Programmable Wireless Networking Overview

Dr. Joseph B. Evans
Program Director
Computer and Network Systems
Computer & Information Science & Engineering
National Science Foundation

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Outline

- Themes and problems
- Research issues
- Needs and focus
- Impact of innovations

Recent Wireless Themes

End-user interest in mobile access to information

Requirements of national defense & homeland security

Applications

Recognition that spectrum is woefully under-utilized

Proposals to dramatically re-architect the modes & mechanisms for using radio frequencies

Policy

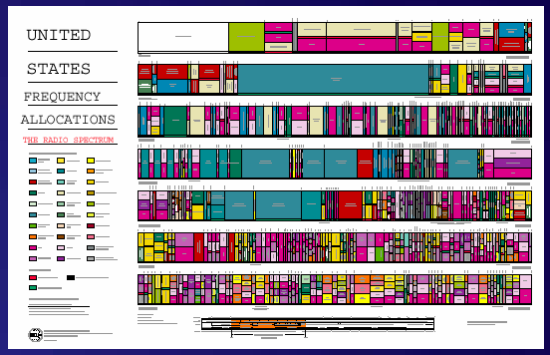
Opportunity - Wireless Networks That Exploit Flexibility

Advances in radio system engineering – flexible radios are just becoming available

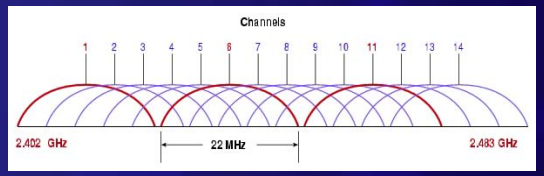
Technology

State of Wireless Networking

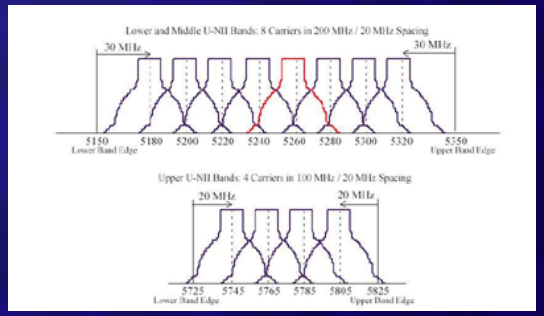
- Wireless systems today
  - Inflexible, wasteful static spectrum allocations
  - Fixed radio functions
  - Limited network and systems coordination
- Implications
  - Proliferation of standards, such as Wi-Fi/802.11, Bluetooth, 3G, 4G, CDMA, GSM
  - Encourages stovepipe architectures and services
  - Discourages innovation and growth



