Multipath bonding at Layer 3

Maciej Bednarek (ETH Zurich), **Mirja Kühlewind (ETH Zurich)**,

Guillermo Barrenetxea Kobas (Swisscom), Brian Trammell (ETH Zurich)

July 16, 2016 - Applied Network Research Workshop (ANRW)

mami

measurement and architecture for a middleboxed internet

measurement architecture experimentation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688421.The opinions expressed and arguments employed reflect only the authors' view. The European Commission is not responsible for any use that may be made of that information.

Supported by the Swiss State Secretariat for Education, Research and Innovation under contract number 15.0268. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the Swiss Government.

Overview

- **Motivation**

  Operator's demand for aggregation of DSL and mobile capacity
- **Layer 3 Bonding Solution**

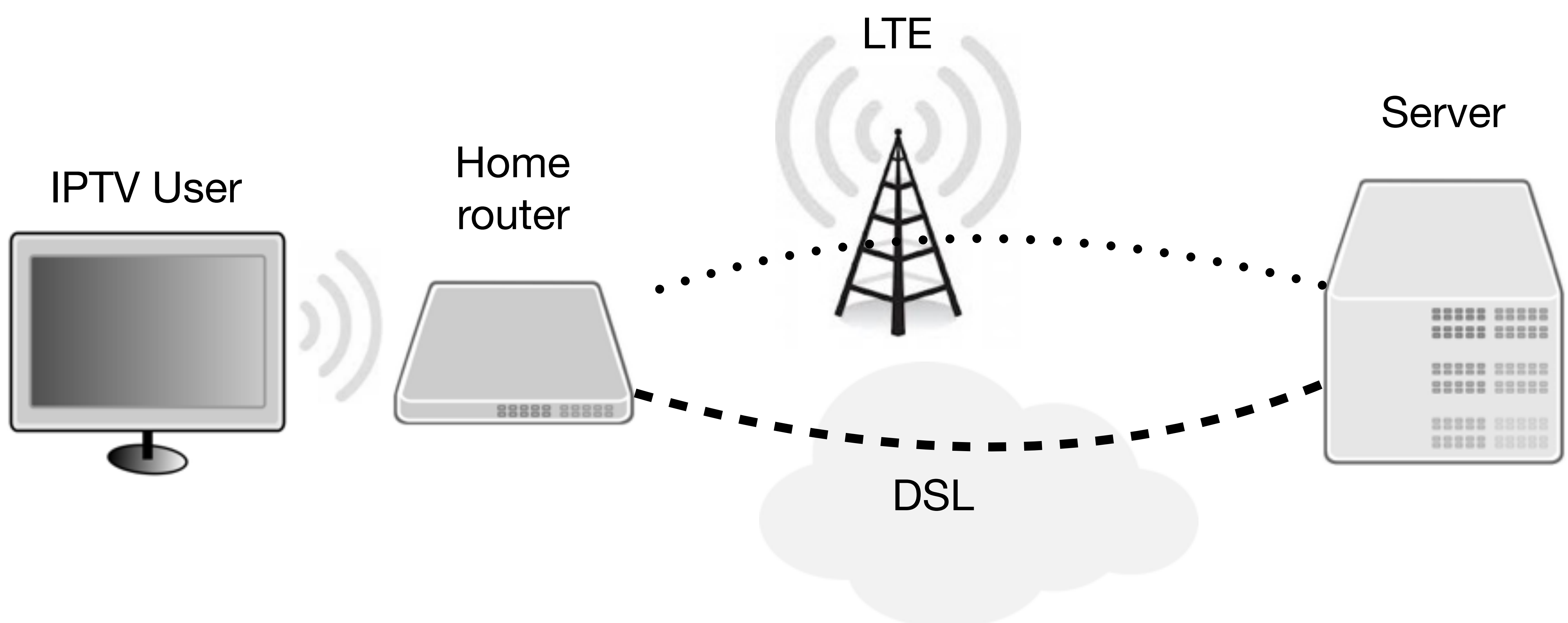
  Architecture and Scheduling Algorithm
- **Implementation**

