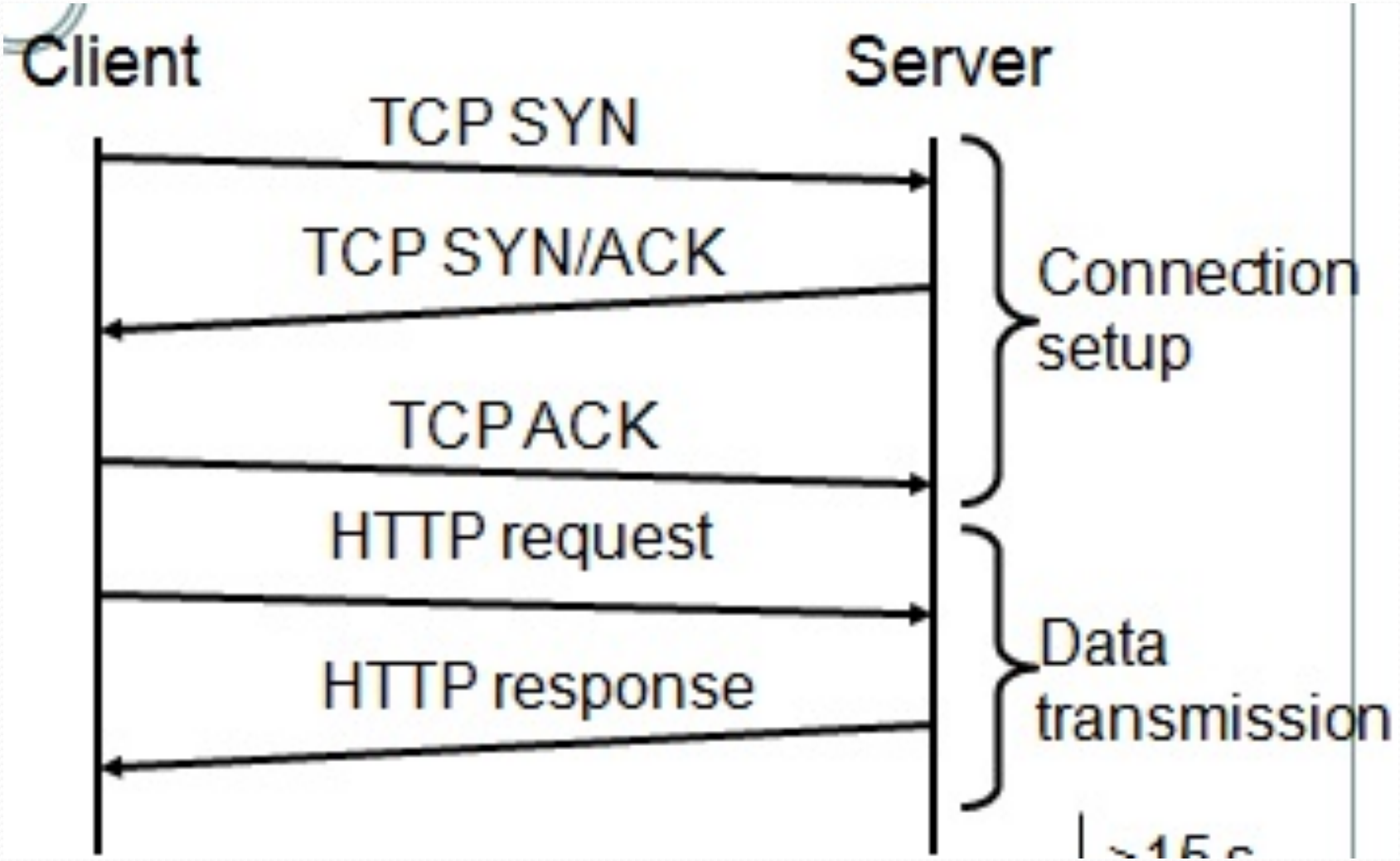
Mobile Computing – Mobile Transport Layer

- MTL provides mobility support for applications
  - TCP
    - Connection oriented, reliable
  - UDP
    - Connectionless, unreliable
- **Functions:**
  - Checksumming ove user data
  - Multiplexing/demultiplexing of data from/to applications
- **Advantage of TCP**
  - In the time of packet loss, TCP assumes network congestion and **slows down the transmission rate**.

