



Wireless Technology Advances ... of interest

09 May 2008

Adaptive Radio Avoids Solving All Problems Itself



Progression of Radio Terminology

- Radio (from RadioTelegraphy)
- Agile Radio
- Flexible Radio
- Adaptive Radio
- Software Defined Radio
- Software Radio
- Cognitive Radio ↔ Aware Radio
- ????????



Quick List of Technologies

Interference

- Smart Antennas
- Dynamic Spectrum Access
- Interference Cancellation
- Statistical Analysis

FDD/TDD

- Technology and Device Solutions
- Spectral Flexibility

Base Stations

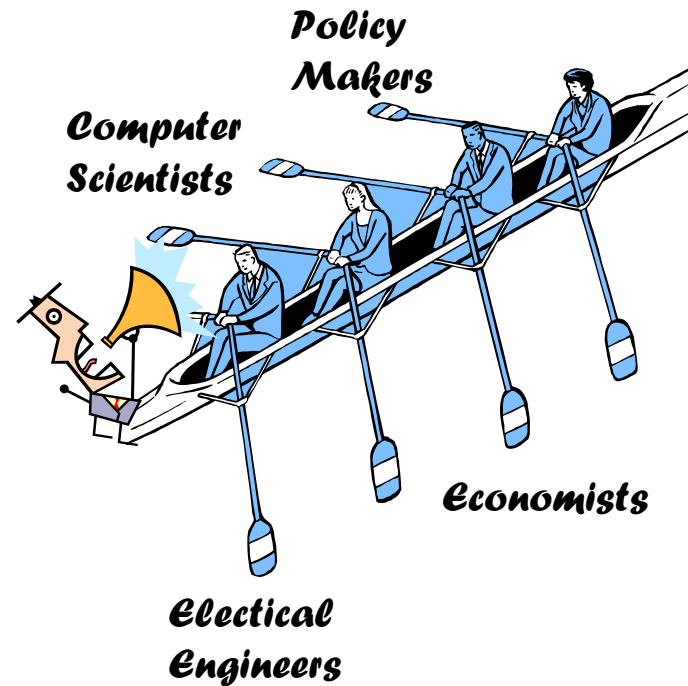
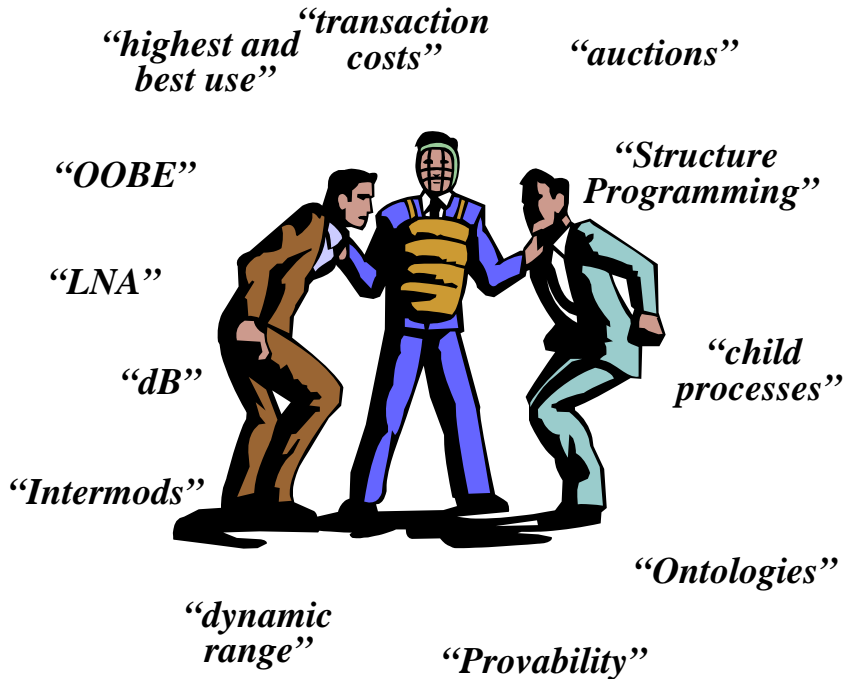
- High Level of Integration
- Higher Power (EIRP)
- Waveform Complexity
- In-building
Wireless/femtocells

Rights and Responsibilities

- Accordion Spectrum ... and variations
- Macro Dynamic Spectrum Access
- Peer-to-Peer Networking
- Policy Engines