  Packet mangling, scheduling, and re-ordering
- **Evaluation**

  Single Flow and TCP cross traffic
- **Conclusion**

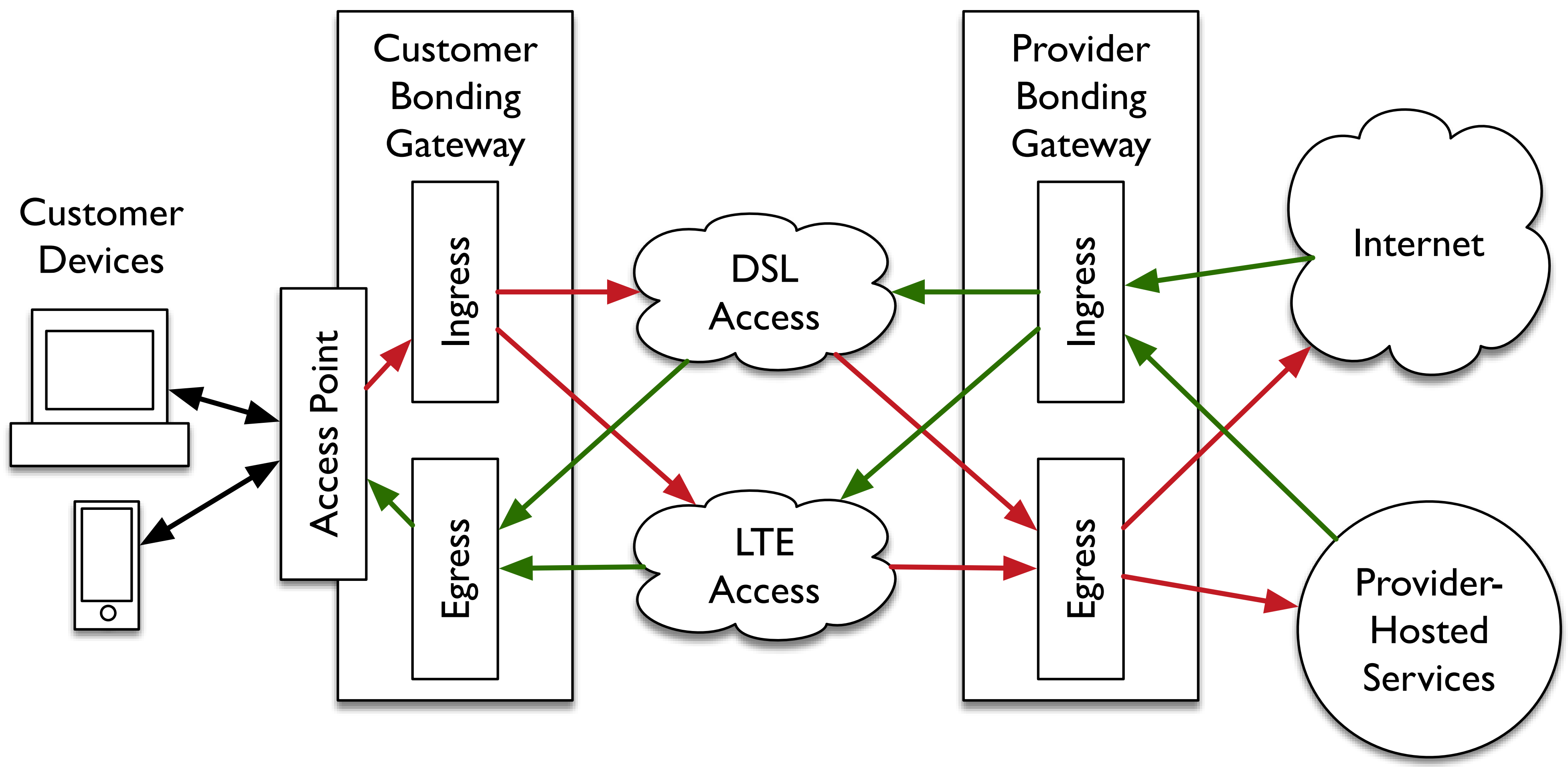
  Works but further work needed…!

