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01CE0701 – Mobile Computing

Unit - 5
Mobile Transport Layer

Outline

- Overview of Traditional TCP
  - Congestion control
  - Slow start
  - Fast retransmit/fast recovery
  - Implications on mobility
- Improvement of TCP
  - Indirect TCP
  - Snoop TCP
  - Mobile TCP
  - Fast Retransmit/fast recovery
  - Time-out freezing
  - Selective retransmission
  - Transaction-oriented TCP

Overview of Traditional TCP

Introduction of TCP

- TCP stands for Transmission Control Protocol.
- TCP is the transport layer protocol that serves as an interface between client and server.
- The TCP/IP protocol is used to transfer the data packets between transport layer and network layer.
- TCP protocol is used for process to process to delivery in network.
- IP protocol is used for host to host delivery in network.
- Transport protocol is mainly designed for fixed end systems in wired networks.
- In simple terms, the traditional TCP is defined as a wired network while classical TCP uses wireless approach.

Traditional TCP

- Mechanisms that influence the efficiency of TCP in a mobile environment:
  - Congestion control
  - Slow start
  - Fast retransmit/fast recovery
  - Implications on mobility

Congestion Control

- TCP has been designed for wired networks with fixed end-systems.
- Hardware and software are mature enough to ensure reliability of data.
- The probable reason for a packet loss in a fixed network is a temporary overload some point in the transmission path, i.e., a state of congestion at a node.
- The packet buffers of a router are filled and the router cannot forward the packets fast enough.
- The only thing a router can do in this situation is to drop packets.
- The sender notices the missing acknowledgement for the lost packet and assumes a packet loss due to congestion.
- Retransmitting the missing packet and continuing at full sending rate would now be unwise, as this might only increase the congestion.

Slow Start

- The behavior TCP shows after the detection of congestion is called slow start.
- The sender always calculates a congestion window for a receiver.
- The start size of the congestion window is one segment (TCP packet).
- This scheme doubles the congestion window every time the acknowledgements come back, which takes one round trip time (RTT) like 1, 2, 4, 8 etc.
- This is called the exponential growth of the congestion window in the slow start mechanism.
- The exponential growth stops at the congestion threshold.
- As soon as the congestion window reaches the congestion threshold, further increase of the transmission rate is only linear by adding 1 to the congestion window each time the acknowledgements come back.

Slow Start

- Linear increase continues until a time-out at the sender occurs due to a missing acknowledgement, or until the sender detects a gap in transmitted data
  - the sender sets the congestion threshold to half of the current congestion window

Fast Retransmit/Fast Recovery

Fast Retransmit

- A receiver sends acknowledgements only if it receives any packets from the sender.
- Receiving acknowledgements from a receiver also shows that the receiver continuously receives something from the sender.
- The gap in the packet stream is not due to severe congestion, but a simple packet loss due to a transmission error.
- The sender can now retransmit the missing packet(s) before the timer expires. This behavior is called fast retransmit.

Fast Retransmit/Fast Recovery

Fast Recovery

- The receipt of acknowledgements shows that there is no congestion to justify a slow start.
- The sender can continue with the current congestion window.
- The sender performs a fast recovery from the packet loss.
- This mechanism can improve the efficiency of TCP dramatically

Implication on mobility

- TCP concludes a congestion situation from a missing acknowledgement
  - typically wrong in wireless networks, here we often have packet loss due to transmission errors
  - 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

- The performance of an unchanged TCP degrades severely
  - 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

Classical TCP Improvement

Classical TCP Improvement

- Indirect TCP (I-TCP)
- Snooping TCP
- Mobile TCP
- Fast retransmit/fast recovery
- Transmission/time-out freezing
- Selective retransmission
- Transaction-oriented TCP

