The University of North Carolina at Chapel Hill
Department of Computer Science

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Tracking the Evolution of Web Traffic: 1995-2003

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http://www.cs.unc.edu/Research/dirt

Web Traffic Measurement and Analysis at UNC-Chapel Hill

- In 1997, *populating web traffic generators* for experimental networking research motivated a large-scale study of web traffic at UNC with three goals:

✓Develop a light-weight methodology
  – Based on passive measurement
  – *Easy* to maintain models up-to-date

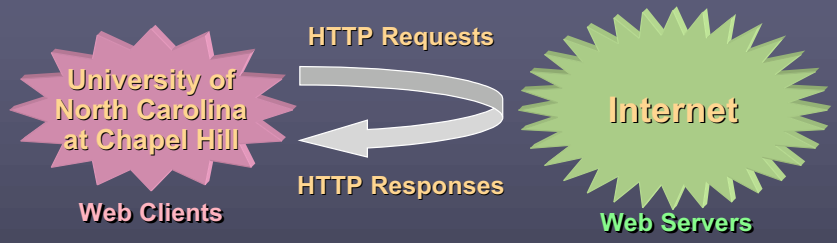
✓Replace smaller-scale, quickly aging models
  – Mah, 1995 data set
  – Crovella *et. al*, 1995 data set (revised with 1998 data)

✓Characterize the use of the HTTP protocol
  – *E.g.*, Use of persistent connections

Web Traffic Measurement and Analysis at UNC-Chapel Hill

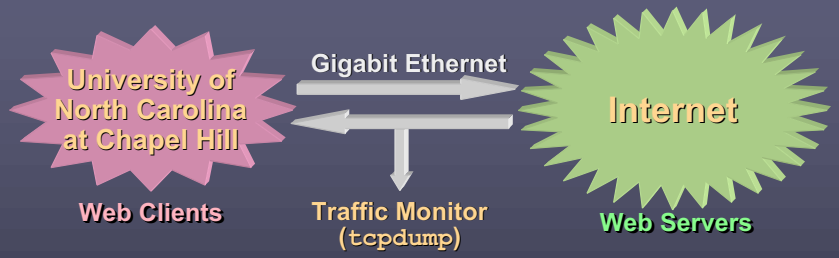
- Our methodology and first results were published in SIGMETRICS/Performance'01
  – *What TCP/IP Protocol Headers Can Tell Us About the Web*
- Modeling aspect explored in a series of papers
  – *E.g., Variable Heavy Tails in Internet Traffic* (with J.S. Marron)
    » (Part I: *Understanding Heavy Tails* published in MASCOTS'02)
- In this talk, I will describe our approach and our observation on the evolution of web traffic:
  – Three data sets: 1999, 2001 and 2003
  – Comparisons to Mah and Crovella *et al.*

Methodology
Study of Web Content Consumers



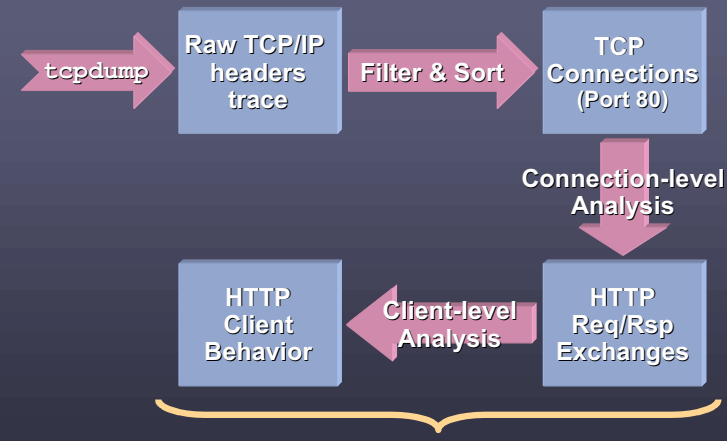
- We studied a large collection of users (~35,000) as *web content consumers*
- The only source of data for our study were packet header traces
  – Anonymized IP addresses
  – No HTTP headers

