Mobile Networks Research: Area Review

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I. Seskar, K. Tepe, M. Ott, D. Raychaudhuri

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MobiNet Project Objectives

- WINLAB initiated a new core research area on next-gen mobile network arch & protocols in AY'01-'02

- Experimentally-based activity centered around the new "MobiNets" lab (in CORE529)
- Goals of research program
  - *new concepts for next-gen ("4G") wireless network protocols, applicable to future cellular, WLAN, sensor nets & pervasive computing*
  - *experimental evaluation of proposed protocols and related algorithms*
  - *system prototyping capabilities for proof-of-concept demos*
  - *advances in network software architecture & implementation*
  - *hands-on software prototyping experience for grad students*

MobiNet Research Challenges

Several basic issues still need to be addressed for next generation wireless networks:

- Fast/reliable broadband radios (PHY/MAC) with QoS
  - *~100 Kbps →1-10 Mbps with adaptivity, link reliability & QoS*
- Scaling of radio networks for ubiquitous wireless devices
  - *architectures that support ~10's of devices/Sq-m, ~Gbps/Sq-Km,..*

scalability, cost

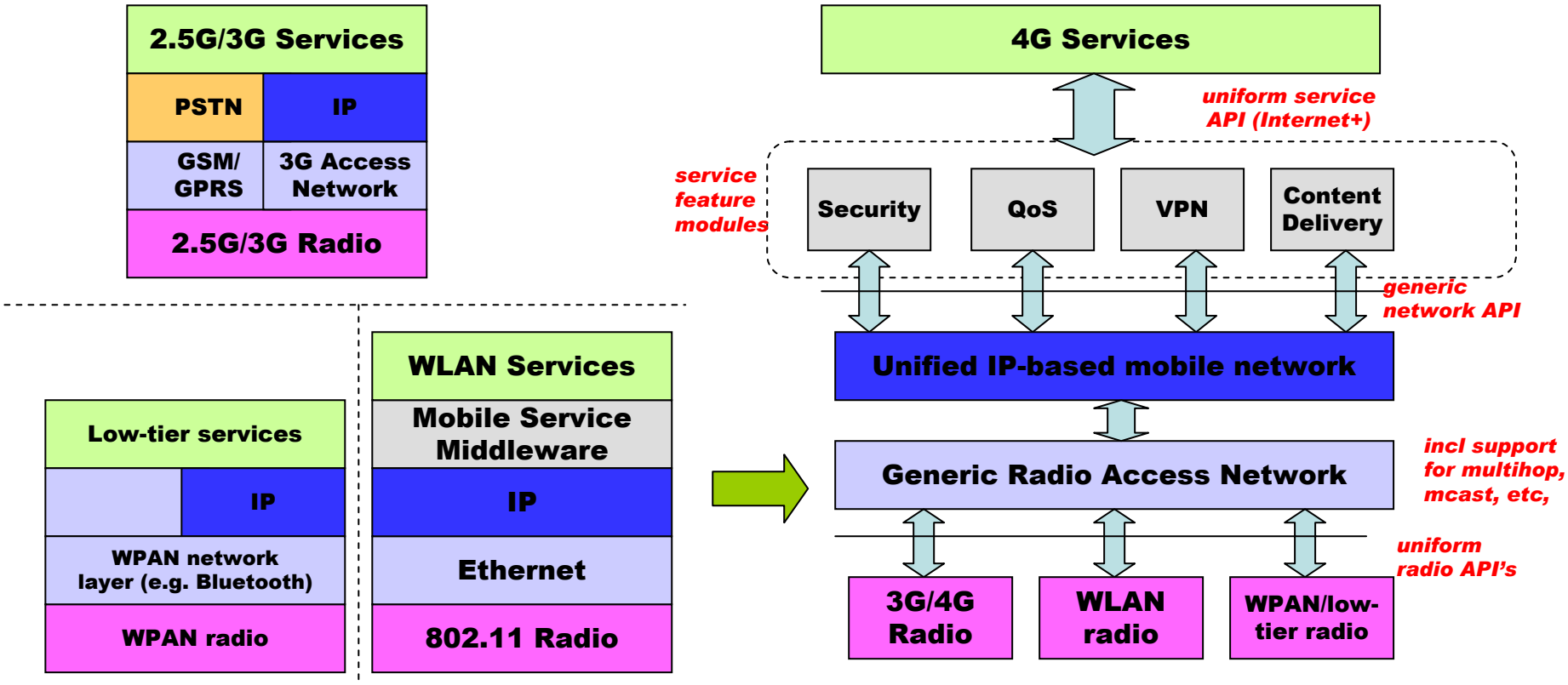
- Integration of multiple radio technologies into single IP network
  - *radio-independent generic mobile network, support for legacy protocols*
- Faster and simpler standardization process, feature evolution..
  - *...open-architecture networks, programmable features, etc.*
- New networking modes, e.g. multicast, multihop & peer-to-peer
  - *...lower-cost infrastructure, networks that grow organically*

network flexibility

- Truly "useful" mobile information services
  - *...beyond web browsing on phones/PDA's, new portable devices*

