HTTP Experiments in Satellite-Based Networks

Mark Allman
NASA Glenn Research Center
mallman@grc.nasa.gov
http://roland.grc.nasa.gov/~mallman

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In collaboration with: Hans Kruse (Ohio U), Jim Griner (GRC), Diepchi Tran (GRC)

*"Open up your engines let 'em roar
Tearing up the highway like a big ol' dinosaur" – BS*

Goals

- Study the impact of GEO satellite channels on popular versions of HTTP
  - Which are "long-delay" friendly? Which are not?
- Perform a preliminary study of the impact of bit-errors on HTTP transfers
- Develop a model that captures many of the current versions of HTTP

Experiment References

- Experiment References
  - Hans Kruse, Mark Allman, Jim Griner, Diepchi Tran. *HTTP Page Transfer Rates Over Geo-Stationary Satellite Links*. March 1998. Proceedings of the Sixth International Conference on Telecommunication Systems. http://roland.grc.nasa.gov/~mallman/papers/nash98.ps
  - Hans Kruse, Mark Allman, Jim Griner, Diepchi Tran. *Experimentation and Modeling of HTTP Over Satellite Channels*. March, 1999. Under submission.

TCP

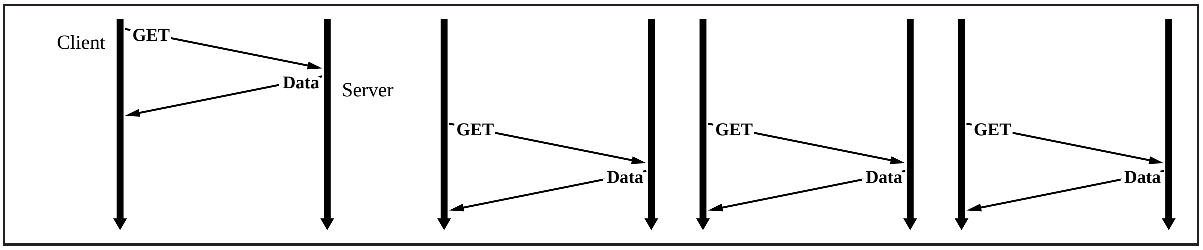
- WWW traffic is delivered using the HTTP application protocol
- TCP provides reliable delivery to HTTP
- Our TCP stack:
  - NetBSD 1.2.1 TCP implementation
    - TCP Reno
  - several bug fixes [All97]
  - some tests used experimental larger initial window [AFP98]

HTTP

- Various versions in use
- Each web page is made up of multiple elements
  - Base HTML page (text)
  - Images
  - Java
  - etc.

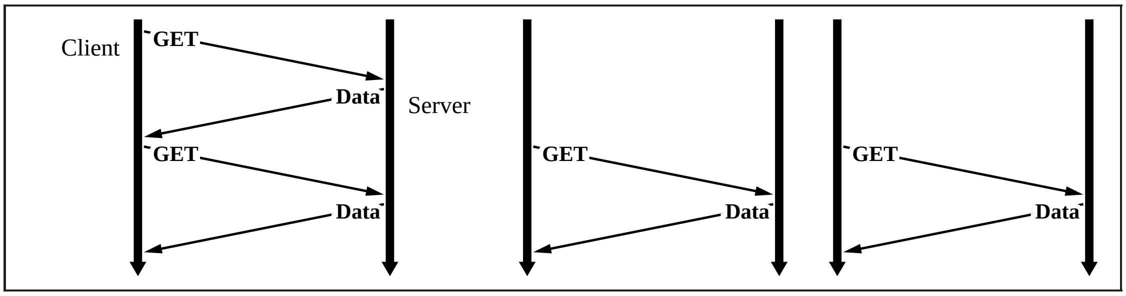
HTTP/1.0

- HTTP/1.0 – original version [BLFN96]
  - each page element is transfered on a separate TCP connection
  - multiple concurrent connections often used



