Default Reasoning

- When giving information, you don't want to enumerate all of the exceptions, even if you could think of them all.
- In default reasoning, you specify general knowledge and modularly add exceptions. The general knowledge is used for cases you don't know are exceptional.
- Classical logic is monotonic: If g logically follows from A, it also follows from any superset of A.
- Default reasoning is nonmonotonic: When you add that something is exceptional, you can't conclude what you could before.

Defaults as Assumptions

Default reasoning can be modeled using

- H is normality assumptions
- F states what follows from the assumptions

An explanation of g gives an argument for g.

Default Example

A reader of newsgroups may have a default:
"Articles about AI are generally interesting".

$$H = \{int\_ai(X)\},$$

where $int\_ai(X)$ means X is interesting if it is about AI.

With facts:

$$interesting(X) \leftarrow about\_ai(X) \wedge int\_ai(X).$$

$$about\_ai(art\_23).$$

$\{int\_ai(art\_23)\}$ is an explanation for $interesting(art\_23)$.

Default Example, Continued

We can have exceptions to defaults:

$$false \leftarrow interesting(X) \wedge uninteresting(X).$$

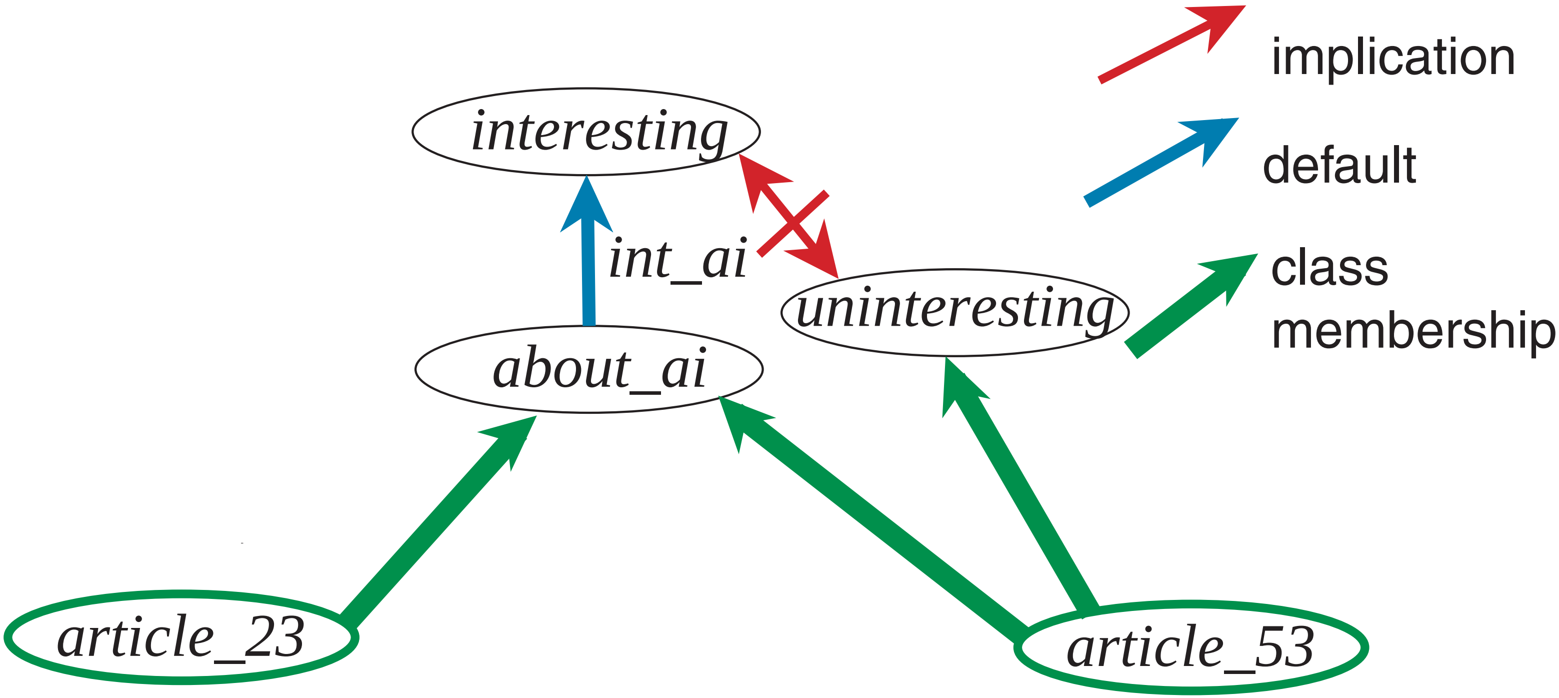
Suppose article 53 is about AI but is uninteresting:

$$about\_ai(art\_53).$$

$$uninteresting(art\_53).$$

We cannot explain $interesting(art\_53)$ even though everything we know about art_23 you also know about art_53.

Exceptions to defaults



Exceptions to Defaults

"Articles about formal logic are about AI."

"Articles about formal logic are uninteresting."

"Articles about machine learning are about AI."

$$about\_ai(X) \leftarrow about\_fl(X).$$

$$uninteresting(X) \leftarrow about\_fl(X).$$

$$about\_ai(X) \leftarrow about\_ml(X).$$

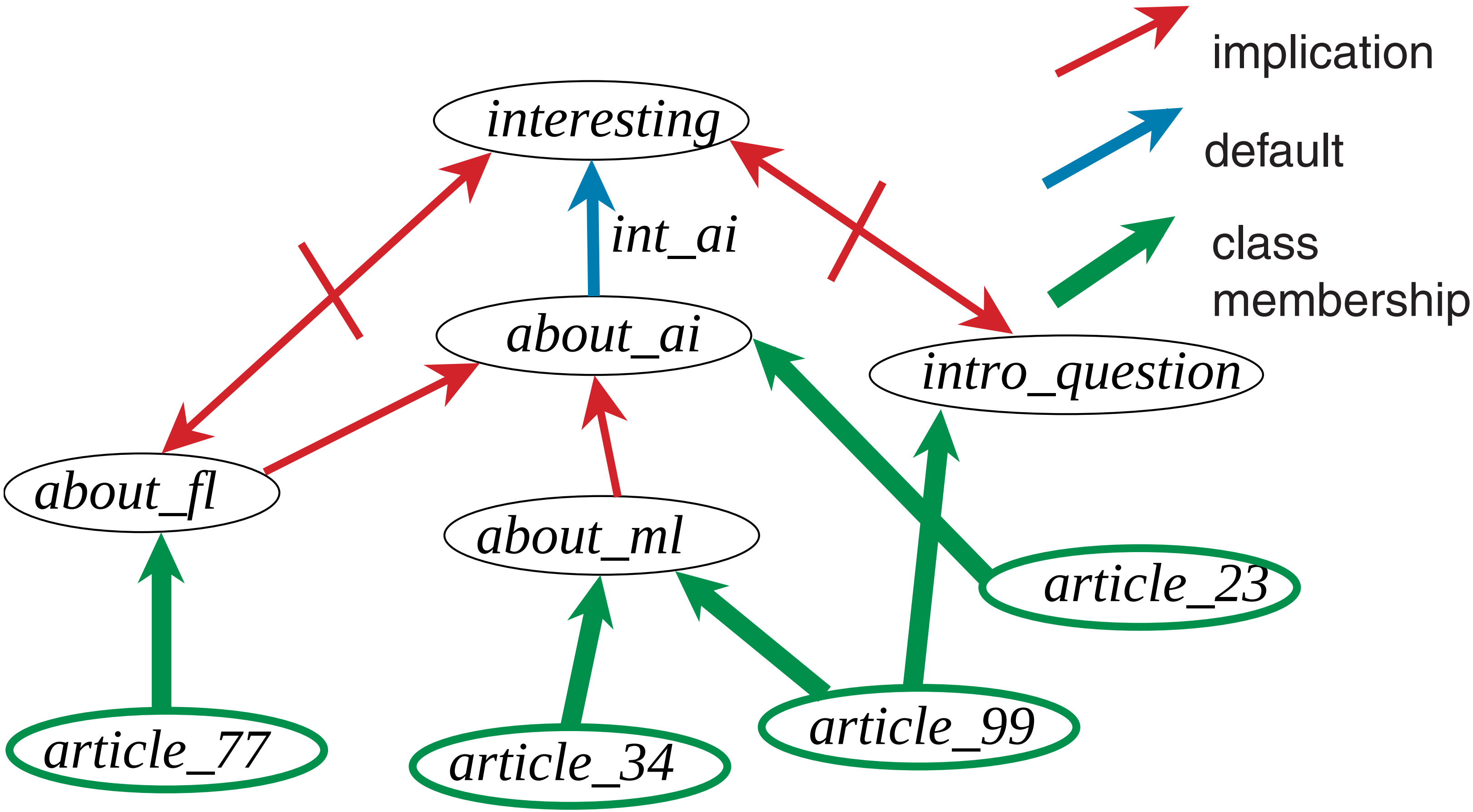
$$about\_fl(art\_77).$$

$$about\_ml(art\_34).$$

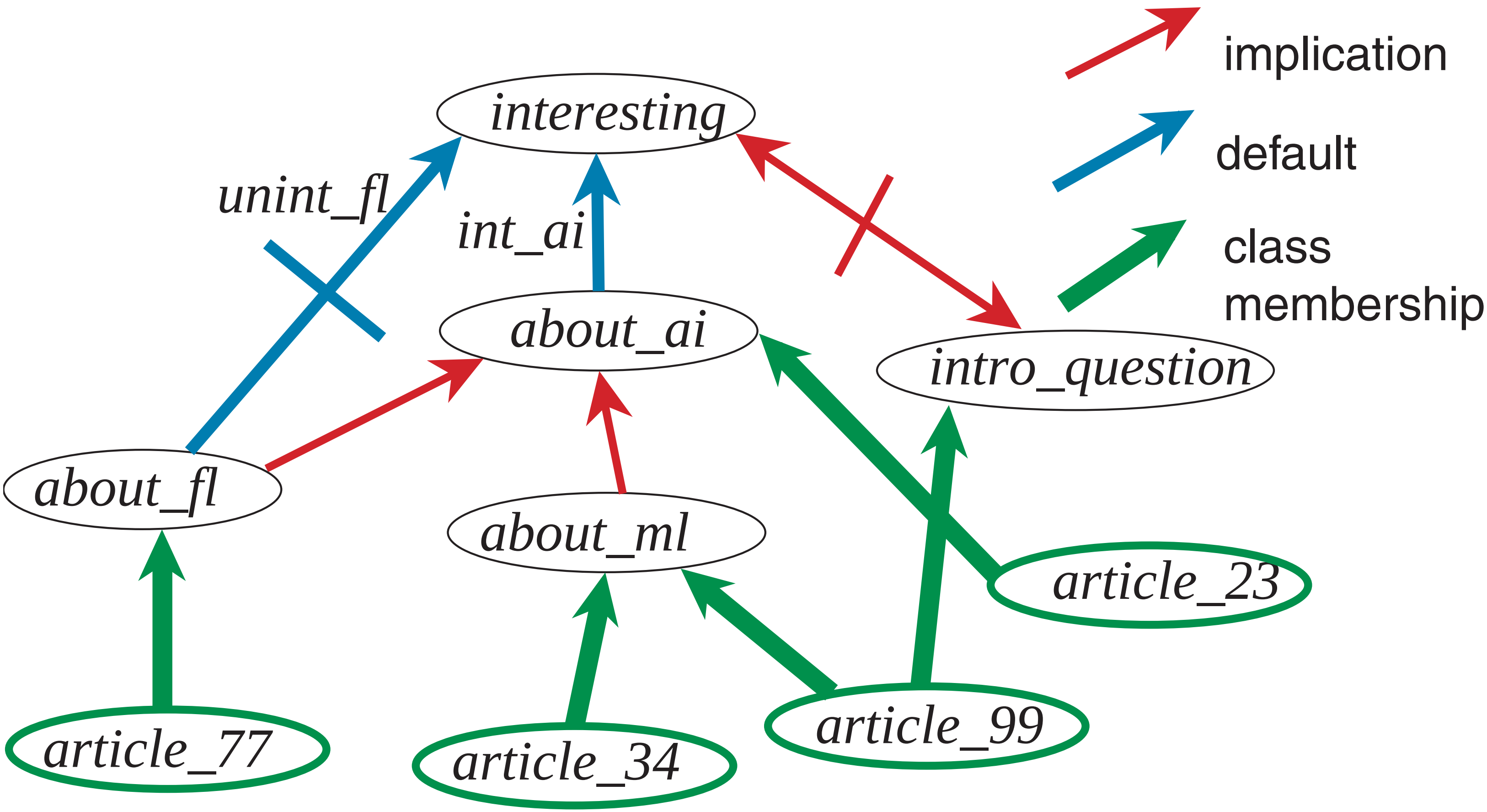
You can't explain $interesting(art\_77)$.