new services

"4G" Network Evolution



Radio-specific vertically integrated systems with complex intetworking gateways

Today's Wireless Systems

Radio Independent modular system architecture for heterogeneous networks

The Future

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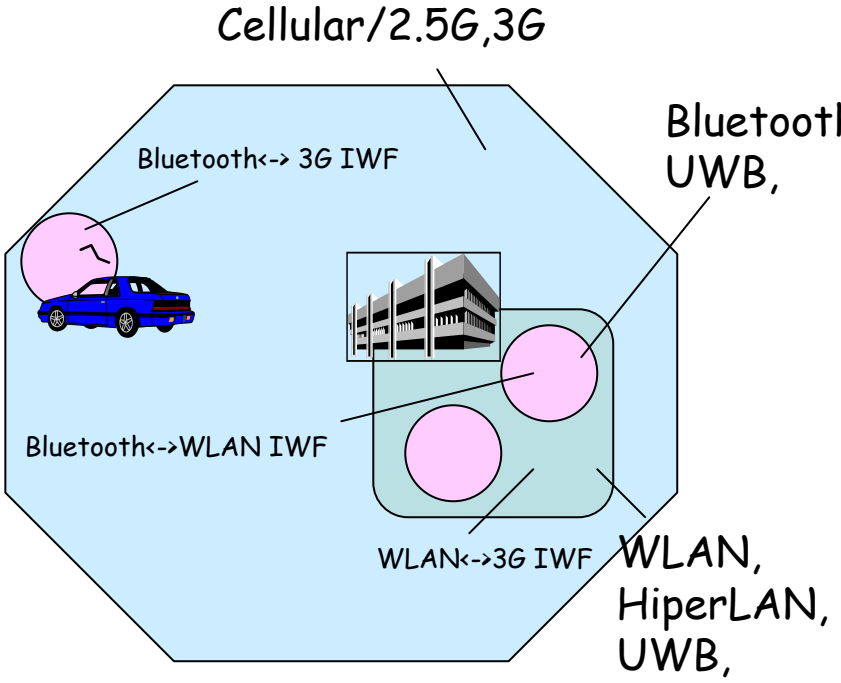
Potential "4G" Network Ideas

A few techniques for achieving the 4G design goals discussed earlier:

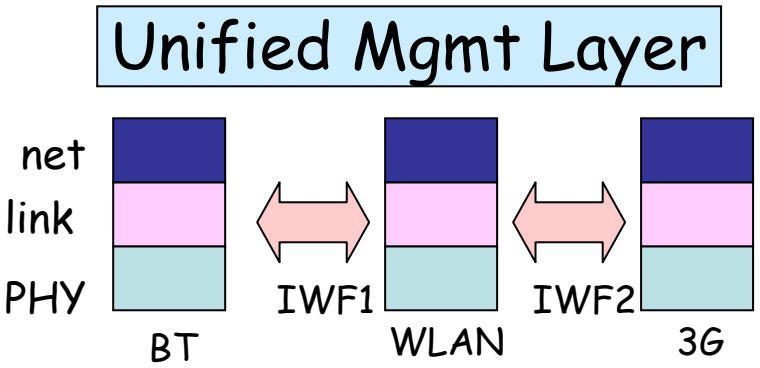
- 3G/WLAN Hot-Spots
  - *Use of WLAN in hot-spots for lower system cost, better end-user performance and more total capacity*
- Infostations
  - *Use of opportunistic "radio caches" for significant reduction in average cost per bit, facilitating qualitatively new mobile services*
- Self-organizing wireless access networks
  - *Ad-hoc wireless network protocols which support multihop and peer-to-peer service models, particularly for low-tier uses (in-home, sensors, etc.)*
- Content-based multicasting
  - *...new network service paradigms for location- and person-aware information delivery to mobiles*

MobiNets: Multimode Networks



3G/WLAN interworking

Multiple devices with various radio interfaces



Protocol stacks

Techniques for seamless service:

- Authentication, global roaming
- Security issues
- Dynamic handoff
- End-to-end QoS control
- Network management
- Service level agreements (SLA)

