A Simulation Study on Increasing TCP's IW - Preliminary Results

Ilpo Järvinen, Aki Nyrhinen, Aaron Yi Ding, Markku Kojo

Department of Computer Science
University of Helsinki

IETF78 / Maastricht
Jul 30th 2010

Introduction

- Simulation study to evaluate effects of increasing IW from 3 to 10 (proposed in draft-hkchu-tcpm-initcwnd-01.txt)
- Focus on (typical) slow/moderate bit-rate wireless links like environments
- Very very preliminary results
  - No in-depth analysis done (yet)
  - Contains only a limited set of all results

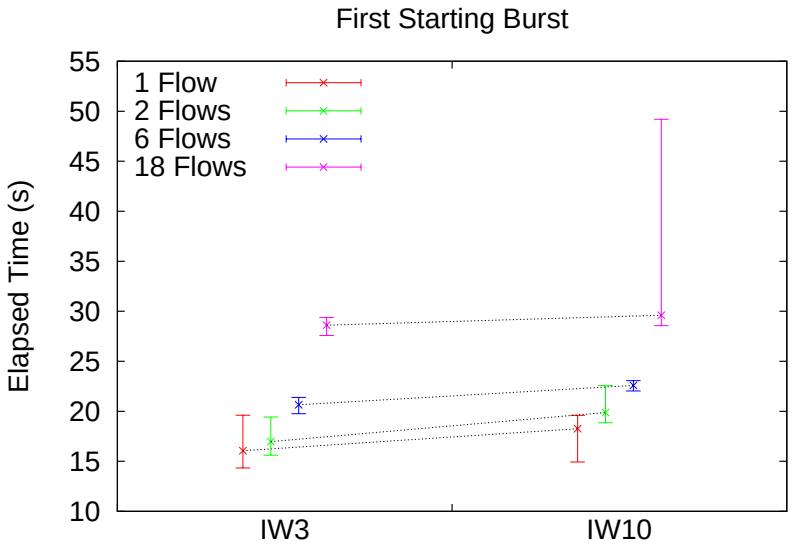
Test setup

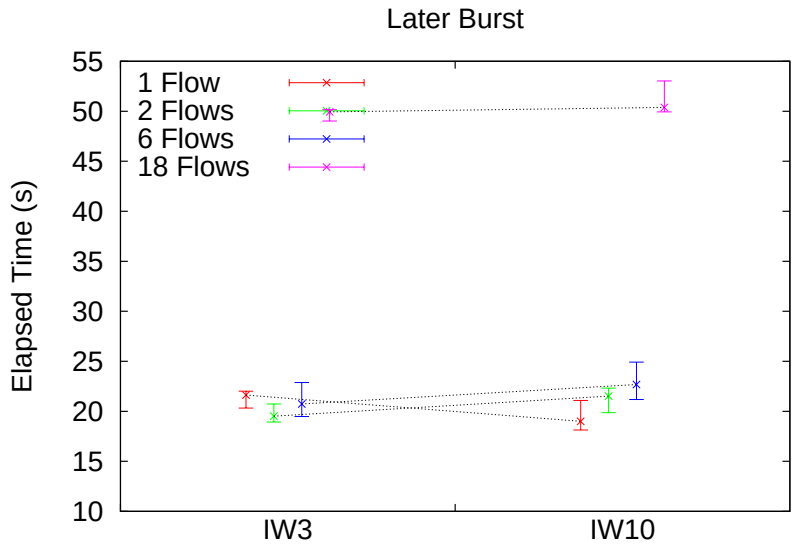
- Links (bw/one-way propagation delay)
  - EGDE 160kbps/250ms, BDP = 7 pkts (6.7)
  - HSPA 2Mbps/70ms, BDP = 24 pkts (23.3)
  - LTE 50Mbps/15ms, BDP = 125 pkts
  - No wireless errors, nor allocation / error related delays considered
- 11ms propagation delay from sender to wireless link
- Buffer sizes
  - BDP (Bandwidth Delay Product)
  - Large (50 pkts, EDGE and HSPA only)
    - Dummy scaling for LTE yields to 933 packets (1.3MB)!
- A later starting burst of 1, 2, 6 or 18 simultaneous TCP flows (total 180kB) competing against:
  - A similar burst (another 180kB)
  - Bulk TCP
- 100 replications per case, start time of the later burst varied

