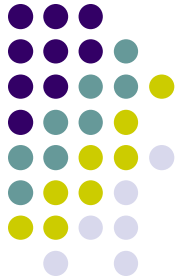
The Design Motivation and Objectives for Fast Congestion Notification (FN)

Mohammed M. Kadhum
Graduate Department of Computer Science
College of Arts and Sciences
Universiti Utara Malaysia
06010 UUM Sintok, MALAYSIA

Outline

- Introduction
  - Congestion Control
  - Queue Management
  - Congestion Information
  - The Need for a New Congestion Management Mechanism
- Design Motivation of FN
  - Actual & Average Queue Size
  - Average Queue Speed
- Design Objectives of FN
  - FN Algorithm
    - Description, Drop Position, Decision Criteria, Control Decisions
- Conclusion

Introduction



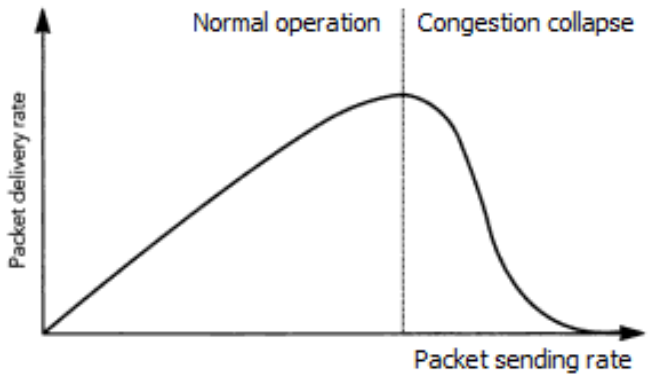
- Computer network is collection of resources which has a finite capacity
- Causes users to compete for resources
  - Buffers, bandwidth, and processor time
- Degrades system performance
  - Throughput goes to zero (Agnew 1988)

- Networks cannot accept traffic offered without control
- There must be regulations
  - Rule receipt of traffic from outside
  - Manage flow inside the network

Congestion Control:

Problems of Congestion

- Congestion happens when resource demands exceed the network capacity
- Queues grow until packets are lost
- Over flown buffers at gateway cause
  - Large queuing delays
  - High packet loss
  - Less effective resources utilization
  - Degradation in performance experienced by users



Congestion Control:

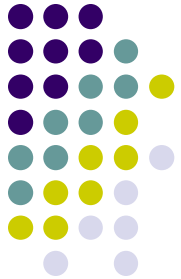
Economically!!!

- Networks are expensive in terms of building & action
- Optimize the network utilization
- Users' satisfaction is determined by network performance
- Reduce congestion occurrence

Increase the number of users

- It is important to improve the network performance & utilization

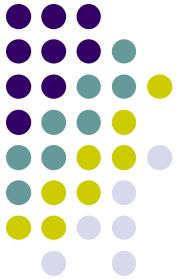
Queue Management



Gateway buffers are created for:

- Buffering temporary increases in incoming packets to avoid packet loss
- Transmitting buffered packets during the subsequent periods of silence to ensure link utilization

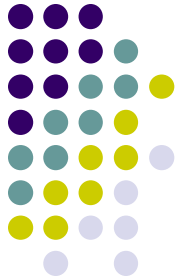
Queue Management & Congestion Control



- Controlling / Avoiding congestion is crucial problem in network design & operation
- Future cheaper buffers, faster links, and processors will not alleviate congestion due to
  - Mismatching of link speeds
  - Higher offered traffic loads
  - Unpredictable traffic patterns
  - Large transient loads
  - Greater degrees of statistical multiplexing

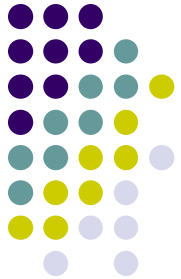
These issues will continue to act as sources of congestion

Queue Management & Congestion Control



- Keep queue sizes small to avoid congestion
- Packet arrival rate should be maintained close to the outgoing link capacity
- Congestion management is responsibility of gateways and end-point hosts
  - Gateways responsible for congestion detection & notification delivery, queue's traffic arrival rate control, and queue size control
  - Sources responsible for the adjustment of their transmission rates

Congestion Information:

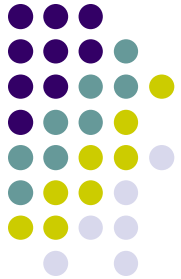


How do gateways inform sources about congestion?