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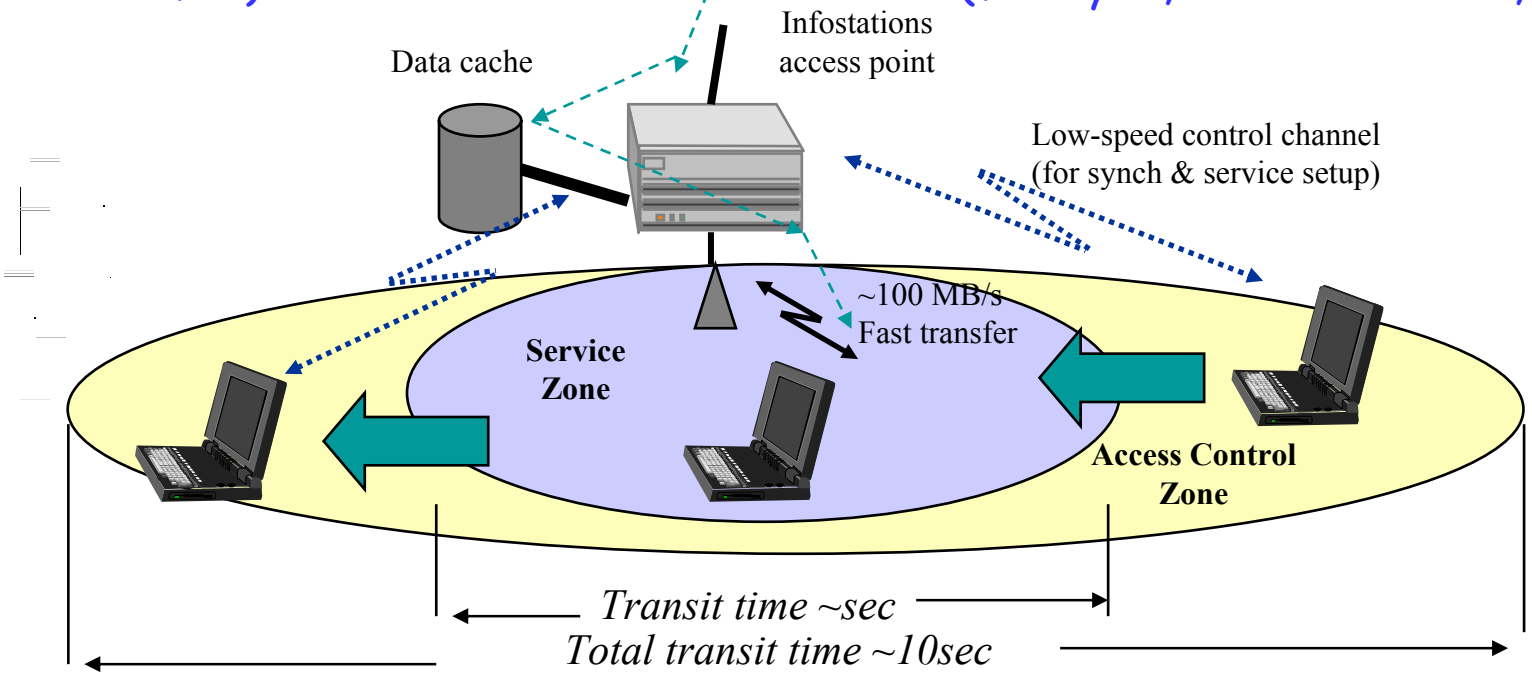
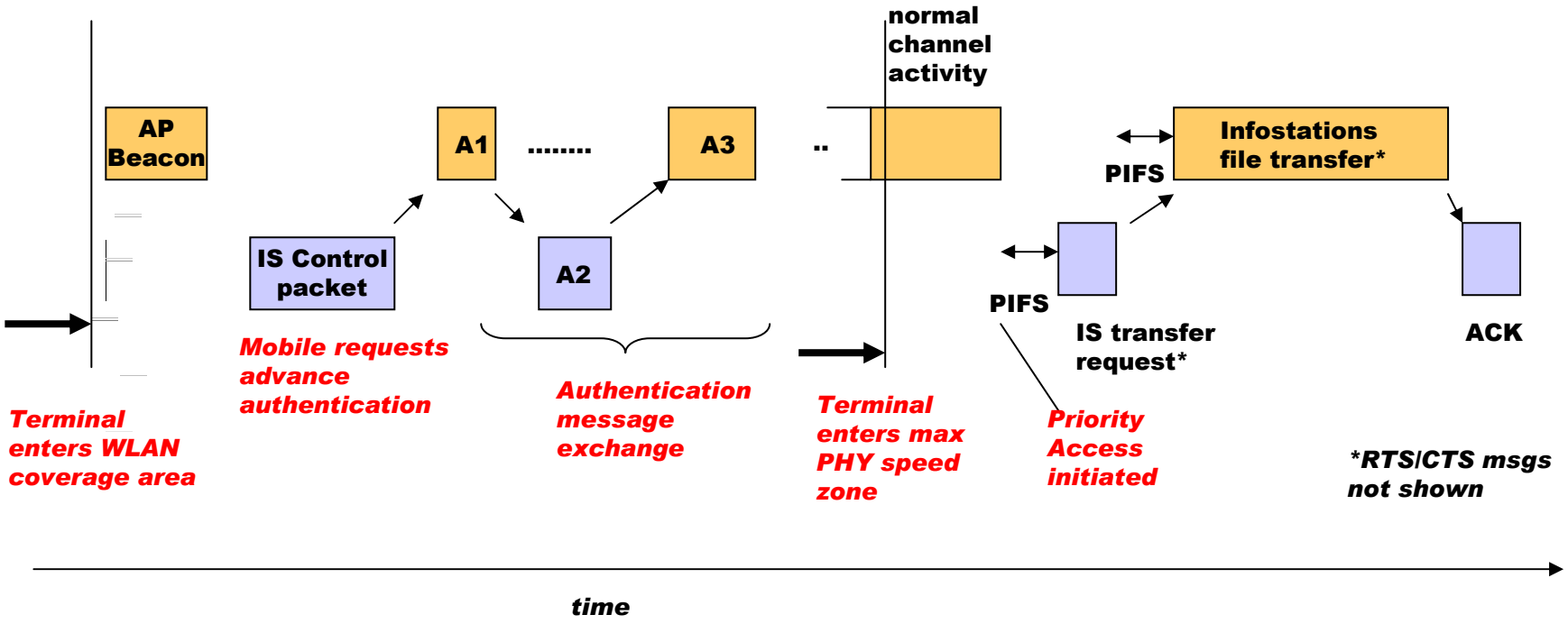
MobiNets: Infostations MAC

- Mobile user passes through Infostation in sec during which ~MB files are downloaded/uploaded
  - Requires modifications to conventional WLAN MAC, incl fast synch, pre-authentication, etc. (...related to interworking discussed before)
  - Motivates 2-tier arch with ~10m service zone (for high-speed data transfer) and ~50m access control zone (for sync, authentication, ..)



