Accessing Information and Services on the DAML-Enabled Web

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Outline

- What is DAML?
- Observations
  - Semantic Web Queries, Requests, Requirements
  - The Big Picture (Web architecture and evolution)
- Work-in-progress at SRI (and elsewhere)
  - Theories & inference on the Semantic Web
  - DAML-S: DAML for Services
    - Coming soon!

What is DAML?

- A DARPA program
- An input to the W3C Semantic Web activity
  - Will likely be proposed as the draft of a working group recommendation
- A markup language

www.daml.org

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Characteristics of DAML

- Based on XML & RDF(S)
  - Beyond RDF: properties of properties, equivalence and disjointness of classes, more constraints, etc.
    Feature comparison: https://www.daml.org/language/features.html
  - Layered approach

    XML => RDF(S) => DAML+OIL => (DAML-L) => DAML-S
- Semantics for Web resources from Knowledge Representation concepts
  - DAML+OIL: can be regarded as a description logic
  - Ontologies
  - Logical rules & inference
- DAML-S: Extension to Services

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Queries, Requests, Requirements

"Find a reference to the latest paper on SHOE with James Hendler as a co-author."

- **All concepts identified unambiguously (by URIs)**
- **Ontologies potentially (likely) distributed**
- **Reasoning about time, etc.**
- **"Latest", etc.: no closed-world assumption**

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Queries, Requests, Requirements

"Find a reference to a paper having 2 authors, both of which have been PIs for a DARPA project."

- **Meta-data for a single response is (very likely) distributed**

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Queries, Requests, Requirements

"If Daniel Dennett has published a book about consciousness, request the Stanford Library to hold it for me."

- **Combine information queries with service requests**

Queries, Requests, Requirements

"Get me a flight to Washington DC, and reserve a room near the airport"

- **Composition of services**

Queries, Requests, Requirements

"Execute the refinancing of my mortgage, using the following parameters and providers: …"

- **Multiple participants in a single transaction**

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Requirements

- All concepts identified unambiguously (by URIs)
- Ontologies potentially (very likely) distributed
- Reasoning about time, etc.
- "Latest", etc.: no closed world assumption
- Data for a single response is (very likely) distributed
- Combines information plus service requests
- Composition of services
- Multiple participants in a single transaction

