Mobile Transport Layer

Bikash Sadhukhan. M.Tech(CSE)
Lecturer. Dept of CSE/IT
Techno India College of Technology

Traditional TCP

- The Transmission Control Protocol (TCP) was designed to provide reliable end-to-end delivery of data over unreliable networks.
- In theory, TCP should be independent of the technology of the underlying infrastructure.
- In practice, most TCP deployments have been carefully designed in the context of wired networks

What are Ad-Hoc Networks?

- Ad Hoc Networks are complex distributed systems that consist of wireless mobile or static nodes that can freely and dynamically self-organize.
- In this way they form arbitrary, and temporary "Ad hoc" networks topologies, allowing devices to seamlessly interconnect in areas with no pre-existing infrastructure.

Problems with TCP in Mobile Ad hoc networks (MANET)

- In Ad hoc networks, the principal problem of TCP lies in performing congestion control in case of losses that are not induced by network congestion.
- Major problems:
  - TCP is unable to distinguish between losses due to route failures and network congestion.
  - TCP suffers from frequent route failures.
  - The contention on the wireless channel.
- Numerous enhancements and optimizations have been proposed over the last few years to improve TCP performance over wireless Ad hoc networks.

TCP's Challenges in AD HOC Networks

The performance of TCP degrades in Ad hoc networks. This is because TCP has to face new challenges due to several reasons specific to these networks

- Lossy channels,
- Hidden and exposed stations,
- Path asymmetry,
- Network partitions,
- Route failures, and
- Power constraints.

TCP congestion control

- In Mobile networks, the principal problem of TCP lies in performing congestion control in case of losses that are not induced by network congestion.
- Since bit error rates are very low in wired networks, nearly all TCP versions nowadays assume that packets losses are due to congestion.
- Consequently, when a packet is detected to be lost, either by timeout or by multiple duplicated ACKs, TCP slows down the sending rate by adjusting its congestion window.
- Unfortunately, wireless networks suffer from several types of losses that are not related to congestion, making TCP not adapted to this environment.