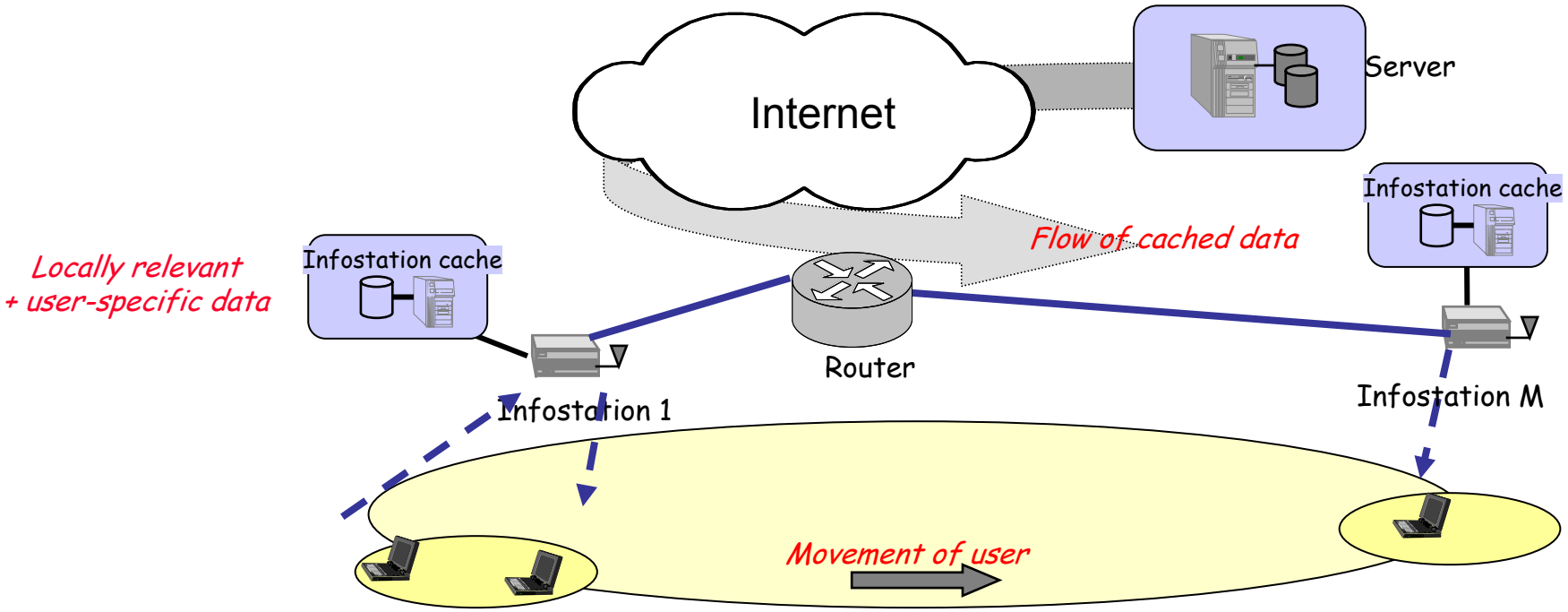
MobiNets: Infostations via 802.11 MAC

- 802.11a MAC can be used for Infostations service
  - Pre-authenticate user in low-bit rate mode (~50m range)
  - Mobile terminal waits for modem to reach max 54 Mbps (~10m range)
  - High priority access mode used for Infostations access



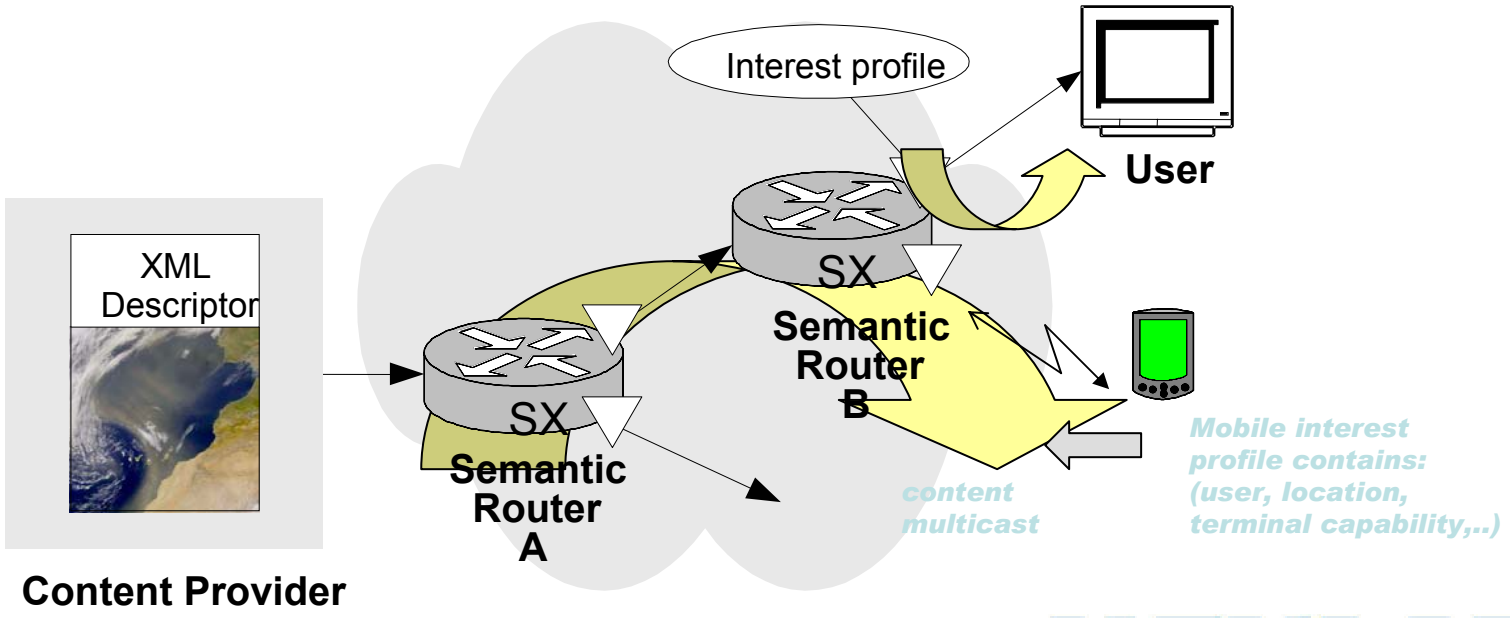
MobiNets: Infostations Caching

- Infostation caches contain location-aware and user-specific data to be downloaded opportunistically
  - proactive caching involves various strategies including location context, user profiles, prediction of user location, etc.
  - content multicasting (with XML classification) potentially useful