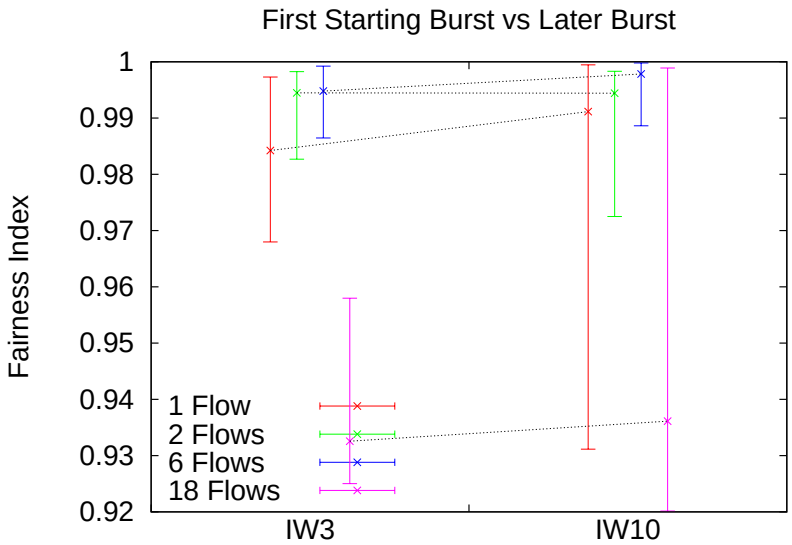
Metrics Used

- The elapsed time reports the elapsed time of the flow that completes last within the burst (25/75th percentile and median shown)
- Fairness calculated according to Jain's Fairness Index:
  $\text{fairness} = \frac{(\sum x_i)^2}{(n \cdot \sum x_i^2)}$

