Programmable Wireless Networking Details and Logistics

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Objectives

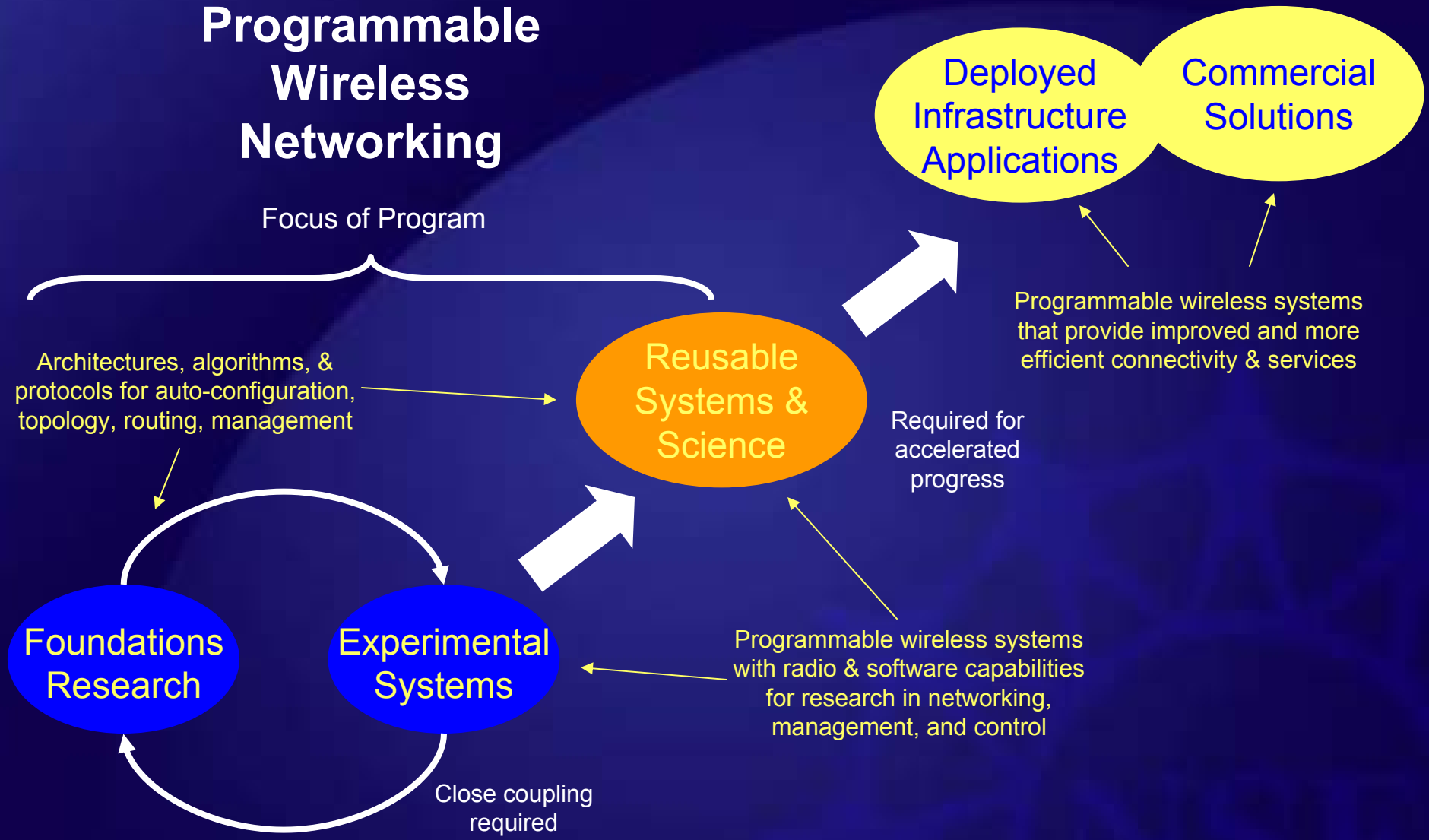
- Provide research area details
  - Revisit motivation, objectives, and areas
  - Discuss areas in detail with examples
  - Discuss relationship of program to ongoing NSF wireless networking efforts and anticipated evolution
- Discuss logistics
  - Provide context on relationship between focus area, the NeTS announcement in general
  - Provide guidance on anticipated award sizes, distribution, and program coordination
  - Discuss timelines and review procedures