Source: FCC



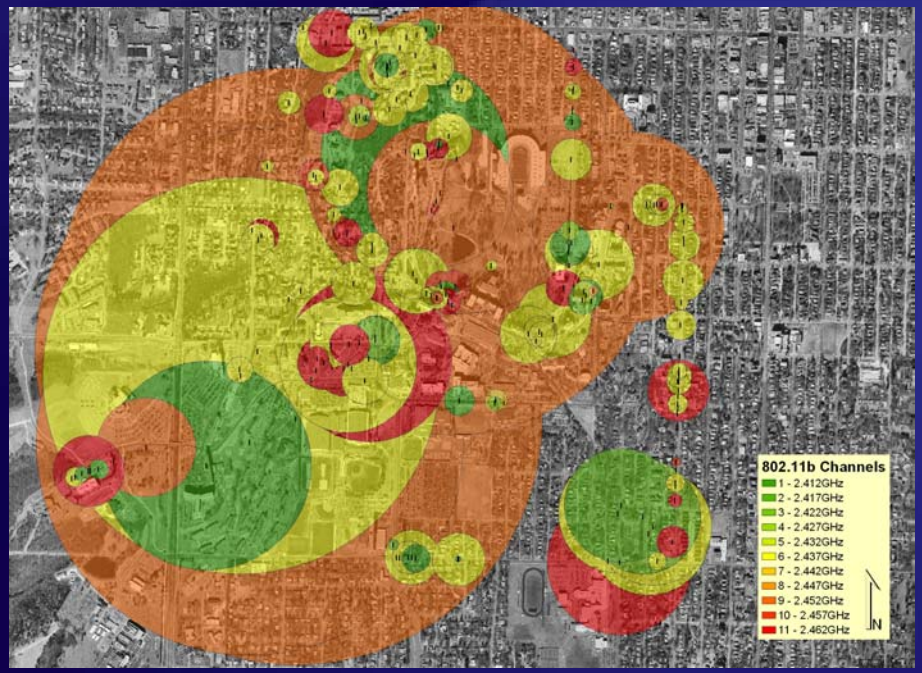
Source: Cisco



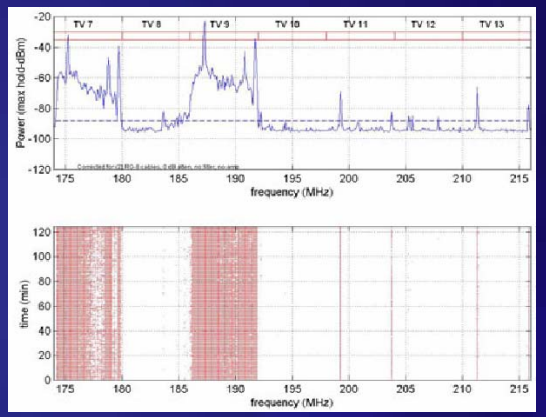
Source: Linksys

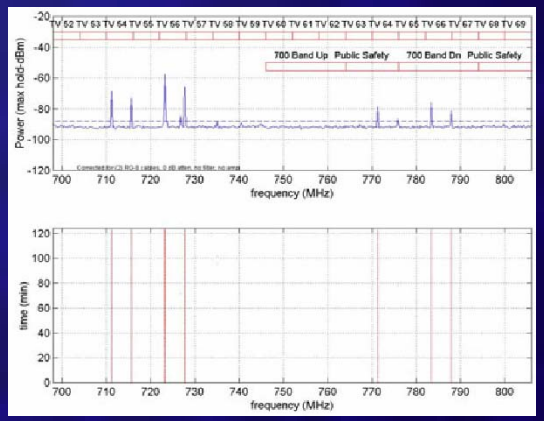
Critical Problems

- Interference in unlicensed bands
- Underutilization in many other bands



Source: B. Becker



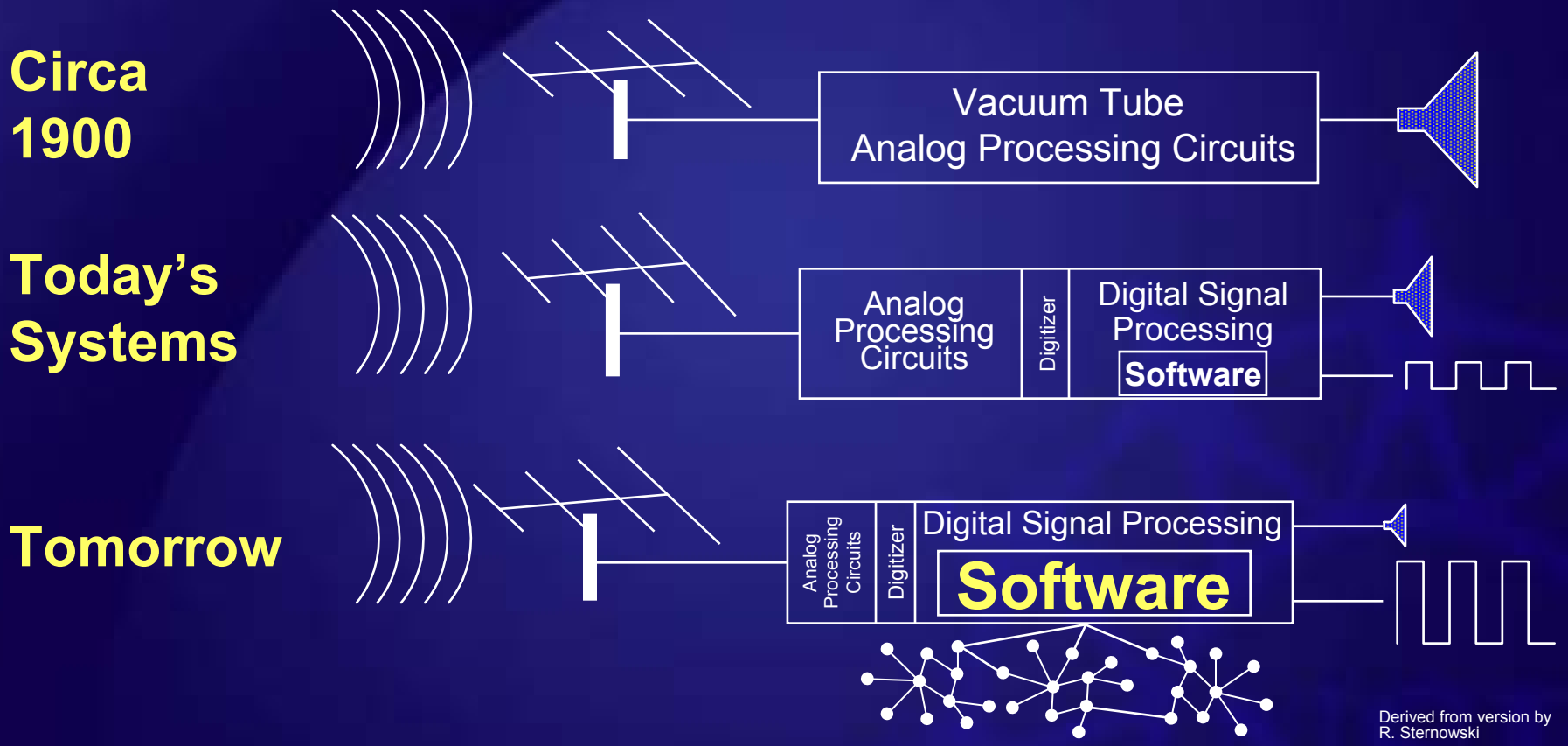


