Emerging Wireless Network Technologies

Pakistan Engineering Council, and M. A Jinnah University, Islamabad
Workshop Plan – Day 1

• **Lecture 1 – Introduction**
  - Wireless Networks, their Importance & Complexity
    - Dr Amir Qayyum

• **Lecture 2 – Wi-Fi**
  - Introduction to IEEE 802.11 Wireless LAN (WiFi)
    - Dr Muid Mufti

• **Lecture 3 – Wi-Fi**
  - PHY and MAC Layer Details of IEEE 802.11
    - Dr Muid Mufti
Workshop Plan - Day 2

• **Lecture 4 – Wi-Fi**
  – IEEE 802.11 Variants (for security, QoS, etc.)
    • Dr Muid Mufti

• **Lecture 5 – Wi-Max**
  – Introduction to IEEE 802.16 Wireless MAN
    • Dr Amir Qayyum

• **Lecture 6 – Wi-Max**
  – Details of IEEE 802.16 and Comparison among its Variants
    • Dr Amir Qayyum
Introduction to Wireless Networks, their Importance & Complexity

Dr Amir Qayyum

M. A Jinnah University, Islamabad
Objectives of this Session?

• Understand the issues that arise
  – When we unplug the wire and go wireless
  – When we move and require connectivity with mobility
• And how to handle these issues
The Emerging Internet
The Emerging Internet

- Single logical IP backbone (provided by a few carriers)
- Overlaid virtual private networks
- Full service network
  - Voice
  - Video
  - Data
- Packet switched backbone
- Packet and circuit switched access networks
Why Wireless Networks

• Cabling is sometimes impossible
  – Even if possible, cabling is quite expensive

• Modern work conditions require the flexibility of installation
  – No cost for re-installation or rewiring

• Radio networks permit to communicate with the mobile stations
Why Wireless Networks?

• Wireless is convenient and not too expensive

• Roaming allows flexibility
  – Stay connected anywhere and any time

• Rapid market growth and application demands
  – Instantaneous, uninterrupted, fast access regardless of the application

• Consumers and businesses are willing to pay for it
Mobile Wireless Technologies

• Higher data rates obtainable with broadband wireless technology
  – Graphics, video, audio

• Shares same advantages of all wireless services: convenience and reduced cost
  – Service can be deployed faster than fixed service
  – Service is mobile, deployed almost anywhere
Limitations of Wireless Technologies

• Physical limitations and political/technical difficulties inhibit wireless technologies
• Wireless transmission inefficiencies
• Lack of an industry-wide standard
• Device limitations
  - E.g., small LCD on a mobile telephone can only display a few lines of text
Limitations of Wireless Networks

• Technology is still expensive
  – Newer technologies are much expensive

• Range is reduced as much as the speed is increased

• Problems of security and confidentiality
Transmission Problems of Radio Networks

- Errors occur much more than in wired networks
- Signal power reduces drastically with the distance
- Carrier lost due to error burst
- Interference with other systems
- Detection of collision is impossible
Transmission Problems of Radio Networks

- Unreliable transmission does not favor to construct a token system
- Networks are often open
  - Random insertion and depart of stations
- Hidden nodes
Radio Transmission

Data receive region of A

Data receive region of B

Collision area

Energy detection area
Mobile Wireless Networks

• What must a mobile network provide?
  – Connectivity with mobility
  – Cost-effective sharing of bandwidth
  – Performance

• How are mobile networks designed?
  – Layering
  – Protocols
  – Standards
Role of Standards

• **Provide (the hope of) interoperability**
  – Equipment from different vendors
  – Existing protocols and software

• **Protection of investment**
  – Product lifetime
  – Support from multiple vendors

• **Volume in the marketplace**
  – Broader support by equipment/software vendors
  – Reduced prices
Classification of Wireless Networks

- **Mobility**: fixed wireless or mobile
- **Communication**: Analog or digital
- **Topology/Infrastructure**: Ad hoc (decentralized) or centralized (base stations)
- **Services**: voice (isochronous) or data (asynchronous)
- **Ownership**: public or private
Classification of Wireless Networks

- **Area:** wide (WAN), metropolitan (MAN), local (LAN), or personal (PAN) area networks

- **Medium:** Switched (circuit- or packet-switched) or broadcast

- **Data Rate:** Low bit-rate (voice grade) or high bit-rate (video, multimedia)

