The use of semantic technology for analyzing spectrum situational awareness

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WIRELESS INNOVATION FORUM

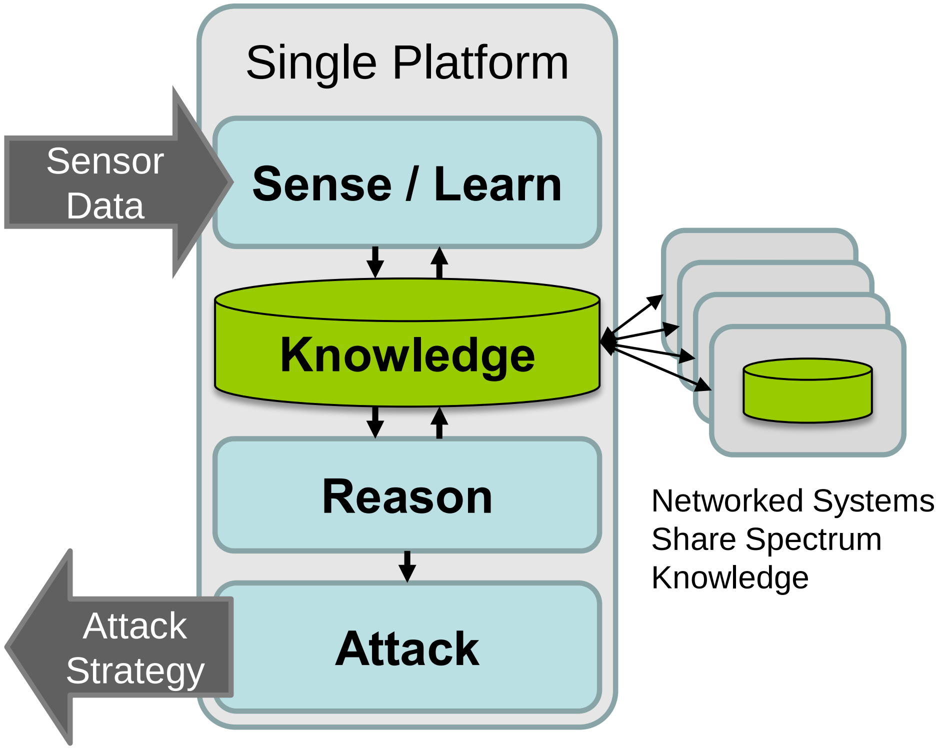
IEEE

Research:
Semantics in the RF Domain

- SKF: Spectrum Knowledge Framework – ONR – JHU APL
- Dev2WALDO: STTR aligned with the DARPA Radio Map program
- SSPARC: DARPA Shared Spectrum Access for Radar and Communications Coexistence, Phase 2
- …

Enabling Cognitive and Adaptive Electronic Warfare

Notional Functional Diagram



A.1 Spectrum Knowledge:
Common framework for representing tactical EM spectral data.

A.2 Spectrum Learning:
Techniques to learn and provide comprehensive knowledge about the spectrum and threat environment.

A.3 Spectrum Reasoning:
Methods to reason about current spectrum conditions and threat knowledge (local and distributed) to develop real-time and resource optimized EA strategies.

A.4 Spectrum Attack:
Leverage knowledge about a RF system's protocol and vulnerabilities to develop targeted and optimized EA strategies.

Spectrum Knowledge

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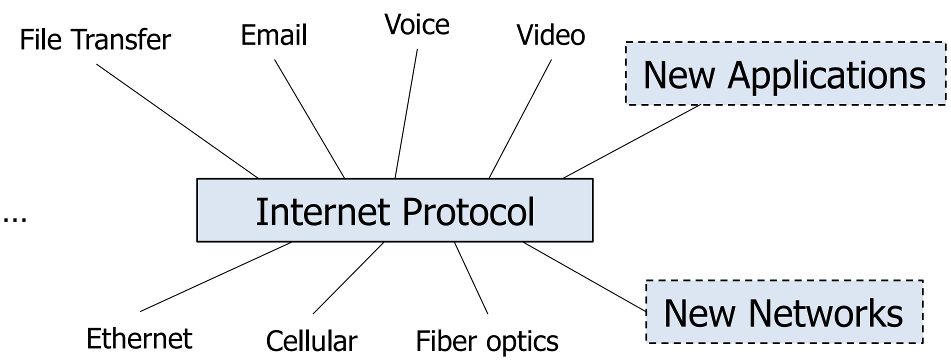
Further Reading (Given as reference only and not intended to guide BAA responses)

