

Improving Cellular Coverage with Indoor Antenna Systems

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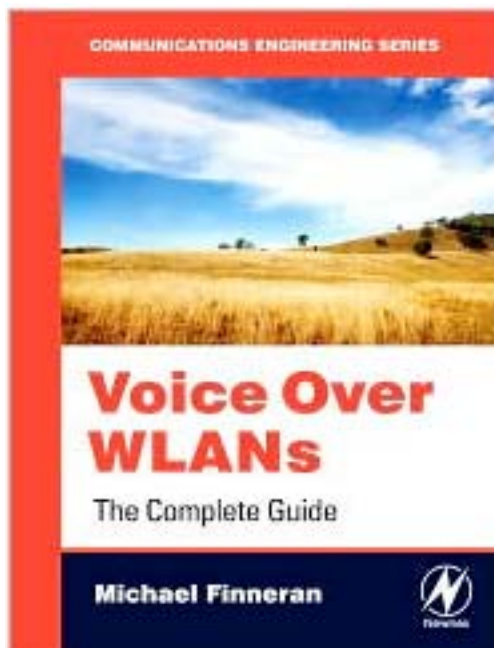
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If you're doing WLAN voice...



Available at Amazon.com and other on-line retailers

Key Questions...



- Why is indoor cellular coverage so problematic?
- What are the options for improving the situation?
- Is there more than one kind of distributed antenna system, and what are the differences?
- What are microcells, picocells, and femtocells?
- Will one of these solutions improve my wireless data as well as my wireless voice coverage?