Methodology
One-Way Packet Header Traces

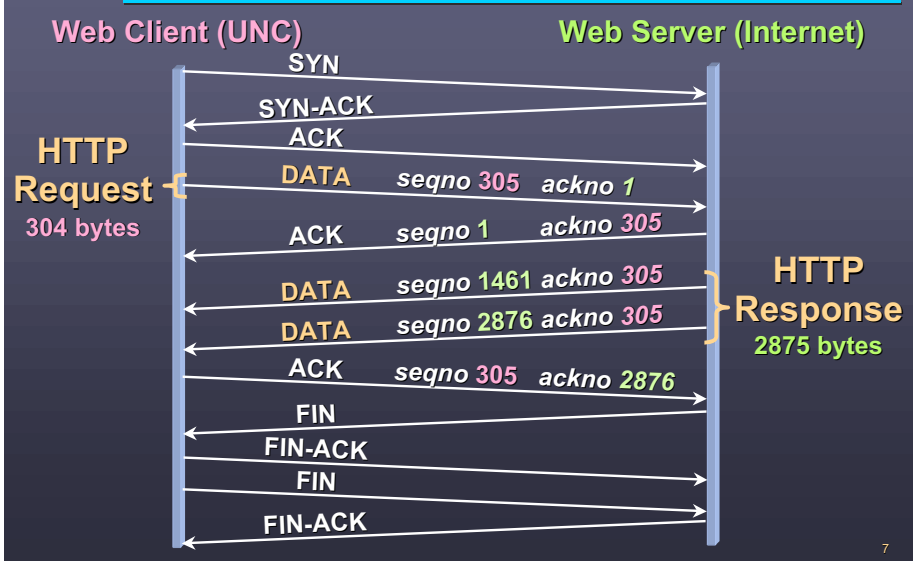


- Only inbound TCP/IP headers are captured
  - Eliminate synchronization and buffering issues on the NIC
  - Reduce trace size
- Trace collection: 2.7 TB of packet headers
  - ~40 billion packets ~16 TB of data transfers

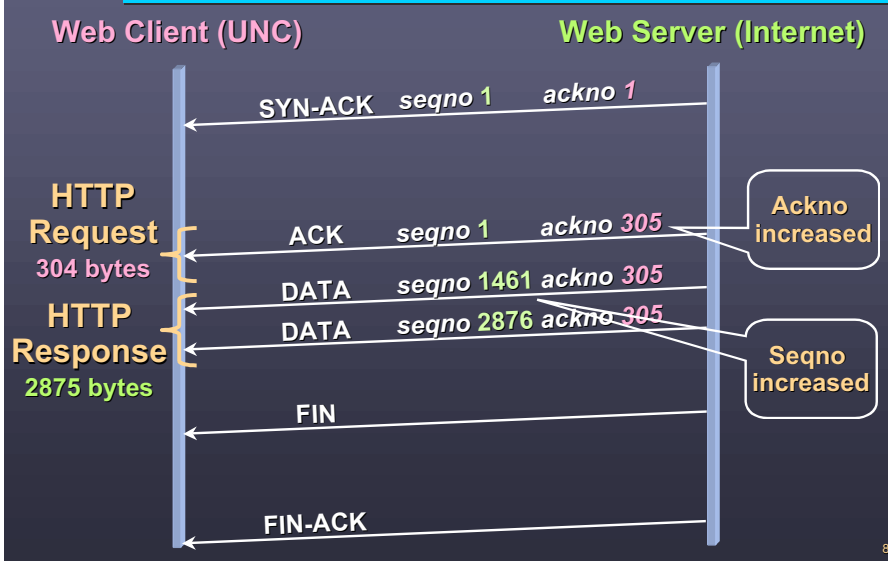
Methodology
Processing Sequence Overview