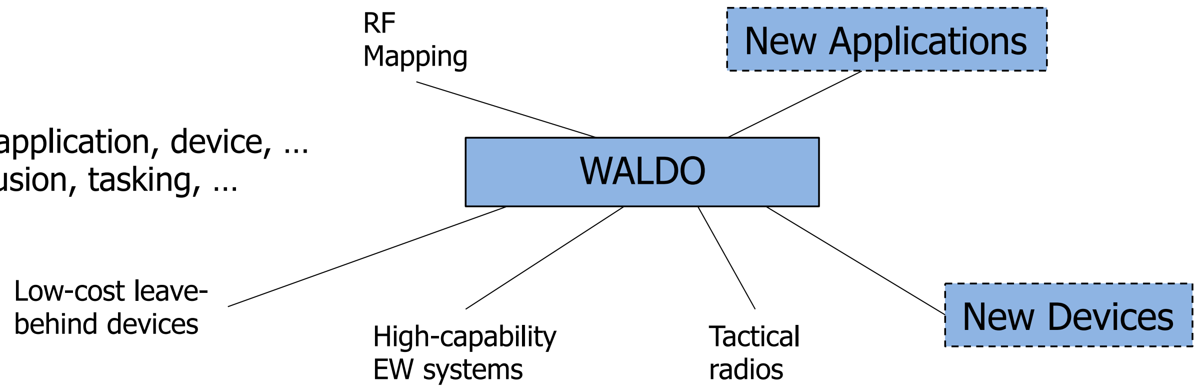
[1] Langley, P., Laird, J. E., & Rogers, S. (2009). Cognitive architectures: Research issues and challenges. Cognitive Systems Research, 10, 141-160. (Specifically section 4.1 Representation of Knowledge)