- By using Explicit Congestion Notification (ECN)
- ECN is a method for informing the sender about the network congestion
- ECN-gateways mark packets instead of dropping them
  - Faster signal propagation
  - Good network utilization

The Need for a New Congestion Management Mechanism

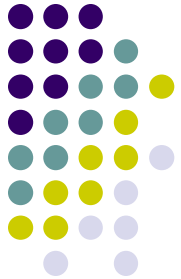
Congestion remains a major problem !



- TCP dominates more than 90 % of the Internet traffic (Barcellos and Detsch 2005)
  - FTP, Web traffic, E-mail (e.g., SMTP), Remote terminal (e.g., Telnet)
- 50-70 % of TCP traffic is short-lived connections (mice) (Liang & Matta, 2001)
- These applications tolerate packet delay or packet losses
- Congestion remains a problem leads to poor performance

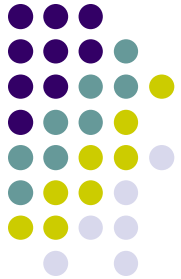
The Need for a New Congestion Management Mechanism

Congestion remains a major problem !



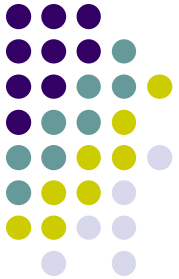
- Congestion causes reduction in the:
  - Network resources' utilization
  - Performance experienced by the network users
- It is worthwhile to minimize the occurrence of congestion situations in a network to:
  - Optimize the utilization of network resources
  - Provide the network users with suitable performance
- If the Internet is to evolve to a high performance network providing global services, including real time voice/video, it must:
  - Understand how congestion arises
  - Find efficient ways to keep network operating within its capacity

