# Knowledge Design Patterns

## *A Three-Hour Tutorial*

**John F. Sowa**

To manage complexity, architects, engineers, and programmers develop *design patterns* as reusable building blocks for constructing systems. The idea is as old as Aristotle, who identified the basic patterns in logic, ontology, and methods of reasoning. Aristotle represented the patterns in a controlled natural language (CNL) supplemented with variables, which other logicians translated to various graphic and algebraic notations. For computer systems, the patterns of logic and ontology are combined with methods for representing data, time, and processes in an often bewildering variety of ways. This tutorial is divided in three parts: historical developments from Aristotle to the 19th century; patterns of modern logic in algebra, graphics, and CNLs; and combinations of those patterns with computational techniques.

1. **Historical:** Aristotle's ontology and syllogisms. Tree of Porphyry for hierarchies of categories. Ramon Lull's rotating circles for reasoning about the categories. An algebra by Leibniz that integrates Porphyry and Lull. Chinese ontology of Yin and Yang, which led to 64 hexagrams, which inspired Leibniz to invent binary arithmetic. George Boole's binary algebra for representing propositions, sets, and monadic predicates. John Venn's overlapping circles for representing sets and relating them to syllogisms.
2. **Modern logic:** Tree diagrams by Frege, algebraic notation by Peirce and Peano, and nested graphs by Peirce. Patterns of inference in trees, algebra, and graphs. Patterns of modal logic, temporal logic, metalogic, higher-order logic, nonmonotonic logic, and fuzzy logic. Expressing those patterns in controlled NLs. Common Logic as a unifying semantics.
3. **Computational:** Combining logic and ontology with data and process representations. Graphic notations for Petri nets, Entity-Relationship diagrams, Unified Modeling Language (UML), semantic networks, concept maps, topic maps, and conceptual graphs. Relating those notations to databases, the Semantic Web, and Linked Open Data (LOD).

**Level of presentation:** Intermediate.

**Prerequisites:** Knowledge of any two notations mentioned above.

**About the speaker:** John F. Sowa is a co-founder of VivoMind Research, LLC. During a 30-year career at IBM, he worked on R & D projects in systems architecture, artificial intelligence, knowledge representation, and computational linguistics. He has published many books and papers on these topics and taught courses about them at IBM, universities, and summer institutes. He is a Fellow of the AAAI and has participated in various standards projects, including ISO/IEC 24707 for Common Logic.