- **Ontology mappings needed**

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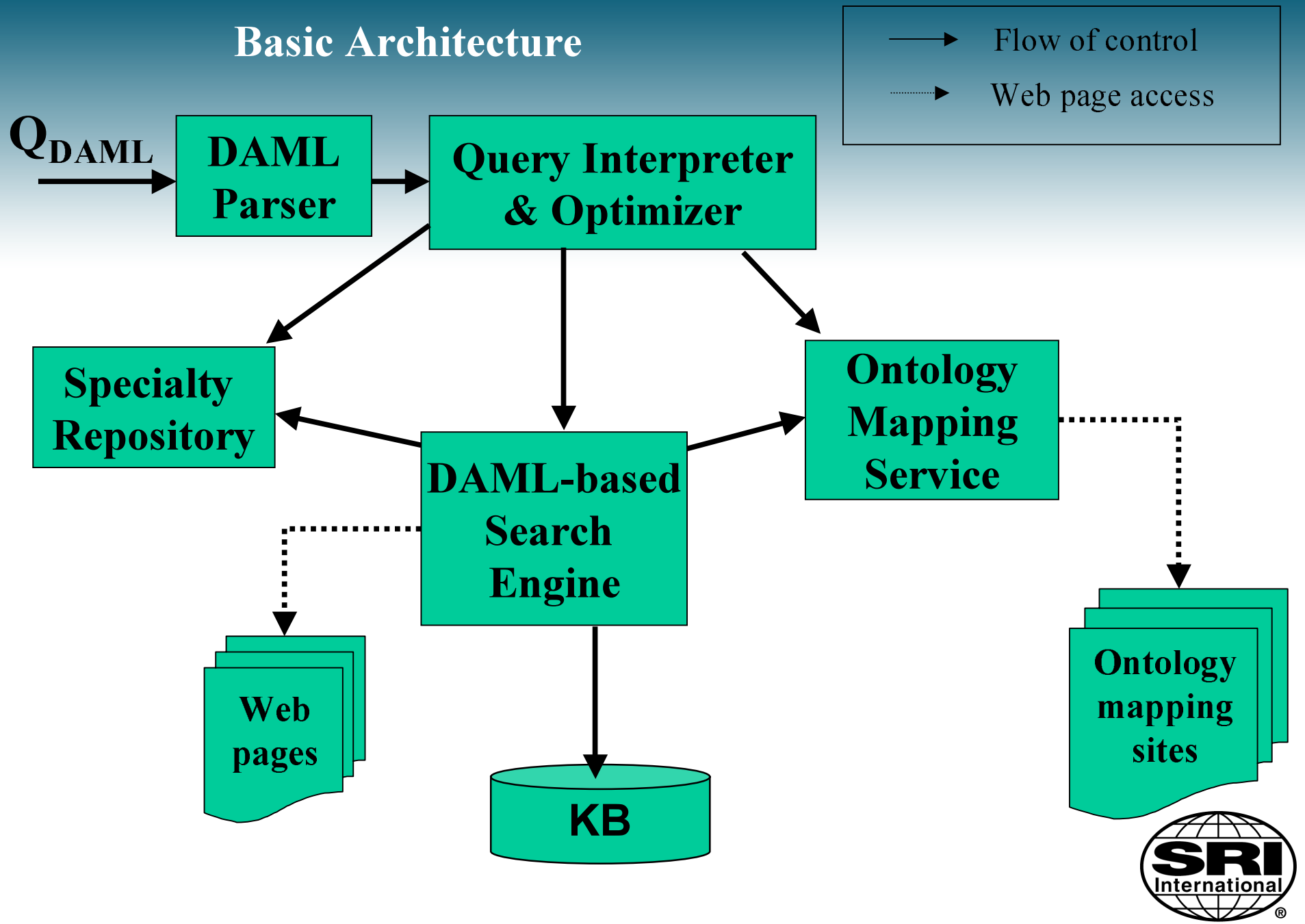
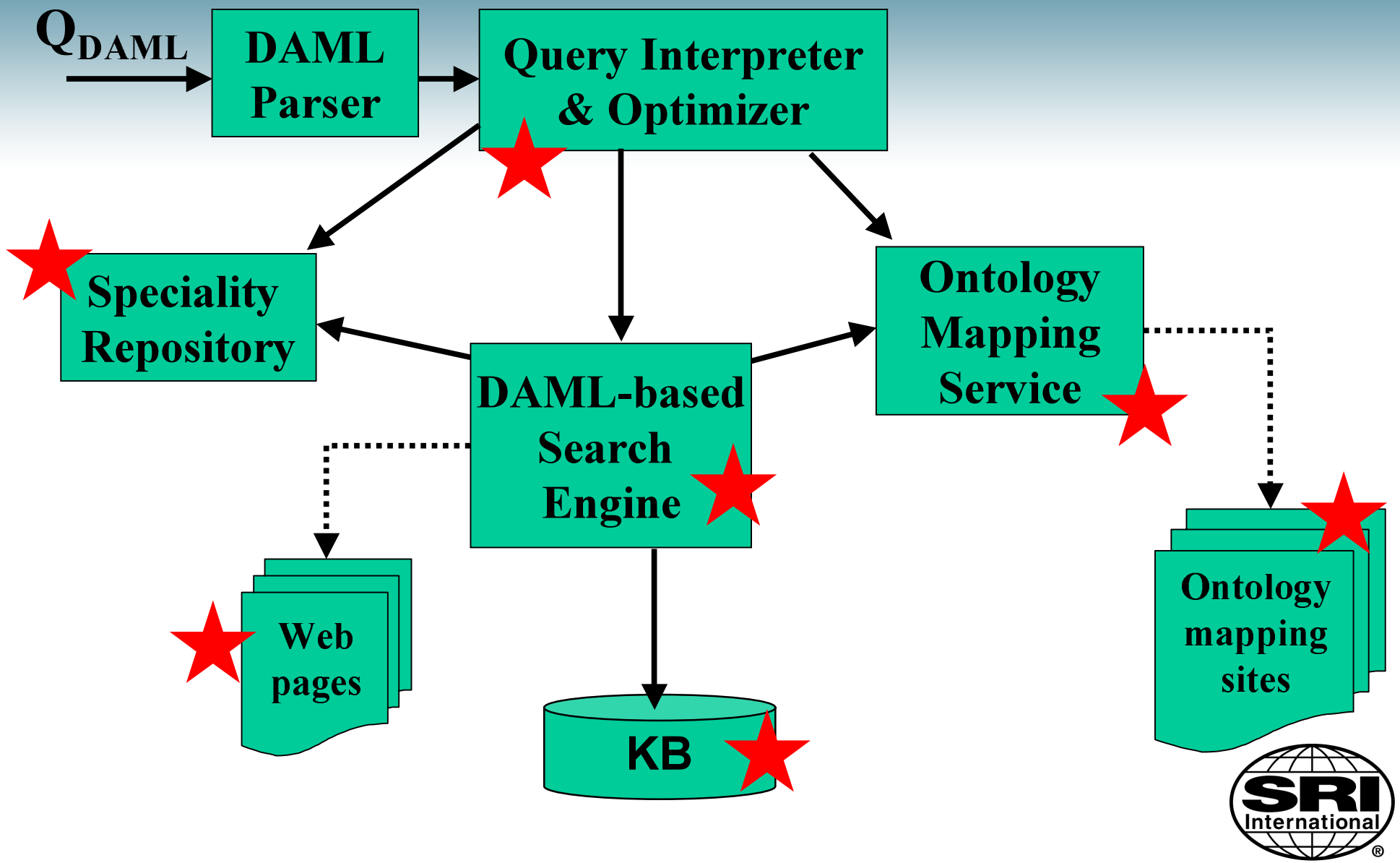
Basic Architecture



