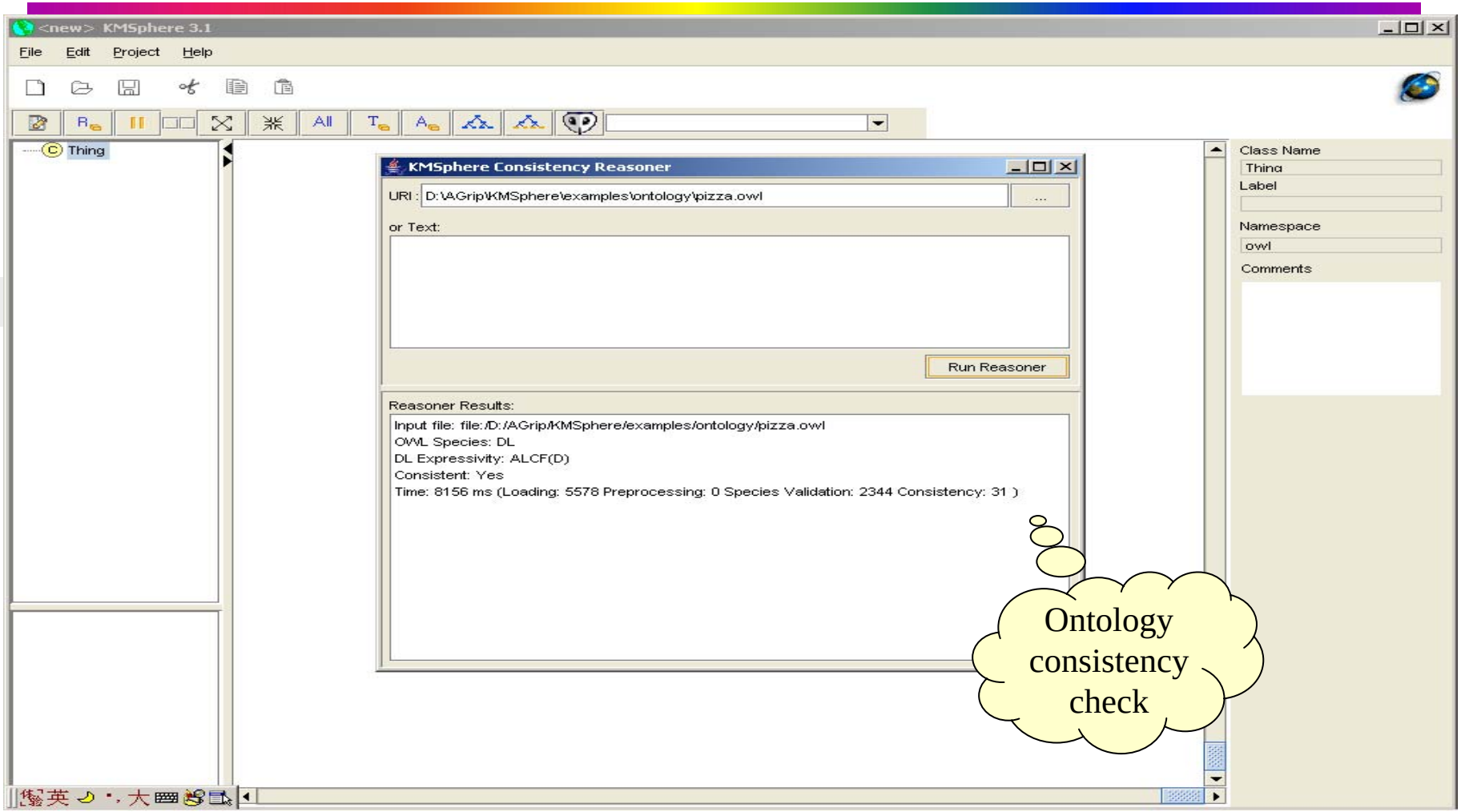

KMSphere Demo

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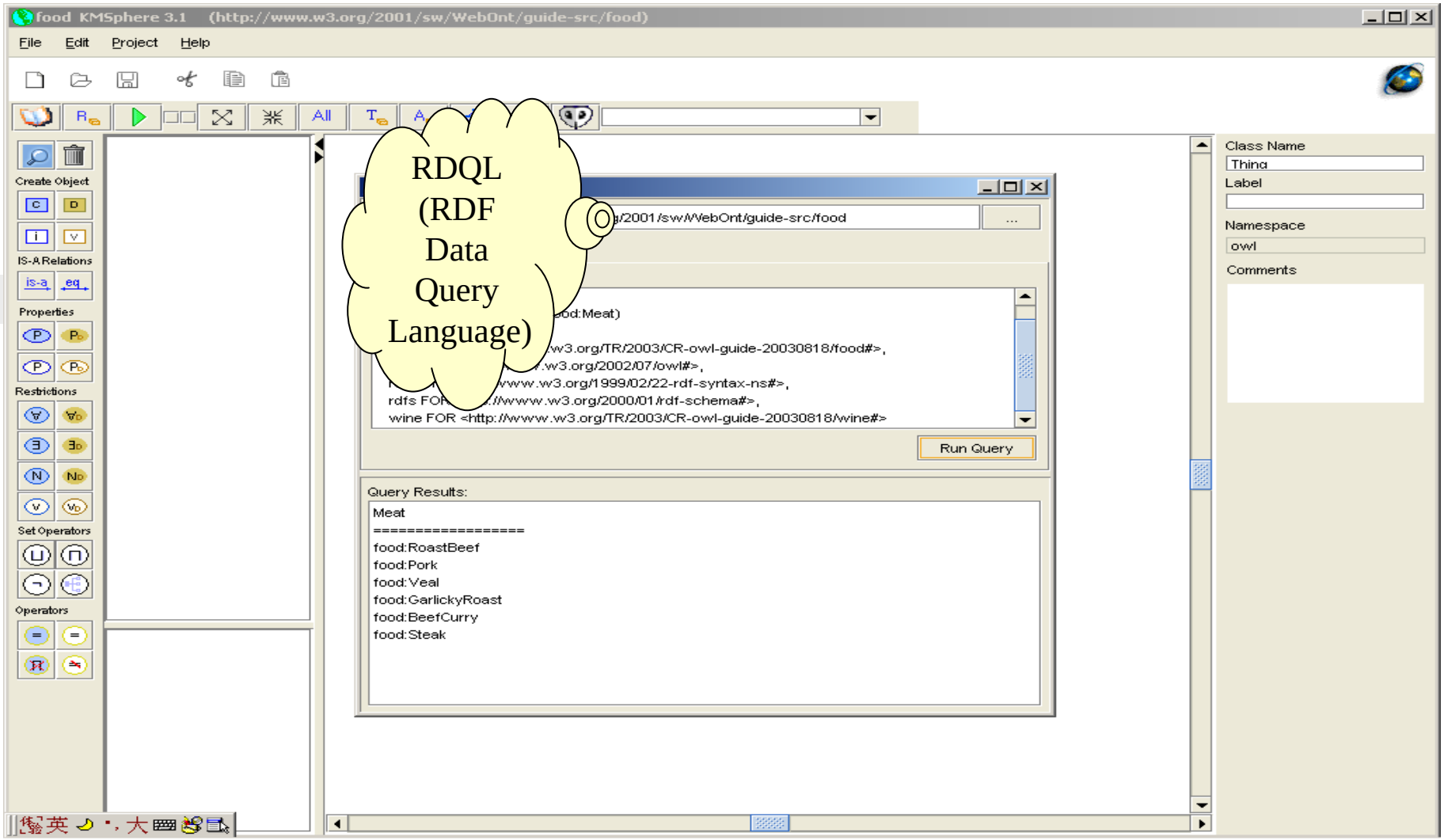

内容提要

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- **Web** 服务自动发现
- **Web** 服务自动组合
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- 群智能决策支持系统 GIDSDP
- 结束语

Web 服务自动组合

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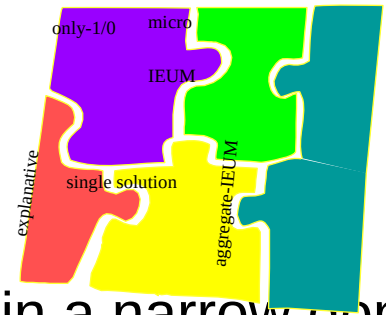
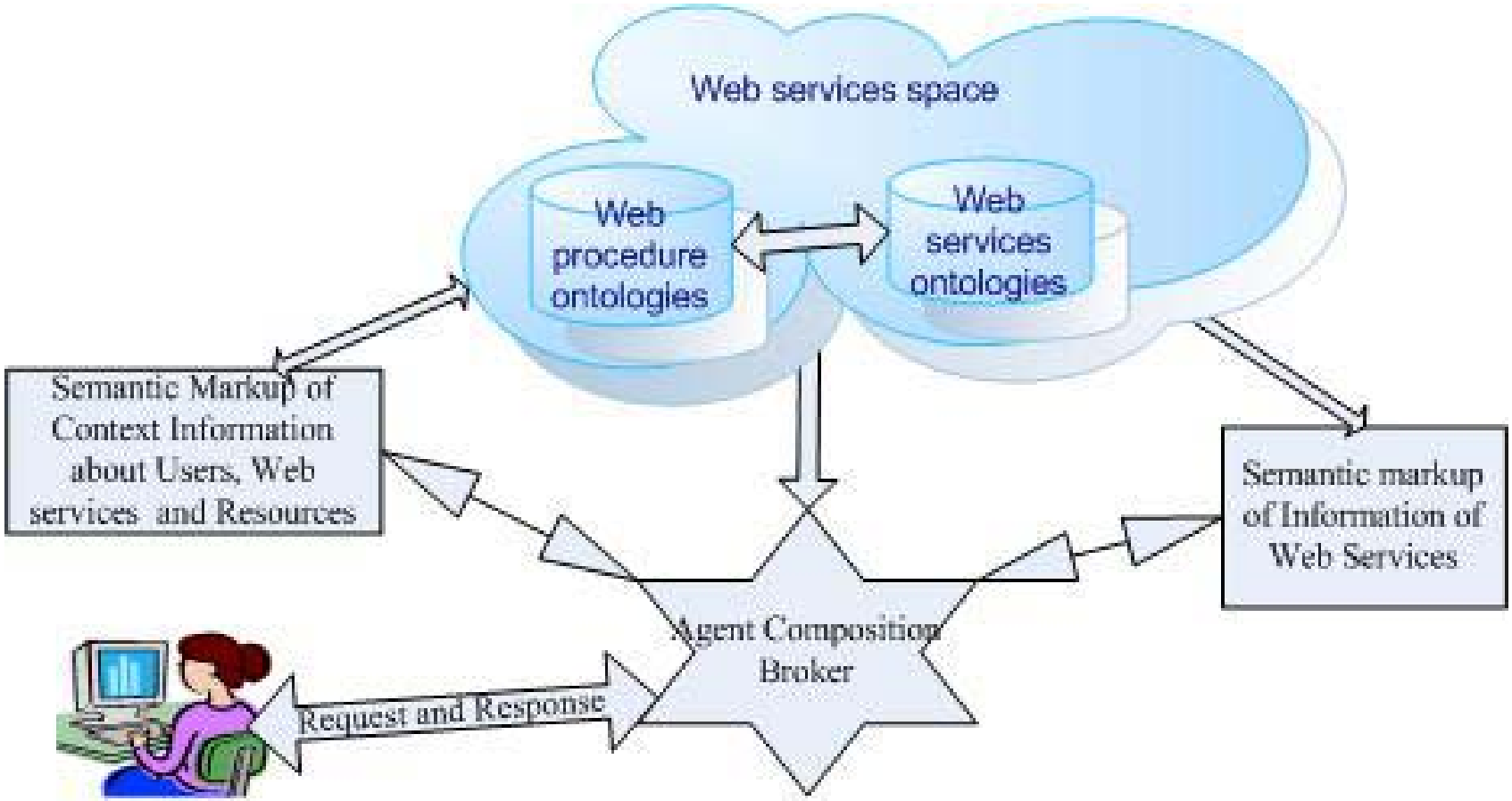
- Planning based approaches:
  - construct a plan from elementary services to obtain a required functionality.
  - reasoning based only on component specifications
  - plan built every time from scratch

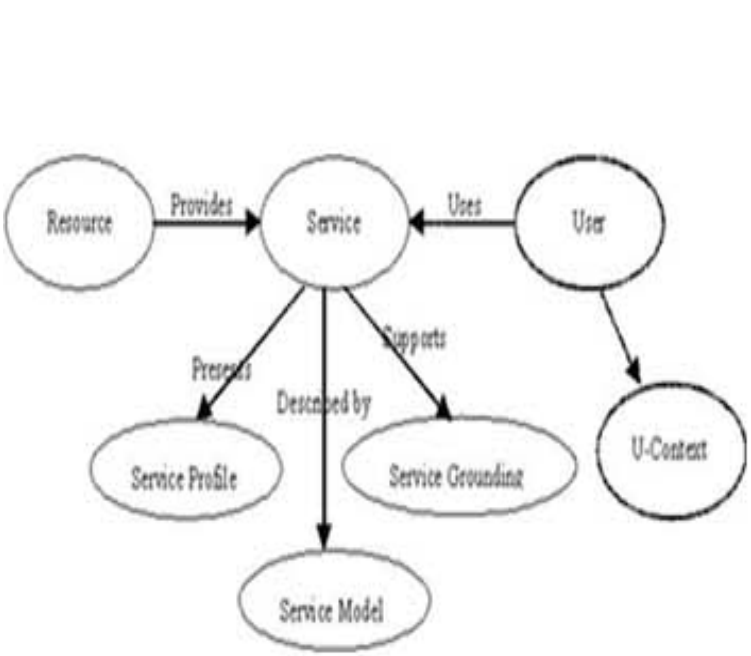


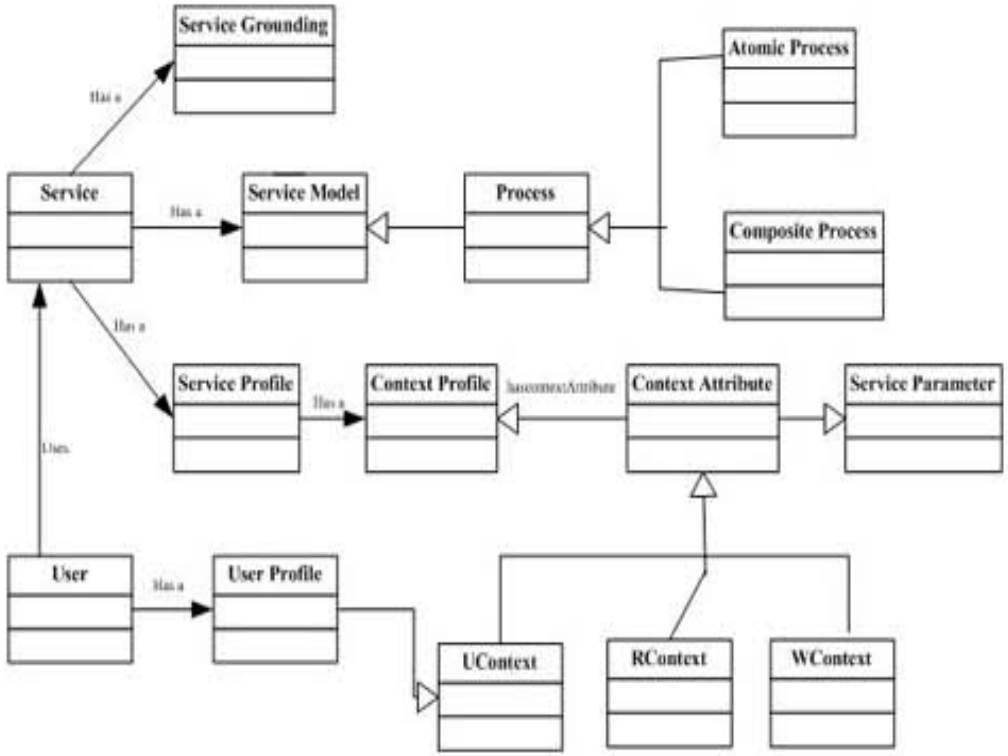
- Knowledge based approaches:
  - re-use preconfigured templates
  - reasoning with specialized knowledge in a narrow domain
  - sophisticated domain knowledge is needed

