Diagnosis using Nonmonotonic Reasoning

- Model-based diagnosis or diagnosis from first principles is contrasted to heuristic diagnosis

- In model-based diagnosis, construct a causal model. If things go wrong, try to figure out what in the model isn't working.

- In heuristic diagnosis, consult experts to determine how they go about diagnosing a problem; then follow those steps

- Examples of heuristic diagnosis: MYCIN, MDs differential diagnosis

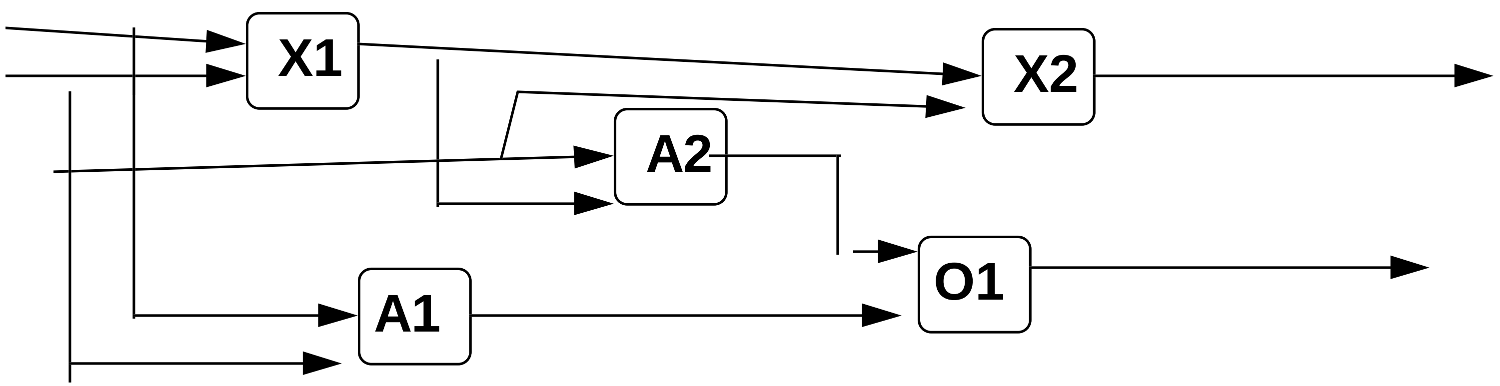
- Examples of model-based diagnosis: Reiter's system, DeKleer and Williams, Microsoft's current help system for Windows 95/98

- Reiter's system (theory) is a classic example of using nonmonotonic logic for diagnosis;   Microsoft uses Bayesian nets

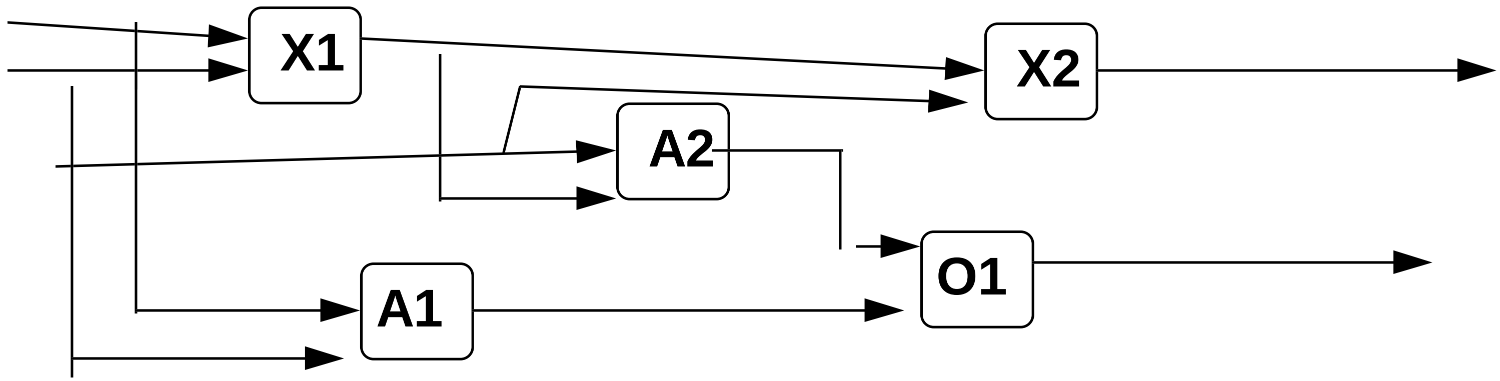
Reiter: A Theory of Diagnosis from First Principles

Developed to diagnose physical devices
Idea: Components usually work. We can specify default rules that say this, using McCarthy's abnormality predicates.
When a device doesn't work, some components will be abnormal.
The trick is finding out which those are.