TCP - Handshake



Traditional TCP

- **Congestion Control**
  - Payload (packet) data could be more – router cannot forward the packet
  - **Control :** router drops the packet
    - Receiver informs the sender missed packet using **sequence number – ack**
    - **Tcp –slows down the transmission** rate when congestion takes place – **to mitigate the congestion**
- **Slow Start** – the way TCP acts after detection of congestion
  - **Congestion window** – sender calculates the CW for a receiver
    - Sender sends one packet and waits for ack
    - After the ack is received, CW is increased everytime (exponential growth)
    - **Congestion Threshold** – sender reduces the CW to **1 packet**
    - Linear increase continues till time-out occurs at sender due to a **missing ack or until sender gets ack for same packet for long time**

Traditional TCP

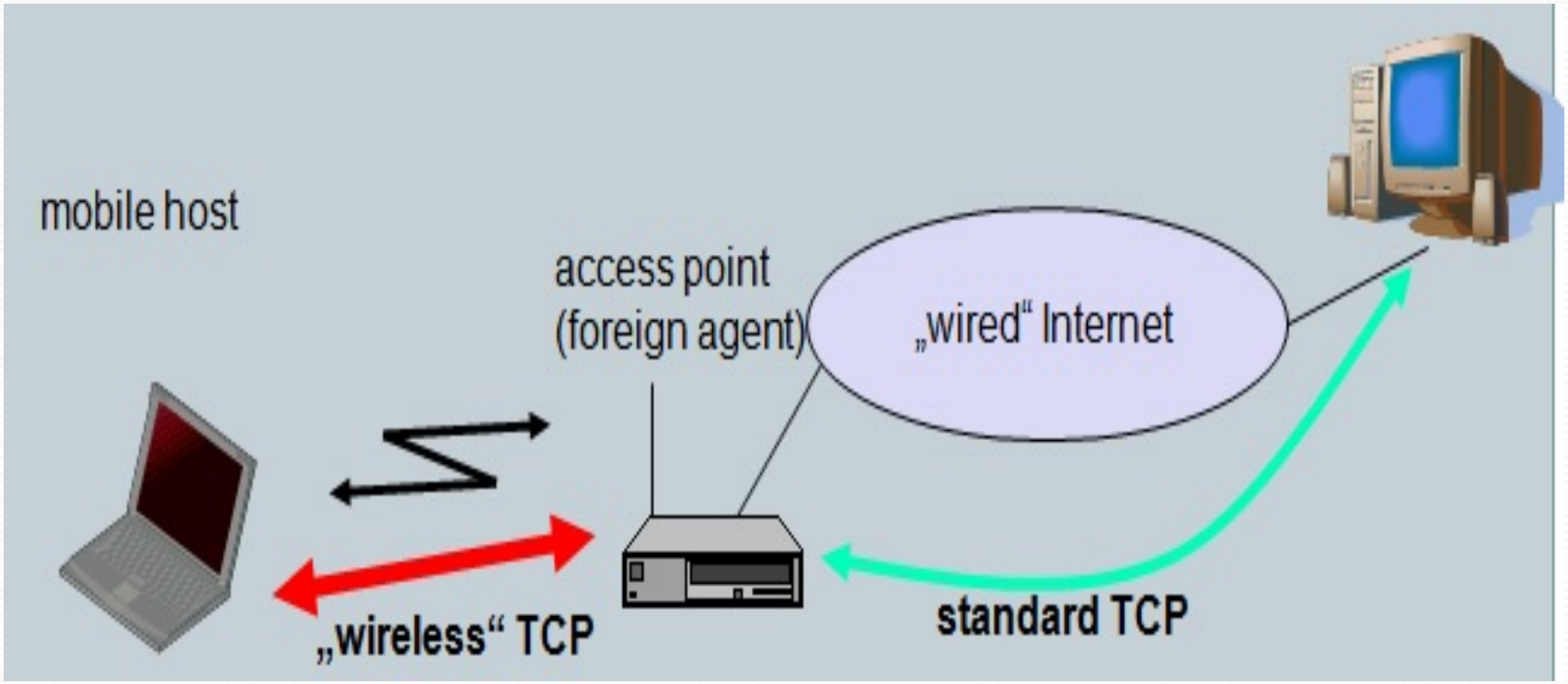
- **Fast retransmit/fast recovery**
  - TCP sends an **acknowledgement** only after **receiving a packet**
  - If a sender receives several acknowledgements for the same packet
    - This implies that **receiver received all packets** up to the acknowledged packet in sequence.
    - Gap in the packet stream is not due to congestion, but packet loss due to a **transmission error**.
  - **Fast retransmit**: sender retransmit the missing packet(s**) before the timer expires.**
  - **Fast recovery**: since the **receipt of ack** shows that there is no congestion to justify a slow start
    - Sender can continue with the current congestion window.