Research Area Details

Principles

- Capitalize on the exciting and promising emerging scientific opportunities in wireless networking
  - Develop flexible wireless networks that promise near universal connectivity
  - Make more effective use of our shared spectrum resources
- Build on NSF's successes in wireless & networking
- Promote wireless networks community building
  - Intermix networking, radio, and policy communities
  - Integrate education with research through focused activities
  - Broaden participation in wireless networking activities
- Sharpen programmatic focus in wireless networks and enhance budget flexibility with determinate plan
- Enhance intellectual coherence in CISE activities in wireless networks

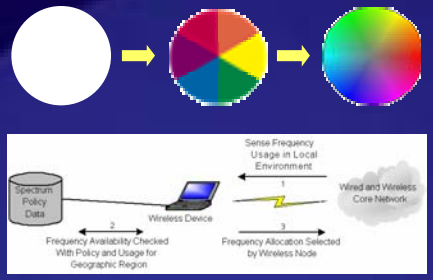
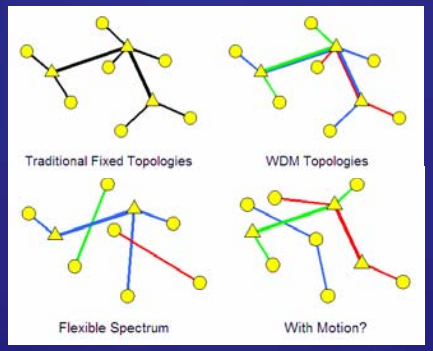
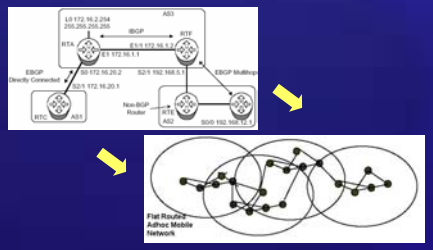
Research Area Approach



Research Areas

- Explore dynamic spectrum management architectures and techniques
- Explore topology discovery, optimization, and network self-configuration as the physical layer moves from fixed to limited to flexible
- Explore interaction between routing, topology, and administration/management
- Provide flexible radios for networking research