TCP/IP Headers and HTTP
Request/response Exchange

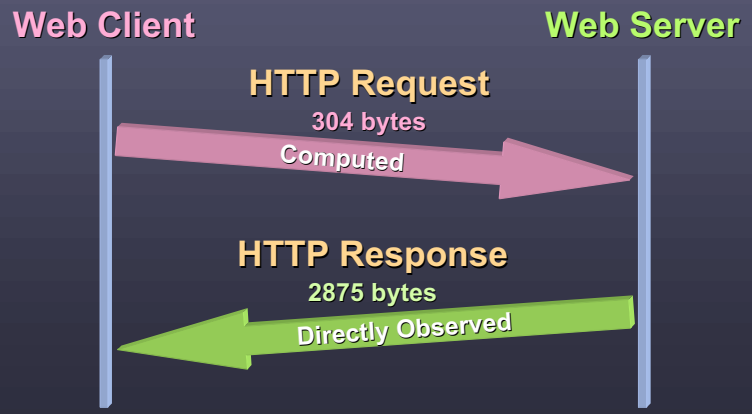


TCP/IP Headers and HTTP
Server-to-client Segments Only

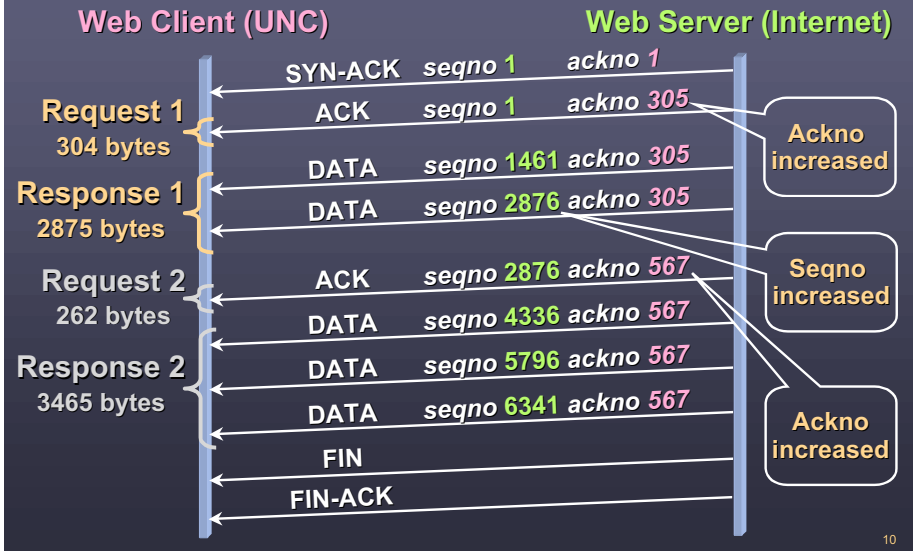


Methodology
Request/Response Traces

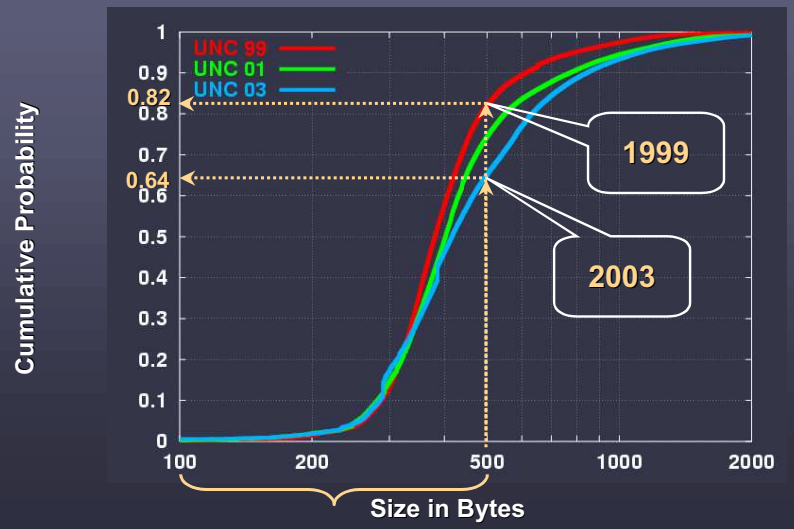
- Unidirectional TCP/IP header traces are sufficient for capturing application-level behavior