Motivation: Aggregation of DSL and mobile capacity



- DSL capacity is not sufficient to e.g. serve HD video service
- MPTCP proxy only suitable for TCP traffic

Bonding Architecture: Costumer and Provider Bondings Gateways



- **Ingress:** accepts traffic, schedules transmission & adds SEQ#
- **Egress:** takes traffic from bonding interface, re-orders & strips SEQ#, sends loss report to ingress

Scheduling Algorithm: Adaptive Weight Increment (AWI)

Goal: fill fixed link first, use mobile link for excess traffic demand only

AWI using Weighted Round Robin (WRR)

- fixed weight for fixed line: $w_{fixed} = 50$
- dynamic calculation for mobile line (initially $w_{mobile} = 0$):

$$w_{mobile} \mathrel{+}= k * \frac{pkt_{lost}}{pkt_{sent}} * w_{fixed}$$

control parameter

Scheduling Algorithm: Initial Weight Increment (IWI)

Goal: react quickly when congestion is arising

If $w_{mobile} = 0$ & loss is reported:

increases w_{mobile} by the number of lost packets

Note: w_{mobile} is clamped to a maximum value $w_{mobilemax} = 50$

Scheduling Algorithm: Delayed Weight Decrement (DWD)

Goal: shift load back to the fixed line without inducing loss by shifting the load too quickly

If no loss reported for T_{dwd}:

decrement w_{mobile} by one for each interval $T_{report} = 50ms$

Note: We investigate different values for T_{dwd} but it must be a multiple of T_{report} (as loss reports are only received every T_{report} milliseconds)

Implementation: Bonding Ingress

intercepts packets using Netfilter queues (in `OUTPUT` chain) and forward to userspace

- **Packet Mangling**
  - Control packets from the egress (loss reports) will be discarded
  - Data packets: sequence number added & forwarded for scheduling
    - Generic Routing Encapsulation (GRE) Sequence Number and Key fields could be used
- **Scheduling**
  - Decides about netfilter mark (`fwmark`) to map data packet to the right output queue using `iptables`
  - Counts the number of packets sent on each interface (pkt_{sent})

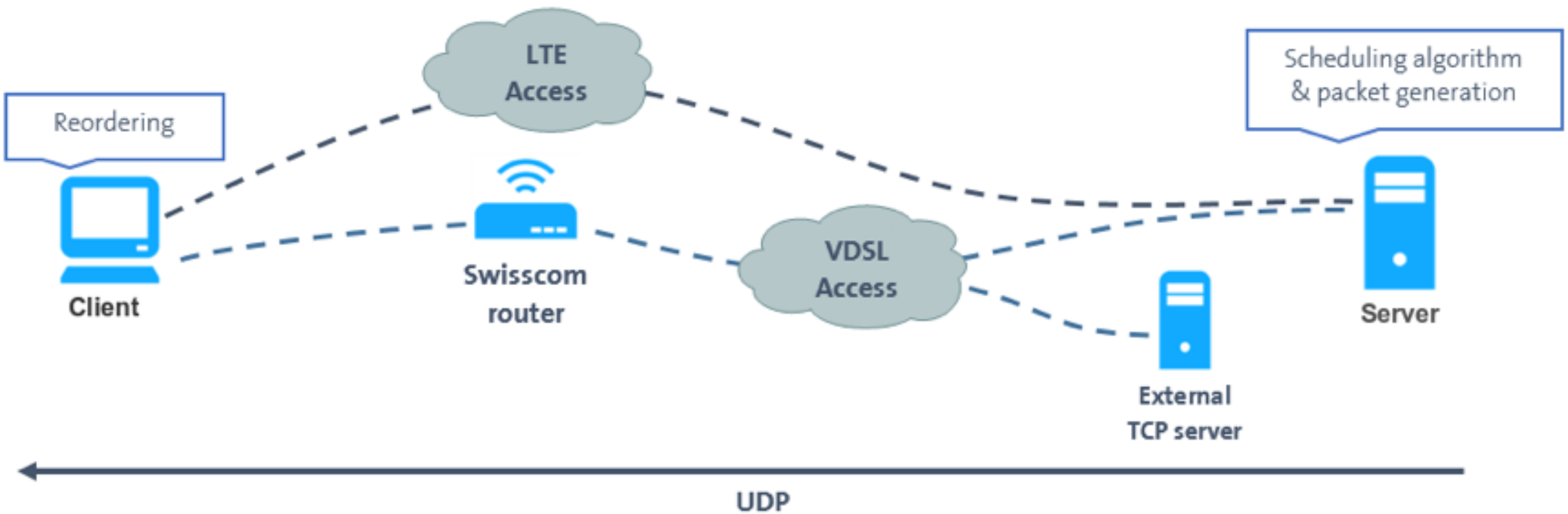
Implementation: Bonding Egress

intercepts all incoming UDP packets using Netfilter queues (in PREROUTING chain)