EDGE 160kbps/250ms, BDP Buffer = 7 pkts, n+n Flows



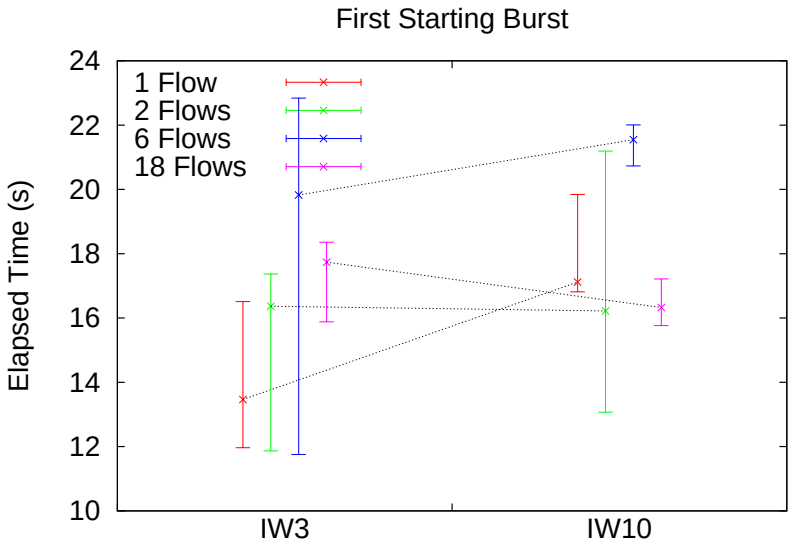


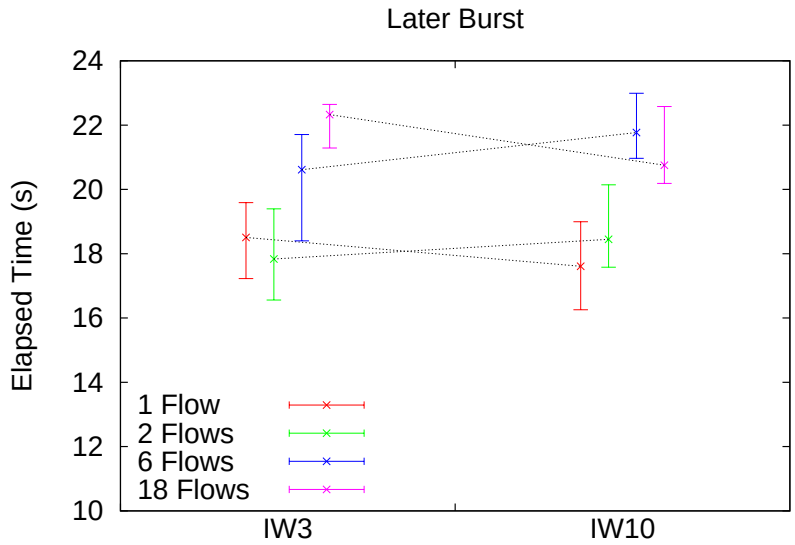


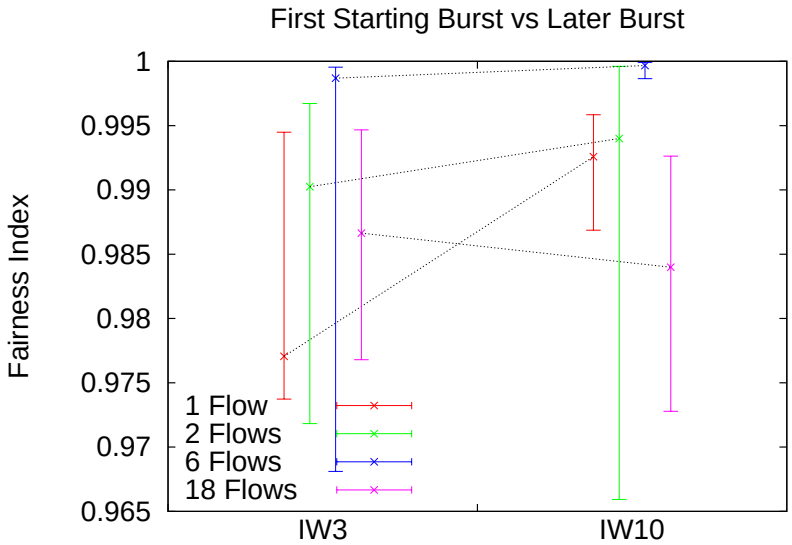
IW10 vs IW3

- First starting burst yields
- Later burst improved only with 1+1 flows
- Median of fairness improves but instability increases