Persistent Connections in HTTP
Example – TCP/IP Headers



Sizes of HTTP Requests
Empirical CDFs



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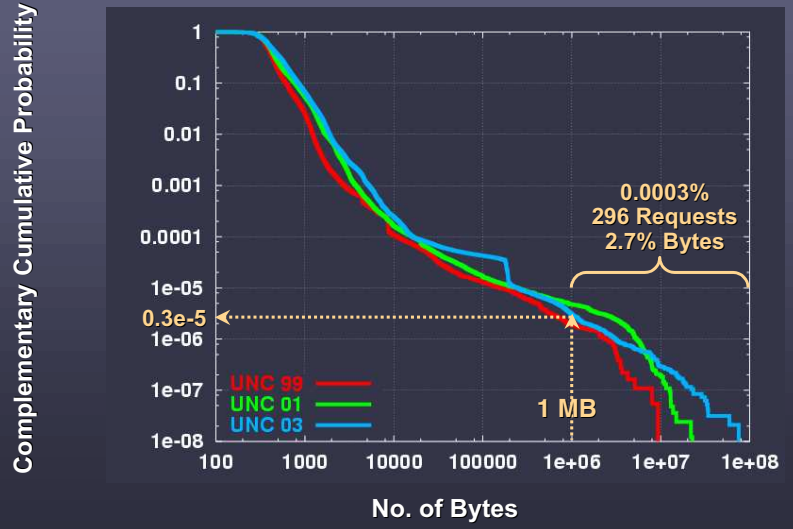
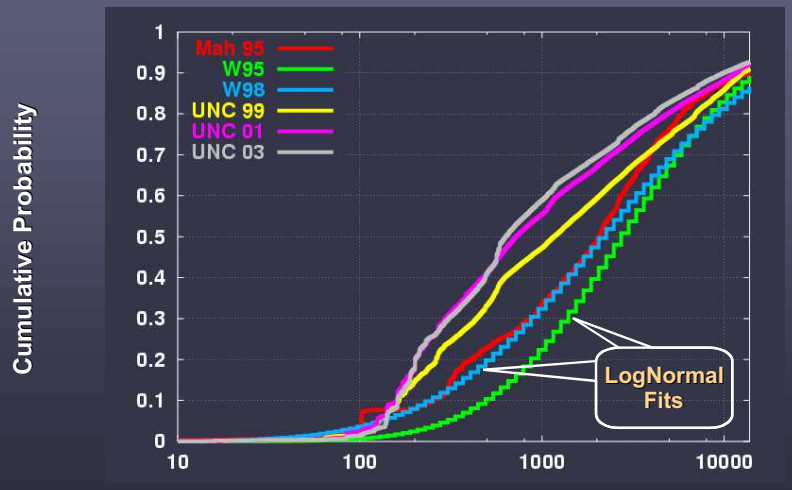


Response Sizes
Comparison with Earlier Studies



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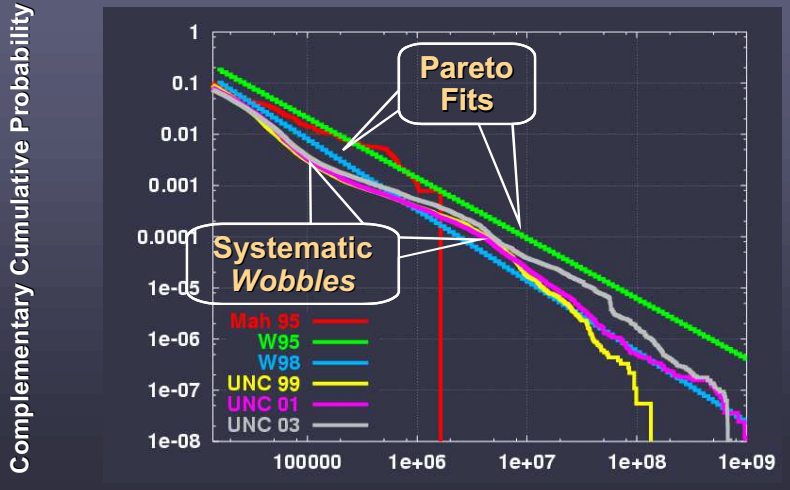

