STI · INTERNATIONAL

Computer Science in the 21st Century

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University of Innsbruck

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Service Ware

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- Computer science is entering a new generation
  - The previous generation was based on abstracting from hardware.
  - The emerging generation comes from abstracting from software and sees all resources as services in a service-oriented architecture (SOA).
- In a world of services, it is the service that counts for a customer and not the software or hardware components that implement the service.
- Service-oriented architectures are rapidly becoming the dominant computing paradigm.

Service Ware

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- In a service-oriented world everything is a service
  - Programs are services.
  - Devices are services.
  - Different types of media (audio, video, text) are integrated.
  - Environments are dynamic and open.
  - Mobility; Ubiquity; RFID
- Service orientation needs to scale up to open and dynamic environments of ***billions*** of services.

Service Ware

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- Current SOA solutions are however still restricted in their application context to companies intranets.
- A service web with billions of services depends on resolving fundamental challenges that SOA does not address currently
- Currently there exists only around 12000 Web services on the Web. See http://www.seekda.com/.

From Service Ware to Service Web

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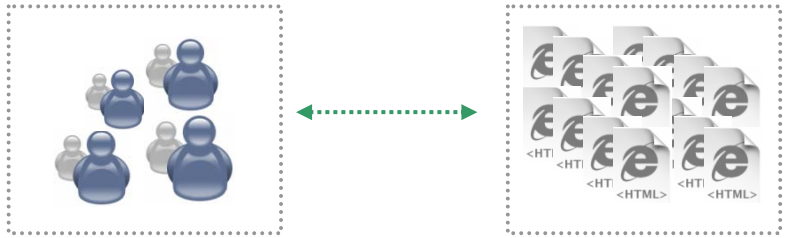

More than a 1 billion users
more than 30 billion pages

WWW

URI, HTML, HTTP

Static

Requirements for Service Web

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- A service Web with ***billions*** of services can be realized only if SOA can deal with
  - **Openness** – everybody can act as a provider or consumer of services.
  - **Heterogeneity** – services are created in isolation from one another thus interoperability is an issue.
  - **Distributedness** – there is no central control of services. Services can appear, change or disappear at any time in an uncontrolled fashion.
  - **Scalability** – with so many services available on the Service Web the Human may become the bottleneck.

SERVICE WEB

Service Web: Openness

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- Principle: everybody must contribute as a provider or consumer of services.
- Usage of this infrastructure as a service provider or consumer must be as simple, smooth, and unrestricted as possible.
- Openness is an essential necessity to ensure the success of an SOA platform.

Service Web: Heterogeneity and distributedness

- Principle: content can appear, change, or disappear in an uncontrolled fashion.

- That is, provisioning and modification of content must be under distributed control of the peers, rather than being controlled by a central authority.

- Central control would hamper access and therefore scalability, an element of chaos or “messiness” must be tolerated.

Service Web: Scalability

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- **Scalability** can be ensured through semantics, that is through semantic descriptions of data and processes.
- Semantic technology enables a new generation of the Web, in which information has machine-processable and machine-understandable semantics.
- Allows machines to perform previously human-intensive tasks, quickly and efficiently at runtime

Semantic Web Services

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Tasks that need to be mechanized:

- **Publishing** create & publish Web service descriptions.
- **Discovery** determine usable services for a request.
- **Composition** combine services to achieve a goal.
- **Selection** choose the most appropriate service among the available ones.
- **Mediation** solve mismatches (data, protocol, process) that hamper interoperation.
- **Execution** invoke Web services following programmatic conventions.

Example: Web Service Discovery

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- Distinguish between “Web service” and “service”:
  - Web service: a computational entity able to provide many services
  - Service: a concrete invocation of a Web service
- What is a match?

Example: Web Service Discovery

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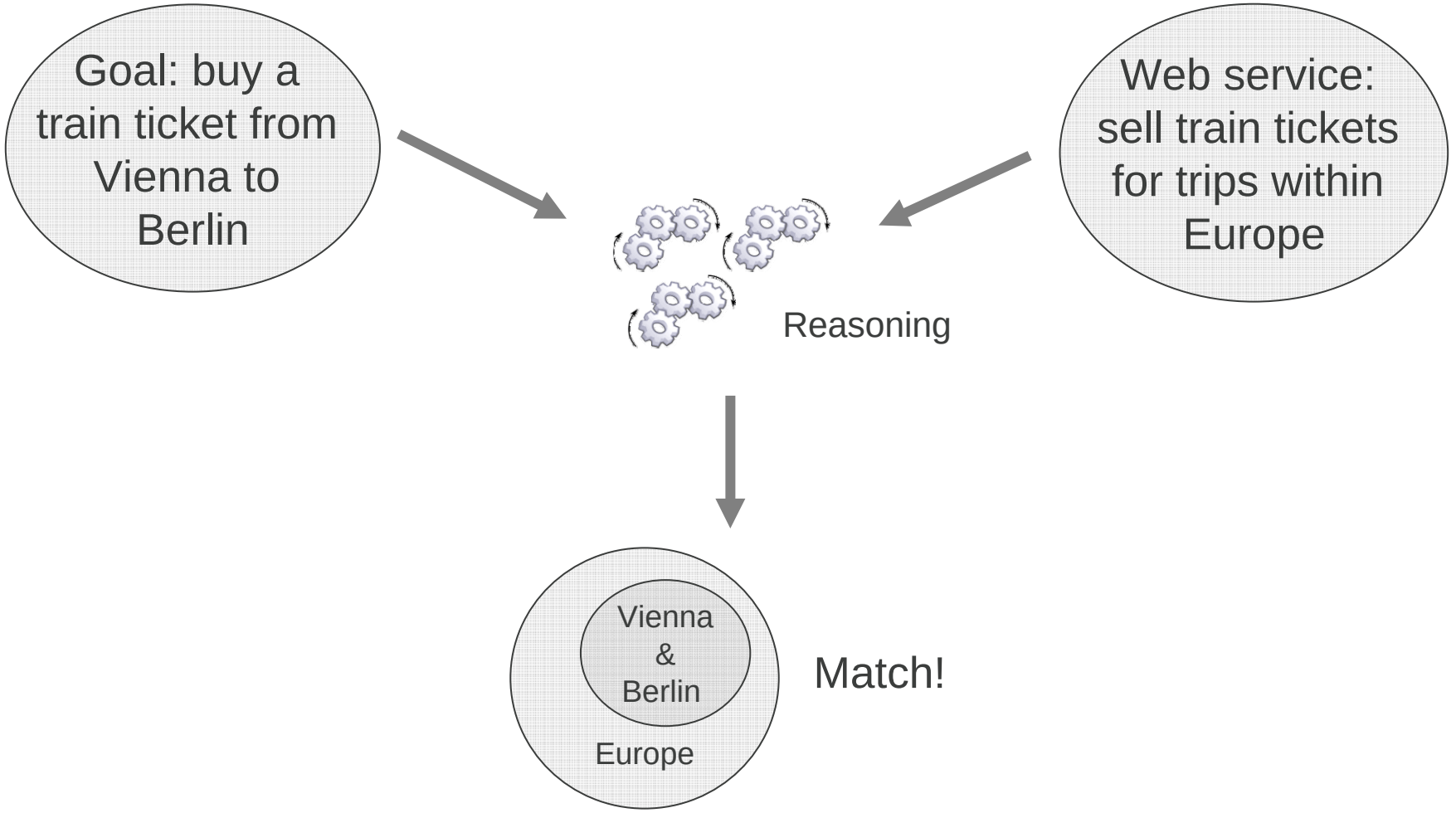
- The task
  - Client is interested in getting a specific service
  - Identify possible Web services, which are able to provide the requested service *S* for its clients
- Discovery
  - Given a goal and some Web Service repository determine the set of relevant services
  - Relevance or Matchmaking can be defined along multiple dimensions
    - *Capability (service semantics)*
    - *Non-functional properties (Quality of Service Parameters, Provider)*
    - *Choreography (how to interact with the web service)*

Example: Web Service Discovery



Example: Web Service Discovery

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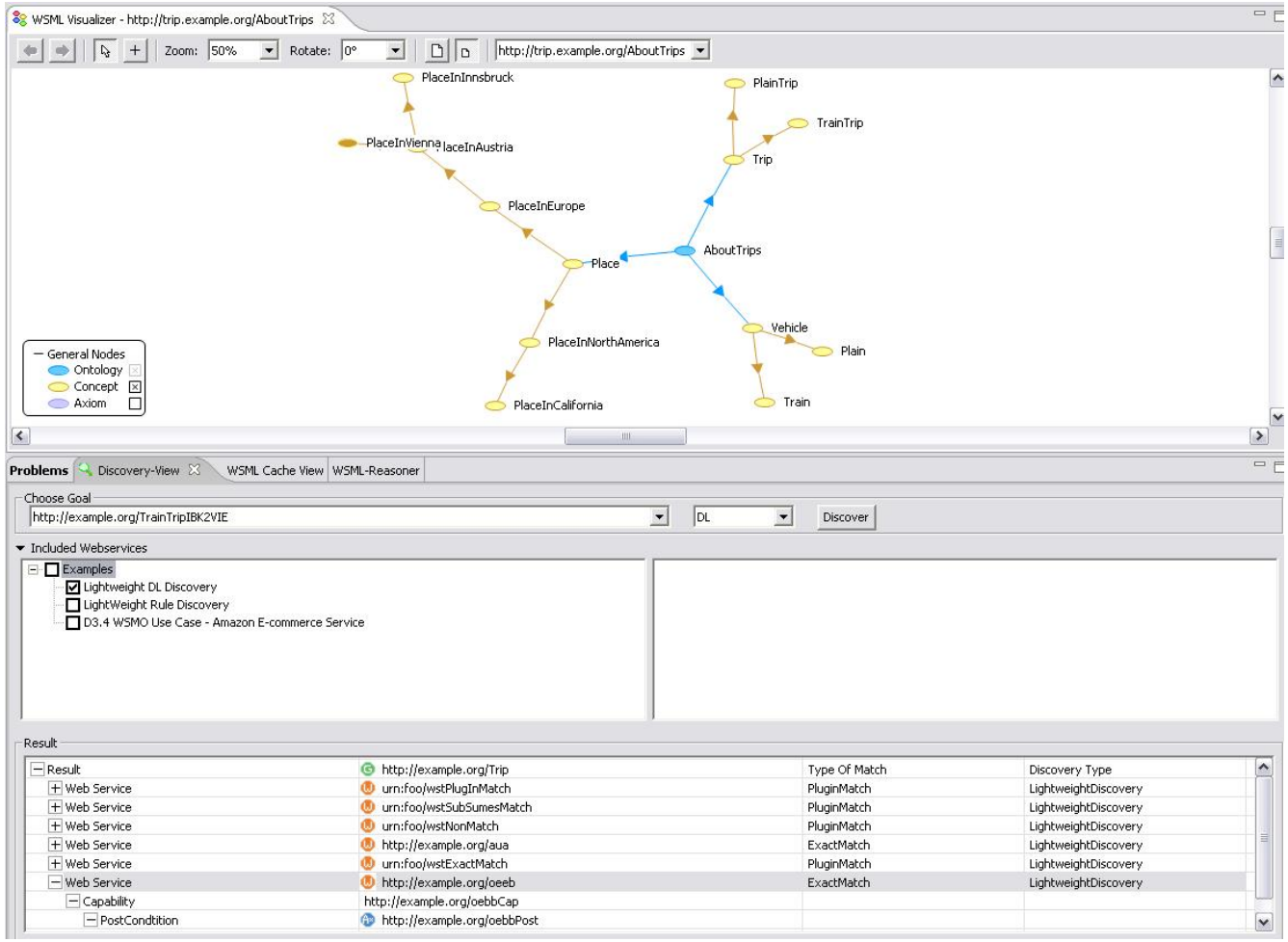

Example: Mediation

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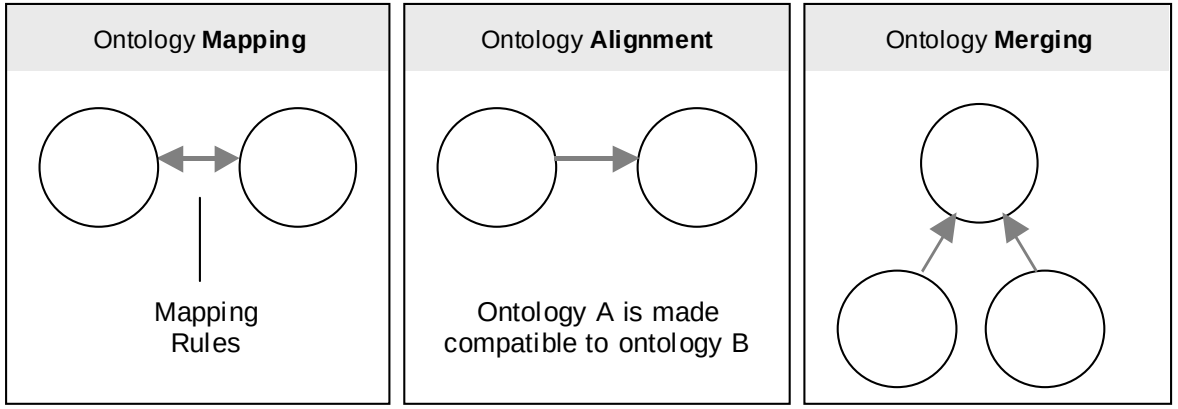
- Heterogeneity as inherent characteristic of Web:
  - heterogeneous terminology
  - heterogeneous languages / formalisms
  - heterogeneous functionalities
  - heterogeneous communication protocols and business processes
- Approach: declarative, generic mismatch resolution
  - classification of possible and resolvable mismatches
  - mediation definition language and mediation patterns
  - execution environment for mediation definitions