- **Placement:** Terrestrial or satellite
A Taxonomy of Wireless Networks

- Desk/Local Area
  - Wireless D/LANs
    - Ad Hoc
    - Infrastructure
  - Links

- Wide Area
  - Satellite
    - Mobile
    - Fixed
  - Terrestrial
    - Mobile Data
    - Fixed
Wireless Networking Concepts

- Fundamental issues
- Range and mobility
- Wireless channel
- Shared Capacity
- Infrastructure
Fundamental Issues

- Broadband access
- Seamless mobility
- Quality of service
- Security
- Large scale network management
- Scalable multicast
- Etc. …
Range

• Range can vary
  – Wide area networks (WANs)
  – Local area networks (LANs)
  – Desk or personal area networks (PANs)

• Trade-offs
  – Data rate
  – Error rate
  – Transmit power
  – Antenna size/antenna gain
Range (Cell Size) vs Data Rate
Mobility

- **Wireless networks enable mobility**
  - Provides considerable functionality and value
  - Introduces substantial complexity
    - Hand-off
    - Routing to mobile hosts
    - Security
  - Motivates portability
    - Packaging
    - Power management, low-power design
Wireless LAN vs Mobile Data

- Mobility
- Mobile Data
- Service Area
- Power
- Number of Users
- Interoperability
- Wireless LANs
- Data Rate
Wireless Channels

• **Infrared (IR)**
  - Limited range, won’t permeate walls

• **Radio frequency (RF)**
  - Greater range, can permeate walls

• **Orderly use of RF spectrum reduces interference**
  - Allocated by some telecom regulatory body, e.g. FAB
  - Licensed spectrum allocated for proprietary use
  - Unlicensed spectrum is open for general use, with restrictions
Wireless Channel Characteristics

• The wireless channel differs substantially from “wired” or “wireline” channels (optical cable, coaxial cables, twisted copper pair)
• Typically higher bit error rates
• Often lower data rates
• Varying properties
  – Interference
  – Propagation
• Fixed bandwidth available that must be shared
• No physical security
Telephone vs Data Networks

- **Telephone networks:**
  - Built around a single application with low bit rate
  - Voice can support high bit error rate
  - Traffic predictability at low and medium time scale

- **Data networks:**
  - Packet network for universal use with high bit rate
  - Data needs error-free communication
  - Traffic unpredictability at any time scale
  - Requires random access protocols
  - QoS on per packet basis
Shared Capacity

- Capacity (bandwidth) of wireless link is limited and must be shared.
- Dictates need for multiple access techniques.
- Multiple access techniques are very much dependent on the channel traffic.

[Diagram showing time on the x-axis and voice and data on the y-axis, with symbols indicating time slots for voice and data communication.]
Sharing of Communication Resources

• In a voice network, sharing is constant in time
  – The share is identical for each of the active stations

• In a data network, demand of resources varies significantly in time, and for each station
Physical Layer Issues

- Range
- Data rate
- Bit (symbol) error rate
- Bit (symbol) coding
- Power management
- Link monitoring
- Etc., etc.
Data Link Layer Issues

- Frame size & overhead
- Frame error rate, error recovery (ARQ)
- Forward error correction
- Multiple access
- Handoff
- Power management
- Link monitoring
Network Layer Issues

- Packet size & overhead
- Routing overhead
- Mobile host routing
- Mobile ad hoc routing
- Layer-3 gateway services
- Quality of service
- Congestion control
- Power management
Transport Layer Issues

- End-to-end error recovery and flow control efficiency
- Connection-level quality of service
- Connection overhead
- Transport-level gateway services
- Connectivity across handoffs
Application Layer Issues

- Encryption and decryption
- Data-specific source encoding
- Application-level quality of service
- Power management
- User interface
- New classes of mobile applications
Components of Wireless Network

- Standards and Systems
- Applications and Interfaces
- Data Link
- Mobility
- Power Management
Wireless Data Link: Techniques

- Ad hoc versus infrastructure networks
- Physical layer constraints
- Multiple access techniques
  - Scheduled
  - Contention-based
- Framing
- Power management
**Wireless Data Link: Systems and Standards**

- **Wireless PANs (Personal Area Networks)**
  - BlueTooth
  - IEEE 802.15

- **Wireless LANs**
  - IEEE 802.11 Wireless LAN
  - HiPERLAN

- **Broadband wireless**
  - IEEE 802.16 Wireless MAN
  - Local Multipoint Distribution Service (LMDS)
Mobility: Techniques