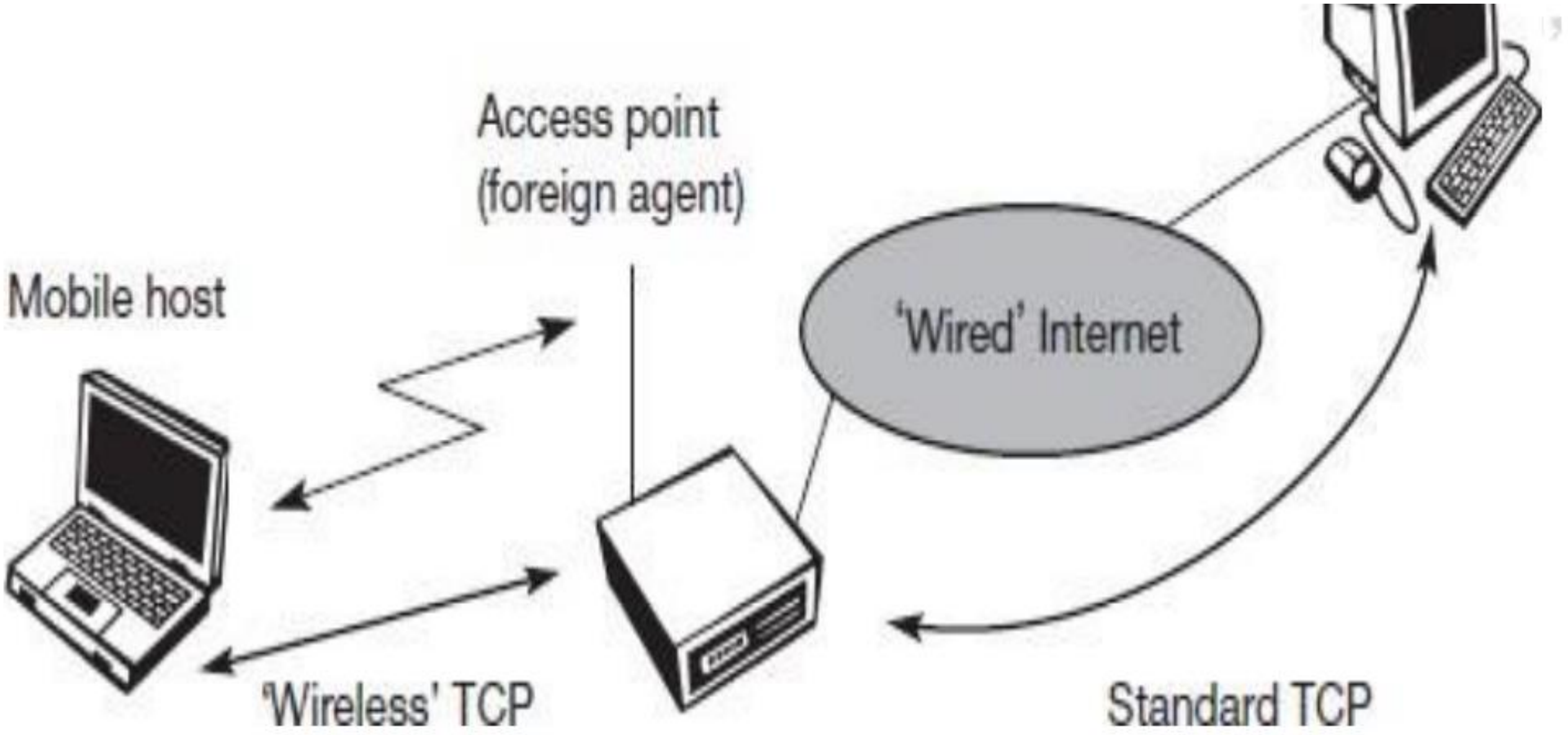
Indirect TCP (I-TCP)

- I-TCP segments a TCP connection into a
  - fixed part - Standard TCP is used
    - no changes to the TCP protocol for hosts connected to the wired Internet, millions of computers use (variants of) this protocol
  - wireless part - optimized TCP protocol
    - optimized TCP protocol for mobile hosts

- Splitting of the TCP connection at, e.g., the foreign agent into 2 TCP connections, no real end-to-end connection any longer