Design Motivation of FN



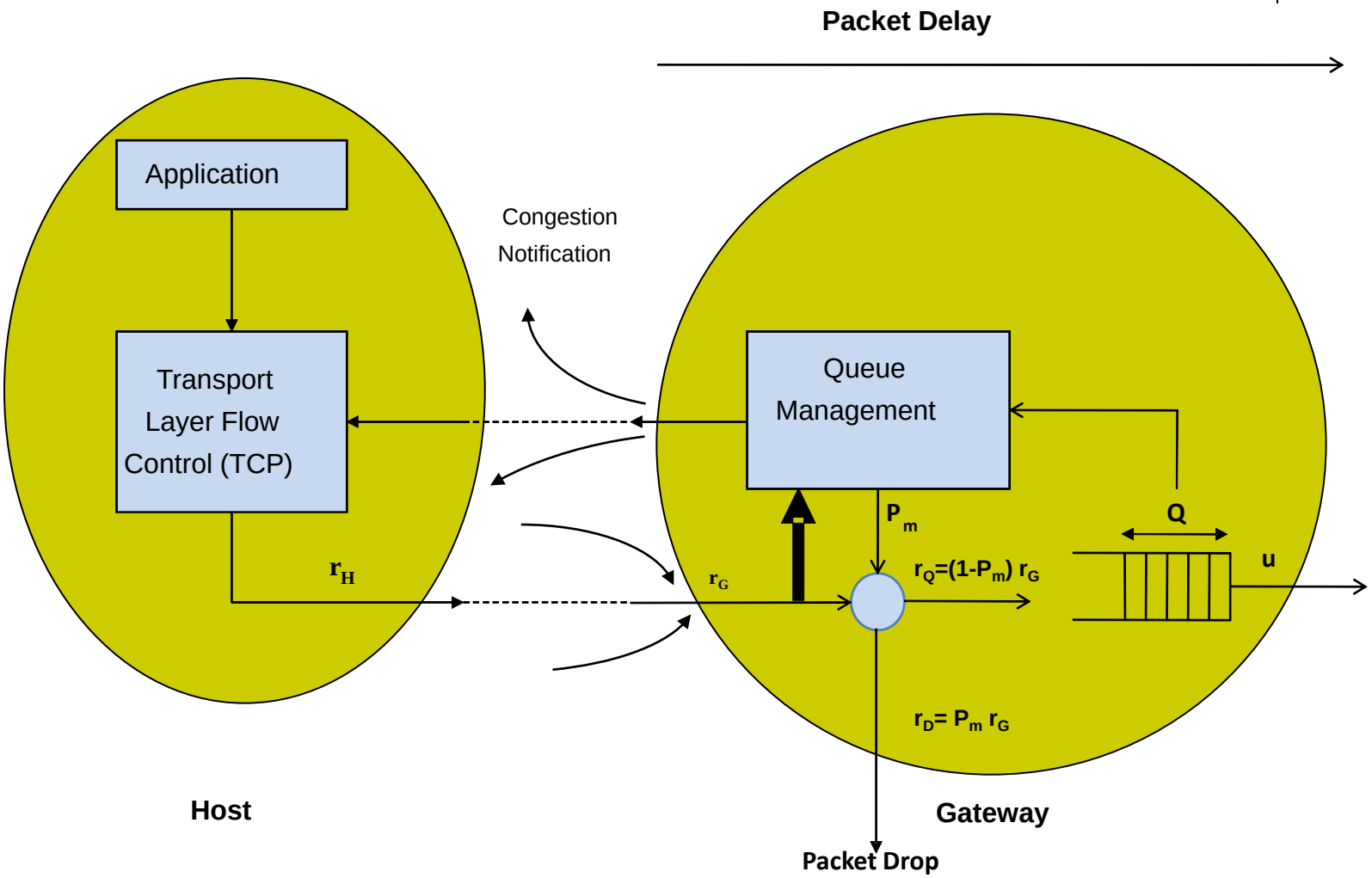
- Congestion in packet switching networks is related to buffer overflow event.
  - Whenever the network gets congested, the buffers start to overflow.
- Designers consider monitoring and controlling queue sizes as the major objective of their algorithms.
  - Maintaining low steady state queue sizes guarantees availability of buffer space -used for housing of temporary traffic increases.
- Dropping packets and sending early congestion notification to traffic sources enable controlling the queue size.

Design Motivation of FN .cont

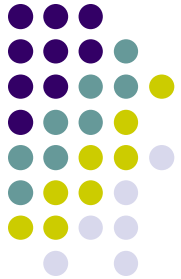


- Queue management policies use some measure of the queue occupancy level as their sole control decision criteria.
- They compare this measure to a set of thresholds for performing control decisions such as congestion detection, drop activation, and drop probability adjustment.

FN Design


Packet Delay
Application
Transport
Layer Flow
Control (TCP)
Congestion
Notification
Queue
Management
r_H
r_G
P_m
$r_Q=(1-P_m)\ r_G$
Q
u
$r_D= P_m\ r_G$
Host
Gateway
Packet Drop

Actual & Average Queue Size

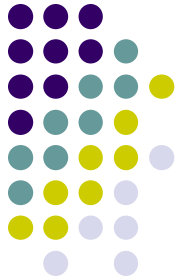


Early Random-Drop

- Using actual queue size as the decision criteria allows controlling queue size directly.
- It sharpens the algorithm's sensitivity to traffic changes and enables early congestion detection.
  - It impairs the algorithm's ability to correctly differentiate temporary traffic increases from constant traffic overload.
  - A temporary increase may result in incorrect congestion detection and unnecessary packet drops.
- This indicates that using actual queue size as a sole decision criterion may not be sufficient for efficient queue management.

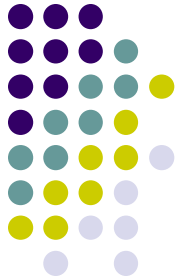
Actual & Average Queue Size

Random Early Detection



- RED requires the use of a small queue averaging weight to make it less sensitive to very short-term increases.
- The gateway's ability to ignore manageable short-term increases comes at the cost of slower detection of congestion.
- Inaccurate packet admission decisions may take place
  - The average queue size merely provides a rough approximation of the actual queue size and the available buffer space upon packet arrivals.
- This is due to the small averaging weight which causes the average queue size to track the actual queue size slowly.