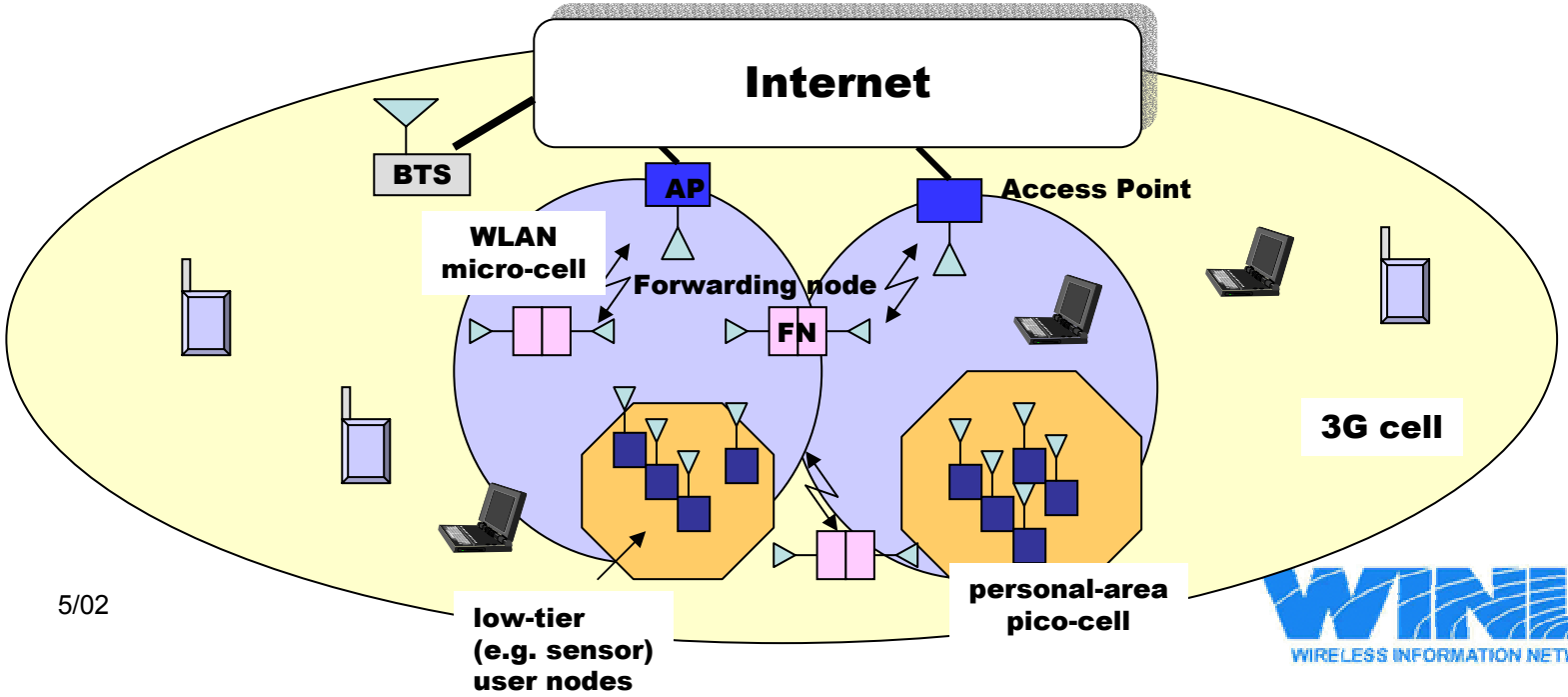
MobiNets: Content Multicast

- New real-time, person- and location-aware information delivery paradigms need to be considered for 4G.
- Content multicasting based on XML investigated as possible option for delivering relevant info to mobiles.



MobiNets: Self-Organizing "4G" Network

- Hierarchical, self-organizing network concepts currently under consideration, based on:
  - 3 service tiers (cellular, WLAN, personal area)
  - BS's, AP's, FN's (forwarding radio nodes), user devices
  - automatic discovery and power mgmt protocols
  - hierarchical, ad-hoc multihop routing and spatial MAC