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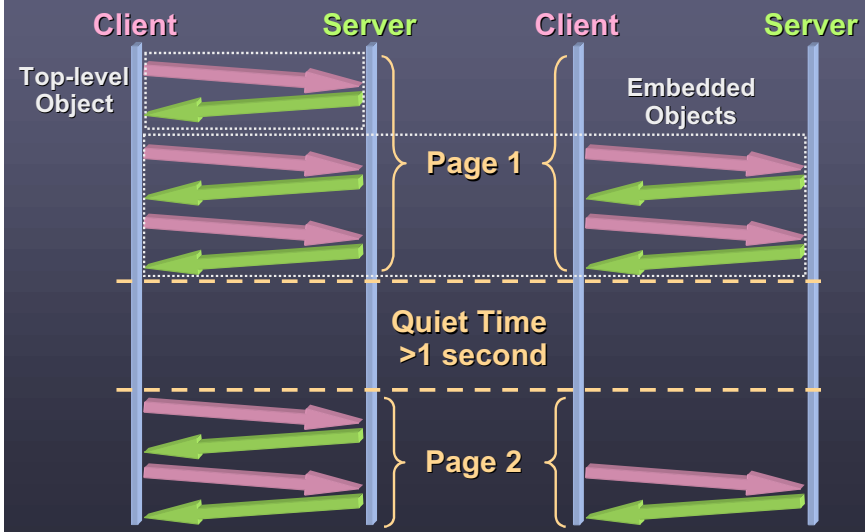
Page Identification Heuristic
Two TCP Connections Example



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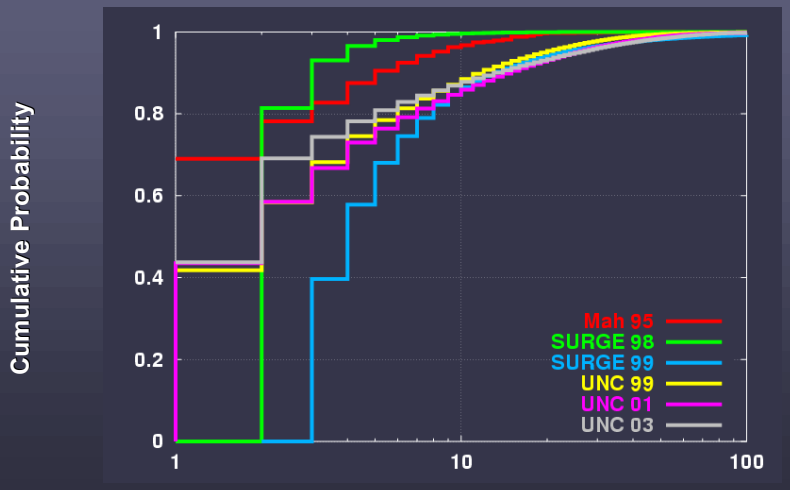
Objects Per Page
Comparison with Earlier Studies



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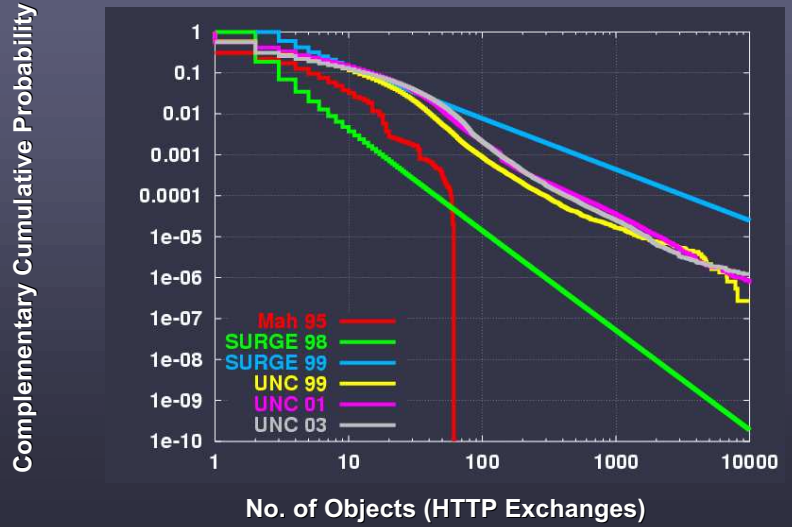
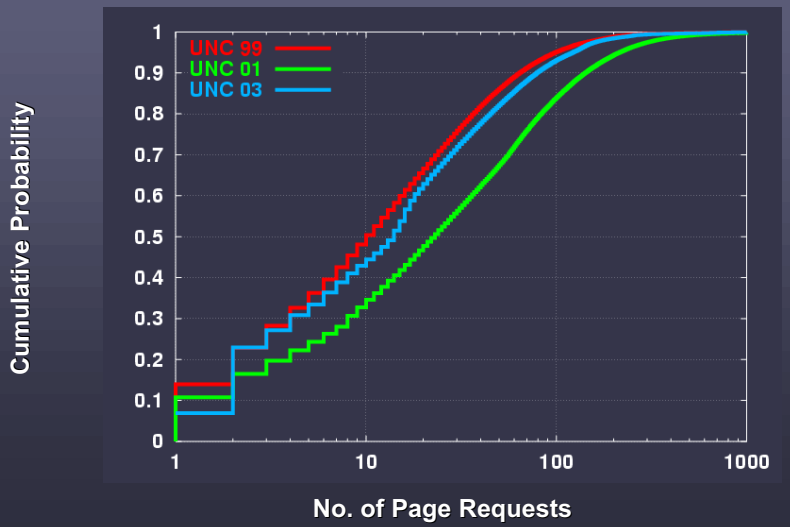


