Knowledge Representation and Reasoning
Logics for Artificial Intelligence

Stuart C. Shapiro

Department of Computer Science and Engineering
and Center for Cognitive Science
University at Buffalo, The State University of New York
Buffalo, NY 14260-2000

shapiro@cse.buffalo.edu

Contents

Part I

Part II

Part III

12 Production Systems
Architecture
Working (Short-term) Memory

Contains set (unordered, no repeats) of
Working Memory Elements (WMEs).
Each being a rather flat, ground (no variables) symbol structure.

Rule (Long-term) Memory

Contains set (unordered, no repeats) of
Production Rules.
Each being a condition-action rule
of form
if $\text{condition}_1 \ldots \text{condition}_n$ **then** $\text{action}_1 \ldots \text{action}_m$
Each condition and action being like a WME,
but allowing variables (and, maybe, other expressions)

Rule Triggering

A rule **if** $\text{condition}_1 \ldots \text{condition}_n$ **then** $\text{action}_1 \ldots \text{action}_m$
is triggered
if there is a substitution, σ
such that each $\text{condition}_i\sigma$ is a WME.

A single rule can be triggered in multiple ways (by multiple substitutions).

Rule Firing

A rule **if** $\text{condition}_1 \ldots \text{condition}_n$ **then** $\text{action}_1 \ldots \text{action}_m$
that is triggered in a substitution σ
fires by performing every $\text{action}_i\sigma$.

Production System Execution Cycle

loop

Collect $\mathcal{T} = \{\mathrm{r}\sigma \mid \mathrm{r}\sigma \text{ is a triggered rule}\}$

if $\mathcal{T}$ is not empty

Choose a $r\sigma \in \mathcal{T}$

Fire $r\sigma$

until $\mathcal{T}$ is empty.

Some Typical Actions

- **stop**
- **delete** a WME
- **add** a WME
- **modify** a WME
- formatted print

Conflict Resolution Strategies

Purpose: to "Choose a $r\sigma \in \mathcal{T}$"

Specificity: If the conditions of one rule are a subset of a second rule, choose the second rule. [B & L, p. 126]

Recency: Based on recency of addition or modification of WMEs, or on recency of a rule firing. [B & L, p. 126]

Refactoriness: Don't allow the same substitution instance of a rule to fire again. [B & L, p. 127]

Salience: Explicit salience value. "The use of salience is generally discouraged" [`http://herzberg.ca.sandia.gov/jess/docs/70/rules.html#salience`].

The Rete Algorithm
Assumptions

Rule memory doesn't change.

WM changes only slightly on each cycle.

WMEs are ground.

Production Systems are data-driven (use forward chaining).

Many rules share conditions.

The Rete Network

Create a network from the conditions (Like a discrimination tree) with rules at the leaves.

Create a token for each WME.

Pass each token through the network, stopping when it doesn't satisfy a test; resuming when the WME is modified.

When tokens reach a leaf, the rule is triggered.

Kinds of branch nodes

- α *nodes:* Simple test.
- β *nodes:* Constraints caused by different conditions.