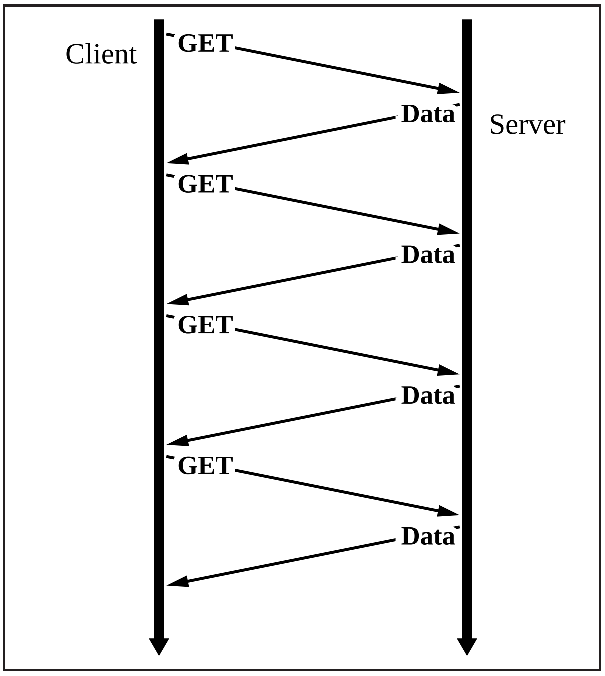
HTTP/1.0 with Persistent Connections

- HTTP/1.0 with Persistent Connections
  - originally outlined in [Mog95]
  - allows a connection to be used for multiple elements
  - concurrent connections often used



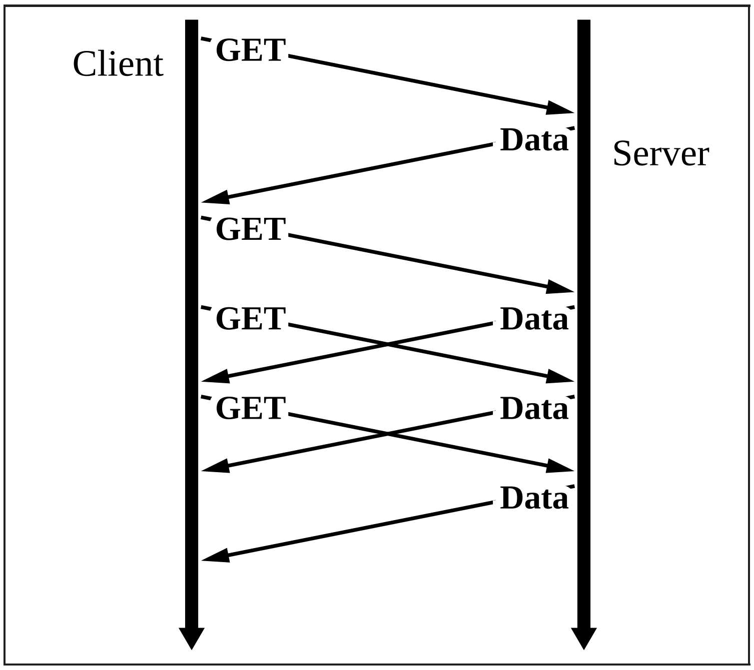
HTTP/1.1

- HTTP/1.1 [FGM+97]
  - single connection used for all page elements
    - the spec actually supports two concurrent connections, however this is not used often and therefore we did not experiment with this option



HTTP/1.1 with Pipelining

- HTTP/1.1 also supports pipelining
  - allows requests to be sent to the server while the server is sending data to the client



