SoftMAC: A Flexible Wireless Research Platform

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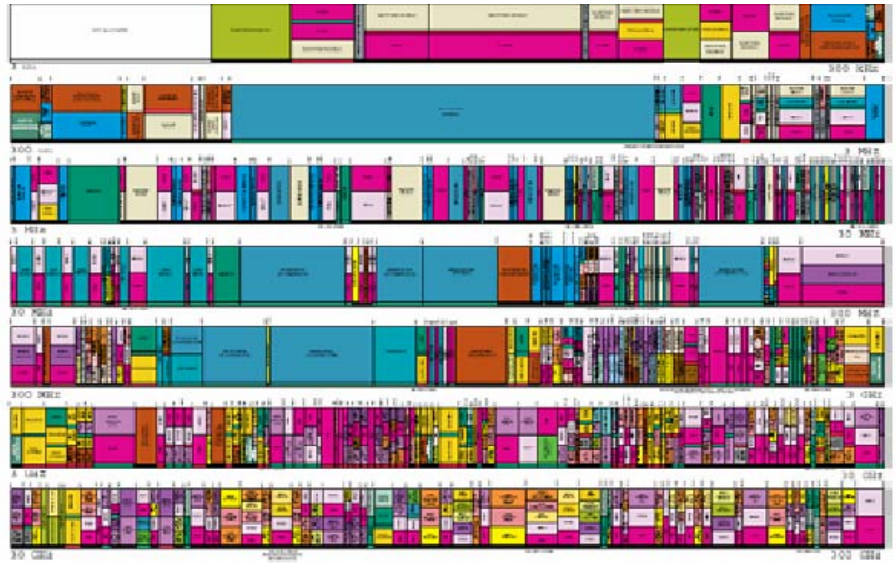
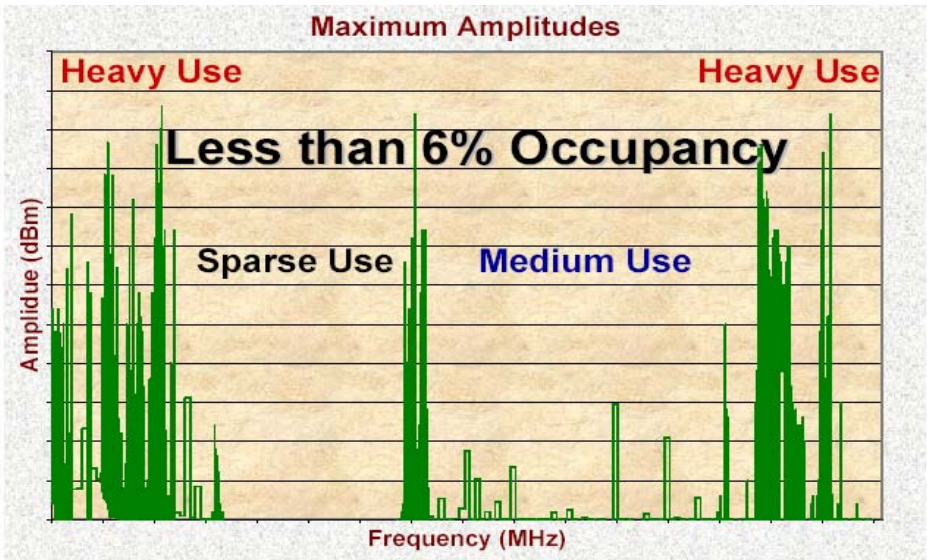
Outline

- Motivation and goals
- System design
- Application examples
- Conclusion

Software Defined Radios

- Enables construction of adaptive, resilient and multipurpose networks
- Building block for “cognitive radio” and “spectrum agile radios”
  - Temporal and spatial reuse of the spectrum
- Dynamic tuning of PHY layer “knobs and dials” like
  - Transmission rate / modulation
  - FEC / ARQ policies & adaptation
  - Channel adaptation
  - Frequency bandwidth