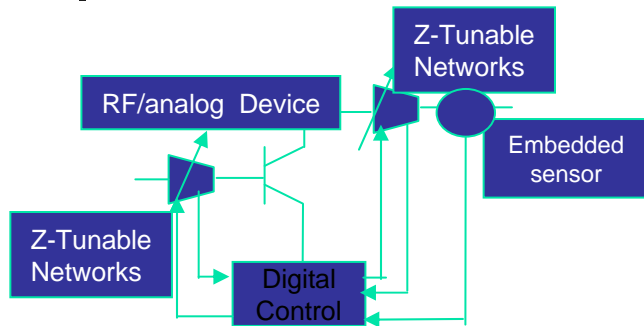
Multi-Disciplinary

Not just in Words

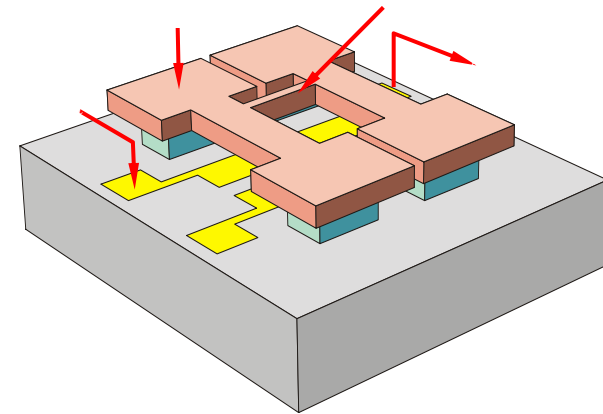


Electrical Engineers, Computer Scientists, Communications Engineers, Lawyers, Policy Makers, Economists, Physicists, Material Scientists, Pontificators

Technology for Agility



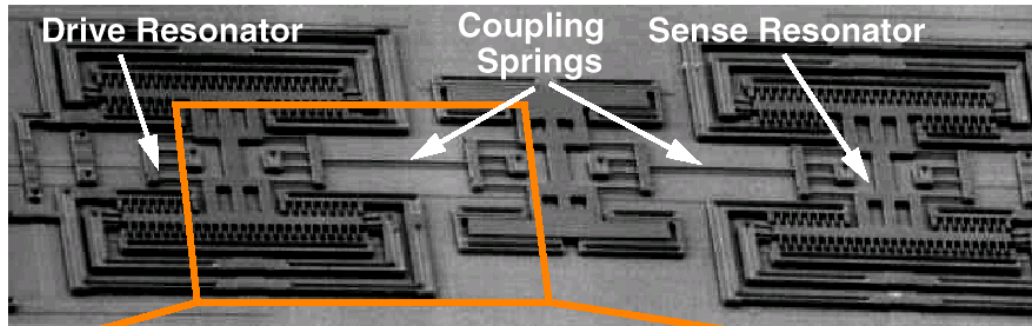
Power Amplifiers



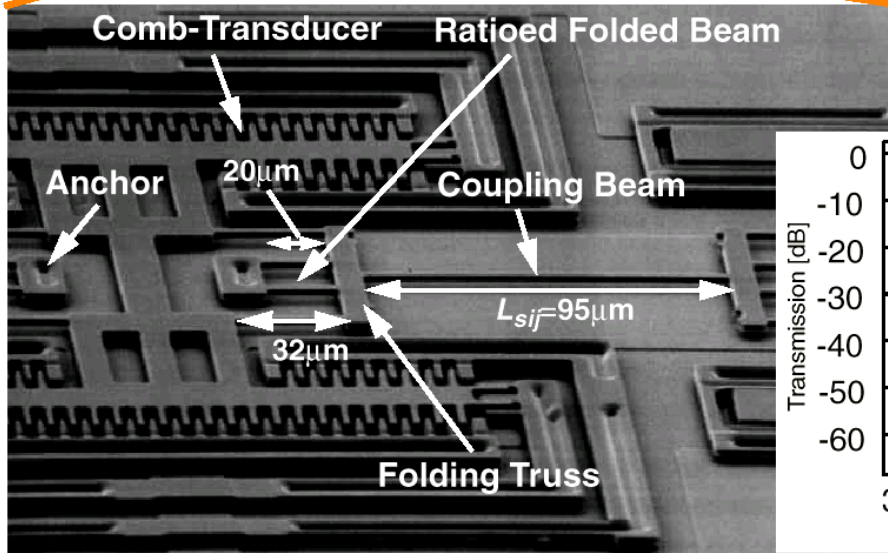
Filters

- **Adaptive RF Components**
 - **Wideband Power Amplifiers**
 - **Broadband Antennas**
 - **Adaptive Filters**

