Next Generation Wireless
Who Needs Base Stations?

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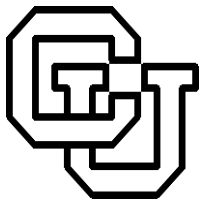

Overview

- **3G challenges**
- **Ad hoc network alternative**
- **Our work on energy aware strategies**
- **3G or Ad Hoc networks?**

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Nada Locatelli, Sukhjinder Singh, James Zeiger**

The 3G Challenge

- **new spectrum —> Europe spent $100–500/pop**
  —> US deferred new allocations
- **more base stations —> 500,000 new cell sites projected**
  —> new base station is $500/ subscriber
- **new handsets —> handset deliveries are delayed**
  —> more expensive
- **better performance —> unrealized rates**
  —> bandwidth shared
- **pervasive 2G —> already provides most wanted service**
  —> entrenched

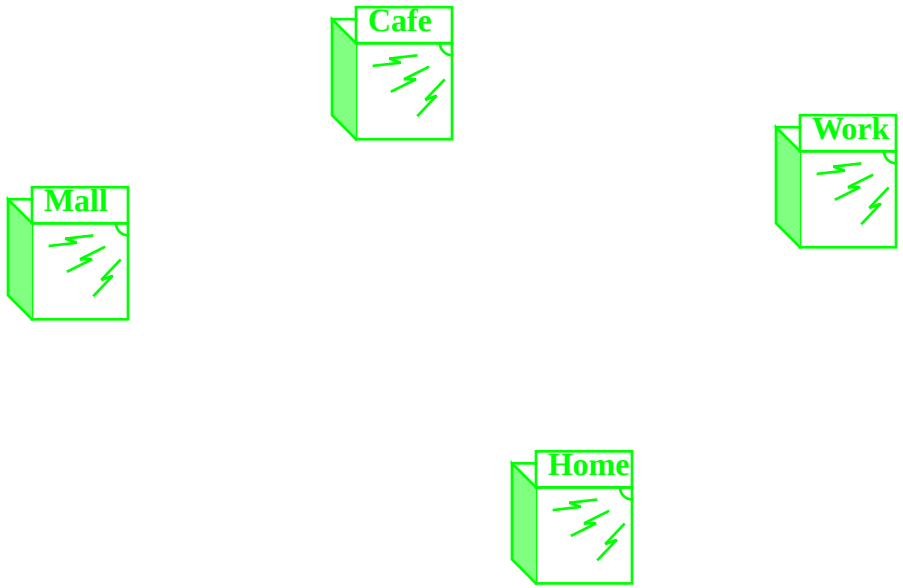
Business proposition uncertain

What if?

- **Spectrum was available now and free**
- **“Base stations” were $200**
- **Mobile terminals were available and cheap**
- **Proven multi-megabit rates**