Web 服务自动组合

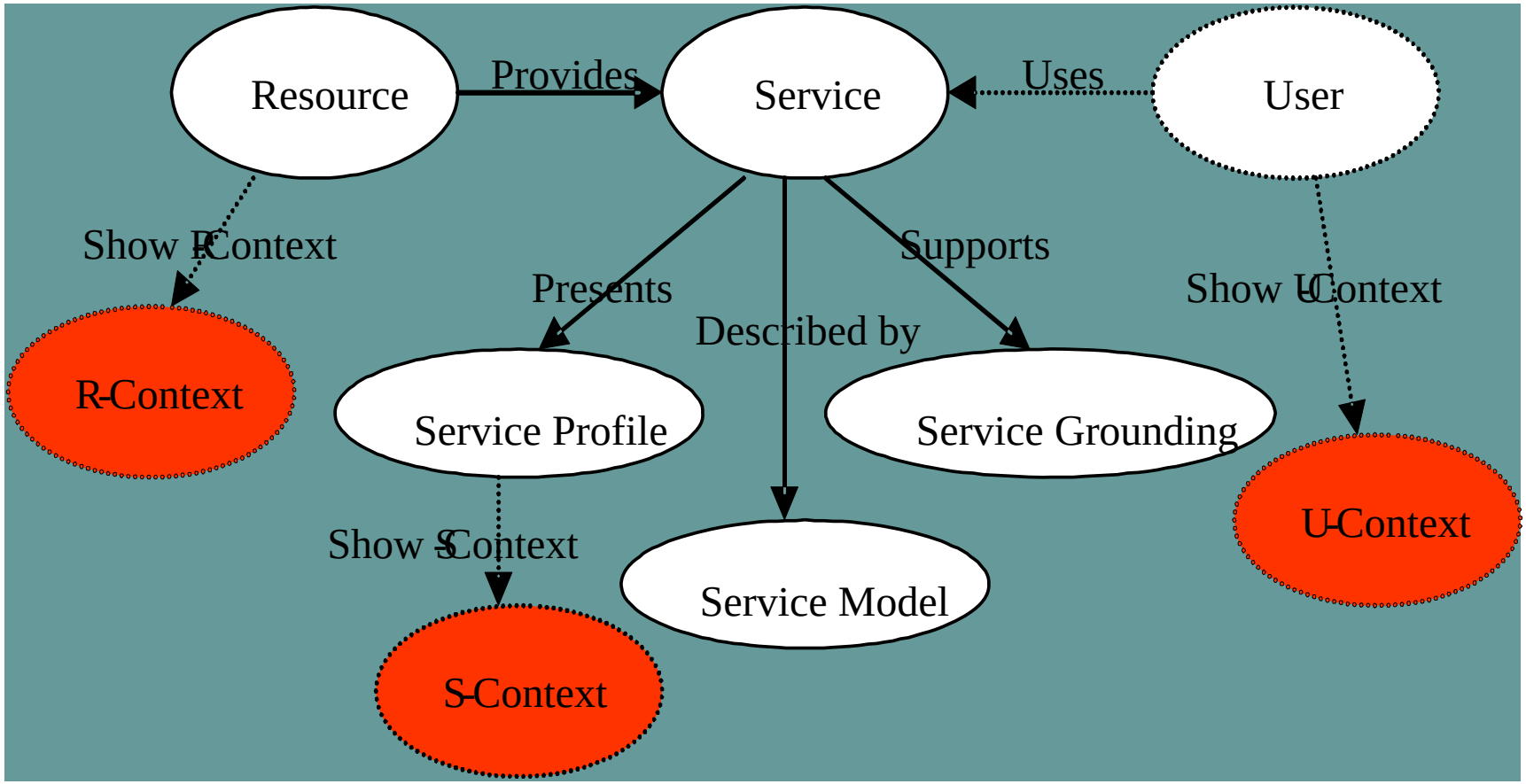

Web services space
Web procedure ontologies
Web services ontologies
Semantic Markup of Context Information about Users, Web services and Resources
Semantic markup of Information of Web Services
Agent Composition Broker
Request and Response

Web 服务自动组合

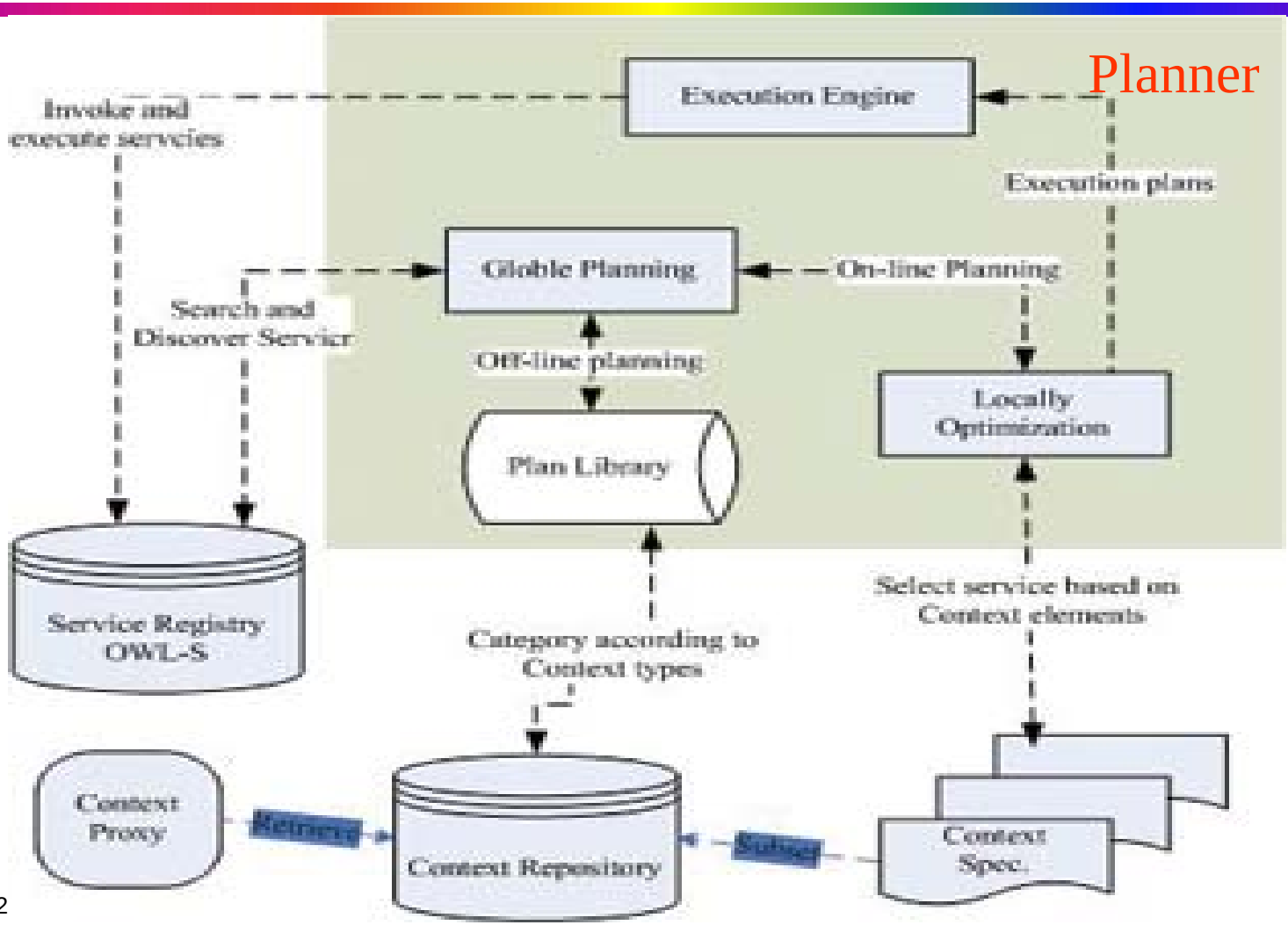

Resource
Provides
Service
Uses
User
Presents
Described by
Supports
Service Profile
Service Model
Service Groundings
U-Context


Service Grounding
Atomic Process
Service
Service Model
Process
Composite Process
Service Profile
Context Profile
Context Attribute
Service Parameter
User
User Profile
UContext
RContext
WContext

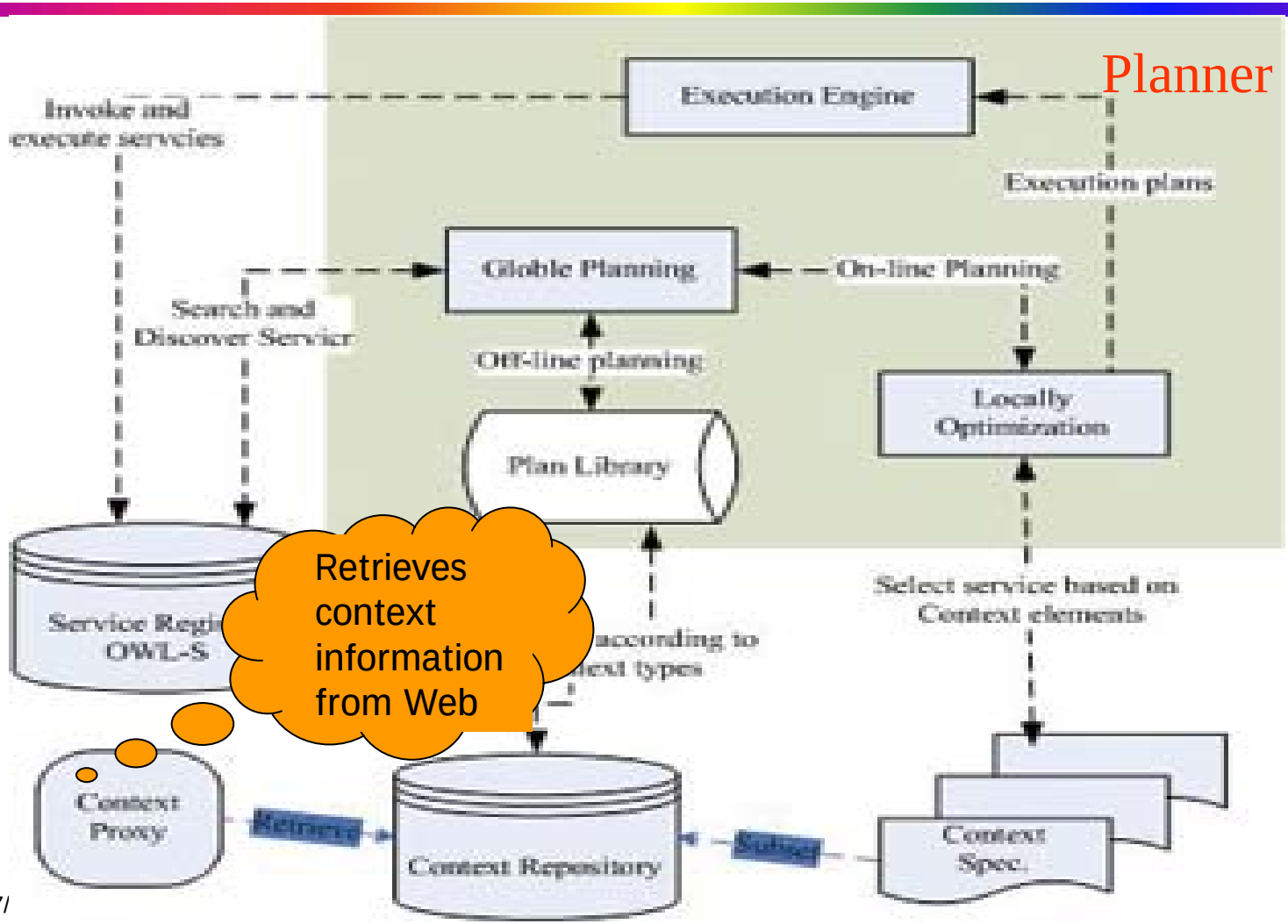
OWL-S 语境


Resource
Provides
Service
Uses
User
Show RContext
Presents
Described by
Supports
Show UContext
R-Context
Service Profile
Service Grounding
U-Context
Show SContext
Service Model
S-Context

基于语境的服务组合规划



基于语境的服务组合规划



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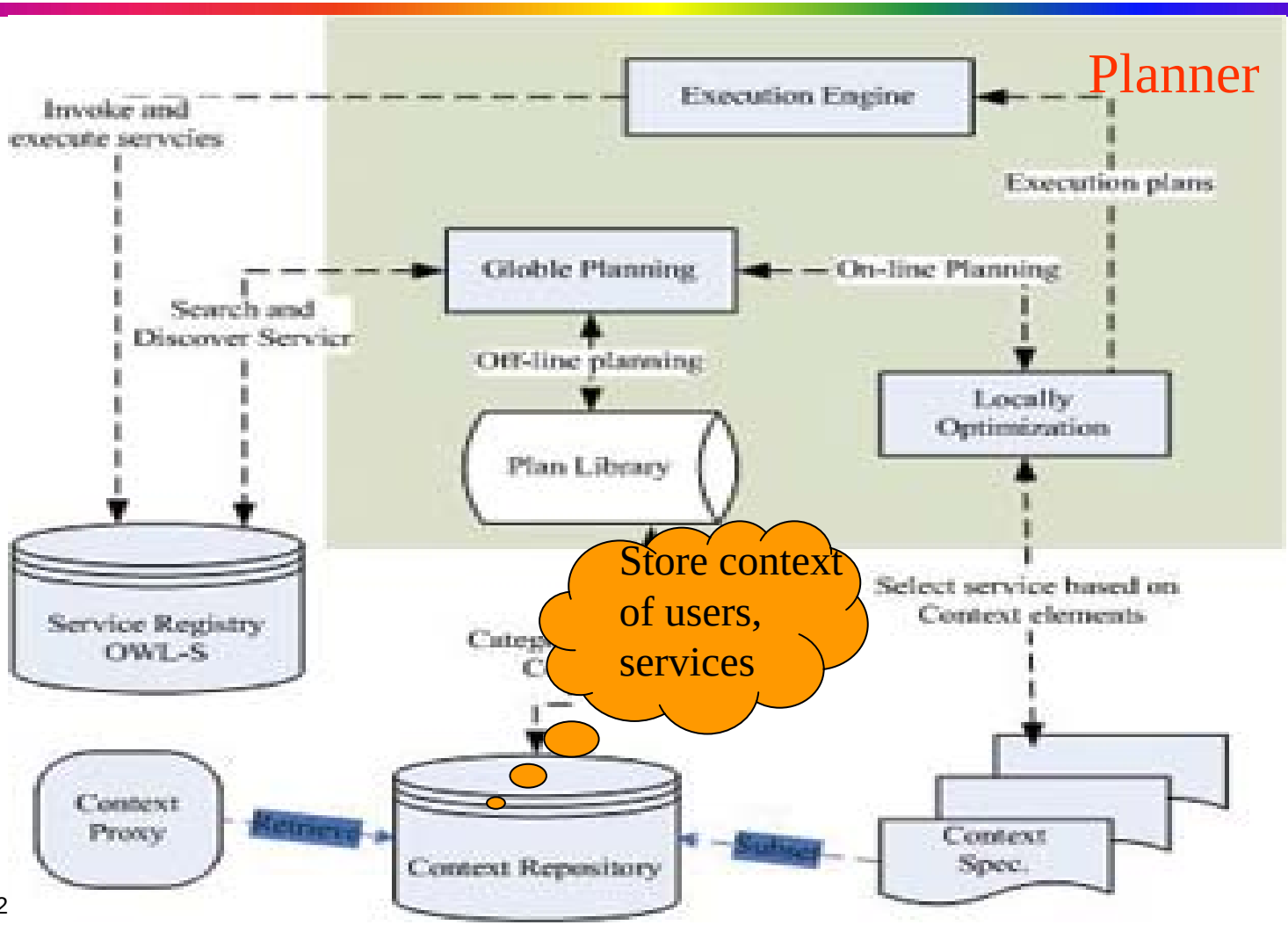