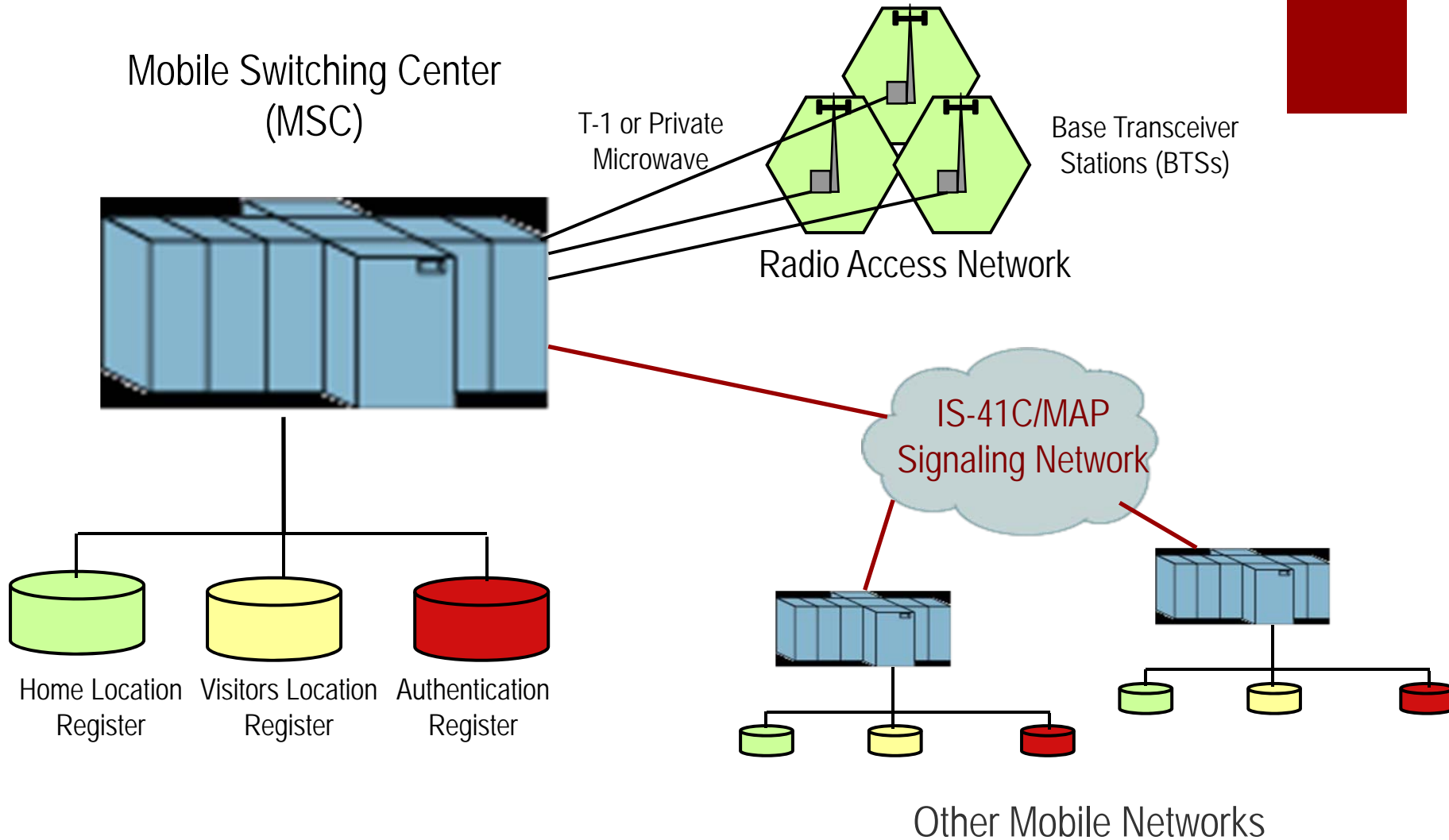


Section 1



Basics of Cellular

Cellular Network Configuration



US Cellular Frequency Bands

	Inbound	Outbound
AMPS	824-849 MHz	869-894 MHz
PCS	1.850-1.910 GHz	1.930-1.990 GHz
AWS	1.710-1.755 GHz	2.110-2.155 GHz
Nextel	806-824 MHz	851-869 MHz

US WiMAX Bands	
Wireless Communications Service (WCS)	2.305-2.320 GHz
	2.345-2.360 GHz
Broadband Radio Service (BRS)	2.495-2.690 GHz

Cellular Market Areas (CMAs)

Metropolitan Statistical Areas (MSAs) and Rural Service Areas (RSAs)



General Difficulties in Wireless

- Distance and Path Loss

 - Inverse square law

- Signal Frequency and Loss

 - 1.9 GHz is about 3x the loss of 800 MHz

- Material Obstructions

 - Minor Issues

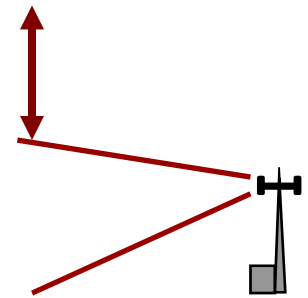
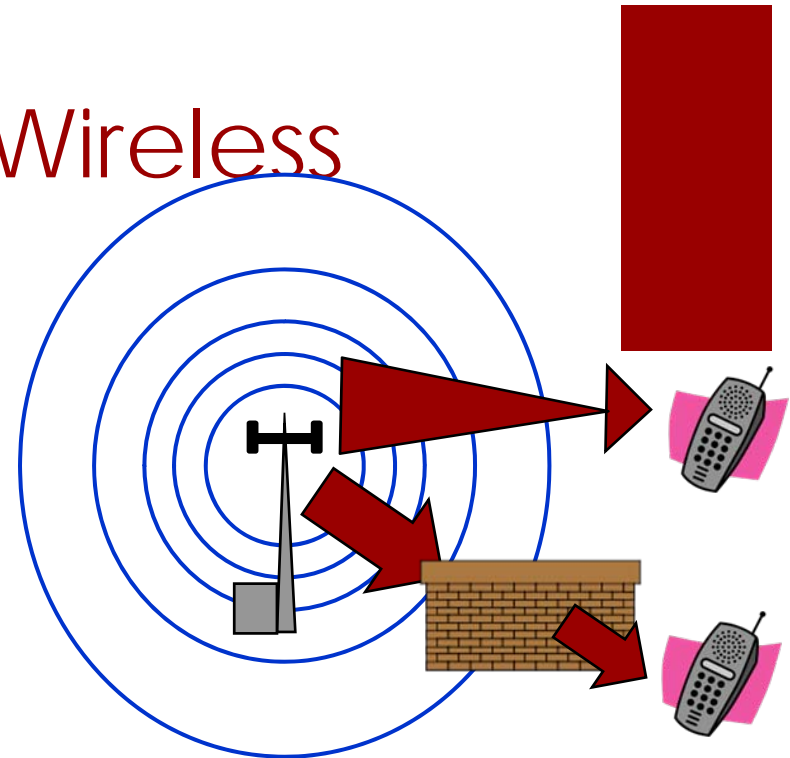
 - Wood
 - Sheetrock
 - Uncoated Glass