The technology is already deployed

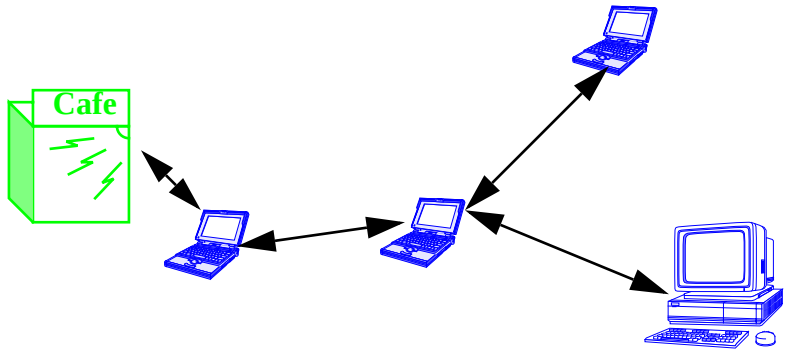
WLAN's



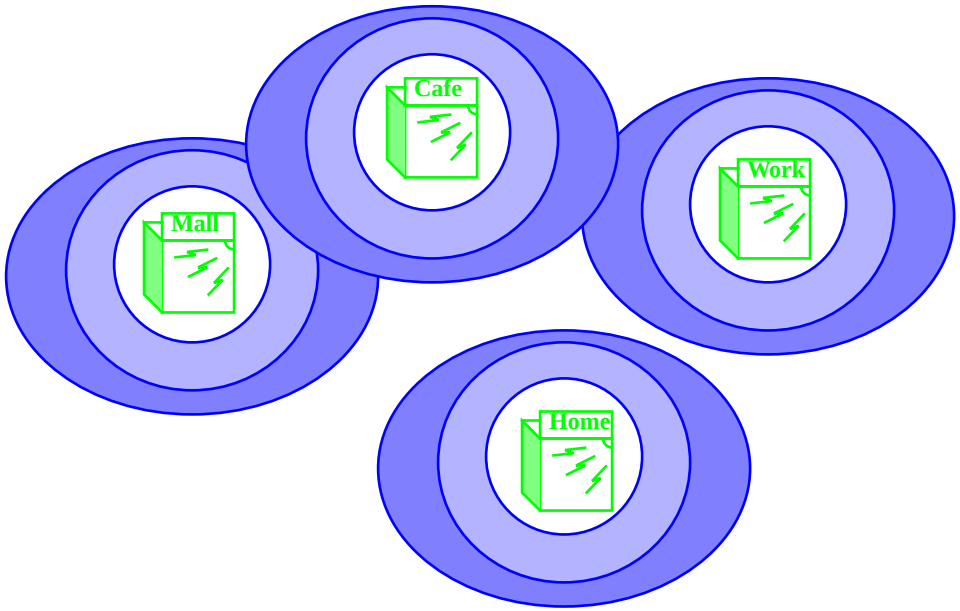
- **Patchwork of local connectivity**
- **High Bandwidth**
- **Migratory Mobility**

Ad Hoc Networks

A cooperative network that emerges when wireless nodes are brought together.

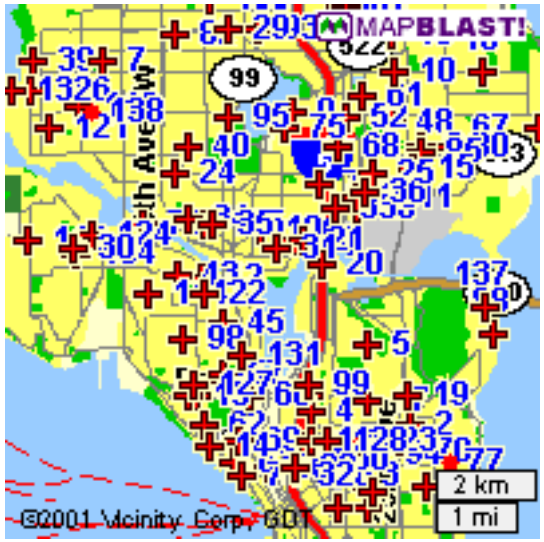


- **Dynamic**
- **Peer-to-peer**
- **Capacity & coverage increase with users**



Ad Hoc Networks

- **Already being deployed**
- **50+ networks in cities worldwide**
- **Low marginal cost per user**
- **No monthly fees**



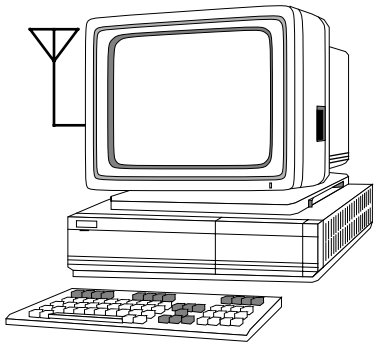
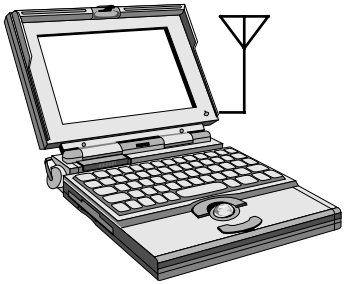
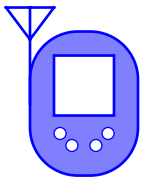
Seattle

Ad Hoc Network Challenges

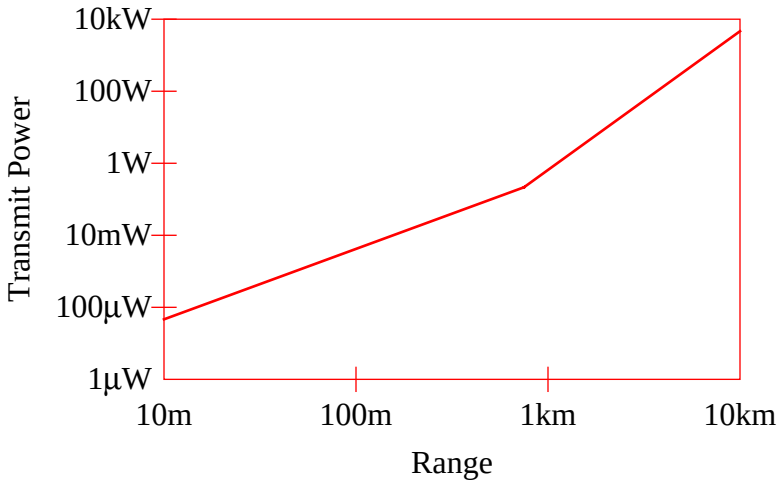
- **Non-technical**
  - **Economic: is growth sustainable?**
  - **Legal: FCC limits, enforcing service contracts, etc.**
  - **Business: winners and losers**
- **Technical:**
  - **Security: malicious “peers”**
  - **Mobility management: this isn’t your fathers internet**
  - **Reliability: poor links, variable connectivity**
  - **Resource Management:**
    - **QoS**
    - **Battery**