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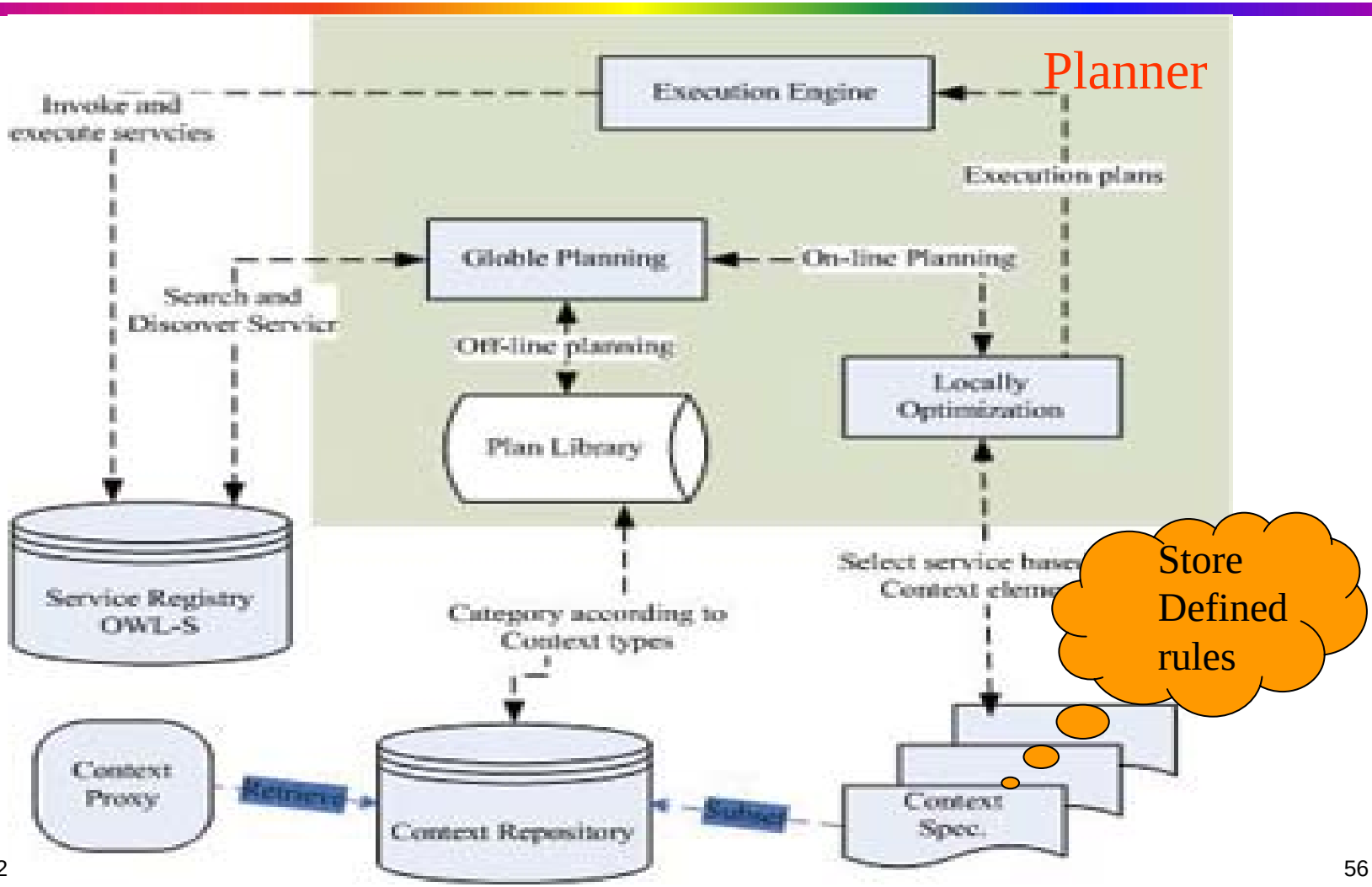

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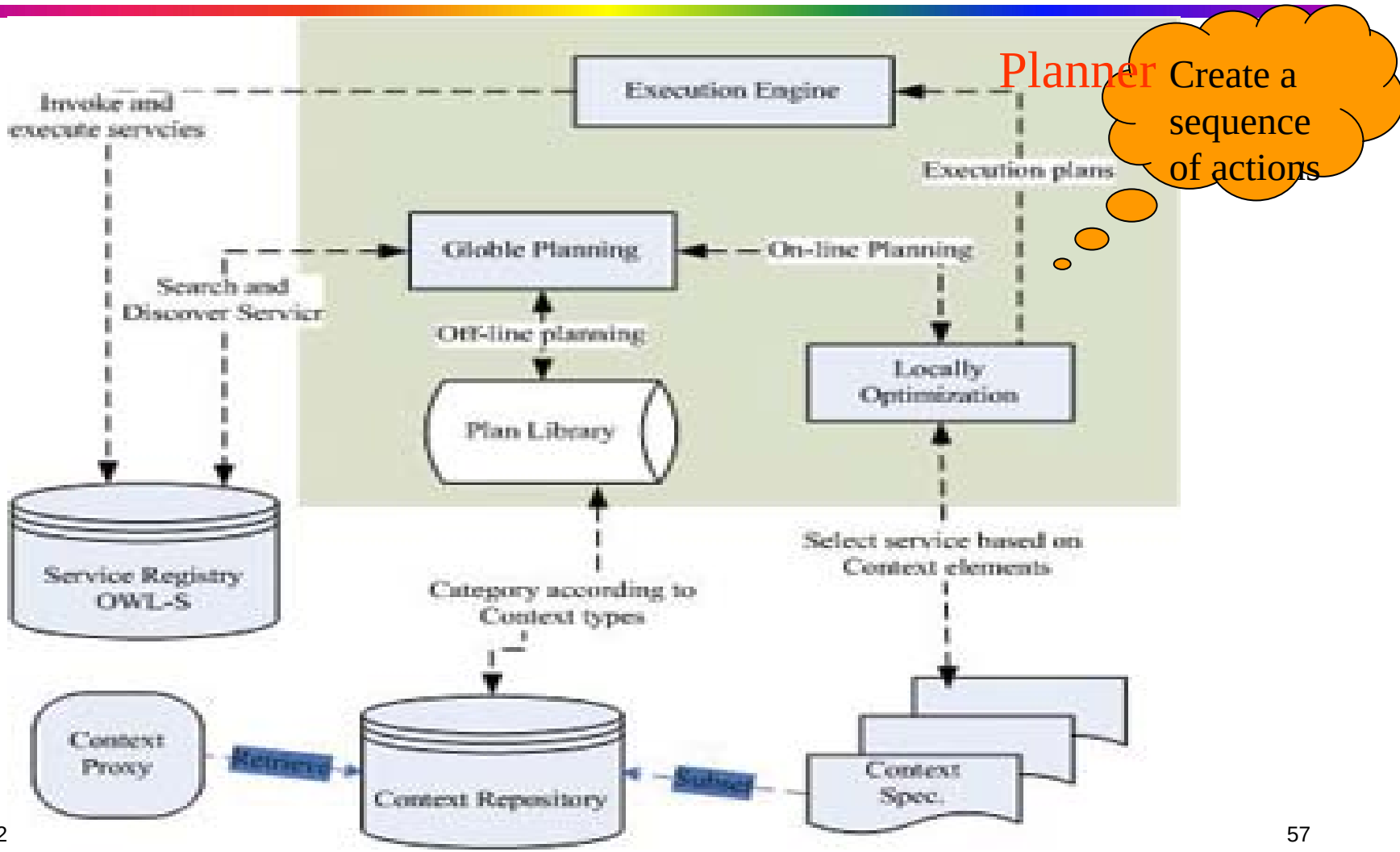

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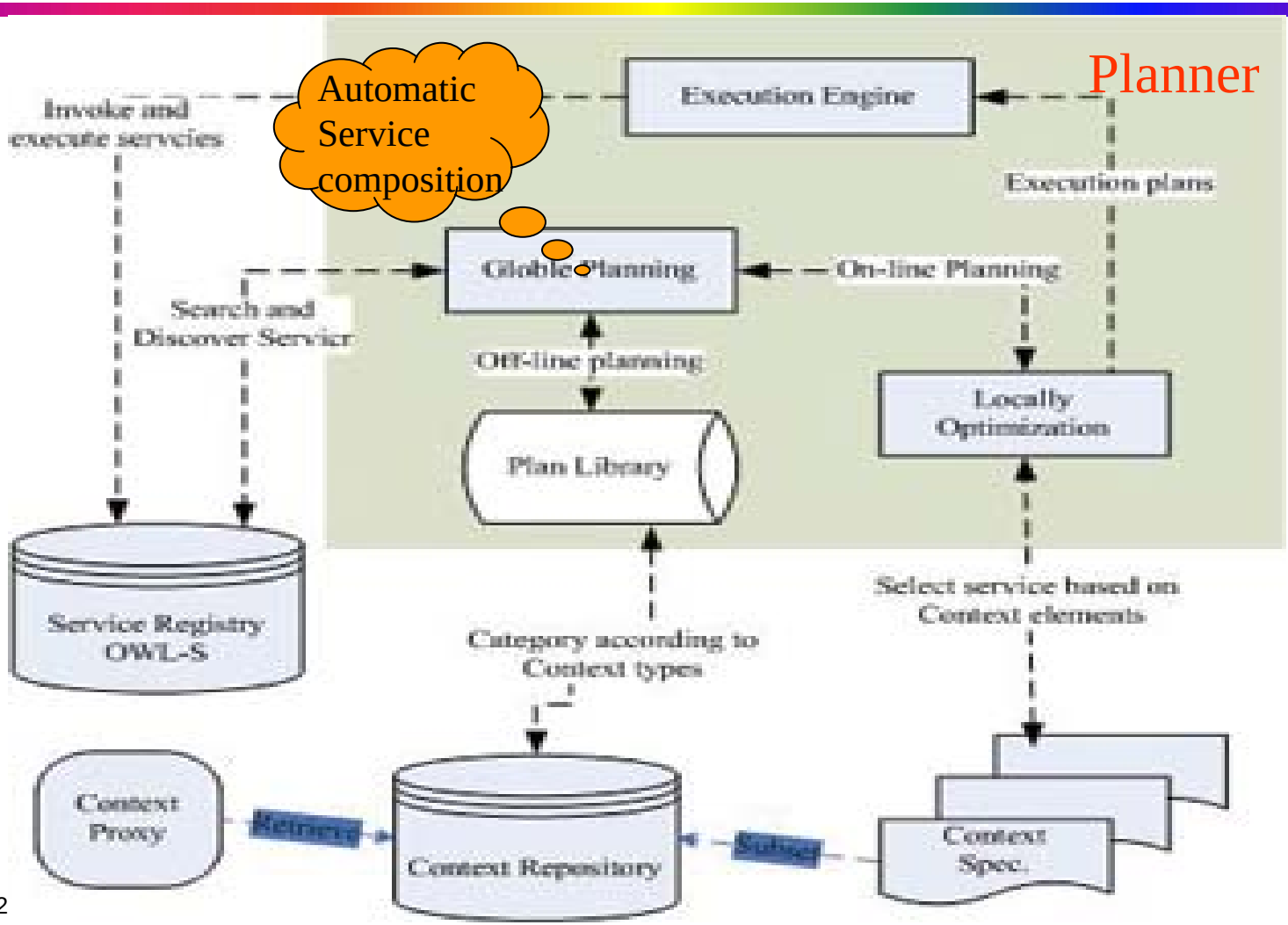

规划模型

$$D = (S, A, C, I, \Gamma, \Upsilon)$$

(1) S *is the set of states.*
(2) A *is the set of actions(services).*

(3) C *is the set of context elements.*
(4) I *is the set of initial states and* $I \subseteq S$*;*
(5) Γ *is the transitional function,* $S \times A \rightarrow 2^s$*, which associates to each current state* $s \in S$ *and to each action* $a \in A$ *the set* $\Gamma(s,a) \in S$ *of next states;*
(6) Υ *is the context function,* $S \times C \rightarrow A$*, which associates to a state* $s \in S$ *and a context* $c \in C$*, an action* $a \in A$ *to be executed,* $\Upsilon(s,c) \in A$*.*

规划任务

- $T=(S_1,S_n,D)$
- S_1: initial states
- S_n: goal state
- D: Domain description