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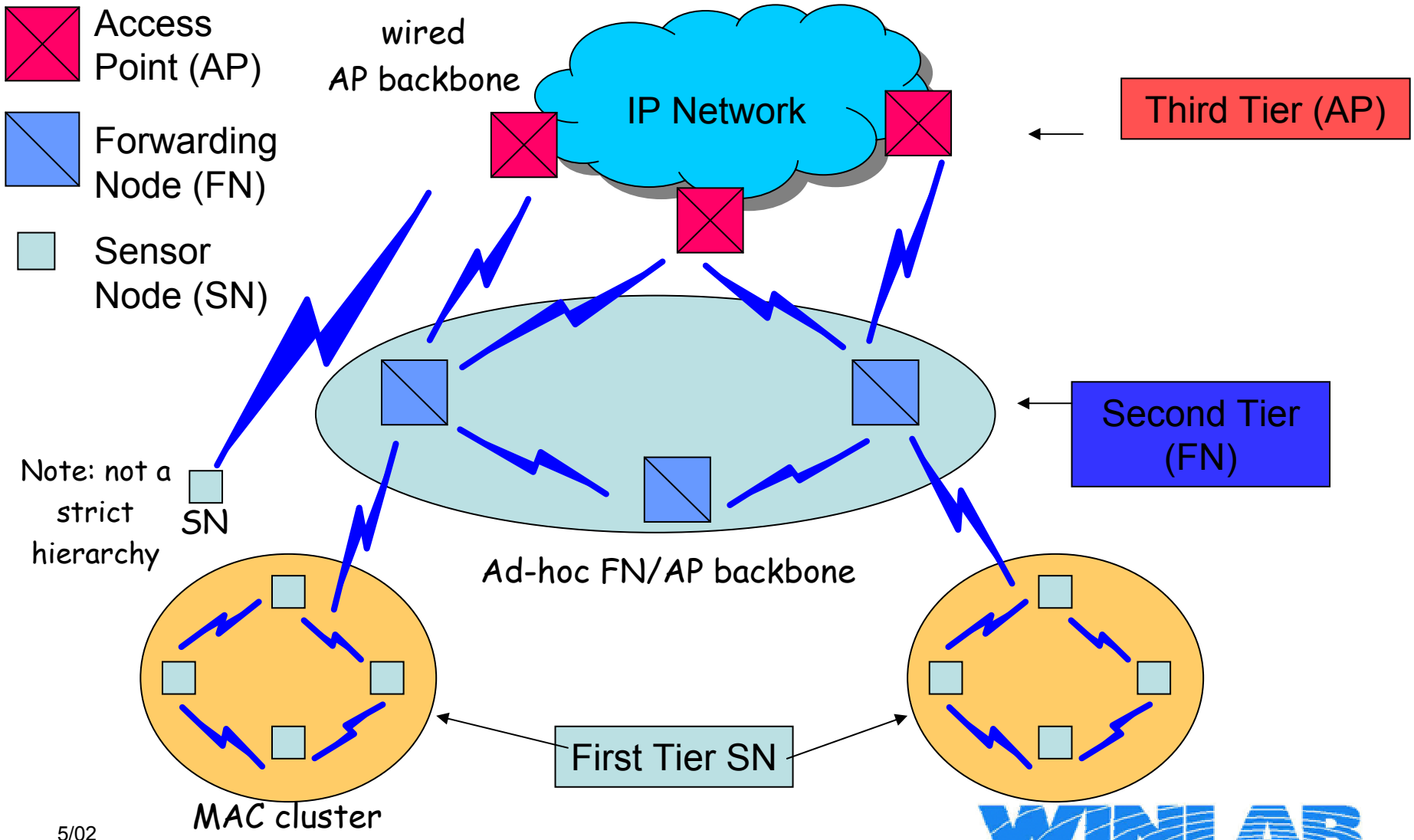
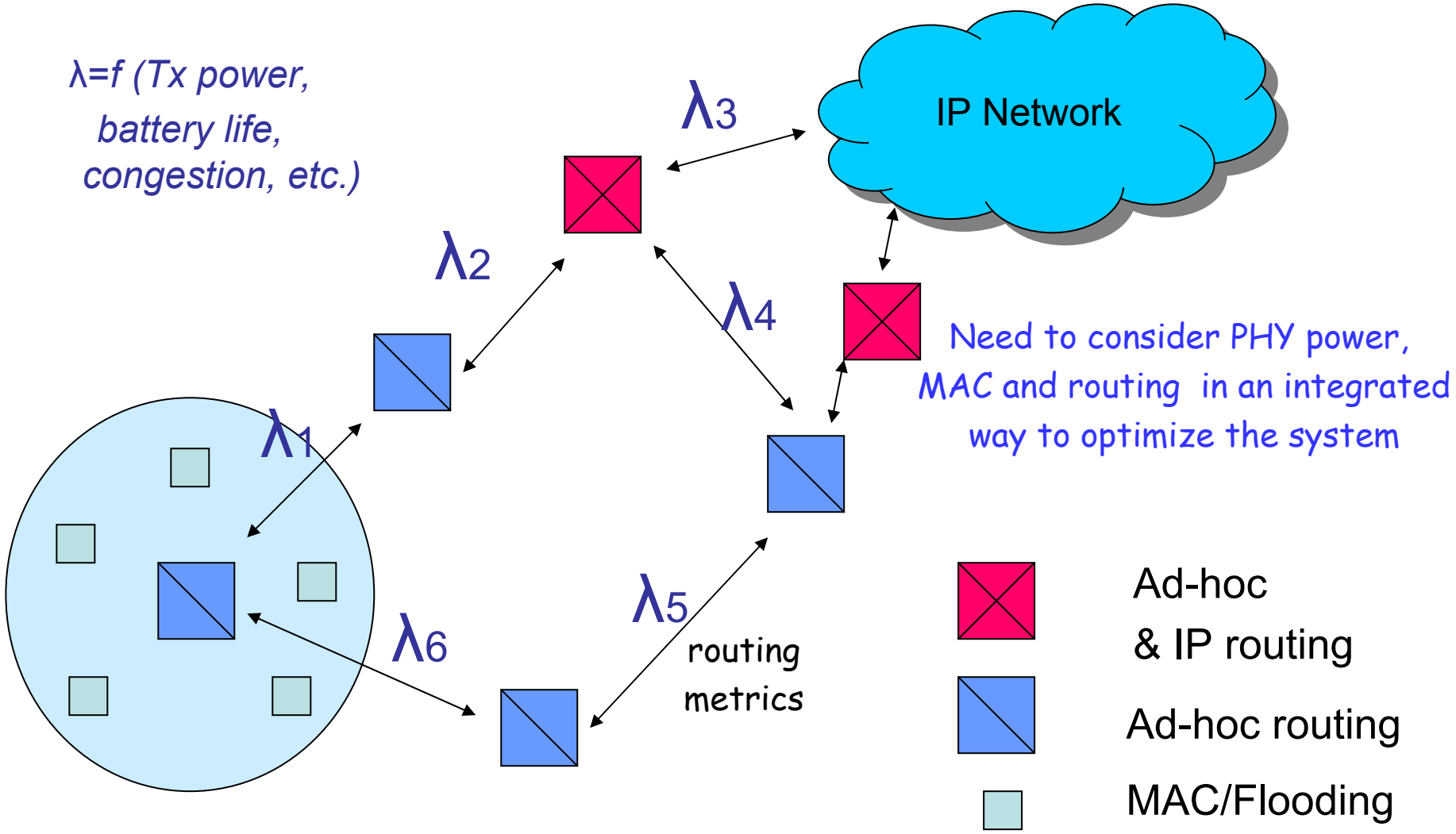
MobiNets: Hierarchical Ad-Hoc Net



