TCP Performance for Vehicular Users through Satellite Links

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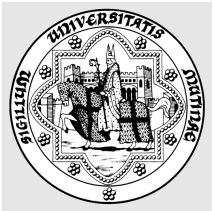

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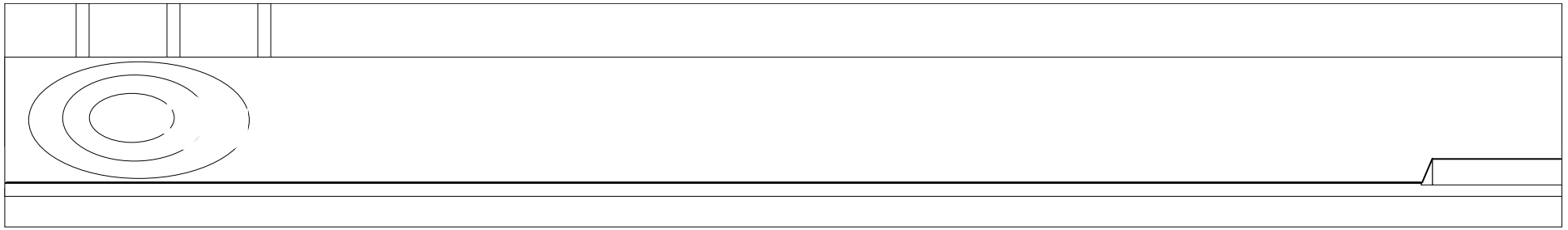
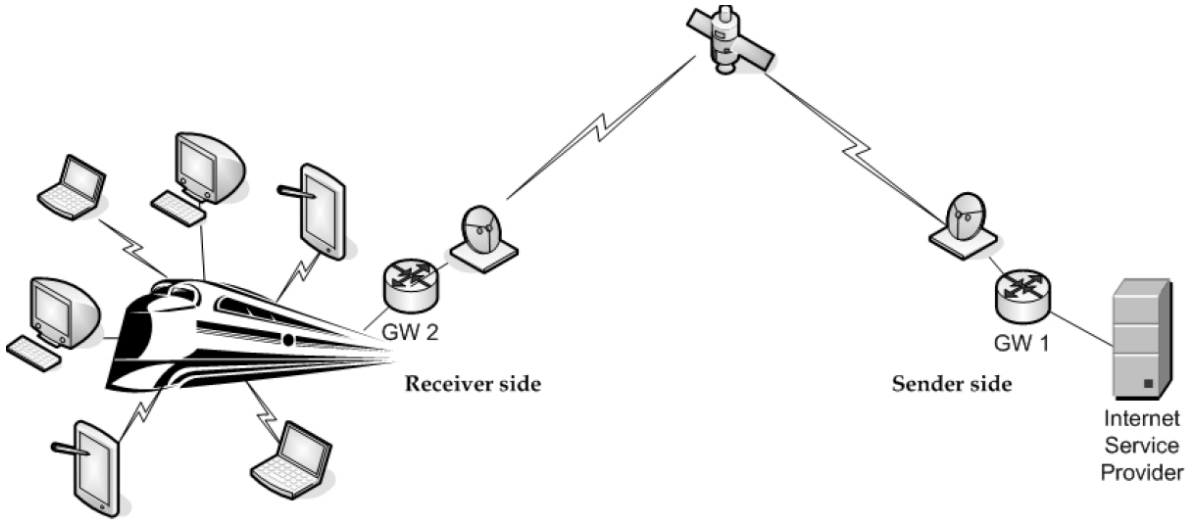
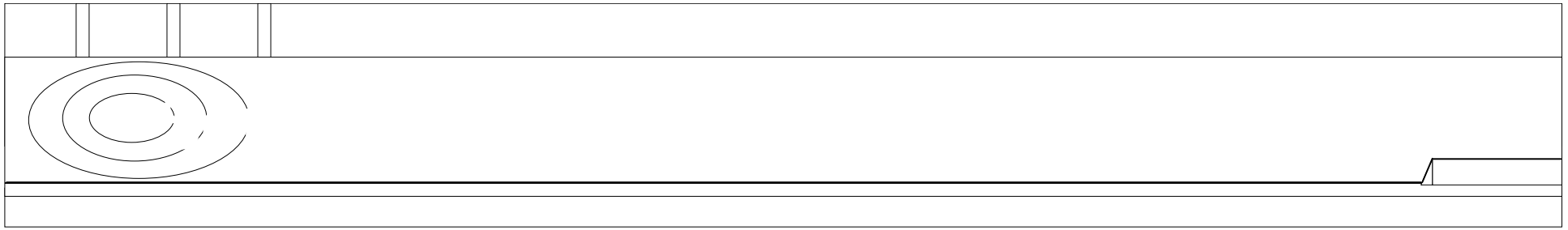