全局规划算法

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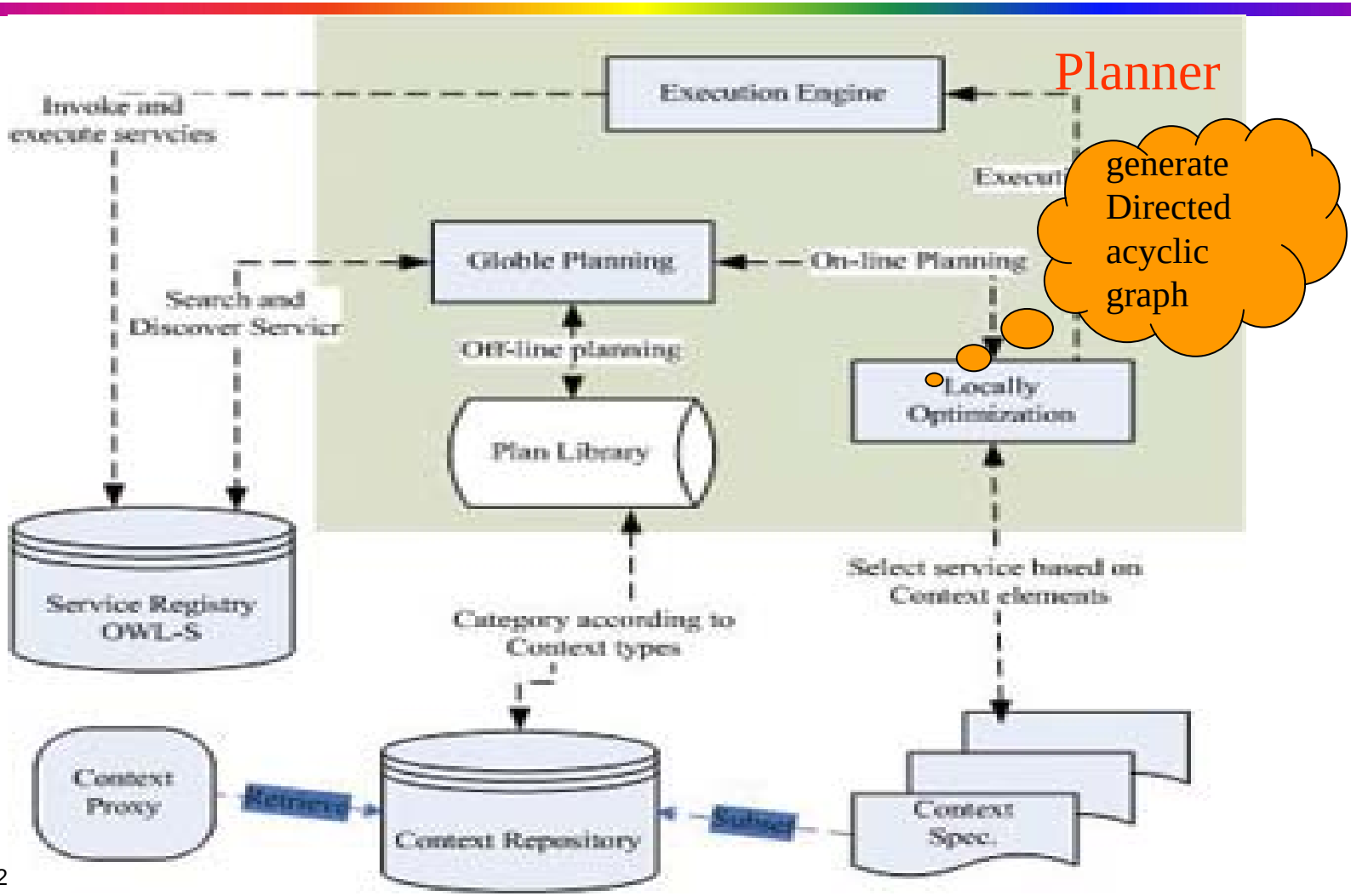
Algorithm 1 Global Planning Algorithm

1: Given a planning Problem (S_1, S_n, D)
2: Search the *Plan Library* in domain D
3: **if** find the plan which initial states is S_1 and goal states is S_n **then**
4: return this plan
5: **else**
6: **if** find a plan which goal states is S_n and initial state is S_i **then**
7: execute another planning task (S_1, S_i, D)
8: **else**
9: **if** find a plan which initial state is S_1 and goal state is S_j **then**
10: check the context consistency of S_j and S_n
11: execute another planning task (S_j, S_n, D)
12: return break
13: **end if**
14: **end if**
15: **end if**

基于语境的服务组合规划



DAG 表示

DAG *G = G(V, E)*

(1)The DAG has at least two nodes Start *and* Finish.
(2)$a_i = (a_{i1}, a_{i2}, \ldots, a_{it})$ *is the action set for state* S_i *in* ST *and* $Eff(a_i) \supseteq S_i$
(3)The DAG has one node for each action $(a_1, a_2, \ldots, a_n)$.
(4) The DAG contains an edge from action a_i *to action* a_j *iff* S_j *is a direct successor of* S_i.
(5) The edge from a_i *to* a_j *is weighed by the context elements* $c \in C$ *and* $\Upsilon(S_i, c) \rightarrow a_i$.

局部优化算法

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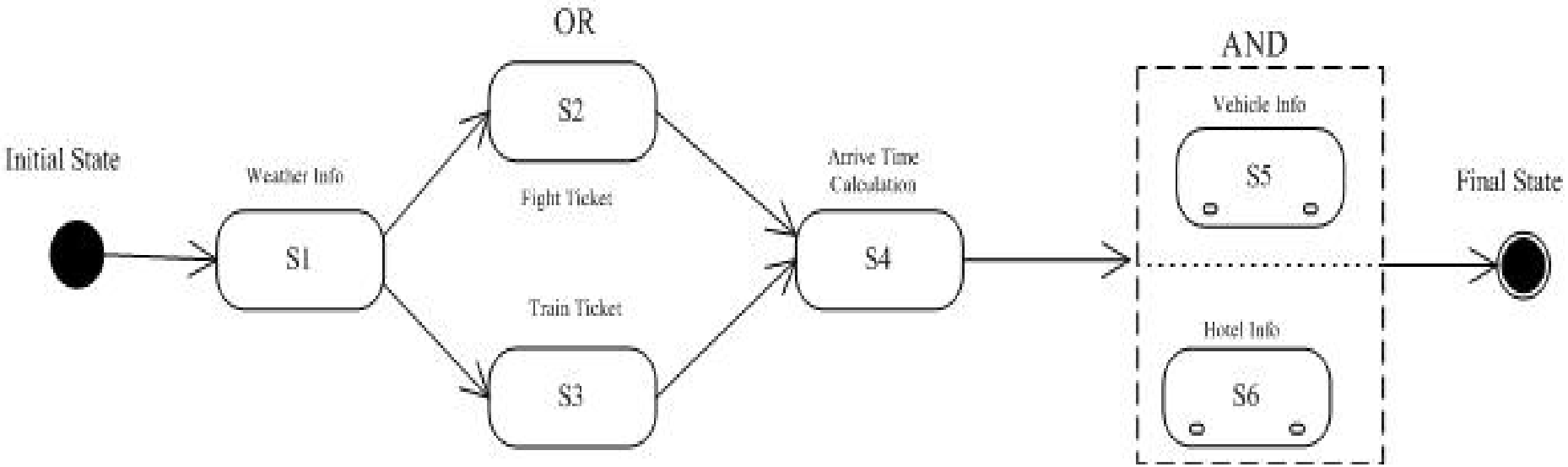
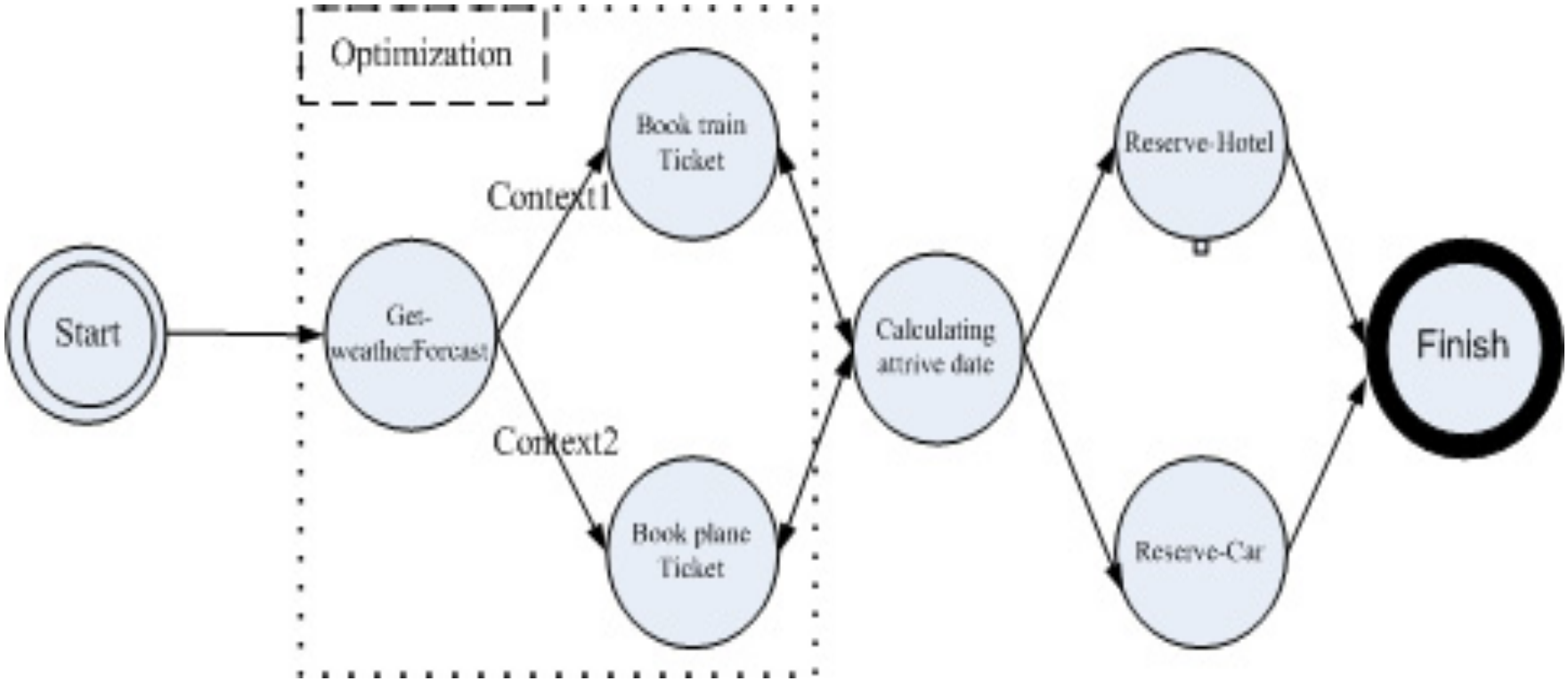
Algorithm 2 Local Optimization Algorithm

1: Given a statechart ST $[S_1, S_2, \ldots, S_n]$,
2: $RestofST \leftarrow ST$,
3: Generate two nodes *Start* and *Finish*
4: $Pre(Start) \in I \cap Eff(Start) = S_1$ and $Eff(finish) = \varnothing$
5: Link *Start* to *Finish*, stored in $DAGCurrentPath$, $DAGDBPath$
6: **while** $RestofST \neq \emptyset$ **do**
7: **if** the first state in ST isn't OR-States **then**
8: $CS \leftarrow getFirstState(RestofST)$
9: $CA \leftarrow GetBestCandidate(CS)$
10: $RestofST = ST - CS$
11: link CA to $DAGCurrentPath$
12: **else**
13: copy $DAGDBPath \leftarrow DAGCurrentPath$
14: $CT \leftarrow findRelatedContextTypes(c)$
15: $OT \leftarrow orderContextTypes(CT)$
16: **for** all $c \in OT$ **do**
17: $T \leftarrow getRelevantSelection(r)$
18: **end** **for**add OR1 part to $DAGCurrentPath1$ add OR2 part to $DaGCurrentPath2$
19: add OR2 part to $DAGCurrentPath2$
20: **end if**
21: **end while**

任务状态图


OR
AND
Initial State
Weather Info
S1
S2
Fight Ticket
Train Ticket
S3
Arrive Time
Calculation
S4
Vehicle Info
S5
Hotel Info
S6
Final State