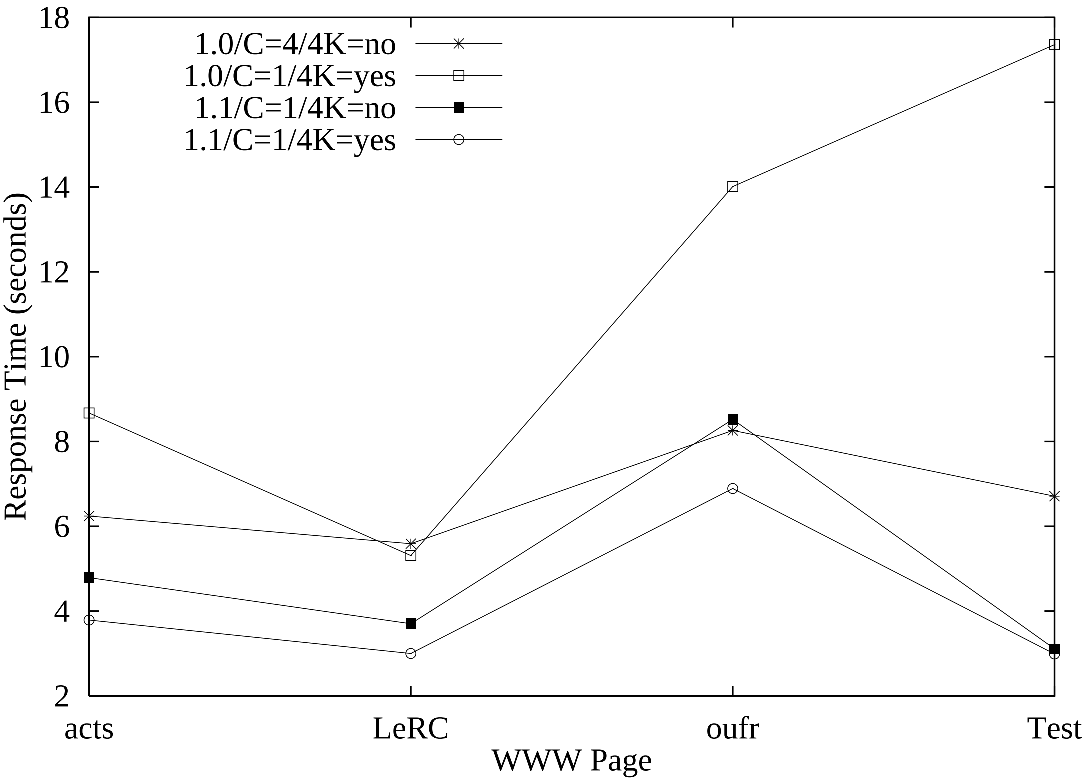
Experimental Setup

- Point-to-point ACTS satellite link
  - between GRC and Ohio University
  - T1 bandwidth
  - $\approx$ 575ms RTT
  - no congestion
- Various WWW pages transferred:

Page	Number of Elements	Page Size (KB)
LeRC	4	48
acts	9	99
oufr	10	491
Test	28	28