EDGE 160kbps/250ms, Large Buffer = 50 pkts, n+n Flows



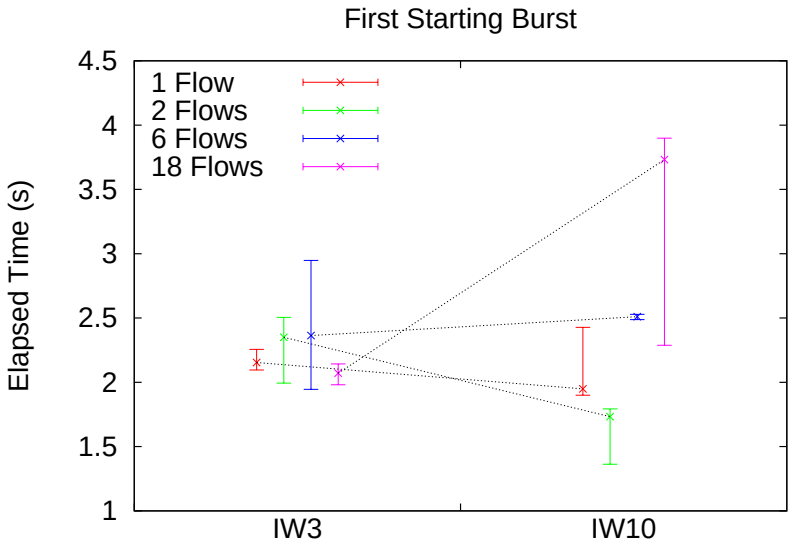


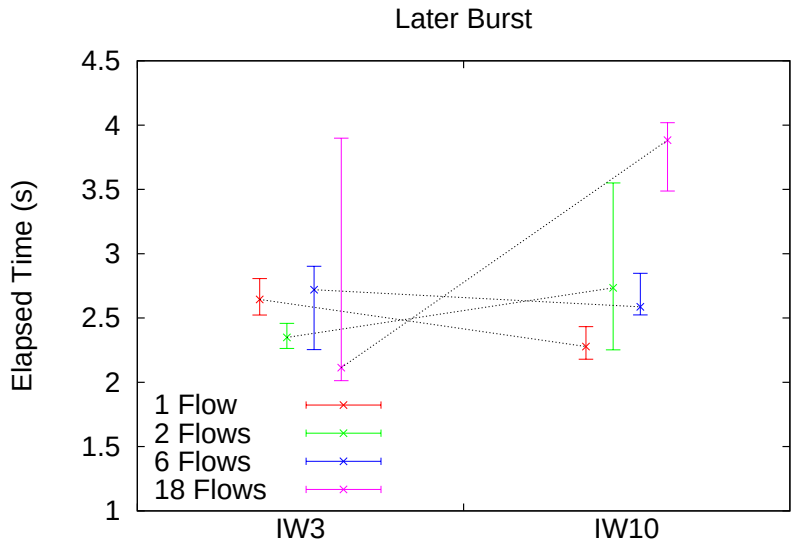


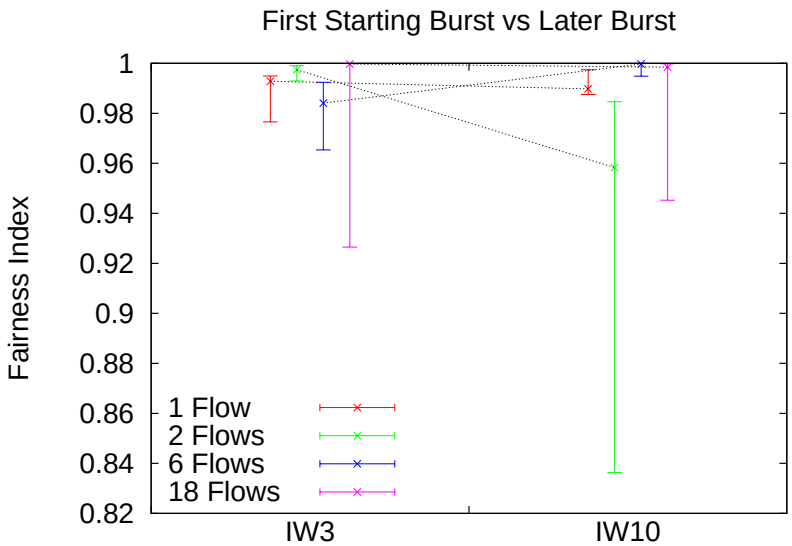
IW10 vs IW3

- First starting burst yields
- Later burst improves only with 1+1 flows
- Fairness improves except for 18+18, also instability increase with 2+2

