TELECOMMUNICATION NETWORK PERFORMANCE

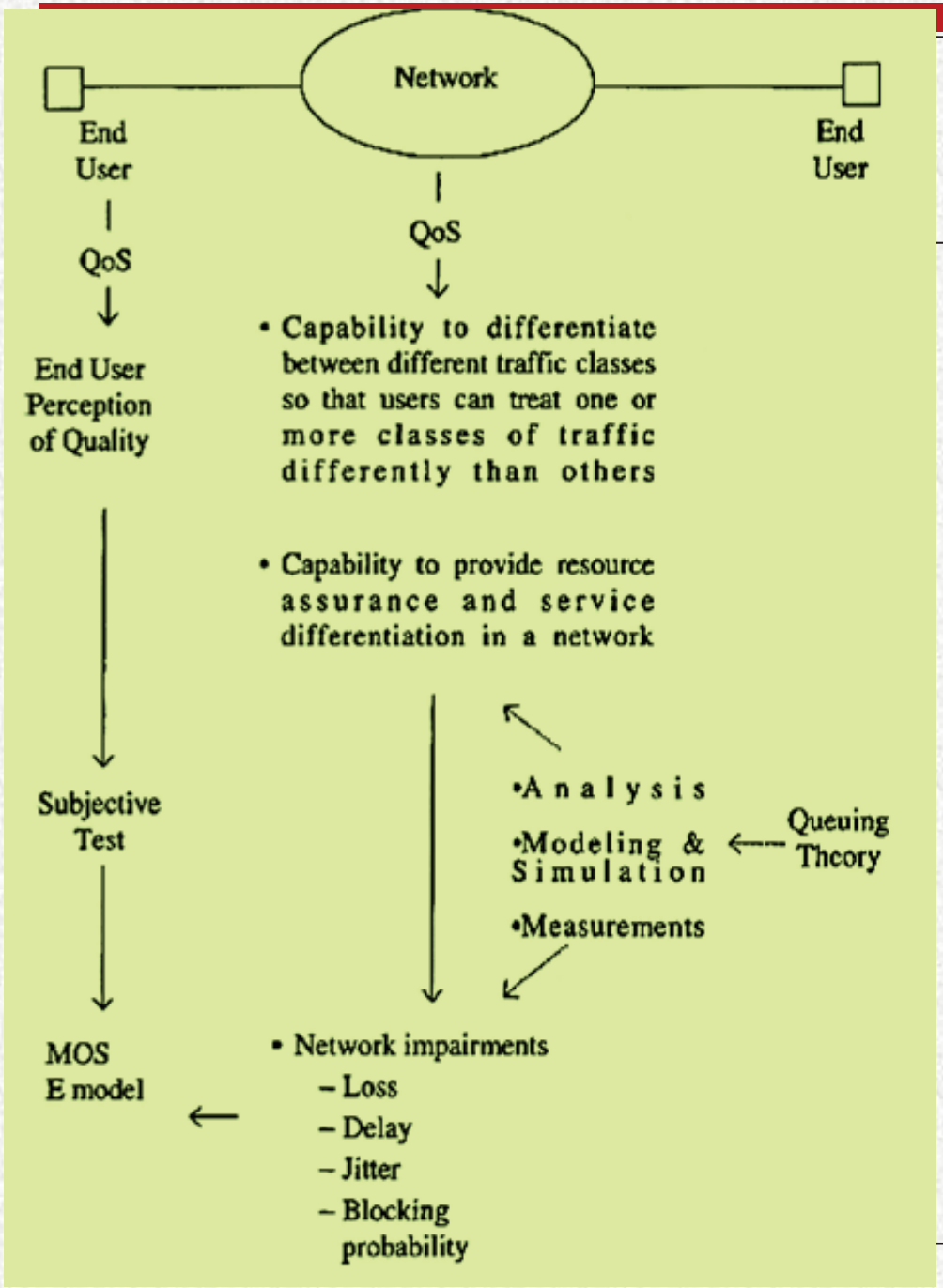
QoS Overview (PHY + Data Link)