Why Power is an Issue? Batteries

Efficiency (DC power --> TX power) << 1

	Power	%WLAN
	>100W	<1%
	10W	~10%
	<1W	>50%

Needed TX power depends on range



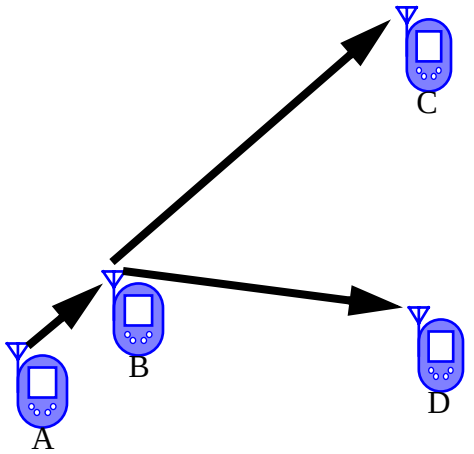
WLAN card power depends on use

Mode	Power
TX	1.5W
RX	1W
sleep	0.05W

Main Question

How should we route traffic to maximize battery life of mobiles?

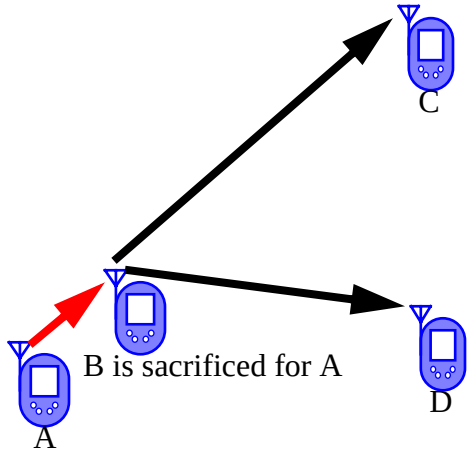
- **A network level question.**
- **Must balance individual vs. group.**