 - Major Issues

 - Metal
 - Water
 - Concrete

- Altitude

 - Cellular coverage is targeted at street level



General Difficulties in Wireless

■ Multipath

- Phase cancellation from receiving multiple images of the signal

■ Co-Channel Interference

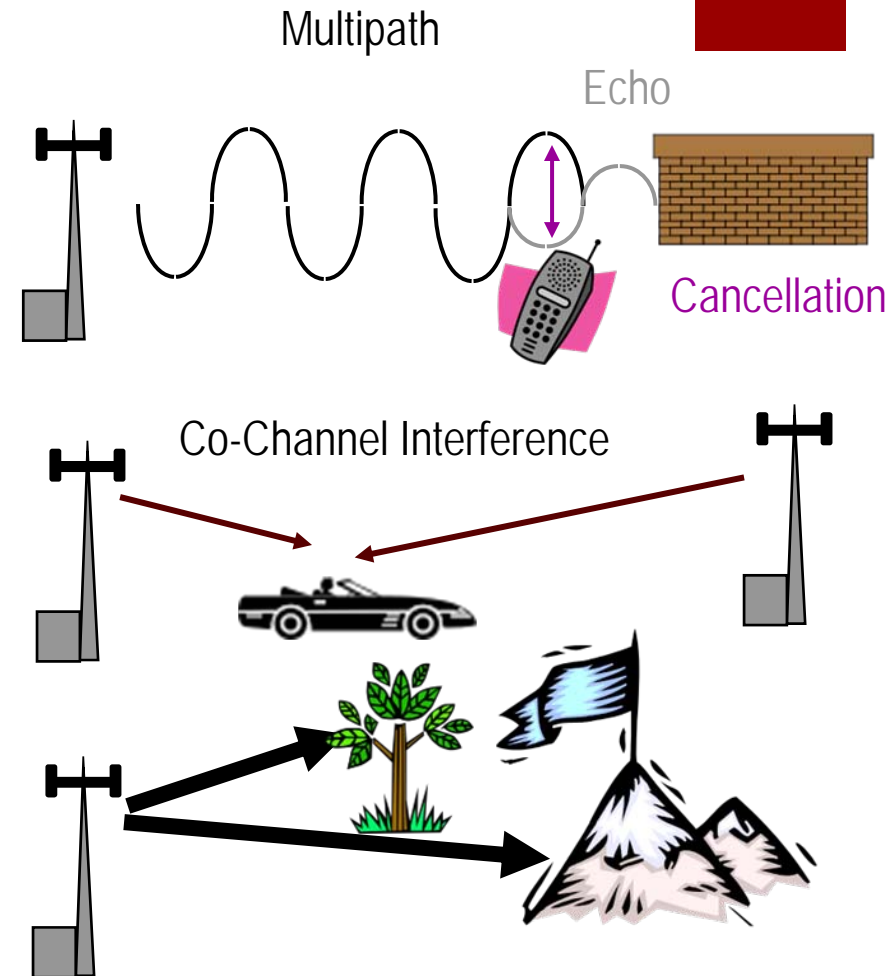
- Interference from channel reuse in other parts of the network

■ Doppler

- Motion induced frequency shift

■ Environmental Factors

- Hills, buildings, trees, rain, etc.



Particular Challenges in Cellular

- User Expectations and growing dependence on cellular (University in-dorm coverage)
- Different services (2G vs. 3G) require different signal quality (CINR)
- Many fixed-mobile convergence solutions depend on cellular data
- Need to compete with WLAN voice for enterprise mobility
- Energy saving window coatings attenuate radio signals
- Tall buildings (RF coverage is targeted to ground level)
- Large enclosed spaces (Convention centers, airline terminals, subways, etc.)
- Periodic concentration of users (Baseball game)

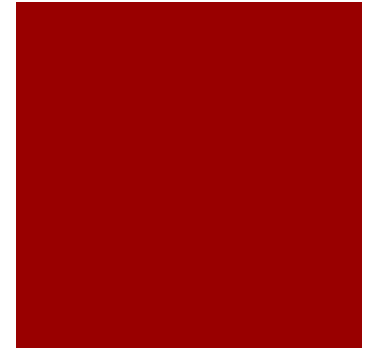


Section 2



Distributed Antenna System Elements

DAS System Elements



- Signal source
 - ◆ Donor Antenna
 - ◆ Base Station and Backhaul Connection
- Channel selection and filtering
- Indoor Distribution
 - ◆ Passive DAS
 - ◆ Active DAS
- Antennas

