# Wormhole

## An Active HTTP-Tunnel for High-Latency Networks

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### Motivation

High-latency networks (UMTS, VPN, TOR) have recently become very popular due to mobility, privacy, and anonymity considerations. Browsing the www over high-latency networks is frustrating as the underlying protocols are not designed to work well in such a scenario.

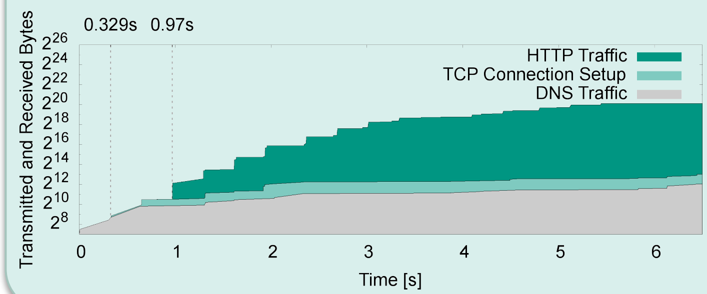
### Problem Analysis

- Today's webpages contain embedded objects (DOM-tree/page requisites)
- These may recursively embed objects
  - Embedded css file may embed images
- Objects are typically spread across multiple domains
  - Static images, scripts, advertisements on different domains
  - 20 most popular Alexa Top 500 pages: 443 domain names
- Fetching requires the following sequential steps per domain
  - Domain name resolution 1 round-trip
  - TCP connection setup 1 round-trip
  - Get "index.html" file 1 round-trip
  - Get page requisites (mult. connections, keep-alive, pipelining)

| Network: | Campus | DSL | UMTS | TOR |
|---|---|---|---|---|
| Average RTT: | 12 ms | 27 ms | 326 ms | 1228 ms |

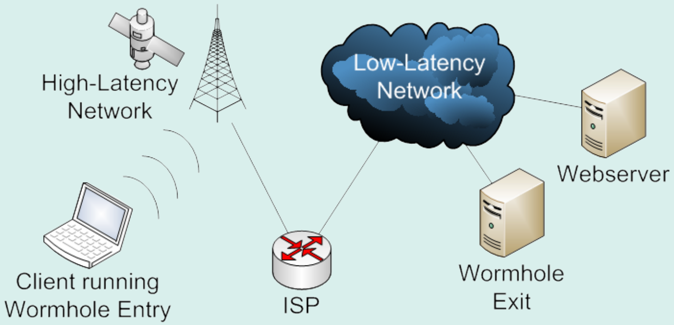
- Interpretation of DOM-tree is done in the client browser
  - Hinders parallelization (e.g., "index.html" needs to be interpreted to convey embedded contents)
  - Aggravates high-latency problem (stop-and-wait behavior)
  - Leads to poor bandwidth utilization
  - Causes a large fraction of the total delay

Initial part of an HTTP GET request with a RTT of 300ms




### Proposed Solution

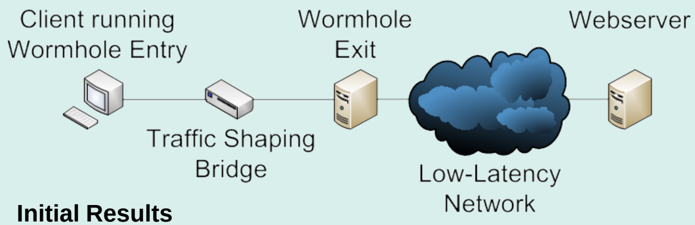
- Active HTTP-Tunnel
  - Wormhole entry at high-latency, low-bandwidth link
  - Wormhole exit at low-latency, high-bandwidth link
- Wormhole entry acts as a web proxy for the browser
  - Passes browser queries through the tunnel
  - Serializes all traffic through a single TCP connection
  - Keeps connection alive between requests
- Wormhole exit fetches and parses objects
  - Resolves all domain names
  - Returns object data to Wormhole entry
  - Piggybacks a list of page requisites that will be pushed subsequently
- Wormhole entry can hold back future requests for announced contents until the data arrives unsolicitedly




- Server push vs. client cache
  - Wormhole exit is unaware of browser cache's state
  - Redundant data is pushed to the Wormhole entry
  - Wormhole implements a self synchronizing cache to mitigate this effect
    - Entry caches received objects
    - Exit has knowledge of entry's cache contents
    - Object hash is saved on exit-side instead of full object
    - Only an index into the cache needs to be transferred for a cache-hit

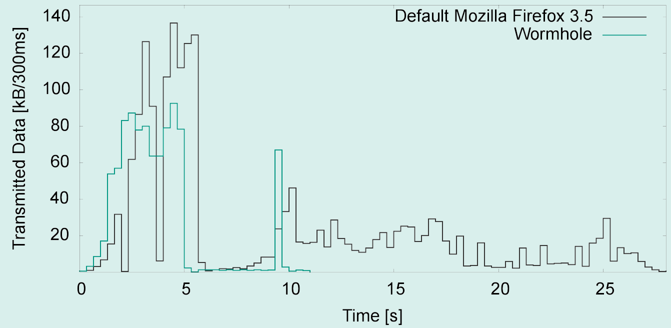
### Evaluation

- Implementation with C++/Qt4
- Measurement with vanilla Mozilla Firefox and tcpdump
- Link traffic shaping with tc (netem, htb)




### Initial Results

- Latency is reduced greatly




- Wormhole-Cache significantly reduces re-transfers of redundant data

| | Cache | No Proxy | Wormhole | Ratio |
|---|---|---|---|---|
| **TX:** | cold | 190.4 Kib | 48.5 Kib | 0.25 |
| **RX:** | cold | 1089.1 Kib | ***1049.3 Kib*** | 0.96 |
| **TX:** | hot | 49.2 Kib | 21.7 Kib | 0.44 |
| **RX:** | hot | 148.0 Kib | ***196.8 Kib*** | 1.33 |

### Future Work/Next Steps

- Thorough evaluation (e.g., scalability of Wormhole exit)
- Compare different scenarios
  - No proxy, local proxy, remote proxy
  - Cold, warm, hot caches; different caching parameters
  - Compression on and off
  - Different latencies/data rates

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