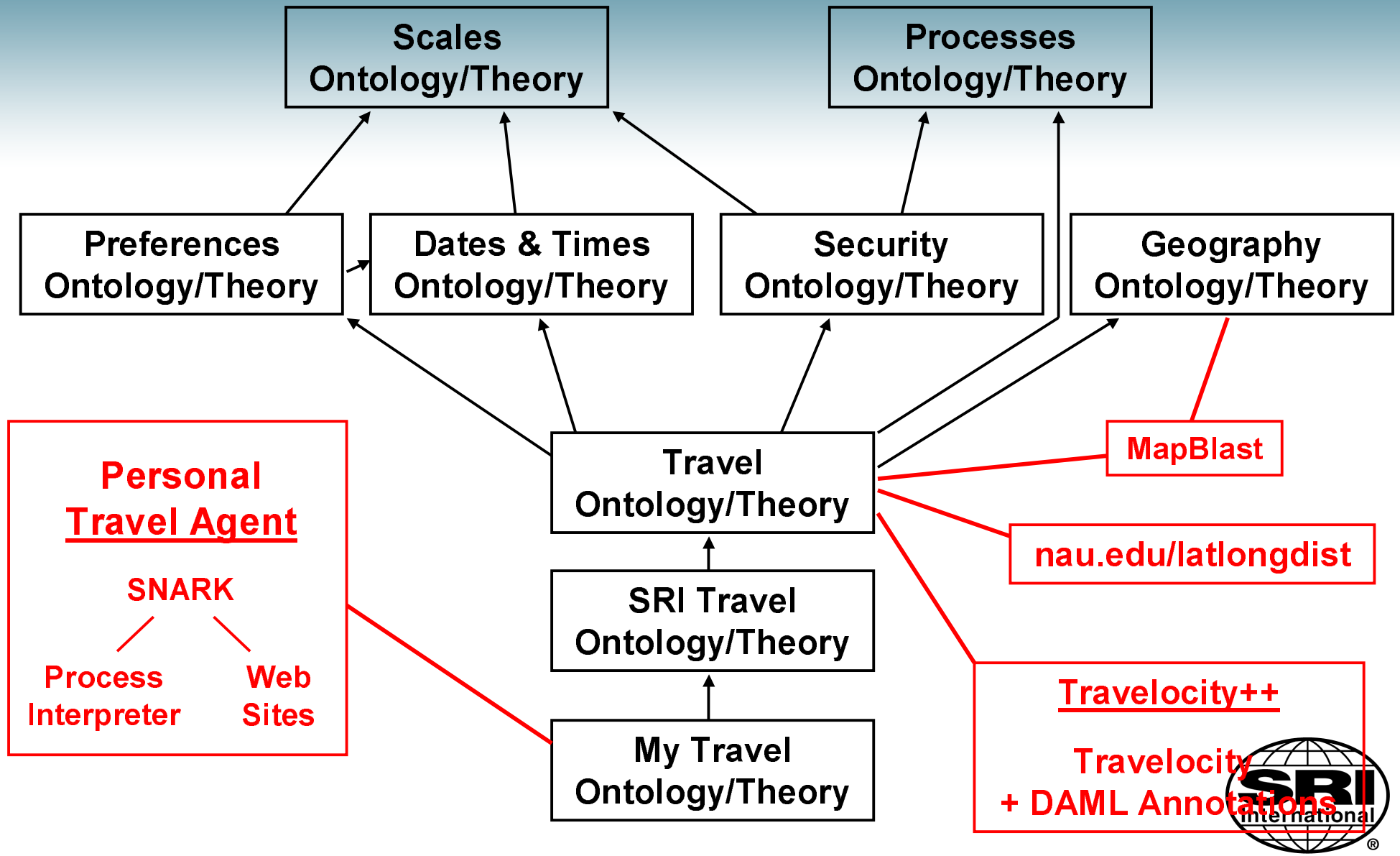
Where can logical rules & inference be used?



Rules, Theories, Inference

- Needed everywhere
  - Class declarations
  - Expressing and answering (decomposing) queries
  - Service descriptions, advertisements
  - Service requests, possibly service bindings
  - Composing services
  - Expressing and using ontology mappings
  - Background knowledge
- Challenge: balance expressive power, high performance, desire for simplicity

Using Distributed Theories



Linking Ontologies

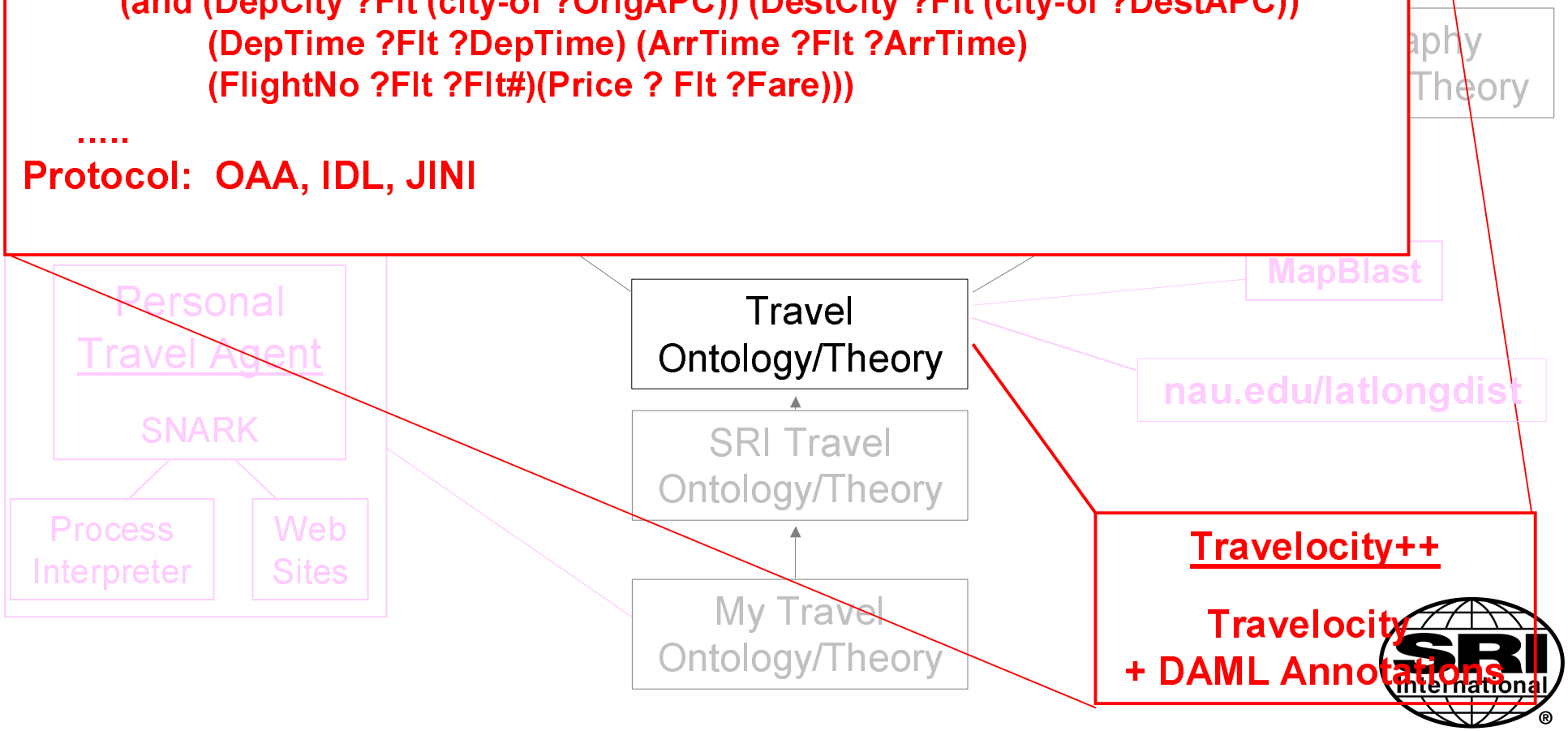
Travelocity++

Linking Axioms:

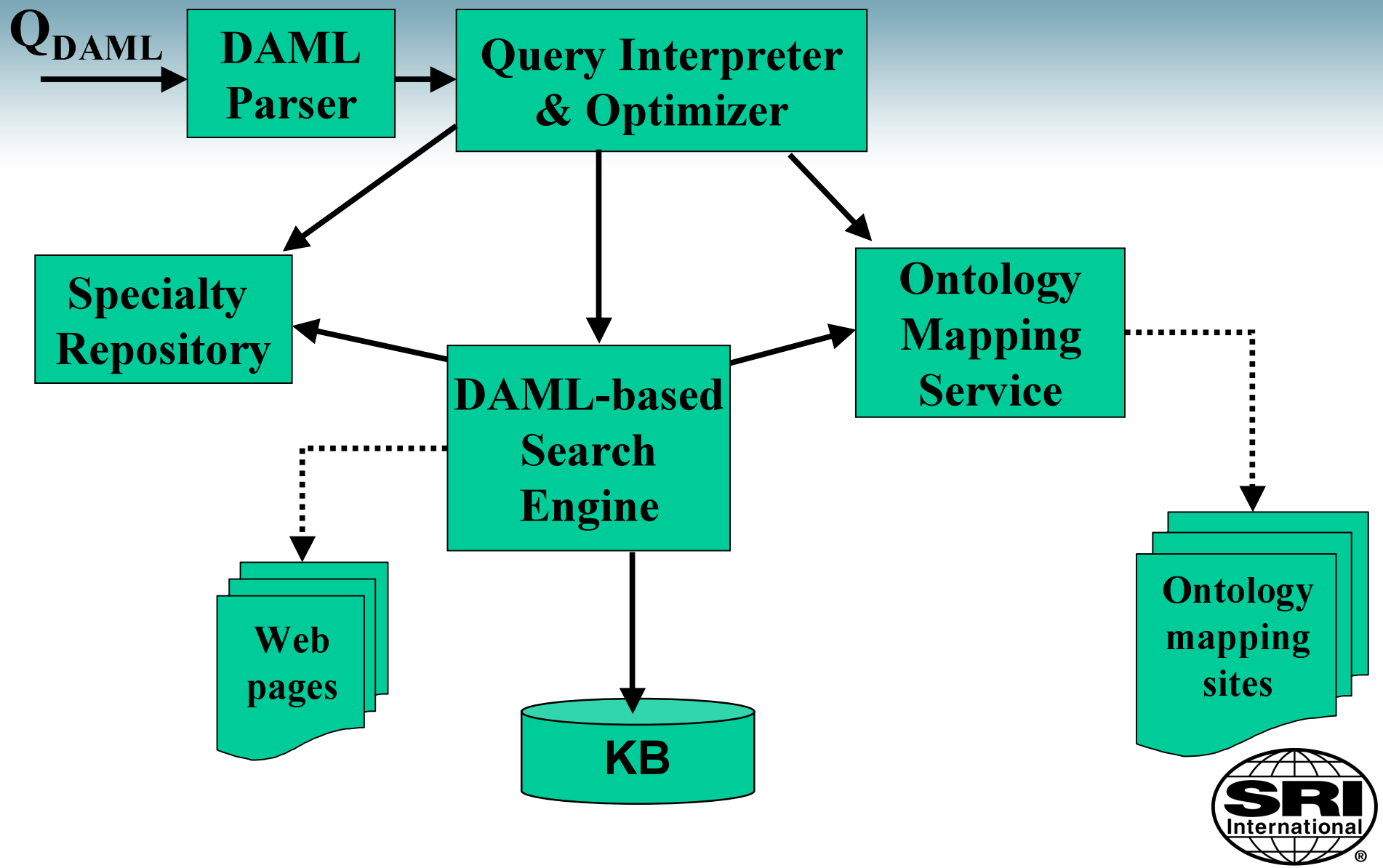
```
(implies
    (Travelocity:Get_Itinerary ?OrigAPC ?DestAPC ?DepTime ?ArrTime
                ?Flt#  ?Fare)
    (and (DepCity ?Flt (city-of ?OrigAPC)) (DestCity ?Flt (city-of ?DestAPC))
         (DepTime ?Flt ?DepTime) (ArrTime ?Flt ?ArrTime)
         (FlightNo ?Flt ?Flt#)(Price ? Flt ?Fare)))
```

.....