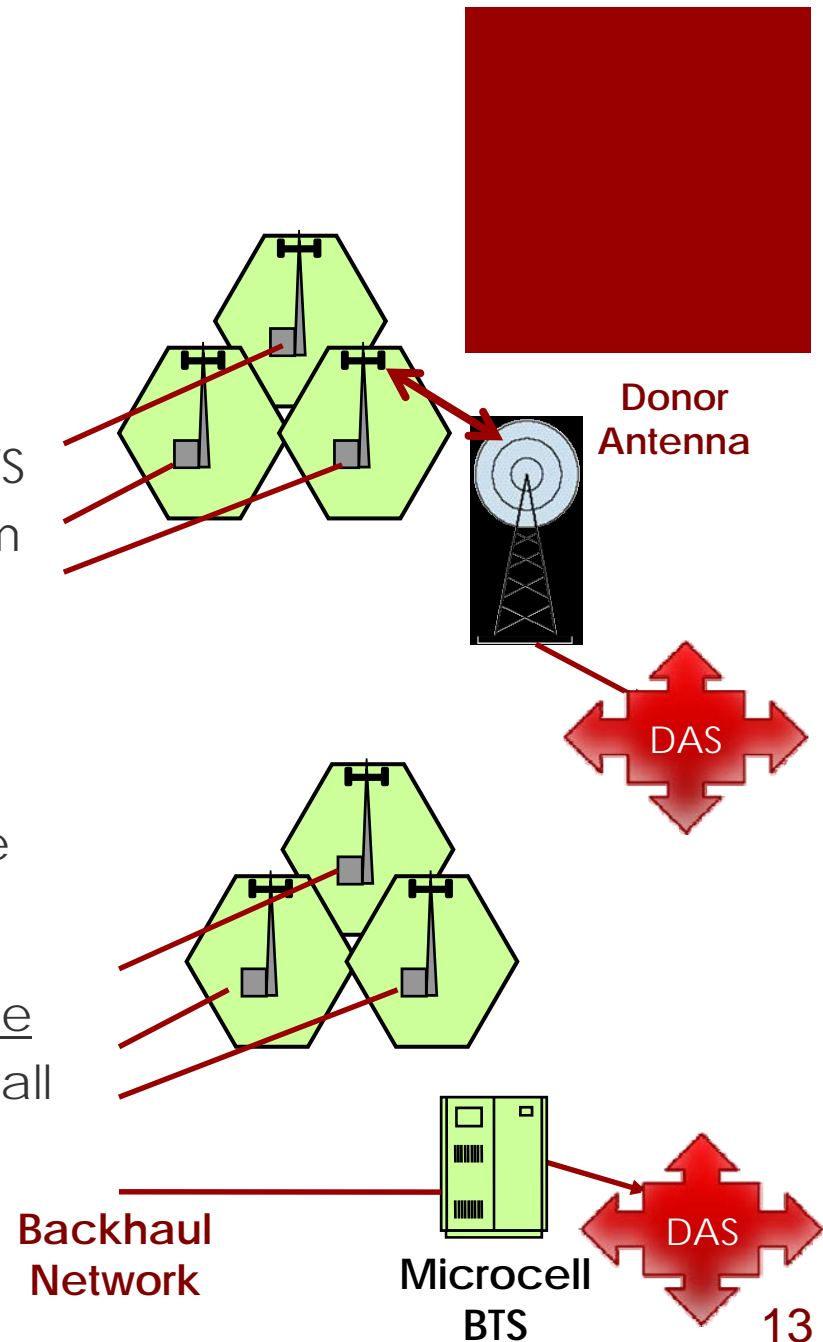
Signal Source

■ Donor Antenna

- ◆ Receives the signal from the nearest BTS
- ◆ Feeds it to the indoor distribution system
- ◆ Addresses coverage but not capacity

■ Base Station

- ◆ Microcells and picocells
- ◆ Requires a backhaul connection to the carrier's network
- ◆ Generates its own cellular channel; addresses capacity as well as coverage
- ◆ Must be integrated in the carrier's overall frequency plan