- **Mobile nodes**
  - Handoff ("small scale" mobility)
  - Mobile routing ("large scale" mobility)

- **Mobile networks**
  - Mobile ad hoc networks
  - Routing
Mobility: Systems and Standards

- Handoff in IEEE 802.11 (and others)
- IETF’s MANET (Mobile Ad Hoc Networking)
- Mobile IP
- IEEE 802.16e
- IEEE 802.20
Infrastructure

- Wireless networks can either
  - Require no infrastructure, or
  - Rely on the presence of some infrastructure for
    - Control
    - Access to wire line networks

- Infrastructure networks usually offer greater functionality

- Ad hoc networks are without infrastructure, where all nodes can move
  - Can be deployed rapidly
Infrastructure-based Wireless Networks

- Provide access to other networks
- Coordinate access between stations
- Can support roaming -- mobility between service areas

Infrastructure-based wireless networks
Infrastructure based Networks

WLAN Roaming

- Access Point A
- Access Point B

- Laptop A (with WLAN card)
- Laptop B (with WLAN card)
- Laptop C (with WLAN card)
  Moving to Access Point B

- Laptop D (with WLAN card)
- Laptop E (with WLAN card)
- Laptop C (with WLAN card)
  Registering to Access Point B

Reassociation Request
Reassociation Response
Ad-Hoc Wireless Networks

- Stations communicate directly with peers
- Routing through peers may be needed if all stations are not “visible”
  - Basis for mobile ad hoc networks
Different Architectures of Radio Networks

- Fully-connected (previously ad hoc)
- Internal routing
- Base station
- Hybrid with cable link
Where To go "Wireless" - Take 1

- Fully wireless network
- Can be ad hoc in that no static structure is required
- Network level interoperability with "wired" networks
- Requires substantial protocol changes, e.g. Mobile IP
Where To go “Wireless” - Take 2

- Wireless MAC layer
- Can be ad hoc, with static structure for access to wired network
- Model for wireless LANs (IEEE 802.11) and wide-area access (WiMax)
- Possible link layer interoperability with wired networks
Where To go “Wireless” -
Take 3

- Wireless physical layer
- Provides point-to-point wireless connection
- Model for wireless bridges
- “Transparent” to existing network
WLAN Standards

Wireless LAN

2.4 GHz
- 802.11 (2 Mbps)
- 802.11b (11 Mbps)
- 802.11g (22-54 Mbps)
- HiSWANa (54 Mbps)
- HomeRF 2.0 (10 Mbps)
- Bluetooth (1 Mbps)
- HomeRF 1.0 (2 Mbps)
- 802.11e (QoS)
- 802.11f (IAPP)

5 GHz
- 802.11a (54 Mbps)
- HiperLAN2 (54 Mbps)
- 802.11i (Security)
- 802.11h (TPC-DFS)
Next Generation Networks

One network for everything

Today

Internet
Telephone network
Mobile radio network

Tomorrow

IP-Network

Multimedia Access - Advantages
- easy to handle
- reliable
- mobile

One network for everything
NGN Architecture

System Management Servers

Applications

Control

Packet Network

Core

Edge

Access

Mobile Gateway

Broadband Gateway

PSTN Gateway

UTRAN

DSL

Cable

WLL

CO

Enterprise Customers

Remote Office/SOHO

Residential Users

Mobile Users

Application Servers

Softswitches

Signaling gateways

Management

Applications

Control

System Management Servers
Data rates

- **HSCSD, GPRS & EDGE**: Bundling of 1-8 channels
- **HSCSD**: Circuit-switched
- **GPRS**: Packet-switched; new infrastructure
- **EDGE**: 8PSK instead of GMSK
- **UMTS**: UTRA (WCDMA)

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**GSM**

- **Phase 1/2**: 9.6 kbit/s
- **4 / (8) x**: 14.4 kbit/s
- **8 x**: 21.4 kbit/s

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**GPRS**

- **171 kbit/s**: New network elements & protocol architectures prerequisite for UMTS!

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**HSCSD**

- **115 kbit/s**: No new network elements; SW modifications

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**EDGE**

- **553 kbit/s**: No new network elements; only modifications to the modulation method

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**UTRA**

- **1920 kbit/s**: New transmission principles (WCDMA), network elements & protocols

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**GSM Phase 2+**
Any question?