Knowledge Based Systems
Short Recapitulation

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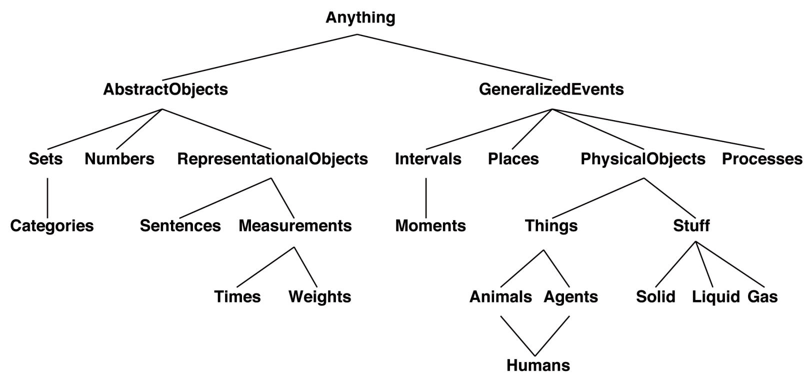
Ontology



Anything

AbstractObjects GeneralizedEvents

Sets Numbers RepresentationalObjects Intervals Places PhysicalObjects Processes

Categories Sentences Measurements Moments Things Stuff

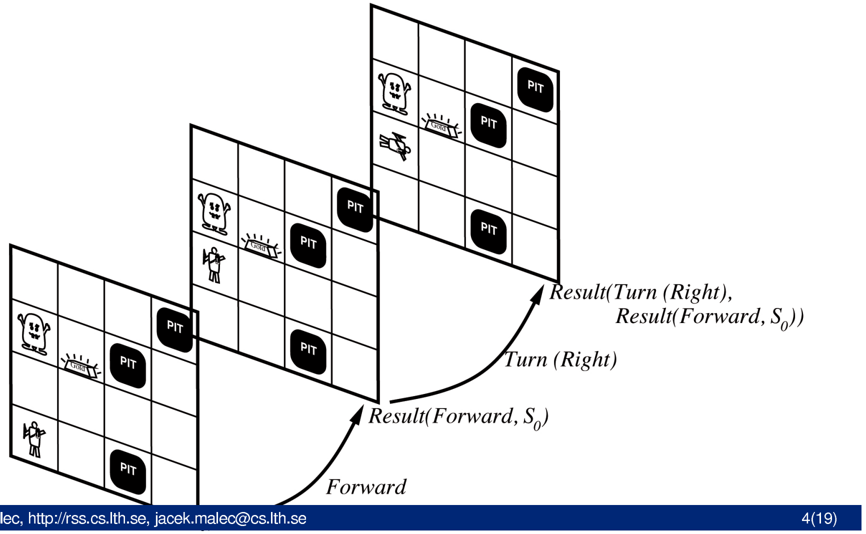
Times Weights Animals Agents Solid Liquid Gas

Humans

Problems with predicate logic:

- static
- flat
- qualification/ramification/frame problem
- exceptions
- strength
- ...

Actions, situations



Situation calculus

Action descriptions:

- possibility axioms (when is an action possible)
- effect axioms (what's its effect, what changes)
- frame axioms (what remains the same)
  Important issue!

Quite often we need richer ontology.

Describing actions

"Effect" axiom—describe changes due to action

$$\forall s\ AtGold(s) \Rightarrow Holding(Gold, Result(Grab, s))$$

"Frame" axiom—describe *non-changes* due to action

$$\forall s\ HaveArrow(s) \Rightarrow HaveArrow(Result(Grab, s))$$

"Successor-state axioms" solve the representational frame problem

Successor-state axioms

Each axiom is "about" a *predicate* (not an action per se):

P true afterwards	$\Leftrightarrow$	[an action made P true
	$\vee$	P true already and no action made P false]

For holding the gold:

$$\forall a, s\ Holding(Gold, Result(a, s)) \Leftrightarrow$$

$$[(a = Grab \wedge AtGold(s)) \vee (Holding(Gold, s) \wedge a \neq Release)]$$

Making plans

Initial condition in KB:
$At(Agent, [1, 1], S_0)$
$At(Gold, [1, 2], S_0)$

Query: $Ask(KB, \exists s\ Holding(Gold, s))$
i.e., in what situation will I be holding the gold?