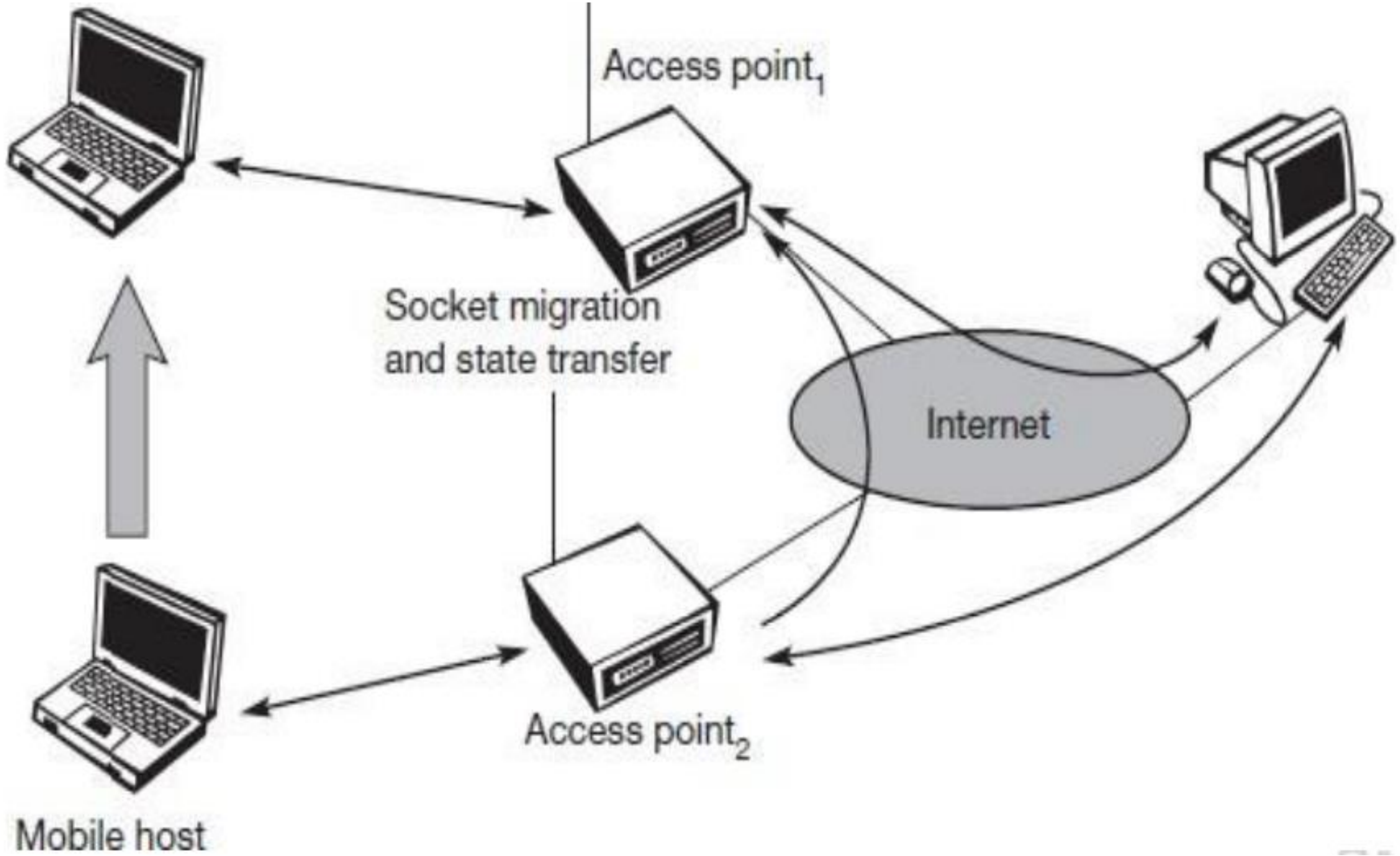
- Hosts in the fixed part of the net do not notice the characteristics of the wireless part

Indirect TCP (I-TCP)



Socket and state migration after handover of a mobile host

Indirect TCP (I-TCP)



