

Primitive and Derived Atoms

- A **primitive atom** is an atom that is defined using facts.
- A **derived atom** is an atom that is defined using rules.
- Typically, the designer writes axioms for the derived atoms and then expects a user to specify which primitive atoms are true.

Primitive and Derived Atoms

Consider two propositions, a and b , both of which are true.

- They can both be primitive, as in the knowledge base:

$a.$

$b.$

- Atom a can be primitive, and b derived:

$a.$

$b \leftarrow a.$

- Atom a can be derived, and b primitive:

$a \leftarrow b.$

$b.$

- Can they both be derived?

$a \leftarrow b.$

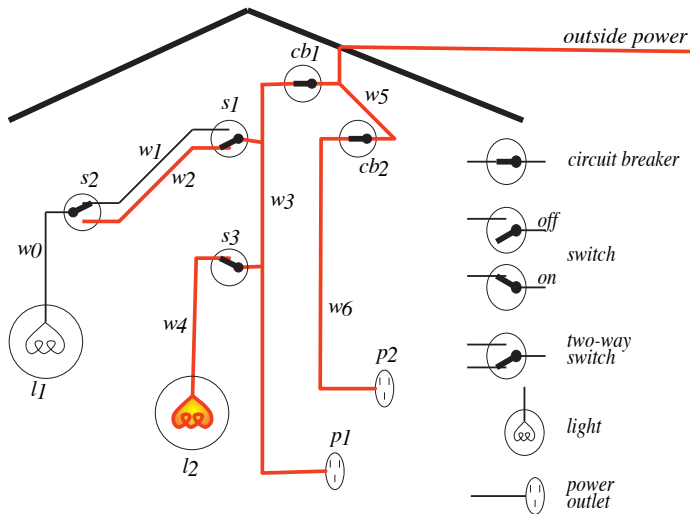
$b \leftarrow a.$

- What if the world changes to make a no longer true?
What happens to b ?

Causal Models

- A **causal model** is a representation of a domain that predicts the results of interventions.
- An **intervention** is an action that forces a variable (proposition) to have a particular value.
- An intervention on a variable changes the value of the variable in some way other than as a side-effect of manipulating other variables in the model.
- Other variables may be affected by an intervention on a variable.
- A **structural causal model** defines a **causal mechanism** for each atom. This causal mechanism specifies when the atom is true in terms of other atoms.
- If the model is manipulated to make an atom true or false, the clauses for that atom are replaced by the atomic fact or are removed.

Electrical Environment



Combining Evidential & Causal Reasoning

$$lit_l_1 \leftrightarrow (up_s_1 \leftrightarrow up_s_2) \quad (1)$$

is logically equivalent to

$$up_s_1 \leftrightarrow (lit_l_1 \leftrightarrow up_s_2).$$

This formula is symmetric between the three propositions; it is true if and only if an even number of the propositions are false.

- The relationship between these propositions is **not** symmetric:
 - ▶ Suppose both switches were up and the light was lit.
 - ▶ Putting s_1 down does not make s_2 go down to preserve lit_l_1 .
 - ▶ Putting s_1 down makes lit_l_1 false, and up_s_2 remains true.
- Structural causal model:

$$lit_l_1 \leftrightarrow (up_s_1 \leftrightarrow up_s_2)$$

$$up_s_1$$

$$\neg up_s_2$$

Structural causal model as logic program

- Structural causal model:

$$lit_l_1 \leftrightarrow (up_s_1 \leftrightarrow up_s_2)$$

$$up_s_1$$

$$\neg up_s_2$$

- As a logic program using negation as failure:

$$lit_l_1 \leftarrow up_s_1 \wedge up_s_2.$$

$$lit_l_1 \leftarrow \sim up_s_1 \wedge \sim up_s_2.$$

$$up_s_1.$$

- An evidential model

$$up_s_1 \leftarrow lit_l_1 \wedge up_s_2.$$

$$up_s_1 \leftarrow \sim lit_l_1 \wedge \sim up_s_2$$

can be used to answer questions about whether s_1 is up based on the position of s_2 and whether l_1 is lit.

It does not accurately predict the effect of interventions.