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Initial Assessment of Proposed Cognitive Radio Features from a Military Perspective

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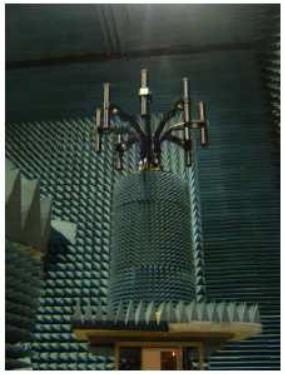
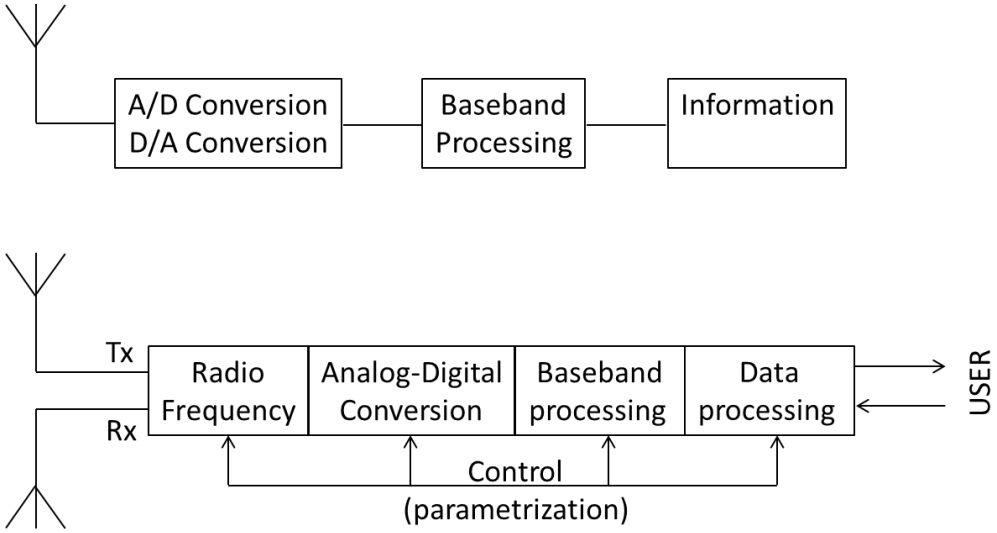
Background



- Advanced radio research in Finland since early 1990’s by Finnish Air Force, Nokia, Elektrobit and University of Oulu / Centre for Wireless Communications (CWC)
- Navy and Army started SDR research in late 1990s
- Finnish Defence Forces’ Software Radio Demonstration 2006, engagement with ESSOR, COALWNW
- 1st gen SDRs being deplyoed to the army now

From Software Defined Radio to Cognitive Radio



SDR: Radio in which some or all of the physical layer functions are software defined

Cognitive Radio as Design Paradigm

An approach to wireless engineering wherein the radio, radio network, or wireless system is endowed with the capacities to:

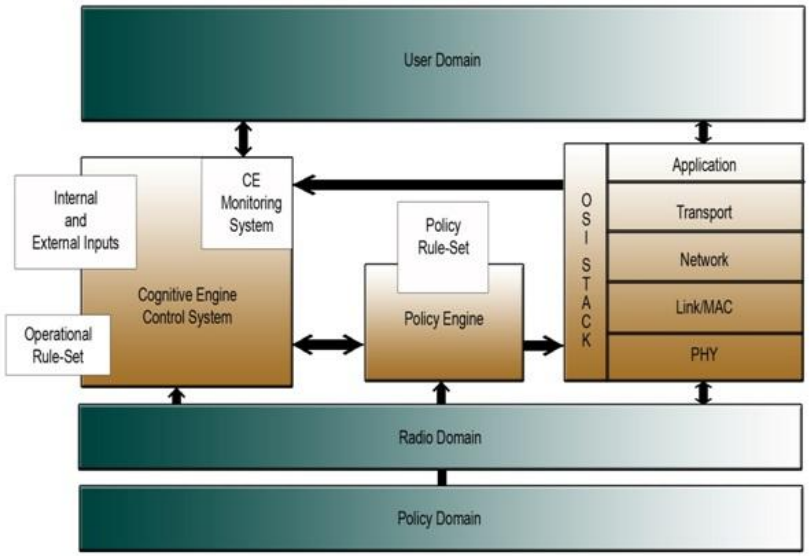
- *acquire, classify, and organize information (aware)*
- *retain information (aware)*
- *apply logic and analysis to information (reason)*
- *make and implement choices (agency) about operational aspects of the radio, network, or wireless system in a manner consistent with a purposeful goal (intelligent).”*

