Cross-layer Assisted Vertical Handoffs for TCP

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Presentation overview

- TCP congestion control
- Vertical handoff (VHO)
- The problems of TCP with vertical handoff
- Cross-layer assisted TCP algorithm for vertical handoffs
- Conclusions and future work

Transmission Control Protocol (TCP)

- Most widely used transport protocol in the Internet
- Applications such as e-mail, file transfer, Web, streaming video and audio use TCP
- Guarantees reliable, in-order, error-free data transfer
- End-to-end protocol implemented at the Sender and the Receiver
  - TCP adapts the data rate to the end-to-end path properties
    - Round-Trip-Time (RTT)
    - Capacity (Bandwidth dealy product BDP)

Vertical handoff (VHO)

- A MN can use multiple radio interfaces to connect to the Internet. Eg. A laptop with WLAN and GPRS interfaces
- The link characteristics of the access networks varies widely.
  - Eg, GPRS data rate 200 Kbps, one way propagation delay 300 ms, WLAN data rate 11 Mbps, one way propagation delay 2 ms,
- Vertical handoff refers to switching between access points which use different link level technologies
- A significant change in the access link (last hop/first hop) characteristics can affect TCP behaviour

- Make-Before-Break Handoff
  - Mobile node´s association with the old access point breaks only after the connection to the new access point is operational
- Break-Before-Make Handoff
  - Mobile node´s association with the old access point breaks before the connection to the new access point is operational

Impact of vertical handoff on TCP performance

- **Make-Before-Break Handoff**
  - **Handoff from a low-delay link to a high-delay link**
    - **Retransmission timeout (RTO) cannot adapt to the sudden increase in RTT after the handoff à Spurious Retransmission timeouts (RTOs)**
  - **Handoff from a high-delay link to a low-delay link**
    - **Packets sent through the fast new link reach the receiver sooner than the packets sent through the slow link à Packet reordering**
    - **Slow Convergence to the new RTO value**
  - **Handoff from high capacity link to a low capacity link**
    - **Congestion à Packet losses**
  - **Handoff from a low capacity link to a high bandwidth link**
    - **TCP´s inability to catch up with high bandwidths**

Impact of vertical handoff on TCP performance

- Break-Before-Make Handoff
  - Disconnection à Packet losses
  - RTOs during disconnection à Unused connection time
    - Retransmission timer is backed off and TCP begins transmission only after the next retransmission timer expiry
    - Prolonged recovery

      If more than one RTO occurs for the same segment, TCP reduces the sending rate

Even if we have seamless handoff, TCP has all possible problems depending on the vertical handoff scenario.

Need to make TCP as well as upper layers aware of vertical handoff

How to make TCP aware of vertical handoff ?

- **By providing cross-layer notifications to TCP**
- How to provide the cross-layer notifications?
  - **Mobile Node (MN) can get the information locally regarding changes in access link characteristics**
  - **MN can send this information to the other end-host (e.g., as part of mobility signaling – binding update message in Mobile IPv6, update packets in HIP**
- In our experiments we model
  - **MN sends to the peer end-host link characteristics notifications** :
    - **occurrence of handoff**
    - **bandwidth and delay of the old and the new access links**

Cross-layer assisted TCP sender algorithms

- **Benefits**
  - **Avoiding spurious RTOs**
    - **Set the retransmission timeout based on the old and the new access link bandwidth and delay**
  - **Minimizing congestion related packet losses**
    - **Adapt the sending rate based on the capacity of the new access link**
  - **Making TCP resume immediately after a disconnection**
    - **Immediate retransmission if TCP is in timeout recovery when TCP gets the handoff notification**
  - **Speeding up RTO convergence**
    - **Initialize the retransmission timer parameters immediately after a handoff**
  - **Reducing the effects of packet reordering**
    - **Detect reordering using the selective acknowledgements, send new packets through the new link while waiting for the old packets; set the sending rate to the capacity of the new access link.**

Conclusions and future work

- Developed cross-layer assisted TCP sender algorithms to reduce the unnecessary packet retransmissions and congestion control actions due to a vertical handoff
- Addressing multiple flows
  - Refining the algorithms
- Potential experimentation in real environment

WISEciti Publications

- L. Daniel, M. Kojo. Employing cross-layer assisted TCP algorithms to improve TCP performance with vertical handoffs, International Journal of Communication Networks and Distributed Systems (IJCNDS), Vol. 1, No. 4/5/6, 2008

- L. Daniel, I. Järvinen, M. Kojo Combating packet reordering in vertical handoff using cross-layer notifications to TCP, Wimob 2008

- L. Daniel, TCP performance with vertical handoff, Licentiate thesis- C 2008.221 University of Helsinki

Thank you
for your attention

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