Example: Data Mediation

- Data Mediation is needed when two different groups have two ontologies representing the same domain
- Ontology Integration Techniques:



- Semi-automatic versus Automatic
  - human intervention needed for “integration decision”
  - graphical support for ontology mapping as central technique

Example: Data Mediation

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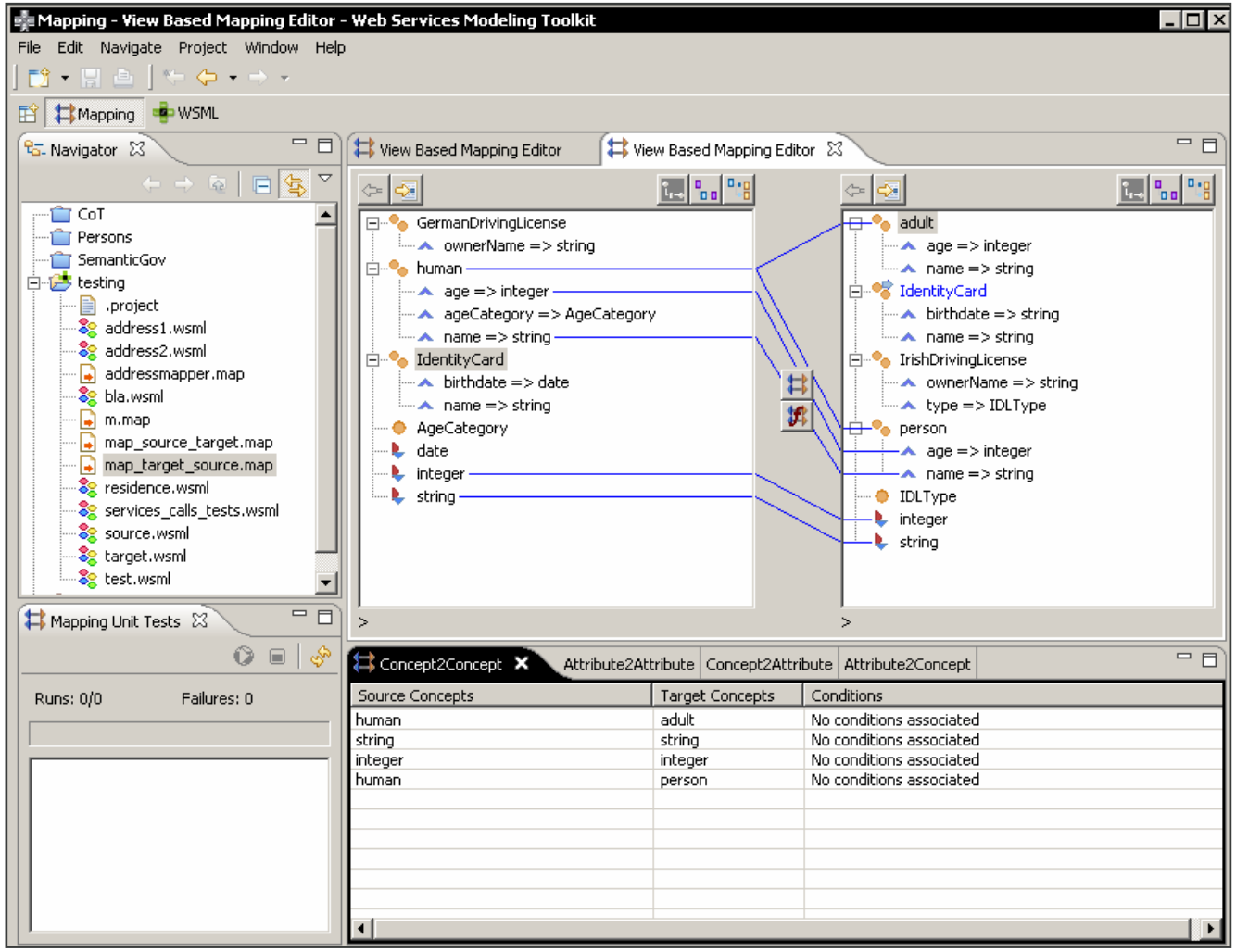

Example: Process Mediation

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- Heterogeneity may exist between exposed communication interfaces of service providers and those expected by service requesters
  - Messages in the wrong order
  - Messages sent separately that are expected together
  - Messages sent together that are expected separately
  - Messages sent that are never expected
  - Messages expected but never sent

- Process Mediation required to addresses these heterogeneity issues and enable dynamic communication between requester and provider

Example: Process Mediation

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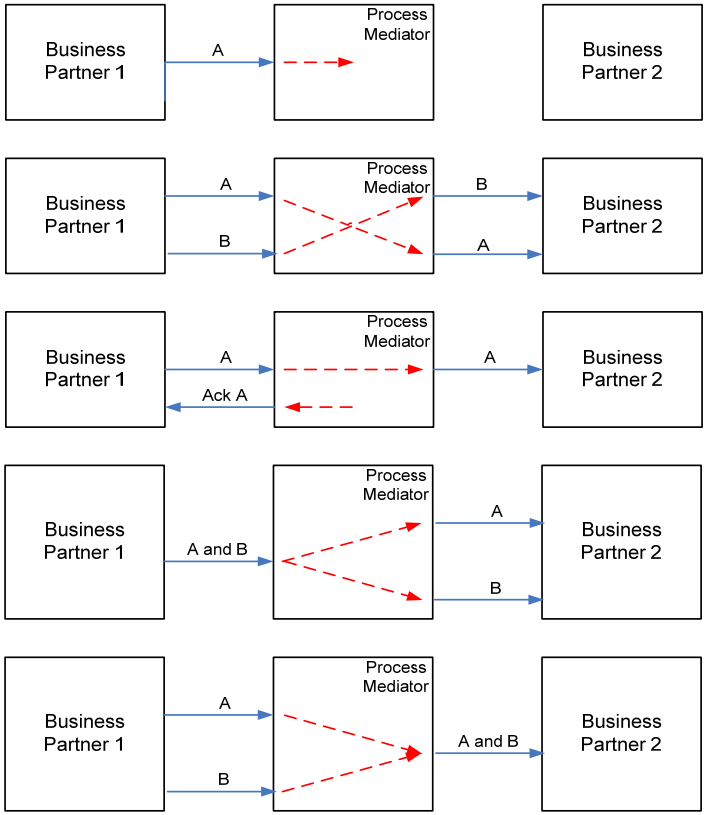
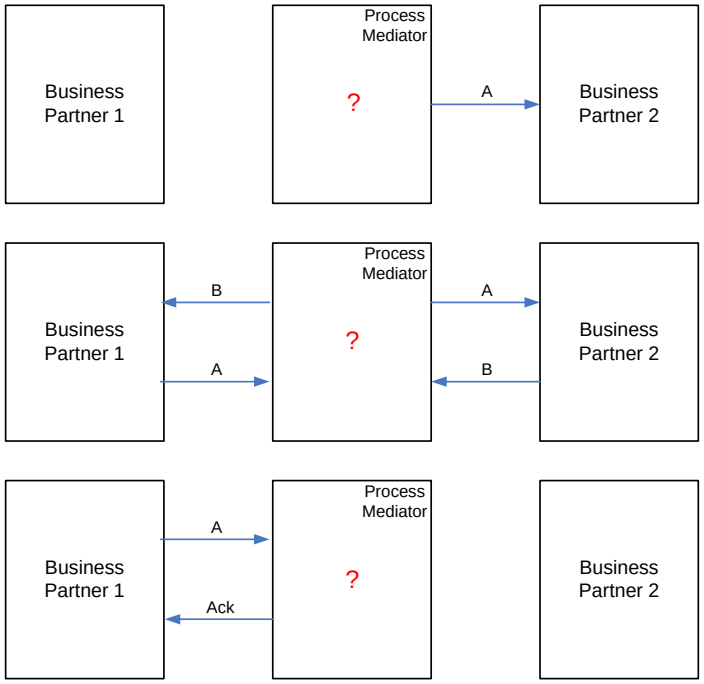
Some Mismatches can be resolved….. Others cannot





SEMANTIC WEB - Data

Semantic Web - Data

- If the Web is about the global networking of data through URL, HTML, and HTTP…
- … the **Semantic Web** is about the global networking of knowledge through URI, RDF, and SPARQL
- This knowledge can be annotating Web data (*this picture depicts Innsbruck*) or just for knowledge‘s sake (*Innsbruck is a city in Austria*)
- The aim is for machines to perform tasks on the Web automatically (*tell me about more about Innsbruck…*)

Semantic Web - Data

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- URIs are used to identify **resources**, not necessarily anything that exists on the Web, e.g. *Sir Tim Berners-Lee*, *Dr Frankenstein*, *my black Mercedes*
- RDF is used to make statements about resources in the form of **triples**

  <subject, property, object>
- Resources can belong to **classes** (*my Mercedes belongs to the class of cars*) and classes can be **subclasses** or **superclasses** of other classes (*vehicles are a superclass of cars, cabriolets are a subclass of cars*)

Semantic Web - Data

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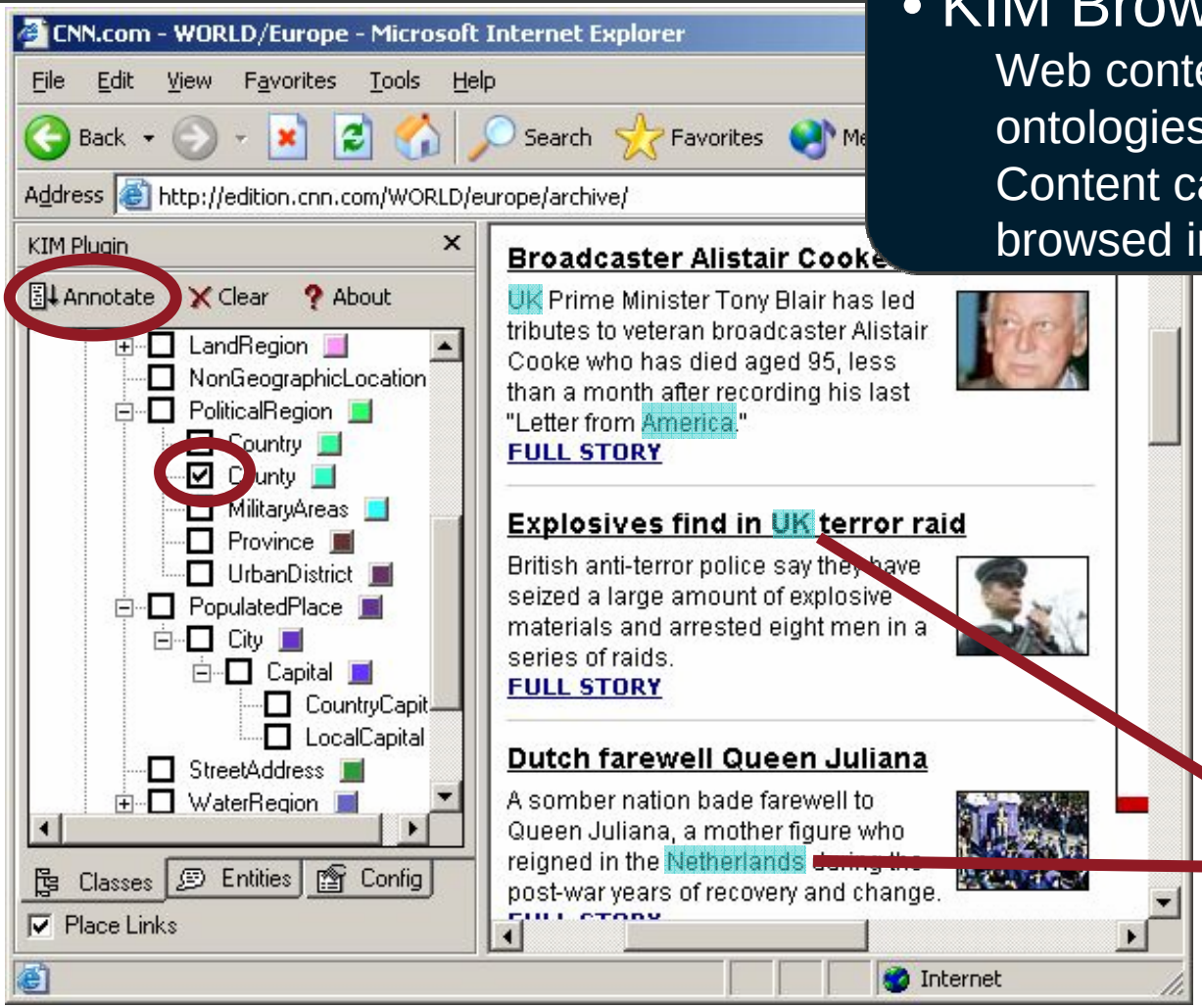
- KIM Browser Plugin
  - Web content is annotated using ontologies
  - Content can be searched and browsed intelligently



