King Fahd University of Petroleum & Minerals Computer Engineering Dept

COE 543 – Mobile and Wireless Networks

Term 072

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Lecture Contents

1.

Main References

- Abbas Jamalipour, The Wireless Mobile Internet – Architecture, Protocols and Services , Wiley, 2003 – Chapter 5: Quality of Service in a Mobile Environment

Quality of Service

- Def: set of specific requirement (quantitative or otherwise) for a particular service provided by a network to users
- Easier to deal with measurable quantitative requirements
  - E.g. good quality video versus FER < 10^{-4}
- Objective: to be able to give QoS guarantees for network users
  - E.g 3/4 G-mobile networks

User-Level QoS Requirements

- Def: requirements that can directly affect the user application
  - E.g voice quality – call drop
- Many of the procedures involved are transparent to user
  - E.g. handoff internode communications
- These requirements are greatly determined by the user application

User-Level QoS Requirements – cont'd

- Categorizes according to
  - Criticality – in accordance with the perceived QoS based on data transmission and application type
    - E.g: for multimedia streaming – factors are: video rate, video smoothness, picture detail, picture quality, audio quality, video/audio synchronization, etc.
  - Cost – money value of the service fees charged by the service provider
    - Cost model – per usage time or per data (more practical for internet applications)
  - Security (refer to previous set of slides)
    - Confidentiality
    - Integrity
    - Digital signature capability
    - Authentication

Technology and Network QoS Requirements

- More indicative (explicit) figures/numbers to illustrate the QoS provided to users
- Categorized into:
  - Bandwidth – data rate available to application
  - Timeliness
  - Reliability

Technology and Network QoS Requirements - Bandwidth

- Typically higher bandwidth network provide higher user data rate (ignoring loading, bandwidth management schemes, etc)
- System-level rate: physical transmission rate (function of static parameters such as modulation, frequency, technology, etc, and of dynamic parameters such as system resource management)
- Application-level rate: application protocols use different compression algorithms to reduce demand on system level bandwidth
- Transaction-data rate: rate of performing tasks (if a task requires transmission of certain info)
- Typically, the "delay time" is the measure used to quantify the bandwidth service provided by the network

Technology and Network QoS Requirements - Timeliness

- Reflected through:
  - Delay time – definition depend on application and network
    - E.g. may include user terminal processing time, transmission delay, link propagation, queueing delay, etc.
    - Typically, higher bandwidth network possesses lower delay time – not true if major components of delay are not bandwidth-related
  - Response time – a measure of how fast the network as a whole provides the requested service
  - Delay variation – for applications like real-time application delay variation is more critical than delay time or response time

Technology and Network QoS Requirements - Reliability

- Time-based measures
  - E.g. average time between failures
- Frequency-based measures
  - E.g. rate of failure, data loss, etc.

Correlation Between the QoS Indicators

- Having all previous indicators as the QoS metrics for all users is neither feasible nor necessary
- Diverse relationship between the QoS indicators

Wireless Networks – Mobility Range Indicator

- How big the geographical area covered by service
  - User application dependent
- Size of area covered by single basestation or access point

Mobility coverage and capacity of different wireless networks		
Wireless network	Coverage	Data rate
Infrared	Room	19.2 kb/s – 4 Mb/s
IEEE802.11	100-500 m around AP	2-11 Mb/s
GSM	Cellular network	9.6 kb/s
CDPD (for AMPS, IS-95, IS-136)	Cellular network	19.2 kb/s
DECT, PHS	Cellular network	32 kb/s
GPRS (for GSM)	Cellular network	155 kb/s
UMTS/IMT-2000	Cellular network	384 kb/s – 2 Mb/s
Iridium LEO satellite	Global	2.4 kb/s
Broadband satellite	Global/regional	2 Mb/s