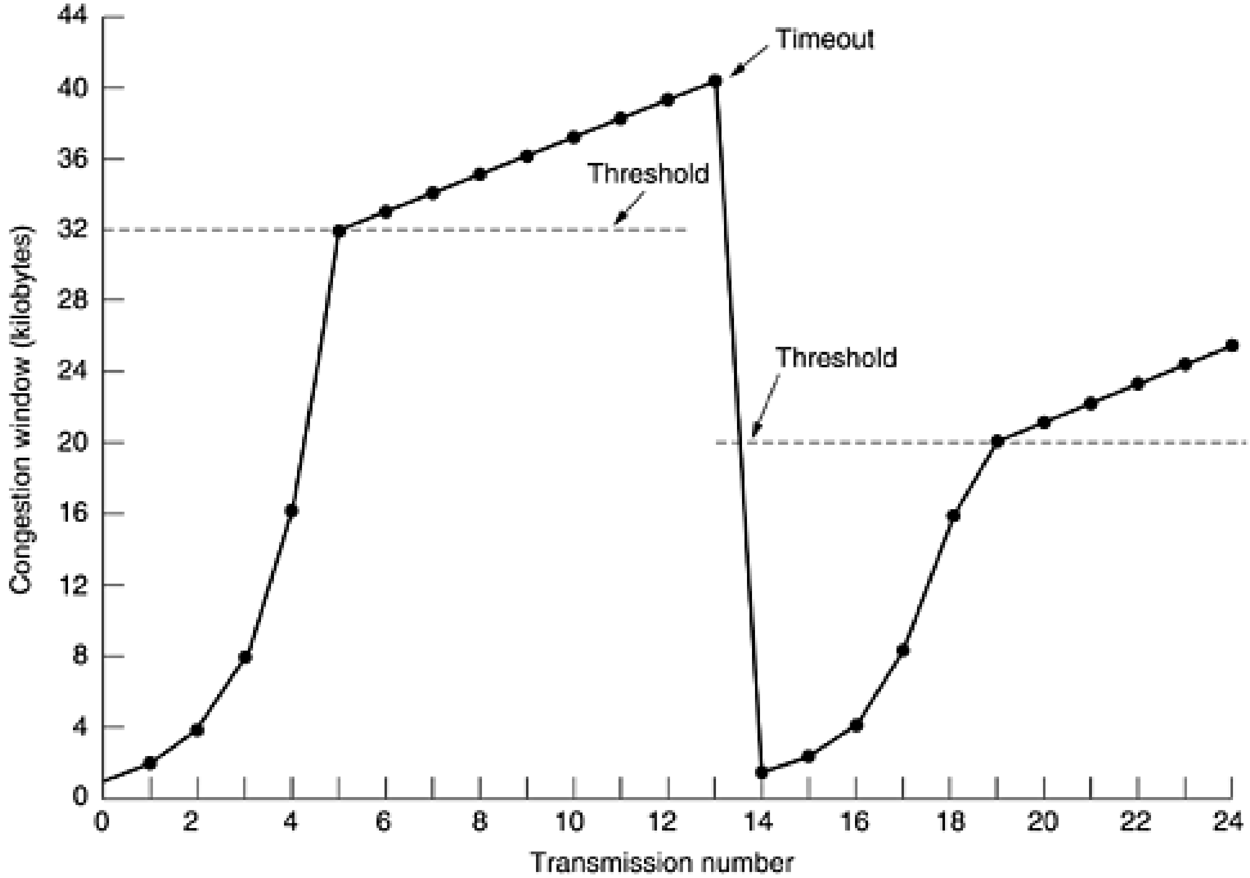
TCP slow-start algorithm

- sender calculates a congestion window for a receiver
- start with a congestion window size equal to one segment
- exponential increase of the congestion window up to the congestion threshold, then linear increase
- missing acknowledgement causes the reduction of the congestion threshold to one half of the current congestion window
- congestion window starts again with one segment

TCP fast retransmit / fast recovery

- TCP sends an acknowledgement only after receiving a packet
- if a sender receives several acknowledgements for the same packet, this is due to a gap in received packets at the receiver
- however, the receiver got all packets up to the gap and is actually receiving packets
- therefore, packet loss is not due to congestion, continue with current congestion window (do not use slow-start)

An example of the congestion algorithm



Influences of mobility on TCP

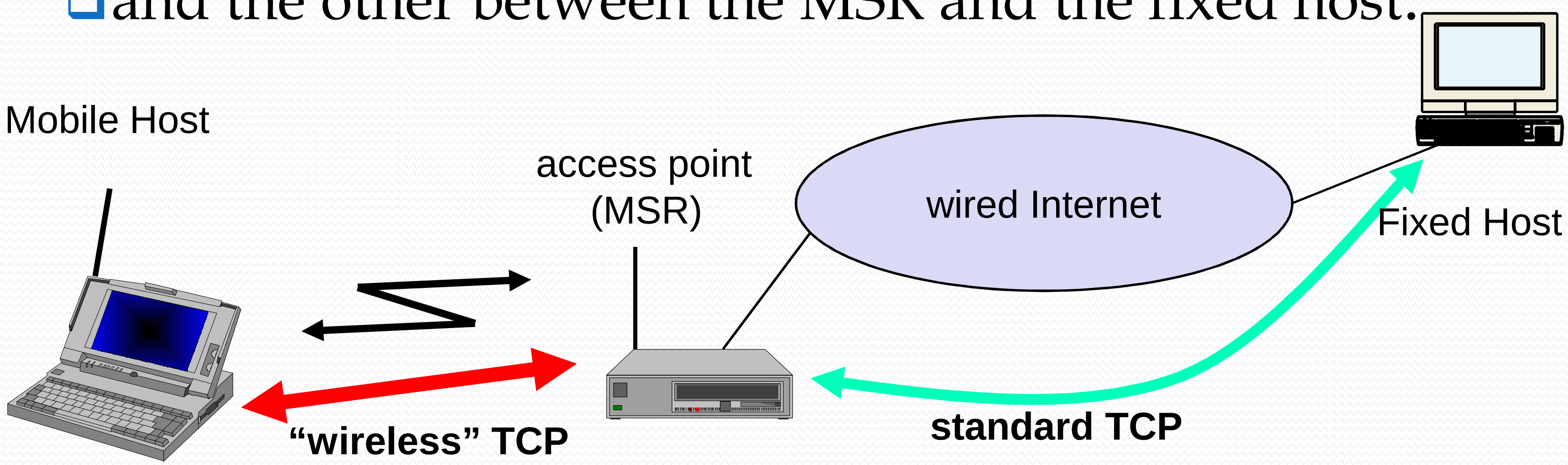
- TCP assumes congestion if packets are dropped
  - typically wrong in wireless networks, here we often have packet loss due to transmission errors
  - furthermore, mobility itself can cause packet loss, if e.g. a mobile node roams from one access point (e.g. foreign agent in Mobile IP) to another while there are still packets in transit to the wrong access point and forwarding is not possible

