

Cognitive Spectrum Access

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**MITRE
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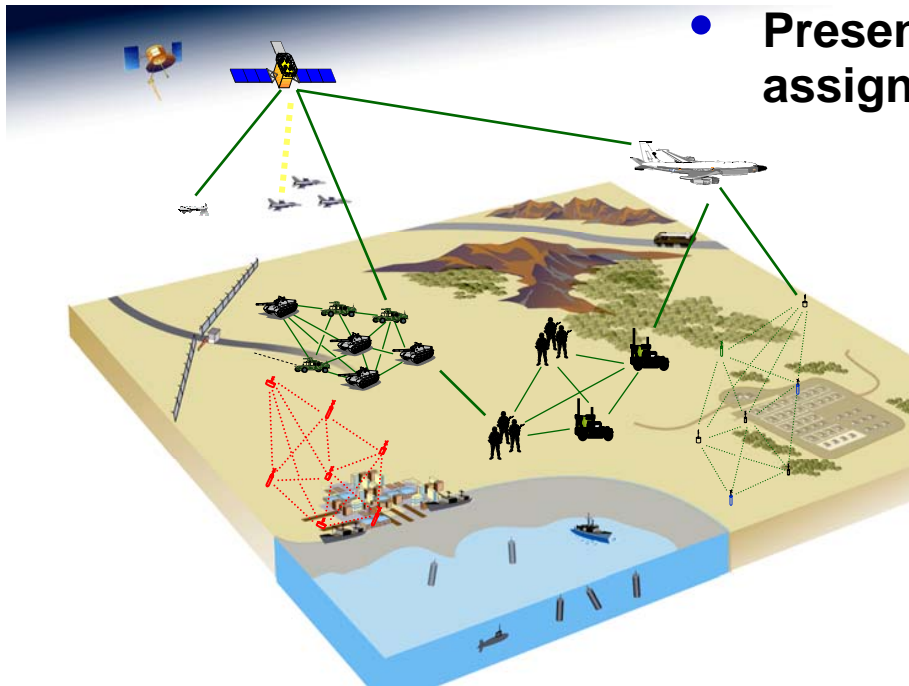
MITRE Sponsored Research

Problem

- **Improving access to the electromagnetic spectrum is a long-standing challenge.**
 - **Communications, navigation, and surveillance systems depend on transmitting, receiving, or measuring energy transferred through the multidimensional spectrum “space.”**
 - **Network-centric warfare, emergency response, and other emerging operational concepts require automated, dynamic, and adaptive decision making for spectrum use.**
 - **Applying cognitive techniques on “smart radios” may greatly improve spectrum access.**

Background

- Complexity of future military and civilian networks requires:
 - Continuous evolution of membership and topology
 - Dynamic link quality and communication needs
 - Large numbers of nodes and connections



- Present static frequency assignments inadequate

**Future Spectrum
Access**

**Automated
Dynamic
Adaptive**

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Objective

- **Develop spectrum access architectures, algorithms, and radio device designs that utilize “cognitive” or “reasoning” techniques to improve access to the electromagnetic spectrum**
- **Take the software defined radio (SDR) to the next evolutionary step: “smart” radios**

Activities

- **Develop a spectrum ontology and apply inferencing processes**
- **Design radio architecture(s) with embedded policy engines that can coexist with legacy radio systems**
- **Create proof-of-concept demonstrations**

Highlight

- XML isn't enough, because there are many ways to describe the spectrum; what is the meaning of a "channel" here?
- Database-oriented spectrum allocation strategies do not provide the inferencing needed for new situations.

