TCP Congestion Control with ACK-Pacing for Vertical Handover

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Outline

- Introduction
- Proposed System
- Simulation
- Evaluation
- Conclusion
Introduction (1/5)

- Horizontal handoff V.S. Vertical handoff
- Packet loss
- BDP drastically changes
  - BDP = bandwidth * estim

Figure 3: WLAN to WLAN/WiMax
Introduction(2/5)

Packet loss: when MN moves into new MA area
Introduction (3/5)

- Mobile IP:
  - IPv4: triangle route
  - IPv6: maintain L3 connectivity
Introduction(4/5)

- Upward: i.e. WLAN to 3G
- Invoking unnecessary TCP congestion control
- Sender is limited by ACK-clocking Alg.
Introduction (5/5)

- Downward: i.e. 3G to WLAN
- Link utilization

**Fig. 4** Downward vertical handover.
Proposed System

- Receiver knows
  - the available bandwidth
  - When a handoff finishes
- We use ICMP to estimate RTT
- No packet loss occur during handoff
Upward vertical handoff

Congestion Control Size Control

Control cwnd by dupACKs: how many times?

\[ \text{num} = \log_2 \frac{\text{cwnd before the handover}}{\text{BDP after the handover}}. \]

Fig. 5. Proposed scheme for upward vertical handover.
Upward vertical handoff

- ACK Rate Control
  - Delay the return of ACK
  - Why the interval is setup
  - Packet length
  - Bandwidth

\[ \text{Interval} = \frac{\text{Packet length}}{\text{Bandwidth of AccessLink}}. \]
Downward vertical handoff

- TCP increase $1/cwnd$ by every ACK receiving
- To increase cwnd quickly
- Return $N$ ACKs with different ACK number during a RTT
- Example: $N=3$

![Diagram showing vertical handover process](image)

Fig. 6. Proposed scheme for downward vertical handover.
Downward vertical handoff

- Some mechanism effect
  - Delay ACK: 500ms or two segment
  - Appropriate Byte Counting (ABC)
Implementation Issue

- Estimation of available bandwidth
  - From behavior of MAC protocol
- Reduction of overhead due to ACK
  - Virtual carrier sensing mechanism
  - Burst transmission of TCP ACK: 802.11e
- We use the access node support
Simulation

- $d$ : the delay of between CN and router
- $B$ : cellular system bandwidth
- Handoff occurs at 100 seconds
Evaluation

- Upward: $d = 25\text{ms}$, $B = 2\text{Mbps}$
- MN’s BDP: $148 \rightarrow 48\text{ k bytes}$
Evaluation

- Downward: $d = 25\text{ms}, B = 2\text{Mbps}$
- MN’s BDP: 48 -> 148 k bytes
Evaluation

BDP is unchanged: $b = 5\text{ms}$, $B = 2\text{Mbps}$.

Fig. 11 Throughput transition in the case of downward handover ($d = 5\text{[msec]}$, $B = 2\text{[Mbps]}$).
Evaluation

- **Upward**: $d = 1\text{ms}, B = 2\text{Mbps}$
- **MN**: $36 \rightarrow 5\text{ k bytes}$
- **FN**: $8 \rightarrow 5\text{ k bytes}$
Evaluation

- Downward: $d = 25\text{ms}$, $B = 0.384\text{Mbps}$
- MN: 9 -> 50 k bytes
- FN: 74 -> 50 k bytes
Conclusion

TCP receiver controls the sending rate by ACK pacing
We will investigate the problem of parameter setting