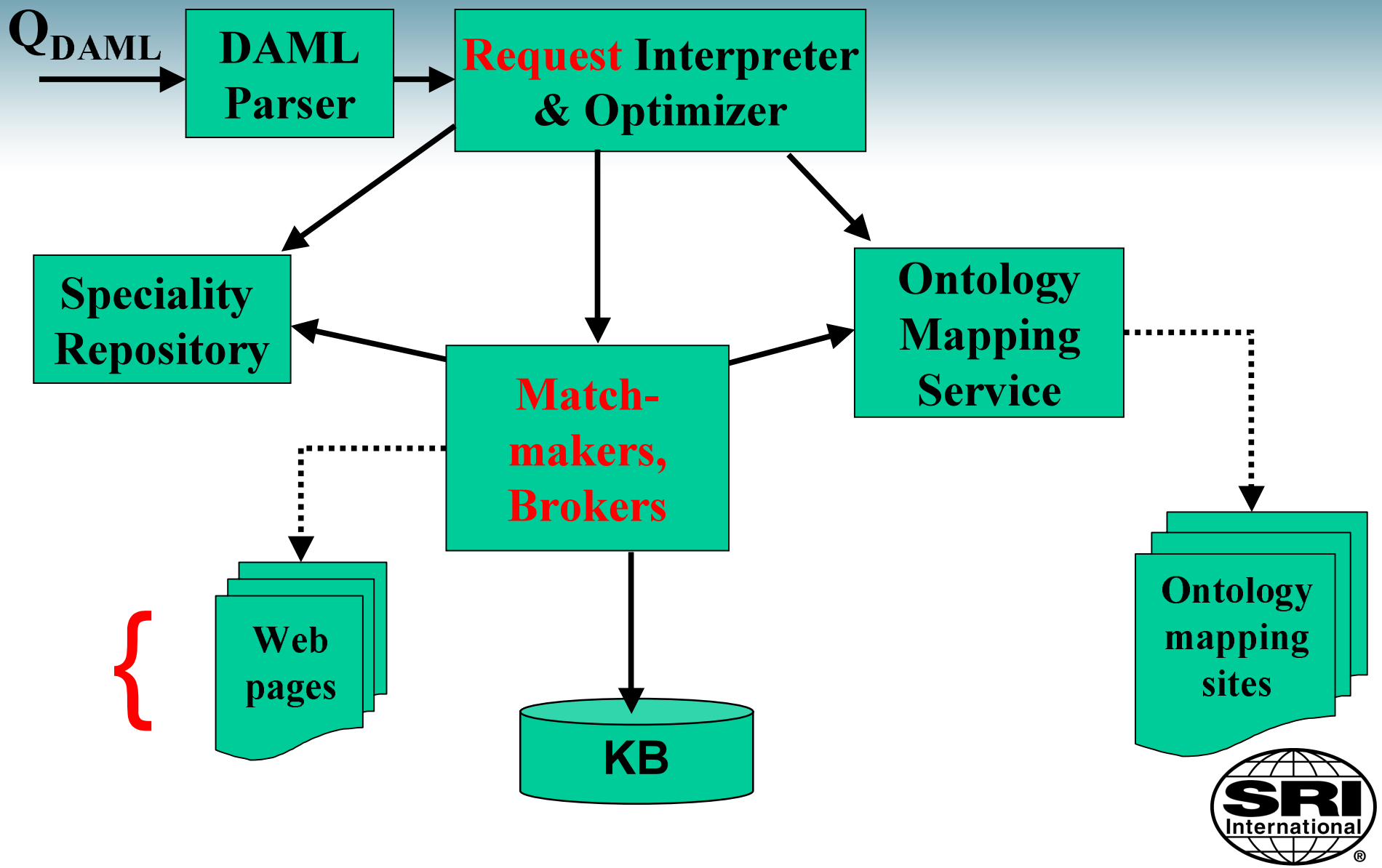
Protocol: OAA, IDL, JINI



How do services change the picture?



How do services change the picture?



DAML-S: Goals

- Full automation of service use
  - DAML markups provide enough info for an agent to find, select, and use a service never before encountered
- Service requests handled seamlessly with information queries
  - Allow for composition of both
  - Many components & tools can work for both
    - Search & selection, ontology translation, …
- Support inference in selecting and using services

Joint work with Stanford, CMU, BBN, Nokia

Upper Ontology for Services

- A foundation for creating many service ontologies
  - But not a mandate for specific ontologies
  - May provide deeper ontologies for Meta-services
- Can be specialized in many different ways
- No one “official hierarchy” of services
  - But agents always know how to get started
  - Top-level specs provide consistency
- Existing taxonomies can be mapped

