## Chapter Overview

Alternatives to Rule-Based Reasoning

**Introduction**

**Semantic Networks**

**Frames**

**Blackboard Architectures**

**Chapter Review**



## Introduction

alternatives to rule-based reasoning

**adequacy**
rules are not suitable for all types of knowledge-based systems

**structured knowledge**
about physical objects or concepts

**composition**
of objects from components

**relationships**
between objects and components

**reasoning method**
opportunistic reasoning

**cooperation**
between relatively independent modules



## Semantic Nets

also: propositional nets, associative nets

**labeled, directed graph**

**nodes**
stand for physical objects, concepts, situations or
properties and their values

**arcs** (links, edges)
represent relationships between nodes

**labels**
describe associated objects / relationships

classic AI representation technique
originally proposed by [Quillian, 1968] for the description of human memory and language understanding



## Links

in semantic nets

**purpose**
basic structure for organizing knowledge
formal basis for inferences

**format**
basically unrestricted, any type of link can be defined

**common types**

- `is-a` an individual is an instance of a class
- `a-kind-of` relates an individual class to a parent class
- `is` defines the value of an attribute
- `cause` expresses causal knowledge

## Inheritance

in semantic networks

**object properties**
properties of the parent node are duplicated for the descendent node

**representation**
usually through is-a links
eliminates the need to replicate information

**operation**
queries about properties of a node can be passed to its parent node

**exception handling**
in some cases, the properties of ancestor nodes must be overridden
the respective property is represented locally



## Semantic Nets

advantages and disadvantages

+ explicit and succinct statement of associations
+ reduced search times through explicit connections
+
- no standard interpretation (human / program)
- no standards for links
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## Frames

structure for representing typical knowledge about objects

**extension of semantic nets**
nodes can have an internal structure

**purpose**
a frame represents related knowledge for a narrow topic

**commonsense knowledge**
frames are very useful for causal and commonsense knowledge

very powerful and flexible, but sometimes inefficient and incorrect



## Structure

of frames

**name**
designates the object to be represented

**slots and fillers**
slots define attributes, fillers contain values

**facets** associated with slots
additional control over property values (e.g. range, data type)

**procedural attachments** special type of facets
procedures (or *methods* invoked in certain situations `if-needed, if-added, if-removal`

frames are somewhat similar to databases; the difference lies in the contents of the slots / fields, and the operations performed on them

## Types

of frames

**class frame** (*generic frame*)
represents general characteristics of a set of objects;
an object with the properties of a generic frame is a *prototype*

**instance frame** (*specific frame*)
specific object within a class
inherits properties and property values from a class

**situational frame**
contains knowledge about situations

**action frame**
slots specify actions to be performed

**causal knowledge frame**
describes cause-and-effect relationship[s



## Frames

advantages and disadvantages

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+

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## Opportunistic Reasoning

flexible evaluation strategy

**reasoning method**
determined dynamically depending on the current status

**architecture**
independent modules cooperate in solving a problem

**applications**
complex problems requiring expertise from different domains

*Blackboard Architectures usually employ opportunistic reasoning*



## Blackboard Architectures

several ES modules share information

**distributed knowledge**
different human experts,
different domains, different representations

**distributed problem solving**
cooperation among different systems
("agents)

**communication**
exchange of information between rule sets

**ES modules**
for different tasks / subproblems

**blackboard**
forum for the exchange of information
accessible for all components

**scheduler**
controls modules
determines overall reasoning strategy

## Knowledge Sources

individual ES units

**domain knowledge**
each source contains knowledge about a specific area

**representation**
may be different for each unit
e.g. frames, rules, procedures

**preconditions**
may have to be satisfied for a unit

**independence**
each unit decides if it can contribute knowledge, and what the contributions are



## Blackboard

central communication mechanism

**information sharing**
central location for common information

**problem description**
data describing the initial problem to be solved
often organized hierarchically, with different representation mechanisms on different levels

**problem state**
contains relevant data for the current status

**modifications**
by knowledge sources as they work on their specific subtask

**panels**
the blackboard can be hierarchically structured and subdivided into *panels*



## Scheduler

control and coordination unit

**coordination**
synchronization between knowledge sources
execution of actions
modifications of the problem description and solution

**focus of attention**
selection of the active knowledge source
selection of the current blackboard object

**heuristics**
granularity
attributes / side-effects of actions
changes in problem characteristics

**strategy**
emphasis on global issues instead of local subproblems



## Operation

of a blackboard system

**change** of a blackboard object
knowledge source makes a change
recorded in the control data area

**examination** of changes
each knowledge source examines the change
determines possible actions
reports them to the scheduler

**focus of attention**
the scheduler examines the possible contributions, and determines the focus of attention (knowledge source, blackboard object)

**execution**
the selected knowledge sources applies its suggested actions to the chosen blackboard objects

How does the system know when to stop?

## Blackboard Systems

advantages and disadvantages

+ flexibility: suitable for a diversity of problems
  diverse forms of input data
  large solution spaces
  pieces of knowledge from different sources must be coordinated
  goals may not be clearly defined, resulting in multiple lines of reasoning
+ distributed operation: very well suited for parallel and distributed systems
+ hierarchical organization
+ data abstraction
+ postponement of decisions
+ loose coupling: all knowledge is accessible through the blackboard
- very expensive: usually custom-built for each application
- partitioning of knowledge difficult
- complex development





## Chapter Review

Alternatives to Rule-Based Reasoning

**Introduction**
inadequacy of rule-based systems

**Semantic Networks**
graph specifying relationships between objects

**Frames**
internal structure of objects

**Blackboard Architectures**
opportunistic reasoning, distributed systems

**Chapter Review**