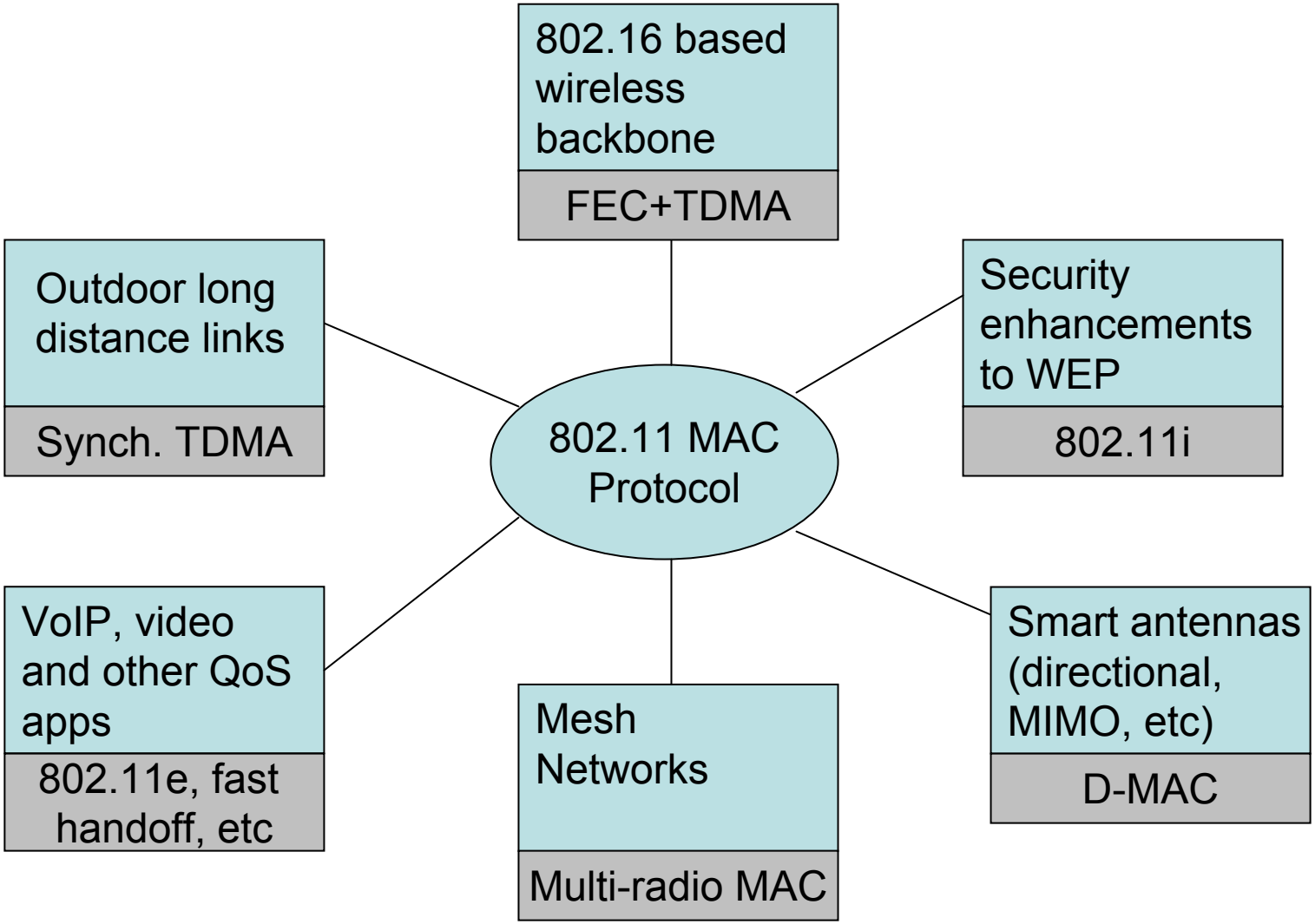


Pic. Source – DARPA XG Vision RFC

Adaptive MAC – Building resilient multipurpose networks

- Require similar set of “knobs and dials” at the MAC layer
- Adaptive/Heterogeneous MAC’s can lead to significant performance improvements
- Example: Media reservation
  - CSMA/CA for low contention periods
  - TDMA mechanism under high contention

Adaptive MAC - 802.11 “One size does not fit all”



Limitations of simulation

+ Assists rapid prototyping
+ Flexible and repeatable experimentation
+ Allows easy scalability testing

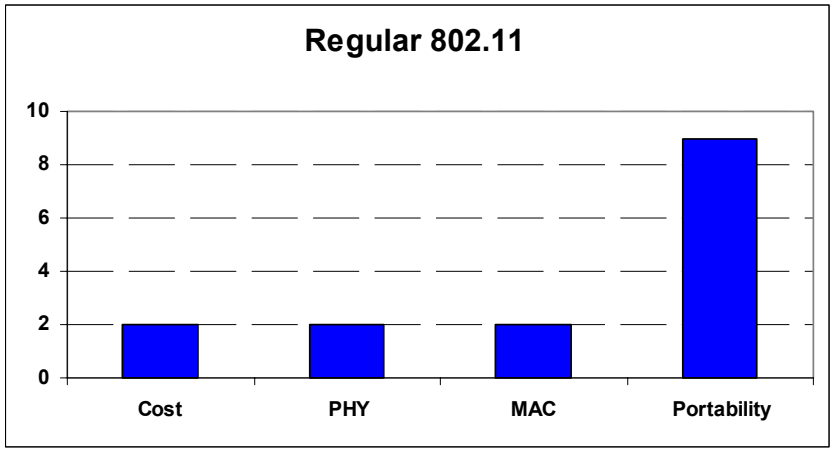
- Abstracts away a large number of real world problems
- Unrealistic assumptions of the real world

