Deals with TCP in mobile environments

Key Ideas

Handoff Performance in Cellular Networks

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Handoff (changing from one base station to another)

TCP's reaction: reduce sending rate

Wireless adds losses due to corruption, collision, handoff

Split-connection TCP: from BS, use one TCP connection to FH and another to MH

Problem: TCP loss handling in wireless

Alternatives

but requires changes to FH, BS, MH

good idea: done with ECN

but done after this work and not widely deployed even

does TCP distinguish congestion vs. other kinds of loss

Incremental deployment

Constraints

Avoid modifying mobile hosts

Preserve TCP end-to-end semantics

Solution should not require modifications to fixed hosts

Incremental deployment

Make TCP distinguish congestion vs. other kinds of loss

must be careful to avoid interactions between link-layer and TCP (works if on different timescale)

Link-layer retransmission

Acknowledges change to FH and MH

don't change Inner-TCP

what does an ACK mean now?

Spill-connection TCP

Snoop Overview

BS adds SACK support (even if FH doesn't support it)

SB snoops passing traffic (data/acks); quickly retransmits data

Fixed Host (FH)

sends data to MH

no change to FH code

Mobile Host (MH)

receives data, sends ACKs as usual

FH-to-MH:

FH

BS

MH

ACKs

Data

MH-to-FH:

FH

BS

MH

ACKs

Data

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Packet loss (corruption)

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2. Forward packet

Add to cache and pass on
Packet in sequence

FH-to-MH Snoop Data Processing

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Greater than last acked:
Pass on
Out of sequence, cached
Lost or delayed out-of-order
Out of sequence, not cached
Else: generate ACK to fixed host (may be caused by a lost ACK)
Pass on, and keep information

In-sequence?
New pkt?
Yes
Yes
Packet arrives from FH
No
No
Common case

Cache packet
Forward to mobile
Sender Retransmission

1. Forward packet
Reset local retransmission counter
Congestion loss
Mark as congestion loss
Should not be common
Pass on to FH
suppress other dupacks
New ACK

FH-to-MH Snoop ACK Processing

Discussion

Implementation
Preserve TCP semantics
Soft-state design
Minimal changes to improve performance
Nice aspect of snoop

Other Issues

TCP over ad hoc networking
What about mobile-to-fixed communication?

General approach:

MH informs BS when it’s changing
BSes are pre-loaded w/ data, can run snoop and quickly repair losses
MH can inform BSs when its changing
Snoop ACKs can be used to multicast packets to several FAs (case)

Handoff Support

Free buffers
Update RTT estimate

First one?
No
Yes
Next packet lost
Retransmit lost packet with high priority
Spurious ack
Discard

Later dup acks for lost packet
Discard

What about mobile-to-fixed communication?

Open area of research
TCP over ad-hoc networking
What about mobile-to-fixed communication?

Other Examples

Does this violate the end-to-end argument?

Deployment solution for wireless performance enhancement
Impact

Other examples?

Does this violate the end-to-end argument?

Layer-4 caching? (i.e., caching HTTP without the end points knowing it)
Other examples?

Fast retransmit in TCP

Discussion

Deployment solution for wireless performance enhancement
Impact