

**WINLAB**

**Fall Research Review**

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# Why are we here?



- You were attracted to his research
- You were attracted to research he inspired

# WINLAB Systems

- 1989 PRMA
- 1990 Digital packet switching
- 1996 Infostations

# WINLAB Algorithms

- Interference cancellation
- Integrated power control, handoff, channel allocation
- Paging and registration algorithms
- Internet Protocols for mobile users

# WINLAB Evaluation Tools

- Hysteresis based Handoff Analysis
- Simulators for Radio Resource Management

# Wireless Timeline

- 1983: Analog Cellular - Local
- 1989: WINLAB Started
- Wireless Information?? 1989??
- 1991: 2G Digital - Roaming
- 1999: Short Message Service
- Wireless Information??

# Wireless Data Over 2G Cellular

- Cellular Voice:
  - Anytime Anywhere
  - Low bit rate: 10K bps
  - High cost/bit
  - $v$  cents/min voice =  $13v$  cents/MB
- Data over Cellular:
  - Slow and Expensive:
    - 20 cents/min voice = \$2.60/MB
    - 100X too high

# Wireless Data over 3G Cellular

- 2X or 3X increase in BW efficiency  
⇒ reduced cost/bit
- Higher speed: 144K or 384K bps
- But voice is still 10K bps  
⇒  $v$  cents/min =  $13v$  cents/MB
- \$/MB still too high for anytime/anywhere data



# WINLAB Research Agenda

- *“Advancing the future of wireless ~~communications~~ information”*
- Every project is about wireless data