Source: M. McHenry

Evolution of Wireless Systems

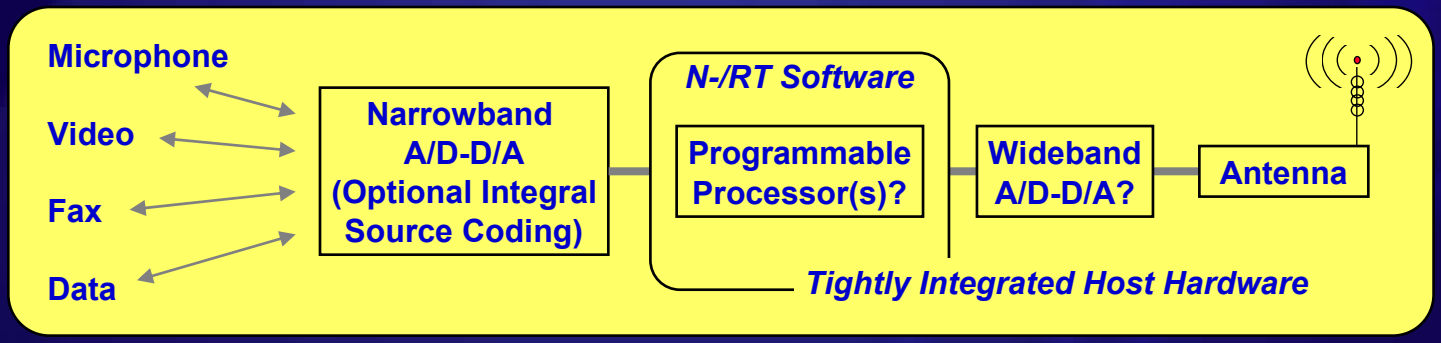
Receive → *Capture radio waves* → *Extract information from radio waves* → *Present information to user*

Transmit ← *Generate radio waves* ← *Implant information into radio waves* ← *Accept information from user*