SoftMAC - Goal

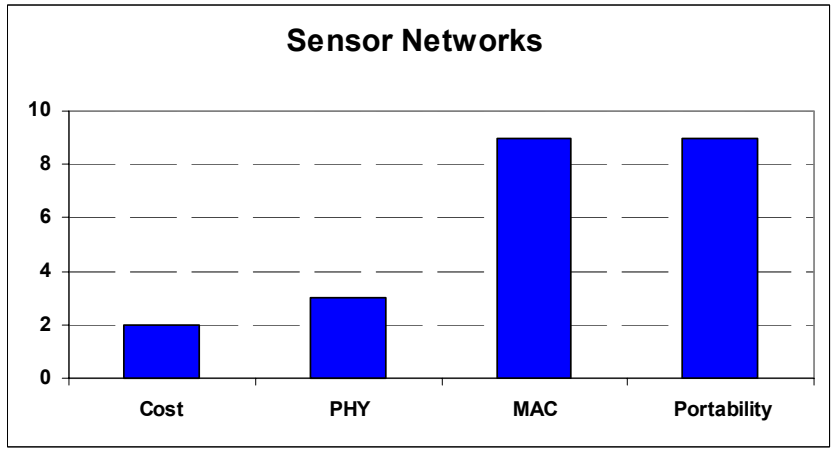
Build a platform that allows flexible and repeatable MAC layer experimentation

- What properties should such a platform have?
- Once such a platform exists, what should the software interface be?

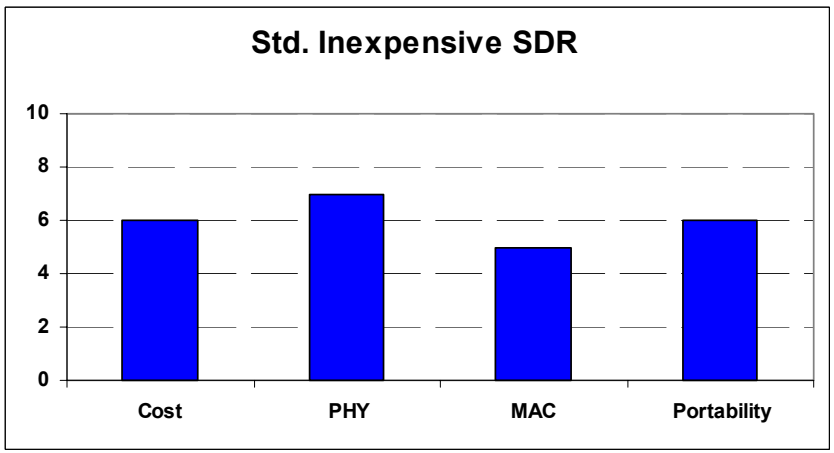
Existing platforms



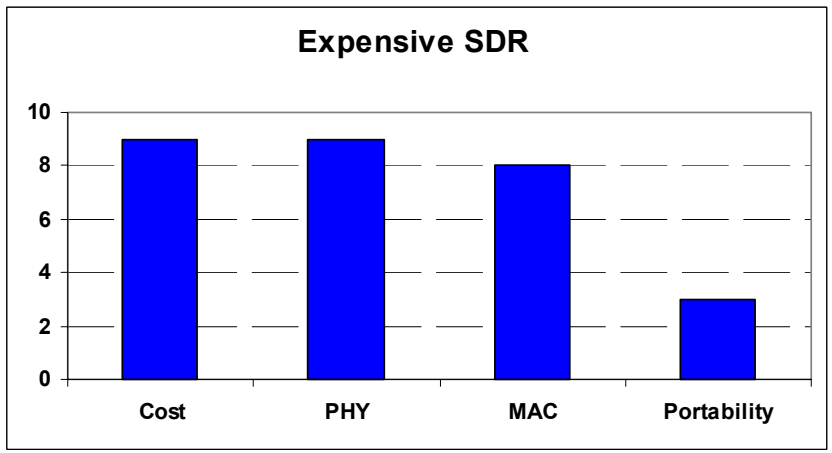
Ubiquitous and low cost. Almost all functionality hidden in firmware



Low cost, low power and highly portable. Very low data rates.