QoS Overview (PHY + Data Link)

FER, MAC Delay, Link Charge Rate

BER, SNR, Transmission delay, C/I

QoS Definition



- 2 perpectives of QoS: Network and End User

Kun I Park, QoS in Packets Networks, Springer, 2005, p 5

Dimitrios Miras , Network QoS Needs of Advanced Internet Applications: A Survey, Computer Science Dept, Univ College London, 2002, p2

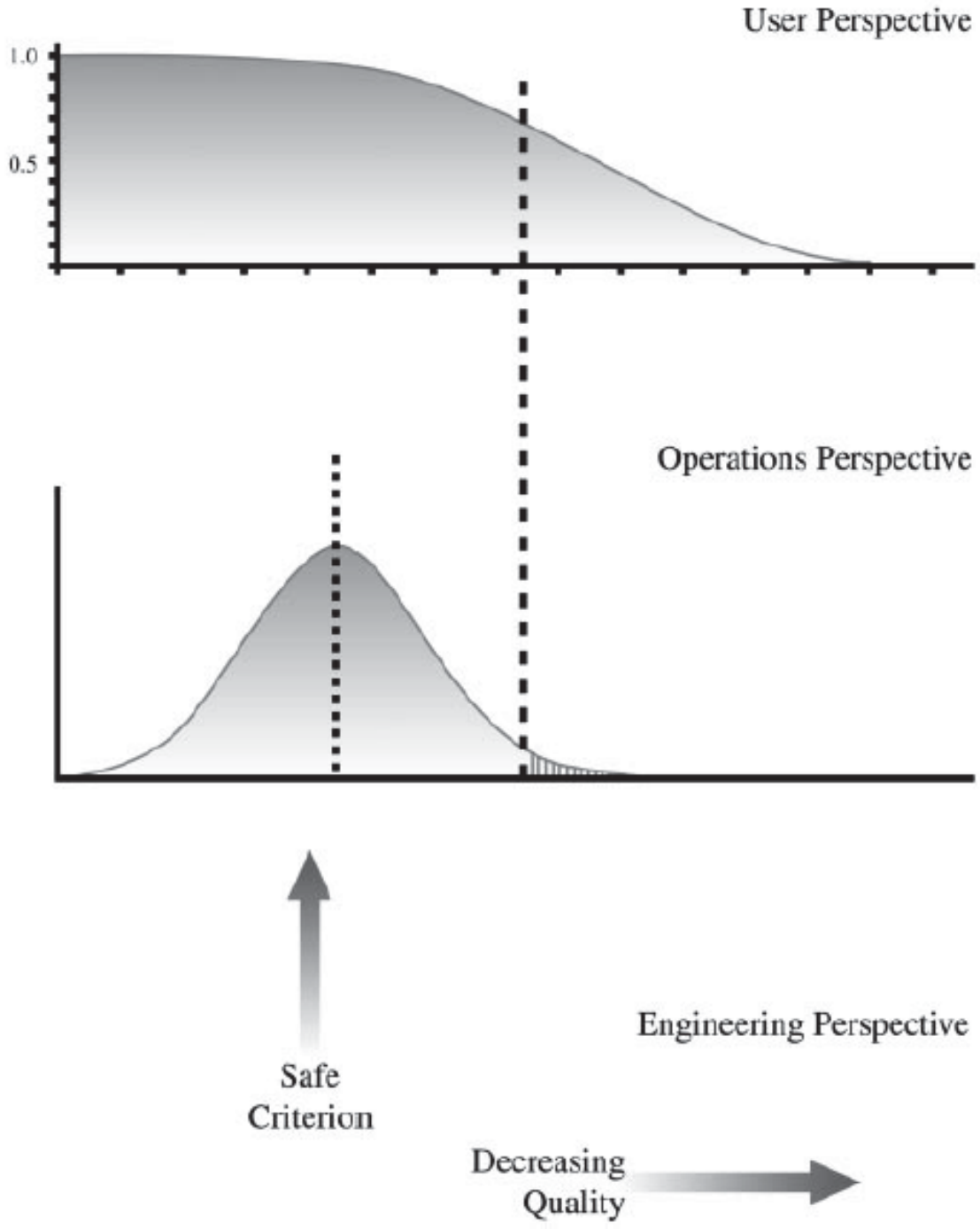
End User perspective

- QoS is the end user's perception of the quality that he receives from the network provider for the particular service or application that he subscribes to, e.g., voice, video, and data
- The end user perception of the quality is determined by subjective testing as a function of the network impairments such as delay, jitter, packet loss, and blocking probability. The amount of impairment introduced by a packet network depends on the particular QoS mechanism implemented in the network.

Network perspective

- The term "QoS" refers to the network's is capabilities to provide the QoS perceived by the end user as defined above.
- Two types of network capabilities are needed to provide QoS in packetnetworks.
- First, to provide QoS, a packet network must be able to differentiate between classes of traffic so that the end users can treat one or more classes of traffic differently than others.
- Second, once the network differentiates between the traffic classes, it must then be able to treat these classes distinctly by providing resource assurance and service differentiation within the network.