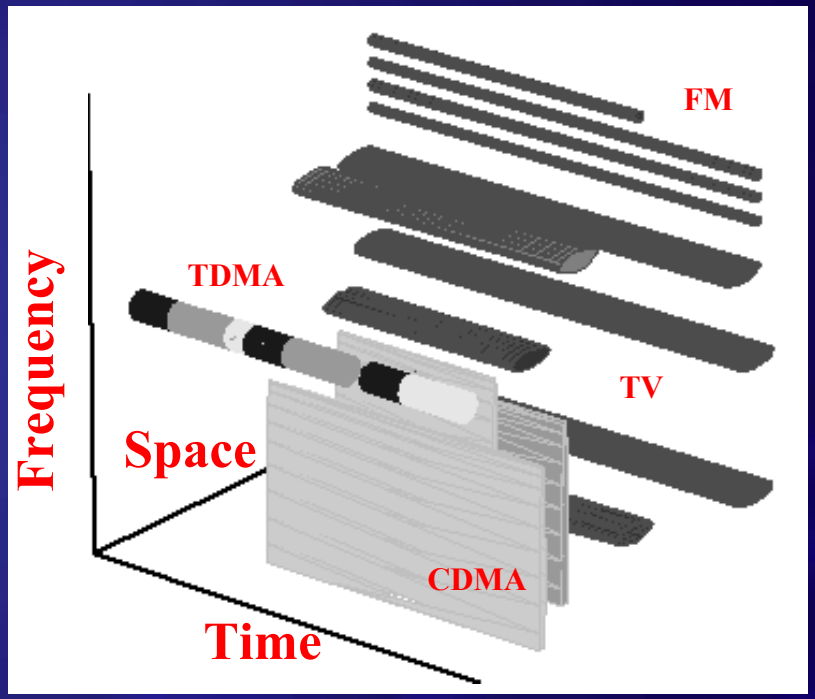
Programmable Wireless Focus

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

Spectrum Management

- 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

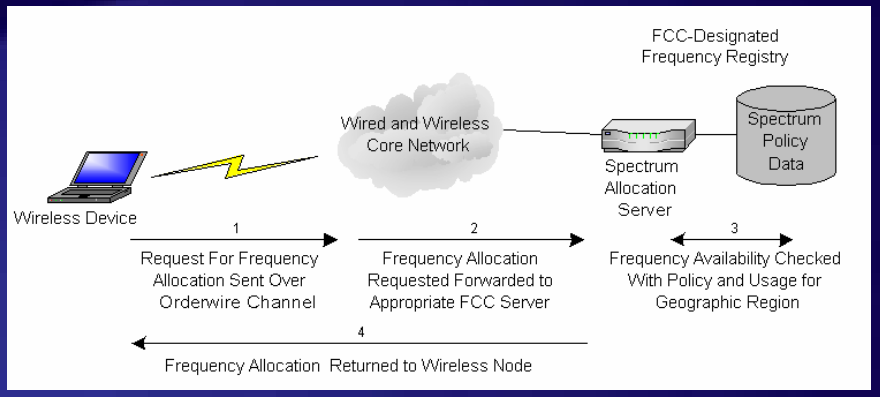


Source: G. Minden

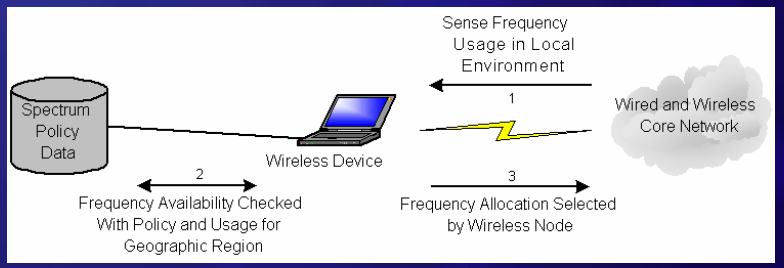
RF resources illustrating a few signals in time, frequency, and space

Dynamic Spectrum Management

- Architectures
  - Broker-based and/or sensing-based
- Issues
  - Implementing policies
  - Secure and robust
  - Quality of service
  - "Contract" enforcement
- Evaluation and innovation needed



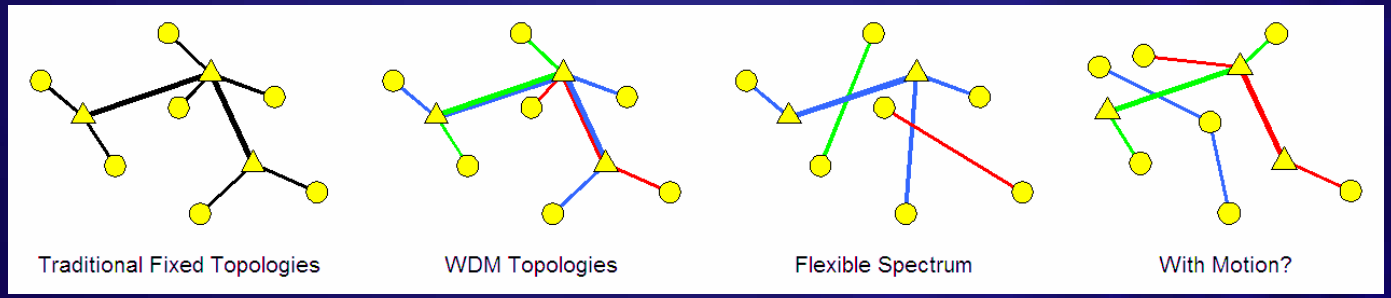
Obtaining Frequencies for Programmable Wireless via Broker