Advances in Radios

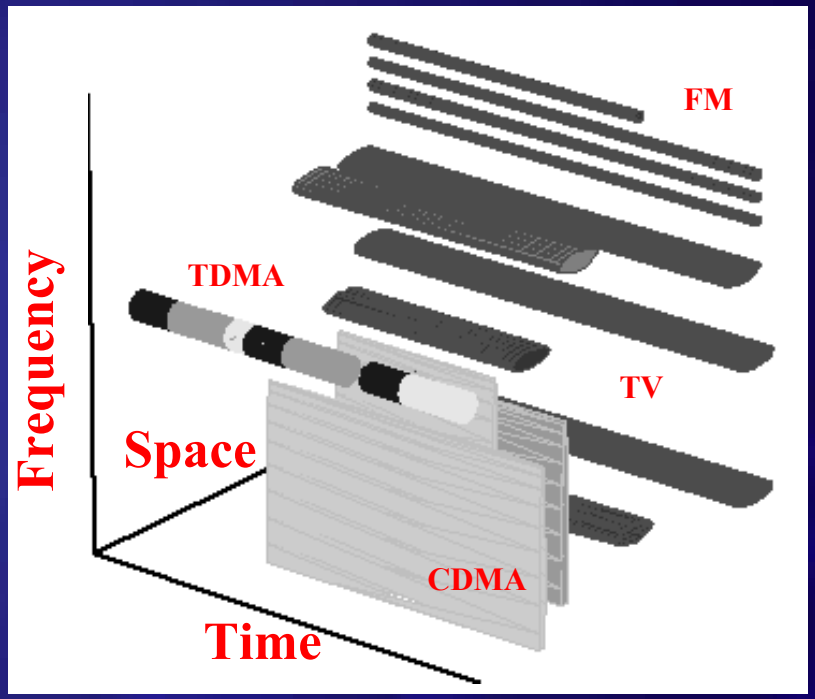
- Software radio attributes and capabilities
  - Wide operational frequency supports novel use of multiple bands
  - Multiple waveforms in a single hardware unit provides interoperability
- Impact
  - Dynamic spectrum management helps prevent interference
  - Adaptable to local & current situation; flexible frequency use provides opportunities for quality of service
  - Rapid deployment and service creation
  - Enables new network architectures through flexible & dynamic connectivity



- Systems and networking issues remain unexplored and unexploited!

Spectrum Resources

- The spectrum resource space consists of
  - Frequency – the radio frequencies used to carry a signal
  - Time – the time duration a signal is transmitted
  - Space – the volume over which the signal transmission is effectively communicated or causes interference
  - Signal format – the manner in which information is encoded on the radio frequency signal