Reasonably low cost. Limited integration with MAC.

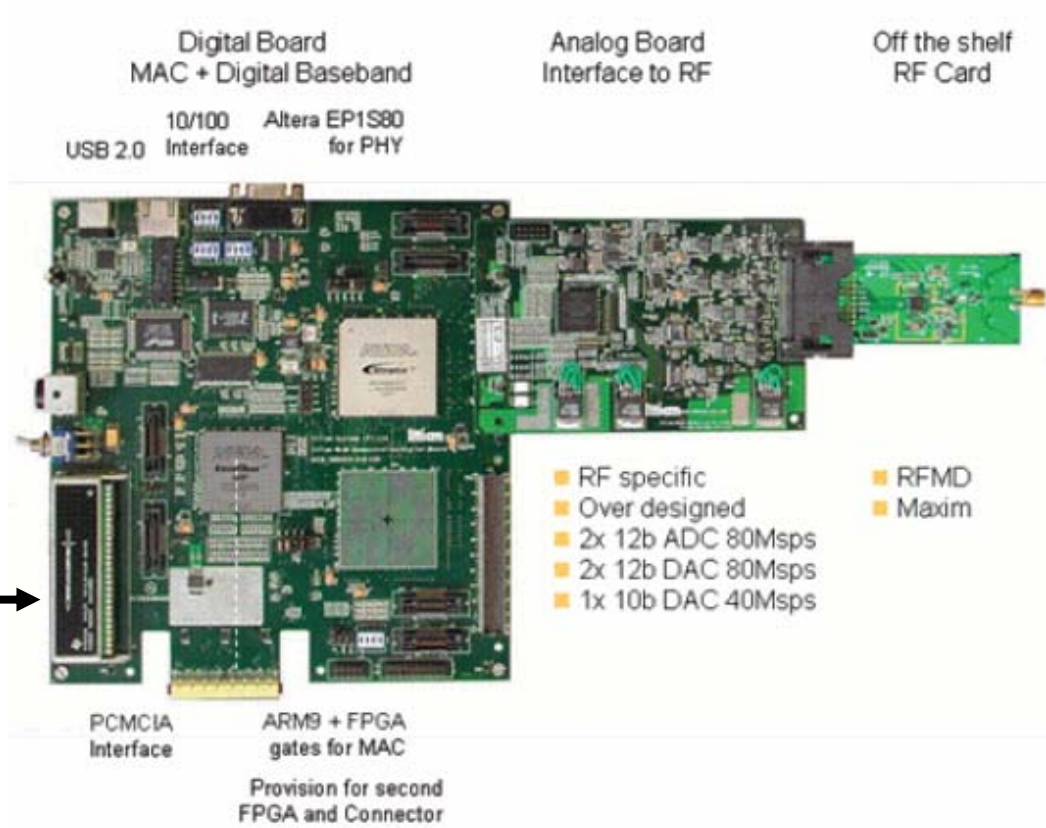


Very expensive and not portable. Overkill for MAC layer experiments.

SDR platform examples

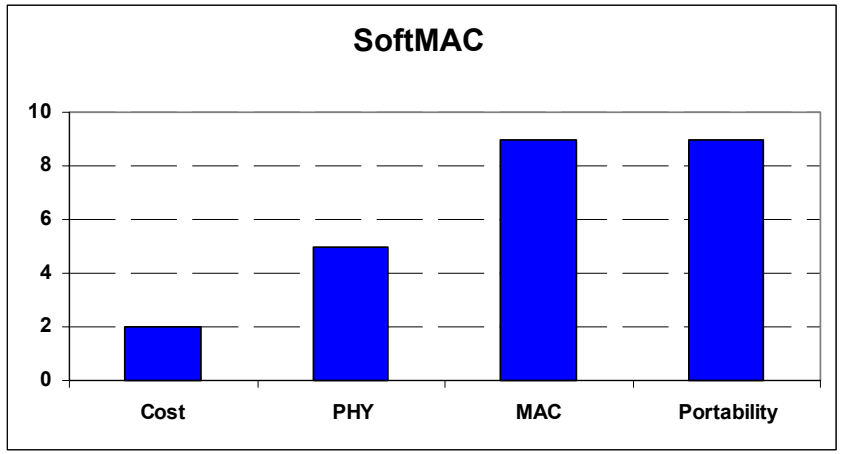
Std Inexpensive SDR platform - $700-$800