Obtaining Frequencies for Programmable Radio via Sensing

Towards Flexible Topologies

- Flexible topologies enabled by multiple simultaneous frequencies to multiple adjacent nodes
  - Novel network architectures possible
  - Significant service and performance improvements possible, including enhanced reliability and immunity
  - Need to determine how to choose among possible topologies, and evaluate network architectures

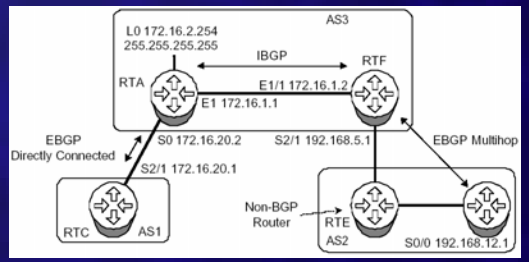


Topology & Interlayer Awareness

- Flexible topology requires inter-layer and inter-plane awareness
- Dials to observe
  - Traffic characteristics measured at network layer
  - Error rate & characteristics (BER and distribution)
    - MAC layer per packet error information
    - Network and transport layer per flow correlations
  - Receive characteristics
    - Physical layer – signal strength, interfering signals, background noise
    - MAC layer – transmit power, antenna in use
- Knobs to influence
  - Physical layer
    - Frequency & bandwidth
    - Transmit power
    - Beam width & direction
    - Data rate, code, & chipping rate
  - MAC protocol
    - FEC strength
    - Retransmit scheme
    - MTU size
    - Encryption & parameters
  - Network layer
    - Routing protocol
    - Addressing plan(s)
    - ACLs
- Interface framework needed to allow interoperation, with a flexible, usable set of scalable parameters

Routing, Topology, Administration

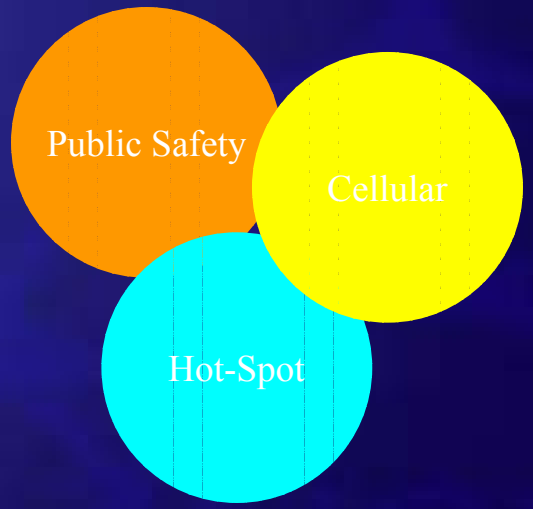
- Flexible wireless topologies implies more opportunity for connectivity with a larger set of other nodes from different administrative domains
- Policy & its implementation will be critical
  - BGP currently the only multi-domain option, with static policies tuned to particular peerings
  - Needs to be more automatic
  - Policy and security framework needs to be integrated



BGP Routing Complexities

Routing and Administration

- Flexibility creates substantial security challenges
  - Already have very hard problems to solve in traditional networks, and flexibility makes these worse
  - Which associations are appropriate and trusted?
- Separate public safety, cellular, hot-spot networks
  - How do they talk?
  - Under what circumstances?
  - With what permissions?
  - At what layer – IP, upper and lower layers?