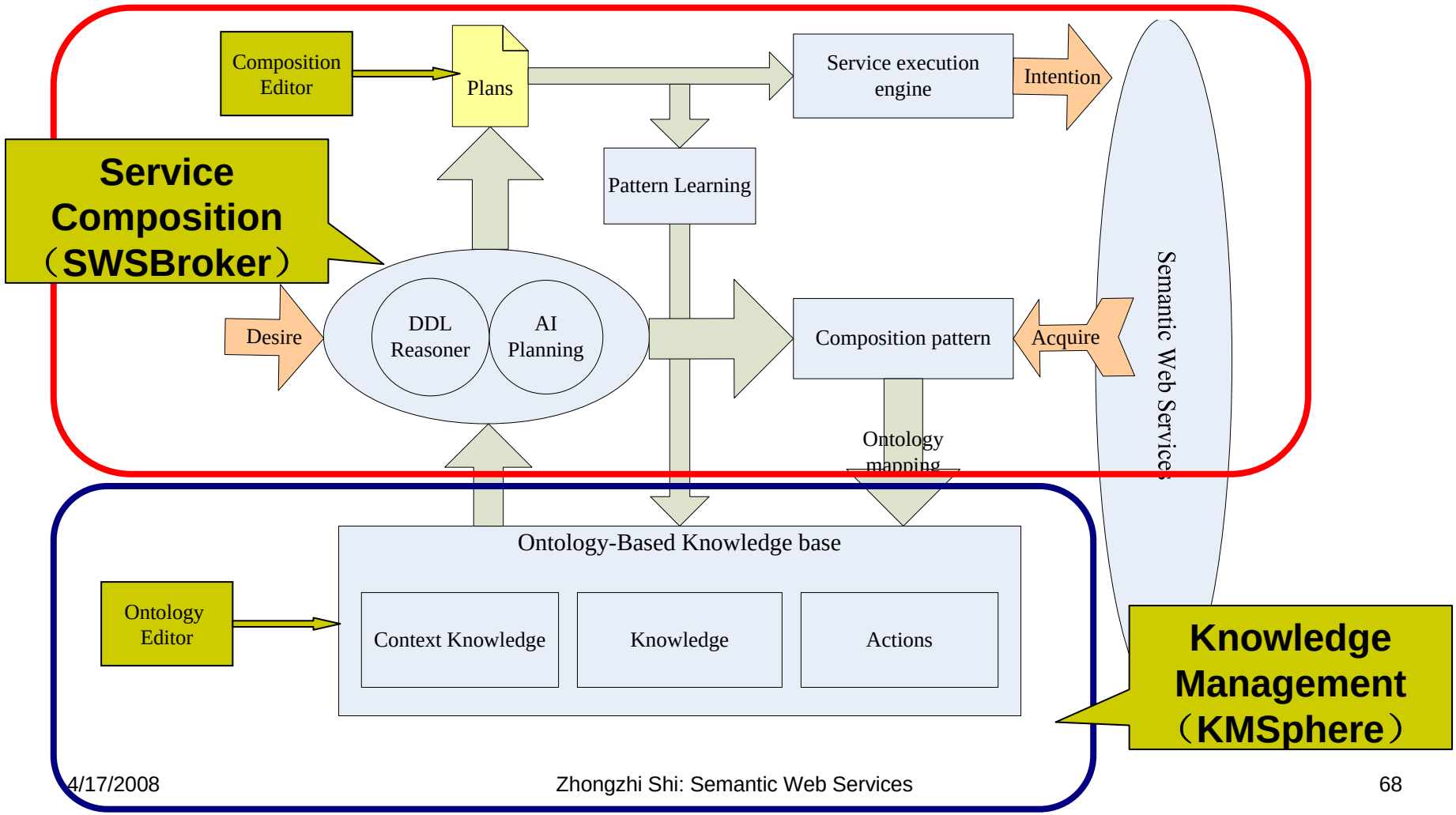
Final Execution Path in DAG



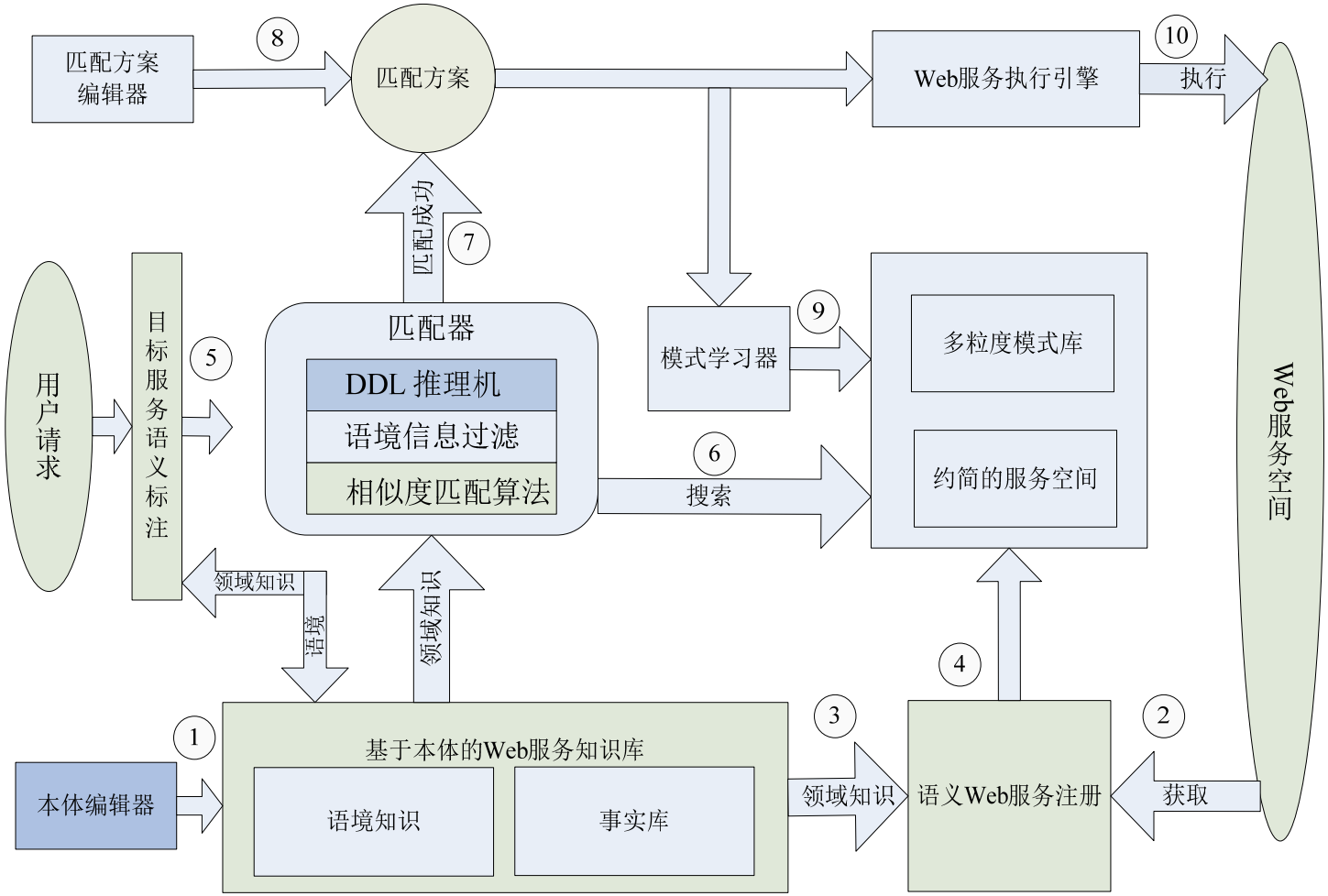
内容提要

- 概述
- **Web** 服务自动发现
- **Web** 服务自动组合
- 语义**Web**服务平台 **SWSBroker**
- 群智能决策支持系统 GIDSDP
- 结束语

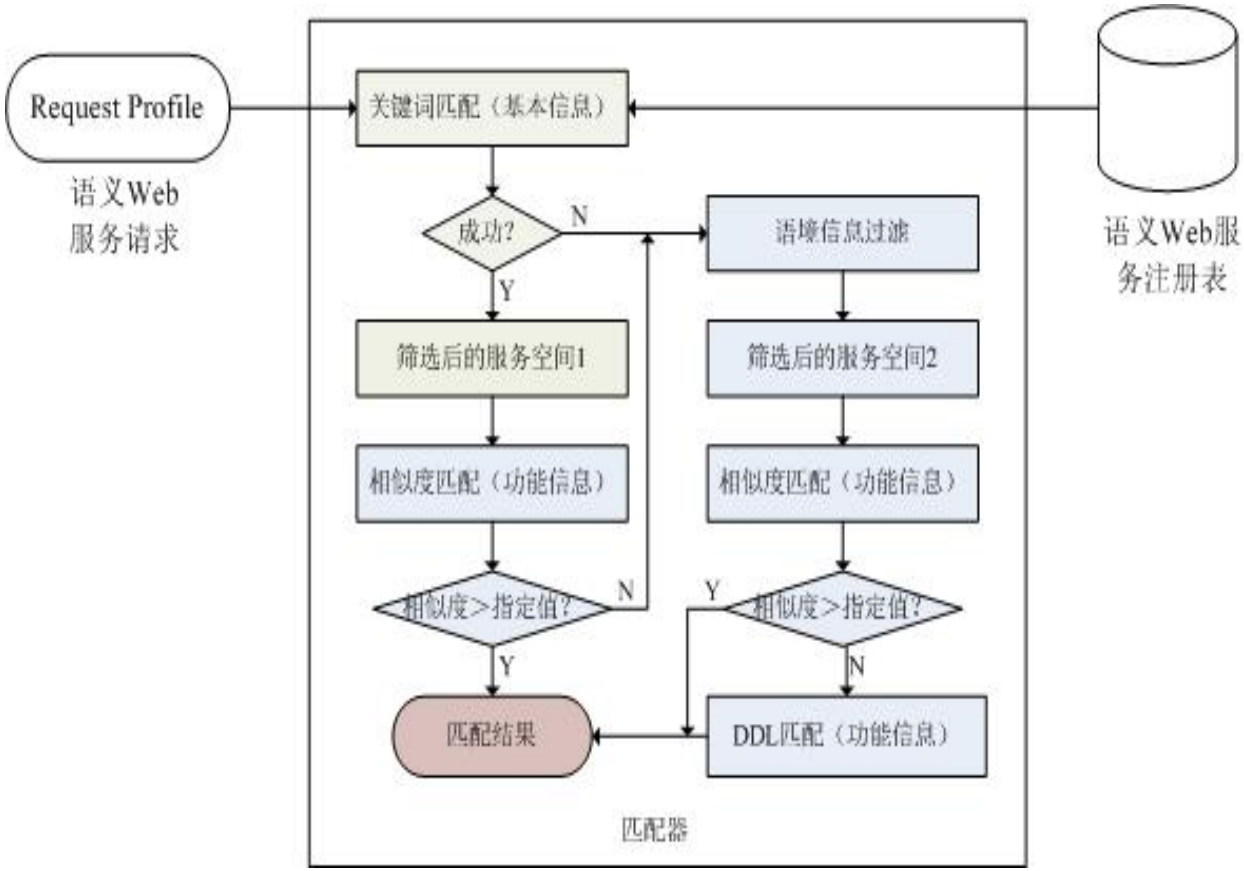
语义Web服务平台 SWSBroker



语义Web服务匹配器


匹配方案
编辑器
8
匹配方案
Web服务执行引擎
10
执行
匹配成功
7
匹配器
DDL 推理机
语境信息过滤
相似度匹配算法
模式学习器
9
多粒度模式库
约简的服务空间
用户请求
目标服务语义标注
5
6
搜索
领域知识
语境
领域知识
Web服务空间
4
1
基于本体的Web服务知识库
3
2
本体编辑器
语境知识
事实库
领域知识
语义Web服务注册
获取

语义Web服务匹配器


Request Profile
语义Web
服务请求
关键词匹配（基本信息）
成功?
N
Y
语境信息过滤
筛选后的服务空间1
筛选后的服务空间2
相似度匹配（功能信息）
相似度匹配（功能信息）
相似度>指定值?
N
Y
相似度>指定值?
Y
N
匹配结果
DDL匹配（功能信息）
匹配器
语义Web服
务注册表

语义Web服务匹配器

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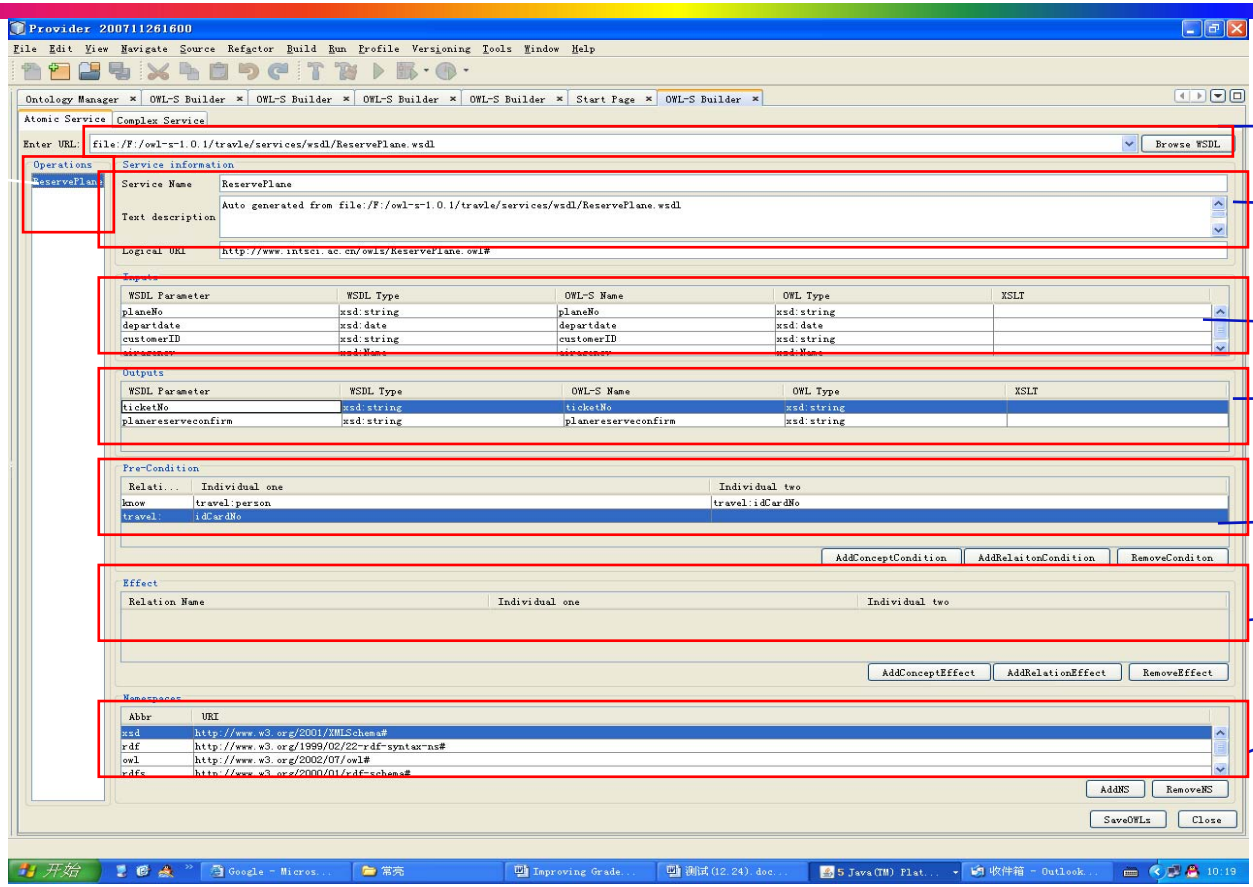
操作