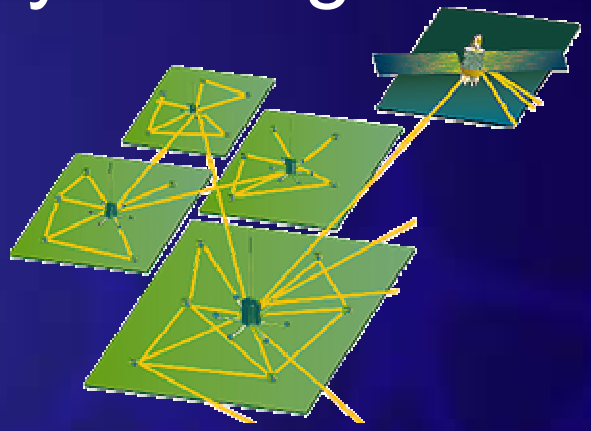


Source: G. Minden

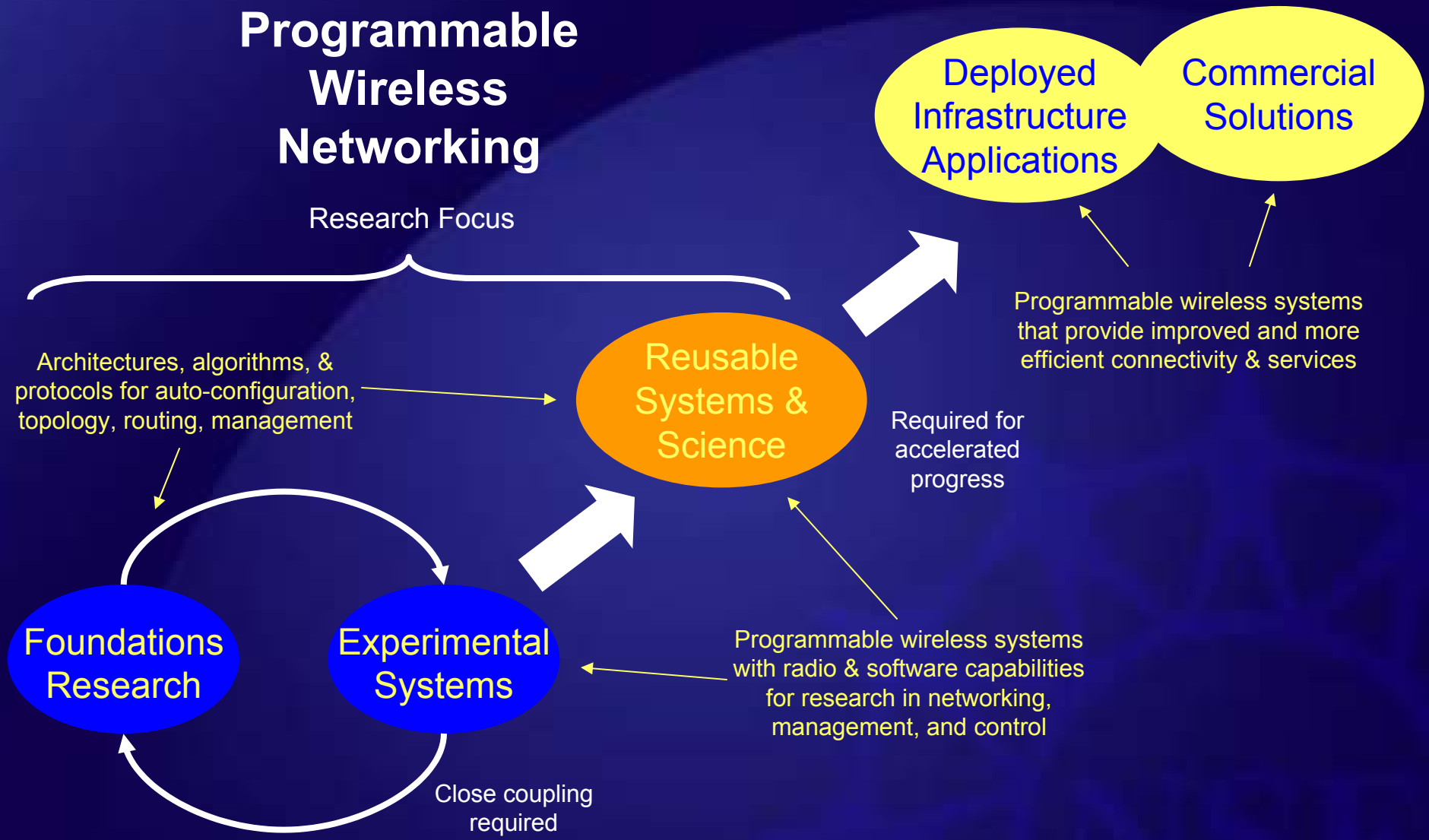
RF resources illustrating a few signals in time, frequency, and space