You can explain $interesting(art\_34)$.

Exceptions to Defaults



Formal logic is uninteresting by default



Contradictory Explanations

Suppose formal logic articles aren't interesting *by default*:

$$H = \{unint\_fl(X), int\_ai(X)\}$$

The corresponding facts are:

$$interesting(X) \leftarrow about\_ai(X) \wedge int\_ai(X).$$

$$about\_ai(X) \leftarrow about\_fl(X).$$

$$uninteresting(X) \leftarrow about\_fl(X) \wedge unint\_fl(X).$$

$$about\_fl(art\_77).$$

$uninteresting(art\_77)$ has explanation $\{unint\_fl(art\_77)\}$.

$interesting(art\_77)$ has explanation $\{int\_ai(art\_77)\}$.

Overriding Assumptions

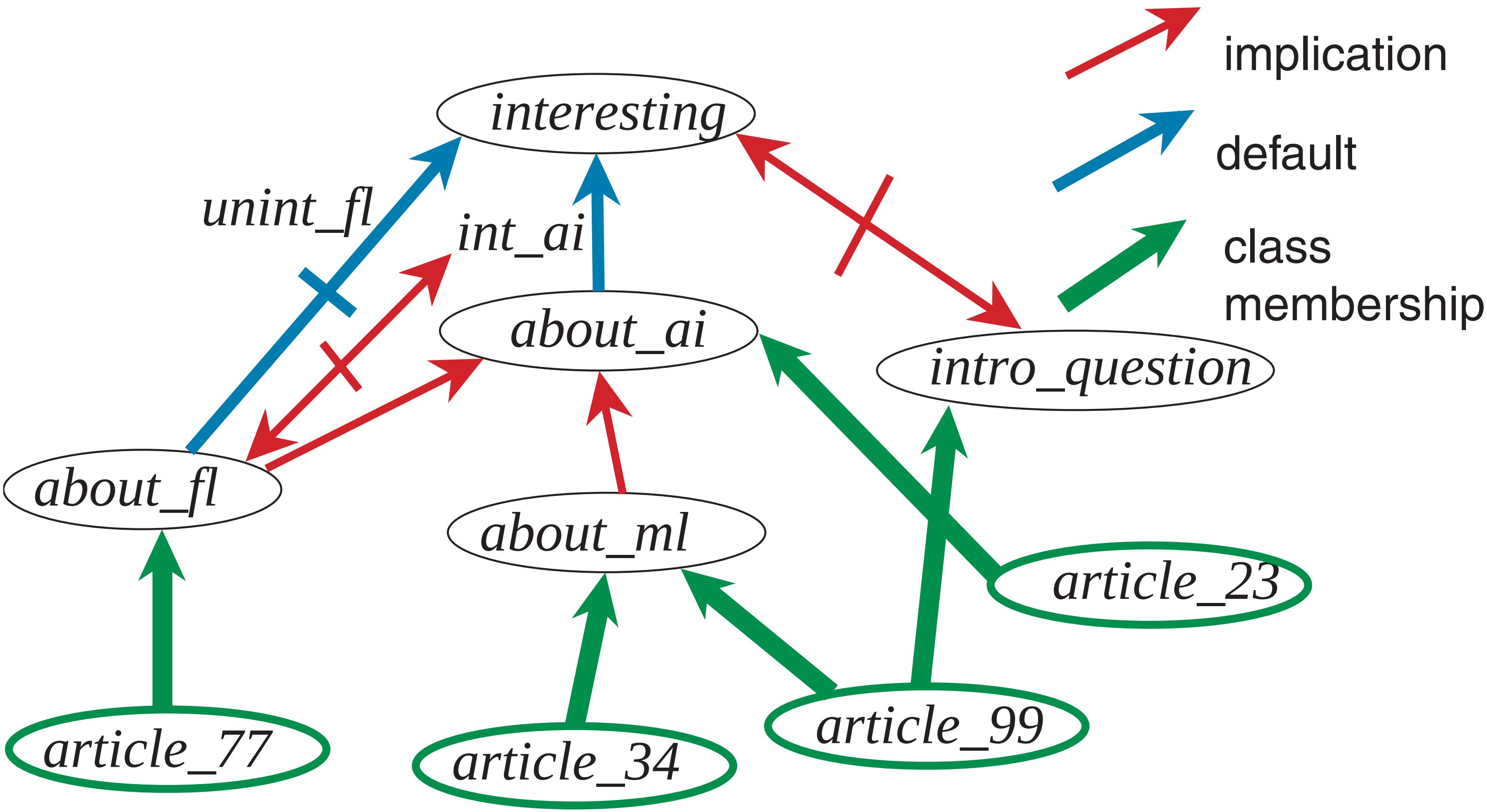
- Because *art_77* is about formal logic, the argument "*art_77* is interesting because it is about AI" shouldn't be applicable.
- This is an instance of preference for more specific defaults.
- Arguments that articles about formal logic are interesting because they are about AI can be defeated by adding:

$$false \leftarrow about\_fl(X) \wedge int\_ai(X).$$

This is known as a cancellation rule.

- You can no longer explain $interesting(art\_77)$.