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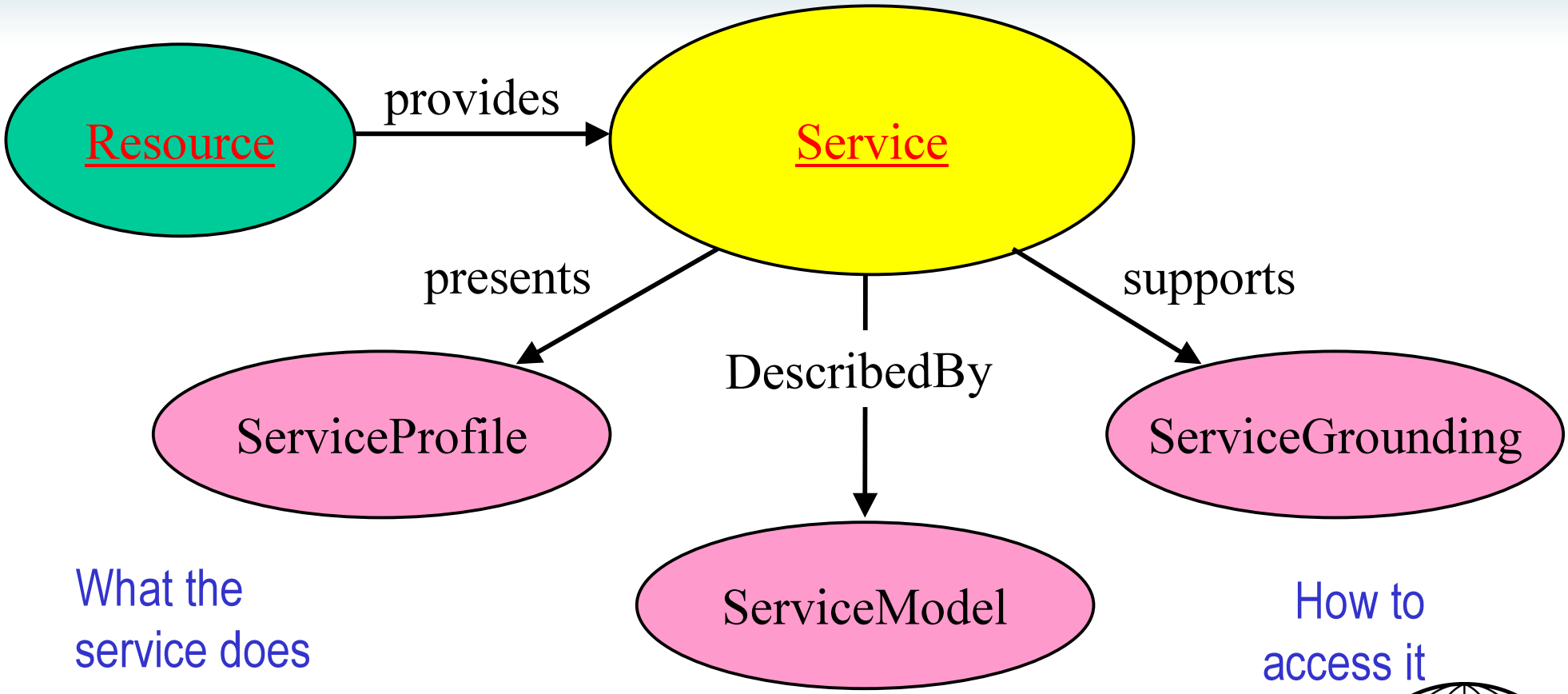
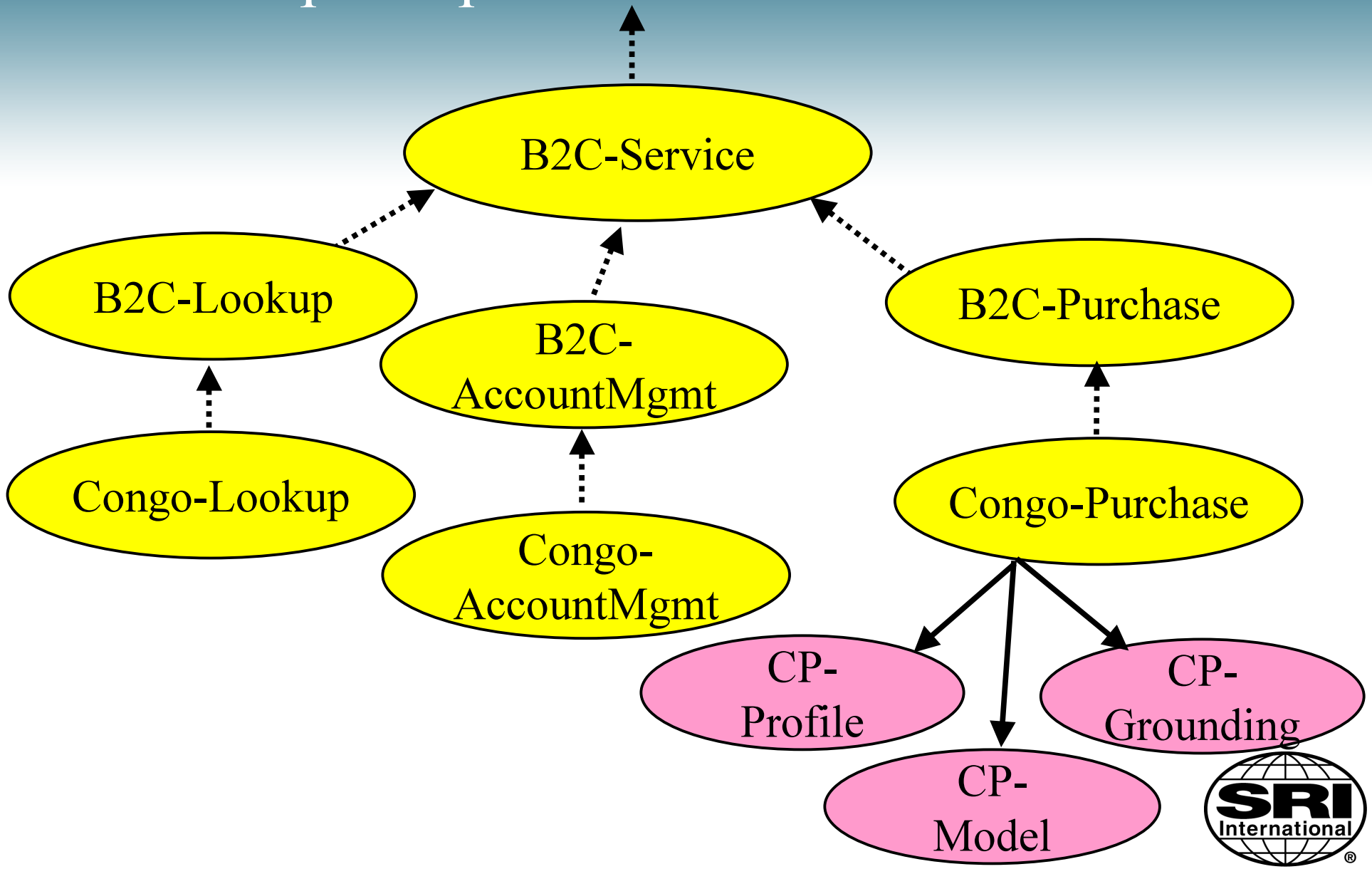
Service Ontology: Top-level Classes



Example: Specialization for a B2C Site



Service Profile

"What does it do?"

- Requirements for use; results of use
  - "Black box" view: Information needed to find and select a service
  - Inputs, outputs, preconditions, effects, …
  - "Binding rules" for inputs, outputs
  - "Roles" involved
- May vary for different service classes
- Can employ logical rules
- Analogous to procedure header, DB schema

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B2C Purchase: Profile

- Input: ItemDescription (several forms), PriceRange, AcctName, Passwd, CreditCard#, Shipping-address, …
- Input usage rule:

  Exists(Acct) => Defined(CreditCard#, Shipping-Address)
- Precondition:

  Exists(Acct) | CanCreate(Acct)
- Output: 'Succeed' + Receipt | 'Cancel' | 'Fail'
- Effect: 'Succeed' ➔ ShippingOrderPlaced

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Service Model

"How does it work?"