- **Re-ordering**

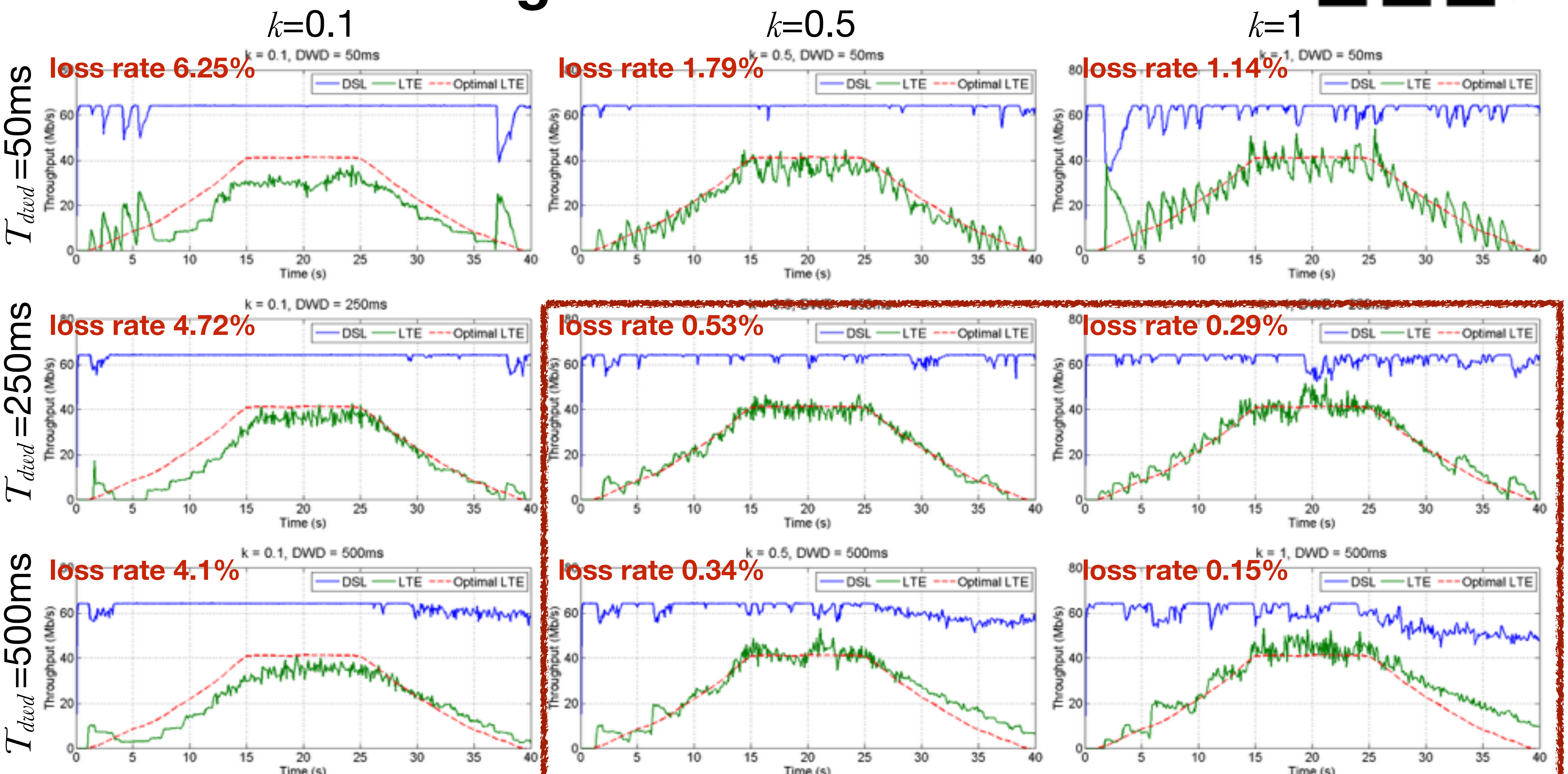
  1. New packet received:
     - ***forward*** packet directly *if SEQ# = last_accepted + 1* (or the first of a new flow) and update last_accepted
     - ***enqueue*** packet *if SEQ# > last_accepted + 1* (and remember timestamp)
     - ***discard*** packet *if SEQ# < last_accepted + 1* (as it has been assumed to be lost)
  2. Further check other packets in queue (and update last_accepted):
     - ***forward*** first packet in queue *if now last_accepted + 1 = SEQ#* of queued one
     - ***forward*** also *if now - T_{dwd} > timestamp* (missing packet is assumed to be lost)