- Introduction: reference scenario
  - multi-segment satellite network
- Target: end-to-end performance evaluation
  - comparison among four TCP flavors
- Performance Enhancing Proxy architecture
- Effectiveness of Window Scale Option and Large Initial Window
- Numerical results
  - Simulation through ns2 tool
- Conclusions

- End-to-end perfomance study (TCP) in presence of satellite and terrestrial links
- Analysis of 2 and 3 segments PEP architectures (symmetric)
- Handover in tunnels
- IEEE 802.11b in the train
- Performance evaluation of 4 TCP flavors (NR+Sack, Vegas, Westwood, Fast TCP) with GEO satellite



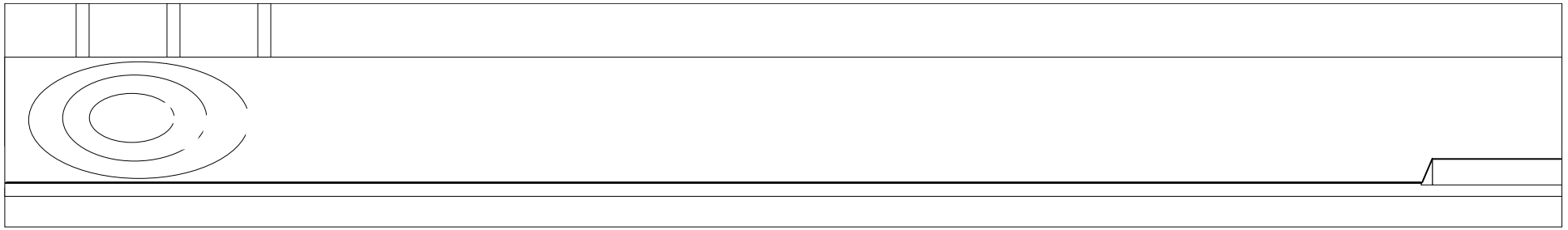


TCP SACK

- SACK option: the receiver informs the sender about the successfully received segments
- sender retransmits lost segments only

TCP Westwood

- estimation of the available bandwidth
- sender continously monitors ACKs from receiver and computes the Eligible Rate Estimate (ERE)
- after apacket loss , sender modifies the values of ***ssthresh*** and ***cwnd*** as a function of ERE



➢ TCP Vegas

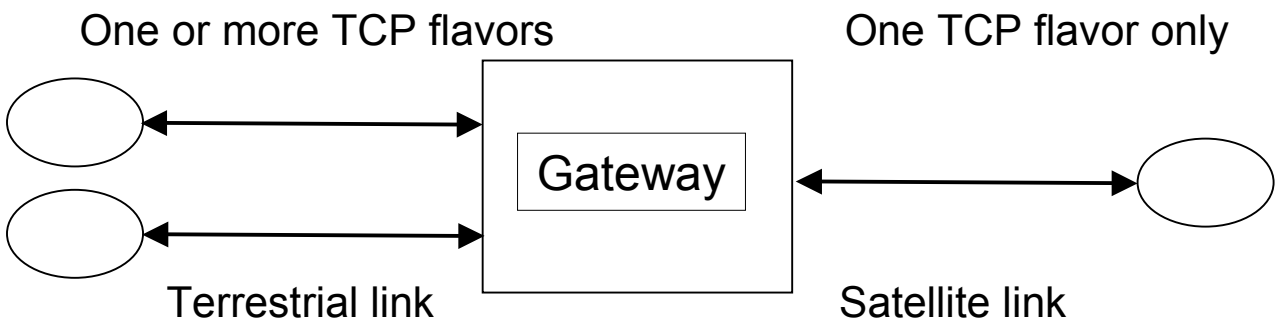
- no need of a loss for reducing the congestion window
- estimation of the *expected throughput*: as the number of bytes in the pipe
- in the event of congestion the *actual throughput* is less than the *expected*
- estimation made every RTT
- *cwnd* lineary increased or decreased as a function of two parameters (α, β)

