EE542 - Reading Assignment – 03

Generalized Window Advertising for TCP Congestion Control

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Paper’s main ideas

- Introducing a new approach to enhance TCP’s congestion controlling property: **Generalized Window Advertising (GWA)**
- Analyzing GWA’s properties and performance under various networks conditions
- Comparing GWA-TCP with traditional TCP congestions controlling performances

Generalized window advertising (GWA) TCP

- TCP's congestion control mechanisms:
  - Receiver advertised window (rcvwnd) field in **TCP datagram** - W_a
  - Amount of data allowed to be transferred is calculated by:

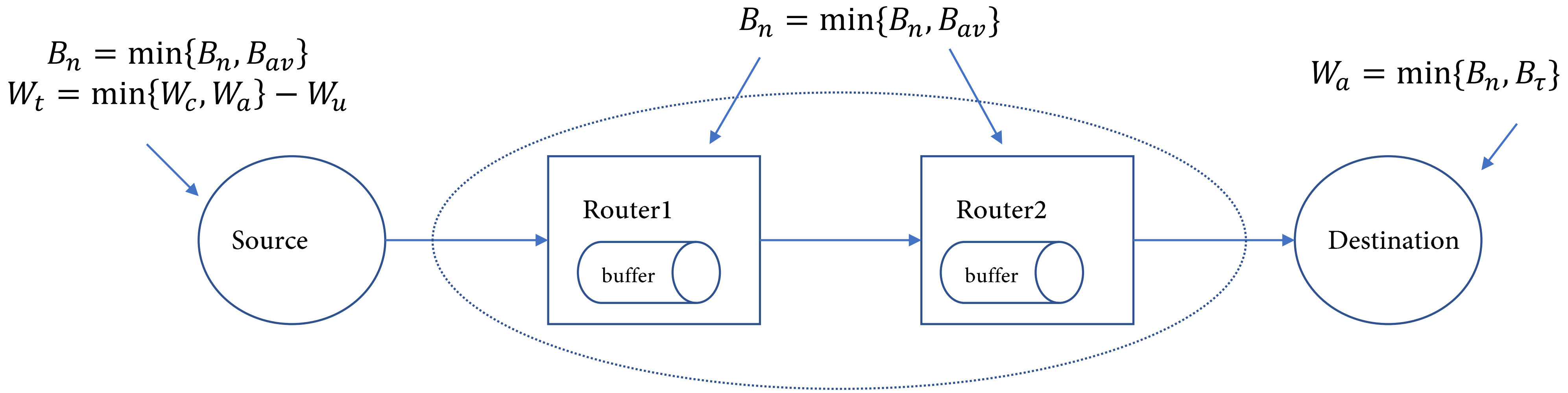
$$W_t = \min\{W_c, W_a\} - W_u$$

  - Where W_c: congestion window size, W_u: outstanding datagrams amount
- GWA key mechanisms:
  - To "generalize" the interpretation and function of W_a, using it convey both the receiver available buffer space B_τ and network congestion status B_n

$$W_t = \min\{B_\tau, B_n\}$$

Generalized window advertising (GWA) TCP

- GWA deployment in a simple network:



GWA's properties and modeling approximations

- GWA always ensures zero loss probability, regardless of the statistical fluctuations of the disturbances.
- This means that there are no losses **even if there is somewhere along the path where the bandwidth goes abruptly to zero**.
- The property can be rigorously verified in the model proposed in this paper, but the real system requires a reinterpretation of more properties:
  - TCP's discrete behavior
  - The effect of transient TCP dynamics

Buffer management policies

Three buffer management policies applied to GWA-TCP

I. Routers with per-flow RR queuing discipline

$$B_{n,i} = \min\left\{B_{n,i-1}, \left\lceil \frac{B_t}{n_f(t)} - q_i^l(t) \right\rceil\right\}$$

II. Routers with FCFS queuing discipline

$$B_{n,i} = \min\left\{B_{n,i-1}, \left\lceil \frac{B_t - q_t^l(t)}{n_f(t)} \right\rceil\right\}$$

III. Bandwidth Aware Routers

$$B_{n,i} = \min\left\{B_{n,i-1}, \left\lceil v_i \cdot d_i - \frac{q_t(t)}{n_f(t)} \right\rceil\right\}$$

Comparison with traditional TCP implementations under various network conditions

- **Comparison settings:**

- Extensions/modifications to the basic ns-2 infrastructure:
  - TCP dynamic window advertisement
  - Introduction of the optional field in the IPv6 header, plus the fields for BA-TCP Implementation of Eq.(2) in GWA-TCP receivers, and the additional control algorithm at the source in BA-TCP
  - Implementation of IP routers which advertise Bn or the available bandwidth vi

- The 6 TCP implementations:
  - TCP-Reno and standard FCFS queuing IP routers, in the sequel named Drop-Tail
  - TCP-Reno and RED IP routers, named RED
  - TCP-Reno with ECN (Explicit Congestion Notification) capabilities and tagging RED IP routers, named ECN
  - TCP-Reno with GWA capabilities and per-flow queuing, RR IP routers, named GWA-RR
  - TCP-Reno with GWA capabilities and FCFS queuing IP routers, named GWA-FCFS
  - TCP-Reno with Bandwidth Aware GWA capabilities; FCFS IP routers capable of measuring the available bandwidth, named BA-FCFS.

Comparison with traditional TCP implementations under various network conditions

- **LAN environments:**
  - Any GWA algorithm ensures perfect fairness and full utilization even with small router buffer size
  - With GWA-FCFS, both the average and the maximum delay increase with buffer size, since the aggregate queue stabilizes to a higher value when the buffer is large. BA-FCFS yields negligible delays since it drives the overall queue length to zero. ECN Telnet delays are also very low.
  - GWA schemes exhibit very stable behavior, without packet drops even during the initial transient.

Comparison with traditional TCP implementations under various network conditions

- **WAN environments:**
  - The fairness improvement as the buffer size increases for GWA-FCFS is explained by the increased buffer occupancy and therefore increased round trip time (RTT) seen by TCP sources.
  - The throughput performance is consistent with the packet loss and delay for GWA-TCP.
  - GWA transient behavior is quite good, although a high frequency ripple is noted, especially with the RR discipline.
  - Both GWA implementations perform remarkably well in a “many flows” situation, with full link utilization and perfect fairness.
  - GWA-FCFS fairness improves when increasing the number of active connections and reducing the available bandwidth.

Conclusions

- Conclude GWA definitions and dependencies:
  - The GWA algorithm presented a new approach to TCP congestion control.
  - The scheme relies on the cooperation between IP network entities (routers) and host based TCP entities.
  - The window control algorithm is based on a classical control theory approach known as Smith Predictor.
- GWA advantages over traditional TCP:
  - GWA in general attains a more stable network operation as well as a higher degree of fairness.
  - It guarantees a loss free operation as predicted by theory.
  - Throughput performance depends on propagation delays and router buffer size; in typical operating conditions, GWA ensures full link utilization.
- GWA's Compatibilities
  - GWA is backward compatible with all TCP versions. Namely, GWA- and non-GWA TCP hosts can always communicate with each other.

Thanks for watching!

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