# Reducing Latency in Tor Circuits with Unordered Delivery

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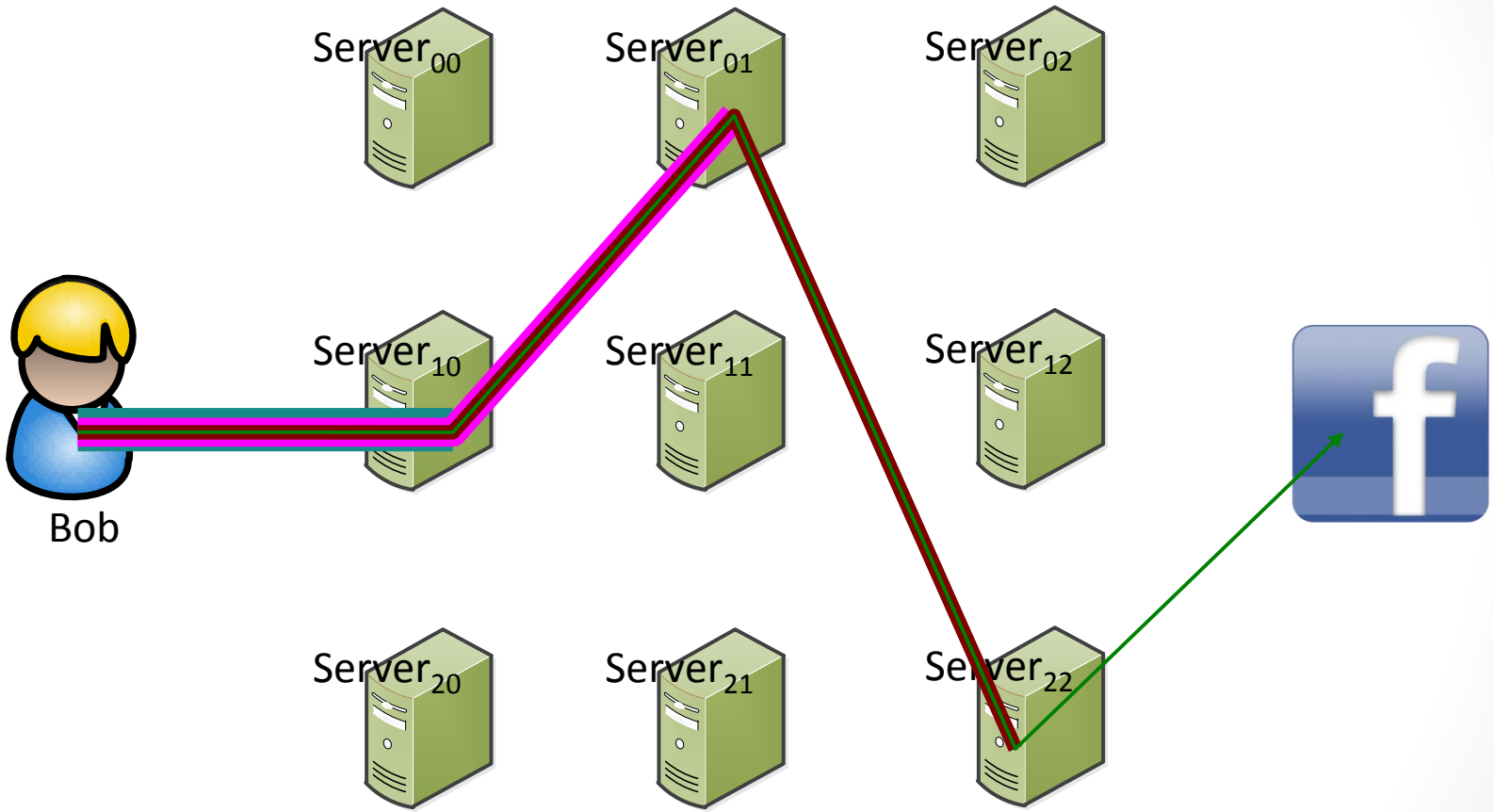
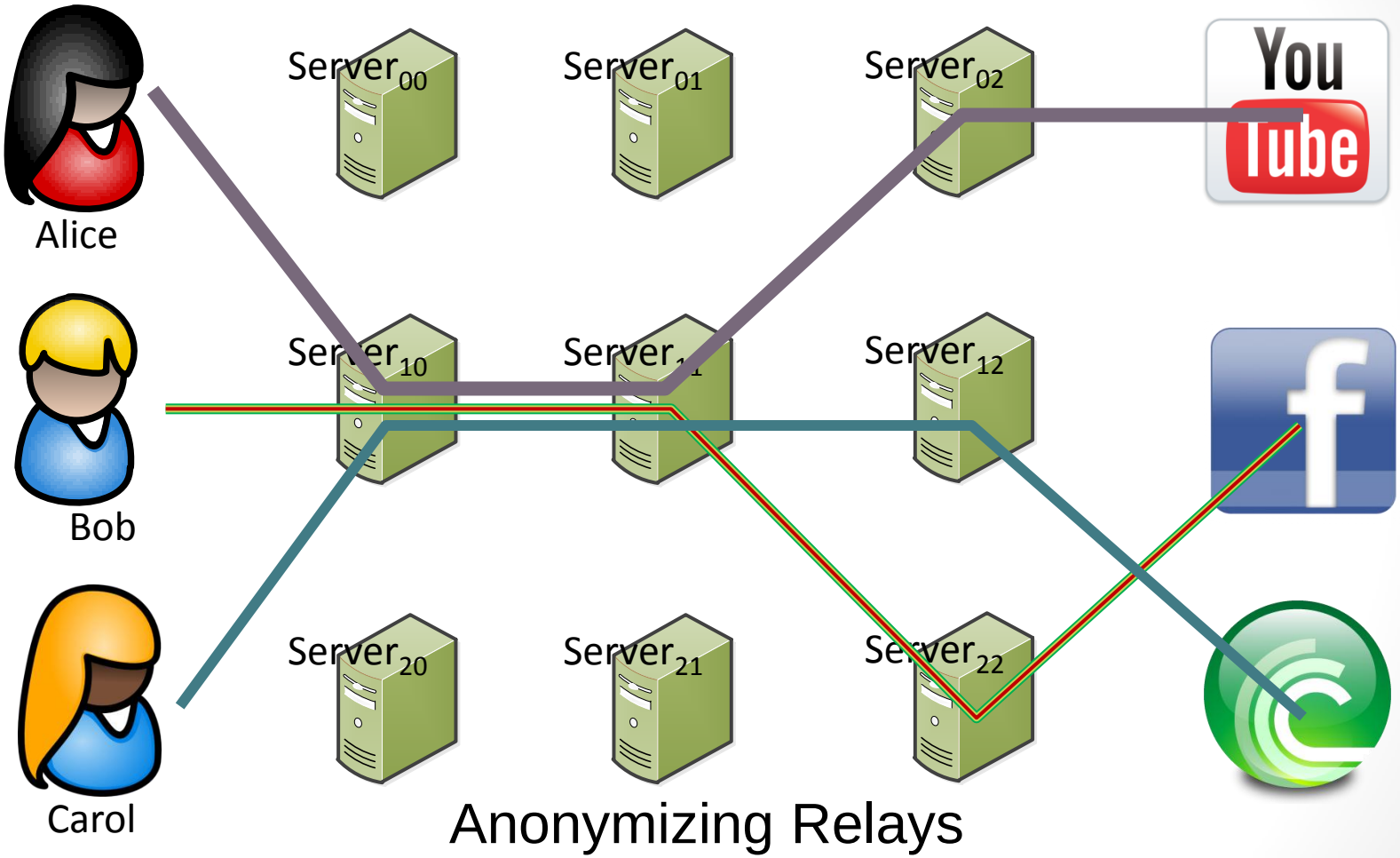
# Tor – The Onion Router