- Semantic description of a service
  - "Glass box" view
  - Detailed characterization of what it does
- May vary for different service classes
- Can employ logical rules
- Analogous to procedure body (but abstract)

Process Model

(SubClass of ServiceModel)

- Shared knowledge to coordinate service's "roles"
- Expresses state changes
- Describes sequences of possible interactions for an extended transaction
- Executable semantics
- Draws on work in AI planning, workflow, …
- Can be used for task planning, scheduling, reachability analysis, etc.

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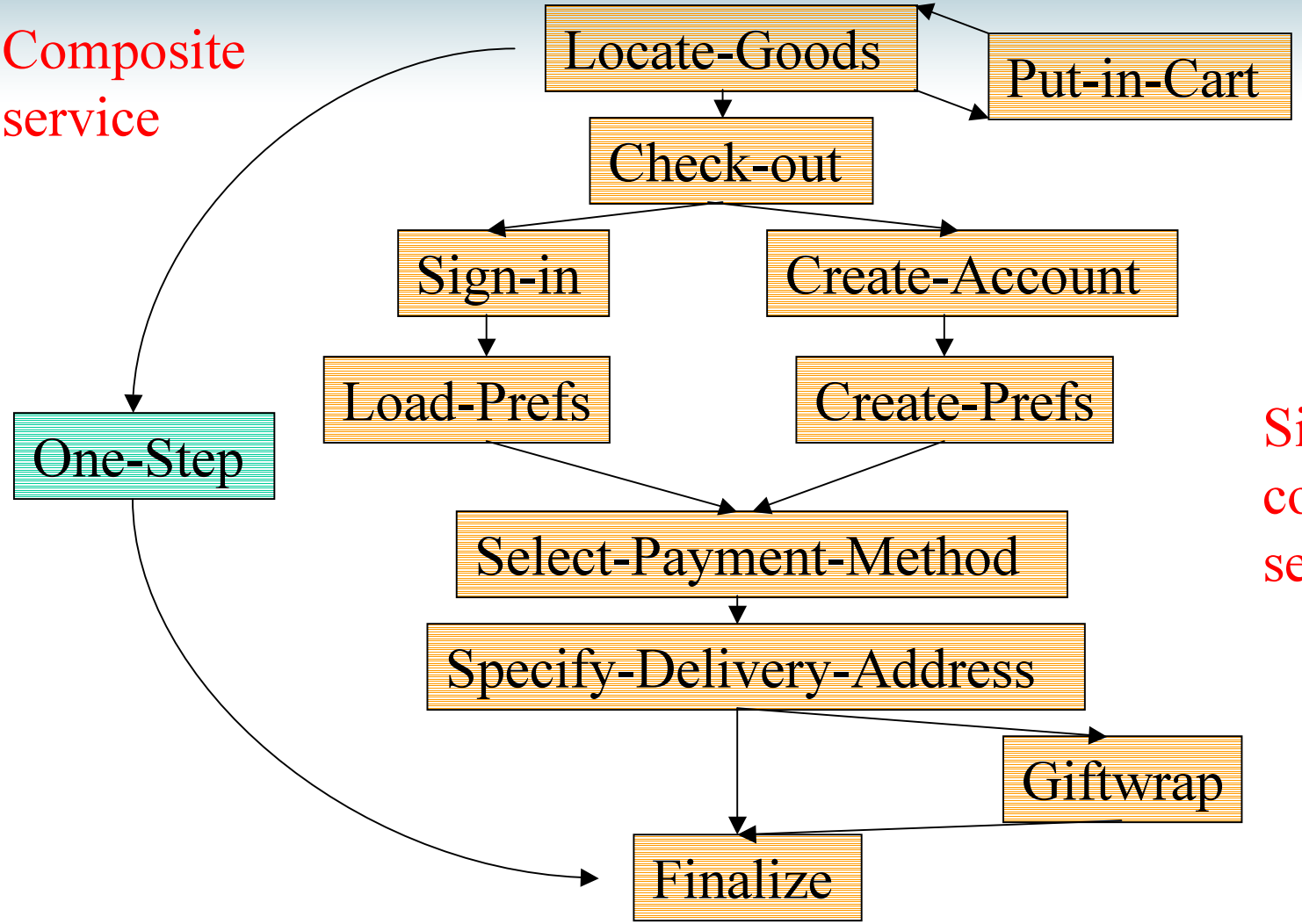
B2C Purchase: ProcessModel