WALDO: The “narrow waist” for networked RF functions

Protocols: IP, TCP, …
Services: Routing, naming, …



Protocols: application, device, …
Services: fusion, tasking, …



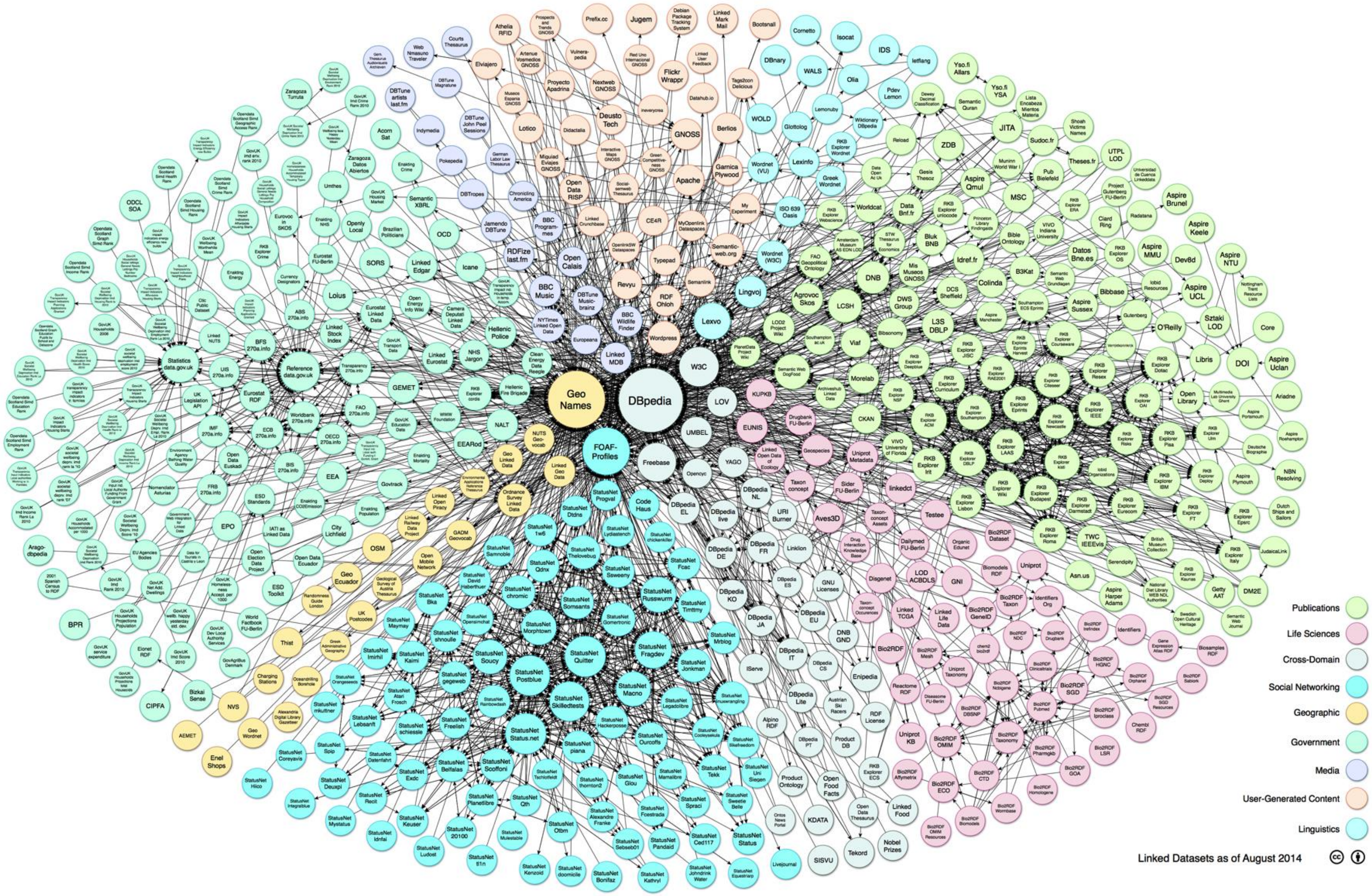
IP enables any application to exploit any available network.
WALDO enables similar modularity for networked RF functions.

Q1: New Types of Analytics

- Discovery of high-level information from spectral data (this could be done via inference). E.g. infer existence of a particular platform and anticipate next spectral activity based on the platform's known capabilities
- Flexible Querying of data
  - Good: “Any” query can be formulated
  - Bad: Too many relations that might need to be checked
  - Good: Semantics will allow an inference engine to identify only those relations that are relevant to a Query!
- Since OWL/RDF model is a graph consisting of <subject, predicate, object> triples, just like in the English language, every sentence about a domain (including Spectrum) can be expressed!
- Numerous tools already exist that support graph analytics (including Big Graph processing with GraphX module of Apache Spark)
- But a semantic layer on top of such analytics framework is under-researched

Linked Open Data cloud diagram

As of 08/30/2014



Linking Open Data cloud diagram 2014, by Max Schmachtenberg, Christian Bizer, Anja Jentzsch and Richard Cyganiak. http://lod-cloud.net/

Q2: Requirements

- Data needs to be annotated in a formal language/ontology
- A formal language/ontology useful for not having design-time limited exchanges of information (via protocols), to leverage and integrate cross-domain data, to support inference

Q3: Mature Techniques, Algorithms, …

- Knowledge representation – ontologies expressed in Web Ontology Language (OWL): tools for developing ontologies
- SPARQL – a standard query language
- Standard automatic inference engines exist: BaseVIsor, Fact++, HermiT, Pellet, Jena reasoners, …

Q4: Unexplored or underexplored research

- A “more natural” query language that maps to SPARQL
- Query/response visualization tools
- A standardized Signal Ontology
- Integration of signal representation & transmission protocols with SPARQL and OWL (e.g., VITA49)
- Data summarization – techniques, algorithms and tools

Q5: Research Resources

- Databases of signals, their features and classifications
- Forensics scenarios and challenge problems
- Query examples
- Simulators