Evaluation: Experimental setup



- Two Linux Debian Wheezy machines (client & server)
- 1492 bytes UDP packets (28 bytes UDP/IPv4 header, 4 bytes for SEQ#, and 1460 bytes of dummy payload)
- TCP cross traffic: file transfer from a public server (cdimage.debian.org) with 50ms to client
- DSL link is shaped to a maximum rate of 64 Mb/s and stable 13ms delay (measured)
- Swisscom's Huawei E3276s LTE stick with about 60Mb/s (and variable delay of 25 - 45ms)

Evaluation: Results for a single flow

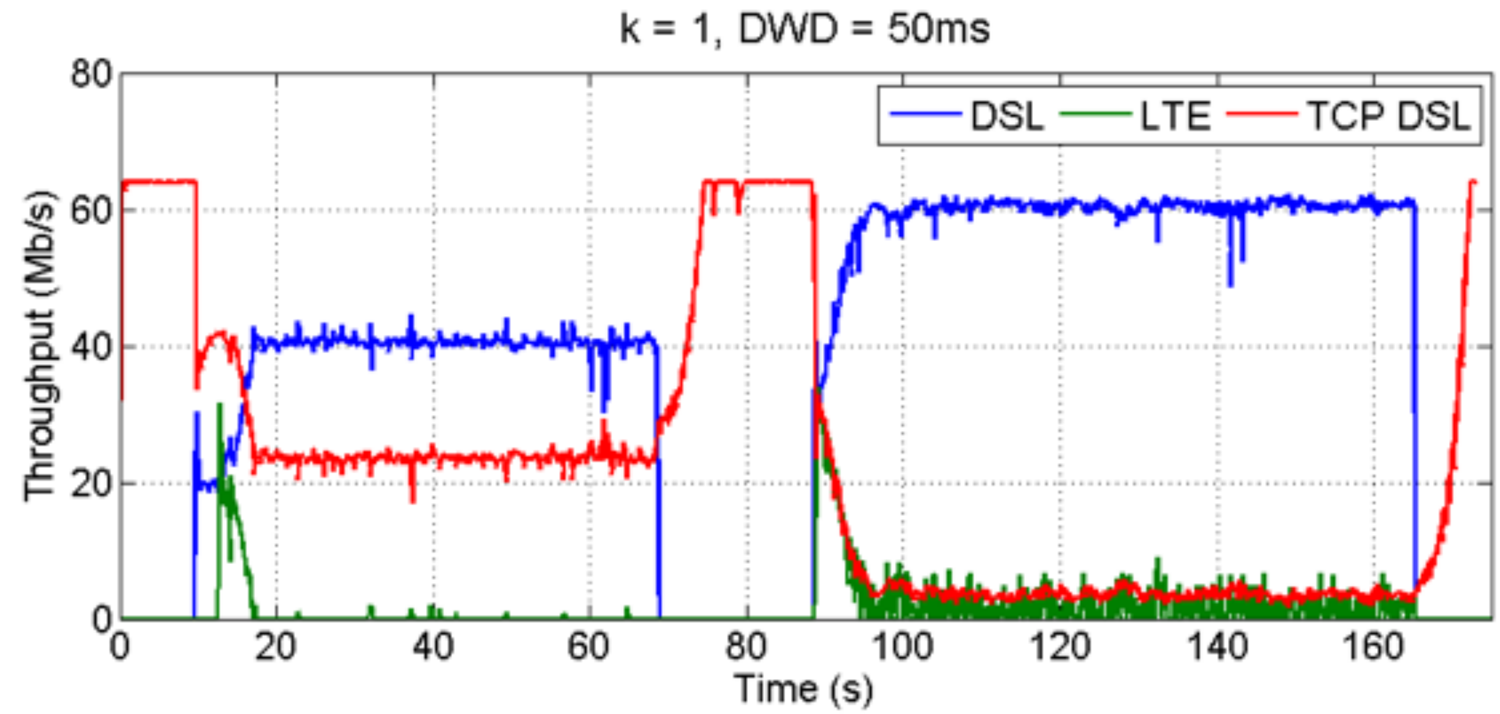


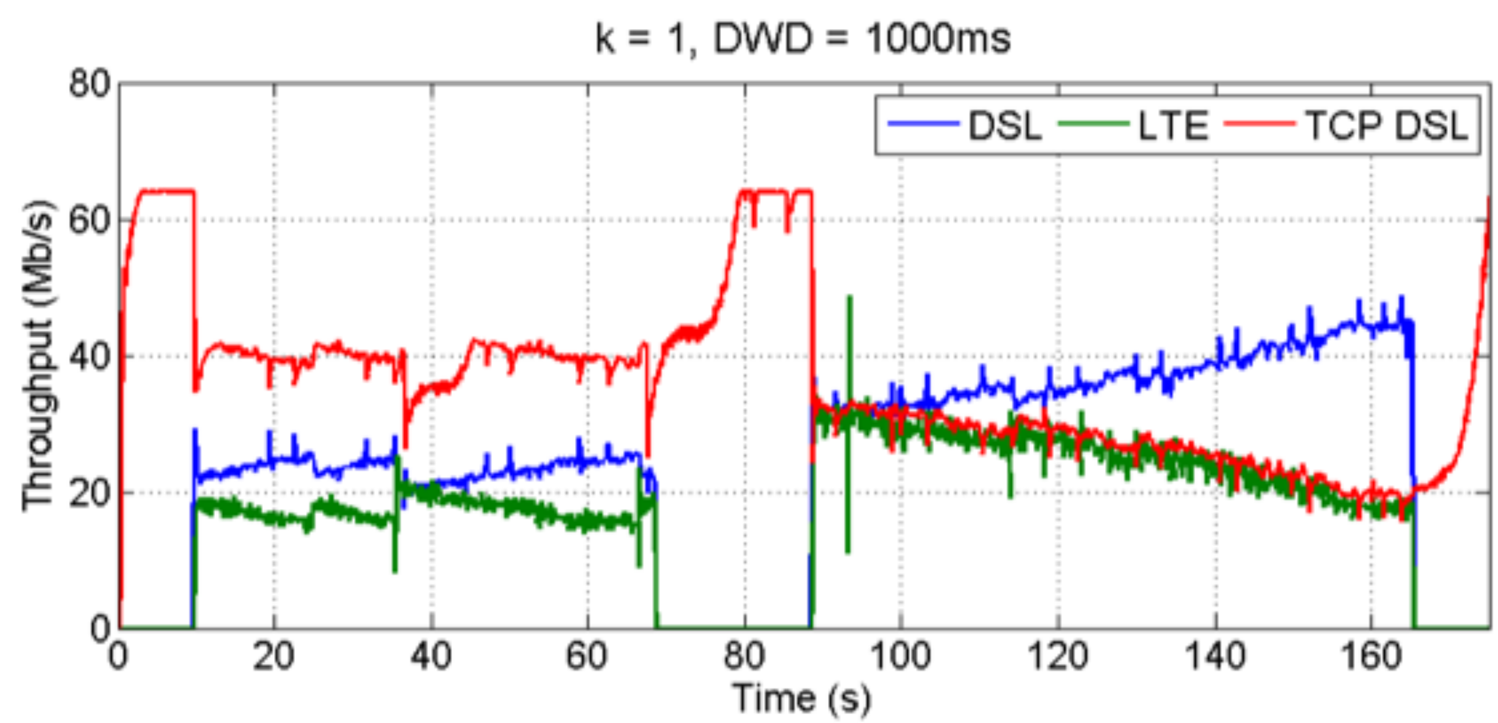
➡ k and T_{dwd} provide trade-off between agressiveness and responsibility

Evaluation:
Results with TCP cross traffic

- $T_{dwd} = 50ms$: TCP flow only gets spare capacity
- $T_{dwd} = 1000ms$: UDP traffic permanently shifted to mobile link

➡ Operator can decide how TCP-friendly the algorithm should be





Conclusion

- **Goal:** Aggregation of DSL and mobile capacity for excess traffic
- Layer 3 bonding solution
  - Ingress: Packet mangling (SEQ#) and scheduling that adapts w_{mobile} dynamically
  - Egress: Re-ordering buffer
- Evaluation of parameters k and T_{dwd}
  - Trade-off between agressiveness and responsibility
- **Future Work**
  - Interoperation with presently deployed MPTCP proxies
  - Middelbox cooperation to indicate if re-ordering sensitivity

Evaluation
Results for a multiple UDP flows