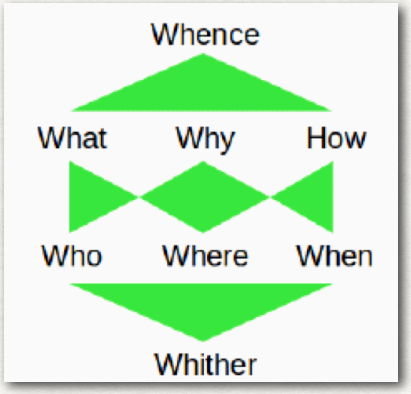
ONTOLOGY COMES OF AGE: FROM AD-HOC WORLD MODELS TO SCIENCE OF AGENTS' MODEL WORLDS



JANET SINGER
ONTOLOGY SUMMIT RETROSPECTIVE PANEL, FEBRUARY 25, 2026
JANET.SINGER@INCOSE.NET

20 YEARS OF SUMMITS: CHALLENGES AND PARTIAL RESULTS

- 2006: the “Upper Ontology Summit”
- 2007: Ontology, taxonomy, folksonomy: Understanding the distinctions
- Accomplishments: Partial harmonizations (e.g., domain ontologies, Semantic Web subsets); foundational work on interoperability; sustained community and education
- Still no shared understanding of
  - What an ontology is, and how ontologies are related to conceptualizations, theories, semantics, intelligence, knowledge, agency, etc.
  - Interoperability scope/scale: Who or What needs to be interoperable? How much needs to be interoperable? Where/When is interoperability needed?

> “We like to think of AI as a challenge to human intelligence. But what if the real problem isn’t how smart AI is becoming—but how little we understand what we mean by knowledge?” (Nguyen, Vuong 2025)

HOW WE GOT HERE: MCCARTHY ON AI AND PHILOSOPHY

"We shall say that **an entity is intelligent if it has an adequate model of the world** (including the intellectual world of mathematics, understanding of its own goals and other mental processes)…

Since the philosophers have not really come to an agreement in 2500 years it might seem that artificial intelligence is in a rather hopeless state if it is to depend on getting concrete enough information out of philosophy to write computer programs. **Fortunately, merely undertaking to embody the philosophy in a computer program involves making enough philosophical presuppositions to exclude most philosophy as irrelevant."**

(John McCarthy and Patrick J. Hayes, 1969)

HOW WE GOT HERE: GRUBER ON ONTOLOGY

"A body of formally represented knowledge is based on a **conceptualization: the objects, concepts, and other entities that are presumed to exist in some area of interest** and the relationships that hold them (Genesereth & Nilsson, 1987). **A conceptualization is an abstract, simplified view of the world** that we wish to represent for some purpose. Every knowledge base, knowledge-based system, or knowledge-level agent is committed to some conceptualization, explicitly or implicitly.

An ontology is an explicit specification of a conceptualization. The term is borrowed from philosophy, where an ontology is a systematic account of Existence. For knowledge-based systems, what 'exists' is exactly that which can be represented."

(Tom Gruber, 1993)

MCCARTHY 1989: APPLYING SPEECH ACT THEORY TO COMPUTERS

"**Requests, permissions and promises** such as those we want Elephant programs to perform **are** called speech acts by philosophers and linguists. The idea is that **certain sentences don't have only a declarative significance but are primarily actions.** A paradigmatic example is **a promise**, whose utterance **creates an obligation to fulfill it and is** therefore **not merely a statement of intention to do something."**

- **Locutionary acts**: the basic, literal act of producing **a meaningful linguistic expression**, such as a word, phrase, or sentence.
- **Illocutionary acts:** What **the speaker** does **by uttering the sentence** (e.g., promising, requesting, questioning, accepting, offering, permitting). These are performative: saying "I promise to deliver the package" **creates an obligation**.
- **Perlocutionary acts: The effect the utterance** has **on the listener or world** (e.g., convincing someone, getting them to act, or actually causing a plane to land safely).

- **A program's correctness was to be judged by whether it performed those acts properly.**