Annotated Content

Semantic Web - Data

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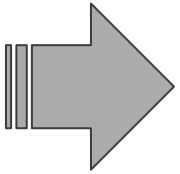
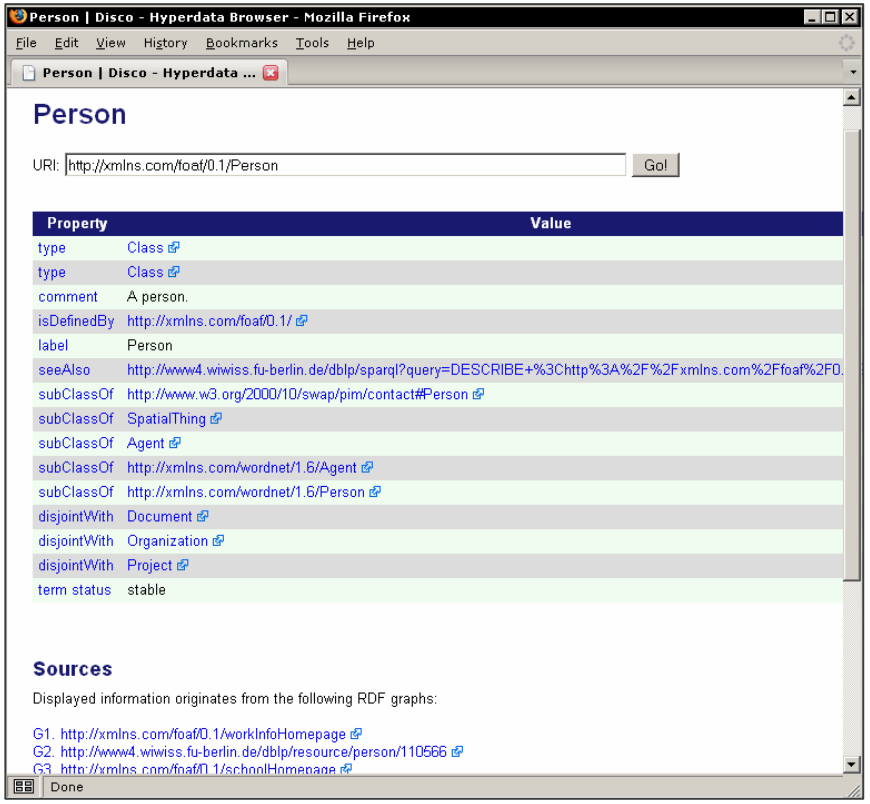
Dereferenceable URI

Disco Hyperdata Browser
navigating the Semantic Web as an unbound set of data sources





Semantic Web - Data

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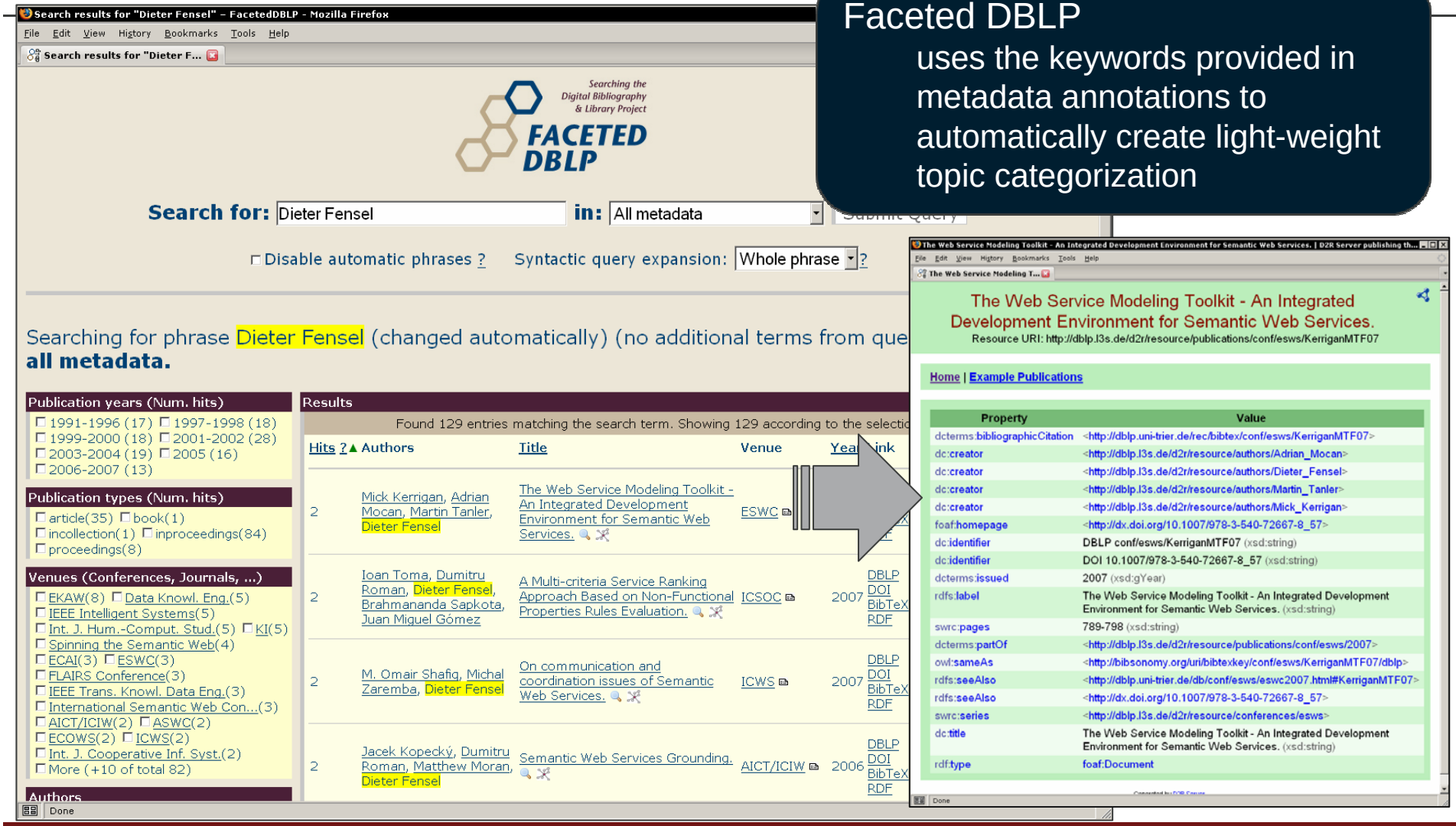
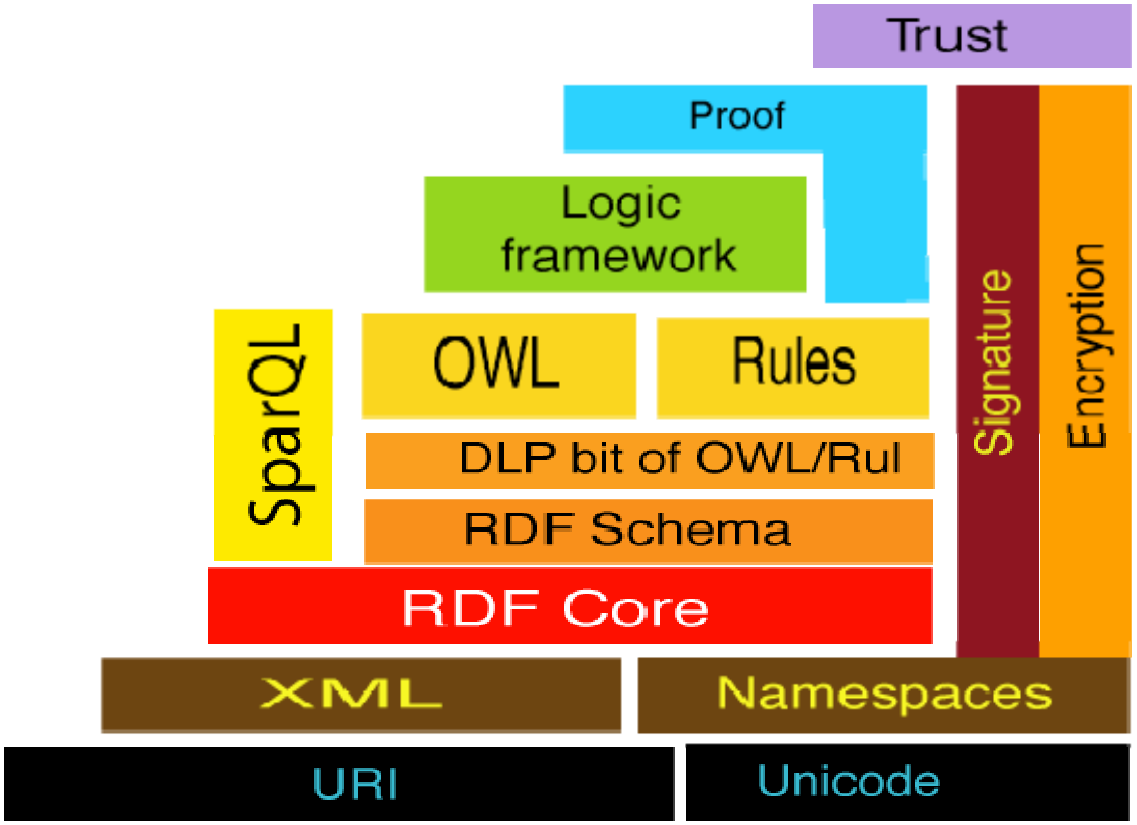
Faceted DBLP
- uses the keywords provided in metadata annotations to automatically create light-weight topic categorization



Semantic Web - Data



SEMANTIC WEB - Processes

Semantic Web - Processes

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- Building Web 2.0, B2B or EAI applications involves huge amounts of human effort
  - Construction of services
  - Generating new information from existing data sources
  - Integrating data and processes between applications within or between enterprises

- Web services and Service Oriented Architectures provide a means to decouple requester and provider. But huge amounts of human effort is required in making these services collaborate and enabling interoperability between them