BTS Backhaul Options



■ Traditional

- ◆ Dedicated Leased T-1/DS-1 Link
- ◆ Private Microwave

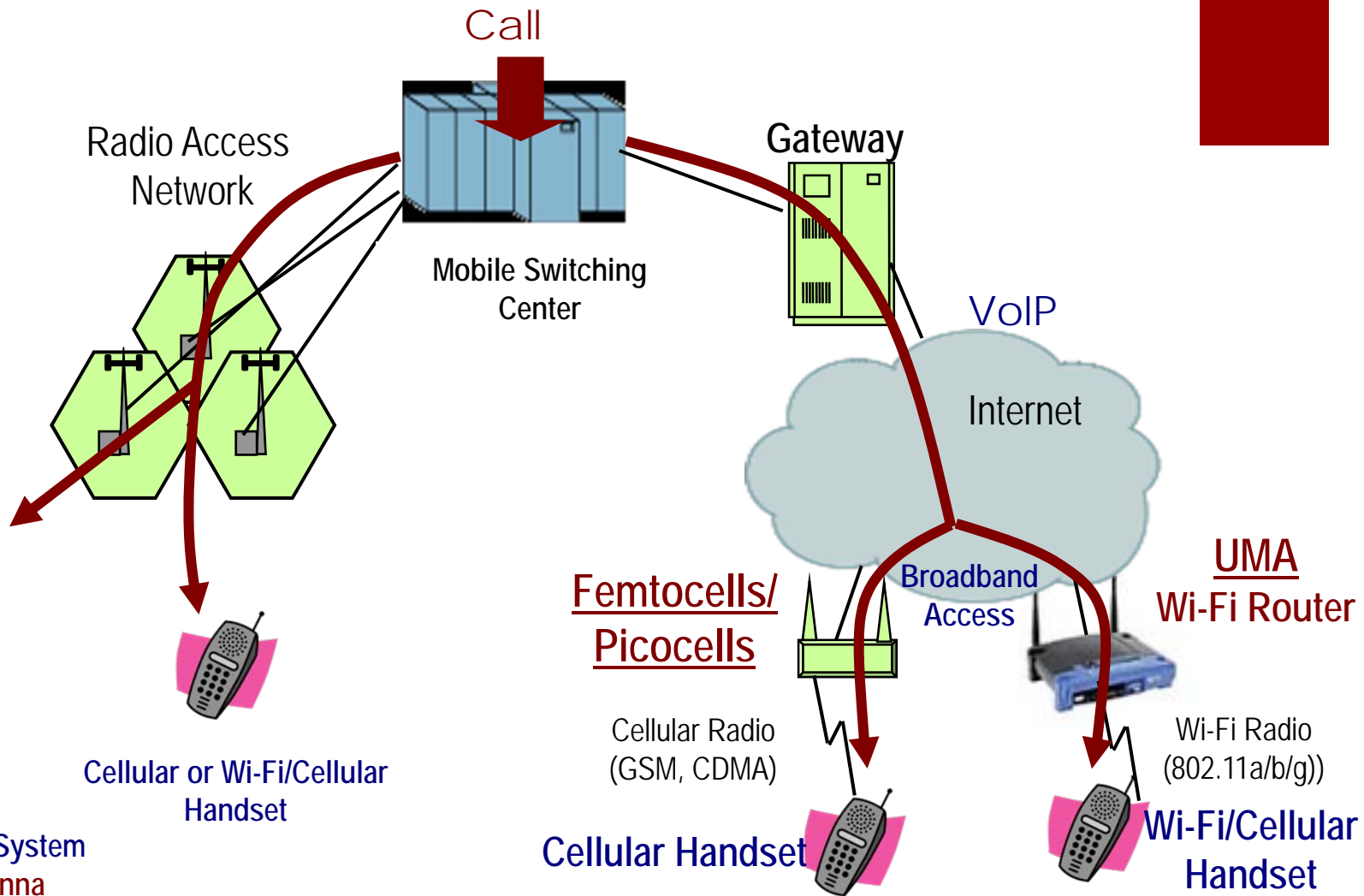
■ Internet Connection (VoIP)

- ◆ Cellular voice encoding, signaling, and authentication in IP packet transport
- ◆ Picocells- Enterprise scale
- ◆ Femtocells- Consumer-scale (Sprint's *Airave*)
- ◆ Wi-Fi Router- Unlicensed Mobile Access (T-Mobile's *HotSpot@Home*)

