CS6504

Mobile Computing

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TCP over Wireless Links

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Outline

TCP over wireless Links

•Taxonomy of Schemes to improve TCP's performance

- •An example of an ELN scheme
- •I-TCP: Indirect TCP
- •Snoop Protocol (TCP-aware LL protocol)

Improving TCP's Performance

•Non-congestion related losses effects on TCP performance

➢Significant throughput degradation

•Schemes to improve TCP performance

End-to-End proposals: Make TCP sender handle losses through

 \checkmark <u>SACK</u> (Selective ACK- allow sender to recover from multiple packet losses in a window without restoring to a smaller timeout)

 \checkmark <u>ELN</u> (Explicit Loss Notification- allow sender to distinguish between congestion and other forms of losses)

≻Split-connection proposals

 \checkmark Hide wireless links from sender by terminating TCP connection at BS

 \checkmark Separate reliable connection between BS and MH

≻Link-layer proposals

✓ Hide link-related losses from TCP sender by using local retransmissions

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ELN: Example of End-to-End Proposals

•Add an ELN option to TCP ACKs [BPS+97]

•When a packet dropped on wireless link, future cumulative ACKs corresponding to lost packet are marked to identify that a non-congestion related loss has occurred

•Sender might retransmit (after receiving 3 dup ACKs) without invoking associated congestion control schemes

•An enhancement \rightarrow Sender can retransmit upon receiving first dup ACK with ELN option set

•Problems \rightarrow Which packets are lost due to errors on wireless link?

≻At the receiver, if a partially corrupted packet is received

 \succ Entire packet is dropped \rightarrow BS generates ELN with ACK stream when observe dup ACKs from MH

I-TCP: Indirect TCP for Mobile Hosts

•Any interaction from a MH to a fixed host is split into 2 separate interactions

≻One between MH and BS over wireless medium

≻Another between BS and fixed host over fixed network

•Advantages

Separate flow and congestion control functionality on wireless and wired network

>Allows using a separate transport protocol for wireless link

•Disadvantages

➢ Breaks TCP end-to-end semantics

Maintenance of TCP state at BS per TCP connection (effect on handoff procedure)

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I-TCP Connection Setup



Snoop Protocol (TCP-aware LL Protocol) 1/2

•A TCP-aware link protocol, running at BS

•Snoop agent at BS monitors every TCP packet that passes through connection in either end

•Agent maintains a cache of TCP packets sent from fixed host that have not been ACKed by MH (Why this works?)

•Agent keeps track of all ACKs sent by MH

•Detect loss of packets either by arrival of a number of duplicate ACKs, or by a local timeout (*local timeout < TCP timeout*)

•Upon detecting packet loss, retransmit lost packets to MH if cached

•Hide packet loss from sender by not propagating duplicate ACKs

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Snoop Protocol (TCP-aware LL Protocol) 2/2

•From fixed host to MH

Cache unACKed TCP data and perform local transmissions based on some policies for ACKs and timeouts

≻Use duplicate ACKs from MH to identify packet loss and perform local transmissions as soon as loss is detected

•From MH to fixed host

≻Detect missing packets at BS and generate negative ACKs for them

► Negative ACKs sent to MH which then retransmits the missing packets

≻Need to modify FH and MH

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From FH to MH 1/3

•BS routing code is modified by adding a snoop module (monitor every packet through connection in either direction)

•No transport layer code runs at BS

•Snoop maintains a cache of TCP packets sent from FH that are not yet ACKed by MH

•Keep track of all ACKs sent from MH

•When a packet loss is detected (arrival of duplicate ACK, or local timeout) retransmit lost packet is cached

•Do not propagate duplicate ACK to FH (unnecessary congestion control mechanisms invocations avoided)

•Two modules: snoop_data() and snoop_ack()

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From FH to MH 2/3

Snoop_data()

- •Processes data from fixed host
- •A new packet in normal TCP sequence
- •An out-of-sequence packet that has been cached earlier
 - Seq # > last Acked \rightarrow forward
 - Seq# < last Acked \rightarrow generate TCP Ack with last ACK seen at BS to sender (on behalf of MH)
- •An out-of-sequence packet that has not been cached earlier
 - ➤Congestion loss on wired network or out-of –order delivery by network
 - ≻Forward to MH
 - Mark as been retransmitted by sender



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Common case

Figure 1. Flowchart for snoop_data().

From FH to MH 3/3

Snoop_ack()

- •Monitors ACKs sent by MH
- •New ACK
- •Spurious ACK \rightarrow discard
- •Duplicate ACK

➢Dup Ack for a packet not in snoop cache or marked as having been retransmitted by sender

✓ Route dup Ack to FH

≻First dup Ack

≻Retransmit at high priority

≻Not first dup Ack

≻discard

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Figure 2. Flowchart for snoop_ack().

From MH to FH

•At BS, keep track of packets lost in a transmission window, and generate negative ACKs for those packets back to MH

•NACKs generated when a threshold number of packets (from a single window) reach the BS, or when a certain amount of time has expired without any new packets from MH

- •Implementation based on using SACK option in TCP
- •Need to enable SACK processing at MH

Routing Protocol 1/3

- •Handoffs use *multicast* and *intelligent buffering* in nearby BSs
- •MH assigned a home address and a multicast address
- •HA intercepts packets destined to MH and encapsulate to the corresponding multicast group
- •Members of multicast group are BSs in vicinity of MH, but not MH itself
- •MH uses statistics such as received signal strength of BS beacons and communication quality to identify nearby BSs
- •MH determines which cells it should join and and which cells it is likely to handoff to in near future

Routing Protocol 2/3

•One primary BS in system to forward packets to MH

•Other BSs (likely handoff targets) are asked to join multicast group, but do not forward packets to MH

•Instead, last several packets from HA are buffered

•When handoff to a previously buffering BS, can start sending packets to MH from buffered packets, hence reducing packet loss during handoff



Figure 4. Home Agent to Mobile Host Routing.

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Routing Protocol 3/3



Figure 5. Typical handoff messaging.