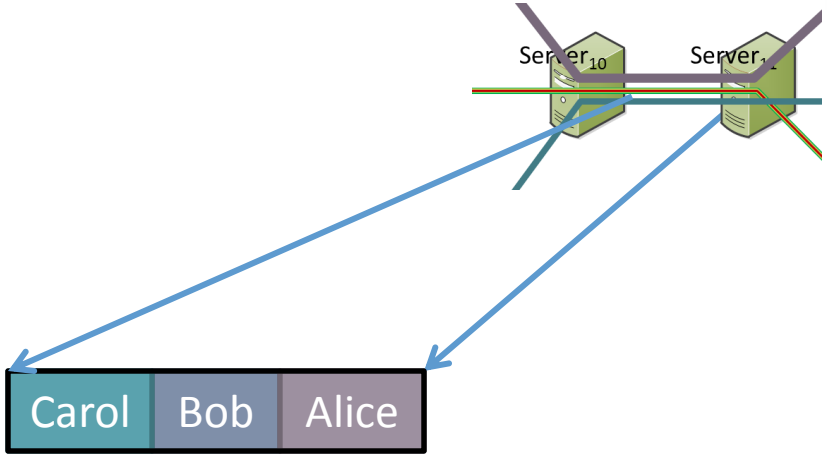

Anonymizing Relays

# Tor – The Onion Router



# Performance Problems

- Traffic between two relays streams across 1 TCP Conn

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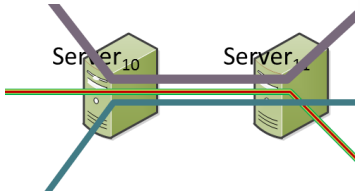
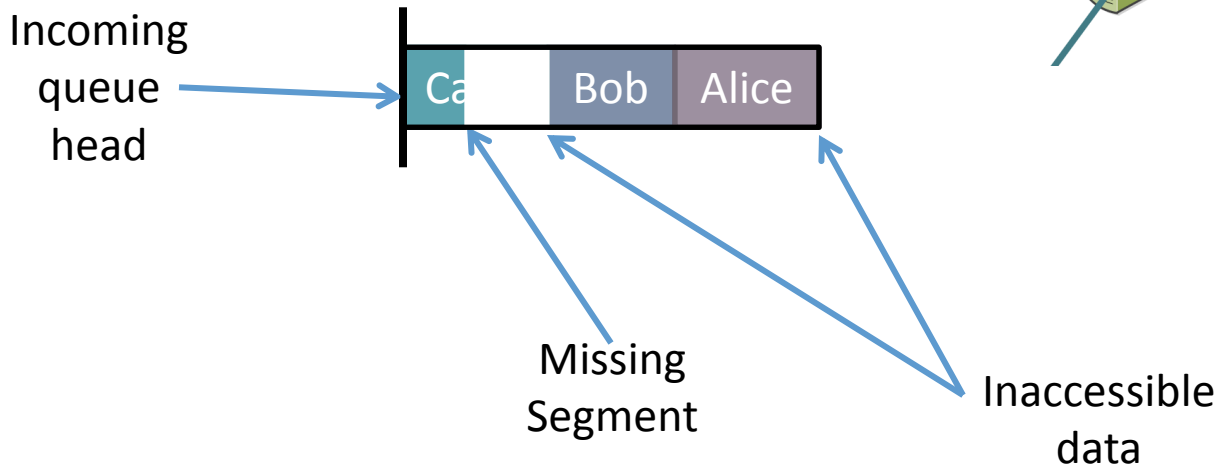
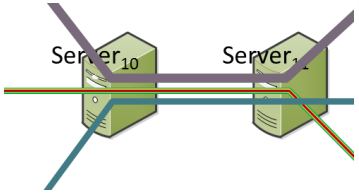
- Traffic between two relays streams across 1 TCP Conn
- Cross circuit Head-of-line blocking