■ Metro Ethernet

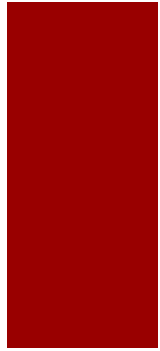
- ◆ Emerging option to reduce the cost of providing both voice and 3G data services
- ◆ Cellular voice encoding, signaling, and authentication in IP/Ethernet packet transport

Current Cellular Access Options



Indoor Antenna System
• Donor Antenna

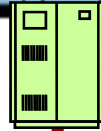
Metro Ethernet Backhaul



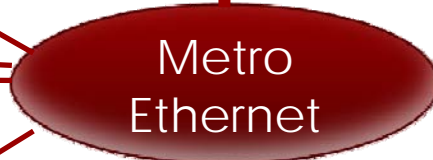
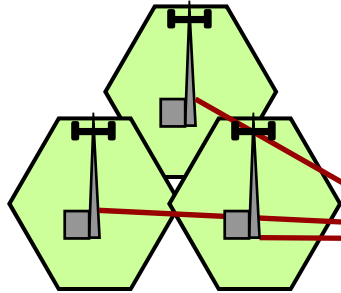
Mobile Switching Center



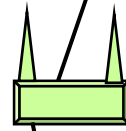
Ethernet/UMA Gateway



Radio Access Network



Femtocells



Cellular Radio (GSM, CDMA)

Cellular Handset



Broadband Access



UMA
Wi-Fi Router

Wi-Fi Radio (802.11a/b/g)