Expensive SDR platform - $9000-$10,000



SoftMAC

- COTS 802.11 hardware and mostly open-source software, *i.e.* cheap and ubiquitous
- Based on Atheros/MADWIFI drivers
- **Surprising** flexibility at MAC layer in *monitor* mode

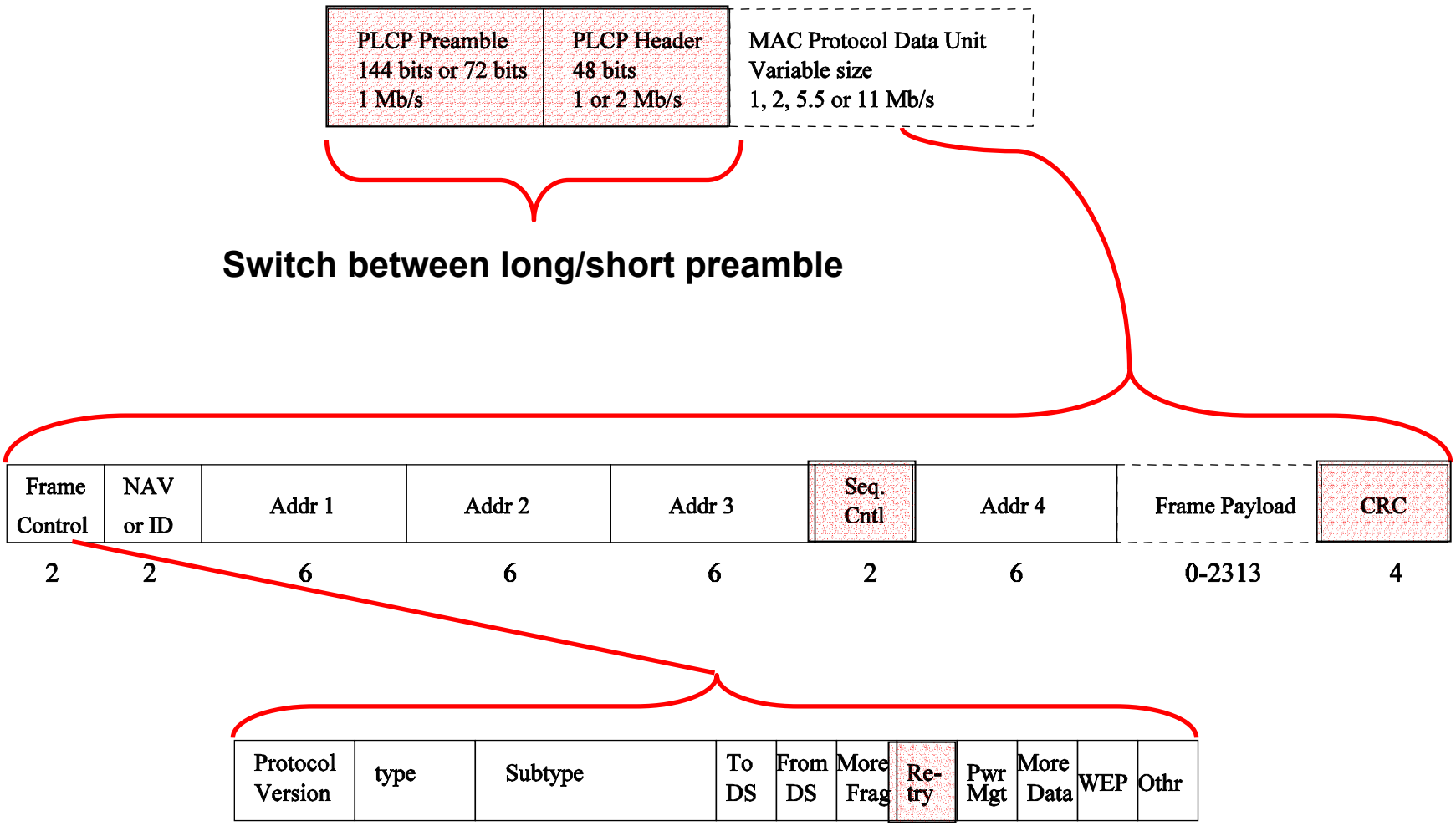


Price ≈ $60

Wish list for a MAC layer experimentation platform

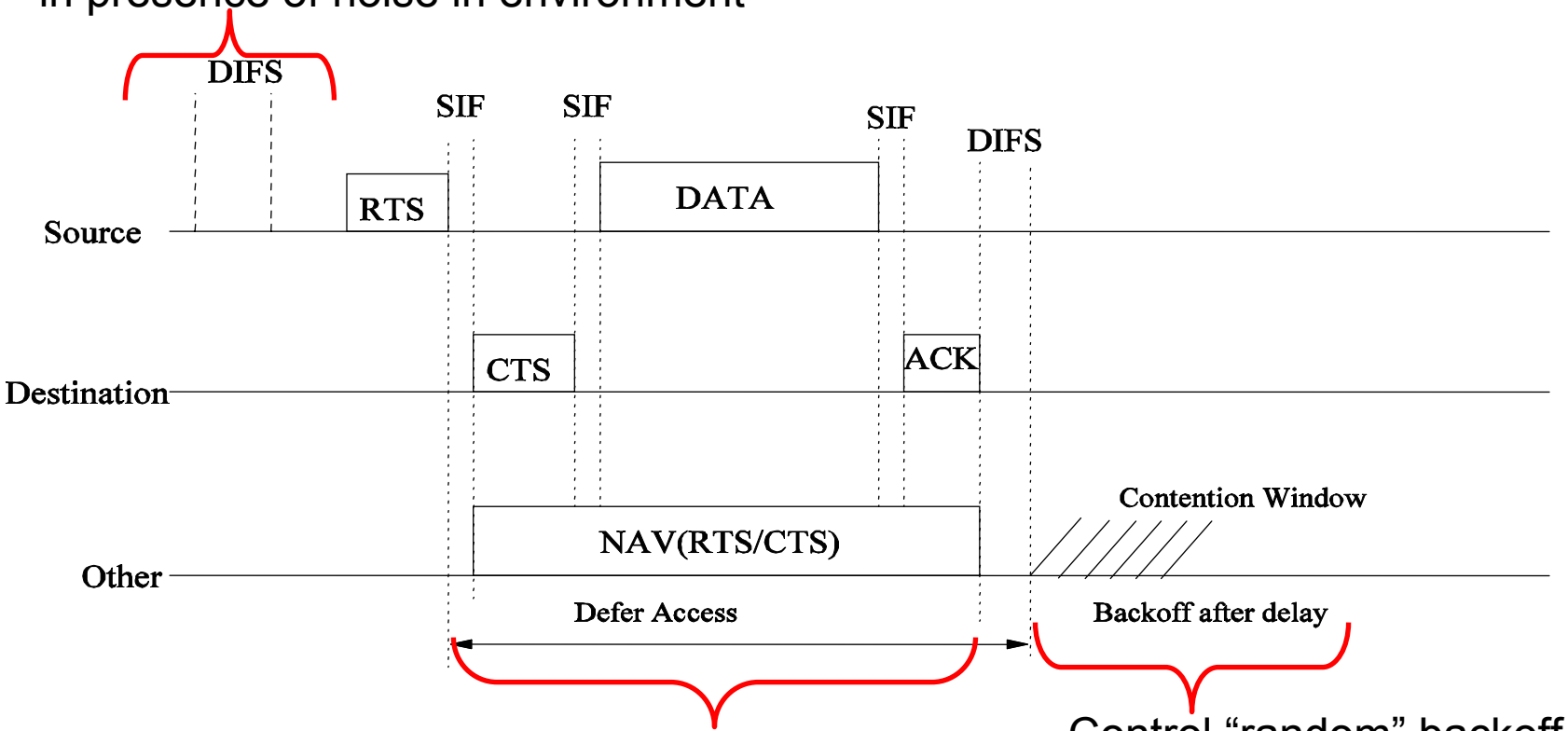
Desirable features		"Undesirable" 802.11 features
Support transmission of custom headers formats	→	Fixed 802.11 preamble and header formats
Fine control over timing of frame transmission (TDMA like protocols)	→	PHY CCA, Random backoff, virtual carrier sensing, etc
Provide visibility into PHY layer	→	Supports no mechanism to read/write PHY parameters
Support reception of arbitrary frames, including error frames	→	802.11 state machine filters malformed and error frames
Compatible with existing 802.11 devices		
Low cost and portable		

Controlling MAC frame format



Controlling transmission timing

Cannot eliminate DIFS interval. However, can control PHY CCA. Allows transmission in presence of noise in environment