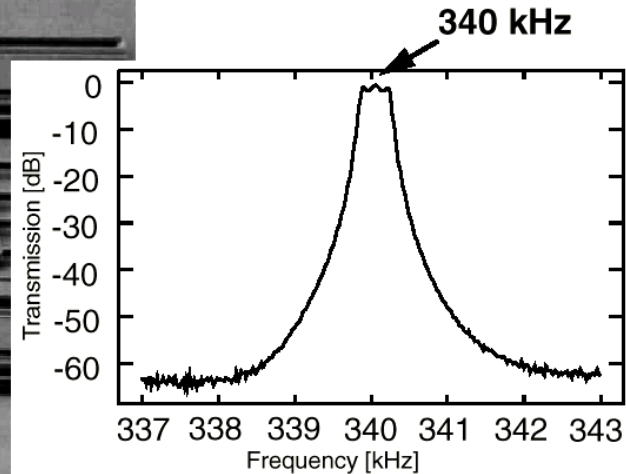
High-Order Filter



3-Resonator MF
(6th Order, 1/5-Velocity Coupled)
 $f_o=340\text{kHz}$
 $BW=403\text{Hz}$
 $\%BW=0.09\%$
 $Stop.R.=64\text{ dB}$
 $I.L.<0.6\text{ dB}$

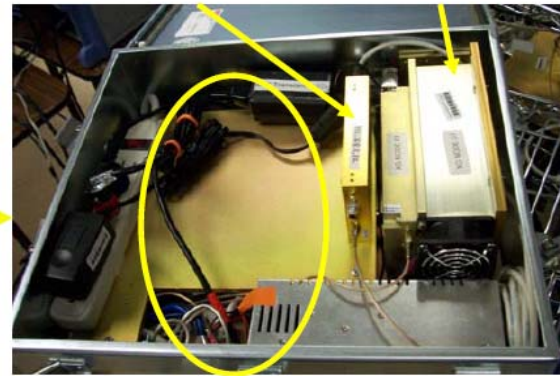
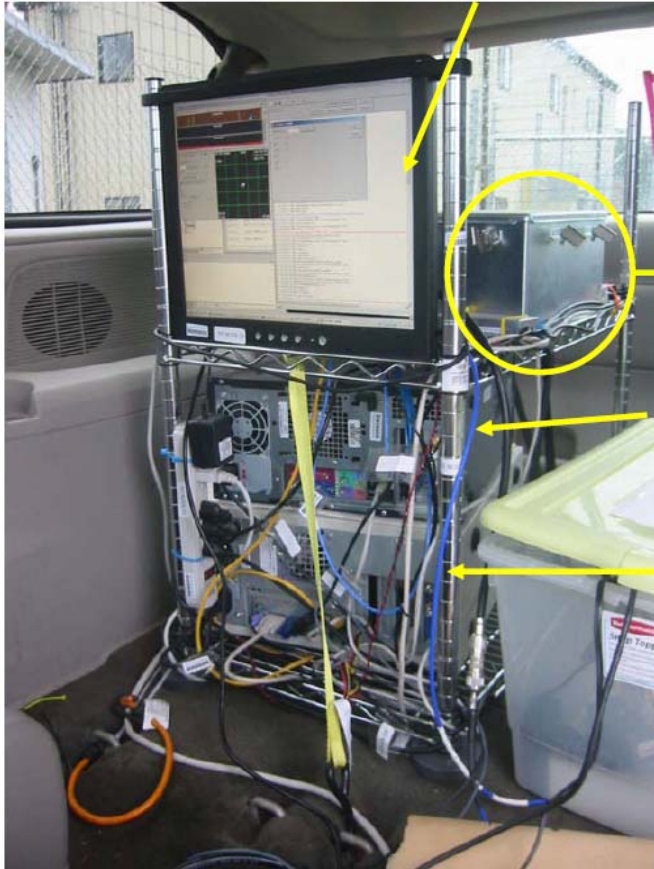


[Wang, Nguyen 1997]