Wi-Fi/Cellular Handset



Indoor Antenna System

- Microcell
- Picocell

Consumer Home Access

DAS Types



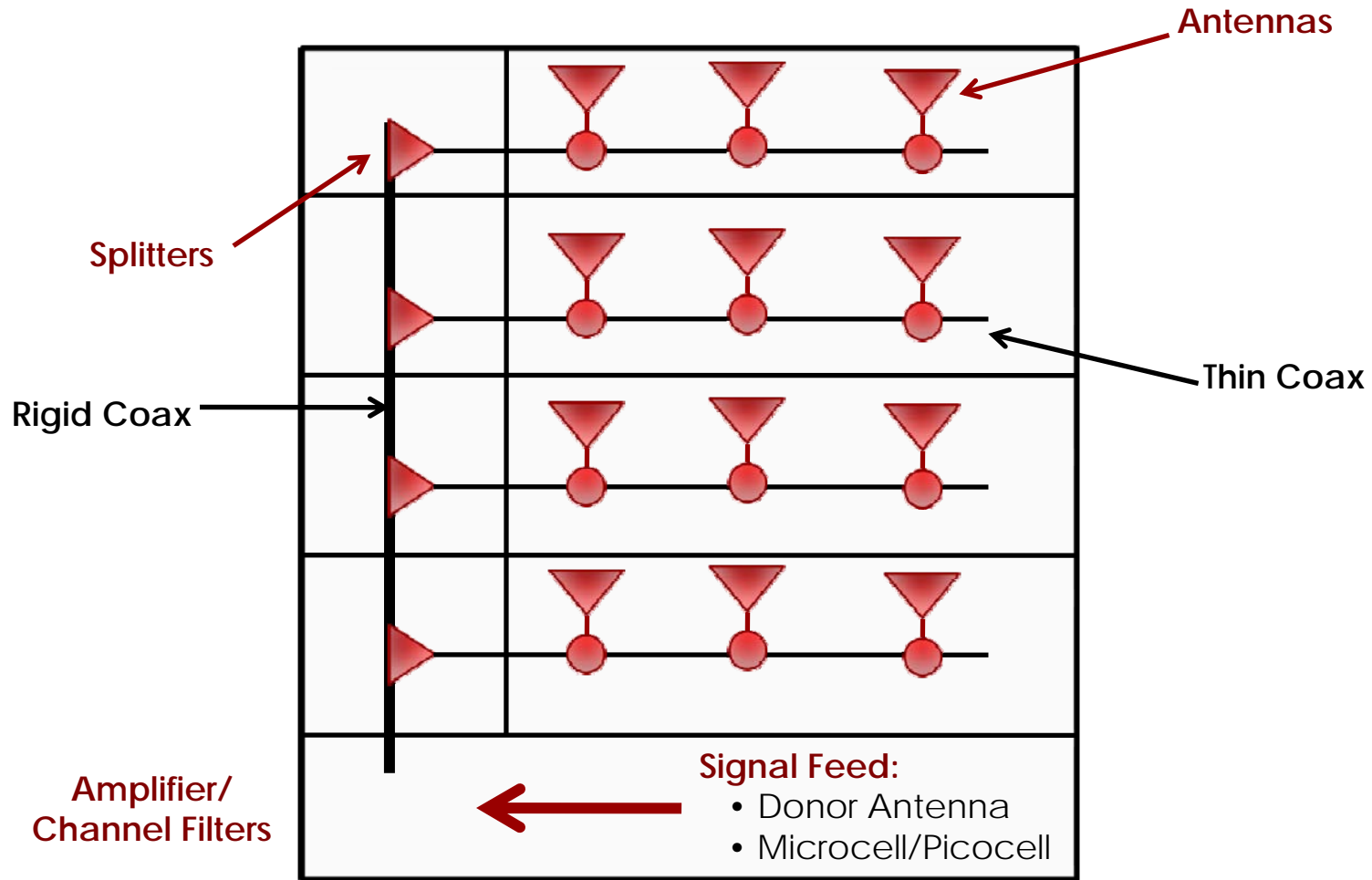
■ Passive DAS

- ◆ Single amplifier with RF signal distribution through the facility
- ◆ Signal feed can be donor antenna or micro/picocell
- ◆ “Zero sum” game