Semantic Web - Processes

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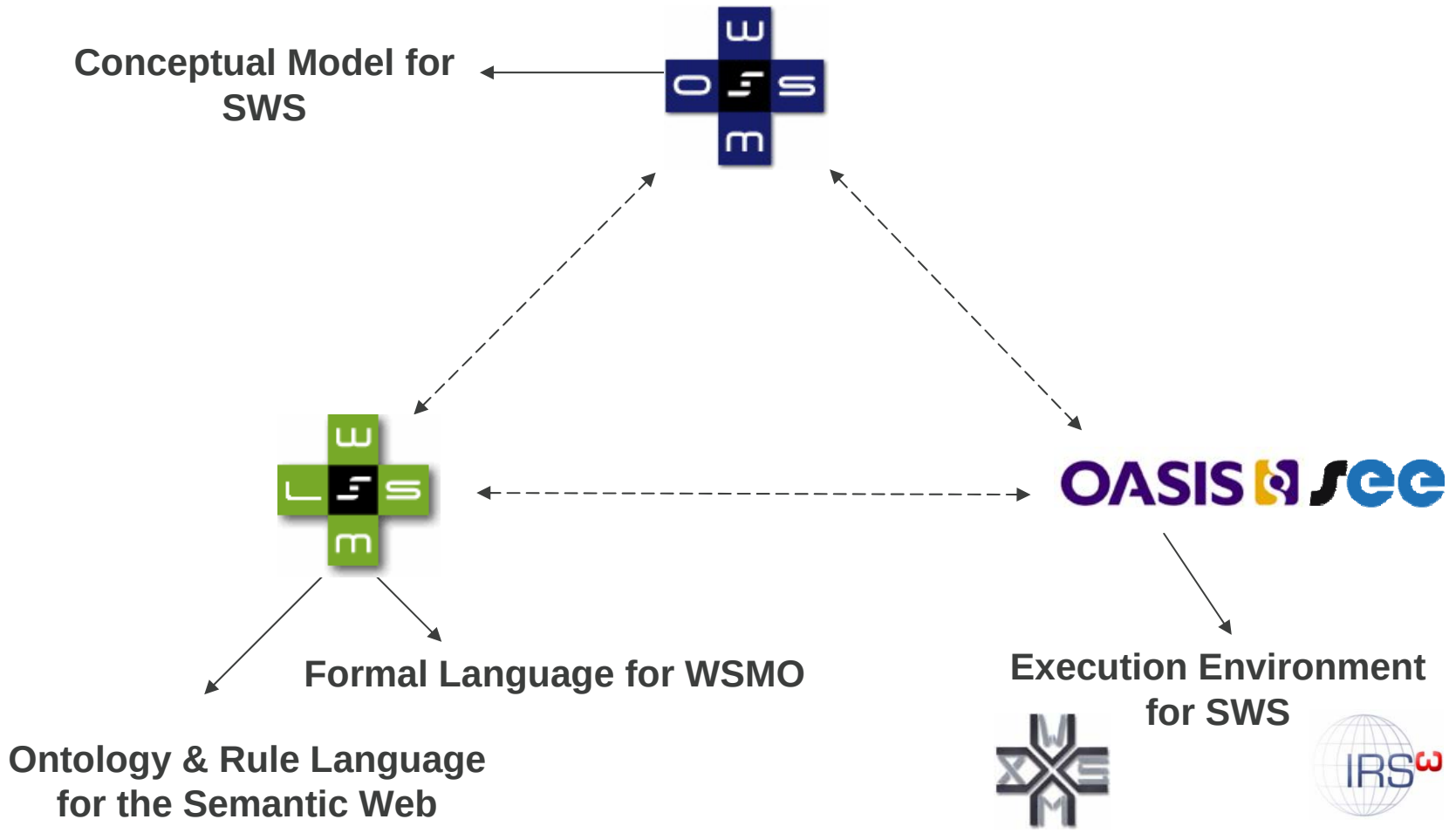
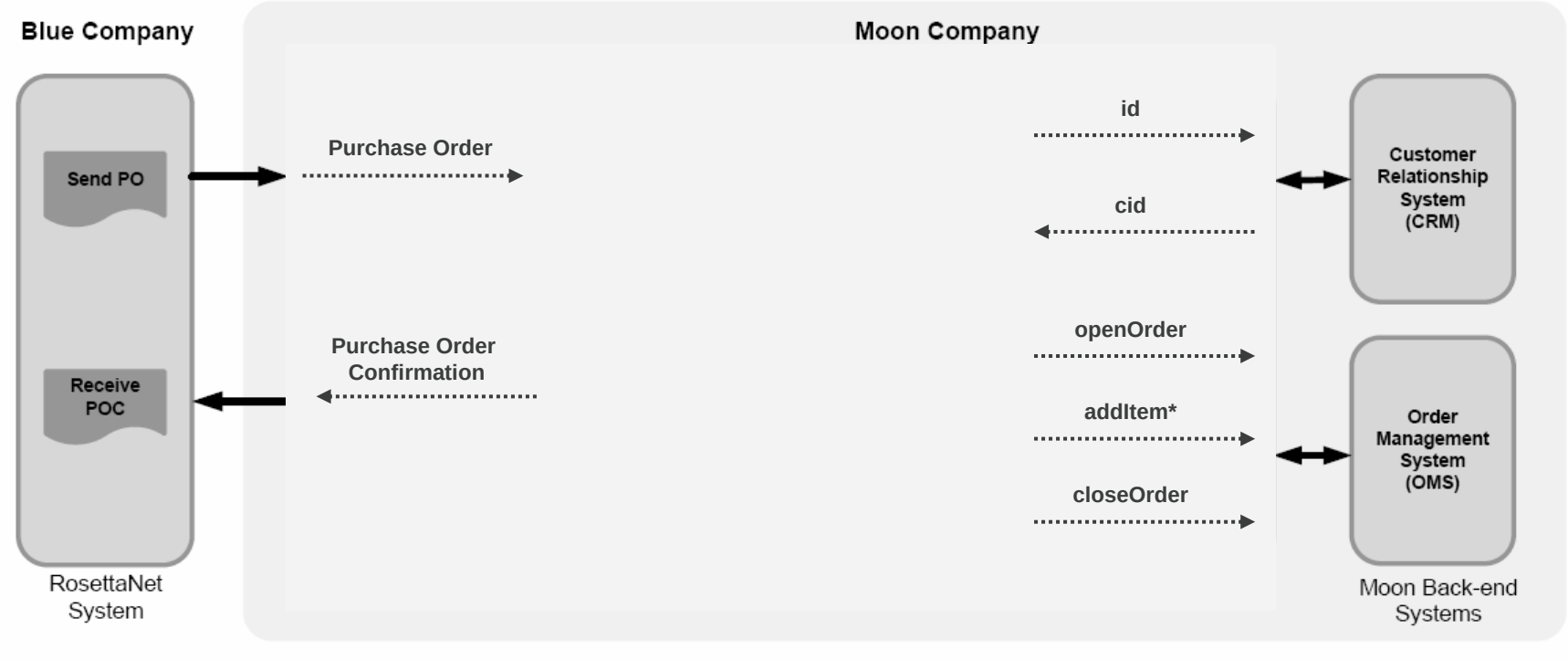
- The addition of semantics to form Semantic Web Services and Semantically Enabled Service-oriented Architectures can enable the automation of many of these currently human intensive tasks
  - Service Discovery, Adaptation, Ranking, Mediation, Invocation

- Frameworks:
  - **SAWSDL (WSDL-S):** Semantic annotation of WSDL descriptions
  - **WSMO:** Ontologies, Goals, Web Services, Mediators
  - **OWL-S:** WS Description Ontology (Profile, Service Model, Grounding)
  - **SWSF:** Process-based Description Model & Language for WS

Semantic Web - Processes



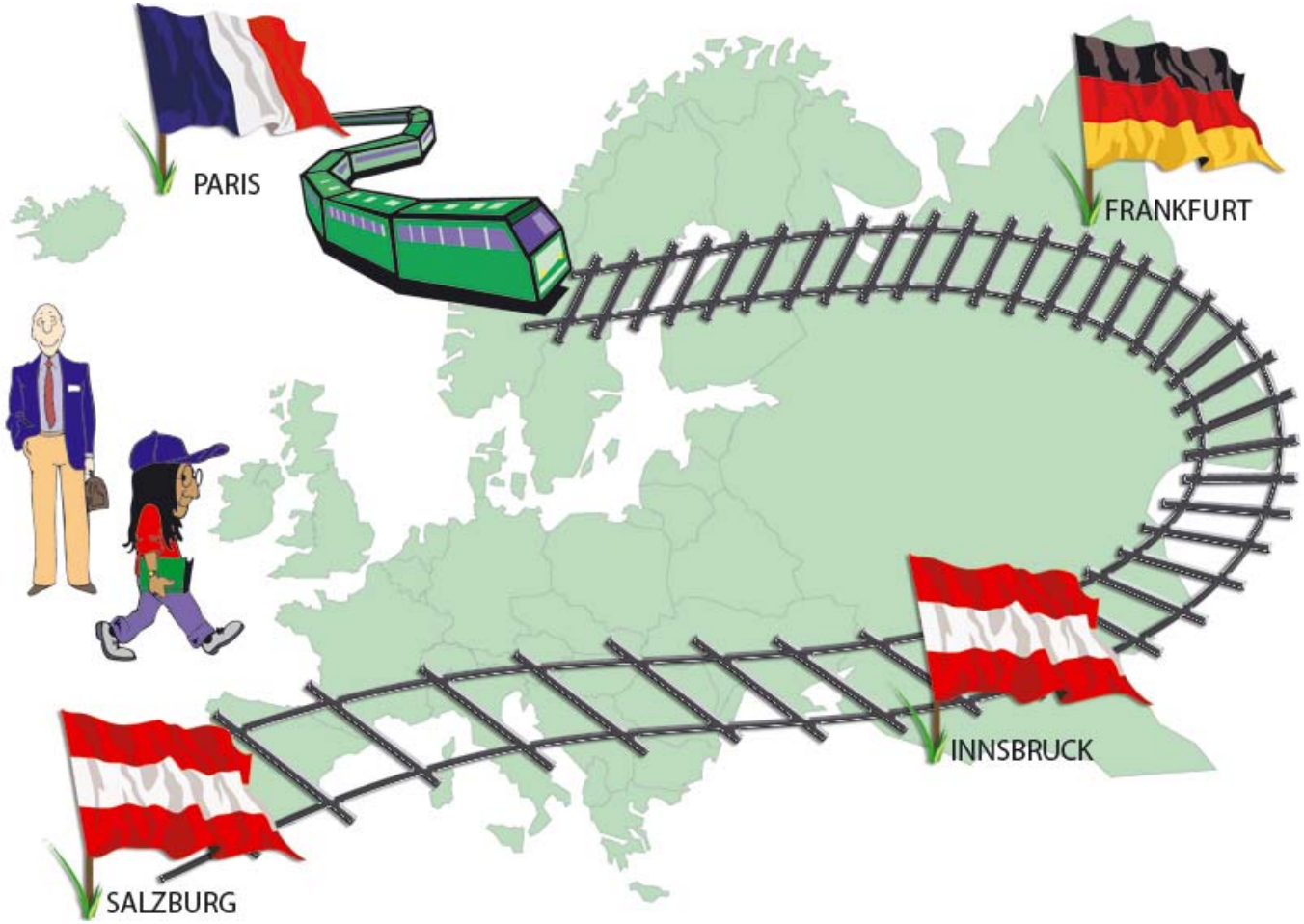
Semantic Web - Processes



- **Blue** company has discovered **Moon** company on the Web
- **Blue** company wishes to communicate with **Moon** company