Kun I Park, QoS in Packets Networks, Springer, 2005, p 5



Other opinion

William C. Hardy, Qos Measurement of Telecommunication Quality of Service, John Wiley & Sons, 2001

QoS Overview (PHY Layer)

Bit Error Rate (BER), defined as the ratio of the number of incorrectly received bits to the total transmitted bits in a transmission. BER is often used as a measure of the signal quality of one/multi hop(s) of wireless channel(s).

Signal-to-Noise Ratio (SNR), defined as the ratio of a signal power to the noise power that is corrupting the signal. SNR can only measured at Physical layer but is often used by upper layer techniques to evaluate the link quality.

Adopted from : Zhuoqun Li, Resource-Efficient Strategies for Mobile Ad-hoc Networking. PhD Dissertation, School of Computing, Communcations and Electronics, Faculty of Technology, November 2007

QoS Overview (Data Link Layer)

Link Change Rate, in addition to be a mobility metric as introduced in the previous section, is also used as a QoS measure of the reliability of wireless links. A link that changes its status frequently is regarded as of low quality and unreliable.

MAC delay, referred to as the time taken to transmit a packet over a wireless channel with contention-based MAC, including the total propagation time in the channel and the time to acknowledge the data [69]. MAC delay is a good indicator of the situation of link level congestions.