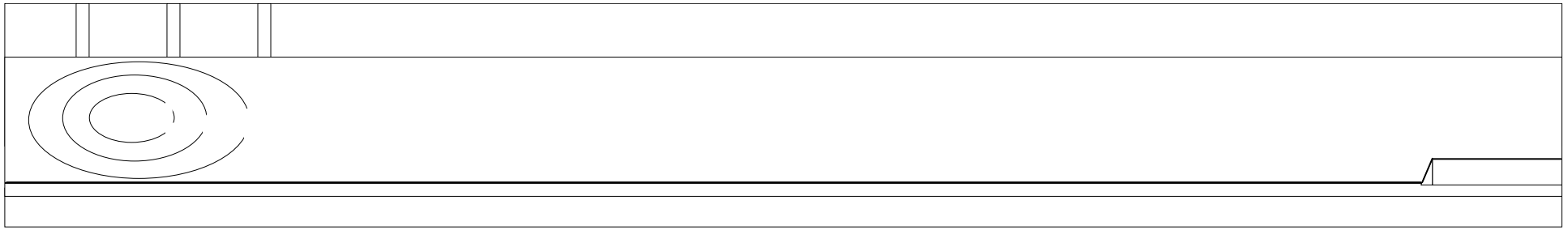
➢ TCP FAST

- congestion control based on queueing delay as measure of congestion
- it aims at fully utilizing link with high bandwidth-delay product
- similar to Vegas but increases and decreases of *cwnd* are larger
- supposed to be a high-speed version of Vegas
- updates periodically cwnd:

  $cwnd \leftarrow \min \{ 2\ cwnd, (1-\gamma) + \gamma\ (\text{baseRTT/RTT}cwnd + \alpha(cwnd, qdelay))\}$

- Many and different TCP versions on the terrestrial side but one on sat side only
- End-to-end connections split in two or three segments (connections)
- All user flows are terminated in GWs and redirected to next hop into new connections which adopt the same TCP flavor
- In case of three segment PEPs, in thethird segment (terrestrial) all flows are reconverted by the second GW to the original TCP flavour





- **Throughput**
  - Measure of the variability of thebandwidth usage over a given time-scale

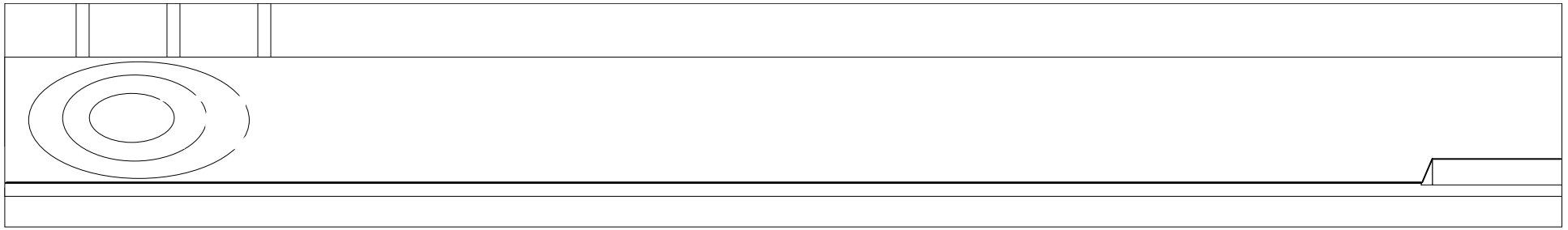
- **Channel Utilization**
  - Related to throughput

$$U = \frac{\sum_{i=1}^{n} B_{P_i}}{Bandwidth}$$

  - B_{Pi} i-th flow throughput for general transport protocol P

- **Fairness**
  - Chiu/Jain's Fairness Index
  - Intra-fairness index
  - Best intra-fairness => F=1

$$F_{\text{intra}} = \frac{B_{P,\min}}{B_{P,\max}}$$



- **Window Scale**
  - Maximum Window Scale of standard TCP is 64 Kbytes: small for satcom
  - Receiver window is increased by setting a scale factor in the TCP header
  - Scale factor is a power of two
  - Goal: improve the throughput limit of:

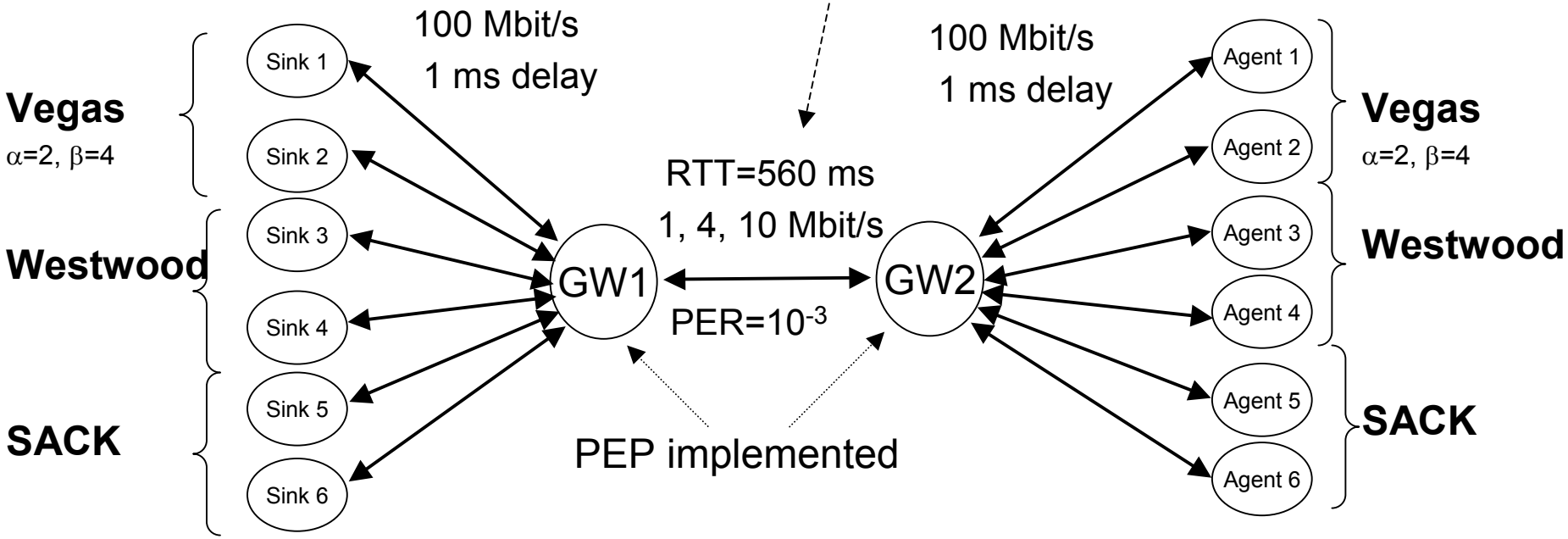
$$Throughput = \frac{window\_size}{RTT} = \frac{64KB}{550ms} \cong 1Mbit/s$$