地址

发布方描述

输入

输出

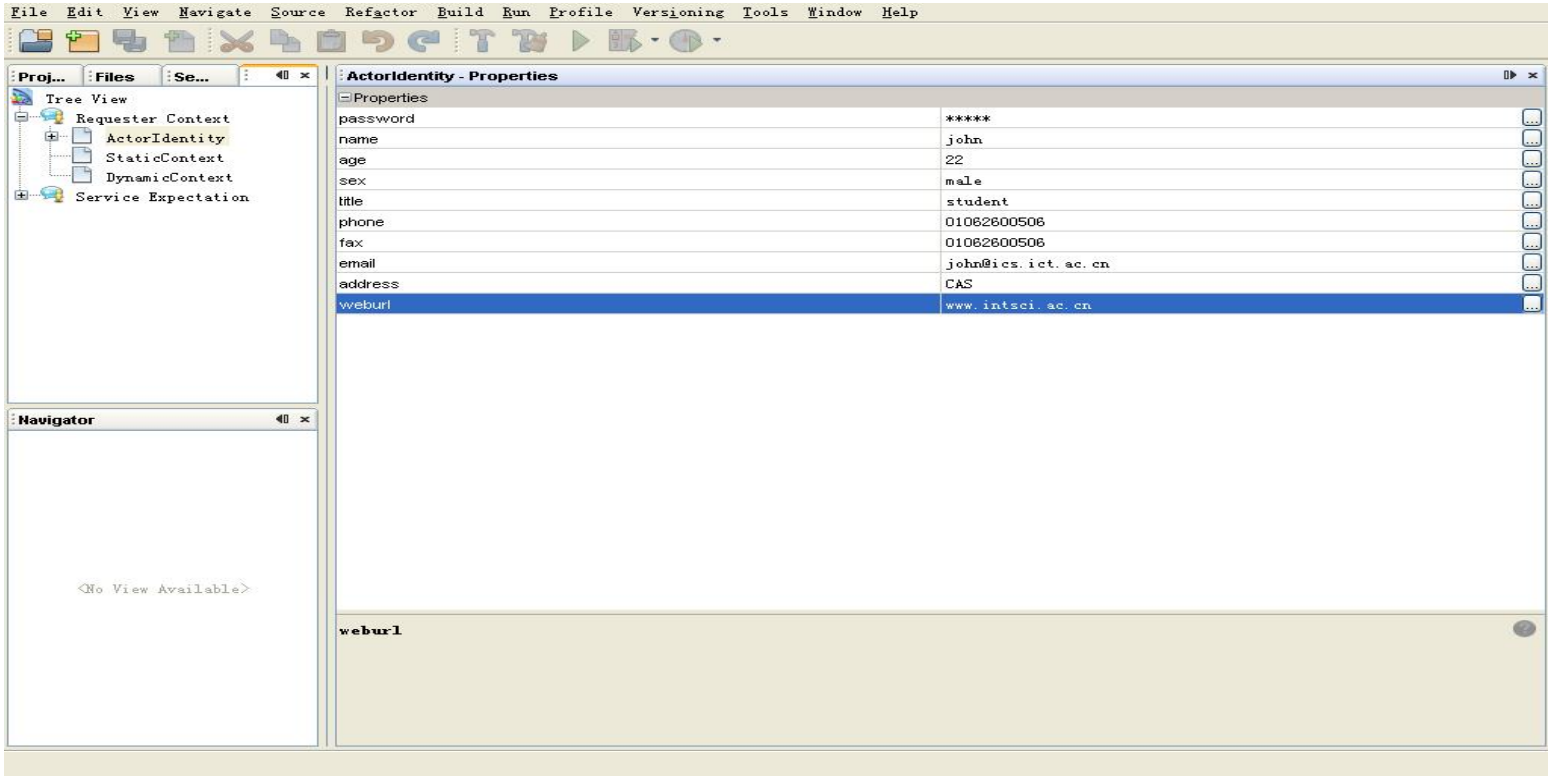
前提

结果

名字空间

语义标注

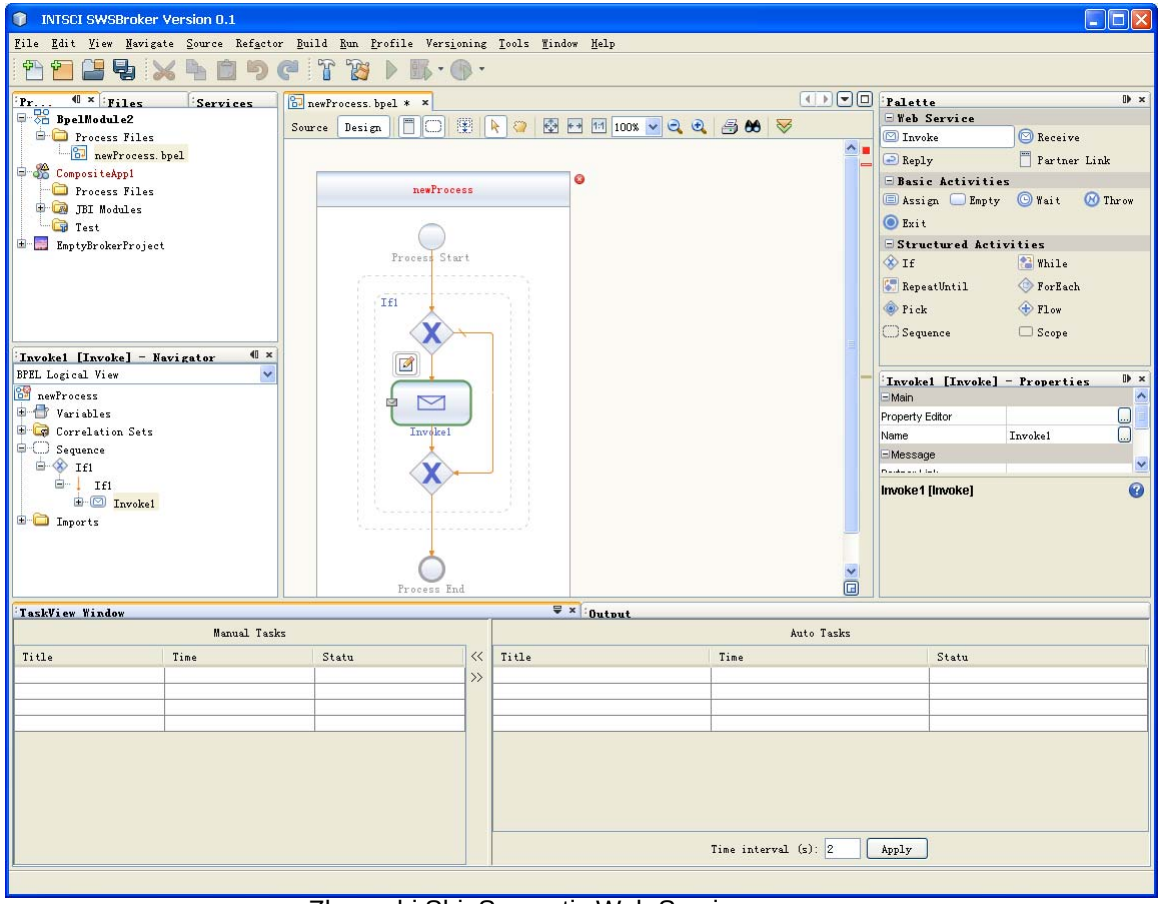
语义Web服务匹配器



语境信息获取

语义Web服务组合平台（SWSBroker）

- 服务代理软件（Broker）



语义Web服务组合平台（SWSBroker）

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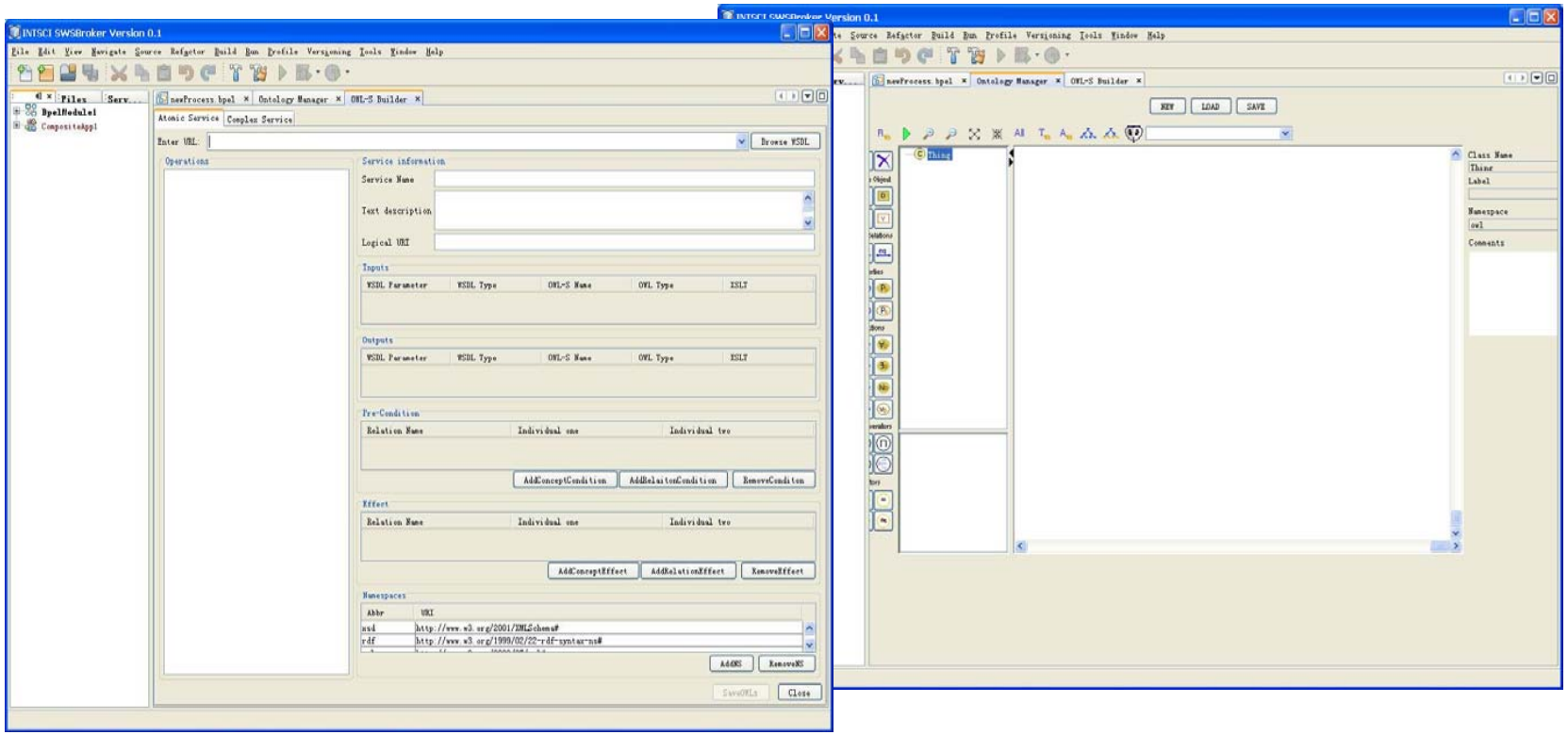
- 服务提供软件（Provider）



语义Web服务组合平台（SWSBroker）

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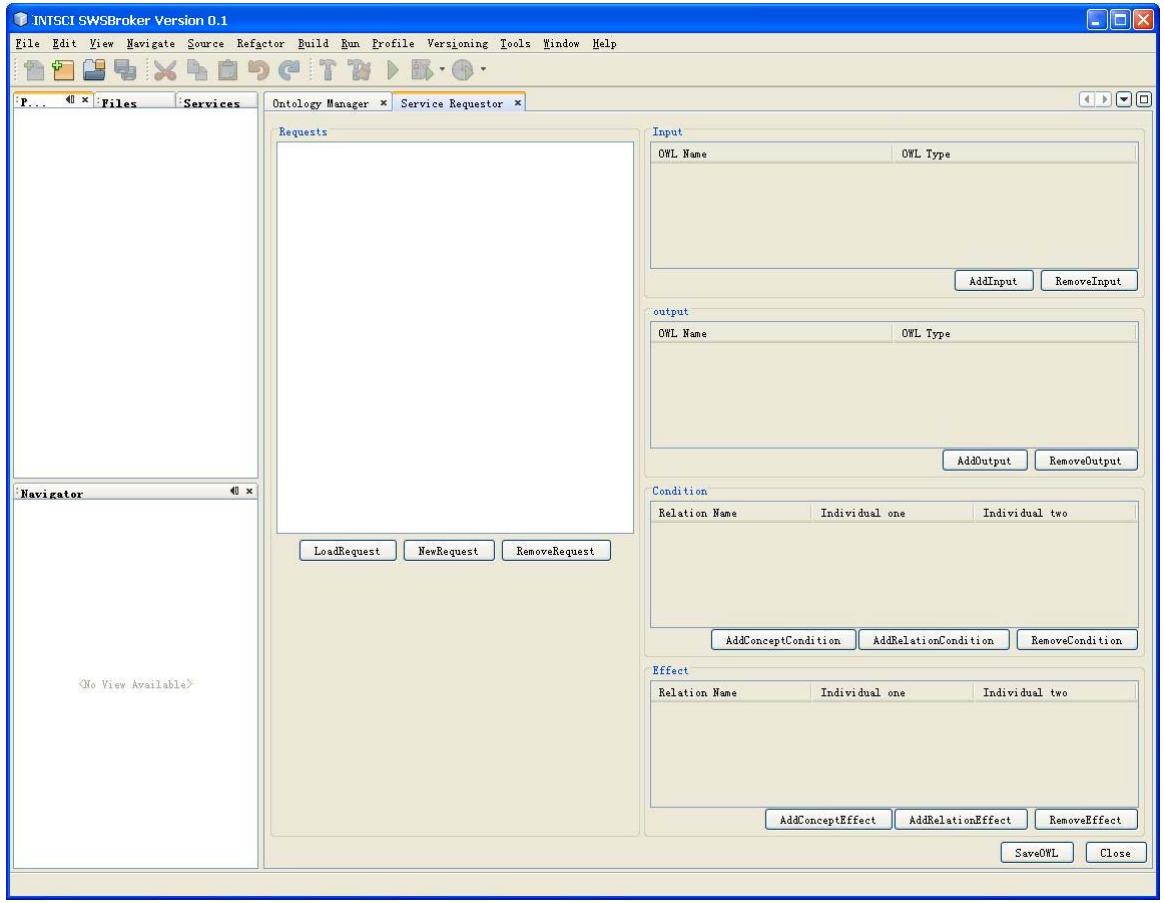
- 服务请求软件（Customer）



Agent-Based Service Composition

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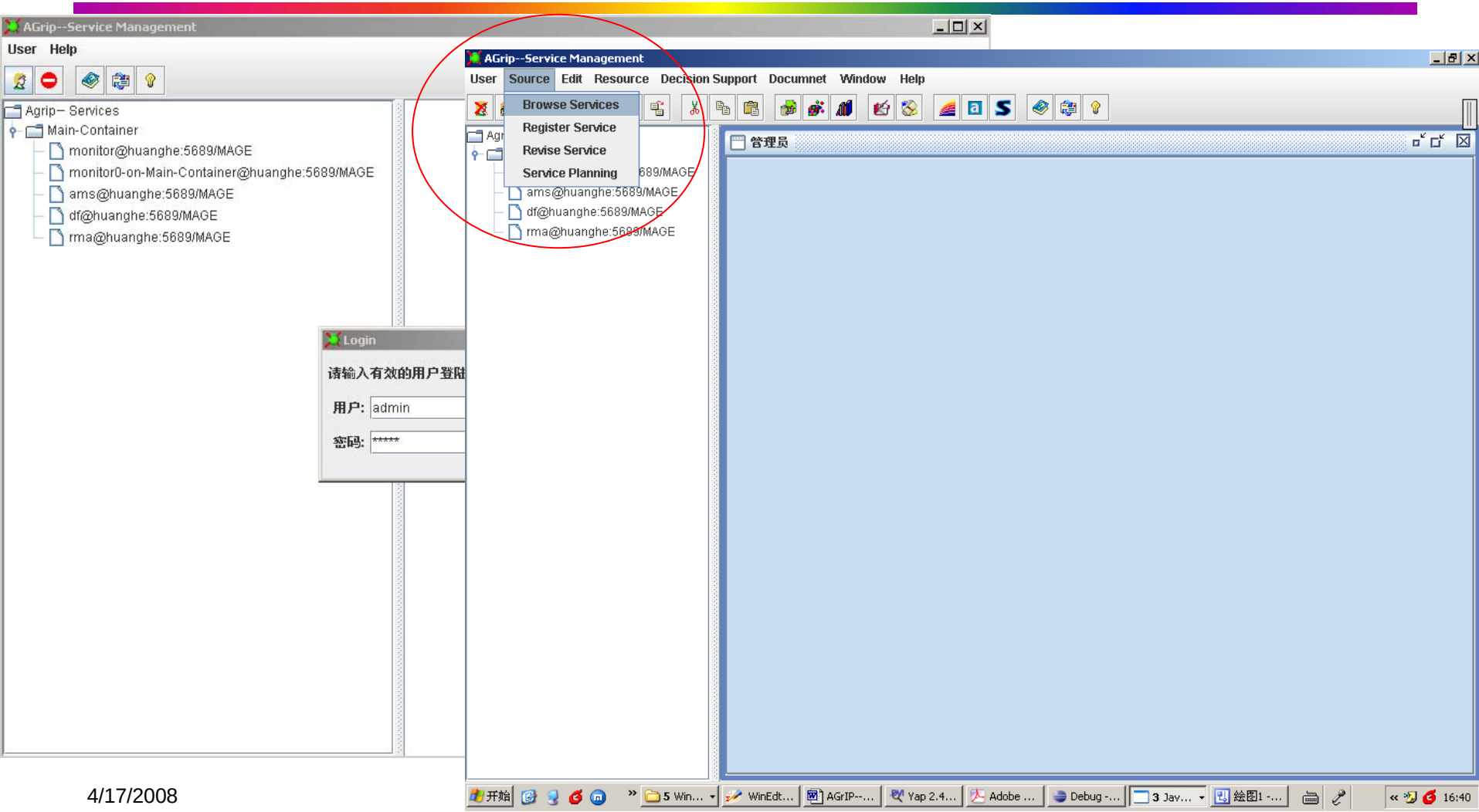
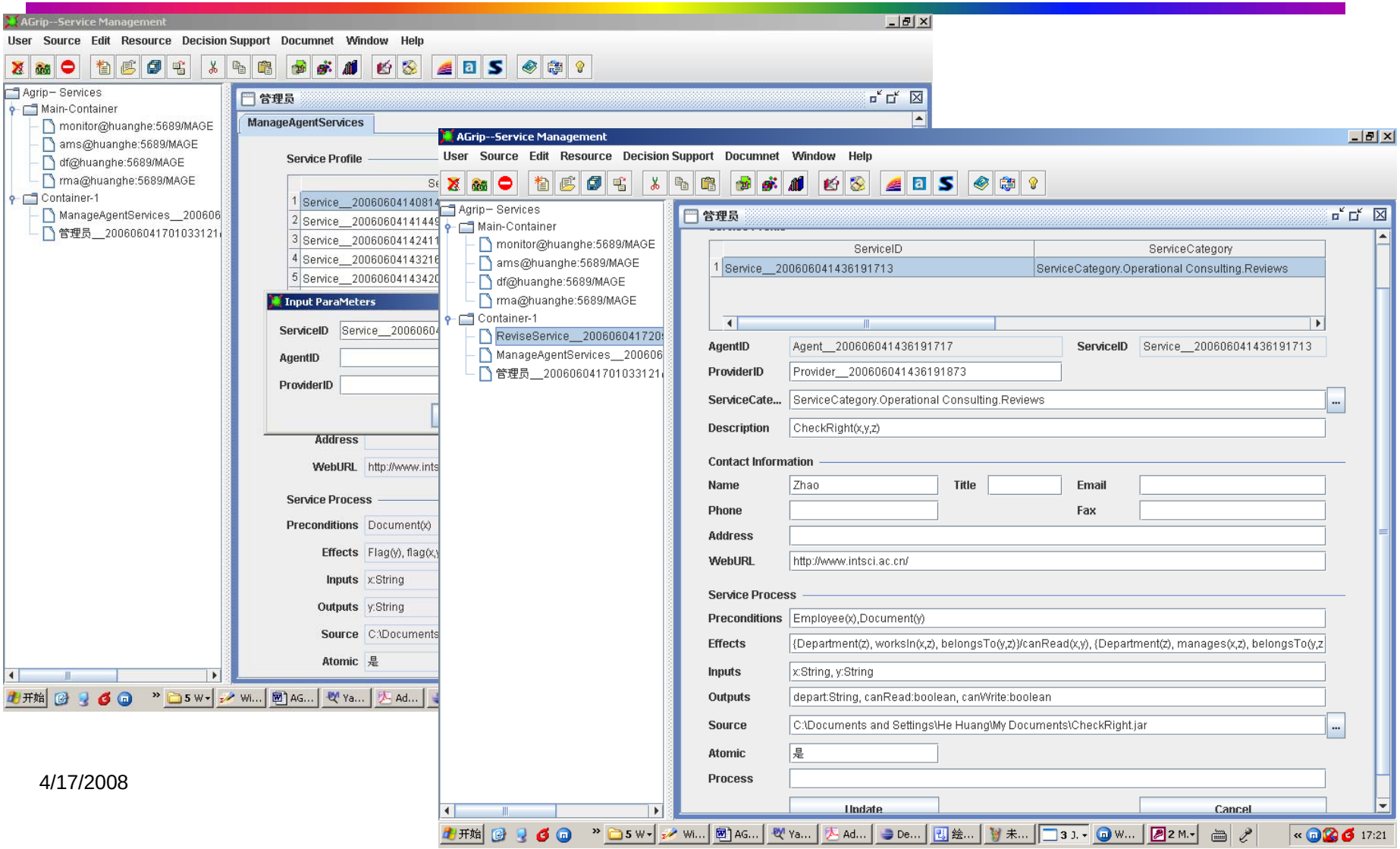