# WINLAB Research Agenda

**Scalable**

**Simulation**

**Framework**

•Xmitter/Recv'r Design

•Radio Link Perf

•Radio Resource Mgmt

•Multiple Access

•Networking, Applications

**Infostations**

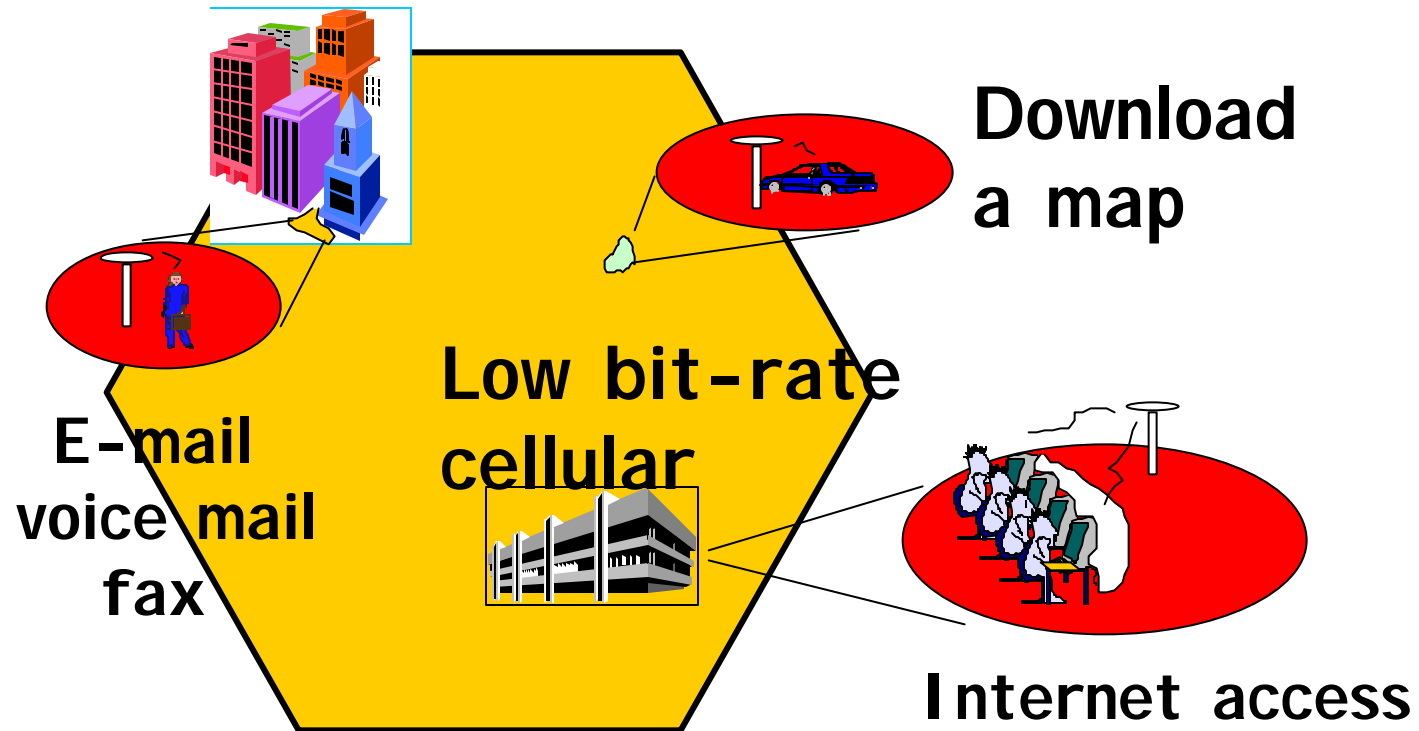
# Research Approaches

- **Systems**
  - Infostations
  - Interference Avoidance
  - Environment Aware Protocols
- **Algorithms**
  - Advanced receivers
  - Multiaccess for Multi-class traffic
- **Evaluation Tools**
  - Scalable Simulation Framework

# Infostations

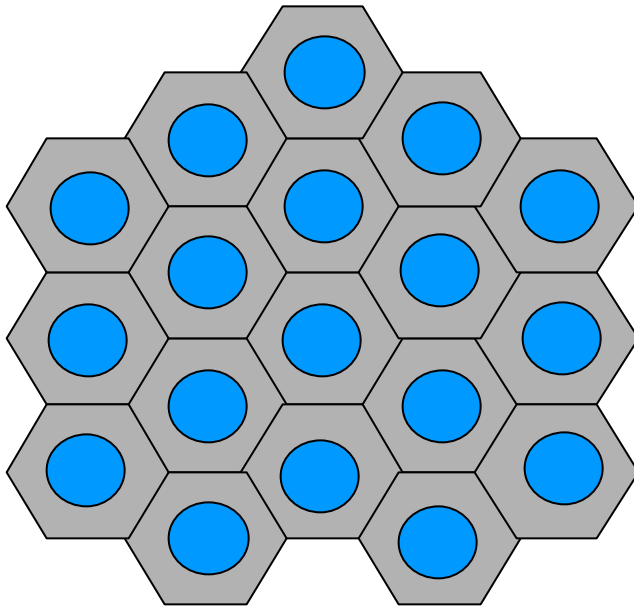
- DATA can tolerate delay!
  - e-mail, voice mail, fax, maps, non-interactive web pages, ...
- We don't need ubiquitous coverage
- Reduced coverage  
⇒ Higher data rates
- A little wait might be worthwhile!