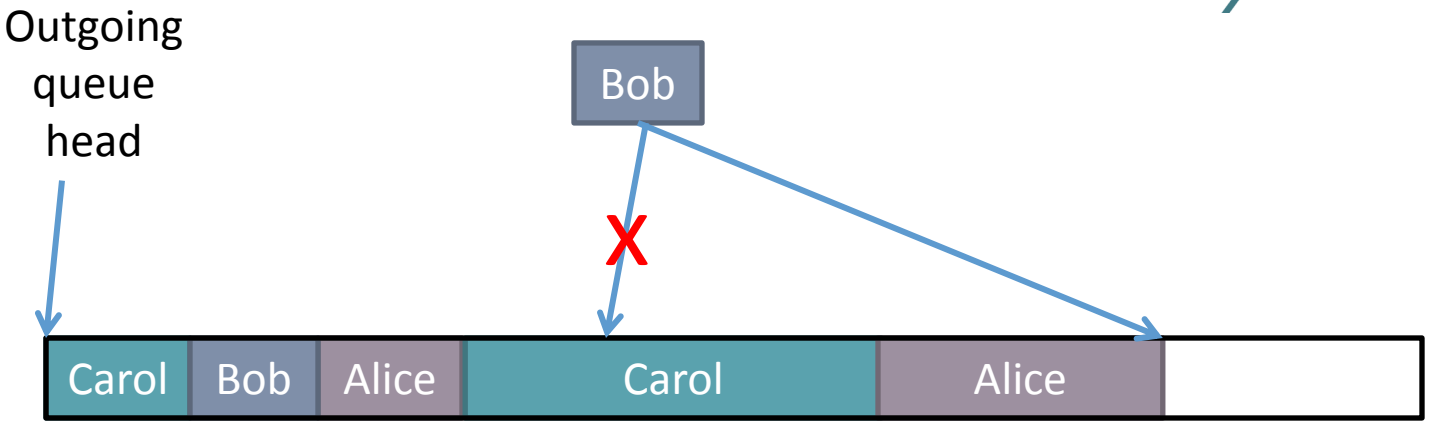


# Performance Problems

- Traffic between two relays streams across 1 TCP Conn
- Cross circuit Head-of-line blocking
- TCP Buffers can create delays



# Outline

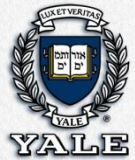
- Introduction to Tor
- Tor / TCP Bottlenecks
- Design Space
- Tool #1: uTCP
- Tool #2: uTLS
- Eliminating Head-of-Line Blocking in Tor
- Conclusions

# Our Goals

- Improve Tor QoS for low latency, low bandwidth
  - Eliminate head-of-line blocking
  - Improve latency for low latency, low bandwidth Apps
- Use existing transport (TCP/TLS)
- Minimal modifications to Tor
- Interoperability with existing Tor deployments

# Design Space

- Different transports
  - DTLS/TCP over UDP, PCTCP, UDP
  - Tradeoff between user-space networking stack or add reliability layer
  - IPSec not universally configurable
- One connection per-circuit
  - OS limitations
  - Potential performance hit
  - No shared congestion state
- One connection per-priority
  - Torchestra
  - May leak information about the flows
  - Doubles active sockets, no shared congestion state



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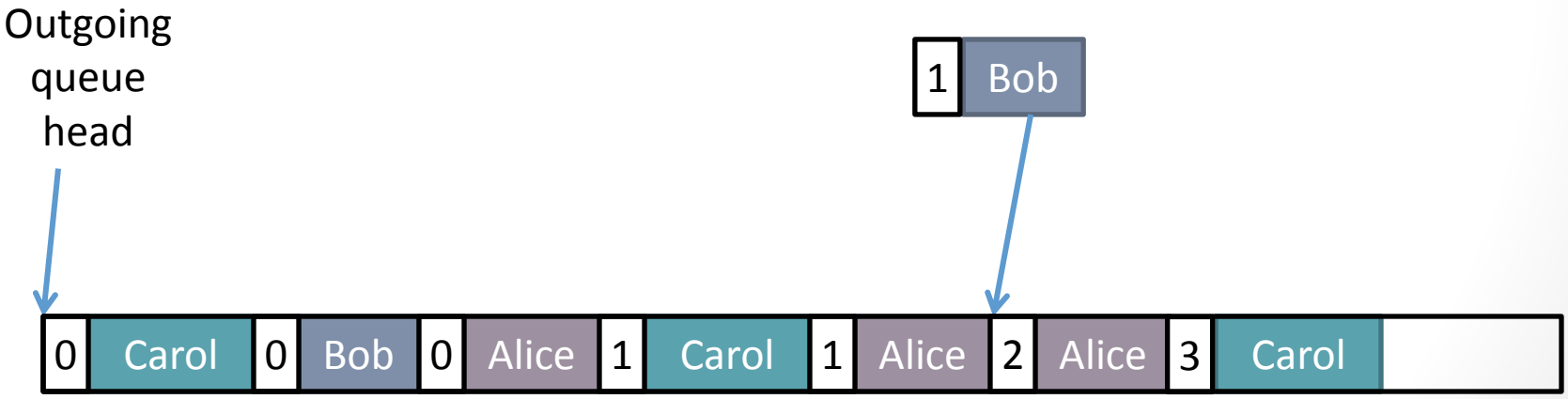
# Unordered TCP (uTCP)

- Small kernel modification and module
  - Less than 600 lines of code
  - Supported on Linux Kernel 2.6 and 3
  - Recent IETF activity by Apple
- Out-of-order reads
- Priority sending
- Disable congestion control