Classical TCP Improvements

- The performance of an unchanged TCP degrades severely
  - however, TCP cannot be changed fundamentally due to the large base of installation in the fixed network, TCP for mobility has to remain compatible
  - the basic TCP mechanisms keep the whole Internet together
- Numerous enhancements and optimizations have been proposed over the last few years to improve TCP performance over wireless Ad hoc networks.
- **Proposal to improve TCP's performance over Ad hoc Network**
  - I-TCP: Indirect TCP for Mobile Hosts
  - Mobile TCP
  - Snoop TCP
  - Fast Retransmit

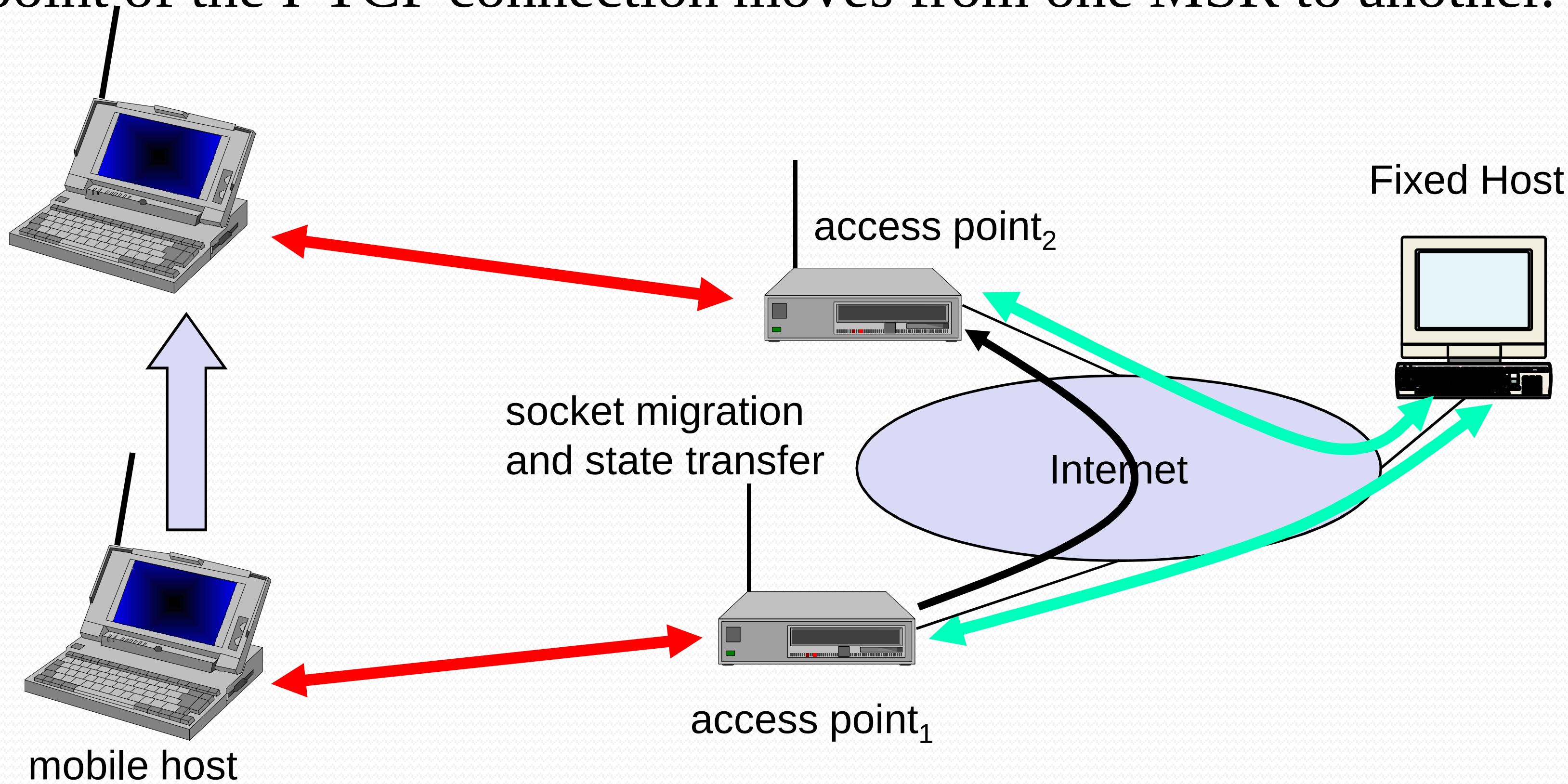
Indirect TCP (I-TCP)

- This involves splitting the TCP connection into two separate connections
  - one between the mobile host and the MSR (Mobile Switching Router)
  - and the other between the MSR and the fixed host.