MobiNets: Routing in Hierarchical Ad-Hoc Network



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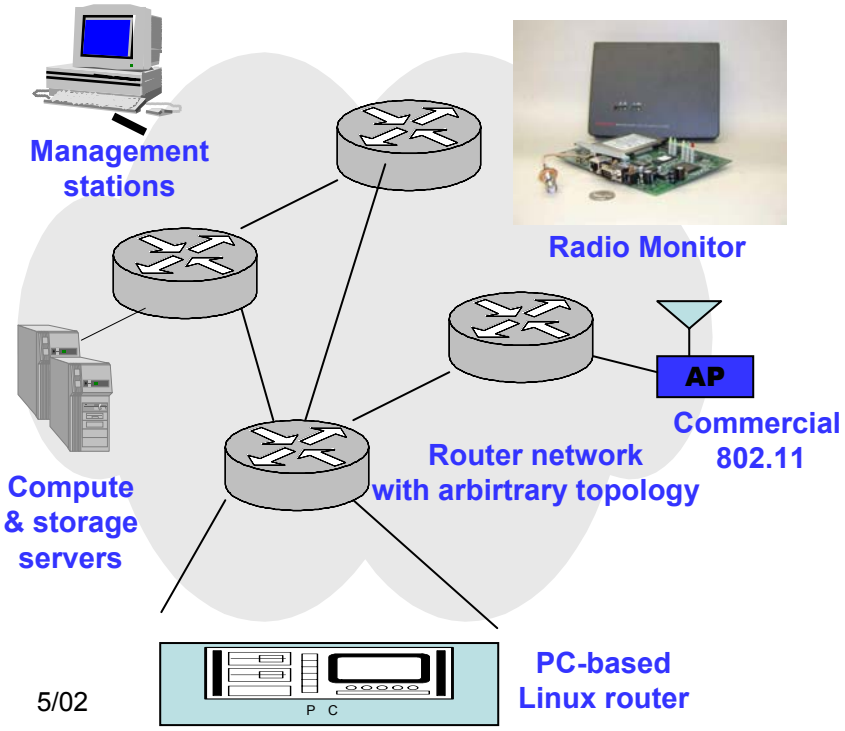
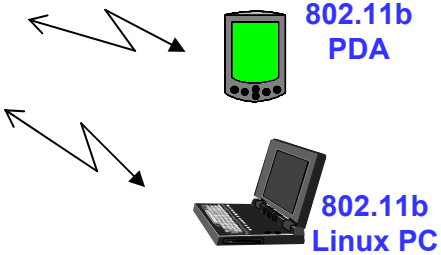
MobiNets Lab: Experimental Network

- A flexible, open-architecture mobile network testbed has been set up during the '01-'02 academic year
  - open-source Linux routers and AP's (commercial hardware)
  - Linux and embedded OS forwarding and sensor nodes (custom)
  - radio link and global network monitoring/visualization tools




Forwarding Node/AP (custom)




Sensor Node (custom)

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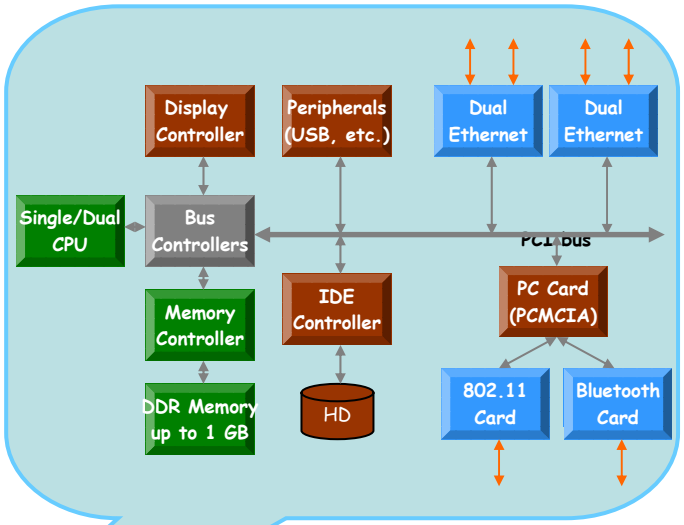
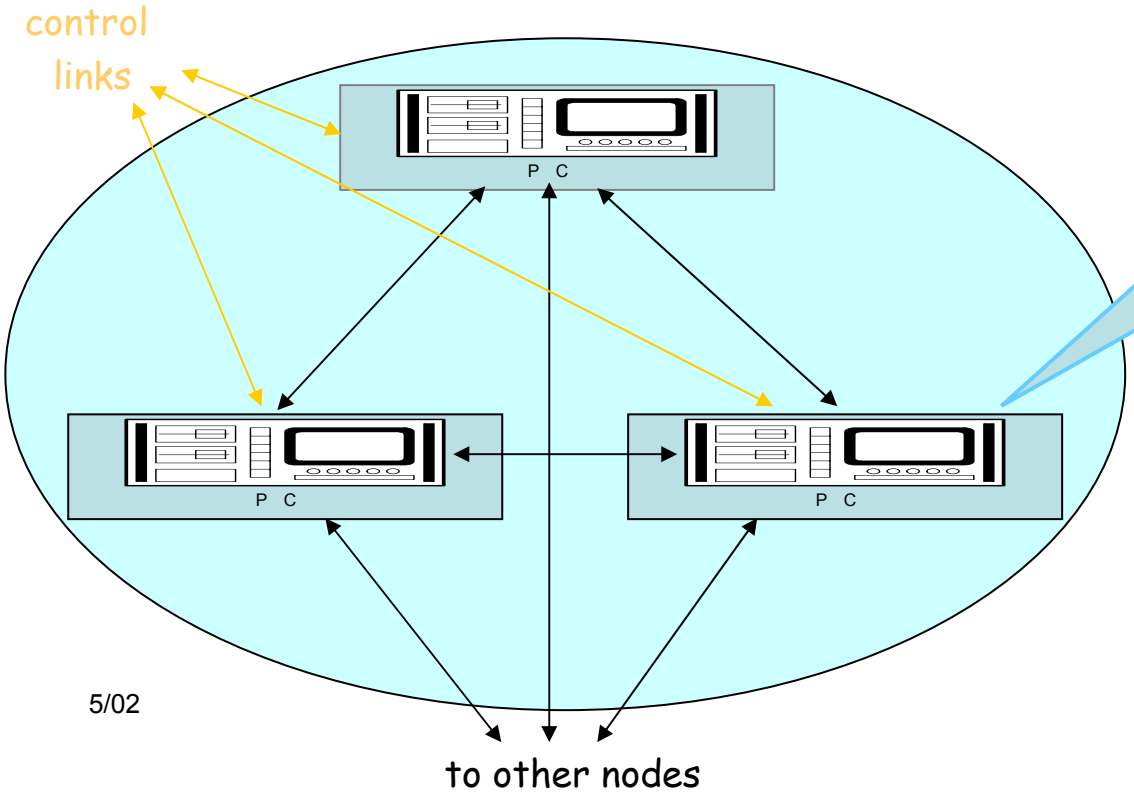
MobiNets Lab: Network Node