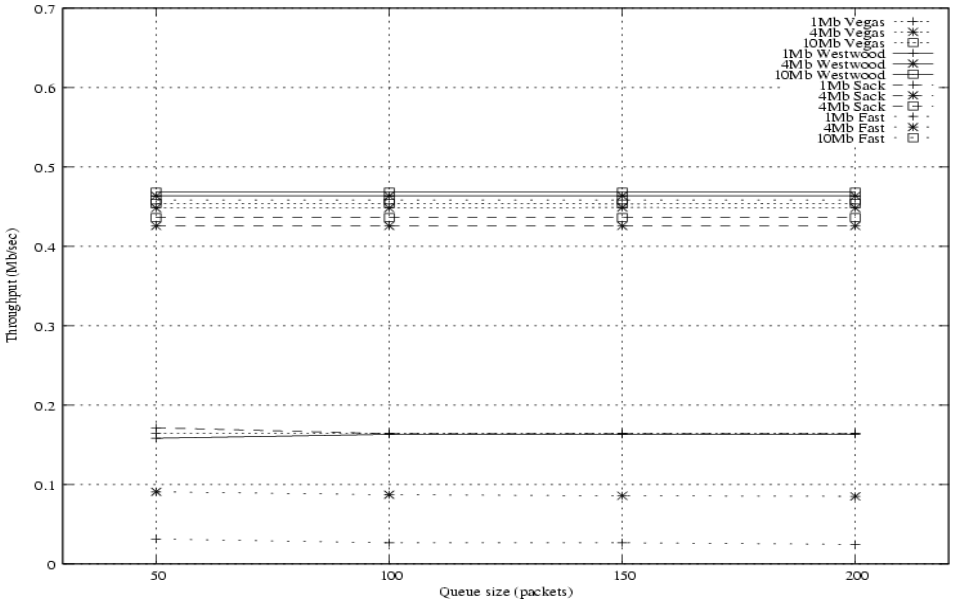
- **Large Initial Window**
  - *Cwnd* determines the amount of data transmitted
  - with high RTT the slow start phase may limit TCP performance
  - It proposes to start with larger values of *cwnd*
  - Slow start phase can be remarkably reduced

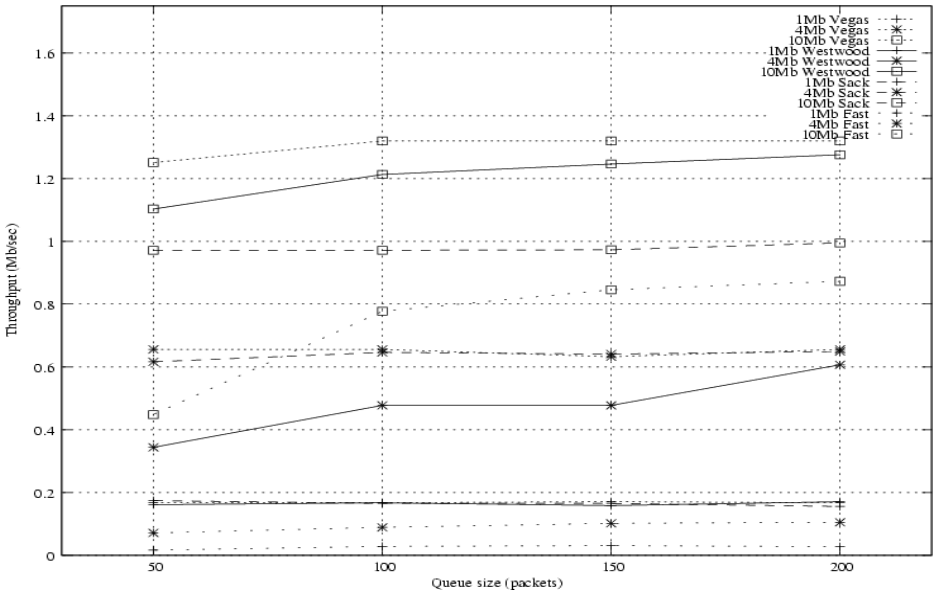
ns-2 version 2.28

All TCPflows converted to :

- SACK or
- Vegas or
- Westwood or
- Fast (α=β=100)







- Satellite links bw: 1, 4, 10 Mbit/s
- Fast TCP: low performance for low bw
- Westwood and Vegas are the best