HSPA 2Mbps/70ms, BDP Buffer = 24 pkts, n+n Flows



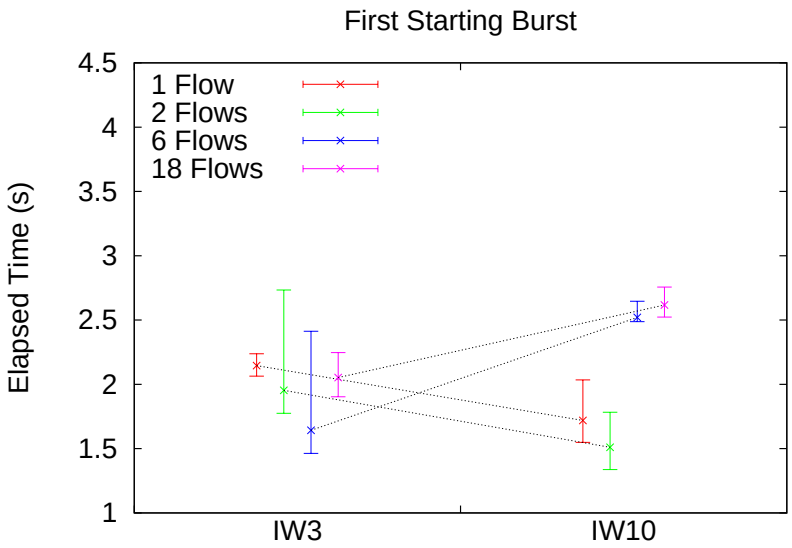


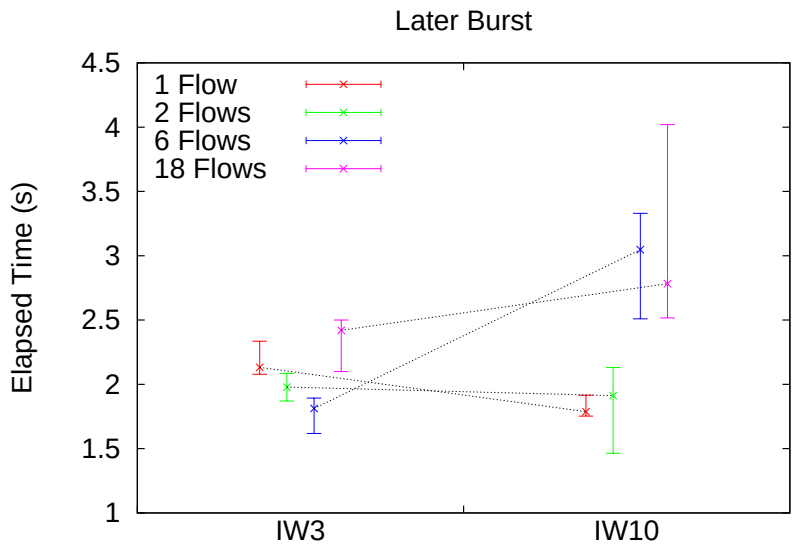


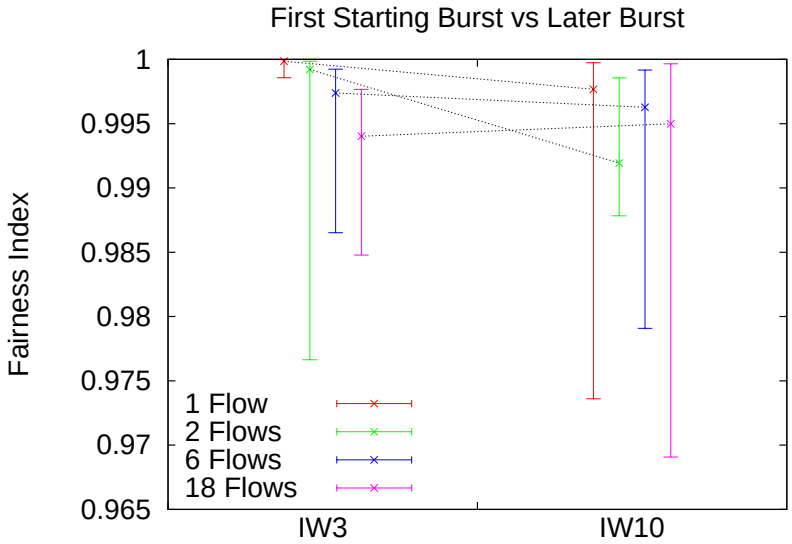
IW10 vs IW3

- 1+1 improves as previously
- With 2+2 overload causes a timeout, both elapsed time and fairness suffer (6+6 outperforms it because first starting burst is hurt more)