# Infostation Scenarios

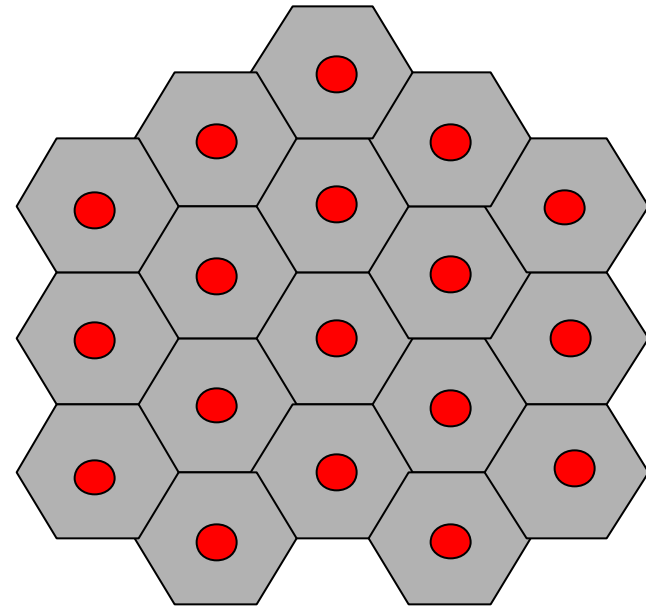


Cost/bit comparison vs cellular?