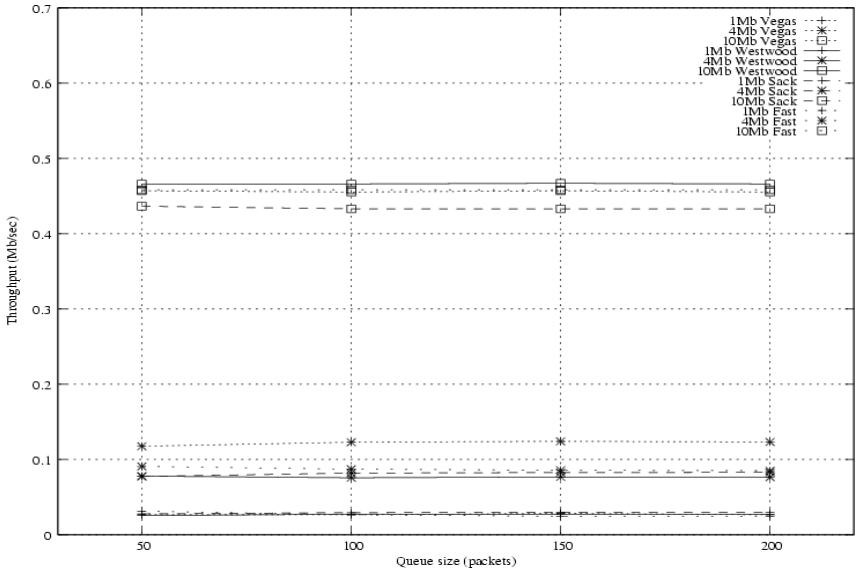
- **with Large Initial Window and WSO**
- Great benefit from their use
- Vegas is the best performing
- Westwood performs well with large buffers
- BWxDelay not so high for Fast

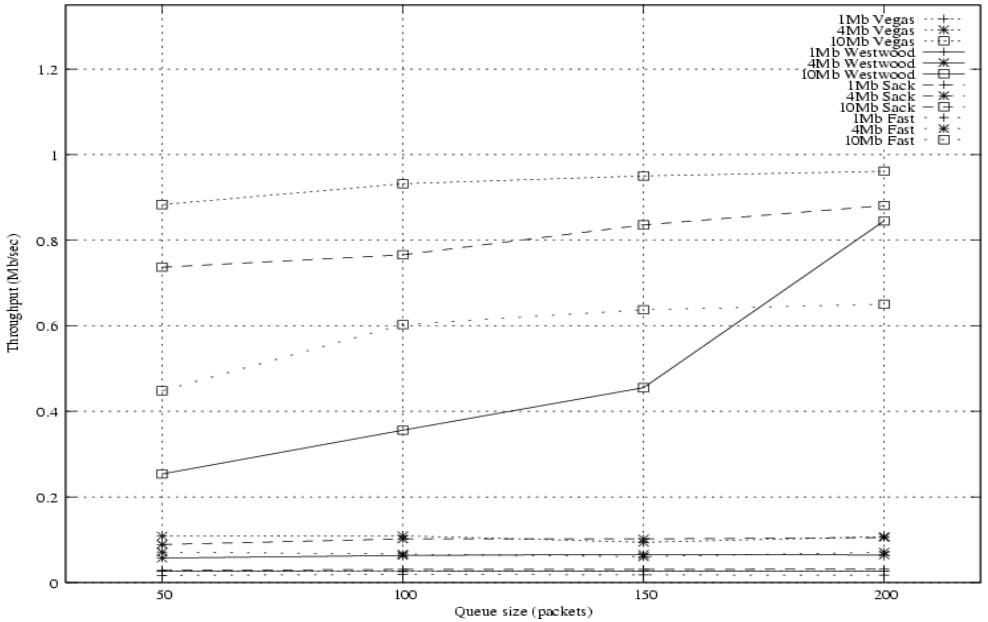
	1 Mb/s	4 Mb/s	10 Mb/s
Sack	0.89	0.92	0.94
Vegas	0.82	0.97	0.96
Westwood	0.91	0.98	0.98
Fast	0.87	0.88	0.93

- Fairness with no options
- 200 packets queue length
- All TCPflavors show high fairness values

- Fairness with WS and LIW on
- 200 packets queue length
- Fairness generally decreased
- TCP FAST the best
- Westwood the worse