I-TCP socket and state migration

The FH is completely unaware of the indirection and is not affected even when the MH switches cells i.e. when the center point of the I-TCP connection moves from one MSR to another.

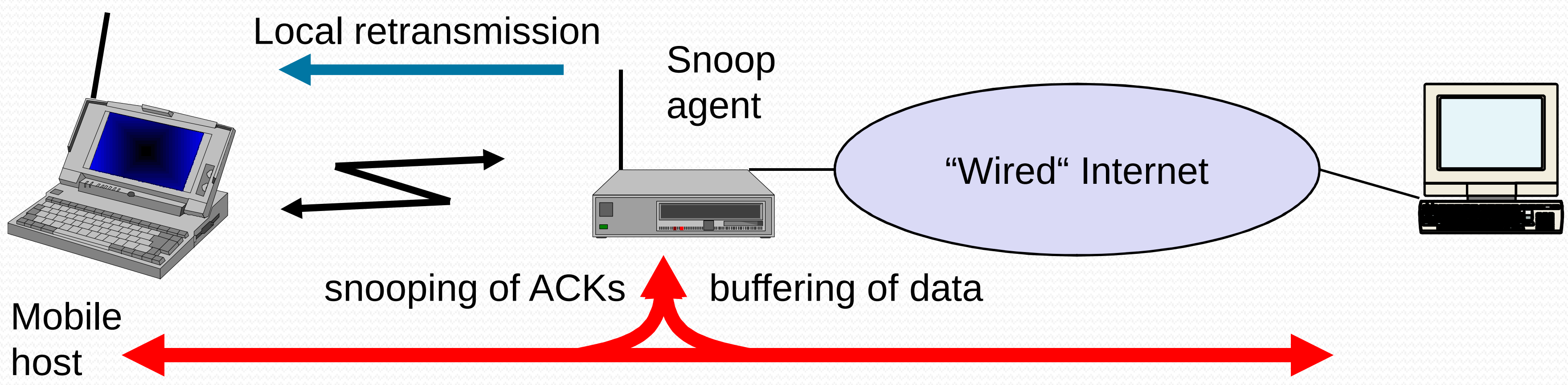


Indirect TCP (I-TCP)

- Advantages
  - no changes in the fixed network necessary, no changes for the hosts (TCP protocol) necessary, all current optimizations to TCP still work
  - transmission errors on the wireless link do not propagate into the fixed network
  - simple to control, I-TCP is used only for one hop between, e.g., a MSR and mobile host
  - therefore, a very fast retransmission of packets is possible, the short delay on the mobile hop is known
- Disadvantages
  - loss of end-to-end semantics, an acknowledgement to a sender does not any longer mean that a receiver really got a packet, MSR might crash.
  - higher latency possible due to buffering of data within the MSR and forwarding to a new MSR

Snooping TCP

- Introduces a module, called the ***snoop agent,*** at the base station.
- The agent monitors every packet that passes through the TCP connection in both directions and maintains a cache of TCP segments sent across the link that have not yet been acknowledged by the receiver.
- A packet loss is detected by the arrival of a small number of duplicate acknowledgments from the receiver or by a local timeout. The snoop agent retransmits the lost packet if it has it cached and suppresses the duplicate acknowledgments.