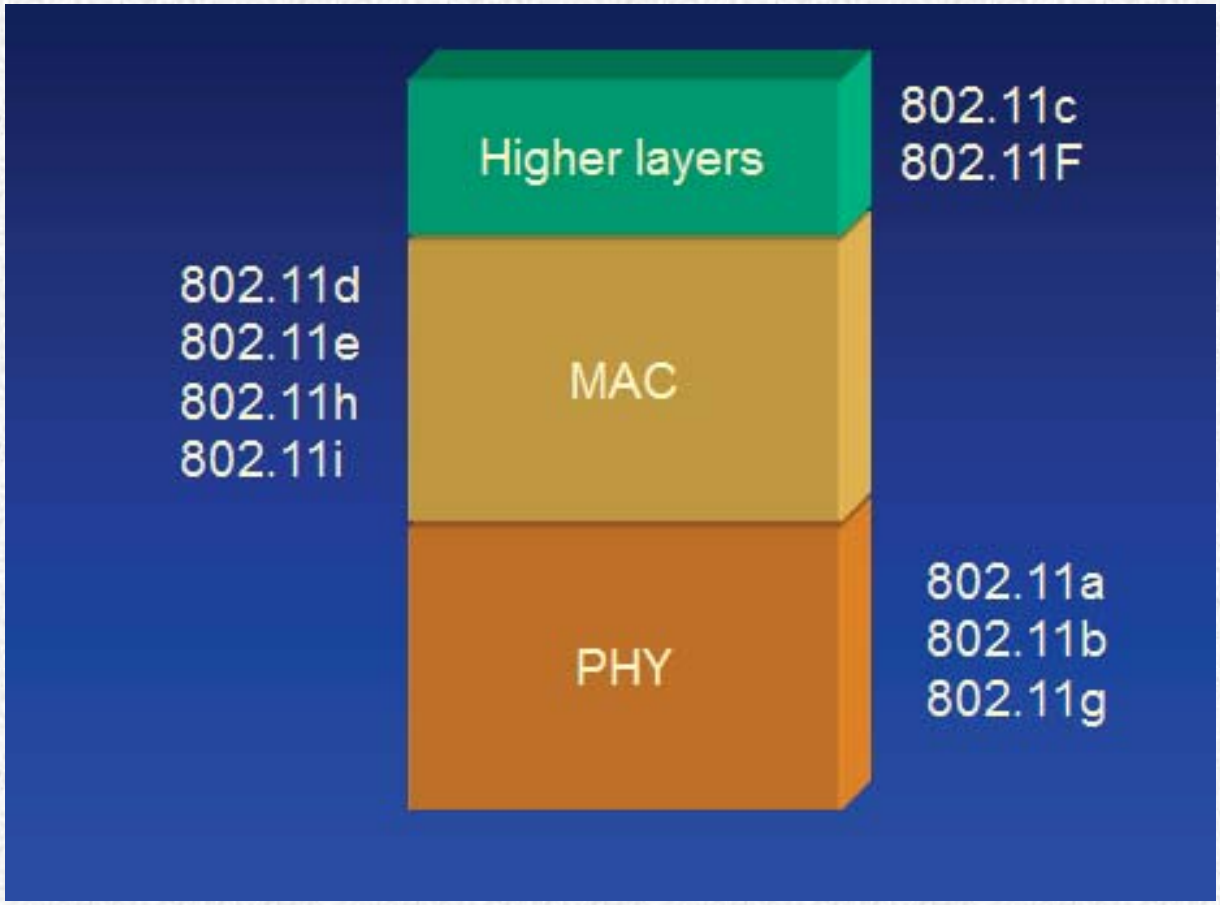
Adopted from : Zhuoqun Li, Resource-Efficient Strategies for Mobile Ad-hoc Networking. PhD Dissertation, School of Computing, Communcations and Electronics, Faculty of Technology, November 2007

QoS Overview (Data Link Layer, Cont.)

Frame Error Rate (FER), defined as ratio of the number of corrupted frames received to the total transmitted MAC frames in an unit time. Its a reflection of the performance of physical layer measures in the link layer.

Adopted from : Zhuoqun Li, Resource-Efficient Strategies for Mobile Ad-hoc Networking. PhD Dissertation, School of Computing, Communcations and Electronics, Faculty of Technology, November 2007

IEEE 802.11 Standard Overview



Adopted from : Intel Corporation Presentation

IEEE 802.11 Standard Overview (Cont.)

The following IEEE 802.11 standards exist or are in development to support the creation of technologies for wireless local area networking:

- **802.11a** - 54 Mbps standard, 5 GHz signaling (ratified 1999)
- **802.11b** - 11 Mbps standard, 2.4 GHz signaling (1999)
- **802.11c** - operation of bridge connections (moved to 802.1D)
- **802.11d** - worldwide compliance with regulations for use of wireless signal spectrum (2001)
- **802.11e** - Quality of Service (QoS) support (not yet ratified)
- **802.11f** - Inter-Access Point Protocol recommendation for communication between access points to support roaming clients (2003)
- **802.11g** - 54 Mbps standard, 2.4 GHz signaling (2003)
- **802.11h** - enhanced version of 802.11a to support European regulatory requirements (2003)
- **802.11i**- security improvements for the 802.11 family (2004)
- **802.11j** - enhancements to 5 GHz signaling to support Japan regulatory requirements (2004)
- **802.11k** - WLAN system management (in progress)

Adopted from : Worcester Polytechnic Institute

IEEE 802.11 Standard Overview (Cont.)