QoS Guarantee in IP Networks

- Original architecture: best-effort; no guarantees
- Principles of providing QoS:
  1. Packet Classification: classify and identify packets according to application requirement
     - E.g. Voice versus FTP packets
     - IPv4 TOS (type of service) bits and IPv6 TC (traffic class) bits – currently rarely used
  2. Packet Isolation: need to monitor and control flows and allocated resources
  3. Efficient Resource Management
     - E.g. different input queues for different flows/classes
     - Dynamic/adaptive management of queues/resources – increase efficiency and utilization
  4. Traffic Load Control: call admission control (CAC) – to handle situations where demand is higher than existing capacity

Internet Solution to QoS Provisioning

- Integrated Services (IntServ) – RFC 1633, June 1994
- Differentiated Services (DiffServ) – RFC 2475, December 1998

Integrated Services (IntServ)

- Goal: to provide guaranteed and controlled services in addition to the already available best-effort service
- An extension to the existing Internet architecture to support both: real-time and non real-time applications over IP
- 'Traffic flows' are classified into:
  - Guaranteed-service class
    - Delay bounded (hard)
    - Quantitative
    - Applications: voice, real-time
  - Controlled-service class
    - Statistical delay requirement (e.g. 90% of packets within 2 seconds)
    - Quantitative
  - Best-effort class
    - No guarantee
    - Applications: interactive burst data (e.g. web), interactive bulk (e.g. FTP), and background or asynchronous traffic (e.g. email)

Integrated Services (IntServ) – cont'd

- Guaranteed and controlled services – require signaling and admission control procedure in the network nodes
- Typically a protocol like: Resource Reservation Protocol (RSVP) is used (RFC 2205 Sept 1997)
- RSVP is a signaling protocol used to reserve resources in the routers, in a hop-by-hop basis considering the applications requirements in terms of throughput guarantees and end-to-end delay bounds
- Advantage of IntServ: it builds on the existing architecture – leaves the traditional forwarding mechanism unchanged – i.e. an IntServ network can still send/receive traffic to an non IntServ network
- Disadvantage: end-to-end service guarantees are required – i.e. all intermediate nodes should support IntServ!
  - Can not be easily scaled to large networks

Differentiated Services (DiffServ)

- Goal: to provide simple, scalable and flexible service differentiation using a hierarchical resource management model
- The resource management model:
  - Interdomain resource management
  - Intradomain resource management
- Network provider can differentiate traffic streams using different per-hop-behaviors (PHB) when forwarding the IP packets of each stream
- Many IP flows can be aggregated in the same traffic stream or behavior aggregate (BA)
- PHB applied to an aggregate and is characterized by a DiffServ code point (DSCP) marked in the header of each IP packet – IPv4 TOS bits and IPv6 TC bits are used for this purpose

http://www.networkmagazine.com/article/NMG20010823S0016
http://www.fact-index.com/d/di/differentiated_services.html

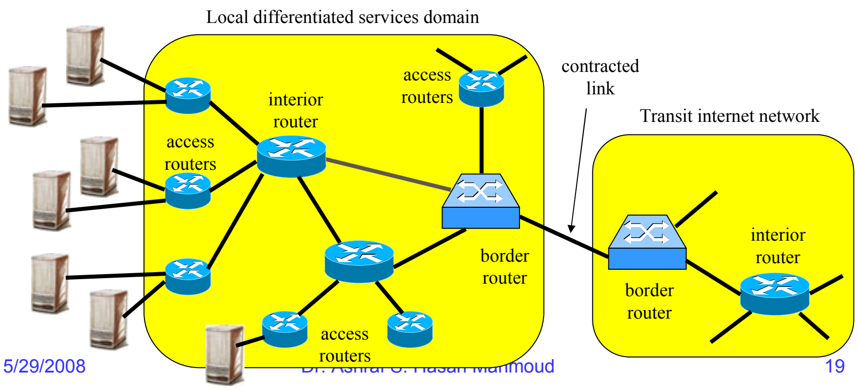
Differentiated Services (DiffServ) – cont'd

- PHBs are implemented on IP routers through the management of network resources: classifiers, markers, meters, queues, droppers, and schedulers
  - Provisioning policies are also required – specify how to manage and control these resources
- Categories of service differentiation: Relative Priority Marking; Service Marking; Label Switching; Integrated Services/Resource Reservation Protocol; and Static per-hop Classification

test

Differentiated Services Network Architecture

- Local DS domain
  - three types of routers: access, interior, and border
- Interdomain resource management: unidirectional service levels agreed at each boundary point between customer and provider for traffic entering the provider network – this is the job of the local network!
- Intradomain resource management: provider's responsibility



