
Policy-Defined, Cognitive Radios

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Vision: Policy-Defined, Cognitive Radios

- Enable policy-based, cognitive device. Such a device
 - Is Aware
 - Of itself, its capabilities, its health, etc.
 - Of its environment, incl. other radios and effects of its actions
 - Can Reason
 - At different levels of abstraction
 - Uses goals, policies, and models of its capabilities and environment
 - Determines behavior (actions-sense/transmit, observations-evaluate, etc.)
 - Can Adapt
 - To new policies, models, goals, strategies, etc
 - Can Learn
 - Better strategies, refined models
 - Are Able To Cooperate and Coordinate with peers
 - For mutual benefit
 - To achieve overall goal

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Benefits of Policy-Defined, Cognitive Radios

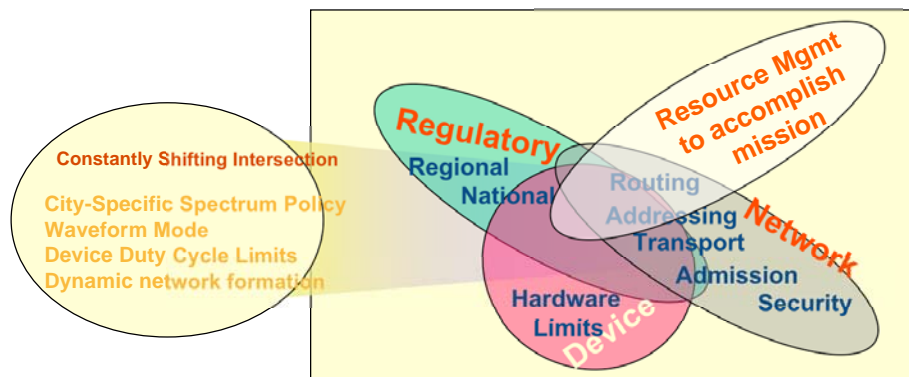
- Radios that obey wide variety of policies
- Flexible and adaptable --- change behavior because of
 - Changes in policies
 - New insights in environment and models
 - Learned behaviors
- Policies & behaviors represented symbolically:
- Policies and their implementation can evolve asynchronously
 - New policies require no changes in software or hardware
 - Existing policies will work on new hardware
- Certification greatly simplified, consider
 - Verifying 1 policy reasoner and 1+ set of policies to run on 1000s of radios,
 - vs Verifying 1000s of software implementations of the policies



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Radios that obey wide variety of policies

Networking, routing, spectrum, resource management, ...



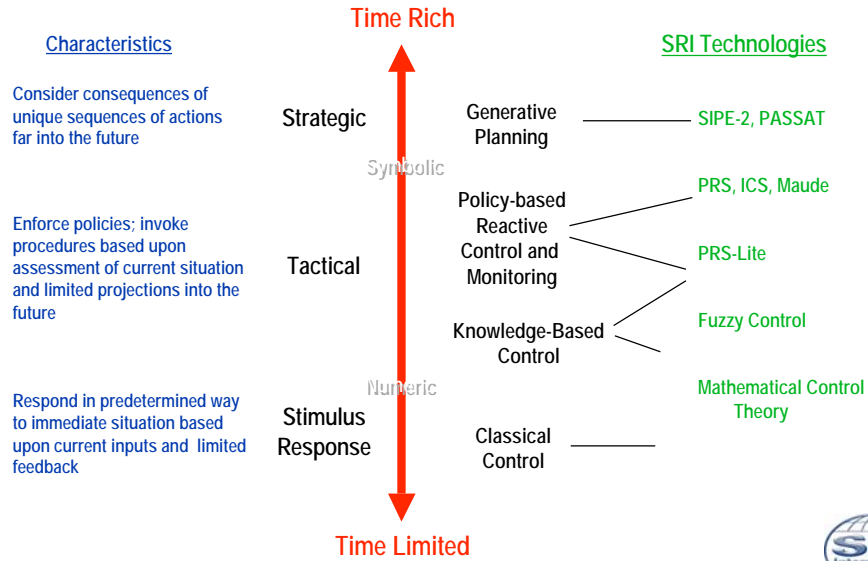
[Adapted from a Preston Marshall slide.]



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Planning & Control Technologies

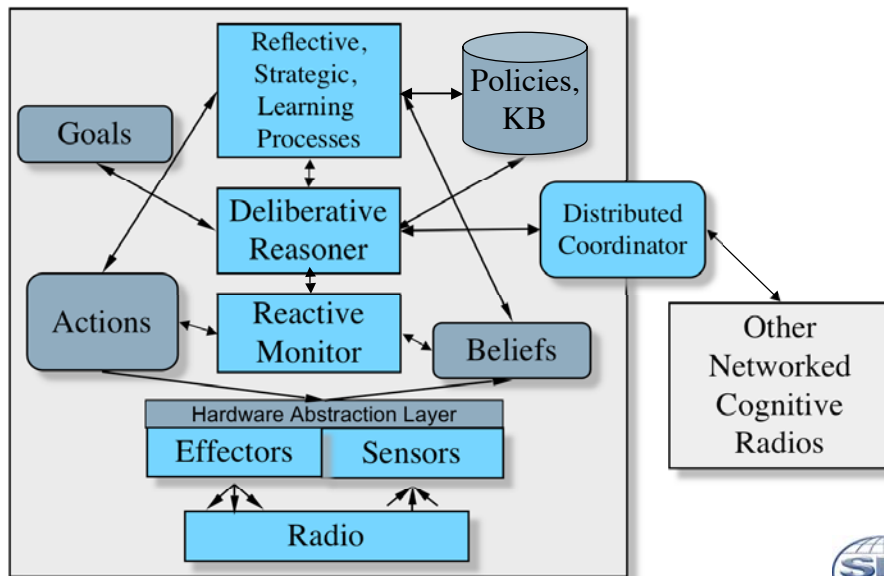
Broad concept of policy may require a variety of techniques:



