How SW Rules + Ontologies Connect to Procedural Aspects of SW Services

Presentation for
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Overview: {SW rules+ontologies} and the procedural aspect of SWS

Quickly review: rule-based SWS cf. the 3/20 SWSL telecon presentation and 4/9 DAML PI Mtg Services Breakout

- Describing post-conditions and pre-conditions, esp. contingent behavior
- Let’s do more use cases and application scenarios

• Situated logic programs (SLP) [the largest emphasis of this presentation]
  - very simple workflow, viewable as timeless and stateless
  - abstraction of event-condition-action rules and OPS5 production rules
  - supported in RuleML and (basically too in) Jess.
  - actions (invoke external procedures) triggered by inferring of conclusions
  - queries (invoke external procedures) during testing of rule antecedent conditions

• Built-ins used in rules and ontologies, e.g.,
  - arithmetic and comparison operators/functions

• Exception handling in workflows and service agreements/contracts

• Representing service post-conditions and state transitions, incl. contracts, persistence defaults [--- next presentation could usefully have more on this]
Rule-based Semantic Web Services

• Rules/LP in appropriate combination with DL as KR, for RSWS
  – DL good for categorizing: a service overall, its inputs, its outputs

• Rules to describe service process models
  – rules good for representing:
    • preconditions and postconditions, their contingent relationships
    • contingent behavior/features of the service more generally,
      – e.g., exceptions/problems
    – familiarity and naturalness of rules to software/knowledge engineers

• Rules to specify deals about services: cf. e-contracting.
Rule-based Semantic Web Services

- Rules often good to **executably specify** service process models
  - e.g., business process automation using procedural attachments to perform side-effectful/state-changing actions ("effectors" triggered by drawing of conclusions)
  - e.g., rules obtain info via procedural attachments ("sensors" test rule conditions)
  - e.g., rules for knowledge translation or inferencing
  - e.g., info services exposing relational DBs

- **Infrastructural**: rule system functionality as services:
  - e.g., inferencing, translation
Application Scenarios for Rule-based Semantic Web Services

- SweetDeal [Grosof & Poon 2002] configurable reusable e-contracts:
  - LP rules about agent contracts with exception handling
  - ... on top of DL ontologies about business processes;
  - a scenario motivating DLP

- Other:
  - Trust management / authorization (Delegation Logic) [Li, Grosof, & Feigenbaum 2000]
  - Financial knowledge integration (ECOIN) [Firat, Madnick, & Grosof 2002]
    - Rule-based translation among contexts / ontologies
    - Equational ontologies
    - Business policies, more generally, e.g., privacy (P3P)
Flavors of Rules Commercially Most Important today in E-Business

• E.g., in OO app’s, DB’s, workflows.

• Relational databases, SQL: Views, queries, facts are all rules.
  - SQL99 even has recursive rules.

• Production rules (OPS5 heritage): e.g.,

• Event-Condition-Action rules (loose family), cf.:
  - business process automation / workflow tools.
  - active databases; publish-subscribe.

• Prolog, e.g., XSB: “logic programs” as a full programming language.

• (Lesser: other knowledge-based systems.)
Heavy Reliance on Procedural Attachments in Currently Commercially Important Rule Families

• E.g., in OO app’s, DB’s, workflows.

• Relational databases, SQL: Built-in sensors, e.g., for arithmetic, comparisons, aggregations. Sometimes effectors: active rules / triggers.

• Production rules (OPS5 heritage): e.g., Jess
  – Pluggable (and built-in) sensors and effectors.

• Event-Condition-Action rules:
  – Pluggable (and built-in) sensors and effectors.

• Prolog: e.g., XSB.
  – Built-in sensors and effectors. More recent systems: more pluggability of the built-in attached procedures.
Situated LP’s: Overview

- Point of departure: LP’s are pure-belief representation, but most practical rule systems want to invoke external procedures.
- Situated LP’s feature a semantically-clean kind of procedural attachments. I.e., they hook beliefs to drive procedural API’s outside the rule engine.
- Procedural attachments for sensing (queries) when testing an antecedent condition or for effecting (actions) upon concluding a consequent condition. Attached procedure is invoked when testing or concluding in inferencing.
- Sensor or effector link statement specifies an association from a predicate to a procedural call pattern, e.g., a method. A link is specified as part of the representation. I.e., a SLP is a conduct set that includes links as well as rules.
Situated LP’s: Overview (cont.’d)

- phoneNumberOfPredicate ::s:: BoeingBluePagesClass.getPhoneMethod. ex. sensor link
- shouldSendPagePredicate ::e:: ATTPagerClass.goPageMethod. ex. effector link
- Sensor procedure may require some arguments to be ground, i.e., bound; in general it has a specified binding-signature.
- Enable dynamic or remote invocation/loading of the attached procedures (exploit Java goodness).

- Overall: cleanly separate out the procedural semantics as a declarative extension of the pure-belief declarative semantics. Easily separate chaining from action.
**SweetJess: Translating an Effector Statement**

Associates with predicate $P$: an attached procedure $A$ that is side-effectful.

- Drawing a conclusion about $P$ triggers an action performed by $A$.