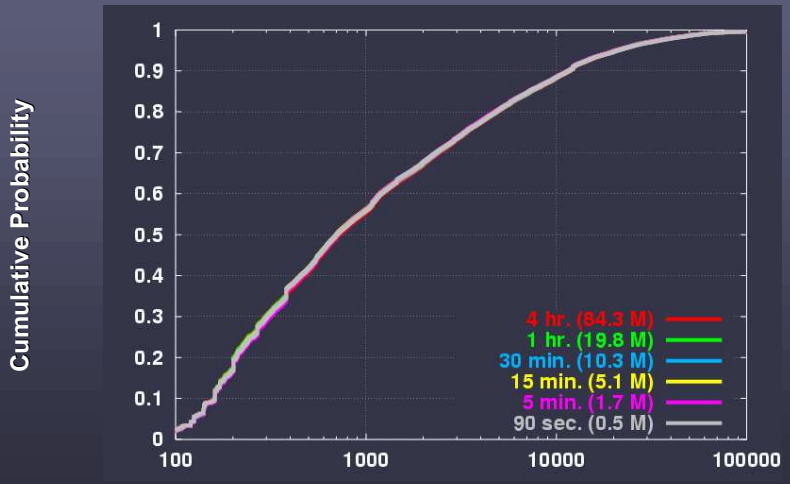
Page Requests Per IP Address



Sampling Issues

- Questions:
  - Can we obtain a *sufficiently large sample* with a small number of short traces?
  - How does the *length of the tracing interval* affect the overall empirical distribution shapes?
  - Should we include in the empirical distributions the data from *incomplete TCP connections*?
- Approach:
  - Examine a wide range of trace lengths
    - » 4 h., 2 h., 1h., 30 min., 15 min., 5 min. and 90 sec.
  - Construct datasets by sub-sampling the 21 4-hour-long traces collected in 2001
  - *E.g.*, remove first and last hour of each trace to produce 21 2-hour-long traces

Sampling Issues
Impact of Tracing Interval Length



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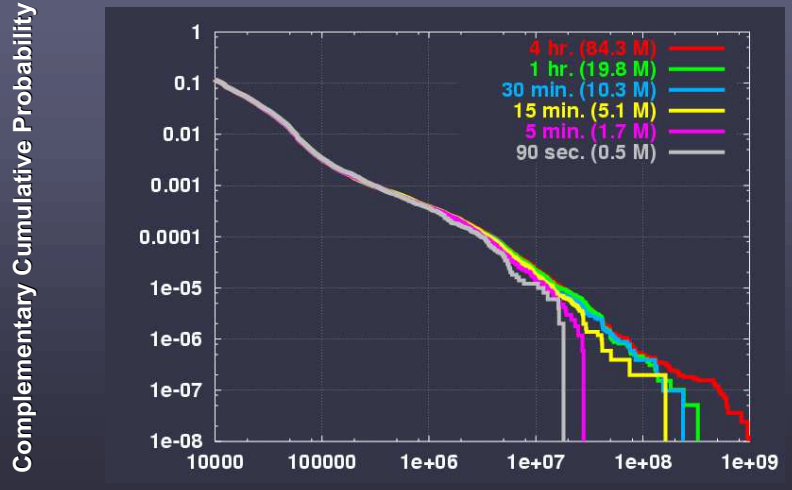