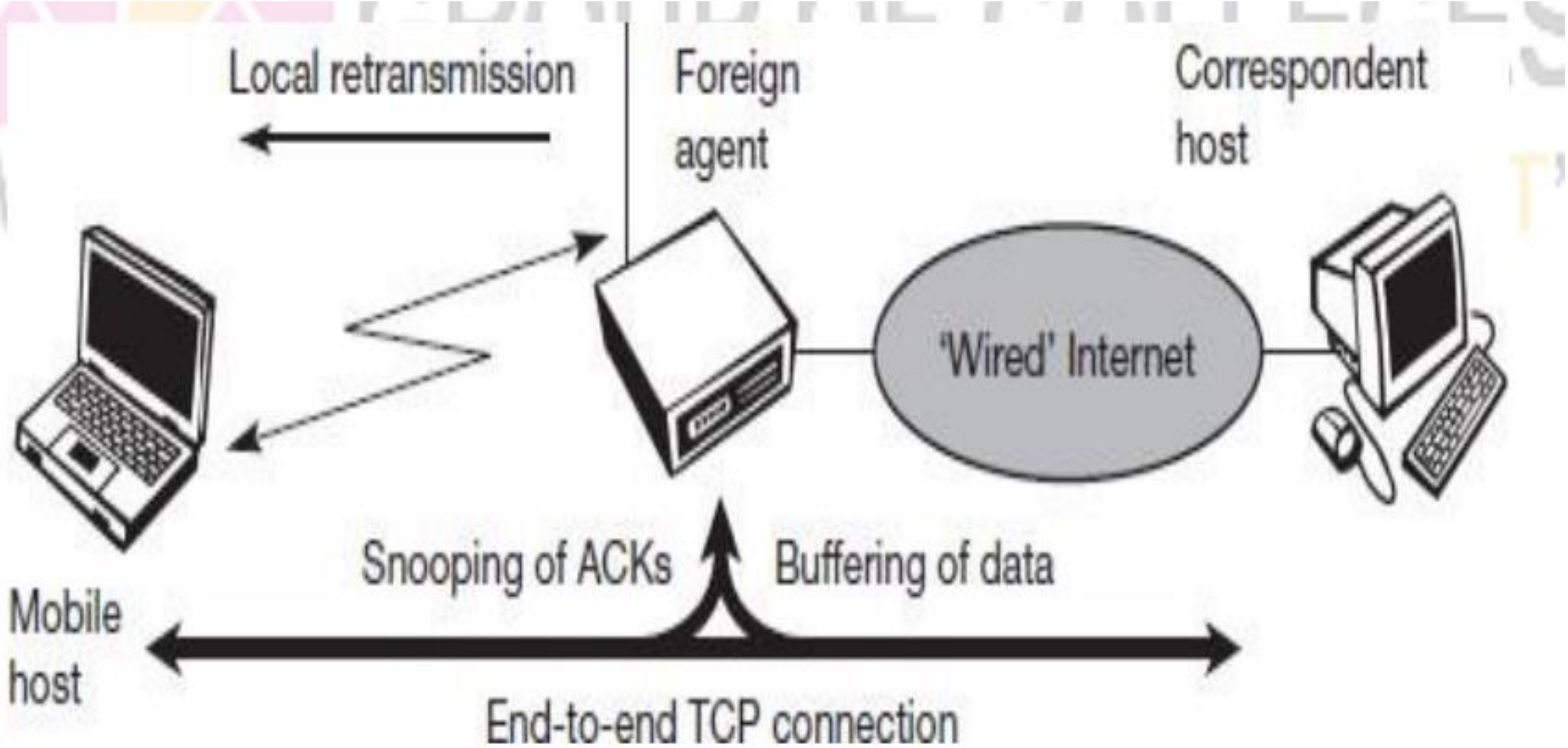
Indirect TCP (I-TCP)

- **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, mobile TCP is used only for one hop between, e.g., a foreign agent 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 now not any longer mean that a receiver really got a packet, foreign agents might crash
  - higher latency possible due to buffering of data within the foreign agent and forwarding to a new foreign agent

Snooping TCP

- The foreign agent buffers all packets with destination mobile host and additionally ‘snoops’ the packet flow in both directions to recognize acknowledgements.
- Buffering enable the FA to perform a local retransmission in case of packet loss on the wireless link.
- **Transparent extension of TCP within the foreign agent**
- Buffering of packets sent to the mobile host.
- Lost packets on the wireless link (both directions!) will be retransmitted immediately by the mobile host or foreign agent, respectively (so called “local” retransmission).
- The foreign agent therefore “snoops” the packet flow and recognizes acknowledgements in both directions, it also filters ACKs.
- Changes of TCP only within the foreign agent.

