



Reaction RuleML: A Reaction Rule Extension of RuleML

Agenda

- Basics / Preliminaries
- Core Syntax Constructs
- Examples
 - Active Global Reaction Rules
 - Active Local Reaction Rules
 - Passive Global Reaction Rules
 - Passive Local Reaction Rules
 - KR Event/Action Logic Reaction Rules
- Complex Event Processing

Adrian Paschke, Alexander Kozlenkov and Harold Boley
Reaction RuleML, Telephone Conference, 2006-10-19

■ Different Styles of Event/Action Definition and Processing

■ Active databases

- ◆ Instantaneous occurrences of atomic or complex events (defined by event algebra operators)
- ◆ Short term perspective (event sequence history to detect complex events)
- ◆ ECA paradigm

■ Production rule systems:

- ◆ Implicit sequences of knowledge updates
- ◆ Condition → Action (mostly Assert / Retract)

■ Event Messaging / Notification

- ◆ Event messages (inbound / outbound messages)
- ◆ Follow some protocol, e.g. realized by state machine

■ KR Temporal / Event / Action Logics

- ◆ Persistent non-transient past or planned events
- ◆ Long term perspective
- ◆ Axioms to formalize events/actions and their effects on knowledge states
- ◆ Transitions from one state to another

Reaction RuleML – General Concepts

■ General reaction rule form that can be specialized as needed

■ Three general execution styles:

- ◆ **Active:** 'actively' polls/detects occurred events, e.g. by a ping on a service/system or a call on an event database
- ◆ **Passive:** 'passively' waits for incoming events, e.g. an event message
- ◆ **Reasoning:** KR event/action logic reasoning and transitions (as e.g. in Event Calculus, Situation Calculus, ACTL formalizations)

■ Appearance

- ◆ **Global:** 'globally' defined reaction rule
- ◆ **Local:** 'locally' defined (inline) reaction rule nested in a outer rule

■ Event: event of reaction rule

- ◆ Production rule systems: Event implicit in starting next cycle
- ◆ Active execution: Actively detect / listen to events (possibly clocked by a time function / monitoring schedule)
- ◆ Passive execution: Passively wait / listen for matching event pattern (e.g. event message)

■ Condition

- ◆ Production rule system: trigger for action
- ◆ Backward reasoning: top-down goal proof attempt based on derivation rules
- ◆ **Strong condition:** on failure completely terminates the execution, e.g. the message sequence or the derivation process
- ◆ **Weak condition:** on failure proceeds with the derivation or waits for further messages without execution of the action

■ Action

- ◆ Executes action either as internal knowledge update or externally, e.g. as sendMessage

■ Postcondition

- ◆ Evaluated after action has been performed
- ◆ **Transactional postcondition:** rolls back action (knowledge update) if failed

■ Alternative Action

- ◆ Executes alternative action if condition or action fails (akin to "if then else" logic)

Reaction RuleML Syntax – Basic Constructs

- **<Reaction>** General reaction rule construct
- **@exec** = "*active | passive | reasoning*"; default = "*passive*"
 - Attribute denoting “active”, “passive” or “reasoning” **execution style**
- **@kind** Attribute denoting the **kind** of the reaction rule, i.e. its combination of constituent parts, e.g. „*eca*“, „*ca*“, „*ecap*“
- **@eval** Attribute denoting the interpretation of a rule: “*strong | weak*”
- **<event>**, **<body>**, **<action>**, **<postcond>**, **<alternative>**
 - role tags; may be omitted when they can be uniquely reconstructed from positions
- **<Message>** Defines an inbound or outbound message
- **@mode** = *inbound | outbound*
 - Attribute defining the type of a message
- **@directive** = [directive, e.g. FIPA ACL]
- **<Assert>** | **<Retract>** Performatives for internal knowledge updates

General Syntax for Reaction Rules

```
<Reaction exec="active" kind="ecapa" eval="strong">
```

```
  <event>
```

```
    <!-- event -->
```

```
  </event>
```

```
  <body>
```

```
    <!-- condition -->
```

```
  </body>
```

```
  <action>
```

```
    <!-- action -->
```

```
  </action>
```

```
  <postcond>
```

```
    <!-- postcondition -->
```

```
  </postcond>
```

```
  <alternative>
```

```
    <!-- alternative/else action -->
```

```
  </alternative>
```

```
</Reaction>
```