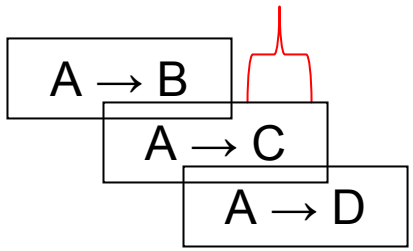


NAV updates are suppressed in monitor mode

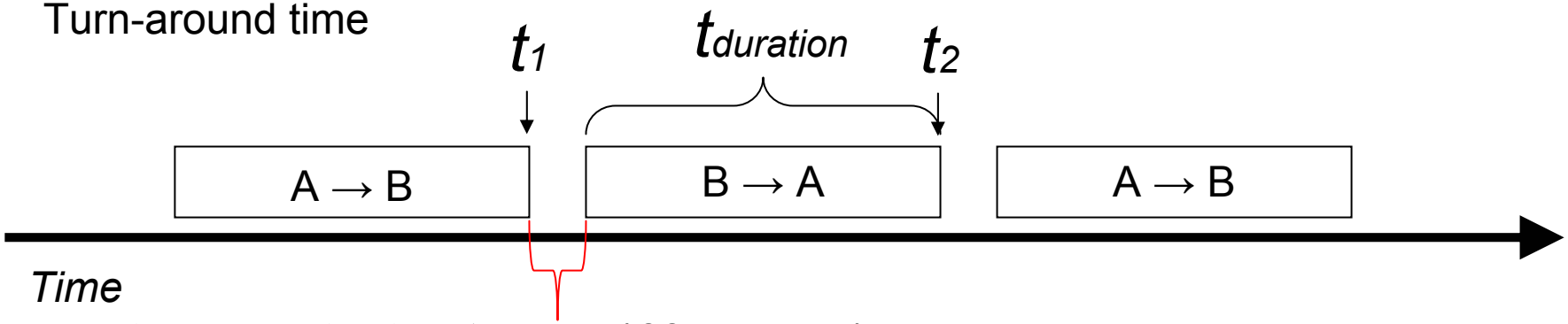
Control “random” backoff by setting the CW interval to 1

Timing micro benchmarks

- Frame transmission rate
  - SoftMAC can send MAC frames every 91μ sec ±1μ sec



- Turn-around time



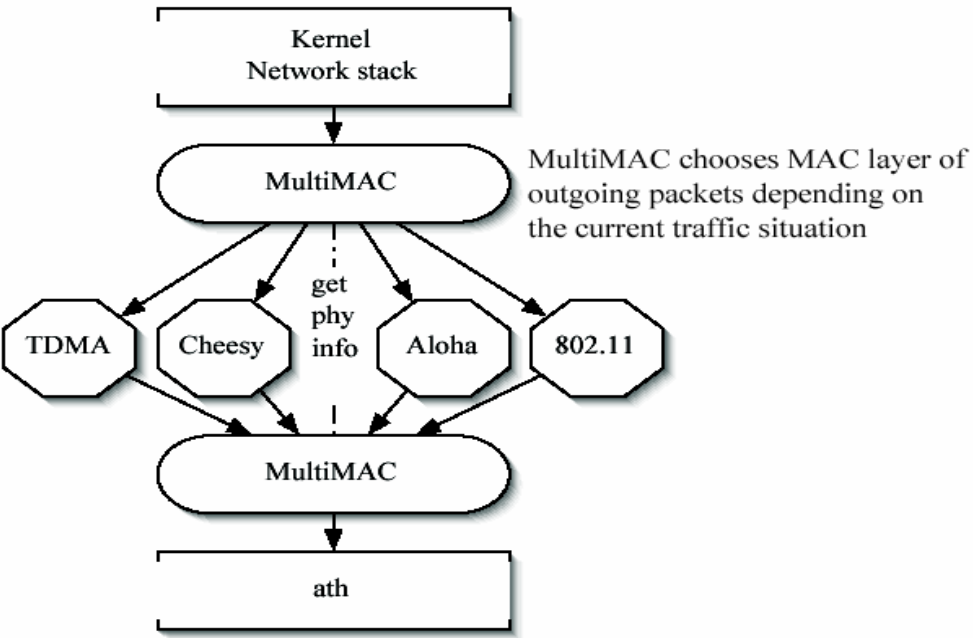
$t_{turnaround} = t_2 - t_1 - t_{duration} = 166$ u sec ± 1 u sec