Results

- Comparison of HTTP versions
  - all errored runs removed

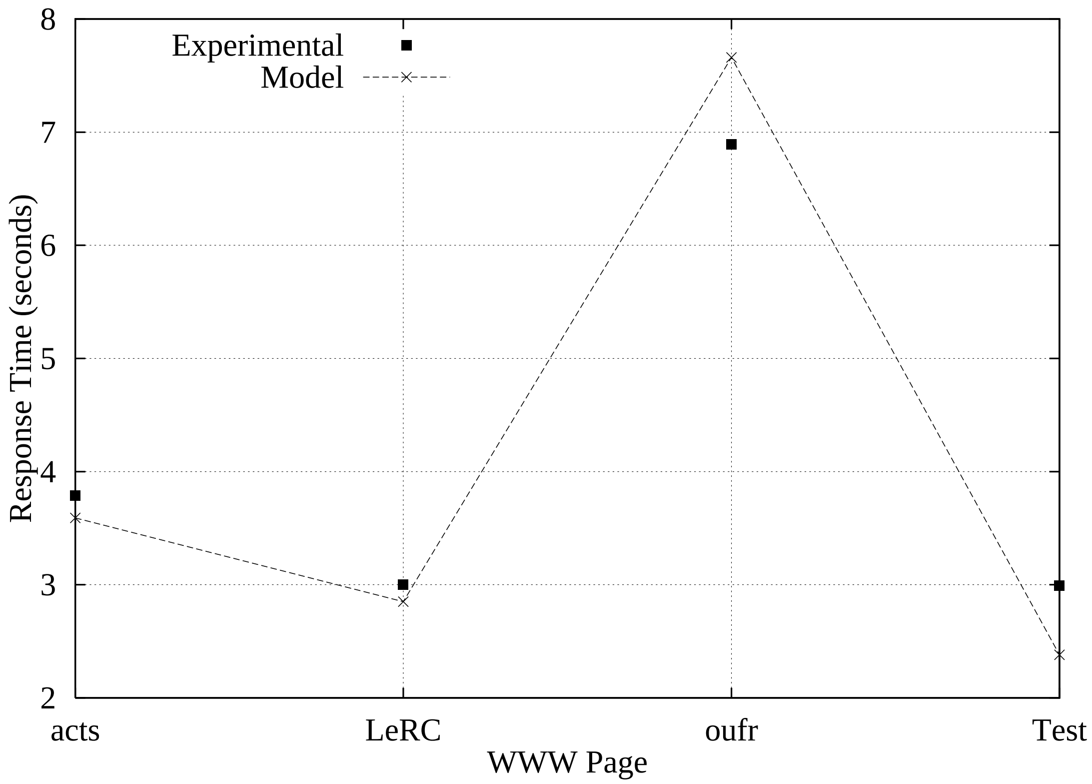


Results (cont.)

- Key Findings:
  - HTTP/1.1 with pipelining provides shorter transfer time than HTTP/1.0 (even with 4 parallel connections) for the WWW pages used in our study
  - Using a larger initial window further reduces the transfer time
  - And, using a single connection is network-friendly and does not contribute to congestion collapse [FF98]

Results (cont.)

- Our model (based on [HOT97]) accurately predicts transfer time
- Example:



Results (cont.)

- Impact of bit-errors on HTTP performance
  - Strong FEC employed on the satellite channel
  - These results are only an *indication* of the impact of bit-errors on HTTP traffic
  - Future work includes a more comprehensive evaluation of how bit-error rates impact TCP traffic

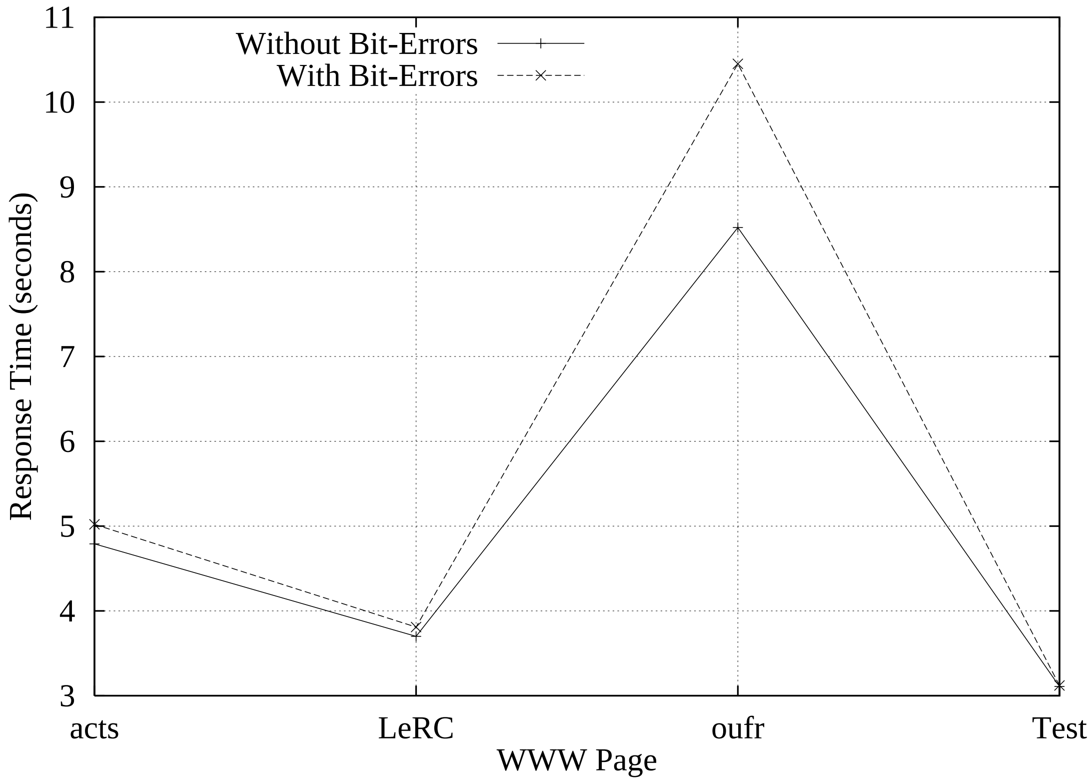
Results (cont.)