Actual & Average Queue Size



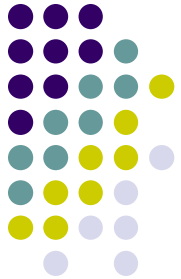
Random Early Detection

- A packet may be not allowed to the buffer while there is plenty space available or it may be allowed to the buffer while there is little room left before the buffer overflows.

- Therefore, the use of the average queue size does not allow the exercise of tight control over the actual queue size, but allows only the average queue size to be controlled.

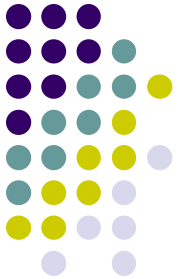
- This could result in higher packet loss and excessive fluctuations in the actual queue size which would generate large delay variations and delay jitter as well as poor link utilization.

Average Queue Speed



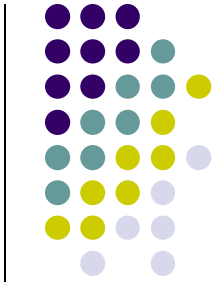
- Using actual queue size along with a dynamic probability function of it enables the queue management policy to exercise control over the actual queue size instead of the average queue size.
- This provides accurate information regarding the state of gateway buffers upon packet arrivals
  - Lowers the chance of unnecessary packet drops, prevents excessive fluctuations in the actual queue size, and improves the link utilization.
- The use of a probability function allows the gateway to define and distinguish a variety of congestion conditions and to treat them accordingly.

Average Queue Speed



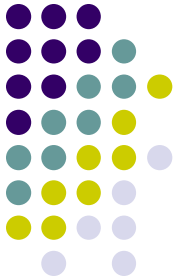
- Queue speed refers to:
  - Direction of changes in the actual queue size: whether the queue level increases or decreases
  - Speed of changes in the actual queue size: how fast the queue level increases or decreases
- Using average queue speed enables the short and long-term traffic increases to be correctly differentiated from each other
- The use the actual queue size along with the average queue speed as the decision criteria along with a dynamic drop probability function is a superior design configuration compared to the use of some measure of the queue occupancy level as the sole decision criteria

Design Objectives of FN



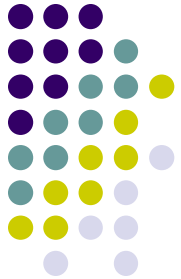
- Objectives considered in designing the FN policy can be summarized as:
  - Combined (aggregate) buffer arrival rate control
  - Actual queue size control
  - Early congestion detection & notification based on prediction
  - Definition & treatment of congestion at different severity levels

Design Features of FN Algorithm



- The FN tries to limit the average buffer traffic rate below the outgoing link capacity and to limit the actual queue size to an optimum queue size.
- Drop Position
  - FN uses queue's tail as its drop position
    - it is simple to implement
    - does not require any modifications to the state of the queue.
    - Decision Criteria
  - The speed at which the queue size will grow or shrink will depend on the relative size of the aggregate arrival rate and the outgoing link capacity.
  - The larger the difference, the faster the queue will grow or shrink.
  - The queue speed reflects the characteristics of the buffer's aggregate arrival

Design Features of FN Algorithm



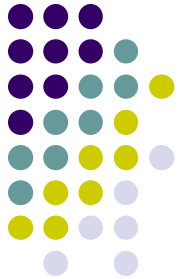
- Control Decisions

Queue management policies exercise control on two different time scales:

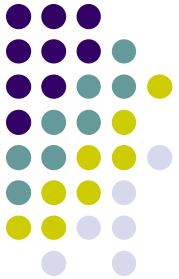
  - Short-Term (small time-scale)
    - Packet Admission: Per-packet buffer entrance admission
  - Long-Term (large time-scale)
    - Congestion Control Directing: Over-time trend of control for congestion avoidance

- The manner in which these decisions are made and the way they will interact depends on the design of the drop probability and the drop activation functions

Conclusion



- The use of the actual queue size in conjunction with the average queue speed (average arrival rate) can provide superior control decision criteria for an active queue management scheme.



Thank you

Q & A