XG Hardware

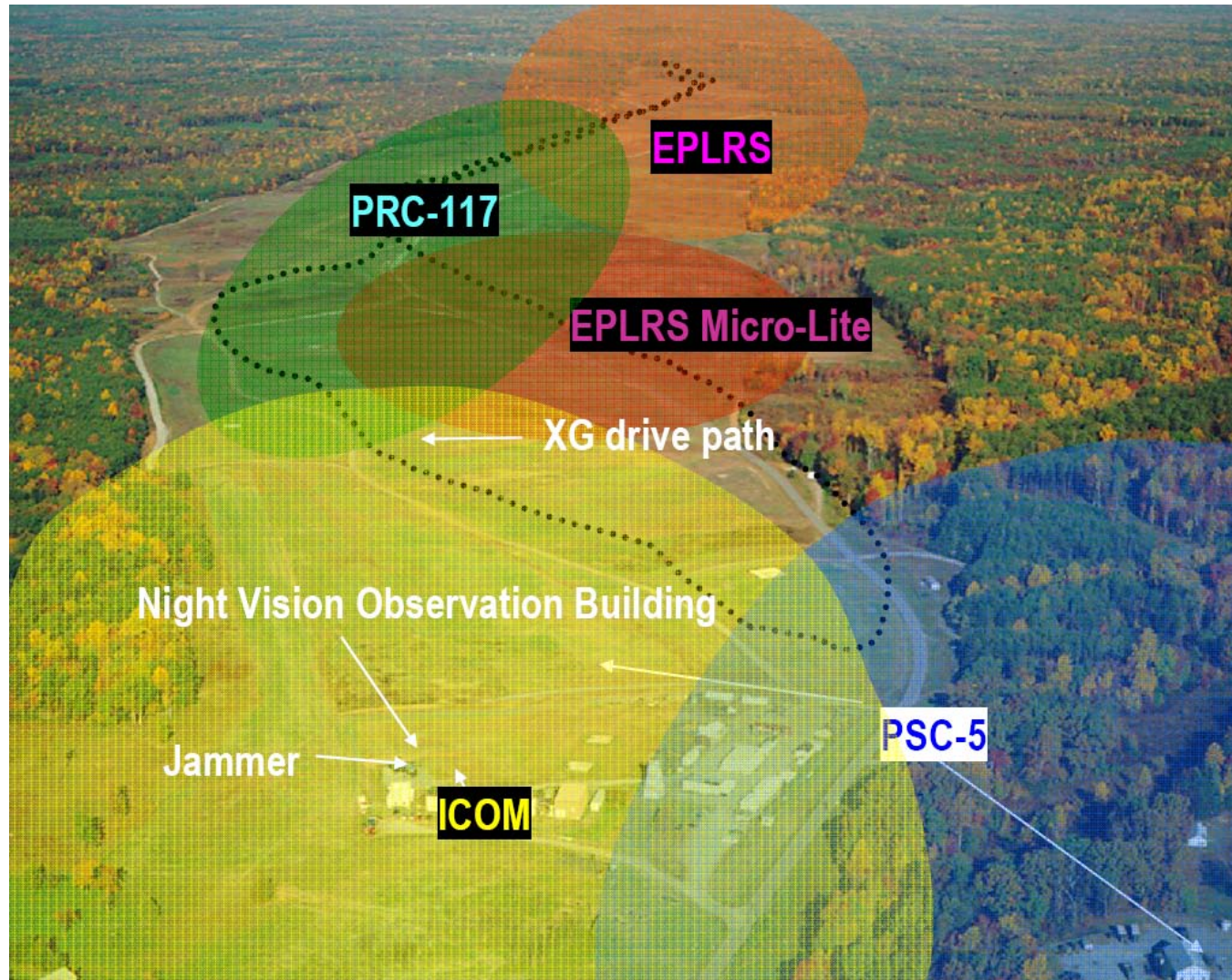
Prime Contractor - SSC



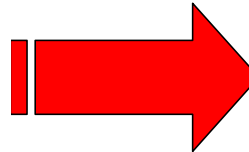
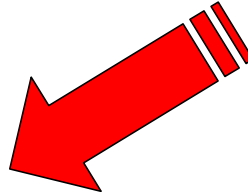
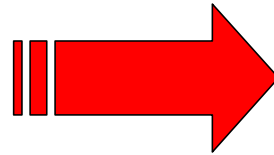
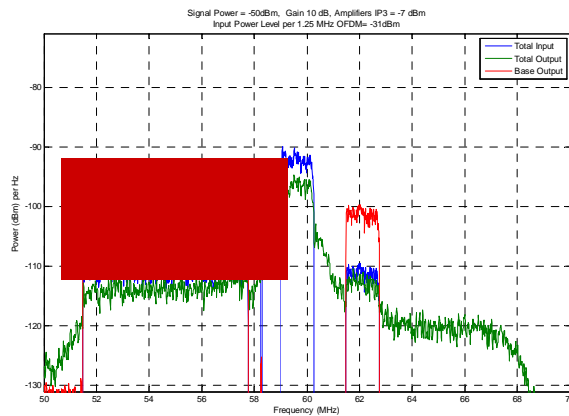
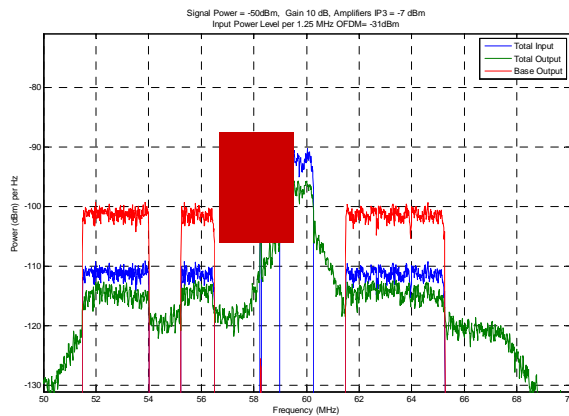
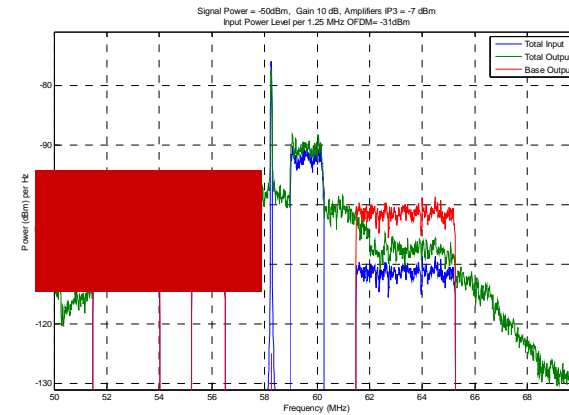
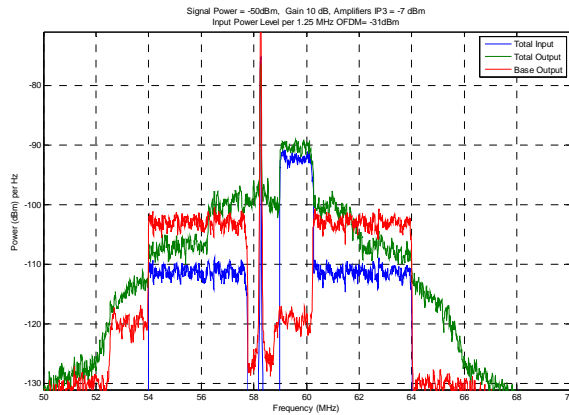
225-600 MHz RF Transceiver
(located under shelf)



