

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:

$$\textit{false} \leftarrow \textit{interesting}(X) \wedge \textit{uninteresting}(X).$$

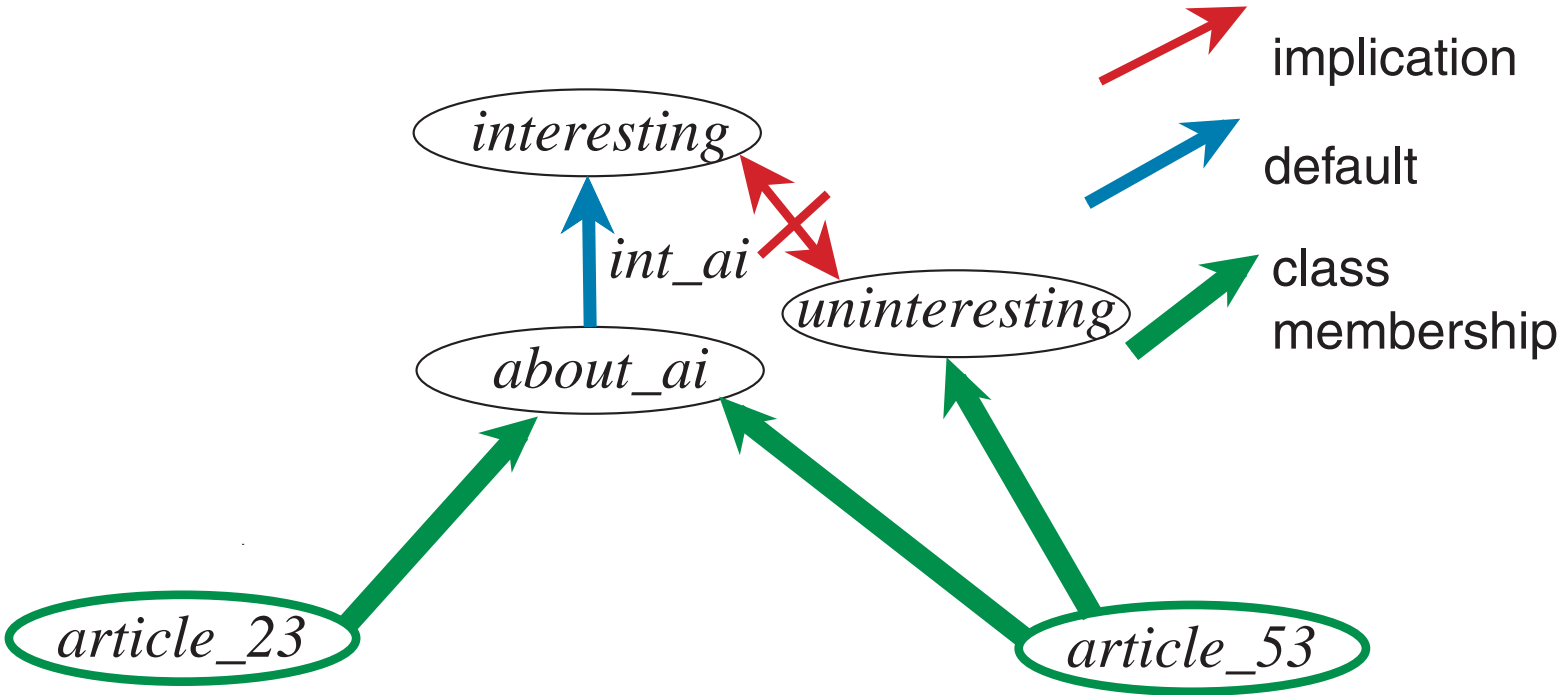
Suppose article 53 is about AI but is uninteresting:

$$\textit{about_ai}(\textit{art_53}).$$
$$\textit{uninteresting}(\textit{art_53}).$$

We cannot explain $\textit{interesting}(\textit{art_53})$ even though everything we know about $\textit{art_23}$ you also know about $\textit{art_53}$.



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.”