# uTCP Out-of-Order Reads

# uTCP Priority Sending

- Give low latency, low bandwidth circuits preference
- Initiate by a setsockopt
- User prepends priority to each packet
- Inserted into send buffer ahead of lower priority data
- Optional squash to erase data from the buffer



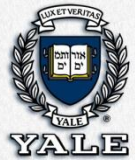
# uTCP Disable Congestion Control

- Initiated with a setsockopt
- Null TCP congestion control kernel module
- Always sets congestion window to maximum size

# uTCP

- Out-of-order reads
- Priority sending
- Disable congestion control

- Remaining issues:
  - Tor uses TLS!
  - Need a framing mechanism for out-of-order msgs!
    - TLS provides framing…



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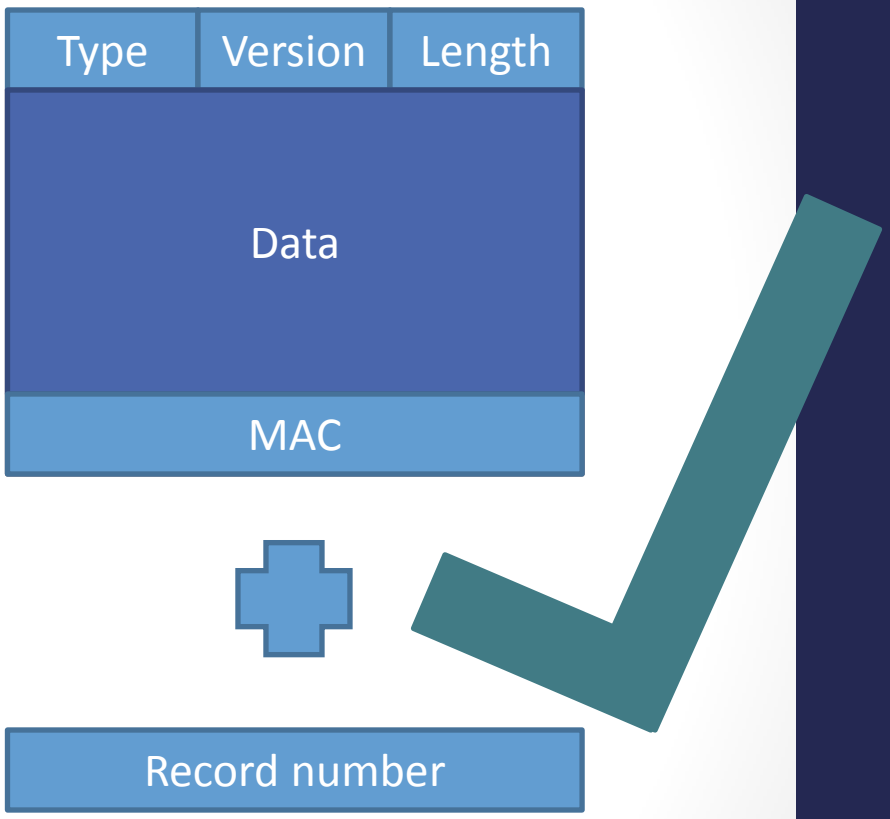
# Processing TLS

- Header
  - Application data – 0x17
  - TLSv1.2 – 0x0303
  - Length – Up to 16 KB
- Data length check
- MAC check
- Decryption
- Deliver