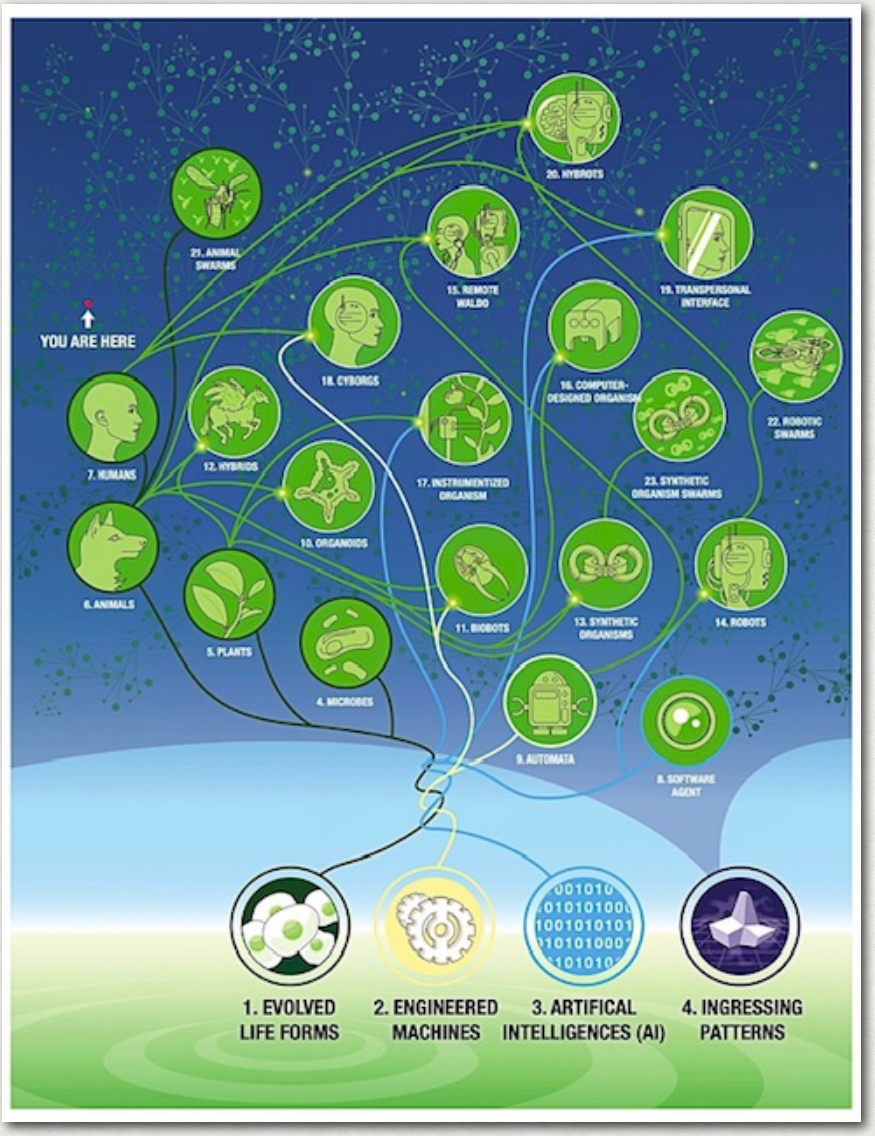
FROM ARTIFICIAL INTELLIGENCE TO COLLECTIVE MULTI-AGENT INTELLIGENCE

"We are all **collective intelligences** – not just ants and bee colonies, but all of us, because we are made of parts (cells), which have to become **aligned to work together** to give rise to a system that has memories, preferences, and goals that don't belong to any of them."

"**Collective intelligence is different than that of its parts** because it often works in different problem spaces, but it's not necessarily greater or more advanced (although it often is)."

"No individual cell knows what a finger is or how many fingers you're supposed to have but the collective absolutely does."

Michael Levin, Developmental biologist, director of the Allen Discovery Center at Tufts University, associate editor of Collective Intelligence Journal



REFRAMING ONTOLOGIES AS MODEL WORLD COMMITMENTS

Aspect	Old: 'God's Eye View' Model of the world	New: Agent-relative model worlds
Ontology definition	A formal explicit specification of a shared conceptualization of what 'exists'	The categorical commitments that ground/construct an agent's capabilities
Ontology Goal	Unified, authoritative model of single reality; shared by humans/classic AIs (FOL/computationalist)	Diverse *Umwelten* relative to agents; interoperation in collective intelligence
Relation to Philosophy	Uncomfortable hybrid of analytic philosophy and unexamined metaphysics	Science-based: critical metaphysics, biosemiotics, speech acts, cybernetics,
Agent Focus	Binary: Humans and machines	Multi-agent: In vivo/in silico, collectives tacit/implicit/ explicit commitments
Validity	Objective universality	Intersubjective relational congruence as well as objective standards in empirical science

KANT'S CRITICAL TURN & EXTENSIONS (PEIRCE, REINACH, UEXKÜLL, ROSEN)

- Immanuel Kant spent decades prompted by David Hume's empiricist challenge:
  - One should not go beyond one's own experience into metaphysical speculation.
  - There was no empirical ground for judging whether causal relationships held between events.
- Kant concluded that not only causality but other 'metaphysical' categorical judgments of quality, quantity, modality, substance, interdependence could not be directly established by observation.
- This did not mean there was no objective basis for those categorical judgments and predications, but they had an objective basis as the innate grounds of what made understanding, intelligence, science, etc. possible for all rational beings.
- On the other hand, attempting create a 'God's-eye-view' world model without grounding in the judgment of the subject was metaphysically incoherent.