HSPA 2Mbps/70ms, Large Buffer = 50 pkts, n+n Flows



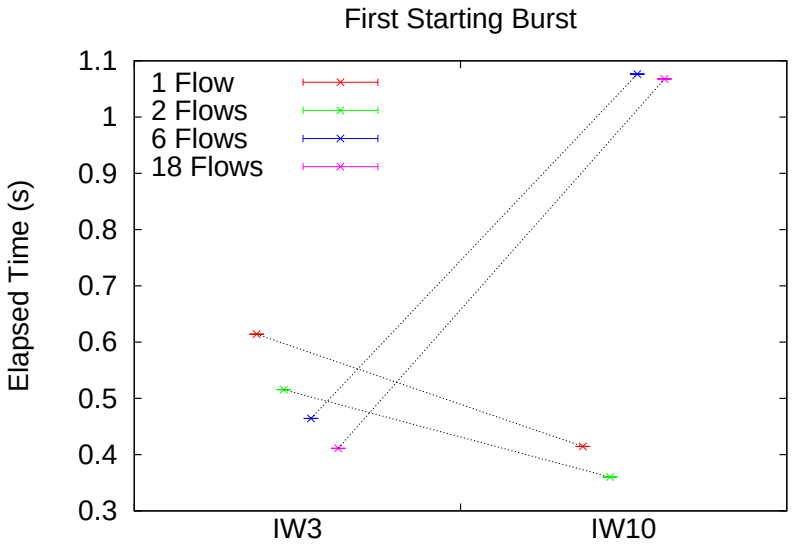


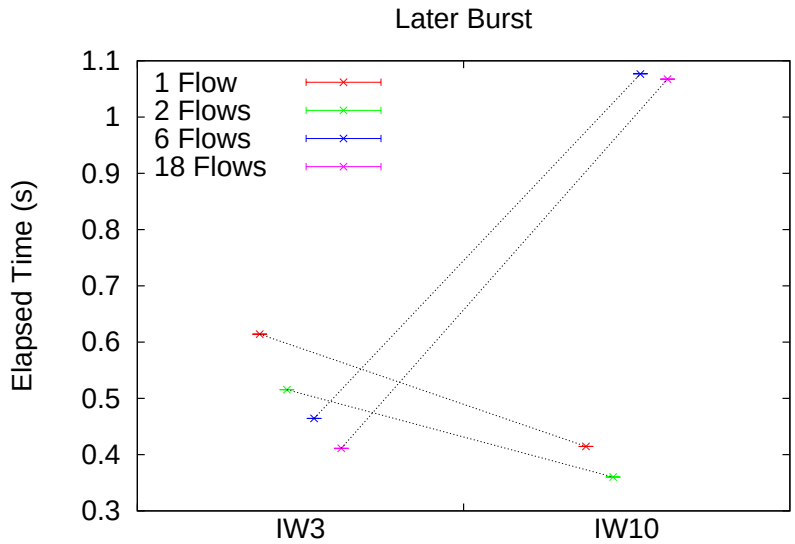


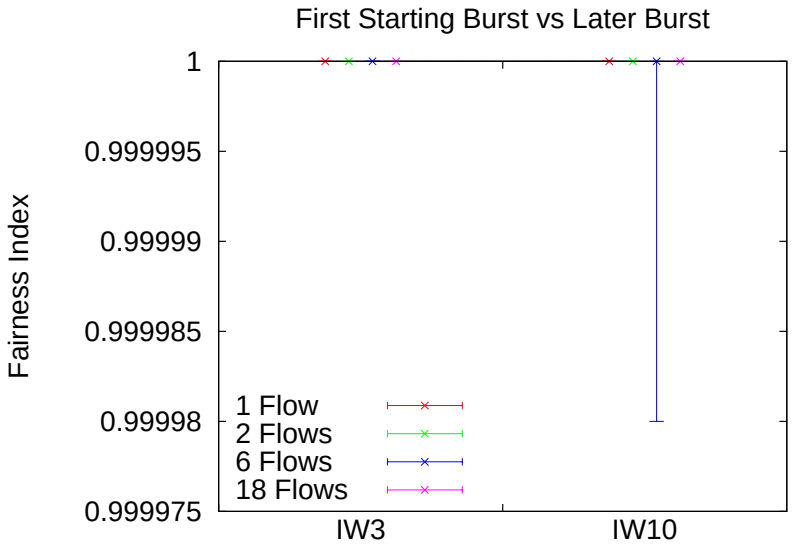
IW10 vs IW3

- 1+1 improves (but more variation in fairness), slight improvement in 2+2
- With 6+6 and 18+18 both bursts complete later

LTE 50Mbps/15ms, BDP Buffer = 125 pkts, n+n Flows







IW10 vs IW3

- 1+1 and 2+2 improve
- IW10 with 6+6 and 18+18 cause losses, reduces performance
- Fairness between bursts very good