Each router node has 3 general purpose PCs:

- 1U form factor
- Single or dual CPU configuration with up to 1 GB of memory
- Quad 100 Mb/s Ethernet





Node can be used as:

- Router
- Server/Cache
- Access point
- Combination of above

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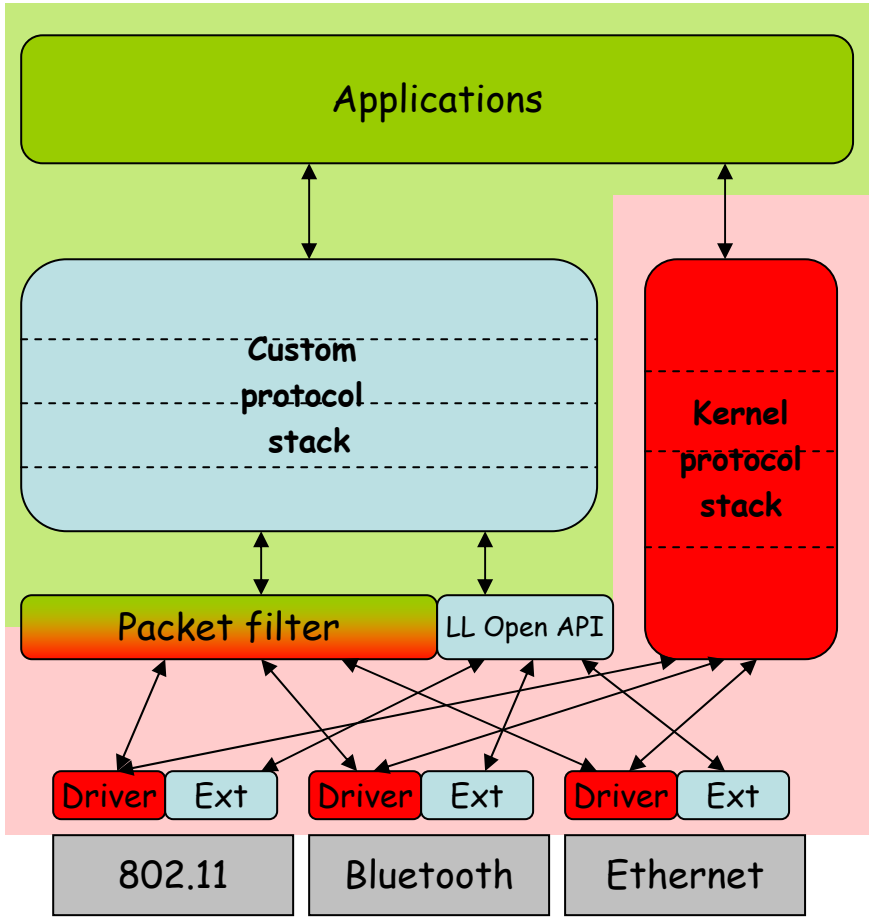
MobiNets Lab: Software platform

Main SW features:

- Open ⇔ Linux OS
- By using packet filters minimizes driver development
- Multiple independent developers each with separate protocol stack
- Uses existing TCP/IP stack for control only
- Java based for ease of reuse and feature addition



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MobiNets Lab: Sensor Module

Small, low-power platform with good hardware feature set sharing the same software platform with other node types

CerfBoard-SA:
- Intel® StrongARM™ 1110 microprocessor @ 206 MHz
- 16 MB ROM (FLASH)
- 32 MB RAM
- Compact Flash Interface
- 16 Digital I/O lines

Wireless Interface: 802.11b - Lynksys WCF11

OS: Linux 2.4.9

Typical power consumption: 450 mW

MobiNets Lab: Forwarding/AP node

Multi-purpose embedded platform with radio in/out, processing, routing and storage capabilities

CompuLab 586CORE:
- AMD ElanCS520 CPU – 133 MHz
- 32 MB ROM (FLASH)
- 32-64 MB RAM
- 2 x 100BaseTx Ethernet
- VGA/XGA, IDE - Hard Disk Interface, Dual PCMCIA Slot

Wireless Interface: 802.11b
- PRISM-2 PCMCIA Card with external antenna
- Cisco 350 with internal antenna

OS: Linux 2.4.17 kernel with both Infrastructure / Add-hoc mode support

Typical power consumption: 8 W

MobiNets Lab: RF Monitoring Node

Off-the-shelf Access Point running modified Linux OS with the wireless interface in RF Monitoring mode – used for spectrum monitoring and management support.

Eumitcom WL11000SA-N:
- AMD ELAN SC400 CPU
- 1 Megabyte ROM (FLASH)
- 4 Megabytes RAM
- NE2000 Ethernet Controler

Wireless Interface: 802.11b Generic PRISM-2 PCMCIA Card with external antenna

OS: Linux 2.4.17 kernel with Infrastructure mode support

Typical power consumption: 4.0 W

MobiNet Project Status & Future Work

- Initial goal of establishing the lab and getting control of router/AP/FN/SN platform software achieved
- Early research-level demo system of discovery in self-organizing network completed
- Infostations (with content multicast) demo for emergency/disaster recovery applications being developed for potential "tech transfer" uses
- Future work during 2003:
  - continue with discovery, power control, MAC and routing in hierarchical ad-hoc network prototoype
  - WLAN/2.5G interworking proof-of-concept prototype
  - start examining security and information flow in pervasive computing scenarios
  - initiate experiments on spectrum collaboration (..new ITR)

MobiNets Lab: Emergency Infostation Prototype

Forwarding node/Access Point with:

- 30 GB Hard Disk for caching
- High-gain directional antenna for backbone connectivity
- Omni-directional antenna for local coverage
- 3 hour battery
- Photovoltaic (solar) panels with the controller as a continuous power/battery charging source

Linux 2.4.17 kernel with:

- Infrastructure 802.11b support
- IP Bridging support
- JAVA Application support

Typical power consumption: 20 W