Diagram of the Default Example



Multiple Extension Problem

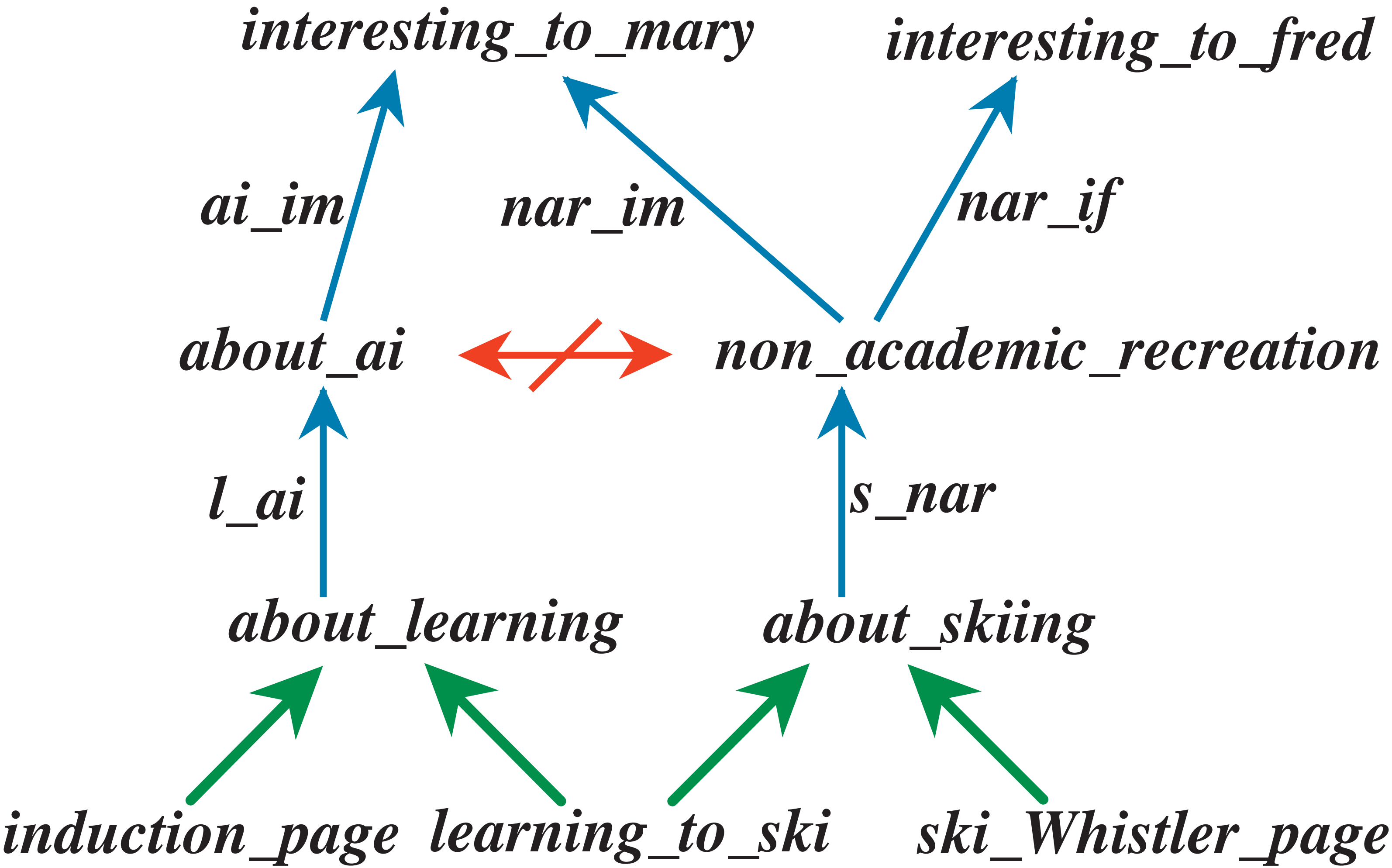
- What if incompatible goals can be explained and there are no cancellation rules applicable?
  What should we predict?

- For example: what if introductory questions are uninteresting, by default?

- This is the multiple extension problem.

- Recall: an extension of $\langle F, H \rangle$ is the set of logical consequences of F and a maximal scenario of $\langle F, H \rangle$.

Competing Arguments



Skeptical Default Prediction

- We predict g if g is in all extensions of $\langle F, H \rangle$.
- Suppose g isn't in extension E. As far as we are concerned E could be the correct view of the world. So we shouldn't predict g.
- If g is in all extensions, then no matter which extension turns out to be true, we still have g true.
- Thus g is predicted even if an adversary gets to select assumptions, as long as the adversary is forced to select something. You do not predict g if the adversary can pick assumptions from which g can't be explained.

Minimal Models Semantics for Prediction

Recall: logical consequence is defined as truth in all models.

We can define default prediction as truth in all **minimal models**.

Suppose M_1 and M_2 are models of the facts.

$M_1 <_H M_2$ if the hypotheses violated by M_1 are a strict subset of the hypotheses violated by M_2. That is:

$$\{h \in H' : h \text{ is false in } M_1\} \subset \{h \in H' : h \text{ is false in } M_2\}$$

where H' is the set of ground instances of elements of H.

Minimal Models and Minimal Entailment

- M is a minimal model of F with respect to H if M is a model of F and there is no model M_1 of F such that $M_1 <_H M$.
- g is minimally entailed from $\langle F, H \rangle$ if g is true in all minimal models of F with respect to H.
- Theorem: g is minimally entailed from $\langle F, H \rangle$ if and only if g is in all extensions of $\langle F, H \rangle$.