$about_ai(X) \leftarrow about_fl(X).$

$uninteresting(X) \leftarrow about_fl(X).$

$about_ai(X) \leftarrow about_ml(X).$

$about_fl(art_77).$

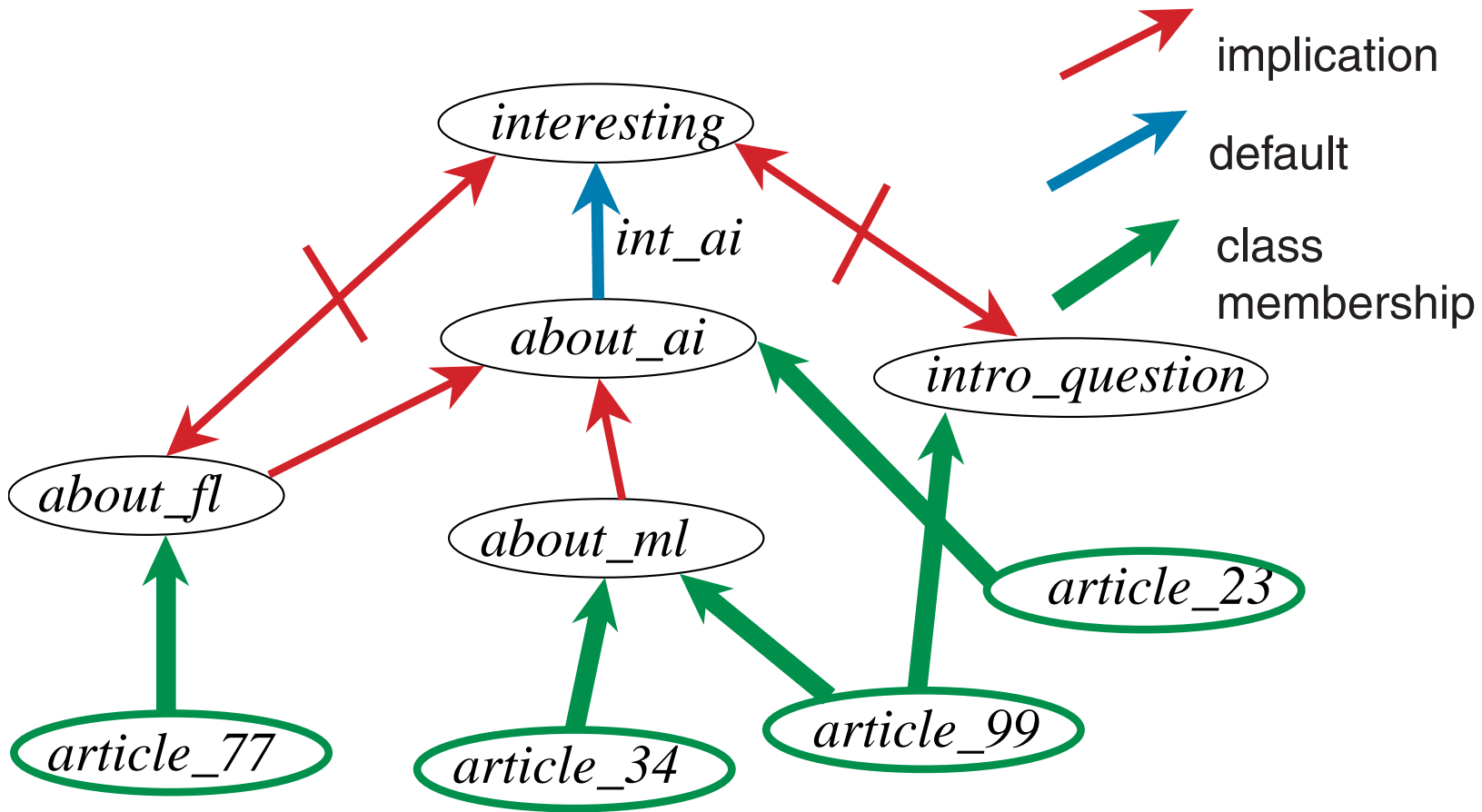
$about_ml(art_34).$

You can't explain $interesting(art_77).$

You can explain $interesting(art_34).$



Exceptions to Defaults



Contradictory Explanations

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

$$H = \{unint_fl(X), int_ai(X)\}$$

The corresponding facts are:

$$interesting(X) \leftarrow about_ai(X) \wedge int_ai(X).$$

$$about_ai(X) \leftarrow about_fl(X).$$

$$uninteresting(X) \leftarrow about_fl(X) \wedge unint_fl(X).$$

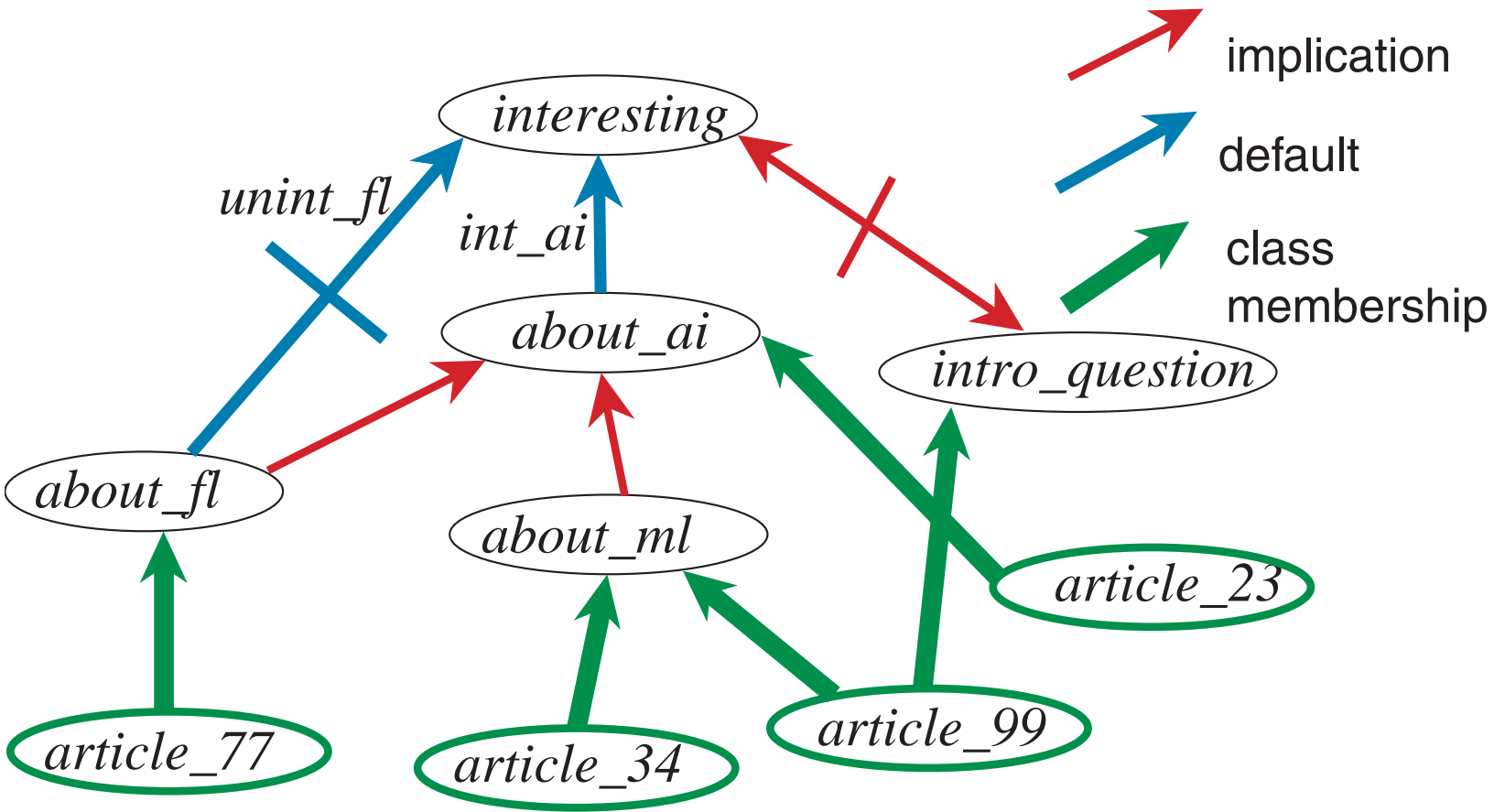
$$about_fl(art_77).$$

$uninteresting(art_77)$ has explanation $\{unint_fl(art_77)\}$.