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Abstract Policy-Defined, Cognitive Radio Architecture



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Agent-Centric Resource Management

- Each node is populated by a single “cognitive-radio” agent
 - Controls sensors, effectors and communication resources
- Cooperative mediation: new paradigm for solving distributed problems that uses dynamically constructed, partial centralization
- Specialize members of the agent population to *dynamically take on multiple, different* goals/roles.
 - Individual agents become “managers” of different aspects of the problem
- Managers form high-level plans to address their goals, and communicate with other nodes to achieve them
 - Sensor to Target Assignment Problem
 - Airspace Deconfliction for UAVs



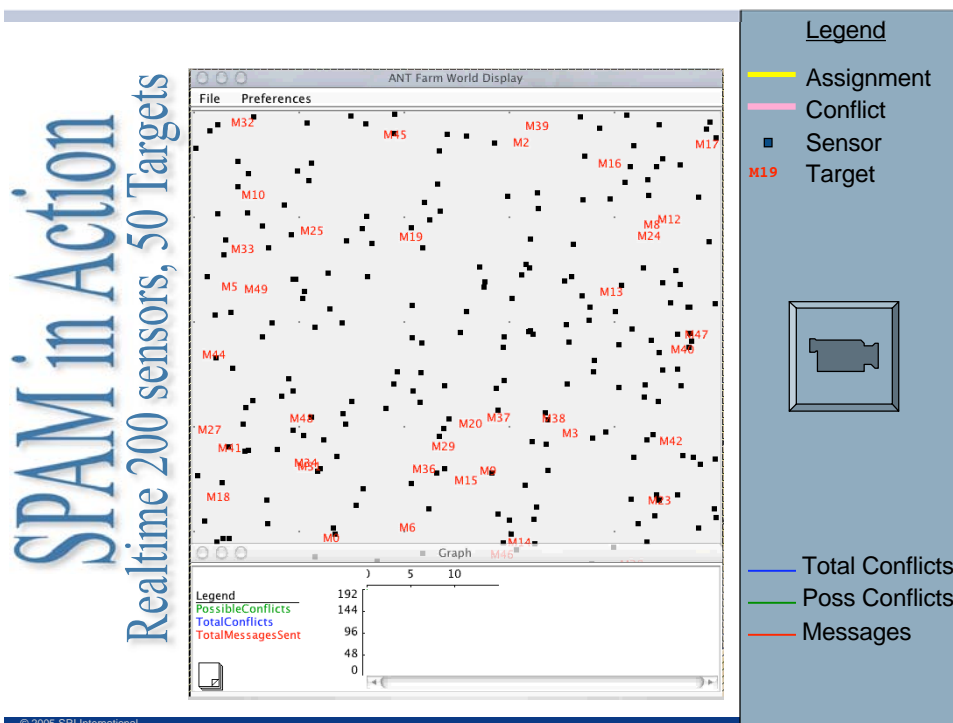
Inter-node Communication

- Information Exchange
- Negotiation
- Distributed (partial) Consent Forming

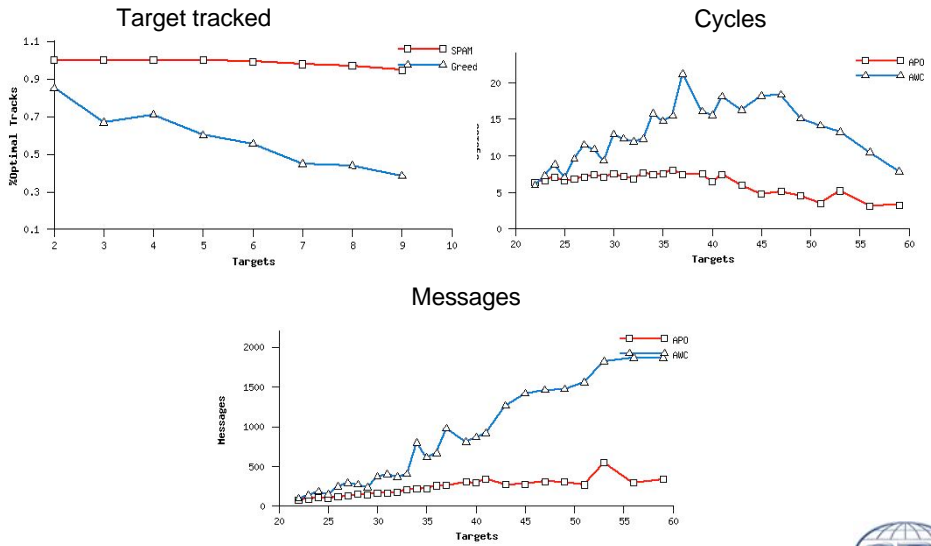
Basis: Mailler's Algorithms for Distributed Resource Management & Control



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Results – Tracking Domain



Backup Slides

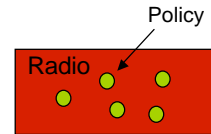
-Policy work in the XG Program



Towards Policy-Defined Radios

- Current Status:

- Policies programmed or hardwired into the radio and intermingled with firmware
- Written in a procedural language (usually C)
- Consequence:
 - Accessible only to radio engineers
 - Difficult or impossible to change
 - Non-standardized



- Objective:

- Separation between policies and firmware
- Policies should be easy to understand and free of implementation details
- Policies can be loaded on different types of radios
- Policies can be written or accredited by regulators
- Policies can be composed and extended in various ways