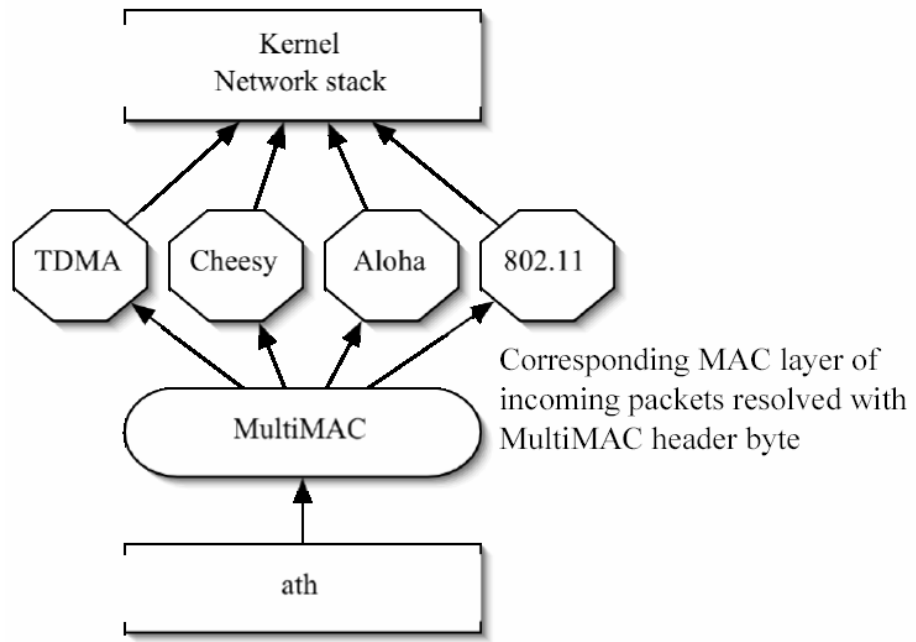
Visibility into PHY

- Measure noise floor
- Receive CRC and PHY corrupted frames
- Diagnose the type of PHY error that corrupted the frame (CCK/OFDM timing errors, illegal rates, illegal parity etc.)
- Set 802.11 specific parameters (CTS/ACK timeout, force PHY CCA calibration, etc.)

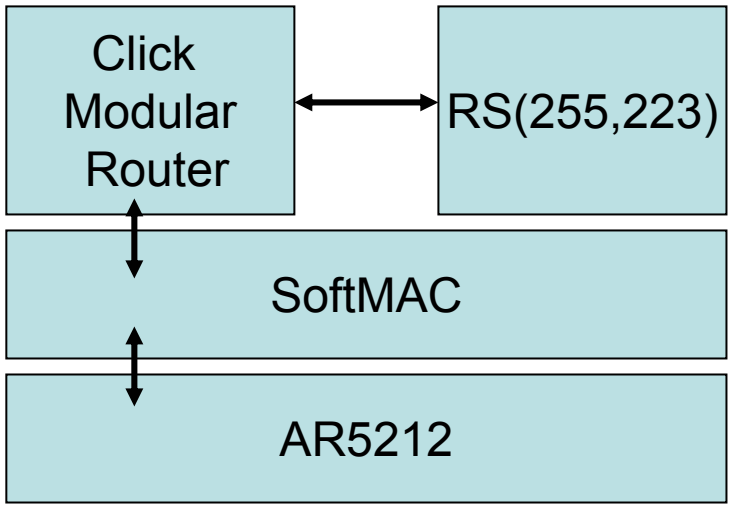
Applications of SoftMAC

- TDMA based MAC
- Adaptive Reed Solomon MAC
- MultiMAC [DySpan ’05]
  - Dynamically switch between different MAC protocols





Adaptive Reed Solomon MAC



s = sample period e = error threshold

c = No error threshold

- Measure error frames for *sample period*

- if error frames > *error thresh* then signal “start RS”

- if error frames < *No error thresh* then signal “stop RS”

• On average 75% of packets were RS encoded

• Packets dropped due to errors reduced from 50% to less than 10%

Reed Solomon MAC for s=10, e=2, c=10			
	Recv	Valid Recv	RS Recv
RS	3859	3660	2971
802.11	3845	1850	0

Limitations of SoftMAC

- Very limited compared to a “real” SDR
  - Little flexibility at the PHY layer
  - Experimentation restricted to the MAC layer

- True innovation for (multihop) wireless is going to rely on new PHY’s
  - “Relay architectures” – radio repeaters
- Network community needs platforms to foster systems research rather than paper designs

Conclusions

- Flexible, low-cost MAC layer experimentation platform
- Significantly more flexible than stock 802.11
- Prove / disprove a significant body of work in “cross-layer” wireless research
- Download from -

  http://systems.cs.colorado.edu/projects/softmac

“[SoftMAC] is a hack, but a very clever and useful hack”
- External reviewer (Jay Lepreau)