PEIRCE AND UEXKÜLL: SEMIOTICS BUILDING ON KANT

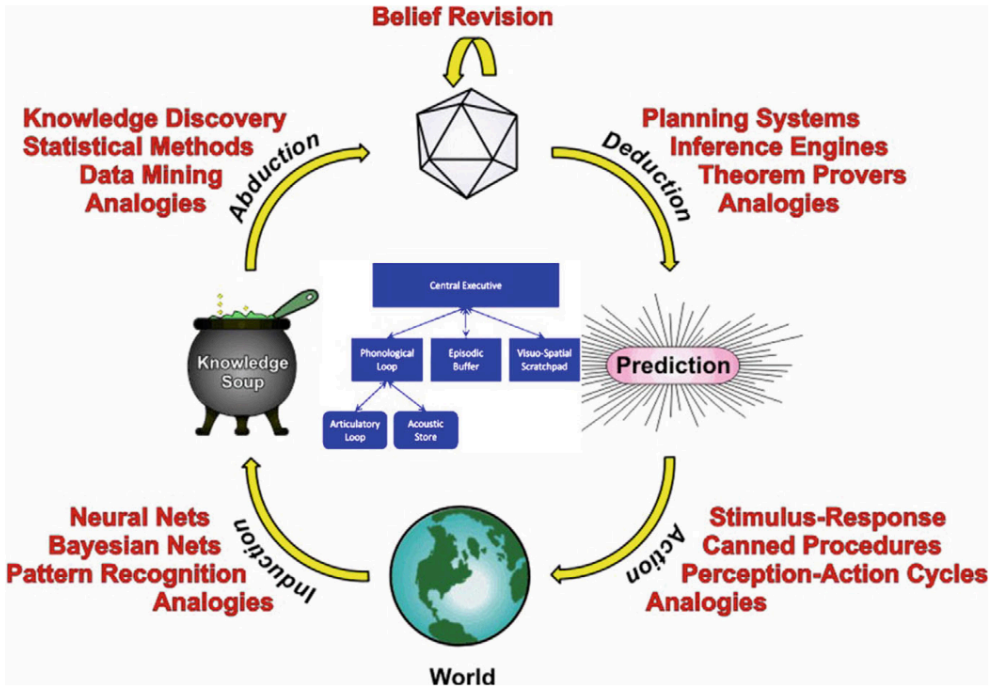


Fig. 5.19 Design for an AI system based on Peirce's theories and cognitive science

- Peirce: "The action of a sign generally takes place between two parties, the utterer and the interpreter. They need not be persons... many kinds of insect, and even plants make their livings by uttering signs" (1907)
- Uexküll: "Every subject weaves its own sensations into a functional structure, which fits it." "Thus we ultimately reach the conclusion that each subject lives in a world composed of subjective realities alone, and that even the Umwelten themselves represent only subjective realities." (1934)

ONTOLOGY COMES OF AGE FOR TRANS-SPECIES CI

- Opportunities:
  - Provides a metaphysically coherent and scientifically grounded basis for ontologies
  - Key to understanding, developing, and working with diverse intelligences — in vivo/in silico, hybrids, and collectives
- Challenges:
  - Bridging computationalist/enactive paradigms of cognition
  - Modeling ‘sub-discursive’ cognition of animals, machines, abstract collectives as ‘agents’ capable of effective operation and interoperation
  - Identifying and representing tacit/implicit ontological commitments of agents in addition to explicit ones
  - Managing interoperation in terms of both model worlds of participating subject agents and unexpected incidental/accidental effects from worlds ‘outside’ their expectations

MOTIVATING QUESTION OF NEURAL NETWORKS

"What is a number that a man may know it and
the man that he may know a number?"

–Warren McCulloch (Cybernetics and neural networks pioneer, 1961)

PROPOSED MOTIVATING QUESTION OF ONTOLOGY

"What is an ontology that it may guide an agent and an agent that it may reflect an ontology?"

REFERENCES

- Gruber, Thomas R. “A translation approach to portable ontology specifications.” Knowledge acquisition 5.2 (1993): 199-220. (link)
- Kant, Immanuel. Prolegomena to any future metaphysics (1783).
- Levin, Michael: “Cognitive glue: stress sharing and memory anonymization holding together anatomical intelligence” (2025, link); “Are we too part of a greater collective intelligence? How would we know?” (2024, link); “Michael Levin: Hidden Reality of Biological Life” (2025, link)
- McCarthy, John, and Patrick J. Hayes. "Some philosophical problems from the standpoint of artificial intelligence." *Readings in artificial intelligence*. Morgan Kaufmann, 1981. 431-450. (link)
- McCarthy, John. "Elephant 2000: A programming language based on speech acts." Conference on Object Oriented Programming Systems Languages and Applications: Companion to the 22nd ACM SIGPLAN conference on Object oriented programming systems and applications companion. Vol. 21. No. 25. 2007. (link)
- McCulloch, Warren S. "What is a number, that a man may know it, and a man, that he may know a number." *General Semantics Bulletin* 26.27 (1961): 7-18. (link)
- Nguyen, M., Vuong, QH. “Navigating the new landscape of knowledge in the age of generative AI.” AI & Soc 40, 6503–6504 (2025). (link)
- Sowa, John F. "Phaneroscopy: A Science of Diagrams." Phenomenology and Phaneroscopy: A Neglected Chapter in the History of Ideas. Cham: Springer Nature Switzerland, 2024. 113-151. (link)
- Von Uexküll, Jakob. A foray into the worlds of animals and humans: With a theory of meaning (Vol. 12) (1934).