The following IEEE 802.11 standards exist or are in development to support the creation of technologies for wireless local area networking:

- **802.11m** - maintenance of 802.11 family documentation
- **802.11n** - 100+ Mbps standard improvements over 802.11g (in progress)
- **802.11p**- Wireless Access for the Vehicular Environment
- **802.11r** - fast roaming support via Basic Service Set transitions
- **802.11s** - ESS mesh networking for access points
- **802.11t** - Wireless Performance Prediction - recommendation for testing standards and metrics
- **802.11u** - internetworking with 3G / cellular and other forms of external networks
- **802.11v** - wireless network management / device configuration
- **802.11w** - Protected Management Frames security enhancement
- **802.11x**- skipped (generic name for the 802.11 family)
- **802.11y** - Contention Based Protocol for interference avoidance

Adopted from : Worcester Polytechnic Institute

Wireless Physical Layer

- Physical layer conforms to OSI (five options)
  - 1997: **802.11** infrared, FHSS, DSSS {FHSS and DSSS run in the 2.4GHz band}
  - 1999: **802.11a** OFDM and **802.11b** HR-DSSS
  - 2001: **802.11g** OFDM
- **802.11 *Infrared***
  - Two capacities: **1 Mbps or 2 Mbps**.
  - Range is 10 to 20 meters and cannot penetrate walls.
  - Does not work outdoors.
- **802.11 *FHSS (Frequence Hopping Spread Spectrum)***
  - **The main issue is *multipath fading*.**
  - ***[P&D] The idea behind spread spectrum is to spread the signal over a wider frequency to minimize the interference from other devices.***
  - 79 non-overlapping channels, each 1 Mhz wide at low end of 2.4 GHz ISM band.
  - The same pseudo-random number generator used by all stations to start the hopping process.
  - Dwell time: min. time on channel before hopping (400msec).

Adopted from : Worcester Polytechnic Institute

Wireless Physical Layer (Cont.)

- **802.11 *DSSS (Direct Sequence Spread Spectrum)***
  - ***The main idea is to represent each bit in the frame by multiple bits in the transmitted signal (i.e., it sends the XOR of that bit and n random bits).***
  - Spreads signal over entire spectrum using pseudo-random sequence (similar to CDMA see Tanenbaum sec. 2.6.2).
  - Each bit transmitted using an 11-bit chipping Barker sequence, PSK at 1Mbaud.
  - This yields a capacity of 1 or 2 Mbps.

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Wireless Physical Layer (Cont.)

- **802.11a *OFDM* (Orthogonal Frequency Divisional Multiplexing)**
  - Compatible with European HiperLan2.
  - **54 Mbps** in wider 5.5 GHz band ➔ transmission range is limited.
  - Uses 52 FDM channels (48 for data; 4 for synchronization).
  - Encoding is complex (PSM up to 18 Mbps and QAM above this capacity).
  - E.g., at 54 Mbps 216 data bits encoded into into 288-bit symbols.
  - More difficulty penetrating walls.

Adopted from : Worcester Polytechnic Institute

Wireless Physical Layer (Cont.)

- **802.11b *HR-DSSS (High Rate Direct Sequence Spread Spectrum)***
  - **11a and 11b** *shows a split in the standards committee.*
  - **11b** approved and hit the market before **11a.**
  - Up to **11 Mbps** in 2.4 GHz band using 11 million chips/sec.
  - Note in this bandwidth all these protocols have to deal with interference from microwave ovens, cordless phones and garage door openers.
  - Range is 7 times greater than **11a.**
  - **11b and 11a are incompatible!!**

Adopted from : Worcester Polytechnic Institute

Wireless Physical Layer (Cont.)

