History of Interoperability

1900 to 1959: Data representation and formatting.
  ● From punched cards to COBOL records and RPG reports.
  ● Fortran, LISP, COBOL, Algol, formal grammars.

1960s: Multiple concurrent programs that use the same data.
  ● Data structures, databases, data models, locking, virtual memory.
  ● PL/I, APL, SNOBOL, Simula 67, Pascal, Algol 68, formal semantics.

1970s: DB wars, Conceptual schema, Expert systems.

1980s: Knowledge bases, object-oriented systems.

1990s: Shared reusable KBs, Need for ontologies, RDF.

2000s: Semantic Web, large ontologies, but slow adoption.

2010s: Success stories, but a slow adoption rate.

For a review of developments from 1980 to the present, see http://www.jfsowa.com/ikl
The Conceptual Schema

Shared ontology to resolve the database wars of the 1970s.

- Discussions led to an ANSI technical report in 1979.
- Further discussions led to an ISO technical report in 1987.
- The Semantic Web became the next great hope.
DARPA Agent Markup Language

The diagram summarizes the requirements for the DAML project.

- From a report by Jim Hendler, the DARPA project manager. *
- The PI of winning proposal was Tim Berners-Lee.

* See http://www.jfsowa.com/ikl/Hendler00.pdf
The diagrams show the evolution of the DAML project.

- The winning proposal in 2000 added detail to Hendler's version.
- The diagram of 2001 moved logic to the side.
- In the final report, the “unifying logic” looks like an afterthought.

Hendler wrote that DAML must support heterogeneous systems.

- Tim B-L emphasized heterogeneous systems in his proposal.
- But the final report does not mention the word 'heterogeneous'.
Approaches to Interoperability

A map of the heterogeneous methods that must be related. *

- Methods at the top address semantic issues.
- Methods in the middle address the external interfaces.
- Methods at the bottom address the low-level APIs.

Human Interfaces

- Controlled English
- Controlled Spanish
- FLIPP Diagrams
- Topic Maps
- Concept Maps
- UML Diagrams

Machine Interfaces

- Common Logic
  - XCL
  - SQL
  - Prolog
  - RDF(S)
  - OWL
  - OCL
  - Datalog
  - RuleML
- CGIF
- CLIF
IKRIS Project

DoD-sponsored project: Design an Interoperable Knowledge Language (IKL) as an extension to Common Logic.

Goals:
- Enable interoperability among advanced reasoning systems.
- Test that capability on highly expressive notations for logic.

Show that semantics is preserved in round-trip mapping tests:
- Cycorp: Cyc Language $\rightarrow$ IKL $\rightarrow$ CycL
- RPI / Booz-Allen: Multi-Sorted Logic $\rightarrow$ IKL $\rightarrow$ MSL
- Stanford / IBM / Battelle: KIF $\rightarrow$ IKL $\rightarrow$ KIF
- KIF $\rightarrow$ IKL $\rightarrow$ CycL $\rightarrow$ IKL $\rightarrow$ MSL $\rightarrow$ IKL $\rightarrow$ KIF

Conclusion: “IKRIS protocols and translation technologies function as planned for the sample problems addressed.”

The IKL Extension to Common Logic

Common Logic is a superset of most logics used in semantic systems, but some require even more expressive logics.

Only one new operator is needed: a metalanguage enclosure, which uses the keyword 'that' to mark the enclosed statement.

- The enclosed statement denotes a proposition.
- That proposition could be a conjunction of many statements.
- It can be given a name, and other propositions can refer to it.
- In effect, IKL can be used as a metalanguage for talking about and relating packages of IKL statements nested to any depth.

CL with the IKL extensions can represent a wide range of logics for modality, defaults, probability, uncertainty, and fuzziness.

For the IKL logic, see http://www.jfsowa.com/ikl/index.htm#ikris