- Broker required to resolve data and process interoperability issues

Semantic Web - Processes



Semantic Web - Processes

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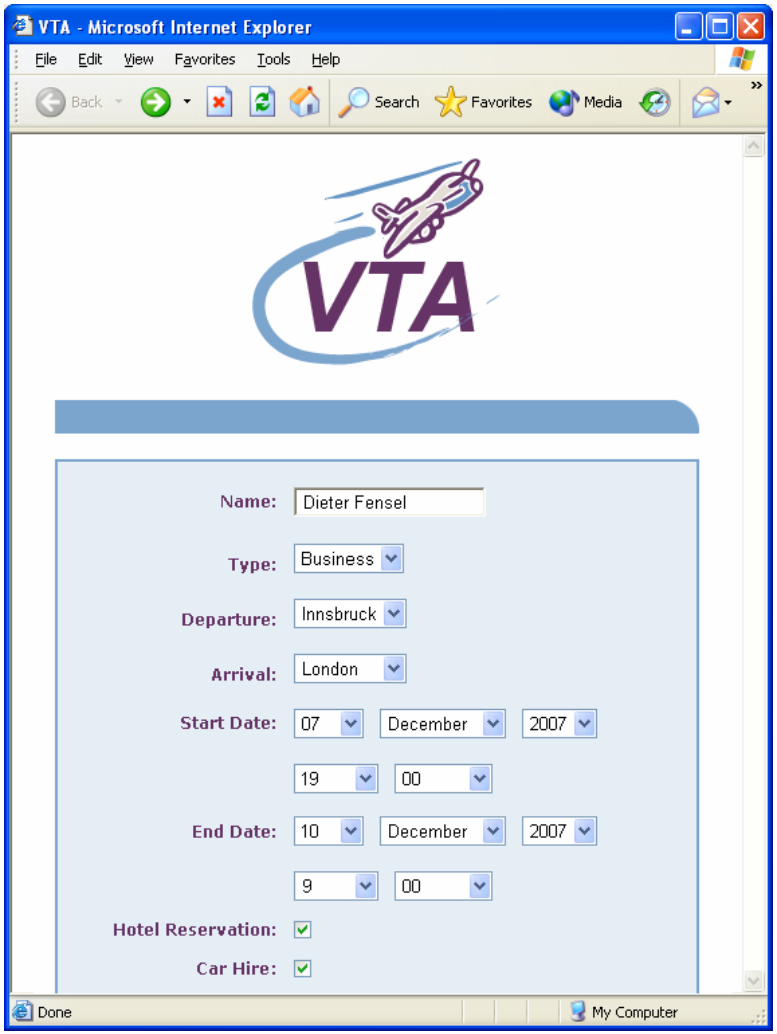
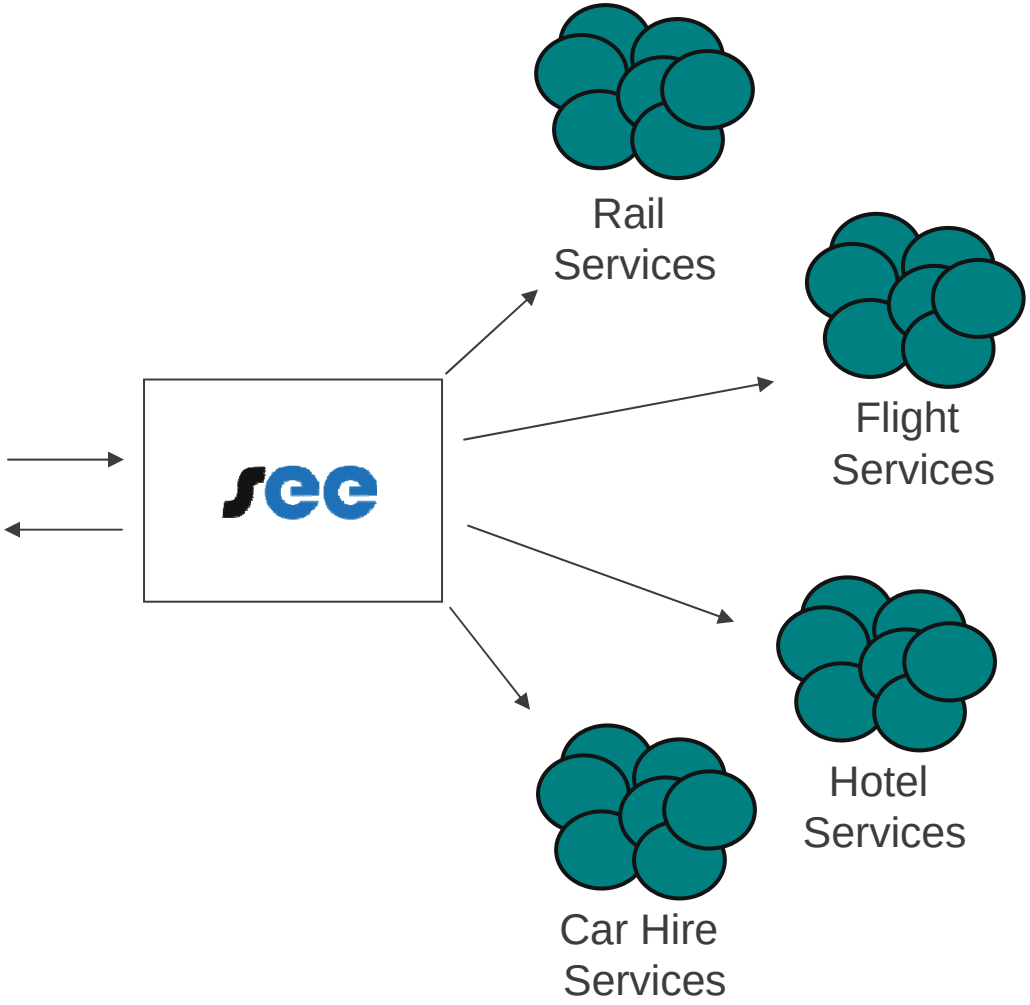
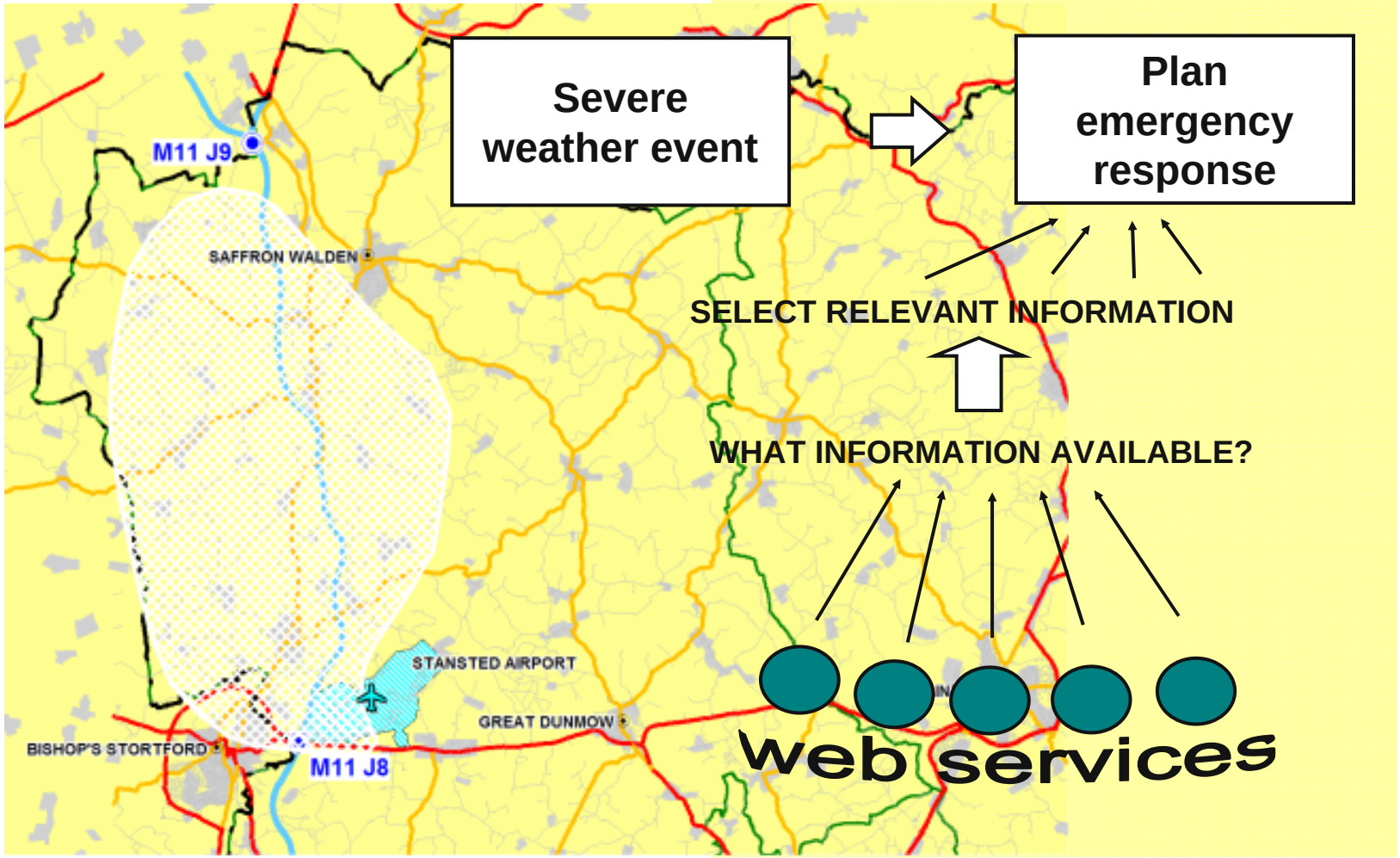




MK3 From Dieter: slide 30-33 need a bit more explanations.
Mick Kerrigan, 2007-10-26

Semantic Web - Processes



John Domingue: Semantic Web Services – Application Areas, Asian Autumn School on Semantic Web (AASSW07)

MK4 From Dieter: slide 30-33 need a bit more explanations.
Mick Kerrigan, 2007-10-26

Semantic Web - Processes

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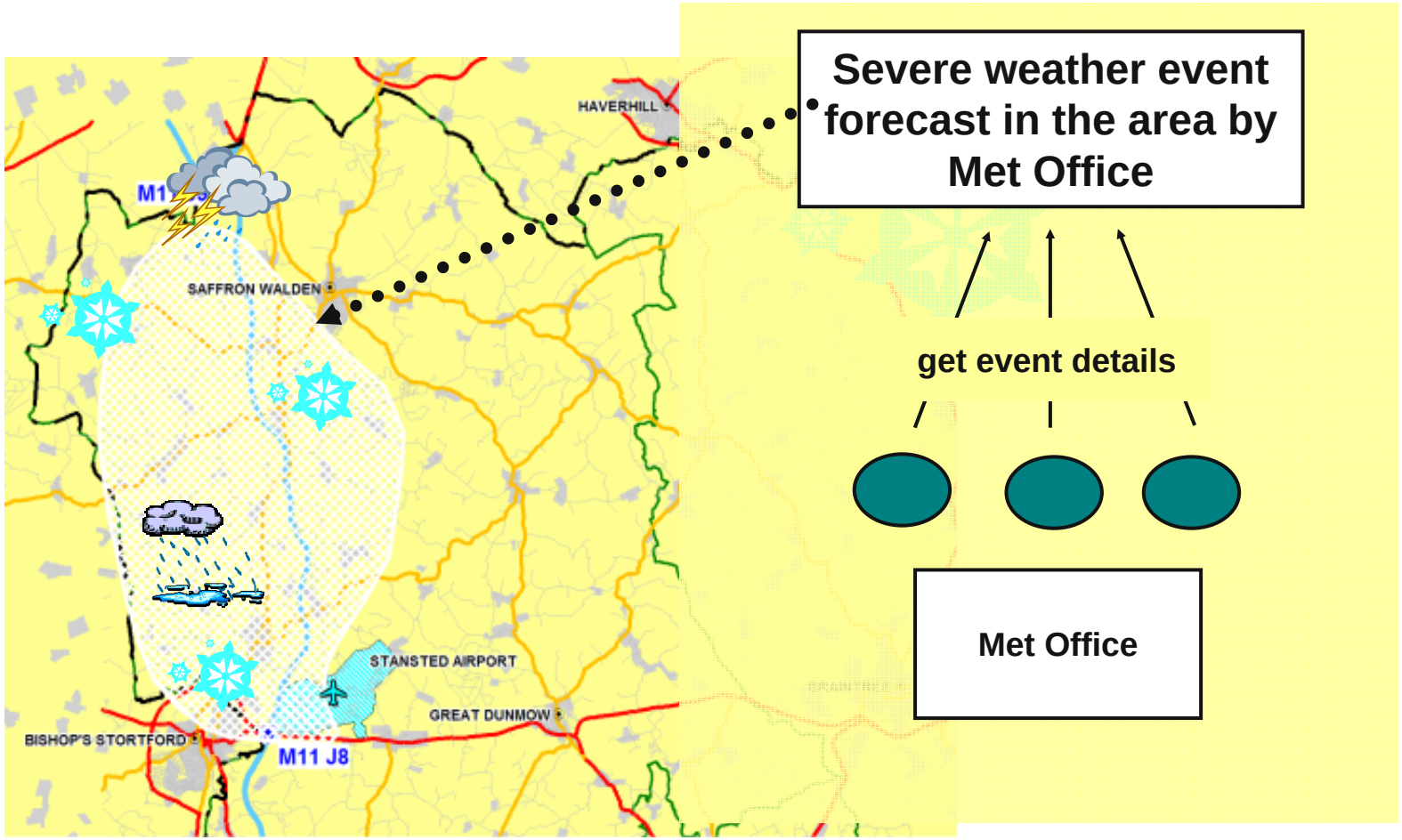

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MK5 From Dieter: slide 30-33 need a bit more explanations.
Mick Kerrigan, 2007-10-26

Semantic Web - Processes

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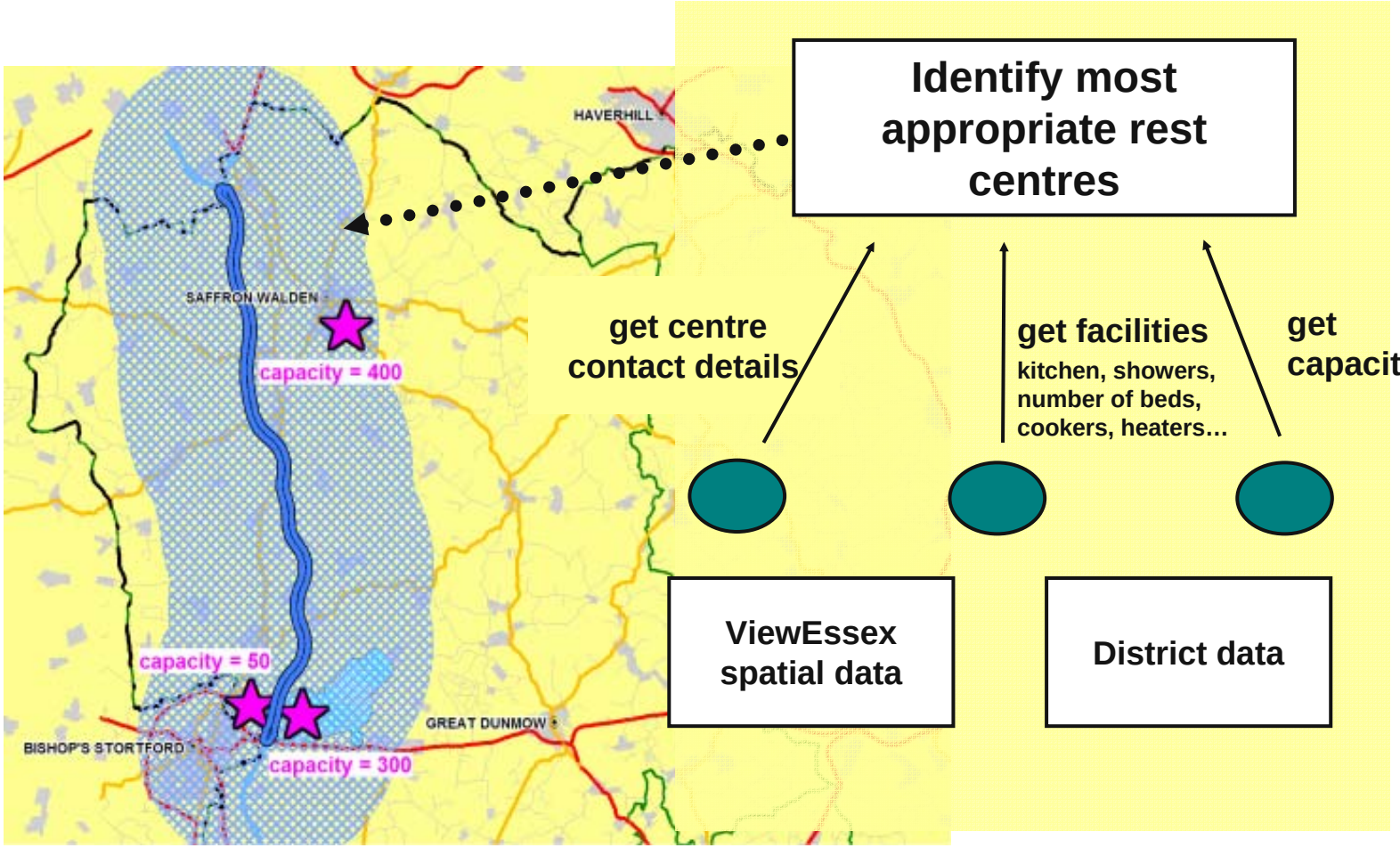