Influences of mobility on TCP-mechanisms

- **TCP assumes congestion if packets are dropped**
  - If the ack for a packet is missed, TCP assumes problem is because of congestion in network
  - **Mobility factor**
    - **Mobile & wireless** end-systems creates more packet loss
    - Trying to retransmit packet on **layer 2 may take too long**
- **Mobility – handover problem**
  - Mobility from old to new foreign agent

Classical TCP Improvements - Indirect TCP

- **Indirect TCP**: I-TCP segments a TCP connection into a fixed part and a wireless part
  - **Reason**
    - TCP performs poorly with wireless links
    - TCP within the fixed network cannot be changed

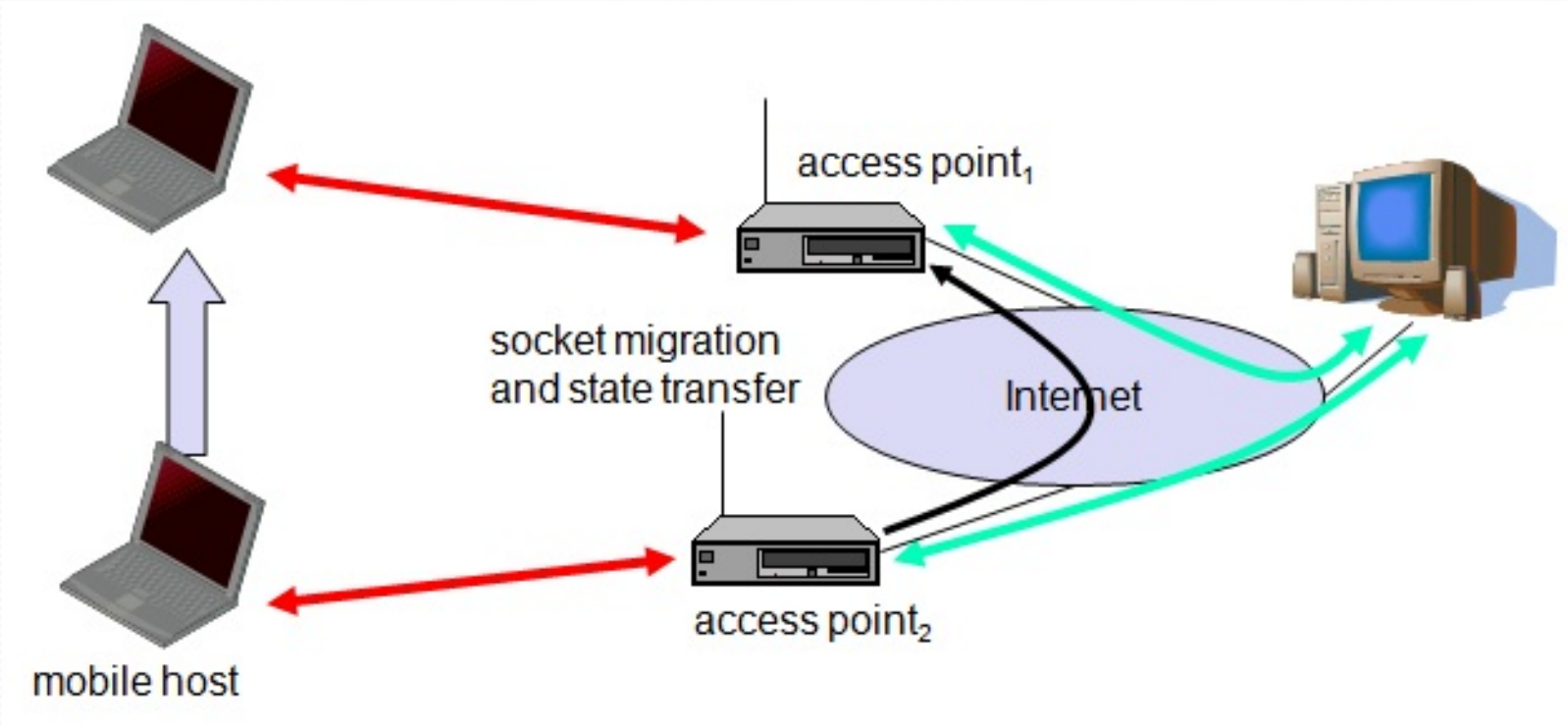


I-TCP- Working of TCP segments

- **Standard TCP** is used between the fixed host and the access point
  - **Access point** – acts as a proxy
    - i.e it is seen as mobile host for the fixed host and as the fixed host for the mobile host.
- **Special TCP** adapted to wireless links is used between access point and mobile host
- **Foreign agent**: **-** is acting as a access point – between fixed host and mobile host
  - **FA –controls the mobility of the MH** and can hand over the connection to the next FA
    - **FA** forwards the packet from **MH to FH**

I-TCP- Working – Handover (Socket & State migration)

- After the handover, old proxy must forward buffered data to the new proxy
  - New **FA** informs the old **FA** about its location to enable **packet forwarding**.