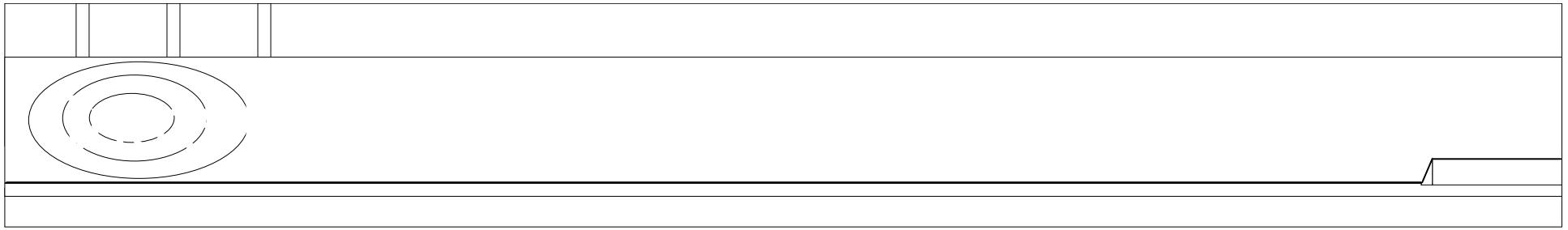
	1 Mb/s	4 Mb/s	10 Mb/s
Sack	0.71	0.69	0.78
Vegas	0.70	0.70	0.77
Westwood	0.57	0.36	0.37
Fast	0.81	0.87	0.93





- Satellite links bw: 1, 4, 10 Mbit/s
- 2 CBR over UDP at 250 Kbit/s
- strong impact for 1 and 4 Mbit/s
- TCP not penalized with BW=10 Mbit/s

- **with Large Initial Window and WSO**
- Great benefit from their use
- Vegas is again the best performing
- Westwood improves with very large buffers



	1 Mb/s	4 Mb/s	10 Mb/s
Sack	0.79	0.84	0.95
Vegas	0.37	0.71	0.96
Westwood	0.72	0.81	0.92
Fast	0.16	0.33	0.65

- Fairness with no options
- 200 packets queue length
- General performance degradation with respect to TCP flows without UDP
- Good fairness for 10 Mbit/s except for FAST which is the worst

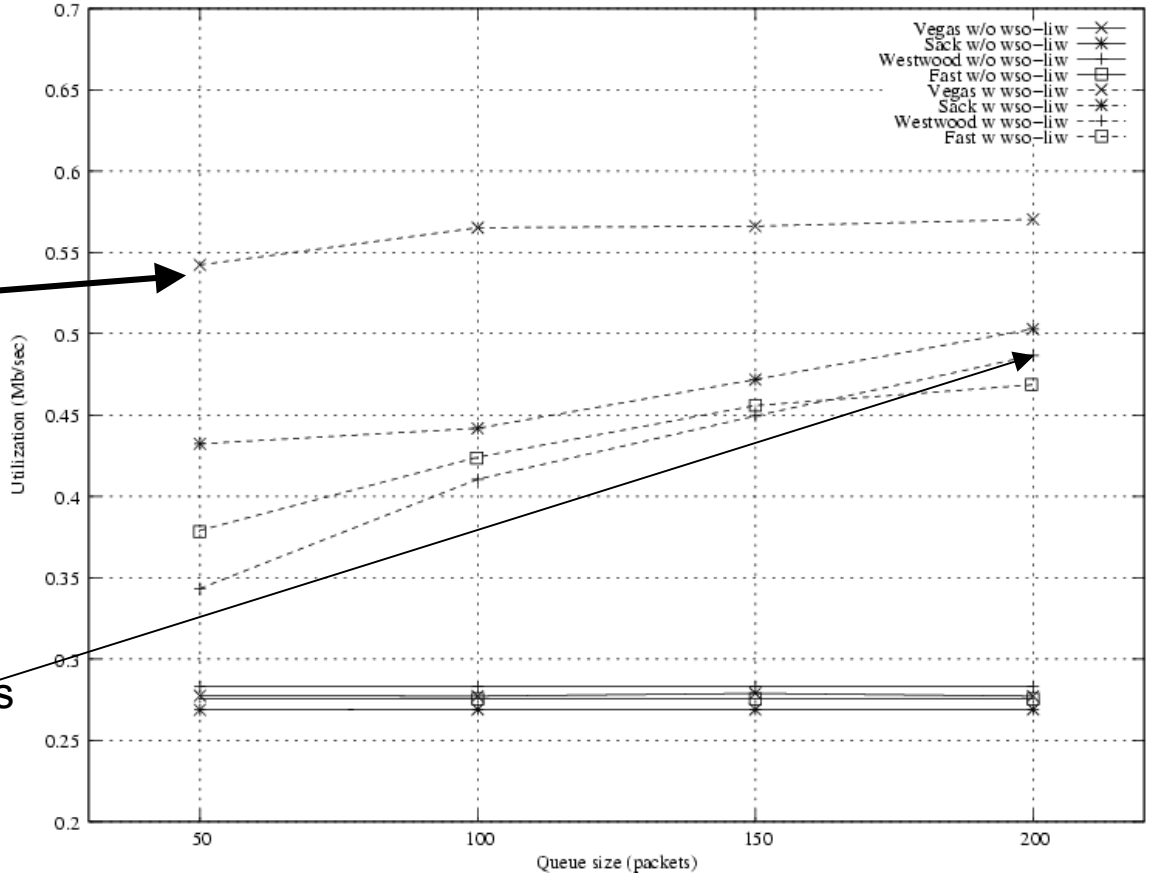
- Fairness with WS and LIW on
- 200 packets queue length
- Fairness generally decreased
- TCP Vegas and FAST are the best for 10 Mbit/s