John Domingue: Semantic Web Services – Application Areas, Asian Autumn School on Semantic Web (AASSW07)

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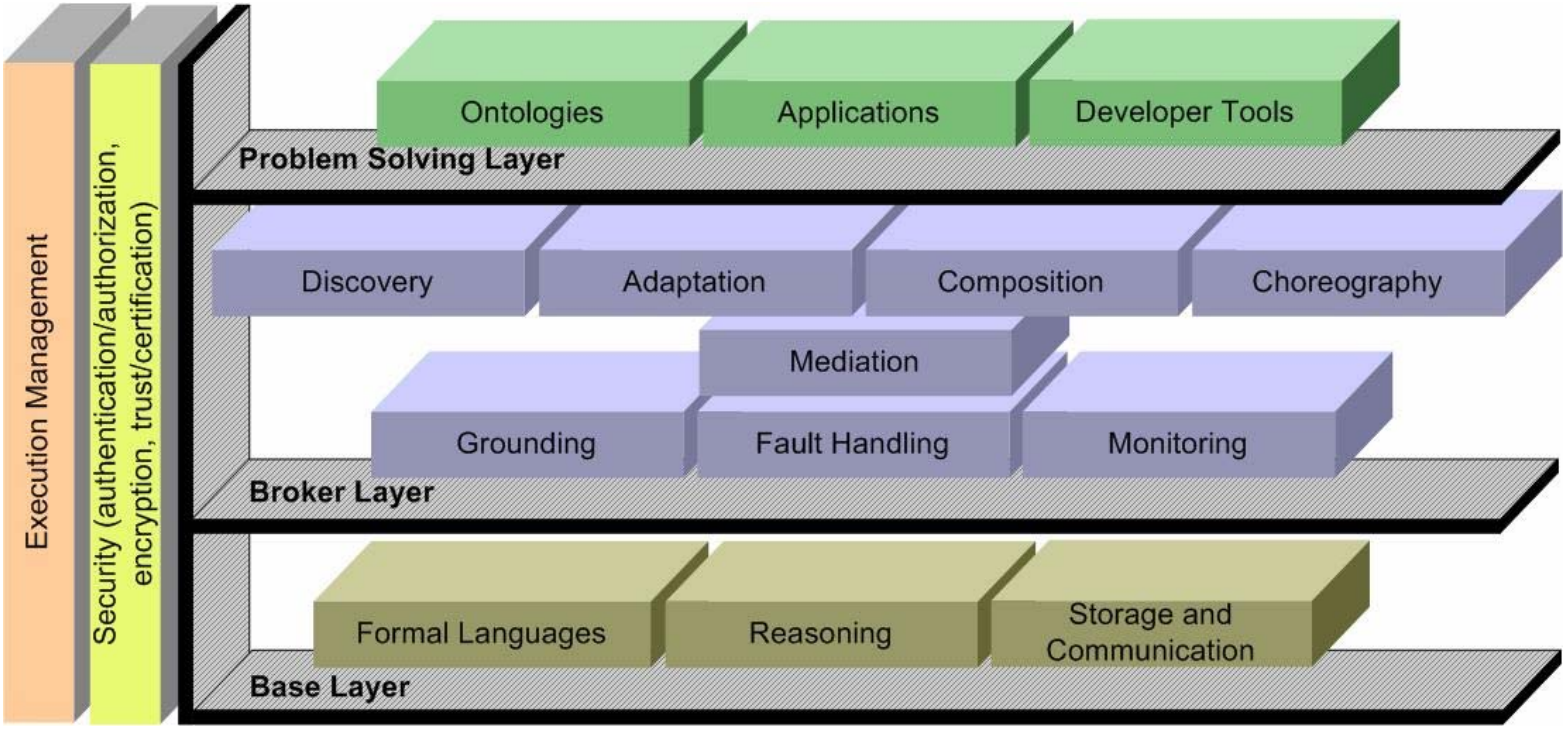
Mick Kerrigan, 2007-10-26

Semantic Web - Processes



BOUNDARIES OF SEMANTICS

Boundaries of Semantics

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- The principal limits of describing large, heterogeneous, and distributed systems
- The principal limits of self representation and self reflection

-> Necessarily incompleteness and incorrectness of semantic descriptions.

Boundaries of Semantics

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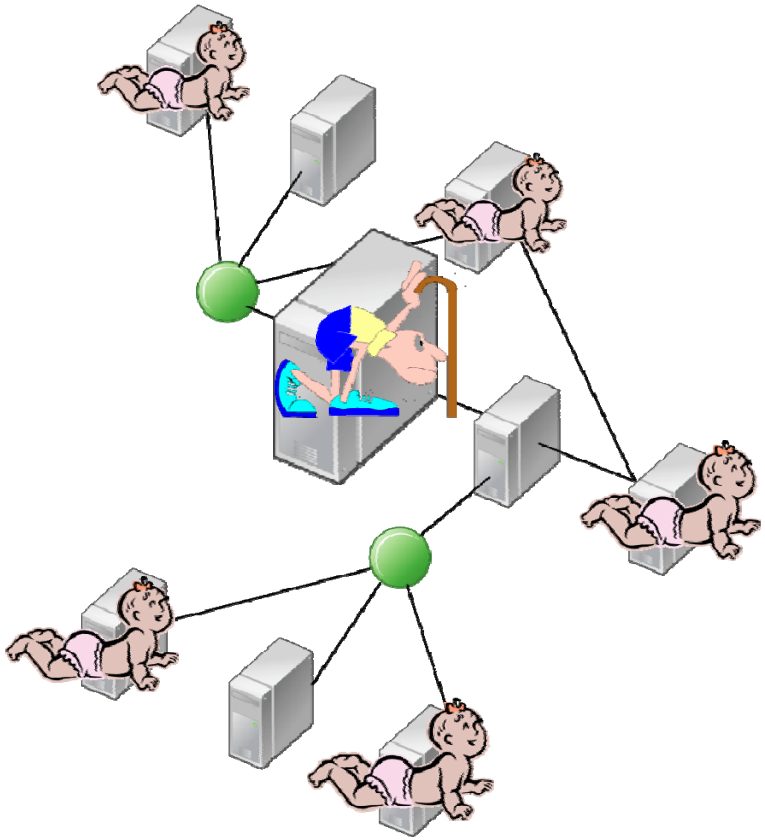
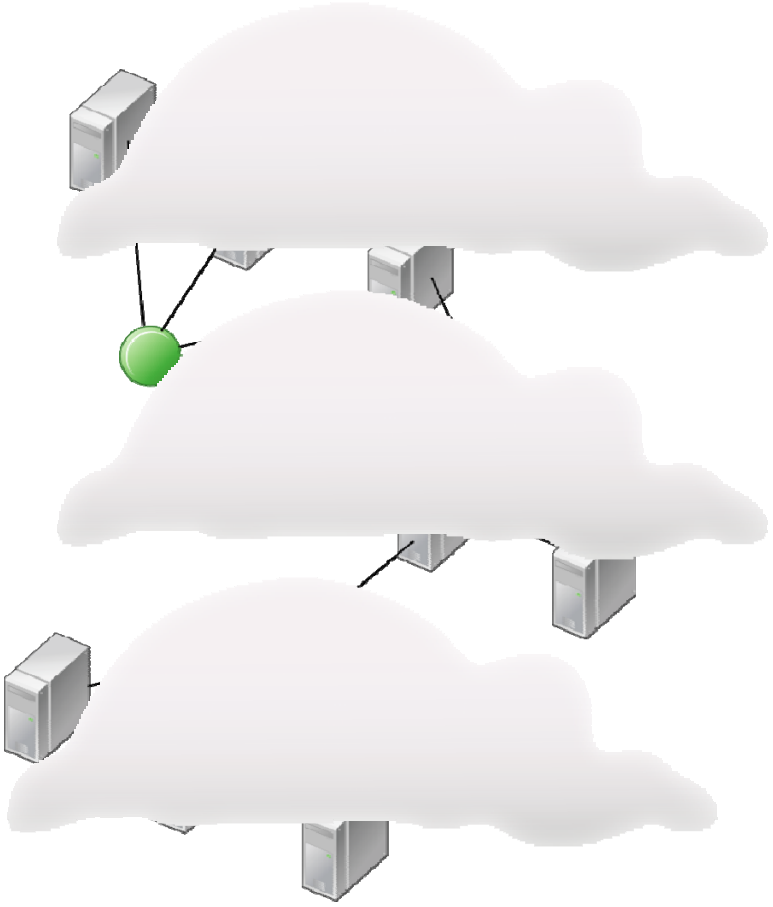
The principal limits of describing large, heterogeneous, and distributed systems





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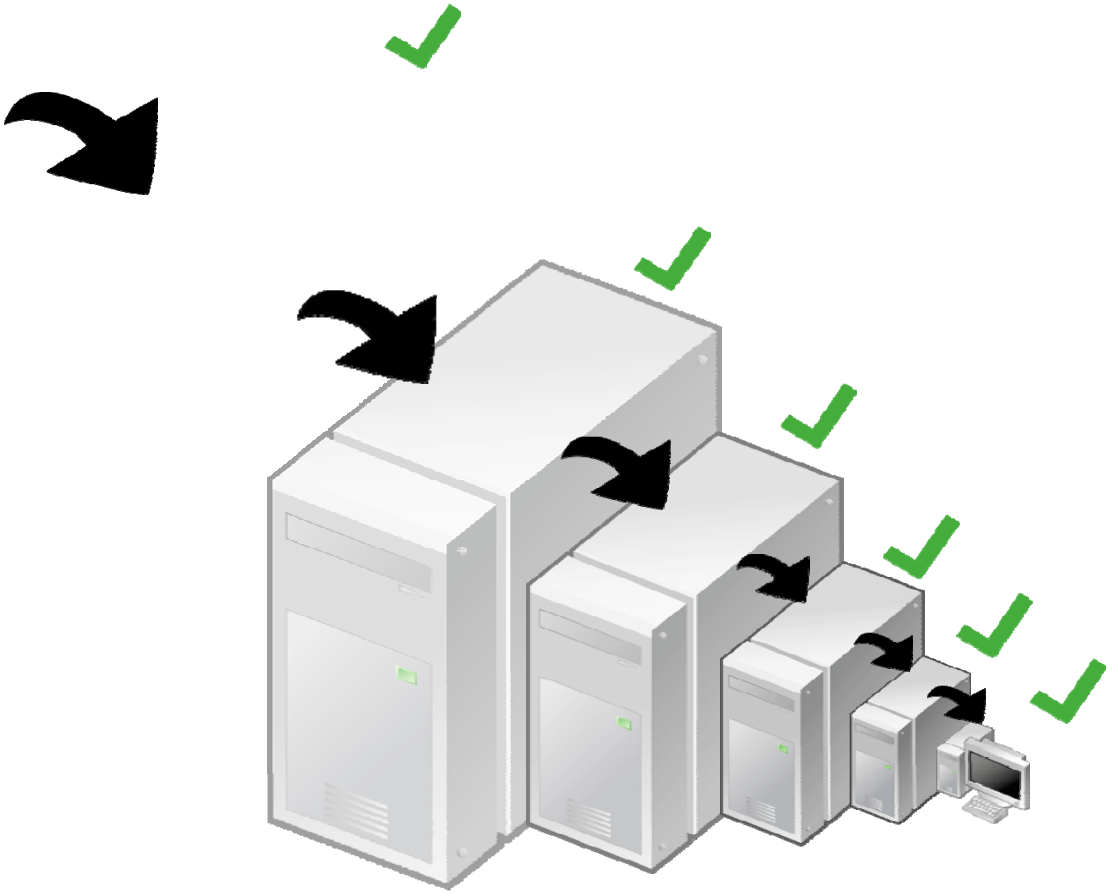
The principal limits of self representation and self reflection