Energy Aware Routing Objectives

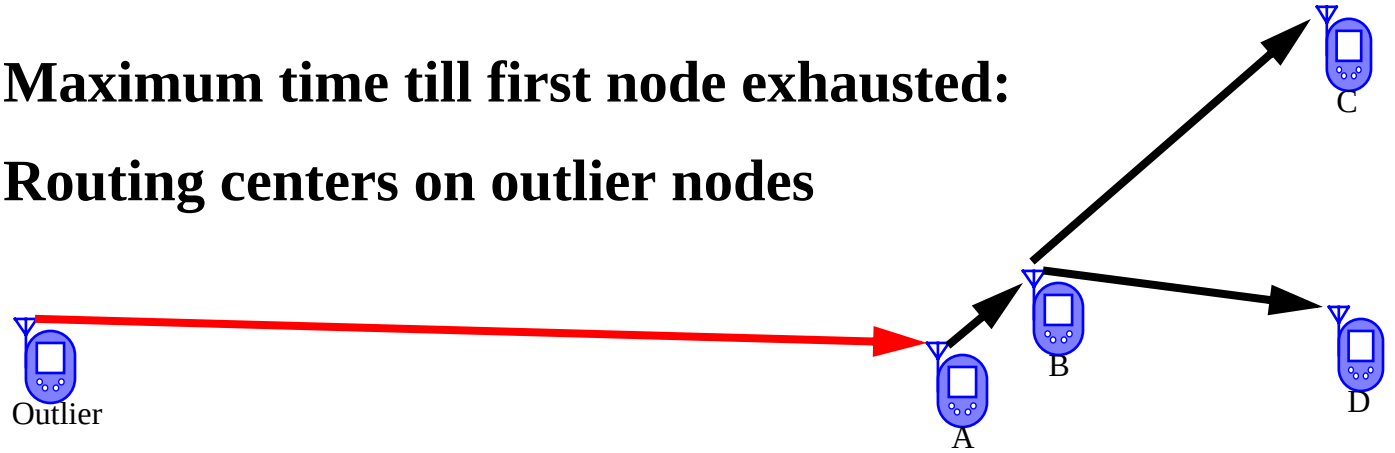
- **Minimum Power:**

  Unfairly sacrifices nodes

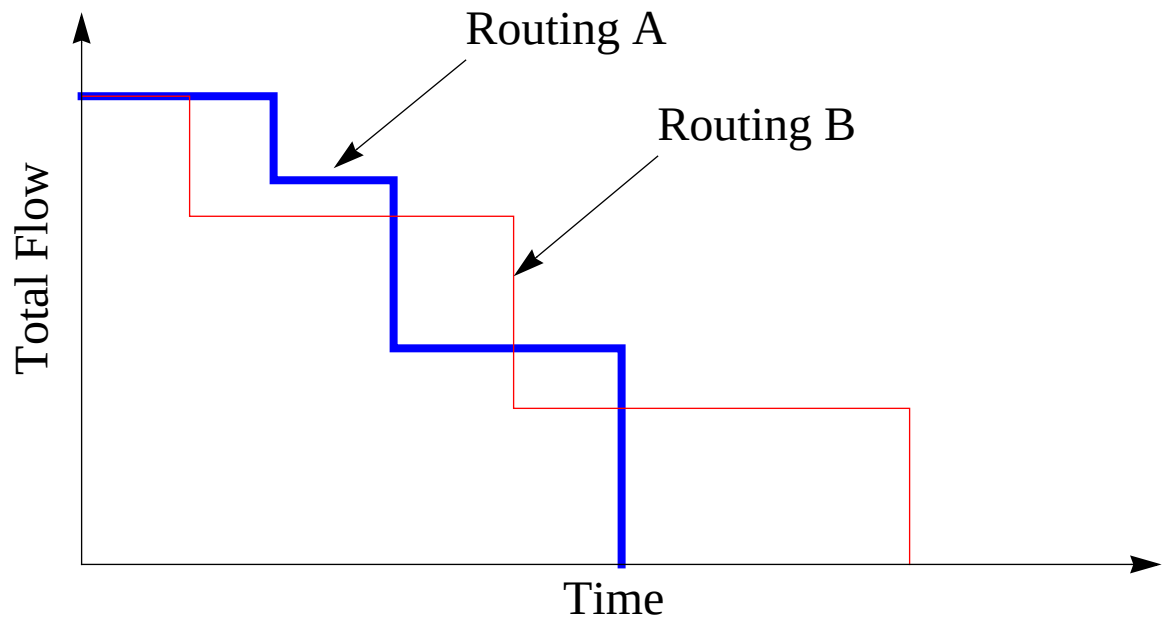


- **Maximum time till first node exhausted:**

  Routing centers on outlier nodes



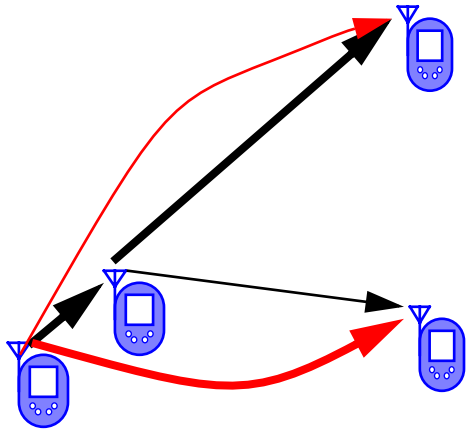
Routing Objective — Max Flow Life



Choose routing that maximizes performance for the longest. (Max flow-life routing)

Computing Max Flow-Life

- For static network with known flows and power cost:
  - Can compute MFL-routing
  - Efficient and compact routes



- Significant Performance Improvement:
  - 60–90% increase in time to network partition
  - most flows last 20–30% longer

Implementing Energy Aware Routing

- **More Routing Overhead:**

  energy-aware route discovery and maintenance
  vs.
  min-hop routes and route errors

- **More physical layer to routing layer communication:**

  physical layer can not do it alone

3G or Ad Hoc Networks

- **3G has significant challenges**
  - **2G can provide the main real-time service**
  - **high bandwidth provided more cheaply with WLAN's**

- **Ad Hoc Networks have significant challenges**
  - **lower security, reliability, QoS**
  - **battery is drained by the user and network**

- **Synergistic solutions being sought**
  - **new dual mode 3G/802.11 handsets**
  - **seamless 3G/802.11 interoperability**

Conclusions

Energy Aware Routing

- **Significant Gains in Network Utility Possible**
- **Requires modified hardware and software**

Next Generation Wireless

- **3G has significant challenges**
  - **2G can provide the main real-time service**
  - **WLAN based ad hoc networks can provide much of desired data service**
- **Unlicensed spectrum congestion, vender inertia, and rising customer expectations will eventually push 3G**