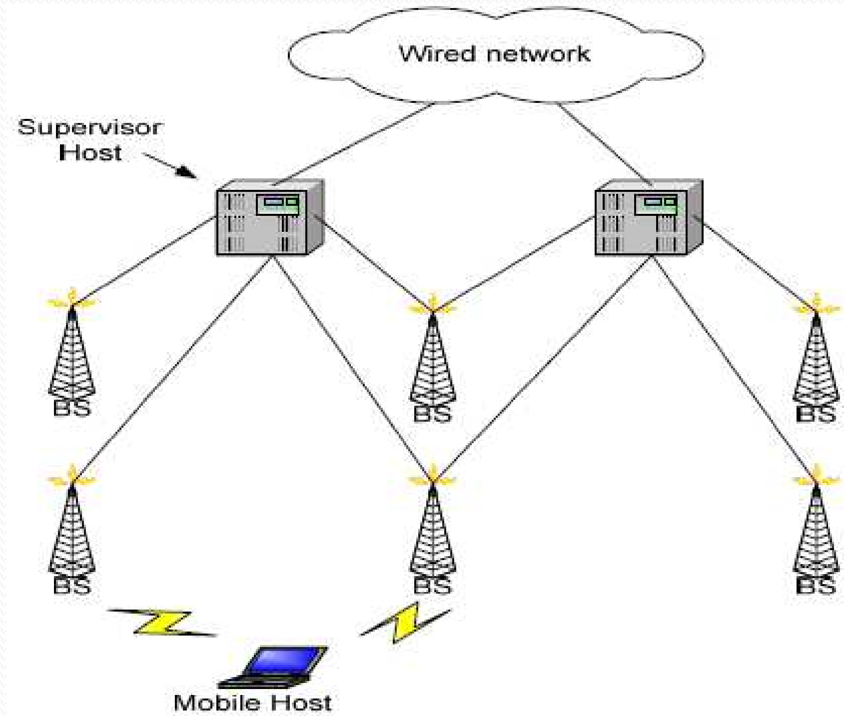


Snooping TCP

- Data transfer to the mobile host
  - Snoop agent buffers data until it receives ACK of the MH, snoop agent detects packet loss via duplicated ACKs or time-out
- Data transfer from the mobile host
  - Snoop agent detects packet loss on the wireless link via sequence numbers, snoop agent answers directly with a NACK to the MH
  - MH can now retransmit data with only a very short delay
- Advantages:
  - it suppresses duplicate acknowledgments for TCP segments lost and retransmitted locally, thereby avoiding unnecessary fast retransmissions and congestion control invocations by the sender.
  - Maintain end-to-end semantics
  - No change to correspondent node
  - No major state transfer during handover
- Disadvantage:
  - Snooping TCP does not isolate the wireless link well
  - May need change to MH to handle NACKs
  - Snooping might be useless depending on encryption schemes

Mobile TCP (M-TCP)

- Breaks up a TCP connection between a FH and a MH into two parts: one between the FH and the BS, and the other between the BS and the MH.
- It is different from I-TCP such that it manages to preserve TCP end-to-end semantics.
- M-TCP is assumed to operate upon the underlying three-level architecture



- One SH is in charge of several BSs
- The number of handoffs is greatly reduced since a MH roaming from one cell to another need not perform handoffs as long as the two cells are controlled by the same SH.

Mobile TCP (M-TCP)

- Supervisory host
  - Has no caching, no retransmission capability.
  - monitors all packets, if disconnection detected
    - set sender window size to 0
    - sender automatically goes into persistent mode.
  - old or new SH reopen the window

- Advantages
  - maintains semantics, supports disconnection, no buffer forwarding
- Disadvantages
  - loss on wireless link propagated into fixed network

Fast retransmit/fast recovery

- Change of foreign agent often results in packet loss
  - TCP reacts with slow-start although there is no congestion
- Forced fast retransmit
  - as soon as the mobile host has registered with a new foreign agent, the MH sends duplicated acknowledgements on purpose
  - this forces the fast retransmit mode at the communication partners
  - additionally, the TCP on the MH is forced to continue sending with the actual window size and not to go into slow-start after registration
- Advantage
  - simple changes result in significant higher performance
- Disadvantage
  - further mix of IP and TCP, no transparent approach

Comparison of different TCP approaches

Approach	Mechanism	Advantages	Disadvantages
Indirect TCP	splits TCP connection into two connections	isolation of wireless link, simple	loss of TCP semantics, higher latency at handover
Snooping TCP	"snoops" data and acknowledgements, local retransmission	transparent for end-to-end connection, MAC integration possible	problematic with encryption, bad isolation of wireless link
M-TCP	splits TCP connection, chokes sender via window size	Maintains end-to-end semantics, handles long term and frequent disconnections	Bad isolation of wireless link, processing overhead due to bandwidth management
Fast retransmit/ fast recovery	avoids slow-start after roaming	simple and efficient	mixed layers, not transparent