Boundaries of Semantics

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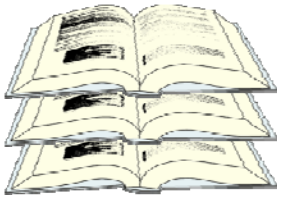
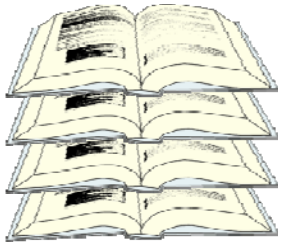
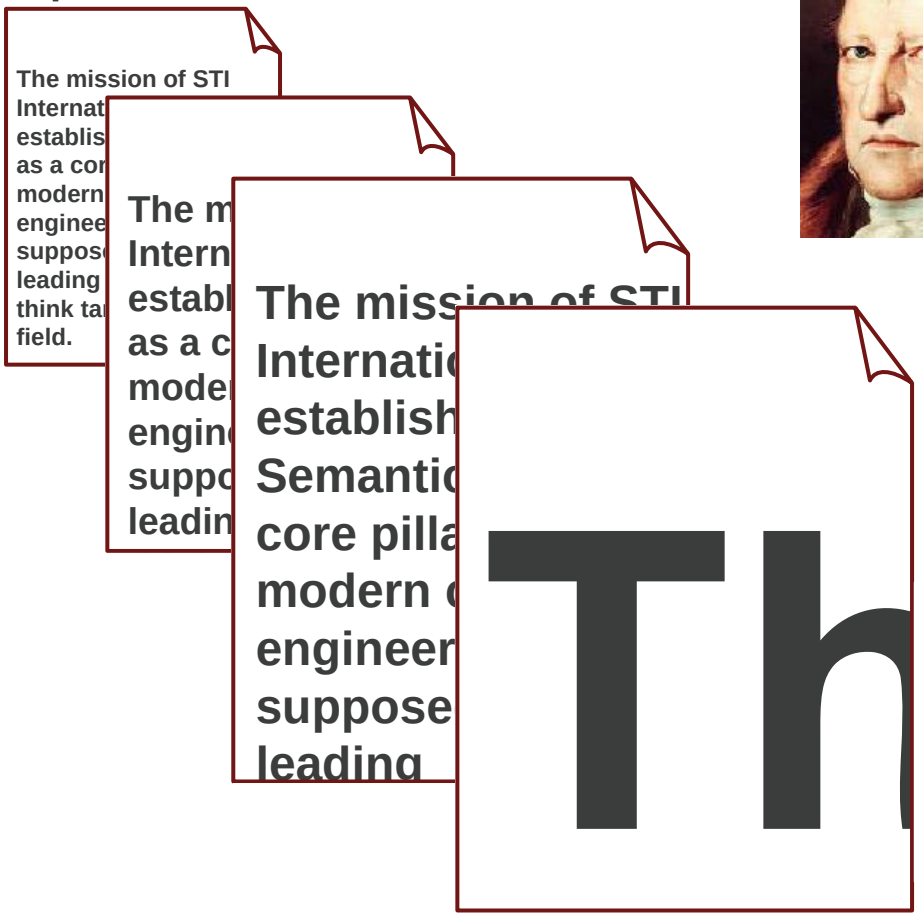
The principal limits of self representation and self reflection







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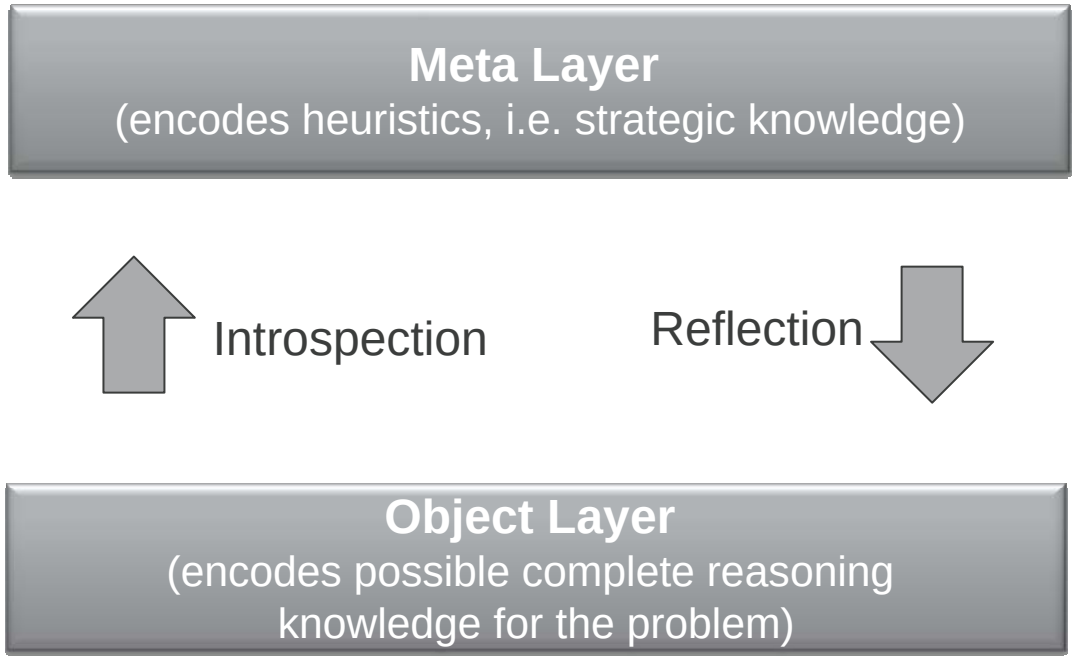
The principal limits of self representation and self reflection



Boundaries of Semantics

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- The meta layer should apply ***heuristics*** that may help
  - Speed up the overall reasoning process.
  - Increase its flexibility.
- Therefore, it needs to be incomplete in various aspects and resemble important aspects of our consciousness.
  - Introspection
  - Reflection
- Unbounded rationality, constrained rationality, limited rationality.

Boundaries of Semantics

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- Description of data by metadata or programs by metaprograms
  - Always larger …
  - … or always an approximation
  - In order to thoroughly describe a computer we need an even larger computer
  - *This is then a recurrent problem*

Data look-up on the Web

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- In a large, distributed, and heterogeneous environment, classical ACID guarantees of the database world no longer scale in any sense.
- Even a simple read operation in an environment such as the Web, a peer-to-peer storage network, a set of distributed repositories, or a space, cannot guarantee completeness in the sense of assuming that if data was not returned, then it was not there.
- Similarly, a write can also not guarantee a consistent state that it is immediately replicated to all the storage facilities at once.

Information retrieval on the Web

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- Modern information retrieval applies the same principles
  - In information retrieval, the notion of completeness (recall) becomes more and more meaningless in the context of Web scale information infrastructures.
  - It is very unlikely a user requests all the information relevant to a certain topic and existing on a worldwide scale on a certain topic since this may easily go far beyond the amount of information processing he or she is investing in achieving a certain goal.
  - Therefore, instead of investigating the full space of precision and recall, information retrieval is starting to focus more around improving precision and proper ranking of results.

Reasoning on the Web

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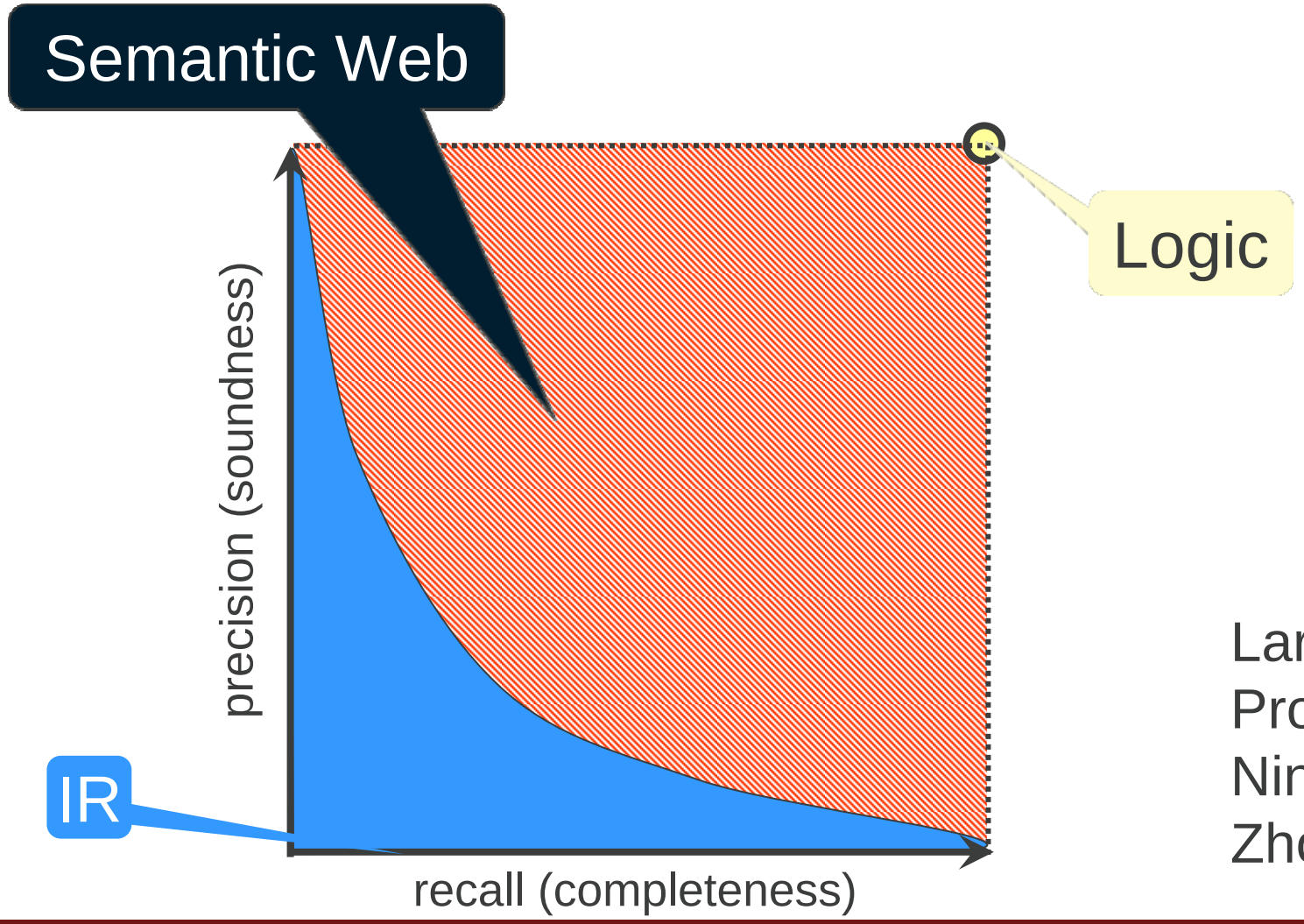
- What holds for simple data look-up holds in an even stronger sense for reasoning on Web scale.
- The notion of 100% completeness and correctness as usually assumed in logic-based reasoning does not even make sense anymore since the underlying fact base is changing faster than any reasoning process can process it.
- Therefore, we have to develop a notion of usability of inferred results and relate them with the resources that are requested for it.

Reasoning on the Web



LarKc – Prof. Ning Zhong

Web Service discovery

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- In a world of billions of services it may significantly cost too much to find the “optimal” service in relation to the gain of having actually found the optimal solution.
- Pragmatic approaches in service discovery will focus on utility, i.e., stop the search process when a service is found that is “good” enough to fulfill a request.
- Also, it is unrealistic to assume that semantic descriptions of services are correct and complete, i.e., duplicate the functionality of a service at the description level.

COMPUTER SCIENCE IN THE 21ST CENTURY

- With the Web we have an open, heterogeneous, distributed, and fast changing computing environment.

- Therefore we need computing understood as
  - A **goal driven approach** where the solution process is only partially determined and actually decided during runtime, based on available data and services.
  - A **heuristic approach** that gives up on absolute notion of completeness and correctness in order to gain scalability.

- The times of 100% complete and correct solutions are gone.

The Need for Trade-offs:

- In all areas one has to define the tradeoff between the guarantees one provides in terms of
  - service level agreements - completeness and correctness are just examples for some very strong guarantees - and
  - what this requires in terms of assumptions, *and*
  - computational complexity

- Different heuristic problem solving approaches are just different combinations of these three factors.

- Service level agreements (or goals) define what has to be provided as result of problem solving.

- Do we request an optimal solution, a semi-optimal solution, or just any solution?