Summary, Workload n+n Flows

Elapsed time								
	First starting burst				Later burst			
n+n	n1	n2	n6	n18	n1	n2	n6	n18
edge bdp	—-+	——	——	——	+++	——	——	——
edge large	——	–+–	—-+	+++	+++	——	——	+++
hspa bdp	++–	+++	—-+	——	+++	+—-	–++	——
hspa large	+++	+++	——	——	+++	++–	——	——
lte bdp	+++	+++	——	——	+++	+++	——	——
Fairness within burst								
n+n	n1	n2	n6	n18	n1	n2	n6	n18
edge bdp	n/a	——	+—-	+++	n/a	——	+++	——
edge large	n/a	–++	——	——	n/a	—-+	++–	—-+
hspa bdp	n/a	+—-	——	–++	n/a	——	——	—-+
hspa large	n/a	—-+	——	——	n/a	——	——	——
lte bdp	n/a	——	——	——	n/a	——	——	——
Fairness between bursts (the longest flows)								
n+n	n1	n2	n6	n18				
edge bdp	–++	—-+	+++	–++				
edge large	+++	–++	+++	——				
hspa bdp	+–+	——	+++	+—-				
hspa large	——	+—-	——	–++				
lte bdp	000	000	–00	000				

In each column + indicates improvement with IW10 for 25th percentile, median, 75th percentile

Summary, Workload Bulk TCP + n Flows

Elapsed time				
Bulk+n	n1	n2	n6	n18
edge bdp	++−	−−	−+−	−-+
edge large	+++	+++	−−	−−
hspa bdp	+++	+++	−−	+++
hspa large	+++	+++	−−	−−
lte bdp	+++	+++	−−	−−
Fairness within burst				
Bulk+n	n1	n2	n6	n18
edge bdp	n/a	−−	+−-	+++
edge large	n/a	−−	−−	−−
hspa bdp	n/a	−−	−−	+++
hspa large	n/a	+−-	−−	−−
lte bdp	n/a	−−	−−	−−

In each column + indicates improvement with IW10 for 25th percentile, median, 75th percentile

Conclusion

- With small number of TCP flows, IW10 improves performance
- With larger number of flows, IW10 tends to decrease performance
  - Regardless of IW, too many flows clearly results in suboptimal performance
- Fairness for later starting traffic improves with IW10
- Fairness between flows starting within a burst worse with IW10