Snooping TCP



Snooping TCP

- Data transfer to the mobile host
  - FA buffers data until it receives ACK of the MH, FA detects packet loss via duplicated ACKs or time-out
  - fast retransmission possible, transparent for the fixed network

- Data transfer from the mobile host
  - FA detects packet loss on the wireless link via sequence numbers, FA answers directly with a NACK to the MH
  - MH can now retransmit data with only a very short delay

- Integration of the MAC layer
  - MAC layer often has similar mechanisms to those of TCP
  - thus, the MAC layer can already detect duplicated packets due to retransmissions and discard them

Snooping TCP

- Problems
  - snooping TCP does not isolate the wireless link as good as I-TCP
  - snooping might be useless depending on encryption schemes

Snooping TCP

- **Advantages**
  - The end-to-end TCP semantic is preserved
  - The correspondent host does not need to be changed; most of the enhancements are in the foreign agent
  - It does not need a handover of state as soon as the mobile host moves to another foreign agent.
  - It does not matter if the next foreign agent uses the enhancement or not

- **Disadvantages**
  - Snooping TCP does not isolate the behavior of the wireless link as well as ITCP
  - Using negative acknowledgements between the foreign agent and the mobile host assumes additional mechanisms on the mobile host.
  - All efforts for snooping and buffering data may be useless if certain encryption schemes are applied end-to- end between the correspondent host and mobile host

Mobile TCP

- Special handling of lengthy and/or frequent disconnections

- M-TCP splits as I-TCP does
  - unmodified TCP fixed network to supervisory host (SH)
  - optimized TCP SH to MH

- Supervisory host
  - no caching, no retransmission
  - 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

Mobile TCP

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

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

Fast retransmit/fast recovery

- **Advantage**
  - simple changes result in significant higher performance
- **Disadvantage**
  - further mix of IP and TCP, no transparent approach

Transmission/time-out freezing

- Mobile hosts can be disconnected for a longer time
  - no packet exchange possible, e.g., in a tunnel, disconnection due to overloaded cells or mux. with higher priority traffic
  - TCP disconnects after time-out completely

- TCP freezing
  - MAC layer is often able to detect interruption in advance
  - MAC can inform TCP layer of upcoming loss of connection
  - TCP stops sending, but does now not assume a congested link
  - MAC layer signals again if reconnected

Transmission/time-out freezing

- **Advantage**
  - scheme is independent of data
- **Disadvantage**
  - TCP on mobile host has to be changed, mechanism depends on MAC layer

Selective retransmission

- TCP acknowledgements are often cumulative
  - ACK n acknowledges correct and in-sequence receipt of packets up to n
  - if single packets are missing quite often a whole packet sequence beginning at the gap has to be retransmitted (go-back-n), thus wasting bandwidth
- Selective retransmission as one solution
  - RFC2018 allows for acknowledgements of single packets, not only acknowledgements of in-sequence packet streams without gaps
  - sender can now retransmit only the missing packets

Selective retransmission

- **Advantage**
  - much higher efficiency
- **Disadvantage**
  - more complex software in a receiver, more buffer needed at the receiver

Transaction oriented TCP

- TCP phases
  - connection setup, data transmission, connection release
  - using 3-way-handshake needs 3 packets for setup and release, respectively
  - thus, even short messages need a minimum of 7 packets!
- Transaction oriented TCP
  - RFC1644, T-TCP, describes a TCP version to avoid this overhead
  - connection setup, data transfer and connection release can be combined
  - thus, only 2 or 3 packets are needed

Transaction oriented TCP

- **Advantage**
  - Efficiency
- **Disadvantage**
  - requires changed TCP
  - mobility not longer transparent

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