The use of semantic technology for analyzing spectrum situational awareness

Mieczyslaw “Mitch” Kokar
m.kokar@neu.edu
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
• ...

August 3, 2016
Enabling Cognitive and Adaptive Electronic Warfare

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

WALDO: The “narrow waist” for networked RF functions

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

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