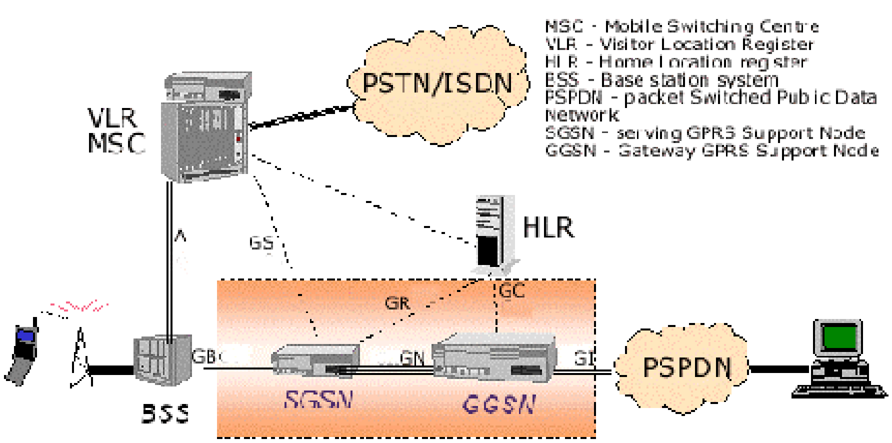
Differentiated Services Network Architecture

- DiffServ – does not specify # of traffic classes
- Provider builds service with a combination of traffic classes, traffic conditioning, and billing ➔ Service Level Agreement (SLA)
- SLA – governs traffic handling between local network and service provider network
  - Static – negotiated and agreed on on a long-term basis (e.g. monthly)
  - Dynamic
- Summary: in DiffServ the entire customer's local network requirements for QoS are aggregated and then an SLA will be made with the network service provider
- It is the local network that is responsible for providing DiffServ to end users through marking the packets with certain flags (using the DSCP)
- Call admission control is required only at of edge DS domains – to avoid congestion
  - Dynamic network re-provisioning may also be required

IntServ versus DiffServ

- DiffServ provides discrimination of services (+)
  - Traffic classes are predefined aggregates
- Simpler network management for DiffServe (+)
  - End systems perform traffic classification
- IntServ over DiffServ (RFC 2998 Nov 2000)
  - IntServ end-to-end model across a network of one or more DiffServ regions
  - RSVP provides end-to-end signaling
  - Processing is removed from core routers to edge and border routers

Cellular Network Solutions To QoS Provisioning – GPRS



Cellular Network Solutions To QoS Provisioning – GPRS – cont'd

- GPRS – defines 'user QoS profile'
  - Stored and maintained @ HLR
  - QoS profile includes
    - Traffic precedence class (priority: hi, normal, or low)
    - Delay class (how much delay is tolerated – four classes)
    - Reliability class (how much loss is tolerated – five classes)
    - Peak throughput class (max data rate allocated – 8~2048 kb/s)
    - Mean throughput class (average data rate allocated – 19 classes, best effort ~ 111 kb/s)
- The Serving GPRS Support Node (SGSN) is responsible for fulfilling the QoS profile for subscriber

Cellular Network Solutions To QoS Provisioning – UMTS

- UMTS uses similar core network architecture as the GPRS
- UMTS follows similar concepts for the QoS provisioning in addition to defining traffic classes:
  - Conversational traffic class – e.g. real-time voice or video, requires constant bit rate (CBR)
    - BER < 10^{-3} is required
  - Streaming traffic classes – e.g. multimedia over the internet
    - BER < 10^{-5} is required
  - Interactive traffic classes – e.g. web browsing and internet games – response delay/jitter is important but not as sever as those for conversational traffic class
    - BER < 10^{-8} is required
  - Background traffic class – e.g. email or FTP – typically delay insensitive.
    - BER < 10^{-8} is required

very much influenced by internet applications