

## Non-monotonic Logic

G. Aldo Antonelli  
University of California, Irvine

Contribution to appear in  
D.M. Borchert, ed., *Encyclopedia of Philosophy*  
MacMillan, 2005

Modern symbolic was developed beginning in the latter part of the nineteenth century for the purpose of formalizing mathematical reasoning, i.e., that process by which mathematicians arrive to conclusions on the basis of a small number of clear and distinct basic principles. This kind of reasoning is characterized by a particular type of cogency: the conclusions are not merely *probable* or *plausible* on the basis of whatever evidential support the basic principles might provide, but *certain* and *indubitable*. In particular, mathematical reasoning enjoys a property referred to as *monotonicity* by modern logicians: if a conclusion follows from given premises  $A, B, C, \dots$  then it also follows from any larger set of premises, as long as the original premises  $A, B, C, \dots$  are included.

By contrast, in many instances of ordinary or everyday reasoning, people arrive to conclusions only *tentatively*, based on partial or incomplete information, reserving the right to *retract* those conclusions should they learn new facts. Such reasoning is often called *defeasible* or *non-monotonic*, precisely because the set of accepted conclusions can become smaller when the set of premises is expanded.

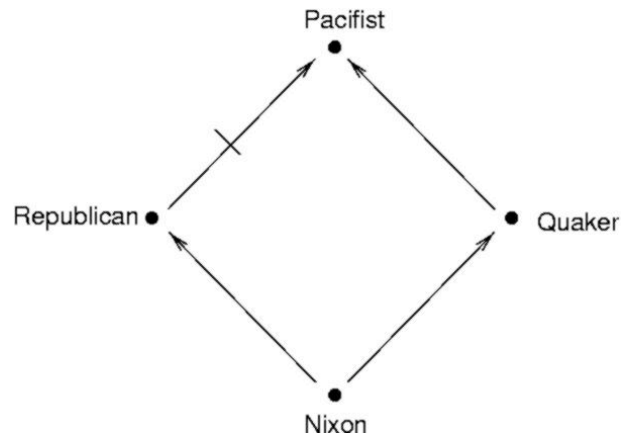
Taxonomies provide a rich source of examples of defeasible reasoning (but they are not by any means the only source). Suppose for instance that you are told that Stellanuna is a mammal. It is then natural to infer that Stellanuna does not fly, because mammals, by and large, are not capable of flight. But upon learning that Stellanuna is a

bat, such a conclusion is retracted in favor of the opposite one. In turn, even the new conclusion can be retracted upon learning that Stellanuna is a baby bat, and so on, in complex retraction patterns that seem to cry out for a systematization.

The aim of non-monotonic logic is precisely that of providing such a systematization. There is, in fact, no one thing which is called “non-monotonic logic,” but rather a family of different formalisms, with different mathematical properties and degrees of material adequacy, that aim to capture and represent such patterns of defeasible reasoning.

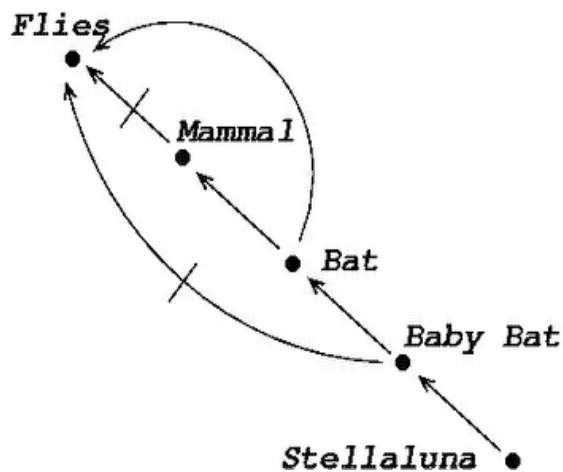
A broad class of non-monotonic formalisms can be characterized as “consistency-based” approaches. The name is derived from the fact that while all non-monotonic formalisms deal with conflicts between new facts and tentative conclusions in the same way (the facts win, and the conclusions are retracted), some of these formalisms also allow for potential conflicts between the tentative conclusions themselves (and then they might differ as to the way this second kind of conflicts are handled).

Non-monotonic inheritance networks provide a consistency-based formalism developed for the purpose of representing taxonomies. A non-monotonic inheritance network is a collection of nodes (each associated with a particular taxonomic category) and directed links between nodes, representing the subsumption relation between categories. Suppose for instance that you are told by a reliable (but fallible) source that Nixon is both a Quaker and a Republican, and that while Quakers, by and large, are pacifists, Republicans are not. The network corresponding to this situation is given below:



Obviously here we have a conflict between the two potential conclusions that Nixon is both and is not a pacifist. Steps need to be taken to maintain consistency. We will not get into the details here, but in general one can take a *credulous* approach and endorse one or the other conclusion, or one can take a *skeptical* approach and, in the presence of conflict, refrain from endorsing either conclusion.

Sometimes, special considerations such as *specificity* can be brought to bear on the resolution of conflicts in other inheritance networks. In the Stellaluna example above, for instance, one wants to conclude that bats fly (because information about bats is more specific than information about mammals) but that Stellaluna does not (because information about baby bats is more specific than information about bats). A network representing the situation is given below:



Inheritance networks are not well suited to deal with complex information (e.g., disjunctive or conjunctive statements). For this reason, a more expressive formalism, *default logic* was developed. The basic representation formalism of default logic is the *default inference rule*, a rule of the form  $\frac{A : B}{C}$ , whose intended interpretation is that if  $A$  is known, and we have no reason to reject  $B$  (i.e.,  $B$  is *consistent* with our knowledge base), then we can conclude  $C$ . Default logic provides a way for the consistency condition to be satisfied both *before* and *after* the default rule is applied.

Among the approaches to non-monotonic logic that are not consistency based, one needs to mention *circumscription*, which is based on the idea that many instances of defeasible reasoning have to do with the *minimization* of certain predicates, particularly those representing the set of *exceptions* to a given generalization. Circumscription uses the expressive power of second-order logic to ensure that any generalization has as few exceptions as possible. So, for instance, in the absence of information to the effect that bats are exceptional mammals, one would conclude that they do not fly, but when that information is adjoined to our knowledge base, circumscription immediately accounts for the exception.

**BIBLIOGRAPHIC REFERENCES**

- Antonelli, A., “ Non-monotonic Logic”, The Stanford Encyclopedia of Philosophy (Summer 2003 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/sum2003/entries/logic-nonmonotonic/>.
- Antonelli, A. “ Logic”, in L. Floridi (ed.), *The Blackwell Guide to the Philosophy of Computing and Information*, Blackwell, 2004, pp. 263-75.
- Gabbay, D., Hogger, C., and Robinson, J., (eds.), 1994, *Handbook of Logic in Artificial Intelligence and Logic Programming*, volume 3, Oxford and New York: Oxford University Press.
- Ginsberg, M., (ed.), 1987, *Readings in Nonmonotonic Reasoning*, , Los Altos, CA: Morgan Kauffman.