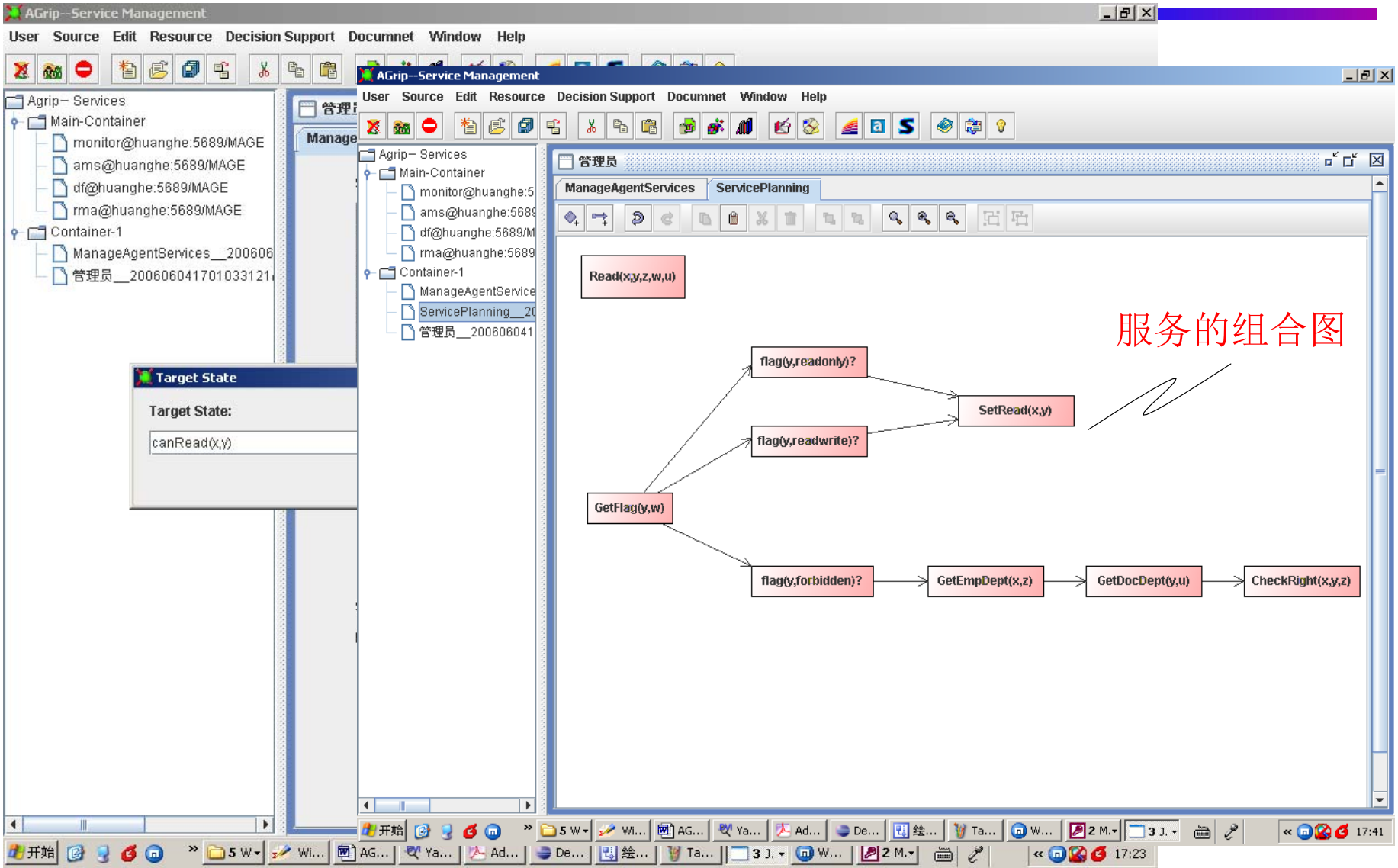
Agent-Based Service Composition

INSTITUTE OF COMPUTING TECHNOLOGY



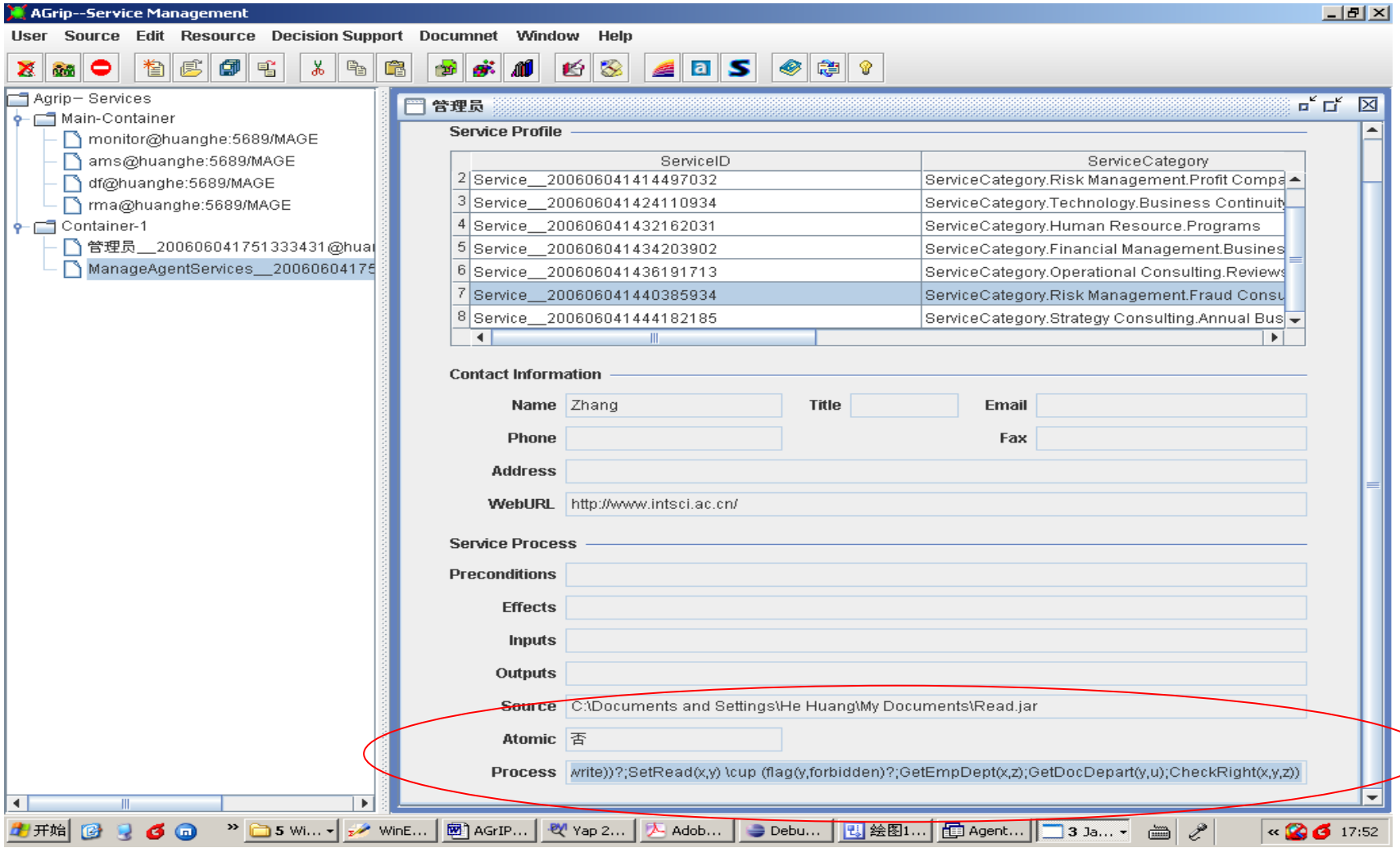
Agent-Based Service Composition

INSTITUTE OF COMPUTING TECHNOLOGY



Agent-Based Service Composition

INSTITUTE OF COMPUTING TECHNOLOGY



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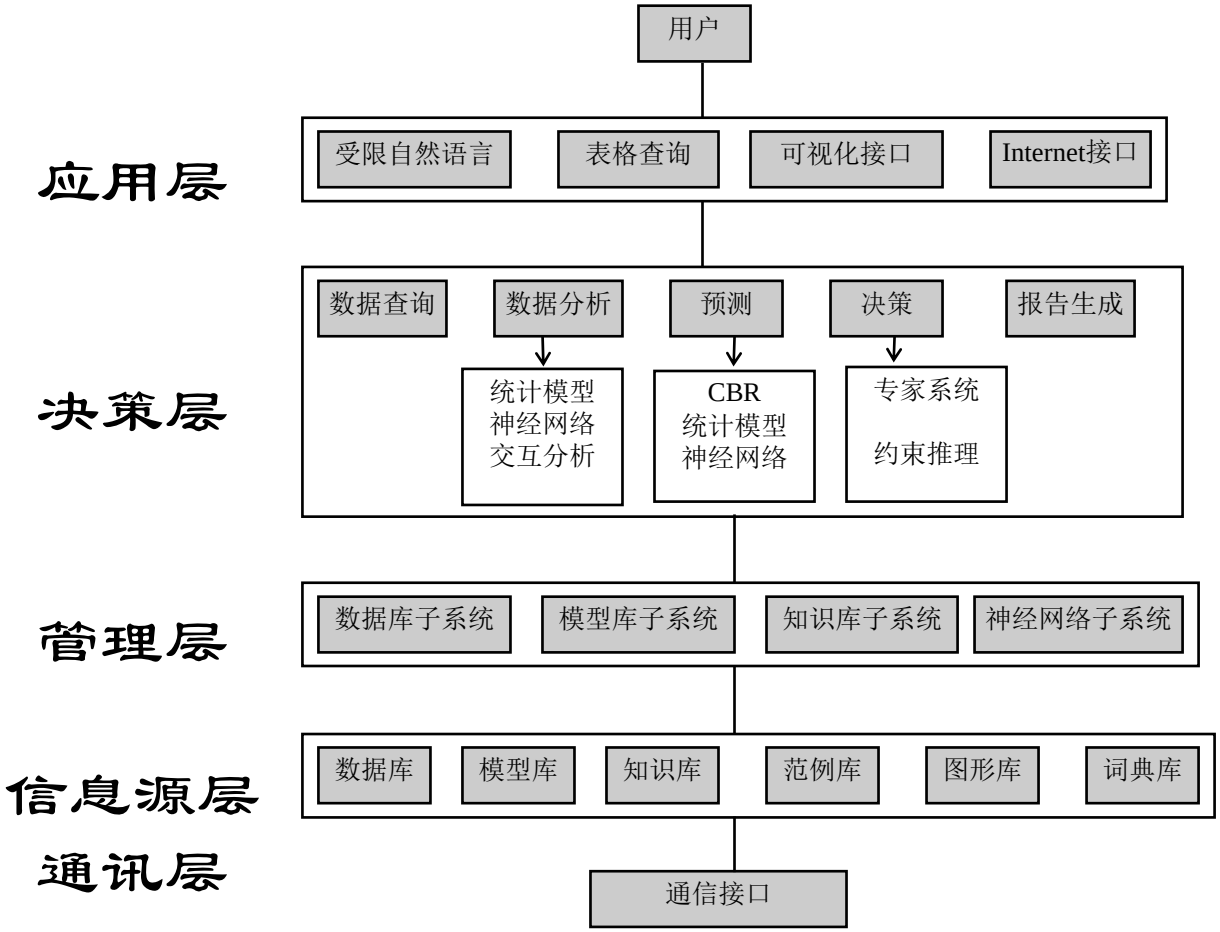
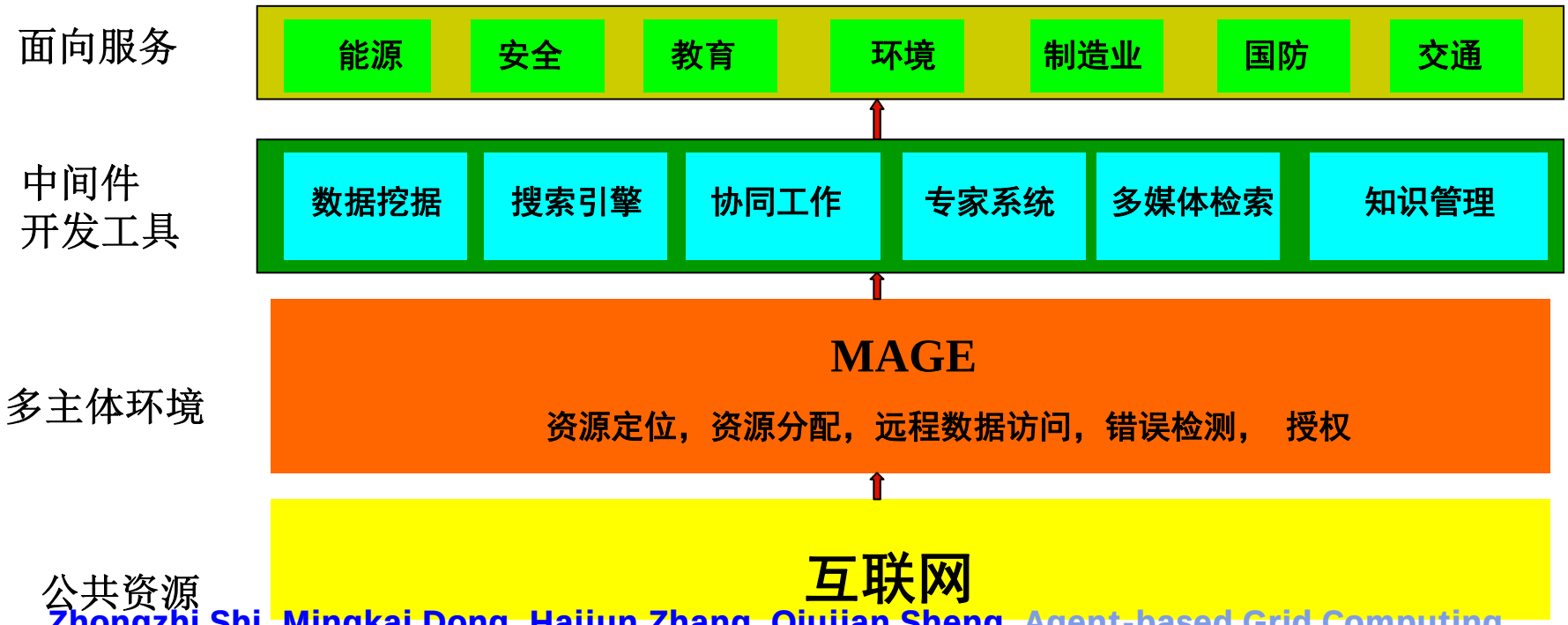
- 群智能决策支持系统 GIDSDP
- 结束语