Programmable Wireless Networks

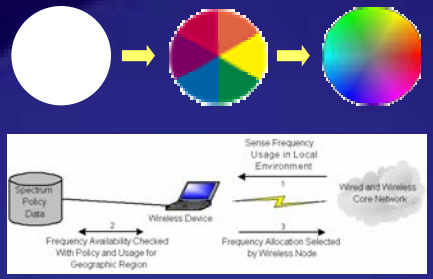
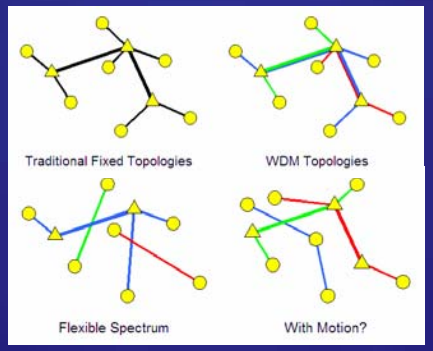
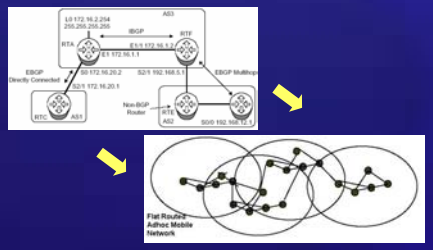
- Route messages through network and interoperate with larger Internet
- Dynamically and cooperatively manage spectrum resources
- Self-organize with rapid initial configuration
- Provide for mobility
- Support variety of network services
- Use adaptation to assure quality of service
- Support multiple users & domains



Research Area Evolution



Programmable Wireless Focus

Research Area	Changes	Needs
Dynamic spectrum management architectures and techniques		Architectures that are secure & robust, with quality of service and policy enforcement
Topology discovery, optimization and network self-configuration – “Spectrum Coordinated Networks” or SCN		How to choose among possible topologies, and evaluate novel network architectures
Interaction between routing, topology, and administration		Which approaches for diverse applications, communication modes, security & policy domains

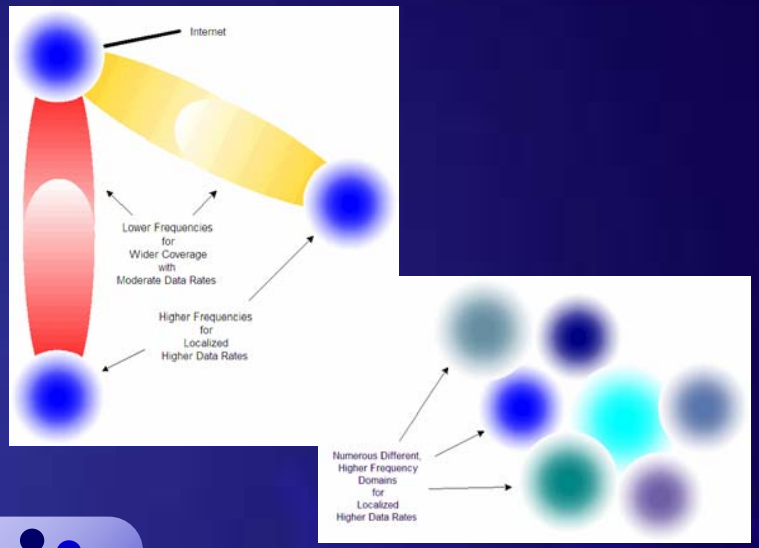
Source: H. Rajan

Some Desirable Radio Attributes

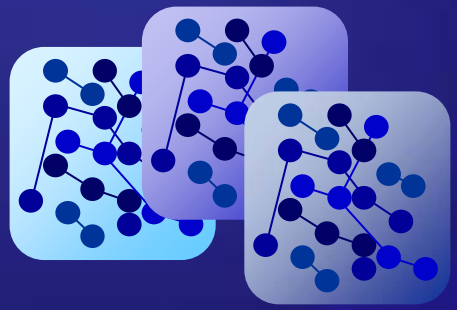
- Flexible in RF carrier frequency (~0 - 6 GHz)
- Flexible in bandwidth (several 10's MHz)
- Flexible in waveform
  - Generally A/D and D/A driven
  - Generated/processed by programmable DSP and/or FPGAs
- DoD's Joint Tactical Radio System (JTRS) is an example
  - Waveforms and network control all in software
  - Significant general and signal processing
  - In the prototype and experimentation stage

Impact of Programmable Wireless Networks

- Vastly improved connectivity
  - Remote areas → use more power and better frequencies where utilization relatively low
  - Urban areas → provide more capacity where utilization is relatively high



- More opportunities for networking devices such as sensors and controllers by providing capacity & adaptability



- More efficient use of a shared national resource

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