Example 1: Active Global Reaction Rule (ECA) (1)

```
<Reaction kind="eca" exec="active">
  <event> <!-- the role tag might be omitted if still unambiguous -->
    <Reaction kind="ea">
      <event>
        <Atom><Rel>everyMinute</Rel><Var>T</Var></Atom>
      </event>
      <action>
        <Atom>
          <Rel>detect</Rel> <Var type="event:EventType1" mode="-">TroubleTicket</Var>
          <Var>T</Var>
        </Atom>
      </action>
    </Reaction>
  </event>

  <body>
    <Atom>
      <Rel>maintenance</Rel>
      <Var>T</Var>
    </Atom>
  </body>
  <action>
    <!-- Boolean-valued procedural attachment -->
    <Atom>
      <oid><Ind uri="rbsla.utils.TroubleSystem,"/></oid> <!-- class/object -->
      <Rel in="effect" lang="java">processTicket</Rel> <!-- method -->
      <Var type="event:EventType1" mode="+">TroubleTicket</Var> <!-- parameter -->
    </Atom>
  </action>
</Reaction>
```

Example 1: Active Global Reaction Rule (ECA) (2)

■ ECA-LP/Prova Syntax (related to ISO Prolog notation)

```
eca(  
    everyMinute(T),                % time precondition (clock)  
    detect(TroubleTicket:event_EventType1,T), % event  
    maintenance(T),                % condition  
    rbsla.utils.TroubleSystem.ProcessTicket(  
        TroubleTicket:event_EventType1  
    )                               % action  
).  
  
% Formalization of time function „everyMinute(T)“ - omitted in slide 6  
everyMinute(T):-  
    sysTime(T),                    % get actual system time/date  
    interval(timespan(0,0,1,0), T). % interval function
```

Example 2: Active Global Reaction Rule (CA / Production) (1)

```
<Reaction kind="ca" exec="active">

  <body>
    <Atom>
      <Rel>occurs</Rel>
      <Expr in="no">
        <Fun>heartbeat</Fun>
        <Var>Service</Var>
      </Expr>
      <Var>T</Var>
    </Atom>
  </body>

  <action>
    <Assert>
      <oid><Ind>availability values</Ind></oid>  <!-- OID of update -->
      <Atom>
        <Rel>alive</Rel>
        <Var>Service</Var>
        <Var>T</Var>
      </Atom>
    </Assert>
  </action>

</Reaction>
```

Example 2: Active Global Reaction Rule (Production Rule) (2)

■ Production Rule (forward-directed):

```
occurs(heartbeat(Service),T) → assert ( alive(Service,T) )
```

■ ECA-LP/Prova Syntax (related to ISO Prolog notation)

```
eca(  
  occurs(heartbeat(Service),T),    % condition  
  add("availability values","alive(_0,_1).", [Service, T]) % action  
).
```

Example 3: Active Local Reaction Rule (EA) (1)

```
<Implies>

<head>
  <Atom>
    <Rel>available</Rel>
    <Var>Service</Var>
  </Atom>
</head>

<body>
  <And>

    <Atom>
      <Rel>service</Rel>
      <Var>Service</Var>
    </Atom>

    <Atom>
      <Rel>sysTime</Rel>
      <Var>T</Var>
    </Atom>

    <Reaction kind="ea" exec="active" eval="strong">
```

... → next slide

Example 3: Active Local Reaction Rule (EA) (2)

```
<event>
  <Atom>
    <oid><Ind uri="rbsla.utils.WebService"/> </oid>  <!-- object / class-->
    <Rel in="effect" lang="java">ping</Rel> <!-- Boolean-valued method -->
    <Var mode="+">Service</Var>
  </Atom>
</event>

<action>
  <Assert>
    <oid><Ind>id1</Ind></oid> <!-- ID of update -->
    <Atom>
      <Rel>occurs</Rel>
      <Expr in="no">
        <Fun>alive</Fun>
        <Var>Service</Var>
      </Expr>
      <Var>T</Var>
    </Atom>
  </Assert>
</action>

</Reaction>
</And>
</body>
</Implies>
```

Example 3: Active Local Reaction Rule (EA) (3)

■ ECA-LP/Prova Syntax (related to ISO Prolog notation)

```
available(Service) :-      % a mixed rule with a local reaction rule
    service(Service),
    sysTime(T),
    eca(
        rbsla.utils.WebService.ping(Service),          % ping service
        _, % no condition
        add(id1,"occurs(alive(_0),_1).",[Service,T])    % add action
    ).
```