群智能决策支持系统 GIDSDP



主体网格智能系统结构

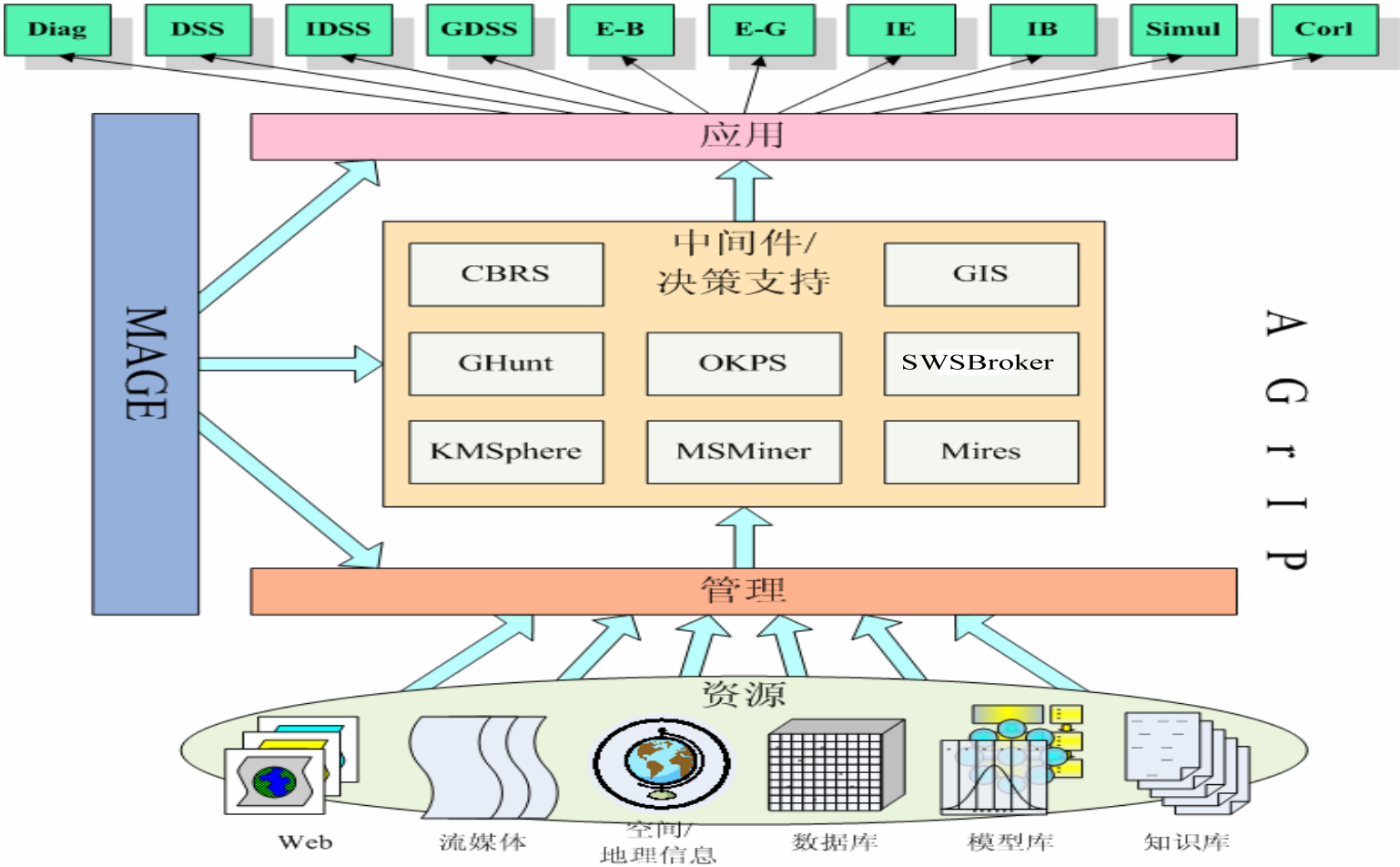
主体网格智能系统结构



Zhongzhi Shi, Mingkai Dong, Haijun Zhang, Qiujian Sheng. Agent-based Grid Computing. Keynote Speech, International Symposium on Distributed Computing and Applications to Business, Engineering and Science, Wuxi, Dec. 16-20, 2002

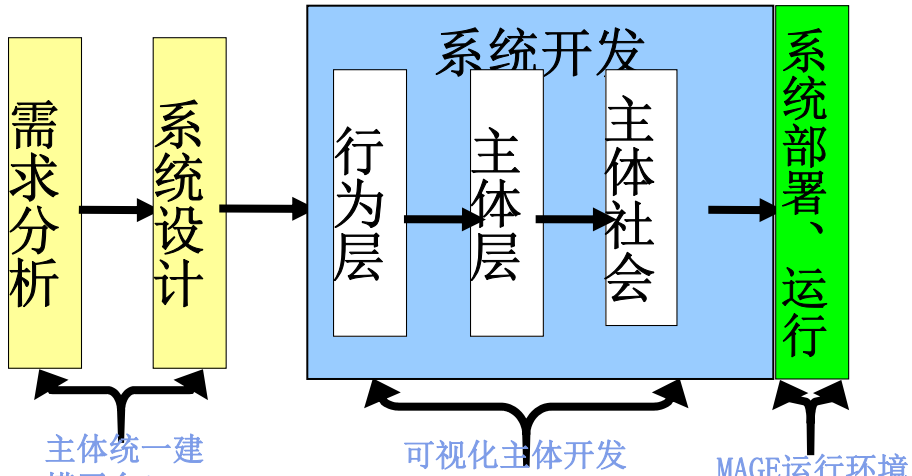
Zhongzhi Shi, He Huang, Jiewen Luo, Fen Lin, Haijun Zhang. Agent-based Grid Computing. Applied Mathematical Modeling, 30(2006): 629-640.

AGrIP体系结构图

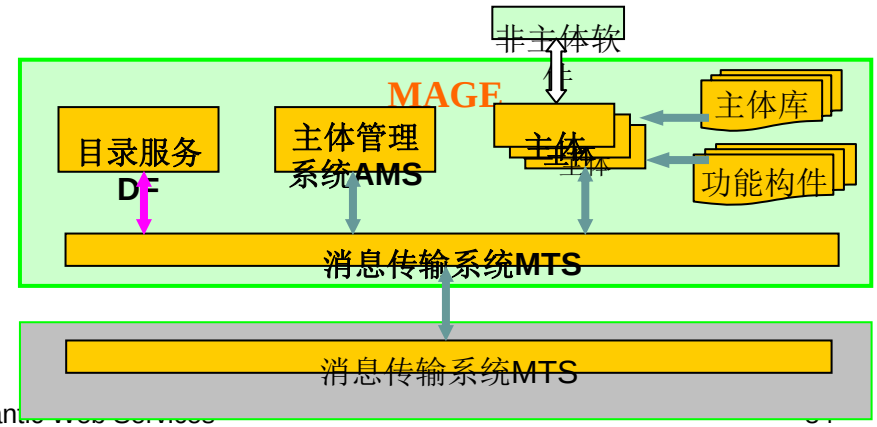

Diag
DSS
IDSS
GDSS
E-B
E-G
IE
IB
Simul
Corl
应用
MAGE
中间件/
决策支持
CBRS
GIS
GHunt
OKPS
SWSBroker
KMSphere
MSMiner
Mires
AGrIP
管理
资源
Web
流媒体
空间/
地理信息
数据库
模型库
知识库

多主体环境MAGE

多主体环境MAGE是一种面向主体的软件开发、集成和运行环境，为用户提供需求分析、系统设计、主体生成以及系统运行等多种工具。用户通过构建新的软件或重用已有软件，可以方便地开发各种大型复杂应用。



MAGE系统结构



其他主体平台

Zhongzhi Shi. MAGE: Multiagent Environment for Humanized Systems. Invited speaker, ISHS2005

主体结构

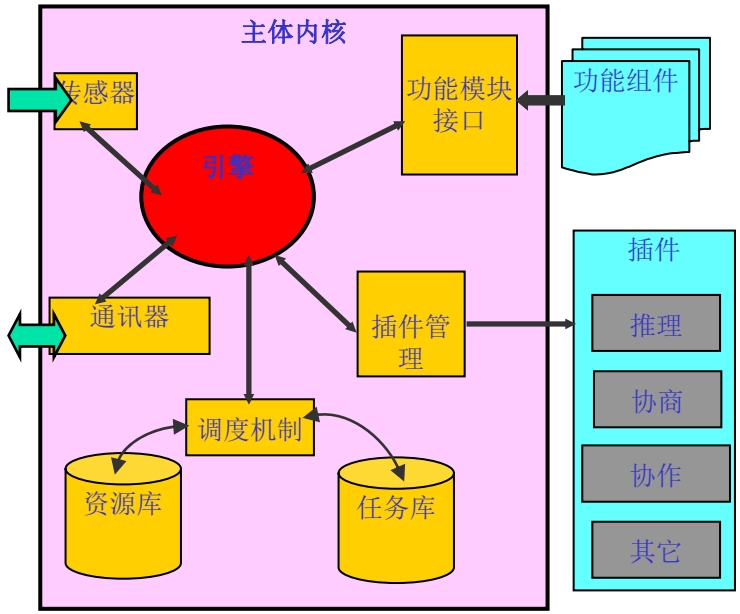
- 问题：具有心智状态的主体如何用软件实现?
- 解决方案: 由两部分构成:

  主体内核(Kernel)

  功能构件(Function Component) 。
- 特点:

  结构灵活

  支持软件复用



史忠植. 智能主体及其应用，科学出版社，2000

结束语

- Web3.0 是人工智能应用的典范
- Web 服务自动发现
- Web 服务自动组合
- 语义Web服务平台 SWSBroker
- 主体网格智能平台AGrIP为构建大型群智能决策支持系统 GIDSDP提供良好环境

会议通知

INSTITUTE OF COMPUTING TECHNOLOGY

- **2008年10月19-22日在北京召开高等智能国际会议（ICAI-08），欢迎投稿，网址是 http://caai.cn:8086/icai08**
- **2008年10月19-22日在北京召开IFIP 智能信息处理国际会议（IFIP IIP-08），欢迎投稿，网址是 http://www.intsci.ac.cn/iip2008**

References

Zhongzhi Shi, Mingkai Dong, Yuncheng Jiang, Haijun Zhang. **A Logic Foundation for the Semantic Web**. *Science in China, Series F Information Sciences*, 48(2):161-178, 2005

Cardoso, J. (2007). Semantic Web Services: Theory, Tools and Applications. Idea Group.. ISBN 978-1-59904-045-5.

Michael Stollberg, Omair Shafiq, John Domingue, Liliana Cabral, Emilia Cimpian, Dumitru Roman, Michal Zaremba: **Semantic Web Services – State of Affairs,**

*ASWC2006***,** Sept. 4-7**,** Beijing

Lei Li and Ian Horrocks. **A software framework for matchmaking based on semantic web technology**. In *Proc. of the Twelfth International World Wide Web Conference (WWW 2003), 2003*

Daniel J. Mandell and Sheila A. McIlraith. **Adapting BPEL4WS for the Semantic Web: The Bottom-Up Approach to Web Service Interoperation.** In *Proceedings of the Second International Semantic Web Conference (ISWC2003),*

Preist, C.: **A Conceptual Architecture for Semantic Web Services**. In Proceedings of the 3rd International Semantic Web Conference (ISWC 2004), 2004, pp. 395 - 409.

Stollberg, M.; Keller, U.; Fensel. D.: **Partner and Service Discovery for Collaboration on the Semantic Web.** Proc. 3rd Intl. Conference on Web Services (ICWS 2005), Orlando, Florida, July 2005.

References

Fen Lin, Lirong Qiu, He Huang, Qing Yu, Zhongzhi Shi: **Description Logic Based Composition of Web Services**. *PRIMA 2006*: 199-210

Lirong Qiu, Zhongzhi Shi, and Fen Lin.: **Context Optimization of AI Planning for Services Composition.** *2006 IEEE International Conference on e-Business Engineering, Shanghai, 2006*

Daniela Berardi, Liliana Cabral, Emilia Cimpian, Dr. John Domingue, Massimo Mecella, Michael Stollberg, Professor Katia Sycara: **Semantic Web Services.** *ESWC2005 Tutorial, Heraklion, Greece, May 2005*

M. Vukovic and P. Robinson. **Adaptive, Planning Based,Web Service Composition for Context Awareness**. In:. *Advances in Pervasive Computing*. Volume 176. (2004) 247–252

Steve Battle, etc**. : Semantic Web Services Ontology (SWSO),** Version 1.0, W3C proposal, 2005

Steve Battle, etc**. : Semantic Web Services Language (SWSL),** Version 1.0, W3C proposal, 2005

Thank You

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