Answer: $\{s | Result(Grab, Result(Forward, S_0))\}$
i.e., go forward and then grab the gold

This assumes that the agent is interested in plans starting at S_0 and that S_0 is the only situation described in the KB

Making plans: A better way

Represent *plans* as action sequences $[a_1, a_2, \ldots, a_n]$

$PlanResult(p, s)$ is the result of executing p in s

Then the query $Ask(KB, \exists p\ Holding(Gold, PlanResult(p, S_0)))$ has the solution $\{p | [Forward, Grab]\}$

Definition of *PlanResult* in terms of *Result*:
$\forall s\ PlanResult([\,], s) = s$
$\forall a, p, s\ PlanResult([a|p], s) = PlanResult(p, Result(a, s))$

Planning systems are special-purpose reasoners designed to do this type of inference more efficiently than a general-purpose reasoner (later today)

Knowledge-Based Systems

A generic term, might denote anything that involves encoded knowledge.
Or might mean a system where the knowledge component is *explicit* and manipulable.

Paradigms throughout history of AI:

- Logic-based systems;
- Rule-based systems (expert systems);
- Blackboard systems;
- Semantic web systems.

Rule-based systems

Or *expert systems*.

Promised much. Delivered (too) little. Back in the game in 2000s.

Simple architecture:

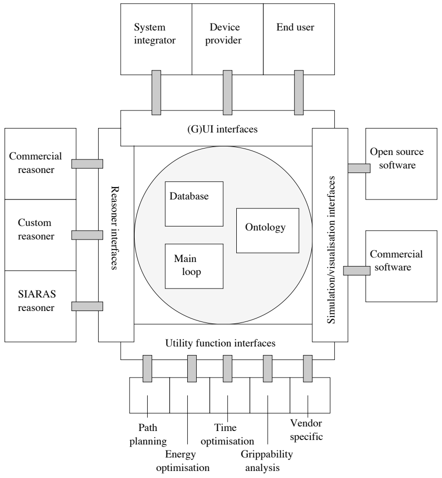
- Facts;
- Rules;
- Inference engine:
  - Matching;
  - Conflict resolution;
  - Rule application.

Blackboard systems

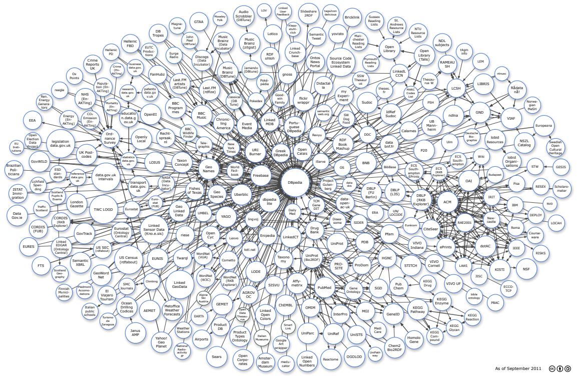
Architecture:

- Knowledge base (blackboard);
- Knowledge sources (expert problem solvers);
- Controller (agenda maintainer).

A blackboard system



Semantic Web



Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. `http://lod-cloud.net/`

Semantic Web

Lots of hype. Lots of acronyms. But some are important!

- URI – Uniform Resource Identifier
- RDF – Resource Description Framework
- RIF – Rule Interchange Format
- SPARQL – SPARQL Protocol and RDF Query Language
- OWL – Web Ontology Language

Open World Assumption!

SPARQL

W3C Recommendation

Queries:

- SELECT (returns a table)
- CONSTRUCT (returns RDF)
- ASK (returns a boolean)
- DESCRIBE (freedom)

Example:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name ?email
WHERE {
  ?person a foaf:Person.
  ?person foaf:name ?name.
  ?person foaf:mbox ?email.
}
```

A SPARQL query

What are all the country capitals in Africa?

```
PREFIX abc: <http://example.com/exampleOntology#>
SELECT ?capital ?country
WHERE {
  ?x abc:cityname ?capital ;
     abc:isCapitalOf ?y .
  ?y abc:countryname ?country ;
     abc:isInContinent abc:Africa .
}
```

A real SPARQL query

http://wiki.dbpedia.org/OnlineAccess
http://asimov.ludat.lth.se

```
select ?s where {
  ?s a rosetta:Camera.
}

select distinct ?s ?v where {
?s a rosetta:Camera.
?s ?p ?n.
?n caex-xml:hasName "FocusRange".
?n caex-xml:hasValue ?v.
}
```

Assignment 2a

Ready at last.

Task 3 asks you to investigate the library web world.