# Cellular Infostations



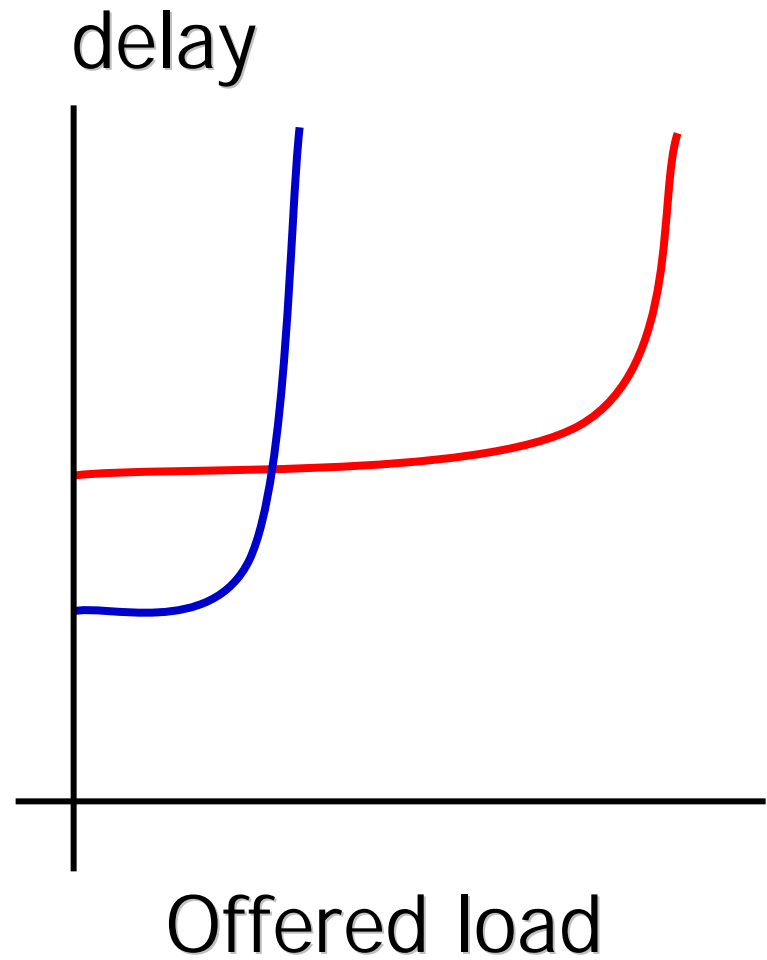
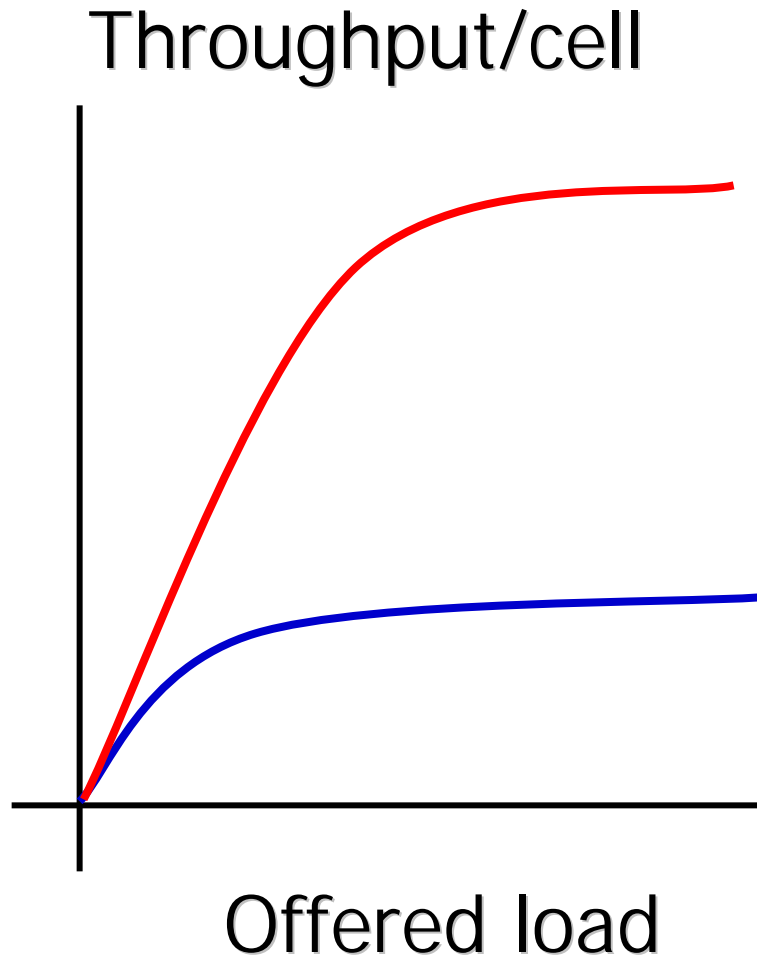
● 2M bps