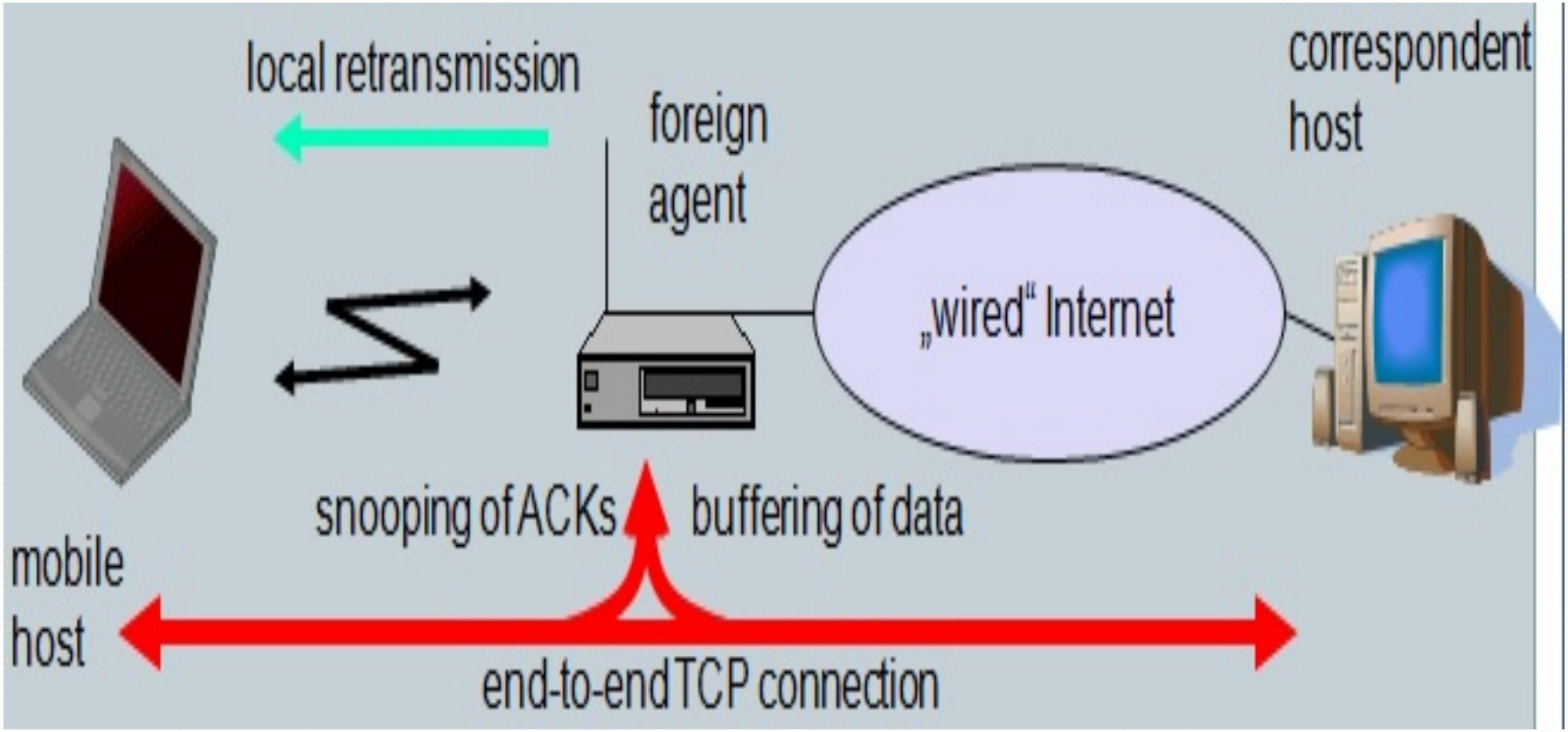
I-TCP – Advantages & Disadvantages

- **Advantages**
  - No changes in the fixed network are necessary.
  - **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
  - Very **fast retransmission** of packets is possible.
- **Disadvantages**
  - Loss of **end-to-end semantics**: foreign agents might crash – **false positive ack**
  - **Higher latency** possible due to **buffering of data** within the foreign agent and forwarding to a new foreign agent

Classical TCP Improvements - Snooping TCP

- **Drawback of I-TCP:** segmentation of the single TCP connection into two TCP connections
  - This **looses the original end-to-end TCP semantic**.
- **Solution: Snooping TCP**
  - "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 **"snoops" the packet flow** and recognizes **acknowledgements** in both directions, it also **filters ACKs**

Snooping TCP



Snooping TCP – Advantages & Disadvantages

- **Advantages:**
  - End-to-end TCP semantic is preserved
  - CH does not need to be changed
    - Enhancements are done in FA
- **Disadvantages:**
  - **It takes some time** until the FA can successfully retransmit a packet from its buffer due to problems on the wireless link.

Classical TCP Improvements - Mobile TCP

- It handles the **occurrence of lengthy and/or frequent disconnections**
  - **Problems:**
    - sender tries to retransmit data controlled by a **retransmission timer** that **doubles** with each unsuccessful retransmission attempt.
    - the longer the period of disconnection, the **more buffer is needed**.
    - **Creates problem in handover**

Mobile TCP

- **M-TCP**- same goals as I-TCP & snooping TCP
  - Tries to **improve overall throughput, lower delay, maintain end-to-end semantics of TCP, handover**
  - Provides solution to **lengthy/frequent disconnections**
- **M-TCP** splits the TCP connection into two parts:
  - **Unmodified TCP connection – supervisory host (SH)**
  - **Optimized TCP connection** – optimization techniques
- **Supervisory host**
  - monitors all packets, **if disconnection detected**
    - Set sender window size to 0
    - Sender automatically goes into persistent mode
  - If it detects connectivity again
    - Reopens the window of the sender
- **Advantages**
  - **Maintains semantics, supports disconnection, no buffer forwarding**
- **Disadvantages**
  - **Loss on wireless link propagated into fixed network**

Classical TCP Improvements – Fast retransmit/fast recovery

- **Change of foreign agent** often results in **packet loss**
  - TCP reacts with **slow-start** although there is no congestion
- **Solution**
  - **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**
    - It **requires more cooperation between the mobile IP and TCP layer** .