Example 4: Passive Global Notification Reaction Rule (1)

```
<Reaction kind="ea" exec="passive" eval="strong">

  <event>
    <Message mode="inbound" directive="ACL:inform">
      <oid><Var>XID</Var></oid>
      <protocol><Var>Protocol</Var>
      <sender><Var>From</Var></sender>
      <content><Var>Payload</Var></content> <!--message payload-->
    </Message>
  </event>

  <action>
    <Assert>
      <oid><Ind>opinions</Ind></oid> <!-- OID of update -->
      <Atom>
        <Rel>opinion</Rel>
        <Var>From</Var>
        <Var>Payload</Var>
      </Atom>
    </Assert>
  </action>
</Reaction>
```

Example 4: Passive Global Notification Reaction Rule (2)

■ Prova AA Syntax (related to ISO Prolog notation)

```
rcvMsg(XID,Protocol,From,"inform",Payload) :-  
    add(opinions,"opinion(_0,_1).",[From,Payload]).
```

Example 5: Passive Local Notification Reaction Rule (1)

```
<Implies>
  <head>
    <!-- Standard derivation rule head or reaction rule (receive) -->
  </head>
  <body>
    <And>
      <Reaction kind="e" exec="passive" eval="strong">
        <event>
          <Message mode="inbound" directive="ACL:inform">
            <oid><Var>XID</Var></oid>
            <protocol><Var>Protocol</Var>
            <sender><Var>From</Var></sender>
            <content><Var>Payload</Var></content>
          </Message>
        </event>
      </Reaction>
    ... next slide →
```

Example 5: Passive Local Notification Reaction Rule (2)

```
<Atom> ... </Atom>
```

```
<Reaction kind="a" exec="passive" eval="weak">
```

```
<action>
```

```
<Message mode="outbound" directive="ACL:inform">
```

```
<oid><Var>XID</Var></oid>
```

```
<protocol><Var>Protocol</Var>
```

```
<sender><Var>From</Var></sender>
```

```
<content><Var>Payload</Var></content>
```

```
</Message>
```

```
</action>
```

```
</Reaction>
```

```
<Atom> ... </Atom>
```

```
</And>
```

```
</body>
```

```
</Implies>
```

Example 5: Passive Local Notification Reaction Rule (3)

■ Prova AA Syntax (related to ISO Prolog notation)

<normal derivation rule head> :-

rcvMsg(XID, Protocol, From, inform, Payload), %inline event

..., % normal literals

sendMsg(XID, Protocol, From, inform, Payload), % inline action

... .

Example 6: KR Temporal Event/Action Logics

```
<Reaction kind="ea" exec="reasoning">
  <event>
    <Atom>
      <Rel>happens</Rel>
      <Ind>StartMaintenance</Ind>
      <Var>T</Var>
    </Atom>
  </event>
  <action>
    <Initiates>
      <state>
        <Ind>maintenance</Ind> <!-- fluent / state -->
      </state>
    </Initiates>
  </action>
</Reaction>
```

Example 6: KR Event/Action Logics (3)

- ECA-LP/Prova Syntax (related to ISO Prolog notation)
 - Event Calculus formalization

```
happens(startMaintenance,t1). % fact (omitted in slide 18)
```

```
initiates(startMaintenance,maintenance,T). % initiate state
```

Complex Events

■ Atomic Events

- simple flat constants <Ind>
- nested complex functions <Expr>
- complex external objects <Attachment> in <Atom> ; might be bound to variables
- messages <Message>

■ Complex Events

- Defined by event algebra operators
- Example: `sequence(concurrent(a,b),c)`

```
<event>
  <Sequence>
    <Concurrent>
      <Ind>a</Ind>
      <Ind>b</Ind>
    </Concurrent>
    <Ind>c</Ind>
  </Sequence>
</event>
```

Complex Event Processing

- Event Definition
 - Definition of event pattern by event algebra
- Event Selection
 - Defines selection function to select one event from several occurred events (stored in an event instance sequence) of a particular type, e.g. “*first*”, “*last*”
 - Crucial for the outcome of a reaction rule, since the events may contain different (context) information, e.g. different message payloads or sensing information
- Event Consumption
 - Defines which events are consumed after the detection of a complex event
 - An event may contribute to the detection of several complex events, if it is not consumed
 - Distinction in event messaging between “multiple receive” and “single receive”
 - Events which can no longer contribute, e.g. are outdated, should be removed
- Separation of this phases is crucial for the outcome of a reaction rule base in the context of complex events
- Declarative configuration of different selection and consumption policies is desirably (also on the syntax layer)



Thank you !

Discussion ?

Reaction RuleML Homepage:

<http://ibis.in.tum.de/research/ReactionRuleML>