Equivalent in JESS: key portion is:

```
(defrule effect_giveDiscount_1
  (giveDiscount ?percentage ?customer)
  =>
  (effector setCustomerDiscount orderMgmt.dynamicPricing
    (create$ ?percentage ?customer) ) )
```

$jproc = \text{Java attached procedure}.$

$meth, \ clas, \ path = \text{its methodname, classname, pathname}.$
Overview: Semantics of Situated Logic Programs

- Definitional: complete inferencing+action occurs during an “episode” – intuitively, run all the rules (including invoking effectors and sensors as go), then done.
- Effectors can be viewed as all operating/invoked after complete inferencing has been performed.
  - Independent of inferencing control.
- But often intuitively less appropriate if only doing backward inferencing.
  - Separates pure-belief conclusion from action.
Overview: Semantics of Situated LP, continued

- Sensors can be viewed as accessing a virtual knowledge base (of facts). Their results simply augment the local set of facts. These can be saved (i.e., cached) during the episode.
  - Independent of inferencing control.
- The sensor attached procedure could be a remote powerful DB or KB system, a web service, or simply some humble procedure.
- Likewise, an effector attached procedure could be a remote web service, or some humble procedure. An interesting case for SW is when it performs updating of a DB or KB, e.g., “delivers an event”.
Overview of Semantics of Situated LP, continued

- **Conditions:**
  - **Effectors have only side effects:** they do not affect operation of the (episode’s) inferencing+action engine itself, nor change the (episode’s) knowledge base.
  - **Sensors are purely informational:** they do not have side effects (i.e., any such can be ignored).
  - **Timelessness of sensor and effector calls:** their results are not dependent on when they are invoked, during a given inferencing episode.
  - **“Sensor-safeness”**: Each rule ensures sufficient (variable) bindings are available to satisfy the binding signature of each sensor associated with any of its body literals – such bindings come from the other, non-sensor literals in the rule body. During overall “testing” of a rule body, sensors needing such bindings can be viewed as invoked after the other literals have been “tested”.
Overview: Semantics of Situated LP, Continued

- Generalizations possible:
  - permit multiple sensors or effectors per predicate.
  - sense functions (or terms) not just predicates.
  - permit sensor priority – i.e., specify the prioritization of the facts that result from a particular sensor.
  - associate sensing with atoms/literals (or terms), but this is reducible to sensing predicates (or functions) – by rewriting of the rules.

- Challenge: error handling info returned from attached procedures
Example: Notifying a Customer when their Order is Modified

- See extended version of B. Grosof WITS-2001 paper
  - “Representing E-Business Rules on the Semantic Web: Situated Courteous Logic Programs in RuleML”
  - In file wits01-report-r2.pdf
  - Also at http://ebusiness.mit.edu/bgrosof
SweetDeal OPTIONAL SLIDES FOLLOW
Example Contract Proposal with Exception Handling
Represented using RuleML & DAML+OIL, Process Descriptions

Using concise text syntax
(SCLP textfile format)
for concise human reading
SCLP TextFile Format for (Daml)RuleML

payment(?R,base,?Payment) <-
http://xmlcontracting.org/sd.daml#result(co123,?R) AND
price(co123,?P) AND quantity(co123,?Q) AND
multiply(?P,?Q,?Payment)

<drm:imp>
  <drm:_head> <drm:atom>
    <drm:_opr><drm:rel>payment</drm:rel></drm:_opr> <drm:tup>
    <drm:var>R</drm:var> <drm:ind>base</drm:ind> <drm:var>Payment</drm:var>
  </drm:tup> <drm:atom> </drm:_head>
  <drm:_body>
    <drm:andb>
      <drm:atom> <drm:_opr> <drm:rel href="http://xmlcontracting.org/sd.daml#result"/>
        <drm:_opr> <drm:tup>
          <drm:ind>co123</drm:ind> <drm:var>Cust</drm:var>
        </drm:tup> <drm:atom>
      </drm:atom>
    </drm:andb> <drm:_body> </drm:imp>

drm = namespace for damlRuleML
Example Contract Proposal, Continued:

lateDeliveryPenalty exception handler module

lateDeliveryPenalty_module {
  // lateDeliveryPenalty is an instance of PenalizeForContingency
  //   (and thus of AvoidException, ExceptionHandler, and Process)
  http://xmlcontracting.org/pr.daml#PenalizeForContingency(lateDeliveryPenalty) ;
  // lateDeliveryPenalty is intended to avoid exceptions of class
  // LateDelivery.
  http://xmlcontracting.org/sd.daml#avoidsException(lateDeliveryPenalty,
       http://xmlcontracting.org/pr.daml#LateDelivery);

  // penalty = - overdueDays * 200 ; (negative payment by buyer)
  <lateDeliveryPenalty_def> payment (?R, contingentPenalty, ?Penalty) <-
    http://xmlcontracting.org/sd.daml#specFor(?CO,?PI) AND
    http://xmlcontracting.org/pr.daml#hasException(?PI,?EI) AND
    http://xmlcontracting.org/pr.daml#isHandledBy(?EI,lateDeliveryPenalty) AND
    http://xmlcontracting.org/sd.daml#result(?CO,?R) AND
    http://xmlcontracting.org/sd.daml#exceptionOccurred(?R,?EI) AND
    shippingDate(?CO,?CODate) AND shippingDate(?R,?RDate) AND
    subtract(?RDate,?CODate,?OverdueDays) AND
    multiply(?OverdueDays, 200, ?Res1) AND multiply(?Res1, -1, ?Penalty) ;
}

<lateDeliveryPenaltyHandlesIt(e1)> // specify lateDeliveryPenalty as a handler for e1
  http://xmlcontracting.org/pr.daml#isHandledBy(e1,lateDeliveryPenalty);
END of SweetDeal OPTIONAL SLIDES
ALSO RELEVANT ARE SLIDES from 3/20/03 SWSL telecon
“Overview of Semantic Web Services”
by Benjamin Grosof