Classical TCP Improvements – Transmission/Time-out freezing

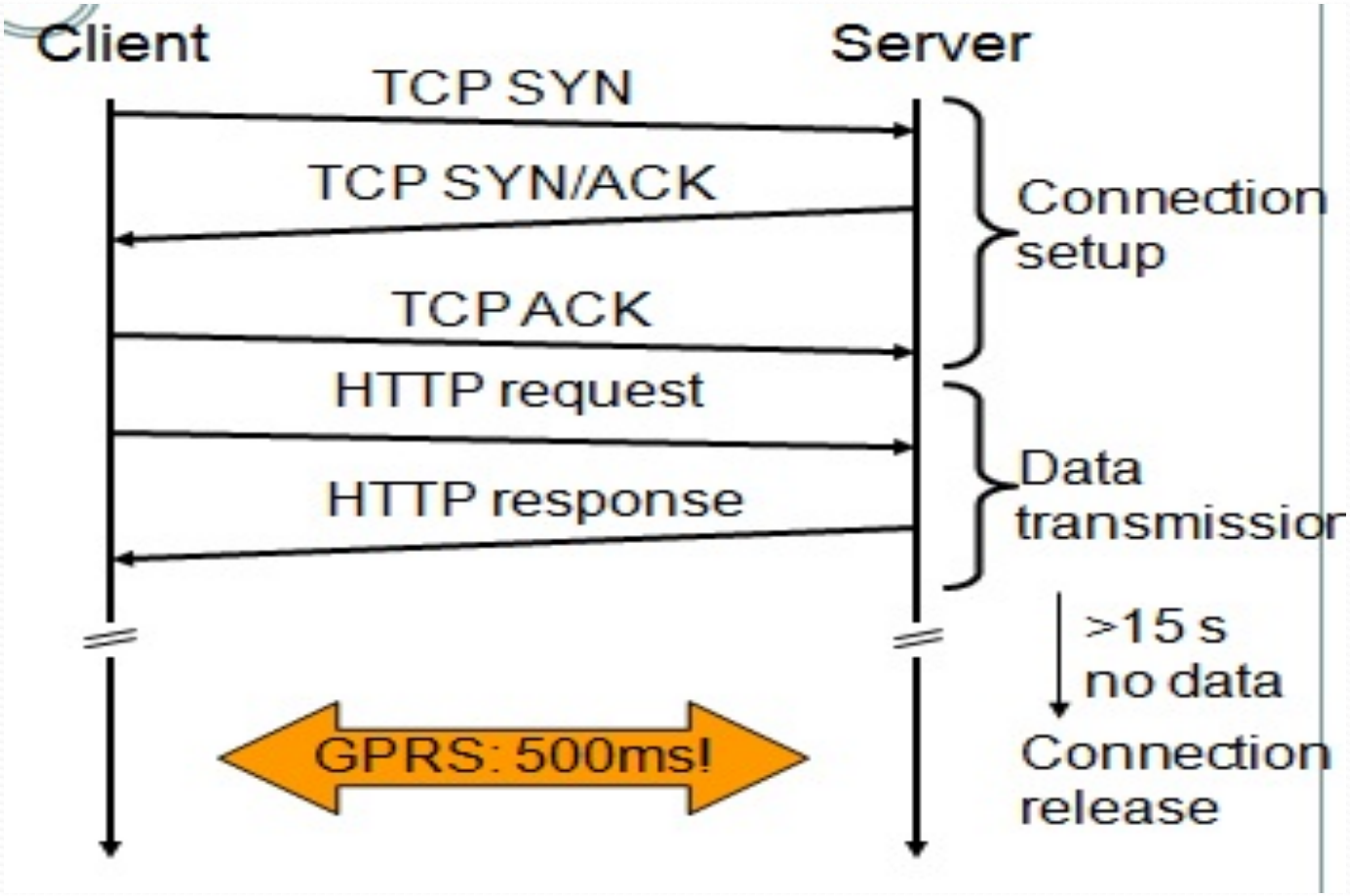
- **Mobile hosts can be disconnected** for a longer time
  - **No packet exchange possible**, e.g., in a tunnel, disconnection **due to overloaded cells** . with higher priority traffic
  - TCP disconnects after time-out completely
- **Solution**
  - **TCP freezing**
    - **MAC layer** is often able 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**
- **Advantage**
  - It is **independent of TCP mechanism**
- **Disadvantage**
  - TCP on mobile host has to be changed, **mechanism depends on MAC layer**

Classical TCP Improvements – Selective retransmission

- **TCP acknowledgements are often cumulative**
  - 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
- **Solution**
  - **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
- **Advantage**
  - much higher efficiency
- **Disadvantage**
  - more complex software in a receiver, more buffer needed at the receiver

Classical TCP Improvements – Transaction –oriented TCP

- Example TCP connection setup overhead



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
- **Advantage**
  - More efficient
- **Disadvantage**
  - Requires changed TCP
  - Mobility not longer transparent