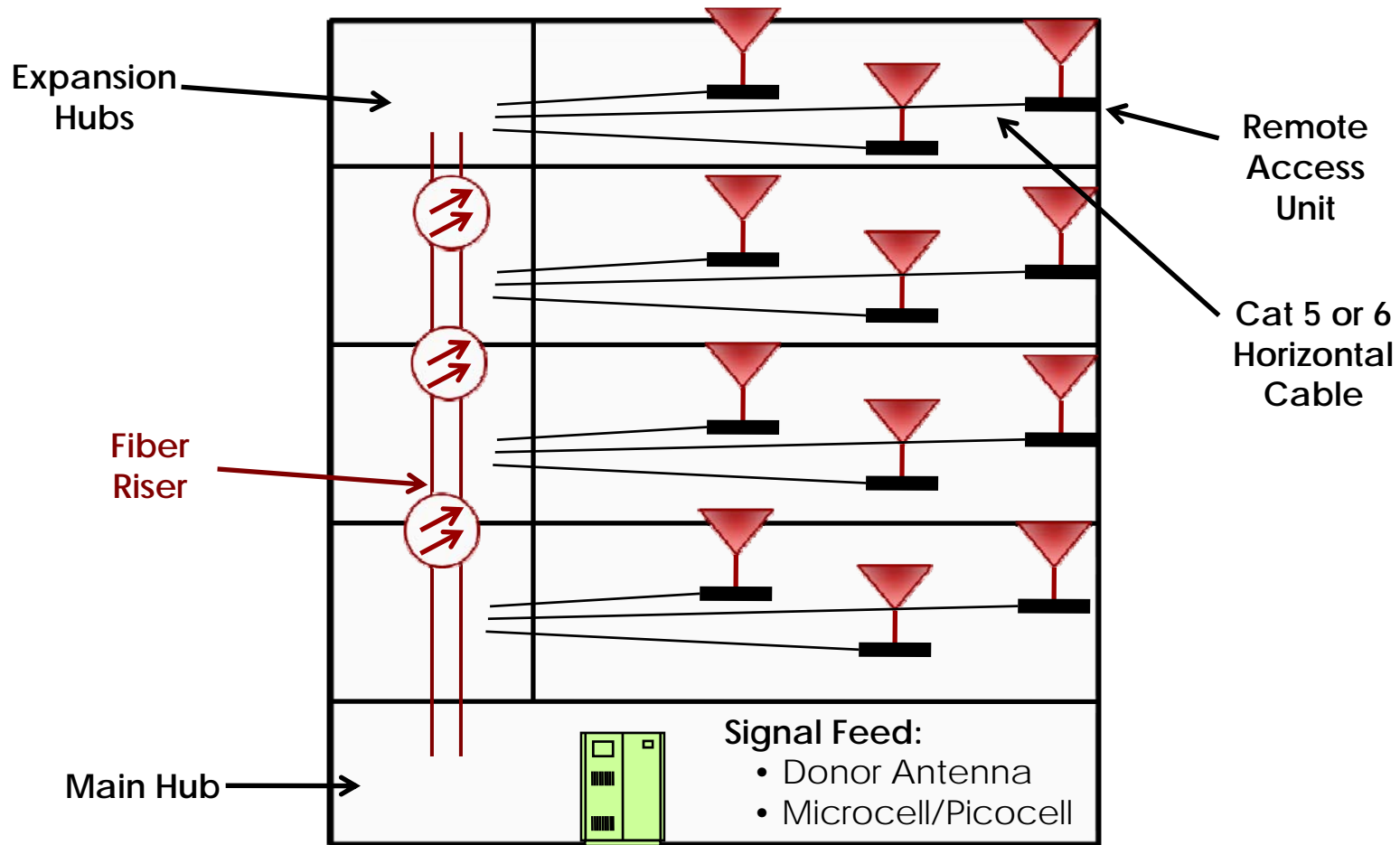
■ Active DAS

- ◆ RF signal demodulation with active electronics
- ◆ Multiple RF generation points
- ◆ Far greater transmission range without RF loss consideration
- ◆ More typical deployment today

Passive DAS Configuration



Active DAS Configuration



Antenna Options



- Omnidirectional
 - ◆ Radiates RF energy equally in all directions in the horizontal plane

- Directional
 - ◆ Radiates energy in a particular direction in the horizontal plane

- Leaky Coax
 - ◆ Coaxial cable with perforations in the shield conductor to propagate energy along a linear track (e.g. a tunnel)

Advantages of Active DAS



- Easier to engineer adequate coverage and CINR throughout a large facility (i.e. >500 Kft²)
- Greater range from the main feed
- Inherently provides channel filtering
- Remote monitoring and reconfiguration
- Ability to support multiple bands (AMPS, PCS, AWS) in a single system
- Operates on fiber and Cat 5/6 cable that is cheaper and easier to handle than rigid coax

Section 3

Negotiating for DAS

Basic Business Models



■ Carrier Provided (70%)

- ◆ Carrier pays full cost of installation
- ◆ User should have input to system specifications
- ◆ Only distributes that carriers' signal (usually)
- ◆ Multiple systems required to support multiple carriers

■ User Provided (30%)

- ◆ User pays full cost of installation and maintenance
- ◆ User defines system specifications
- ◆ Can distribute all carriers' services
- ◆ Charges carriers monthly rental to connect

Carrier Provided



- Generally part of the negotiation for enterprise-wide cellular service contract
- Carrier is responsible for channel selection, overall system design, and network performance
- User should have input to the design (2G-only, 3G support, network capacity, etc.)
- User requires some mechanism to measure/confirm performance improvement
 - ◆ Cell phone walk-around
 - ◆ User complaints
 - ◆ Cellular testing equipment

User Provided



- Most users lack design expertise in cellular networks
- Depend heavily on the equipment supplier for system specification and design
- Space must be allocated for DAS and carrier-provided equipment and feeds
- User must define overall system objectives:
 - ◆ Number and type of cellular carriers (GSM, CDMA)
 - ◆ Services carried (2G cellular, 2.5G/3G, iDEN [Nextel])
 - ◆ Provision for other technologies (WiMAX, Wi-Fi, SMR, Public Safety, etc.)

Major DAS Providers



	Active DAS	Passive DAS	Multi-Frequency Support
ADC/LGC	√		√
Andrew	√		√
CSI		√	√
Ericsson		√	√
InnerWireless		√	√
Mobile Access	√		√
Powerwave	√		

Conclusion



- IT responsibilities now include cellular
 - ◆ Users expect their cell phones to work indoors
 - ◆ Public venue operators (hotels, airports, universities) must make indoor cellular access available
- Cellular technology is in transition
 - ◆ Signal quality and backhaul costs are changing with 3G
 - ◆ Subscriber acquisition costs are escalating
- Voice over WLAN
 - ◆ May change the requirements for enterprise DAS
 - ◆ Visitors will still need cellular access
- "Open Cellular"
 - ◆ Will the cellular carriers change their competitive posture to encourage open initiatives and integration of other wireless technologies?