Composite service



Simple or composite services

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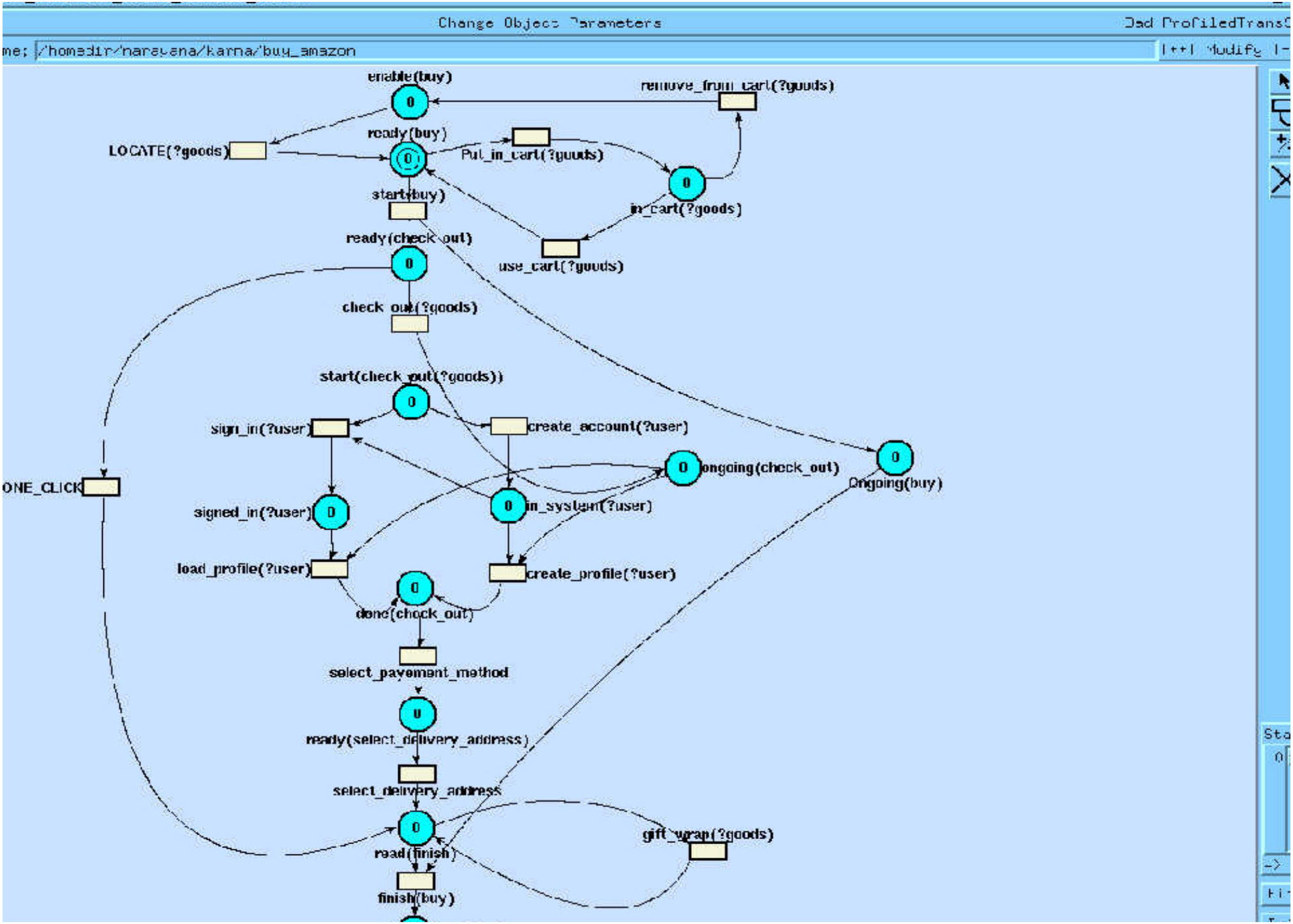
Change Object Parameters
/homedir/narayana/karna/buy_amazon
enable(buy)
remove_from_cart(?goods)
LOCATE(?goods)
ready(buy)
Put_in_cart(?goods)
start(buy)
in_cart(?goods)
use_cart(?goods)
ready(check_out)
check_out(?goods)
start(check_out(?goods))
sign_in(?user)
create_account(?user)
ONE_CLICK
ongoing(check_out)
Ongoing(buy)
signed_in(?user)
in_system(?user)
load_profile(?user)
create_profile(?user)
done(check_out)
select_payement_method
ready(select_delivery_address)
select_delivery_address
gift_wrap(?goods)
read(finish)
finish(buy)

CongoPurchaseProcessModel.daml (sketch)

```
<process>
    <name> purchase </name>
    <sequence>
        <process> locate_goods (?goods)</process>
         <alternative>
          <alt1><task> One_step </task></alt1>
          <alt2> <sequence>
             <task> put_in_cart(?goods)</task>
                <process>
                  <name> check_out_info</name>
                   <alternative>
                     <alt1> <sequence>
                         <task> Sign_in (?user)</task>
                          <task> Load_profile(?user.profile) </task>
                      </sequence></alt1>
                      <alt2> <sequence>
                          <process> Create_Account (?user)</process>
                          <process> Create_profile(?user.profile) </process>
                       </sequence></alt2>
                     </alternative>
                   </process>
               <task> Select_Payment_Method  </task>
              <process> Select_Delivery_Address </process>
            </sequence></alt2>
           </alternative>
          <task> Finalize </task>
    </sequence>
</process>
```

Service Grounding

"How is it used?"

- Implementation-specific details for accessing the service
- Message formatting, transport mechanisms, protocols, serializations of all types
- Service Model + Grounding give everything needed for using the service
- Examples: HTTP forms, SOAP, KQML, CORBA IDL, OAA ICL, Java RMI

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B2C-Purchase: Grounding

- Transport: Secure HTTP
- Protocol: HTTP Forms
- Address: https://buybot.congo.com:4040/initsub.htm
- Type Serializations
  - ItemDescription (keywords): Set of DAML literals
  - PriceRange: pair of monetary units, ISO 5678
  - CreditCard: https://transcredit.com/S1.daml#SecureTransferFormat

Recap of Upper Ontology for Services

- Profile supports service selection
- Model + Grounding support execution, monitoring, composition, …
- Profile and Model are abstract; Grounding makes it concrete
- There can be multiple of each
  - One-to-one correspondence not required

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Summary

- The Semantic Web will be big
- It will support a wide variety of (mixed) queries and requests, in a semantically-grounded way
- KB representational techniques, ontologies, axioms, reasoning are likely to be important elements
- Services can be advertised, found, executed, monitored, and composed using DAML-S
- Search engines & portals will evolve; ontology translation services will become essential
- Interesting new challenges for distributed DB/KB technology and Web architecture

Status

- DAML-S coming soon to

  http://www.daml.org/services/daml-s

  - Joint work with Stanford KSL, CMU, BBN, Nokia

- SRI's DAML work is described at

  http://www.ai.sri.com/daml

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