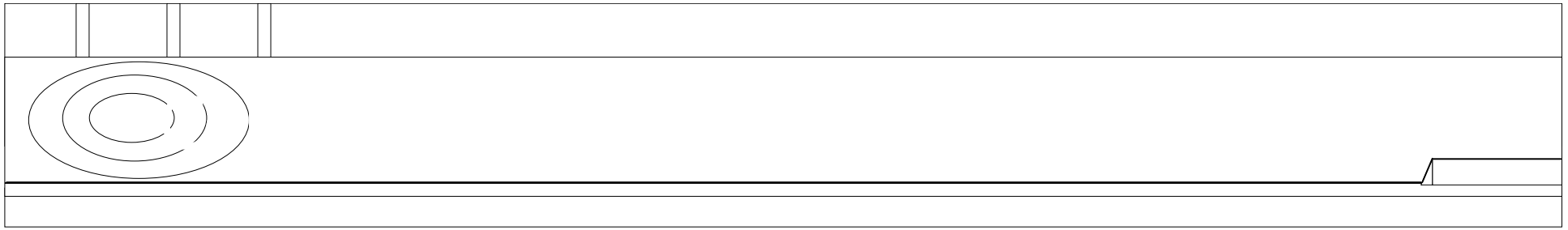
	1 Mb/s	4 Mb/s	10 Mb/s
Sack	0.82	0.70	0.74
Vegas	0.37	0.41	0.83
Westwood	0.81	0.51	0.46
Fast	0.26	0.32	0.85

- Six TCP and 2 UDP flows
- with Large Initial Window and WSO
- satellite BW = 10 Mbit/s

- Vegas is the best
  for channel utilization and
  for buffer utilization

- Westwood bw estimator is effective
  only with large output buffers





- A multi-segment satellite network for serving fast trains has been studied
- Three segments PEP architecture has been employed to improve end-to-end performance
- Several TCP flavours have been employed and evaluated in the satellite link by means of simulation
- TCP performance determined by throughput, fairness and utilization
- Benefits from Window Scale and Large Initial Window options
- Effects of multimedia streams (i.e. UDP flows) on TCP
- Results:
  - Vegas has revealed as the best in presence of multimedia flows with options on
    - Best in terms of throughput and buffer usage, good in terms of fairness
  - Westwood shows good throughput with very large buffers only and low fairness with WS and LIW
  - FAST does not make to be effective due to the not so high bw-delay product
- Current works deal with terrestrial hand-over in case of satellite link outage

THANK YOU FOR YOUR ATTENTION

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… suggestions are very very welcome