Radios for the Community

- Radios with programmable features are urgently needed to enable advanced systems
- Possible characteristics
  - 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
  - Flexible in MAC layer
  - Flexible in network layer

Radios for the Community

- Many variations possible
- Efforts to build upon
  - XG efforts
  - JTRS radios
  - UWB systems
  - Multiband OFDM
- Prototype programmable radios within approximately 18 months
- Kits for networking experimentation to researchers by end of effort

Federal Research & Development

- Recent NSF efforts
  - Measurements of spectrum for scientific basis
  - Testbeds, preliminary flexible radio, workshops
- Ongoing DoD wireless efforts
  - DARPA
    - XG – spectrum management architectures, languages, and radios
    - Connectionless Networks (CN) – cross-layer protocols for power conservation
    - Mobile Network MIMO (MNM)
    - Future Combat Systems - Comms (FCS-C) – beamforming and ad hoc routing
  - Joint Tactical Radio System (JTRS)
    - Focus on addressing urgent military needs including legacy systems
- NASA
  - Investigating software defined radio for space applications including inter-satellite links; research prototypes include ITT Low Power Transceiver (LPT) and SSP SDR-3000

DARPA GloMo Transceiver
- 20-2500 MHz
- Up to 10 MHz BW
- 1 Hz tune step
- 100 µs tune time
- 1 watt output
- Software radio
- 20 cubic inches

Source: R. Sternowski

Source: J. Freebersyer

Source: P. Marshall

Source: DoD

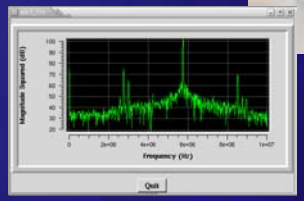
ITT Low Power Transceiver

Industry and Community R & D

- Vanu, Inc. software radio systems
  - Integrating cellular systems
  - Currently lower bandwidth services
  - Partially supported by NSF SBIR

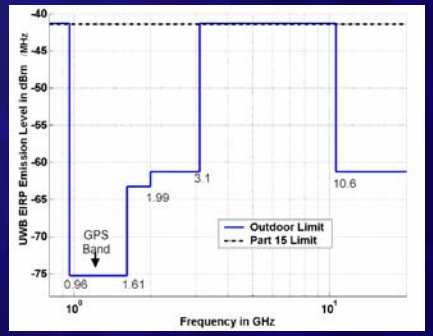
Source: Vanu, Inc.

- GNU Radio
  - Similar to Vanu efforts in technical concept and capabilities
  - Provide publicly-available platforms for development and fielding of more flexible radios