Cognitive Radio as examples of implementation

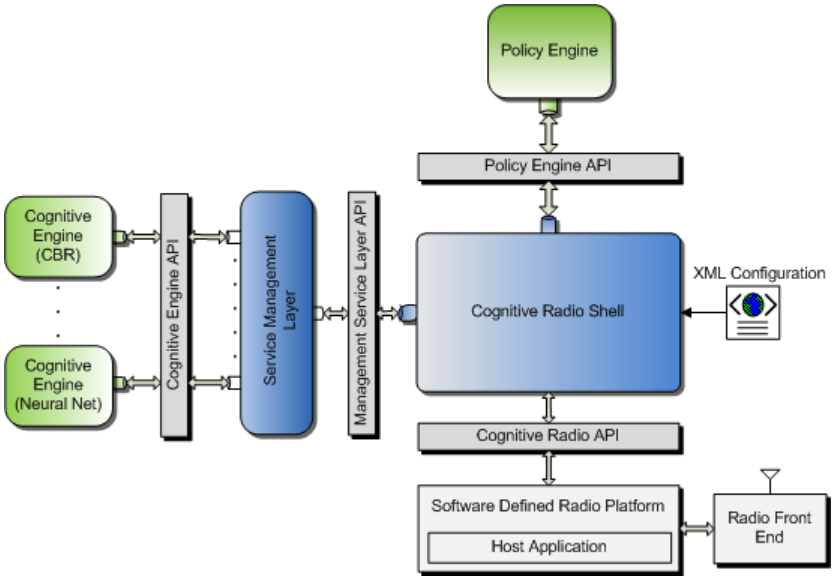
A radio designed according to the cognitive radio engineering paradigm.

- *Cognitive radio as defined above that utilizes **Software Defined Radio**, Adaptive Radio, and other technologies.*
- *A radio endowed with the capacities: to acquire, classify, retain, and organize information, to apply logic and analysis to information, and to make and implement choices about operational aspects of the radio in a manner consistent with a purposeful goal.*
- *A radio, radio network, or wireless system designed according to the cognitive radio engineering paradigm.*