- Prevalence of bit-errors:

Page	**Corrupted Transfers (%)**
LeRC	7
acts	13
oufr	41
Test	2

Results (cont.)

- Impact of bit-errors on HTTP/1.1 transfers



Results (cont.)

- Bit-errors had a small impact on performance in our tests
- Findings:
  - The busier the channel the more likely a packet is going to experience a bit-error
  - HTTP has some natural lulls such that the channel is not always busy, and thus avoids some bit-errors that way

Results (cont.)

- Findings (cont.):
  - Bit-errors are interpreted as congestion and cause a reduction in sending rate
    - This impact is not large in short HTTP transfers that do not have a high sending rate to begin with
    - This impact is worse on bulk transfers, as evidence by the performance of the *oufr* WWW page, as well as various works in the literature

Conclusions

- We have developed and verified a model of HTTP performance that includes a number of popular versions of HTTP.
- We have shown that HTTP/1.1 with pipelining reduces HTTP transfer time in networks with satellite paths.
- We have presented a *preliminary* finding that suggests that a non-zero BER is not a large problem for HTTP.

References

- References:

  - [AFP98] M. Allman, S. Floyd, C. Partridge. Increasing TCP's Initial Window, September 1998. RFC 2414. http://ftp.isi.edu/in-notes/rfc2414.txt
  - [All97] M. Allman. Fixing Two BSD TCP Bugs. Technical Report CR-204151, NASA Lewis Research Center, October 1997. http://roland.grc.nasa.gov/~mallman/papers/bugs.ps
  - [BLFN96] T. Berners-Lee, R. Fielding, H. Nelson. HyperText Transfer Protocol – HTTP/1.0, May 1996. RFC 1945. http://ftp.isi.edu/in-notes/rfc1945.txt
  - [FF98] S. Floyd, K. Fall. Promoting the Use of End-to-End Congestion Control in the Internet. Technical Report, LBNL, February 1998. ftp://ftp.ee.lbl.gov/papers/collapse.feb98.ps
  - [FGM+97] R. Fielding, J. Gettys, J. Mogul, H Frystyk, T. Berners-Lee. HyperText Transfer Protocol – HTTP/1.1, January 1997. RFC 2068. http://ftp.isi.edu/in-notes/rfc2068.txt
  - [HOT97] J. Heidemann, K. Obraczka, J. Touch. Modeling the Performance of HTTP Over Several Transport Protocols. IEEE/ACM Transactions on Networking, 5(5):616–630, October 1997. http://www.isi.edu/~johnh/PAPERS/Heidemann96a.html
  - [Mog95] J. Mogul. The Case for Persistent-Connection HTTP. In ACM SIGCOMM, pages 299-313, 1995. http://www.acm.org/sigcomm/ccr/archive/ccr-toc/ccr-toc-95.html