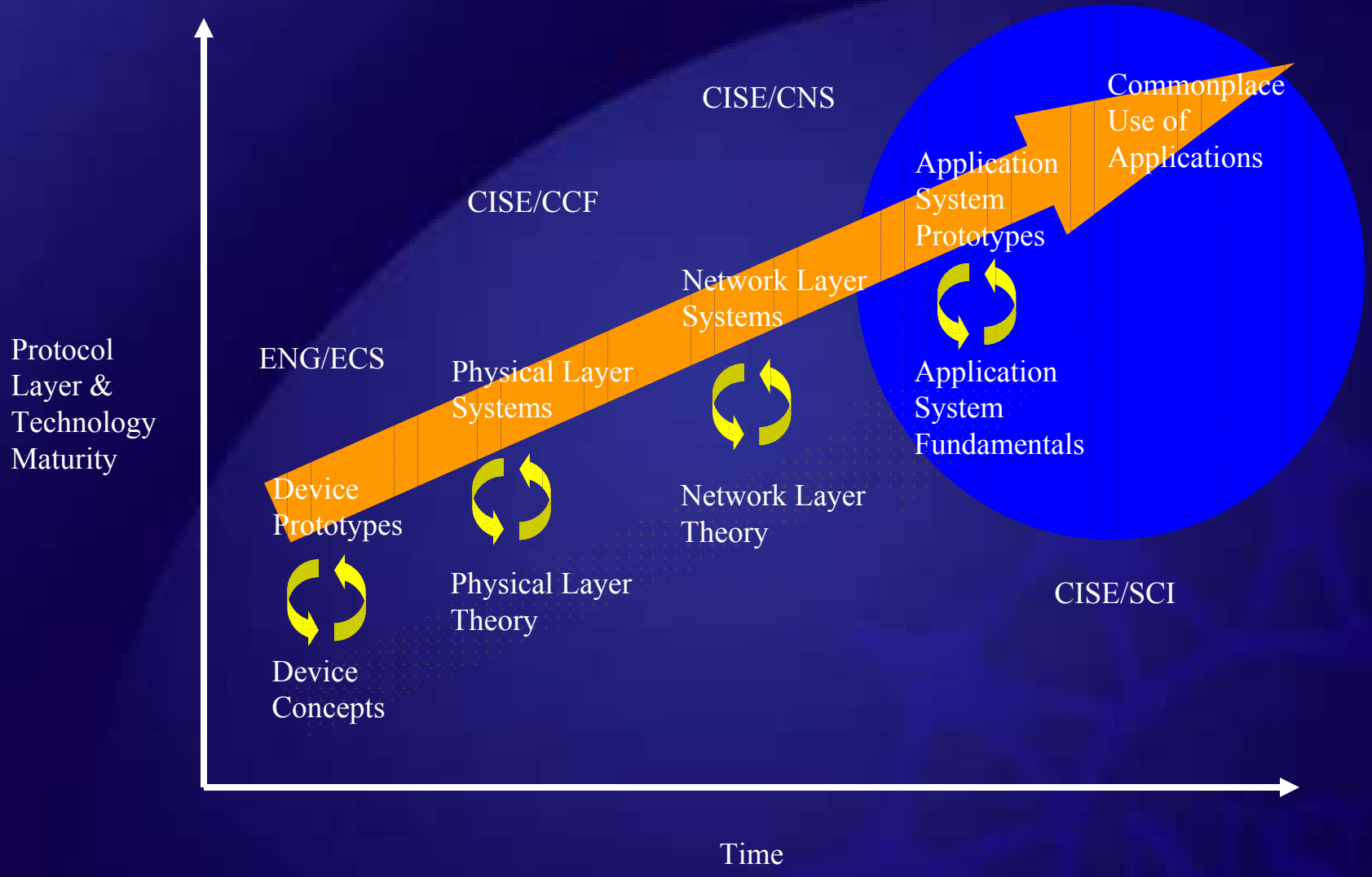
Source: GNU Radio

- Substantial UWB efforts focusing on physical layer under regulatory constraints



Source: FCC

Wireless Networking Evolution



Logistics

NeTS and ProWiN

- Programmable Wireless Networking is a focus area within the Research on Networking Technology and Systems program
- Efforts in the focus areas will be coordinated so that individual projects build upon each other
- Other wireless networking efforts that are not programmable wireless networking will be funded separately under NeTS