Examples of Cognitive Radio Architecures



WINNF



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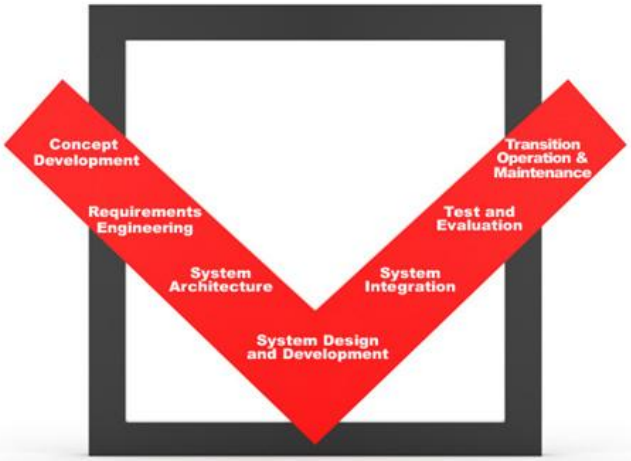
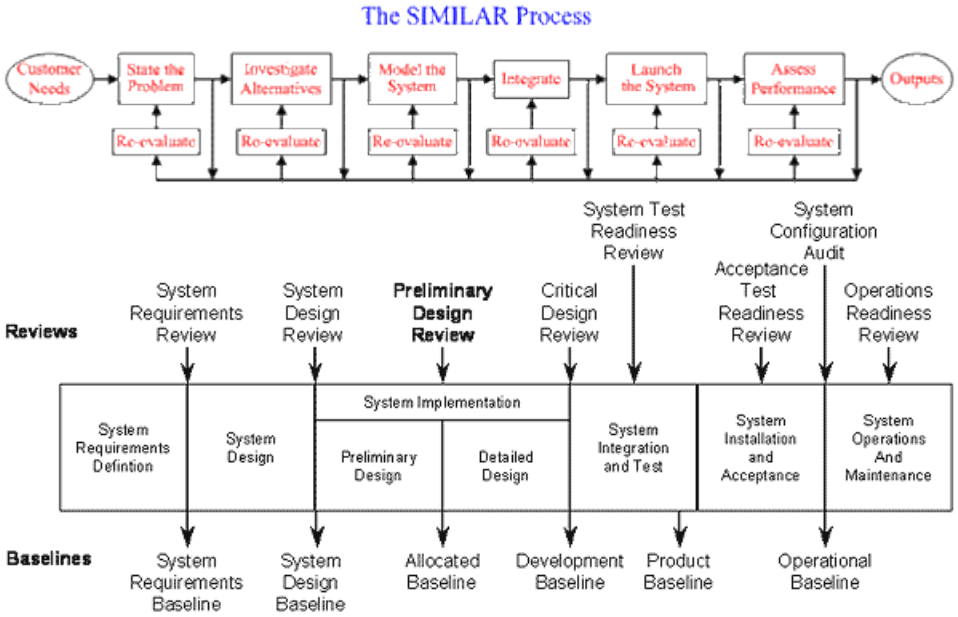
Systems Engineering Life Cycle



MITRE



INCOSE

System Definition Phase

Category	***Definition***
User requirements (U)	what the users want to do with the system from the operational point of view
System requirements (S)	show what system will do, but not how it will be done
Design (D)	what is to be built

Classification of system effectiveness

Category	***Descriptive characteristics***
PERFORMANCE	capability, behaviour
AVAILABILITY	reliability, maintainability
ADAPTABILITY	flexibility, expandability
INTEROPERABILITY	communication, protocol
USABILITY	human factors, man-machine interface
SURVIVABILITY	avoidance of detection, self-defence, damage-tolerance
SECURITY	data, physical
SAFETY	development, operation, maintenance, disposal

CATWOE

- is a soft systems derived technique applying multiple criteria
- especially useful for revealing stakeholders and the system description.

Component	***Definition***
CLIENT (C)	Those who benefit from what the system produces
ACTORS (A)	Those who carry out the work within the system
TRANSFORMATION (T)	The change which system causes to happen; the process by which an input is changed to a particular output
WORLDVIEW (W)	The perception of the system from a distinct point of view; the assumptions which are made about the system from that perspective
OWNER (O)	The person or organization who has ultimate authority over the system, who can cause it to cease or exist
ENVIRONMENT (E)	What surrounds, or lies outside the system; the system may influence it, but has no control over it

Proposed Cognitive Radio Features (WINNF grouping)

- Dynamic Spectrum Access
- Multiple Antenna Systems
- Radio Resource Management
- Spectrum Markets
- Single Link Adaptation
- Commercial Market Characteristics
- Public Safety Characteristics
- Military Applications