● 6M bps

Which system is better?

# Infostation Performance



# Infostation Conclusions

- Reduced coverage  $\Rightarrow$ 
  - High level modulation, small cluster sizes
  - increased throughput
  - but higher “travel” delay
- Coverage needs to adapt to load
- System comparisons are nontrivial



# Wireless Systems are Complex!

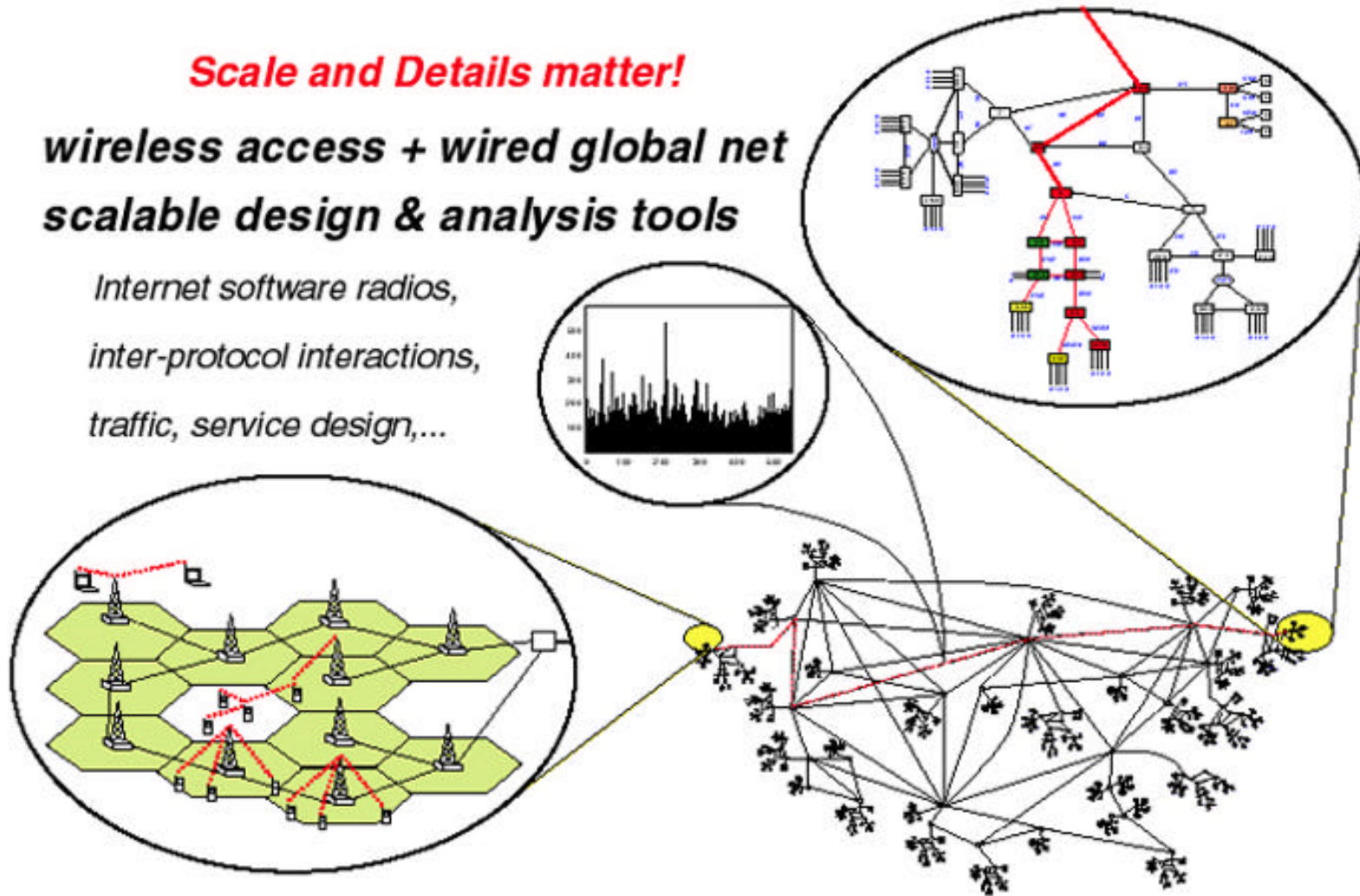
- Physical Layer (wideband)
  - Interference suppression/cancellation
  - antenna beamforming
    - ⇒ Radio Resource Mgmt Models???
- Network Layer Interactions
- WINLAB approach:
  - integrated simulators
  - Reusable code libraries

# SSF 2000 - integration of Internet & Wireless models

**Scale and Details matter!**

**wireless access + wired global net**  
**scalable design & analysis tools**

*Internet software radios,*  
*inter-protocol interactions,*  
*traffic, service design,...*



# SSF Applications

- Current Applications:
  - Mobile Dynamic Resource Allocation
  - Chip level Multicell signal processing
    - W-CDMA air interface, receiver
  - GPRS Reverse Link MAC
- Future Applications
  - GSM/EDGE physical layer
  - Bluetooth? Wireless LAN?

# WI NLAB Deliverables

- **1989:** WI NLAB Technical Reports
  - Early dissemination of research papers
- **1999:** Immediate WWW paper distribution!
  - expected mode of academic research
- **WI NLAB Packages:** the new deliverable
  - Tech Report, Software (simulation code, matlab files, etc), HTML instructions

# The WINLAB Future

- Academic Year 1999-2000
  - WINLAB Director Search
  - WINLAB/ECE Faculty Search
    - Searches follow the slow academic calendar
- Academic Year 2000-2001
  - WINLAB/ECE Faculty Search
- WINLAB Needs More Networking!

# Research Review (Morning)

- Interference Management for CDMA
- Hierarchical Control for Resource Management in Wireless Data Networks
- Break/Posters
- Interference Avoidance and Dispersive Channels
- Protocol Interactions in the Wireless Internet
- Lunch

# Research Review (Afternoon)

- Signal Processing Simulation for a WCDMA System
- Infostations + WINMAC Research
- Data Partitioning for Disconnected Client Services Databases
- Break/Posters
- Industrial Advisory Board Meeting
- Dinner