$interesting(art_77)$ has explanation $\{int_ai(art_77)\}$.



Formal logic is uninteresting by default



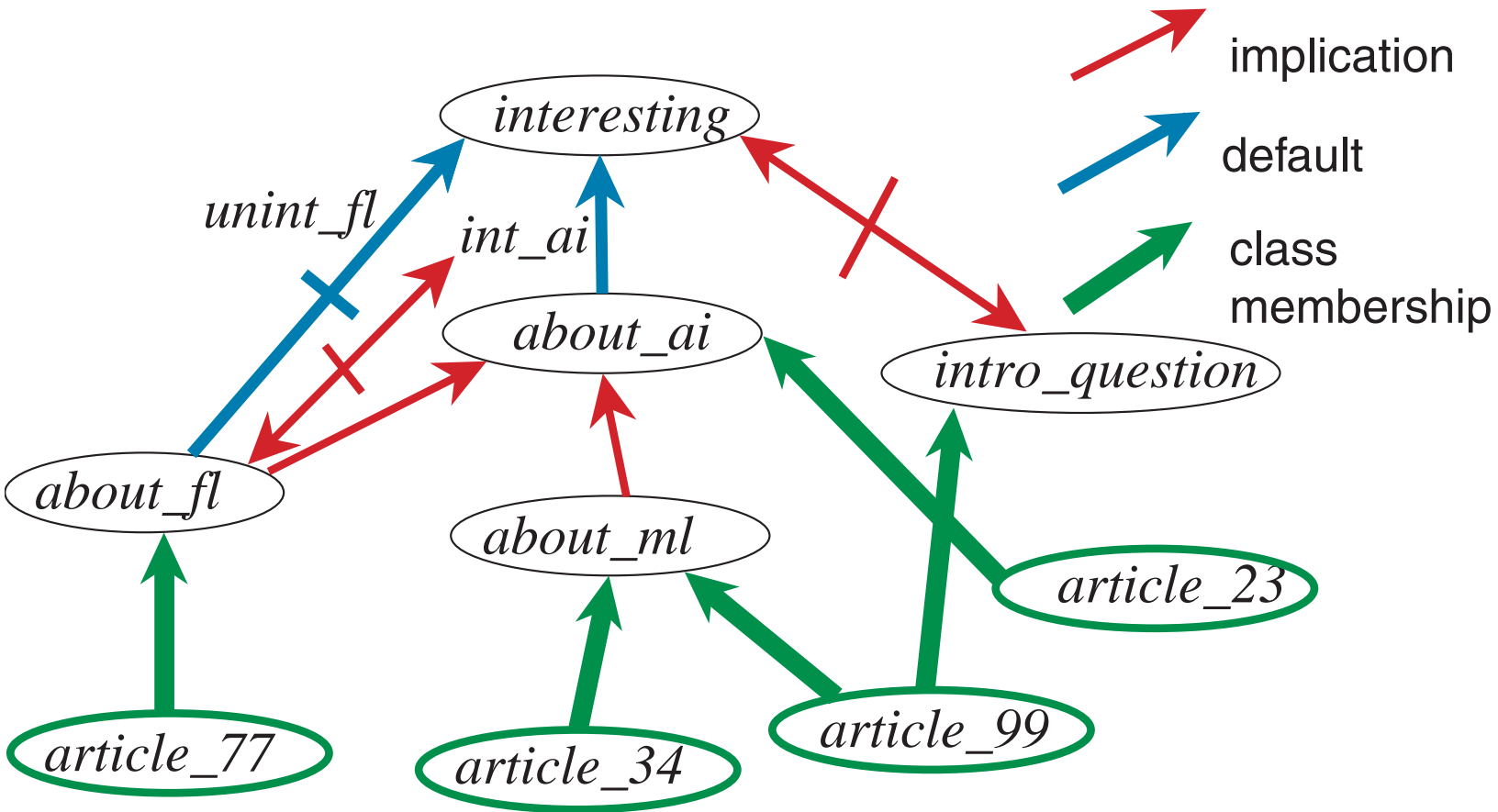
Overriding Assumptions

- 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)*.