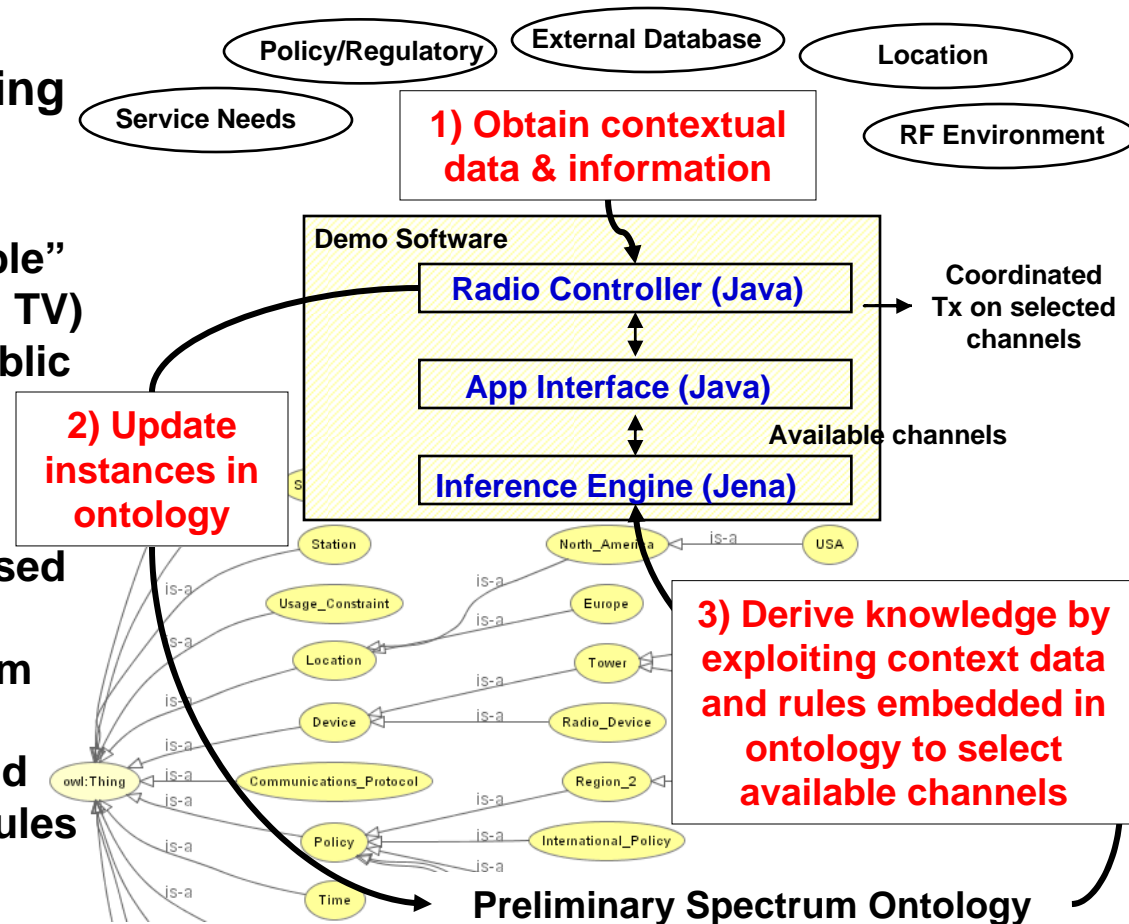
```
AdaptiveSpectrumPolicy
<!--(it is assumed that the overall frequency band is already specified in a higher level policy object)-->
REGION REGION_POLICY_INDEX=10
| Tahiti
<!--(could include regional coordinates here)-->
UNITS FREQUENCY=MHz TIME=s POWER=dBm PSD=dBm_per_Hz RATE=Hz
TX_SIGNAL MODULATION=A-OFDM MAX_TX_POWER=10.0
| Transmitter Class ABC
TX_SPECTRUM_MASK BAND_EDGE_POWER=-55.0 OFFSET_30KHZ_POWER=-55.0 OFFSET_60KHZ
| Transmitter Class ABC at <= +10.0 dBm
TX_ACTIVITY MIN_QUIET_TIME=0.1
| Profile A
<!--(i.e., minimum time between transmissions)-->
SENSE_BEHAVIOR MIN_SENSE_RATE=5 SENSE_RULE=PSD PSD_THRESHOLD=-65.0 LOWEST_FF
| Sense Mode 1
<!--(i.e., how to test for presence of primary users)-->
PROHIBITED_RANGE LOWEST_FREQUENCY=304.8 HIGHEST_FREQUENCY=305.76
| Fire Company 1
PROHIBITED_RANGE LOWEST_FREQUENCY=306.72 HIGHEST_FREQUENCY=307.68
| Police Department 1
TIMED_LOCKOUT_RANGE LOCKOUT_TIME=5 LOWEST_FREQUENCY=309.6 HIGHEST_FREQUENCY
| Wireless Service A
```

Reasoning/Proof	Inference Engine
Higher Semantics	OWL
Semantics	RDF/RDF Schema
Structure	XML Schema
Syntax: Data	XML

Demonstration

■ Channel Selection Using Ontology Inferencing

- Select “available” channels (e.g., TV) for tactical, public safety, or commercial networking
- Availability based on derived knowledge from contextual information and policy/usage rules



Impacts

- **Develop system and radio device architectures and techniques:**
 - **Military Applications: Tactical & Sensor Networks**
 - **Public Safety**
 - **Aviation**
- **Help MITRE maintain leadership and be a recognized source in developing “smart” radios**
- **Influence development of this emerging technology through participation in standards and technology organizations such as IEEE 802.22**

Future Plans