- **802.11g *OFDM(Orthogonal Frequency Division Multiplexing*)**
  - **An attempt to combine the best of both 802.11a and 802.11b.**
  - Supports bandwidths up to **54 Mbps**.
  - Uses 2.4 GHz frequency for greater range.
  - Is backward compatible with 802.11b.

Adopted from : Worcester Polytechnic Institute

802.11 MAC Sublayer Protocol

- In 802.11 wireless LANs, “seizing the channel” does not exist as in 802.3 wired Ethernet.
- Two additional problems:
  - Hidden Terminal Problem
  - Exposed Station Problem
- To deal with these two problems 802.11 supports two modes of operation:
  - **DCF (Distributed Coordination Function)**
  - **PCF (Point Coordination Function).**
- **All implementations must support DCF, but PCF is optional.**

Adopted from : Worcester Polytechnic Institute

Challenges and future work
Wireless Internet and Interoperability

- IEEE 802.11 WLANs have been successfully applied as the last mile technology where there is a need for wireless/mobile users (Wireless Hotspots).
- There is an urgent demand for e2e QoS guarantee to be provided in wire-cum-wireless heterogeneous networks.
- Interoperability between ***IEEE 802.11*** and ***DiffServ*** or ***IntServ.***

Adopted from : Hua Zhu, Ming Li, Imrich Chlamtac, B. Prabhakaran, A Survey of Quality of Service in IEEE 802.11 Networks. Presentation, The University of Texas at Dallas.

QoS and Mobility Management in Hybrid Wireless Networks

- Seamless horizontal handoff and roaming among 802.11 WLAN supporting QoS anytime anywhere.

- Vertical handoff between WLAN, mobile and ad hoc networks (MANET), Bluetooth, Universal Mobile Telecommunications System (UMTS) and Wideband Code Division Multiple Access (WCDMA)

Adopted from : Hua Zhu, Ming Li, Imrich Chlamtac, B. Prabhakaran, A Survey of Quality of Service in IEEE 802.11 Networks. Presentation, The University of Texas at Dallas.

WLAN – MANET Integration

- [Lamont & Wang]:
  - Routing within MANET is handled by the Optimised Link State Protocol (OLSP).
  - Handoff between MANETs & WLANs is supported through automatic node detection and node switching capabilities of the mobiles.
  - Functionalities of OLSP are extended to support Mobile IPv6

Adopted from : Hua Zhu, Ming Li, Imrich Chlamtac, B. Prabhakaran, A Survey of Quality of Service in IEEE 802.11 Networks. Presentation, The University of Texas at Dallas.

WLAN – 3G Integration

- [Jaseemudin]:
  - A mobile node is maintaining two connections in parallel:
    - Data connection through WLAN.
    - Voice connection through UMTS.
- [Park &Yoon]:
  - Vertical handoff between WLANs and CDMA
  - Real time traffic takes into account handoff delay
  - Best effort traffic takes into account throughput.

Adopted from : Hua Zhu, Ming Li, Imrich Chlamtac, B. Prabhakaran, A Survey of Quality of Service in IEEE 802.11 Networks. Presentation, The University of Texas at Dallas.

WLAN – 3G Integration (Cont.)

- Integration of WLANs and 3G/4G requires a low call dropping probability in the 3G/4G networks.
- [Lou & Li]:
  - Adaptive allocation scheme termed measurement based preassignment in order to prevent handoff failure in wireless cellular networks. A periodic measurement of traffic status within a cell help to adjust the number of reserved channels for handoff.

Adopted from : Hua Zhu, Ming Li, Imrich Chlamtac, B. Prabhakaran, A Survey of Quality of Service in IEEE 802.11 Networks. Presentation, The University of Texas at Dallas.