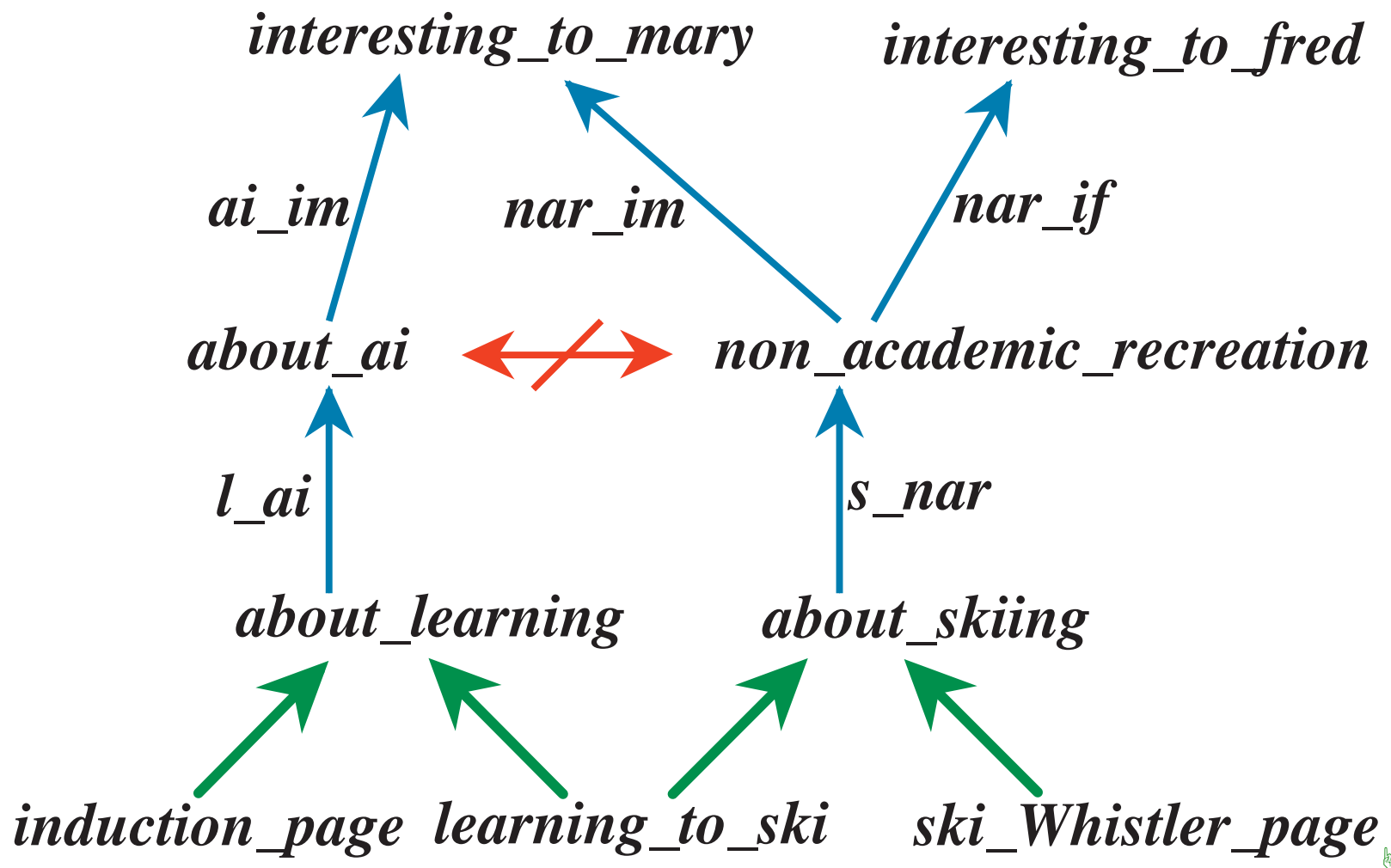
Diagram of the Default Example



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 $\langle F, H \rangle$.