Summary Table of Analysis

Offered CR features (numbering according to the article)	System Definition	System Effecti-veness	Customer (C)	Actor (A)	Transformation (T)	Worldview (W)	Owner (O)	Environment (E)
5.1 Spectrum sensing, signal detection and classification	SYSTEM	PERF	MIL: *end-user *mid-mngmnt	MIL: *end-user	Ease of planning, mgmt., use	a)natl.defence+ expeditionary ops b)superpower global ops	Military in general	See (W)
5.2 Awareness, decision making, param selection	SYSTEM	ADAPT	See 5.1	See 5.1	Reliability, availability and QoS	See 5.1	See 5.1	See 5.1
5.3 Geo-location awareness	SYSTEM	PERF	See 5.1	See 5.1	Reliability, availability and QoS	See 5.1, note: Selection of (W) may affect implementation	See 5.1	See 5.1
5.4 Enhanced data rate, coverage, capacity, link reliability, QoS	SYSTEM	PERF	See 5.1	See 5.1	See 5.1	See 5.1, note: selection of (W) affects waveforms to be implemented	See 5.1	See 5.1
5.5 Spectrum access, policy management	SYSTEM	PERF	*ops planners *acquisition offices	See 5.1	See 5.1	See 5.1	See 5.1	See 5.1
5.6 Information sharing	SYSTEM	INT.OP	See 5.1	See 5.1	See 5.1	See 5.1	See 5.1	See 5.1
5.7 Multiple waveforms, RRM	SYSTEM	PERF	See 5.1	See 5.1	Facilitates new networking paradigms	See 5.1	See 5.1	See 5.1
5.8 Interference avoidance and rejection	SYSTEM	PERF	See 5.1	See 5.1	Reliability, availability and QoS	See 5.1	See 5.1	See 5.1
5.9 Advanced antennas, beam forming etc.	DESIGN	PERF	Op CDR	See 5.1	LPD/LPI	See 5.1	See 5.1	See 5.1, note: each use case
5.10 Service and traffic prioritization / self-organizing networks	SYSTEM	PERF	See 5.1	See 5.1	See 5.1	See 5.1	See 5.1	See 5.1
5.11 Interoperability / cognitive RF gateways	SYSTEM	INT.OP	MIL generally	MIL generally	New tactics: mixed composition forces, flexible AOO/AORs	See 5.1	See 5.1	See 5.1
5.12 Reconfiguration, near-zero setup	USER	USAB	*Ops planners * signals officers	Signals officers	Rapid deployment, Interoperability Improved capability to deploy to under-developed/denied env	See 5.1	See 5.1	See 5.1
5.13 Security, circumventing hostile jamming, tactical self-protective jamming	USER	SECUR	Op CDR	End-users Signals officers	Mission accomplishment	See 5.1	See 5.1	See 5.1
5.14 Cost, size, battery life	USER	PERF	Logistics Materiel administration	Logistics Materiel admins	Durability, Portability Constrained platforms	See 5.1	See 5.1	See 5.1
5.15 Spectrum trading, markets, revenue models	DESIGN	ADAPT	Regulator, Vendor, Network Service Operator	End-user	Paradigm shift in spectrum use Note: threats to MIL spectrum	Gov. regulated, commercially driven civilian access	Regulator	Civilian

Discussion

1. Demand for bandwidth -> DSA
2. Cognition ?
3. So far R&D focused on performance
4. Applying CATWOE useful
    * (W) insights to which features and how to be implemented
    * (T) drivers for R&D for a specific military CR
6. Markets seem to diverge

DSA - Civilian, non-aligned with military objectives and may be contrary to military interests. (Although some new useful innovations, services, or approaches to spectrum management may eventually arise from these concepts).

Discussion (cont'd)

7. CR concept not mature for a) waveform b) radio itself or c) network to be addressed as independent entities

⇒ 1st Gen CRs designed using a holistic systems-engineering approach.

⇒ 1st Gen CRs require more cross-domain, multi-discipline research, efforts and investments

10. In terms of metrics and characteristics <COGNITION> remains unexplored

Discussion (cont'd)

CRs facilitate changes in tactics

However, we are yet unable to formulate exact, measureable, and verifiable requirements for a CR.

Mil R&D advised to:
- continue developing knowledge and understanding of CRs
- initiate activities to draft initial military requirements for CRs
- utilize modern iterative development models that enable the development of competencies, understanding, and, implemented capabilities in a balanced manner

Questions ?