Dynamic Spectrum Challenge

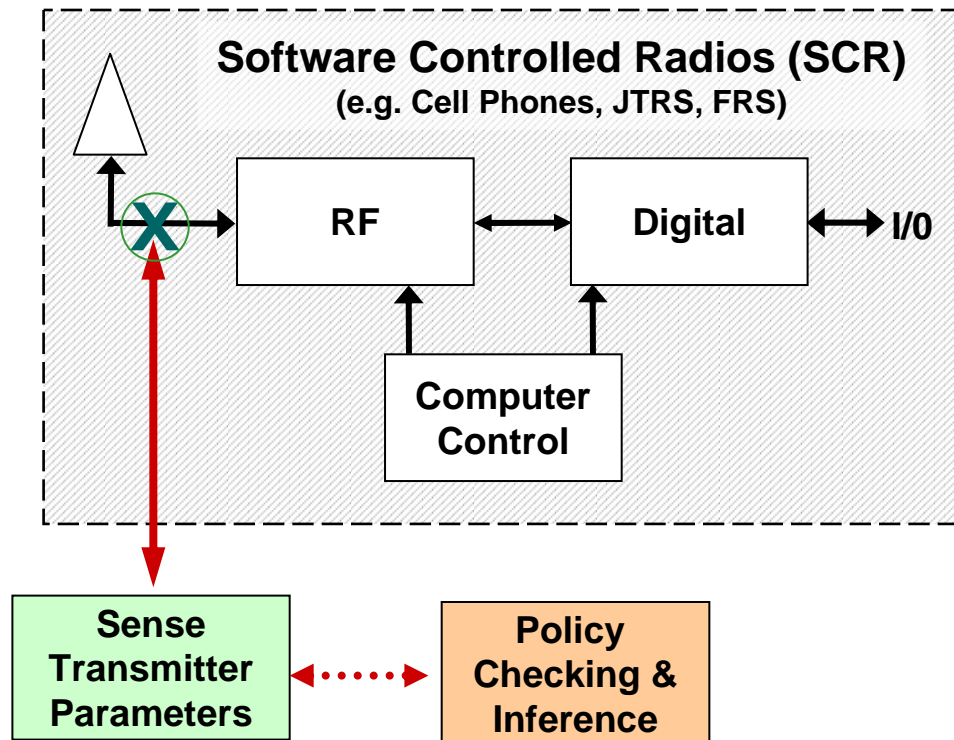


Dynamic Interference Avoidance



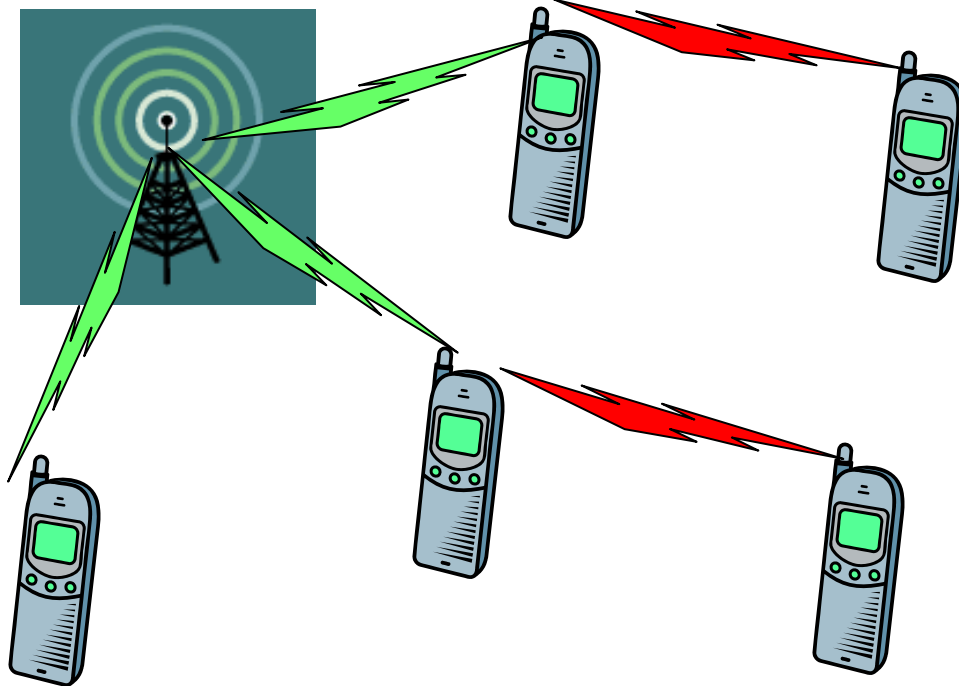
NG Radios that are Aware of Interference Effects Can Adapt to Mitigate Effects

