

## Semantics empowered Physical-Cyber-Social systems

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The role of semantics for interoperability, integration, and improved querying has been investigated for a few decades. Coining of the term 'Semantic Web' brought focus to using semantics and metadata initially to the Web documents. As the Web provided useful mechanisms to access and use new types of resources--richly represented data, services, user generated content and other social data, sensor and devices (WoT) data--techniques increasingly moved from syntactic and structural to semantic ones. Compared to the semantic systems built using Semantic Web languages, standards and mainstream Semantic Web technologies, however, more systems are being built using informal and implicit forms of semantics rather than formal representations of semantics.<sup>1</sup> One reason is that the role of the Web is increasingly becoming diffused and incidental (e.g., more people access content through applications compared to the Web browsers). The second reason is that lighter-weight approaches have led to better developer and user engagements, and have become a lot more scalable. Apple Siri, IBM Watson, and Google Knowledge Graph, are excellent examples of using semantics at scale, but where the formal form of semantic representation or RDF/SPARQL have not found a place. All these lead me to think that 10 years from now, Semantic Web would be thought of as something that popularized the core value proposition of semantics -- better search, interoperability/integration and analysis -- to deal with and exploit a vast variety of things that the Web (and its on going transformations) interconnects. An analogy that comes to mind is that of Object Oriented Databases which generated huge excitement in the 1980s, and indeed has a number of secondary impacts, but it only remained a niche technology, product class and market. Simultaneously, Semantic Web is increasingly merging with other powerful technologies that support semantics, including Machine Learning, NLP, and Knowledge-based systems where background knowledge is applied. Consequently, what we think of as rather distinct Computer Science areas today will not retain strong distinctions, but will broadly incorporate semantics.

While making a 10 year forecast is foolhardy, a vision that has been forming in my head since I first broached it in 2008 is Computing for Human Experience.<sup>2</sup> It has a long lineage, starting in part with Vannevar Bush's Memex through Mark Weiser's "Computing in the 21st Century" and others. But the essence of the vision incorporates technology that serves human needs without explicit human effort to use the technology. The coming decade will see unique opportunities with the evolution of physical-cyber-social systems that will involve the following (among several other) areas of significant progress:

- make human interaction with technology very natural (e.g., gesture computing); blur the differences between human's physical, cyber and social presence
- incorporate powerful ways the human brain works into the fabric of computing and communication (significant progress from neuroscience to cognitive science, and the resulting ability to model and mimic the human brain or thinking processes)
- bring the physical world, cyberspace and human closer with the help of devices around, on and inside human body
- continuously and dynamically create collective intelligence and background knowledge, combine that with historical and common sense knowledge, and contextually apply relevant knowledge and experiences to enhance technological support at all levels of physical-cyber-social systems (i.e., [continuous semantics](#)).

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<sup>1</sup> A. Sheth, C. Ramakrishnan, and C. Thomas, 'Semantics for The Semantic Web: the Implicit, the Formal and the Powerful', *International Journal on Semantic Web & Information Systems*, 1 (1), 2005, pp. 1-18.

<sup>2</sup> Keynote talks on "[Computing for Human Experience: Semantics Empowered Cyber-Physical, Social and Ubiquitous Computing Beyond the Web](#)". First given at ASWC 2008; last given at On-the-Move Federated Conferences 2011. Also, vision article in IEEE Internet Computing: [http://knoesis.org/index.php/Computing\\_For\\_Human\\_Experience](http://knoesis.org/index.php/Computing_For_Human_Experience)