The motivating example:



Formal definition: a system is a pair (SD, COMP)
where SD, the system description, is a set of first-order sentences and COMP, the system components is a finite set of constants

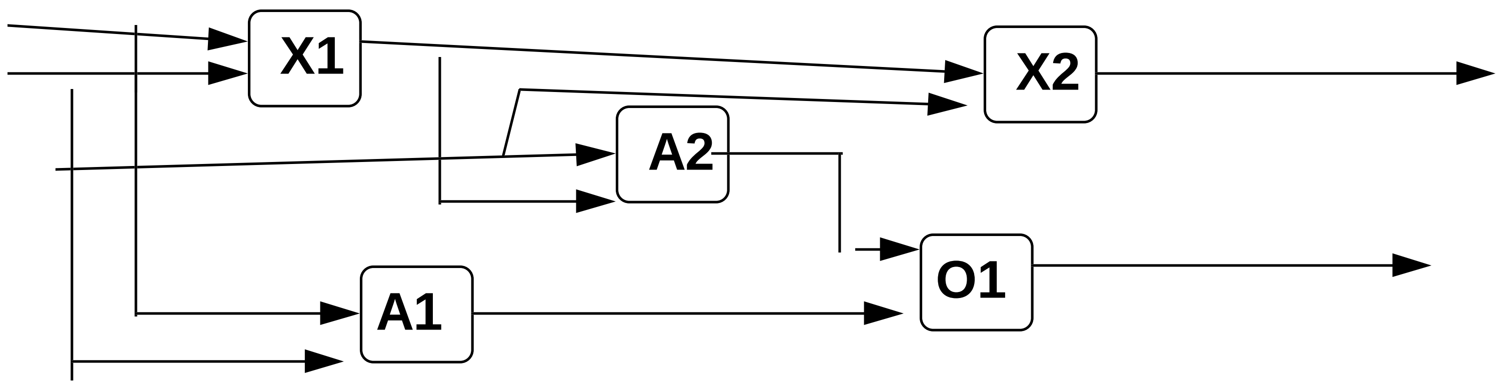


For example, the system above can be described as:
COMP = {A1, A2, X1, X2, O1)
andg(x) & ~ ab(x) => out(x) = and(in1(x), in2(x))
xorg(x) & ~ab(x) ==> out(x) = xor(in1(x),in2(x))
org(x) & ~ab(x) ==> out(x) = or(in1(x),in2(x))

out(X1) = in2(A2)　　in1(A2) = in2(X2)　　out(A1) = in2(O1)
out(X1) = in1(X2)　　in1(X1) = in1(A1)
out(A2) = in1(O1)　　in1(X1) = in2(A1)

Plus axioms that circuit inputs are binary valued; plus axioms of boolean algebra

Formally, an observation is a set of first-order sentences



For example, we might have the following observation for this system:

in1(X1) = 1 out(X2) = 1
in2(X1) = 0 out(O1) = 0
in1(A12) = 1

Thus, circuit is faulty.
Formally, system is faulty if
SD union {~Ab(c)| c in COMP} union OBS is inconsistent

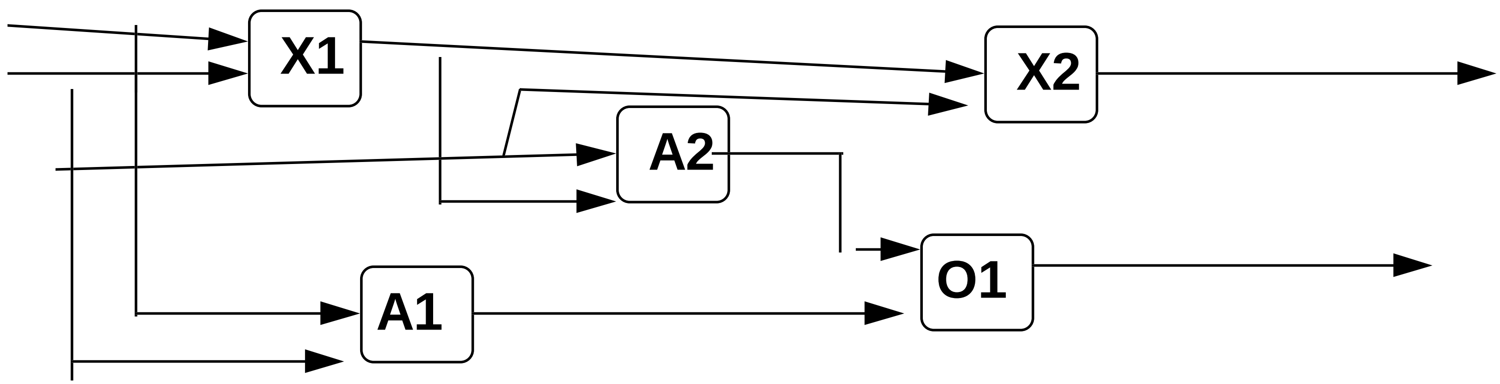
Intuitively: diagnosis is conjecture that certain components are faulty and the rest are normal.

Principle of Parsimony: diagnosis is a conjecture that some minimal set of components is faulty

Formally: Diagnosis for (SD, COMP, OBS) is a minimal set D subset of COMP such that
SD union OBS union {Ab(c) | c in D} union {~Ab(c)| c in COMP -D} is consistent

Turns out that D is determined by COMP - D, so can restate as:
Diagnosis is minimal D subset of COMP such that
SD union OBS union {~Ab(c) | c in COMP - D} is consistent.

Formally, an observation is a set of first-order sentences



in1(X1) = 1
in2(X1) = 0
in1(A12) = 1

out(X2) = 1
out(O1) = 0

In this case, there are 3 possible diagnoses:
{X1} {X2, O1} {{X2, A2}

How to compute D?

1. generate all subsets of COMP; check for inconsistency. Very inefficient

2. More efficient: formalize notion of conflict set, choose D such that
COMP - D is not a conflict set for (SD, COMP, OBS);
formalize notion of hitting set; get minimal hitting set;
tree-labeling algorithm given by Reiter