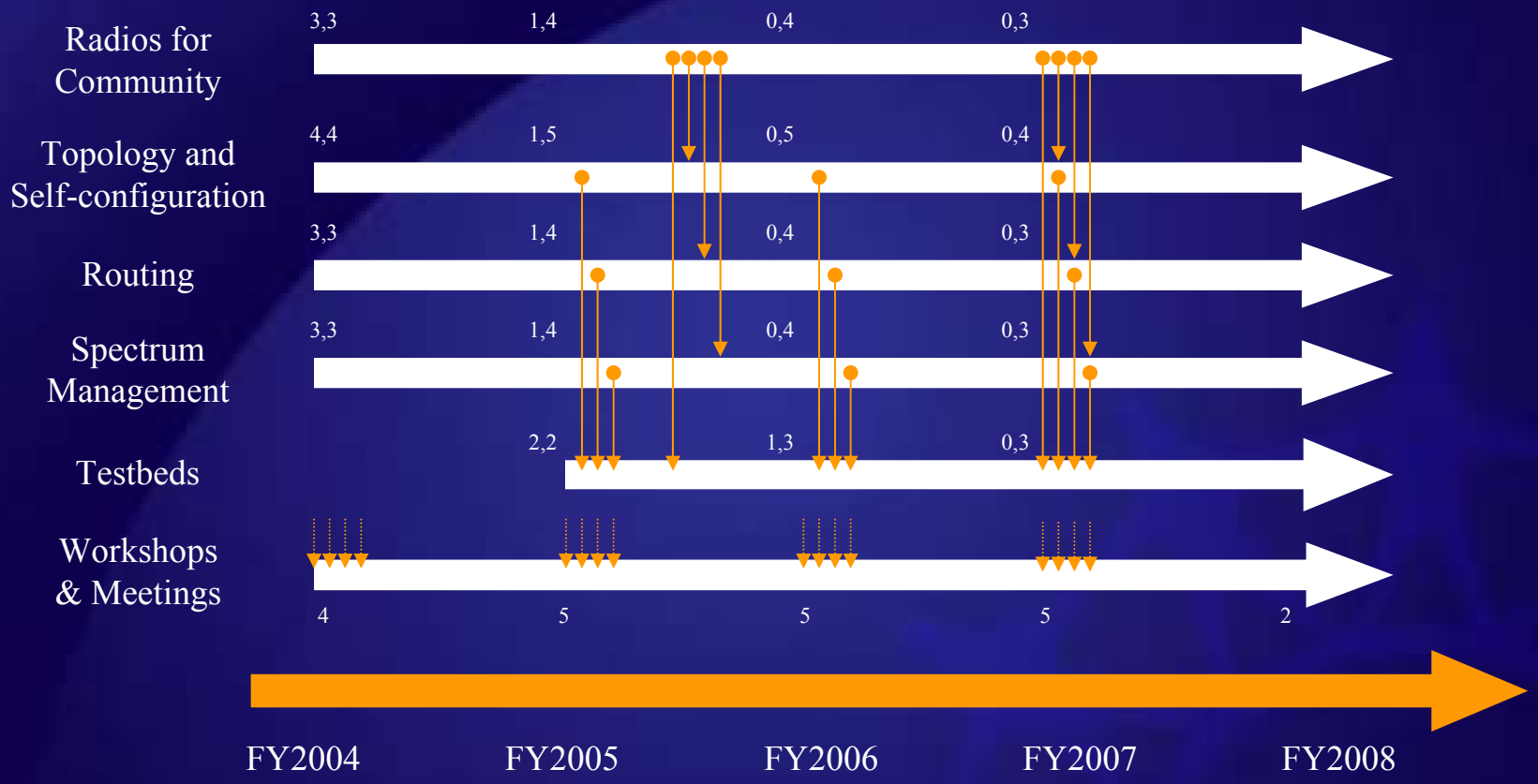
Typical Project Characteristics

- Projects investigating specific research topic areas
  - Spectrum management, topology and auto-configuration, or routing and administration
  - Interdisciplinary with people from necessary areas of the problem
  - Two or three investigators
  - Up to $300,000 per year for three years
  - Likely to be standard grants or CGIs

Typical Project Characteristics

- Programmable radio efforts
  - Goal is a non-trivial number of functional programmable wireless networking experimental kits
  - Efforts will likely need to involve industrial partners
  - Up to $600,000 per year for three years
  - Likely to be cooperative agreements

Possible Timeline



Notation: N,M is N new projects, M total efforts

This Solicitation's Schedule

- Announced in January 2004
- Proposals due 14 April 2004
- Panel review in May and June 2004
- Award notifications in July or August 2004

- And then, next year…

Program Coordination

- Principal Investigators meetings
- Research student meetings
- Site visits as appropriate
- Annual challenges of appropriate scope
- End of effort targets

Metrics for Success

- Annual challenges to encourage progress as well as information sharing between projects
  - Architectures evaluated using simulations and emulations under particular scenarios
  - Demonstrate emulation with many nodes sharing realistic spectrum allocation
- End of effort targets
  - Prototype “complete” systems
  - Demonstrate systems with non-trivial number of nodes using unlicensed and/or research frequencies under selected scenarios of applied traffic, node location & external connectivity, and security threat
- Student participation in wider research community, facilitated and very strongly encouraged through workshops and meetings

NSF Programmable Wireless Networking