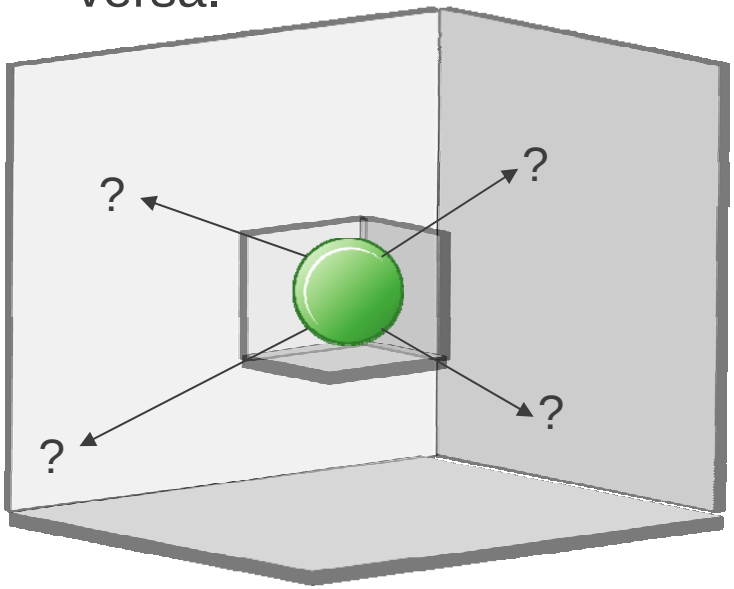
- Assumptions describe the generality of the problem solving approach.
  - Assuming that there is only one solution allows stopping the search for an optimum immediately after a solution has been found.
  - Instead of a global optimization method, a much simpler heuristic search method can be used in this case, which would still deliver a global optimum.

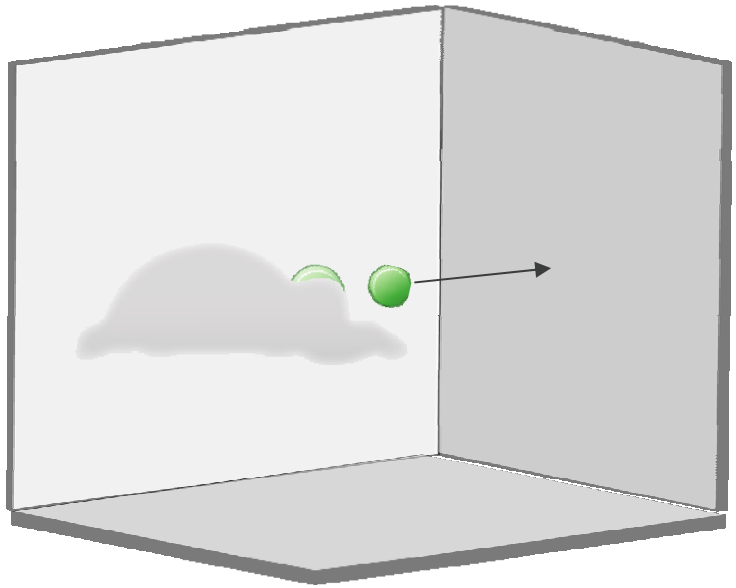
- Computational complexity (scalability) or the resources that are required to fill the gap between the assumptions and the goals.

- Computer science in the 20th century was about perfect solutions in closed domains and applications.

- Computer science in the 21st century will be about approximate solutions and frameworks that capture the relationships of partial solutions and requirements in terms of computational costs, i.e., the proper balance of their ratio.

- This shift is comparable to the transition in physics, from classical physics to relativity theory and quantum mechanics,
- ...where the notion of absolute space and time is replaced by relativistic notions and the principle limits of precision.
- the more precise we know about the location of a particle in space, the less we know about its movement in time and vice versa.





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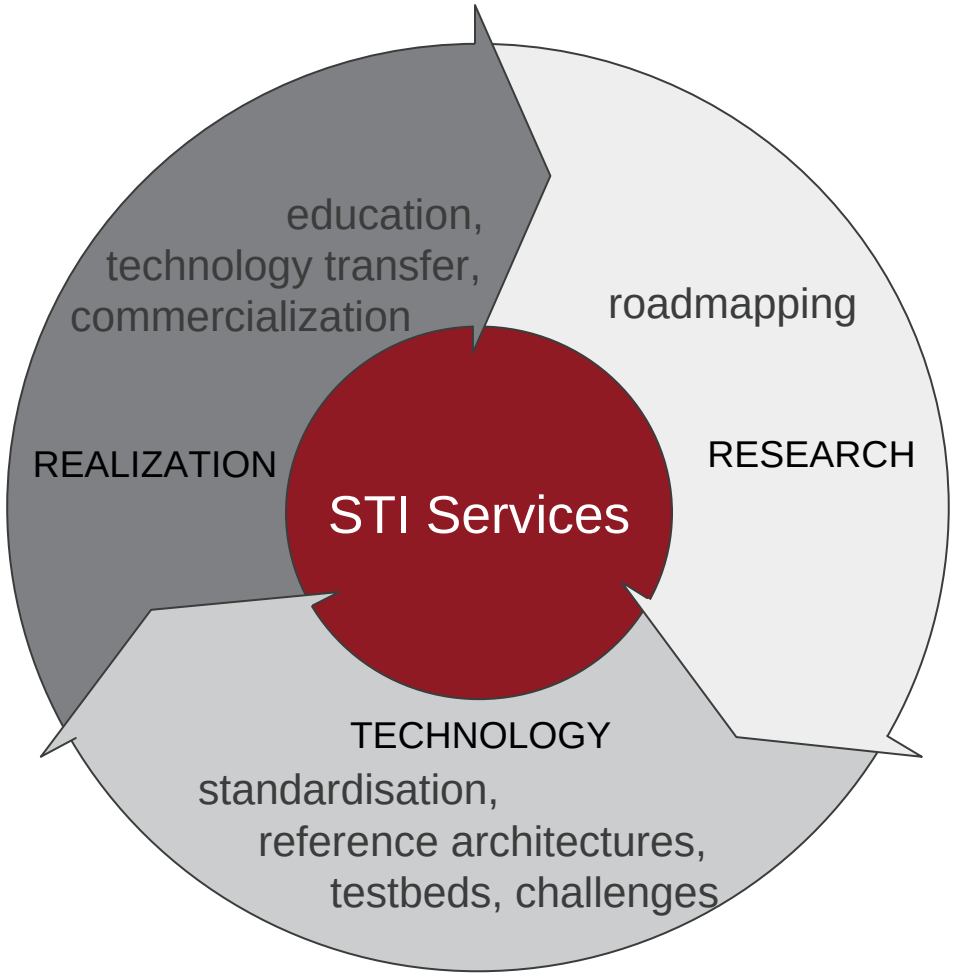
Service Ware
Service Web
Semantic Web
Boundaries of semantics
Computer science in the 21st century

Semantic Technology Institute International

Making this real…STI International

- The mission of Semantic Technology Institute International is to establish semantics as a core pillar of modern computer science.
- STI is organized as an association of jointly interested academic, industrial and governmental parties.
- It provides services to facilitate research, education, and commercialization activities around semantic technologies and the service web beyond the boundaries of individual projects or initiatives.

STI – The Services



STI Research - Roadmapping

- STI International will create, maintain, and publish roadmaps as a means of planning and coordinating its activities towards the achievement of the mission.
- The service will focus on the five main areas of research in the field of semantic systems and services:
  - Ontologies and Ontology Engineering
  - Reasoning
  - Knowledge Acquisition and Sharing
  - Semantic Web Services
  - Social Networks.

Prof. Dr. Fabio Ciravegna
University of Sheffield, UK
Service Coordinator

STI Technology – Standardization and Reference Architectures

STI · INTERNATIONAL

- STI International will provide services to academic and industrial communities interested in the Semantic Web focusing on standardization activities and the creation of reference architectures which could support the Semantic Web.

- We aim at
  - Establishing a communication channel with W3C, OASIS and OMG
  - Facilitating communication across the various projects and initiatives
  - Gaining leverage and impact by combining efforts
  - Providing relevant know-how.

Dr. John Domingue
The Open University, UK
Service Coordinator

Dr. Michal Zaremba
University of Innsbruck, AT
Service Coordinator

STI Technology – Testbeds and Challenges

- STI International will facilitate the shared development of open, globally distributed testbeds for developing, deploying and testing Semantic Web technologies and Semantic Web Services at global scale.

- Challenge services will offer participants the chance to show the best of the Semantic Web and Semantic Web Services technologies in execution to identify promising approaches and to support relevant developments.

Dr. Emanuele Della Valle
CEFRIEL, Politecnico di Milano, I
Service Coordinator

Prof- Dr. Asunción Gómez-Pérez
Universidad Politécnica de Madrid, E
Service Coordinator

STI Realization – Commercialization

- STI International will facilitate the commercial exploitation of R&D results with the aim of increasing business opportunities.
- STI International performs, among others, the following activities for its members:
  - Knowledge Capitalization Structure
  - Market surveillance
  - Comprehensive offer building for proving the interest of SWS and Semantic Web in general
  - International position strategy
  - Diffusion by consolidation of dissemination plans and activities

Dr. Antonio Campos
CTIC Foundation, ES
Service Coordinator

STI Realization – Education

- STI International will provide educational activities in the field of semantics and semantic technologies for academia and industry.

- The STI educational program includes:
  - Generation of high-quality training materials for specific target communities
  - Development and maintenance of training repositories and expert databases
  - Organization of different types of training and educational events
  - Provision of different types of training
  - Set-up of joint doctoral or exchange/internship programs between research institutions and between researchers and industry and operational support for their implementation.

Dr. Elena Simperl
University of Innsbruck, AT
Service Coordinator

STI – The Executive Board

STI · INTERNATIONAL

Dr. Michael Brodie
Chair Advisory Board

Dr. John Davies
Vice President Realization

Univ.-Prof. Dr. Dieter Fensel
President

Prof. Dr. Fausto Giunchiglia
Vice President Internationalization

Prof. Dr. Guus Schreiber
Vice President Technology

Prof. Dr. Rudi Studer
Vice President Research

Alexander Wahler
CEO

Univ.-Prof. Hannes Werthner
Vice President Members

STI – The Members

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20 members
October 2007

More at www.sti2.org

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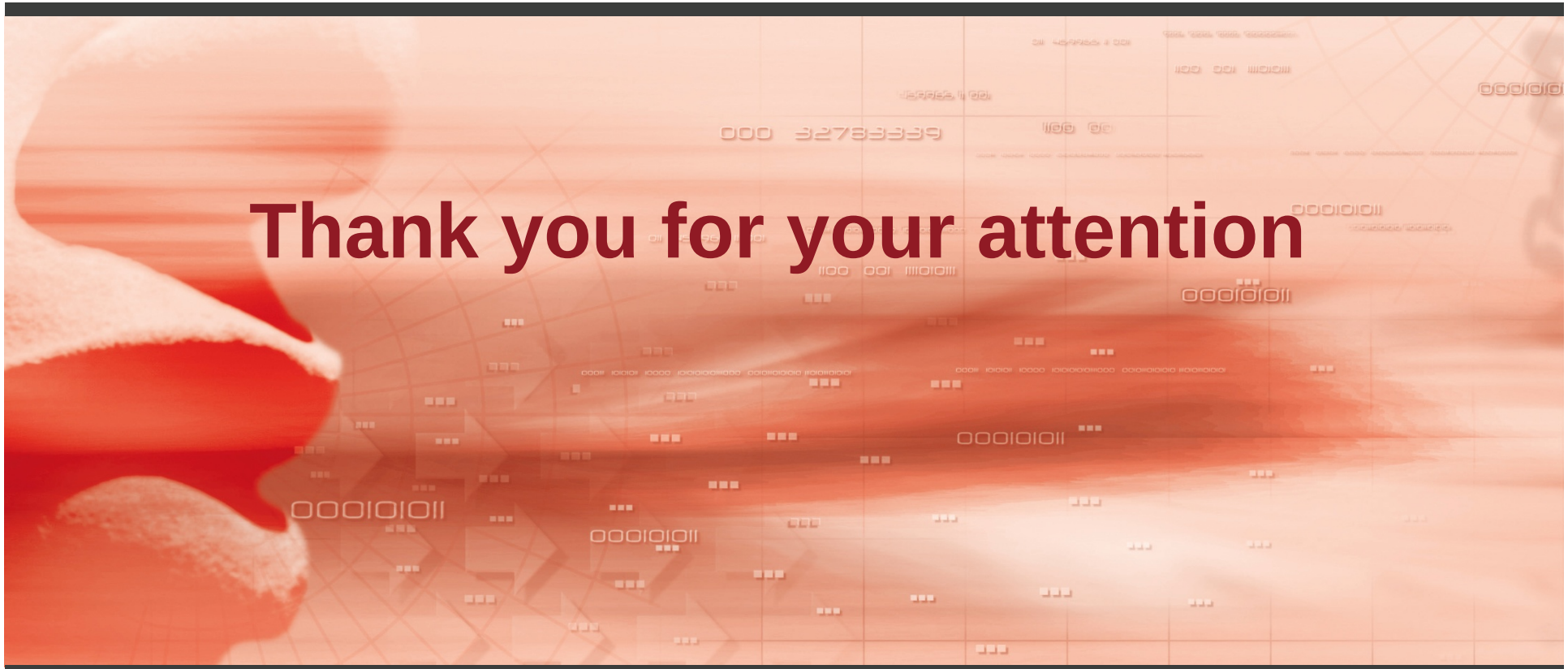

Thank you for your attention