Hardware Cognitive Radio VV&A



**Software-Based Accreditation May Not Be Attainable
– Hardware Solution May Provide an Opportunity**

Higher Density can Translate into Higher Capacity

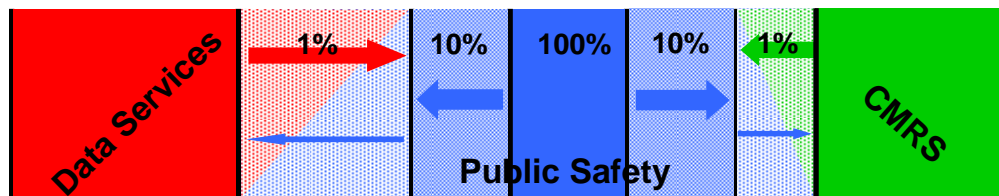
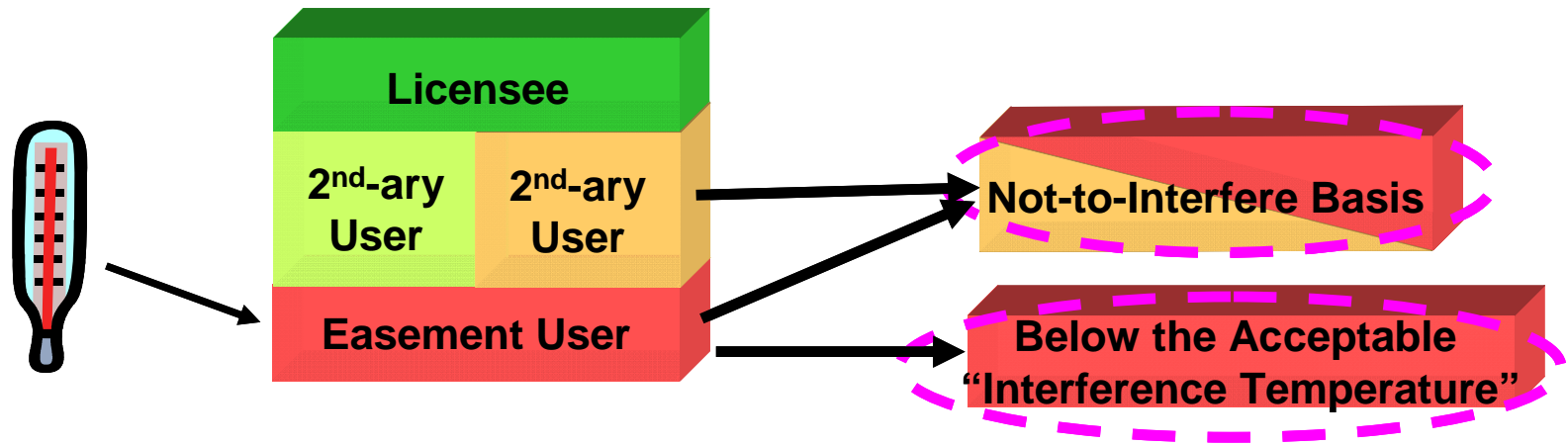