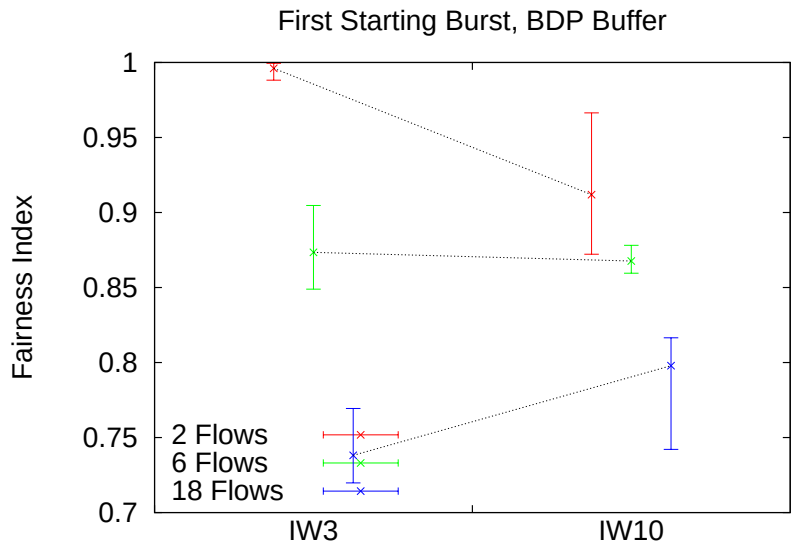
Future Work

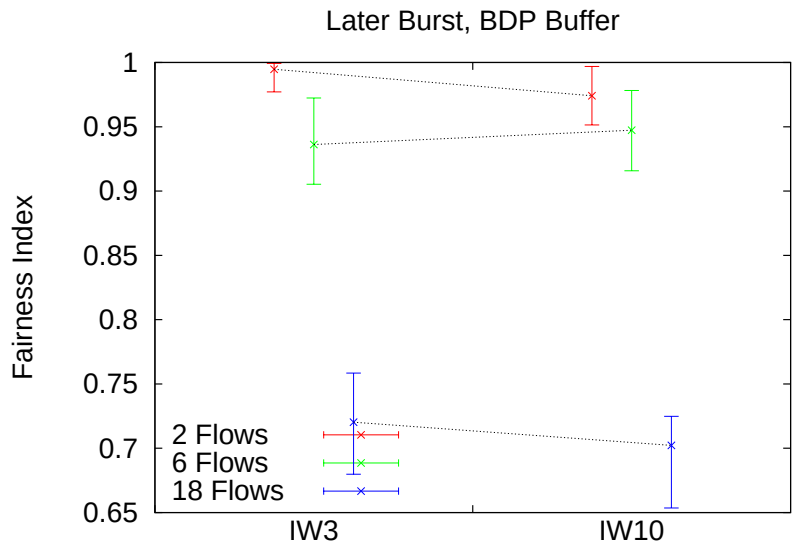
- In depth analysis of the results
- Analysis of workload with mixed filesizes (tests run already)
- Include other variables
  - Initial RTO
  - Longer delay on the Internet side
  - Possibly others...
- Testing in real wireless networks planned

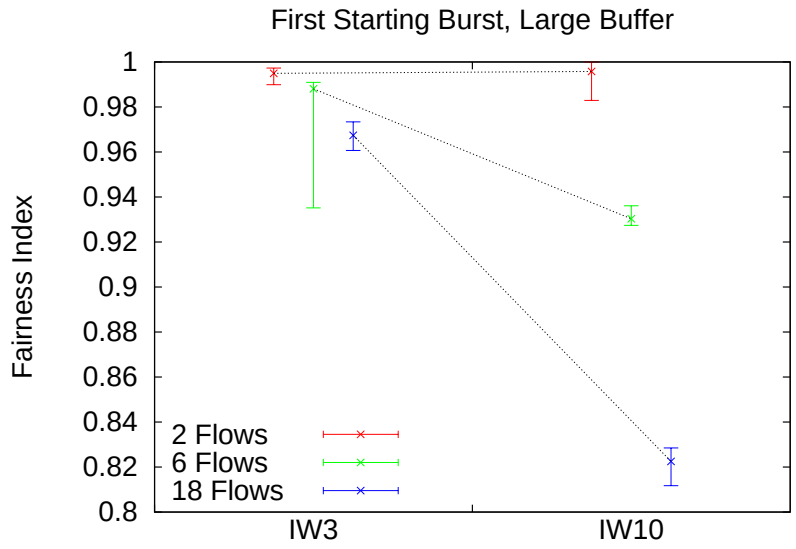
Discussion

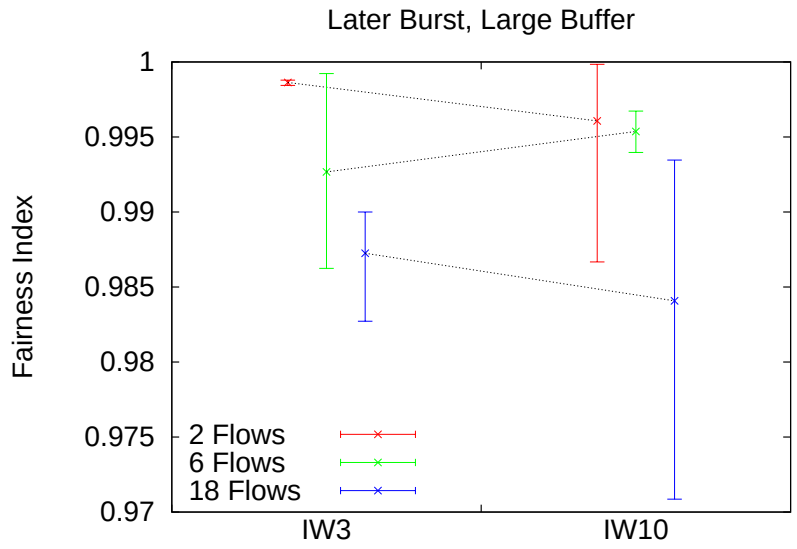
Backup Slides

Fairness EDGE 160kbps/250ms, n+n Flows









HSPA 2Mbps/70ms, n+n Flows