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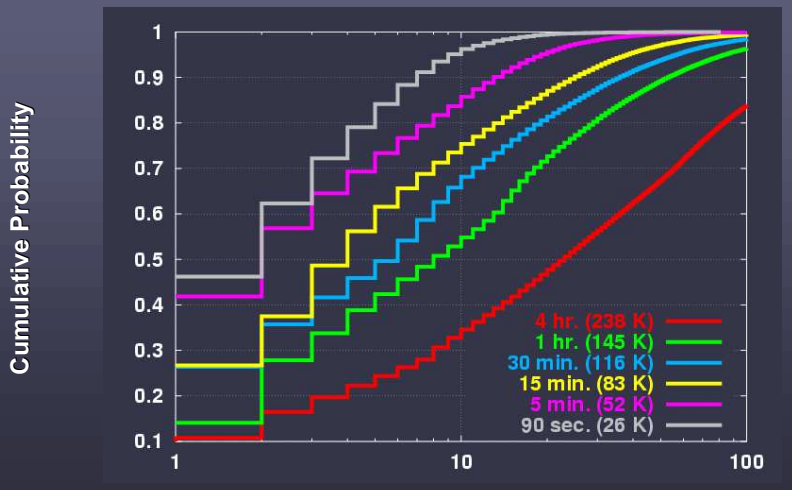
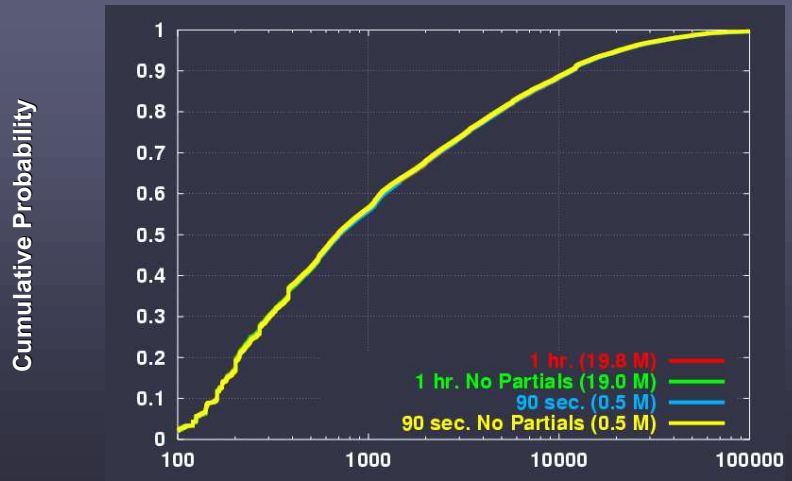


Sampling Issues
Impact of Partially-Captured Objects



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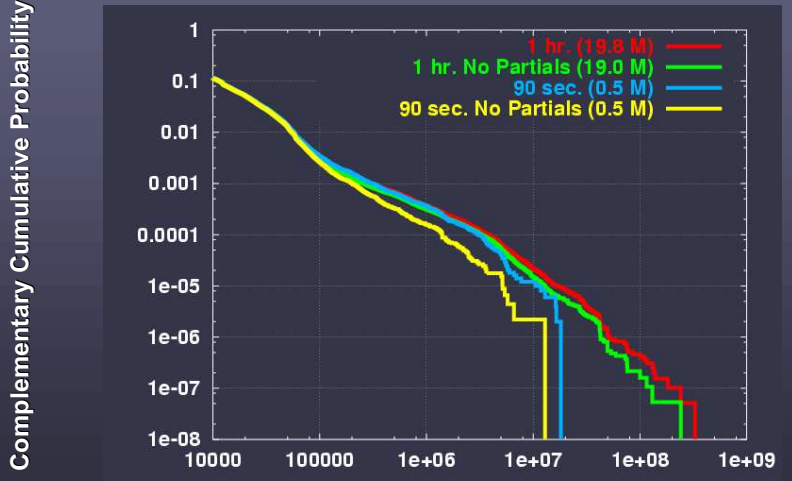

Summary and Conclusions
Web Traffic Characterization

- New data to populate traffic generators
  - Request sizes
  - Response sizes
  - Use of persistent connections
  - ...
- 1-hour long traces are sufficient to capture application-level behavior
  - Short traces cut off large objects, which skews the tails of the distributions
- Persistent Connections:
  - ~15% of all the HTTP connections
  - 40-50% of all the transferred HTTP bytes