- **Pros**
 - Lower Power
 - Frequency/Code Reuse

- **Cons**
 - Complexity
 - Latency

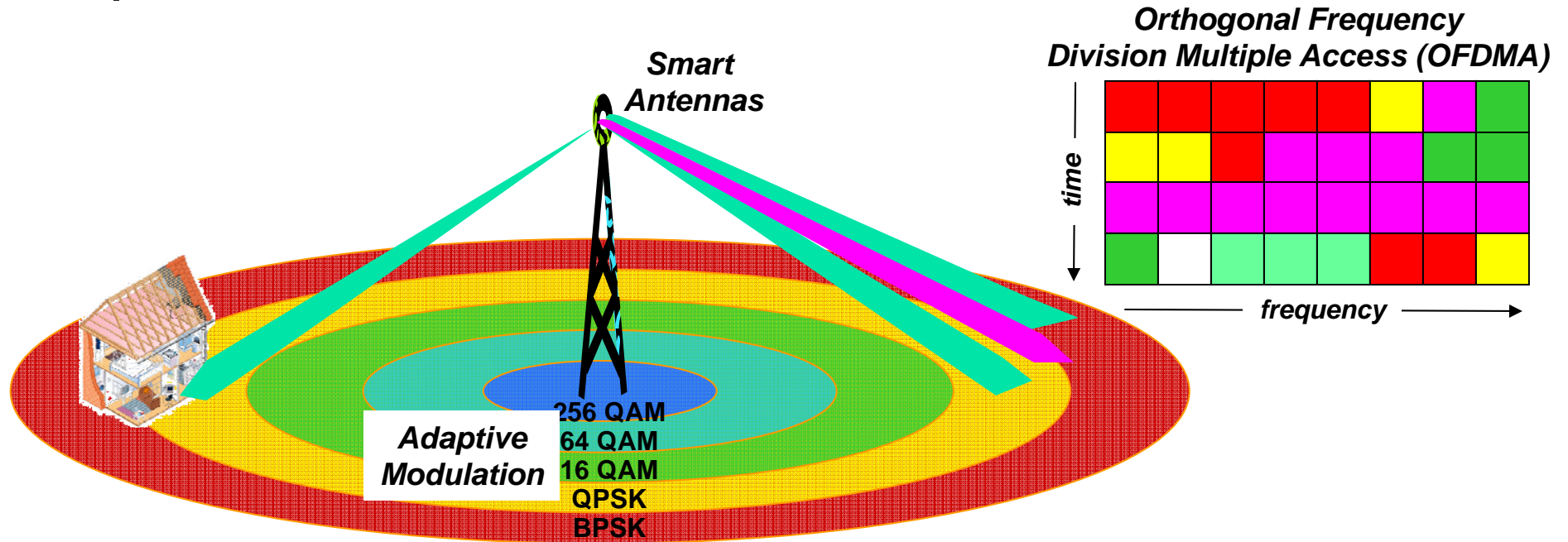
Peer-to-Peer Mobile Ad Hoc Networks Increase the Capacity of the Network at the Cost of Complexity

Promoting Access to Spectrum The New Model



Duty Cycle	
	100%
	10%
	1%

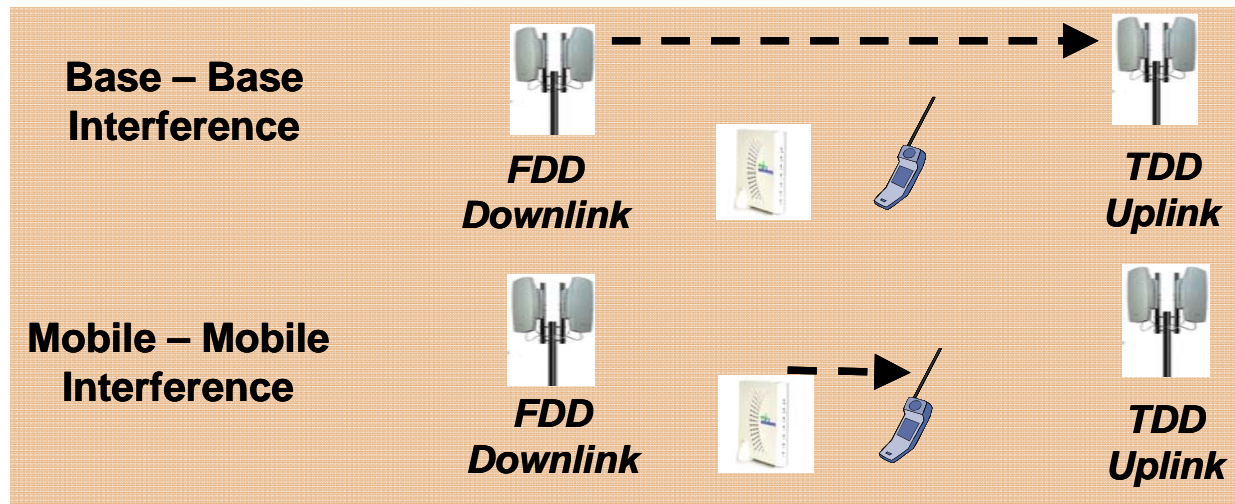
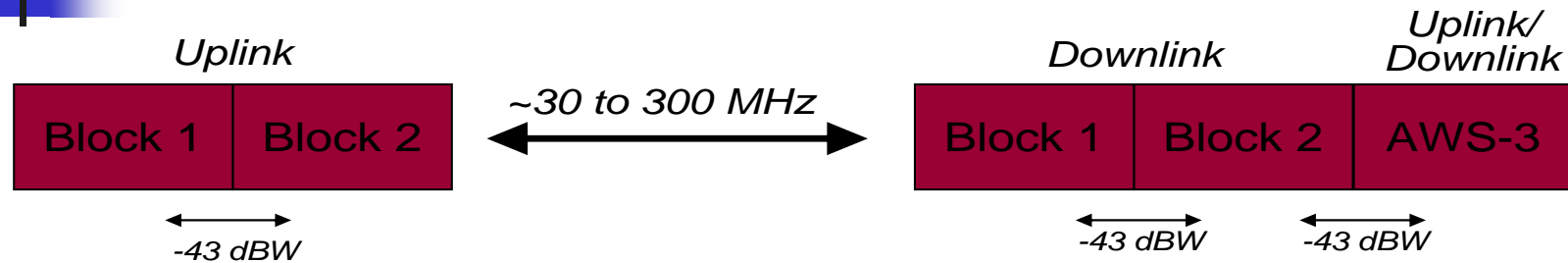
Commercial Technology Enablers



- **Technology Enablers**
 - Smart Antennas – Increases Wireless Performance
 - Adaptive Modulation – Exploits Stronger Signals for Increased Capacity
 - OFDMA – More Efficient Resource Utilization

The New Challenge

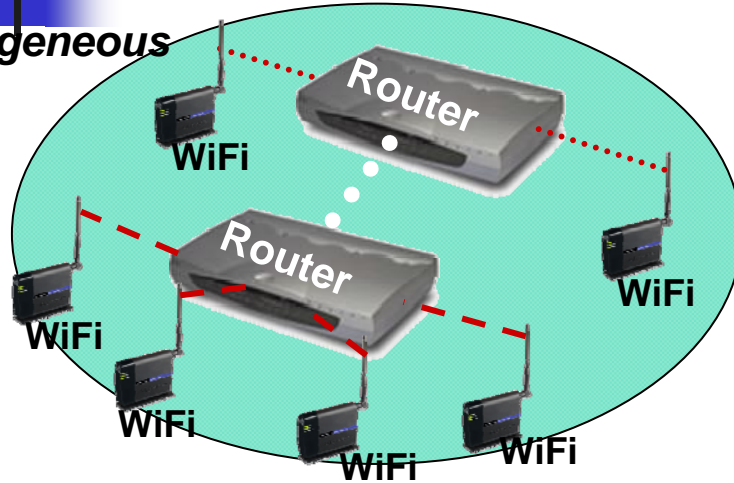
FDD (Commercial) – TDD (DoD)



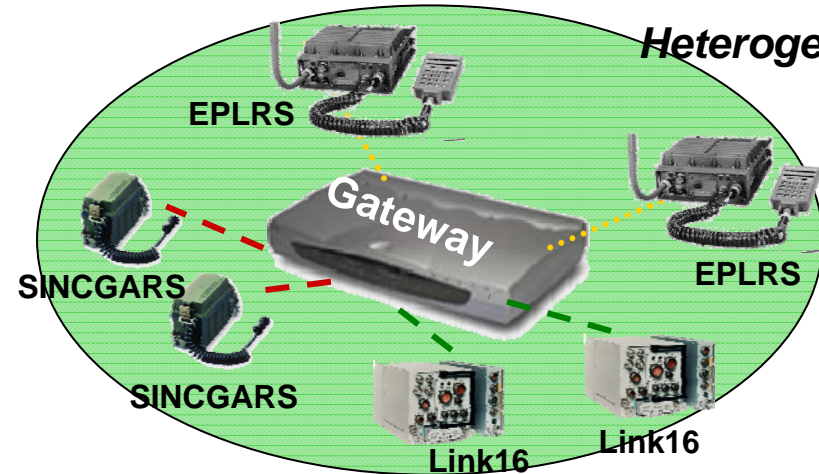
Mismatch between Commercial Technology (commonly FDD) and DoD Technology (commonly TDD) requires better technology development to make more compatible

Current Routers are not Network Gateways!

Homogeneous



Heterogeneous



Router:

Homogeneous Networking

- Enables data/voice to flow between ***similar*** networks
 - Similar Radios and Routers (e.g. WiFi – WiFi, Cell Phone – Cell Phone)
 - Disparate Networking Protocols (e.g. TCP, UDP, SCTP)
- Significant Commercial Leveraging

Gateways:

Heterogeneous Networking

- Enables data/voice to flow between ***different*** networks
 - Disparate Nodes with differing Physical Attributes (RF, Optical), Waveforms (Frequency Hopping, Spread Spectrum, UWB), Protocols (CDMA, TDMA, FDMA)
 - Networking Protocols and Networks (Infrastructure, Ad Hoc, MANETs, Fixed, Mobile)
- No Commercial Leveraging