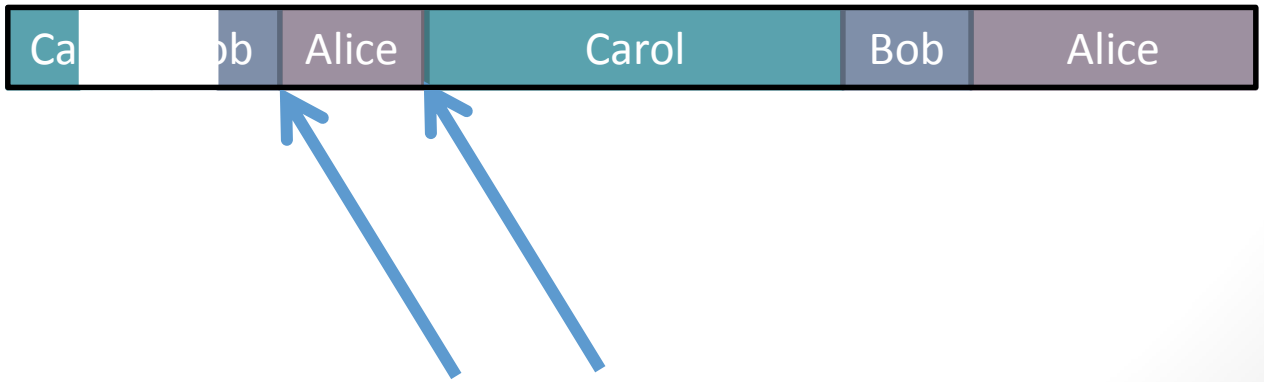


# uTLS

- Identifying records

| Type | Version | Size |
|---|---|---|
| 0x17 | 0x0303 | <= 2^16 |

  - Search for header:
  - Verify sufficient bytes for size
- Perform a MAC check – Must guess record number
  - Try a sequence
  - Rollback state when processing out of order
  - Fail otherwise
- Requires explicit IV an then decrypt and deliver



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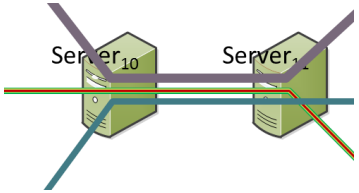
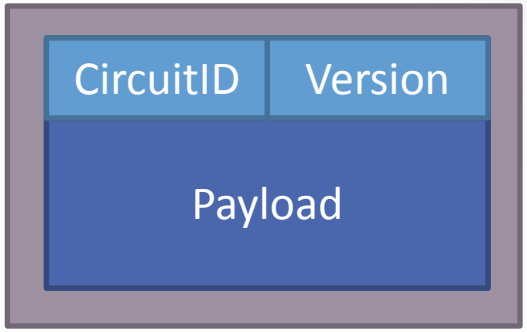
# From Tor to Unordered Tor

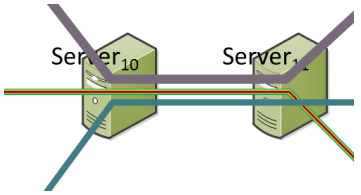
- Apply uTCP and uTLS to Tor to make it support unordered delivery – uTor
- Tor has multiple circuits sharing a single TCP stream
  - Each circuit passes datagrams or cells
  - Each circuit has independent state



# uTor – Cell Processing

- One cell per record
- Each cell specifies its circuit
- Can we process cells out of order?
  - Assume no, for now
- Process cells in order
  - Add sequence number to cells
  - Header size goes from 5 to 7 bytes
  - Payload remains the same



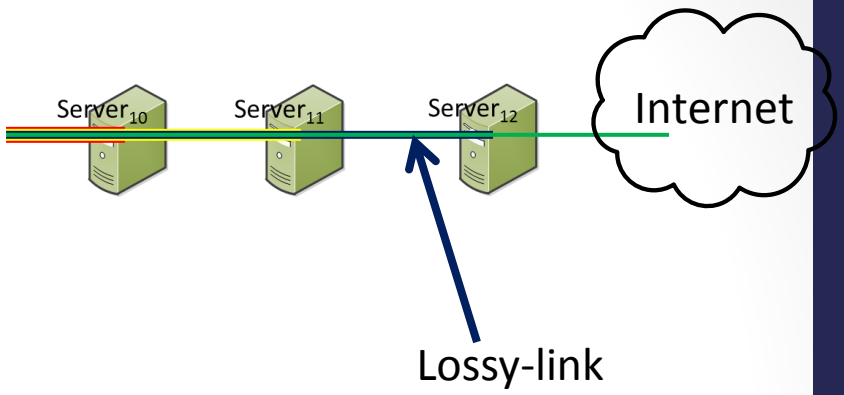
| | Tor | uTor | Delta |
|---|---|---|---|
| LoC | 81418 | 81513 | +95 (0.0001%) |

# Deployment Challenges

- uTCP / uTLS adoption
  - Not found in main stream kernels
  - Currently only truly beneficial for ORs
  - Virtualization?
- uTor adoption
  - uTor must negotiate to use 2 byte cell ID
  - Compatible with existing Tor deployments

# Preliminary Evaluation of uTor

- Tor configuration
  - 3 Relays
  - 3 Directory Authorities
  - A single proxy
  - OP takes the same path through the 3 relays
  - Version 0.2.5.0-alpha-dev (git-7c670895b02ba731)
- Normally distributed, 50 ms latency
- 0 and 5% loss
- Experiment
  - Requests to 40 popular sites on the Internet
  - Data sizes 10 KB to 400 KB



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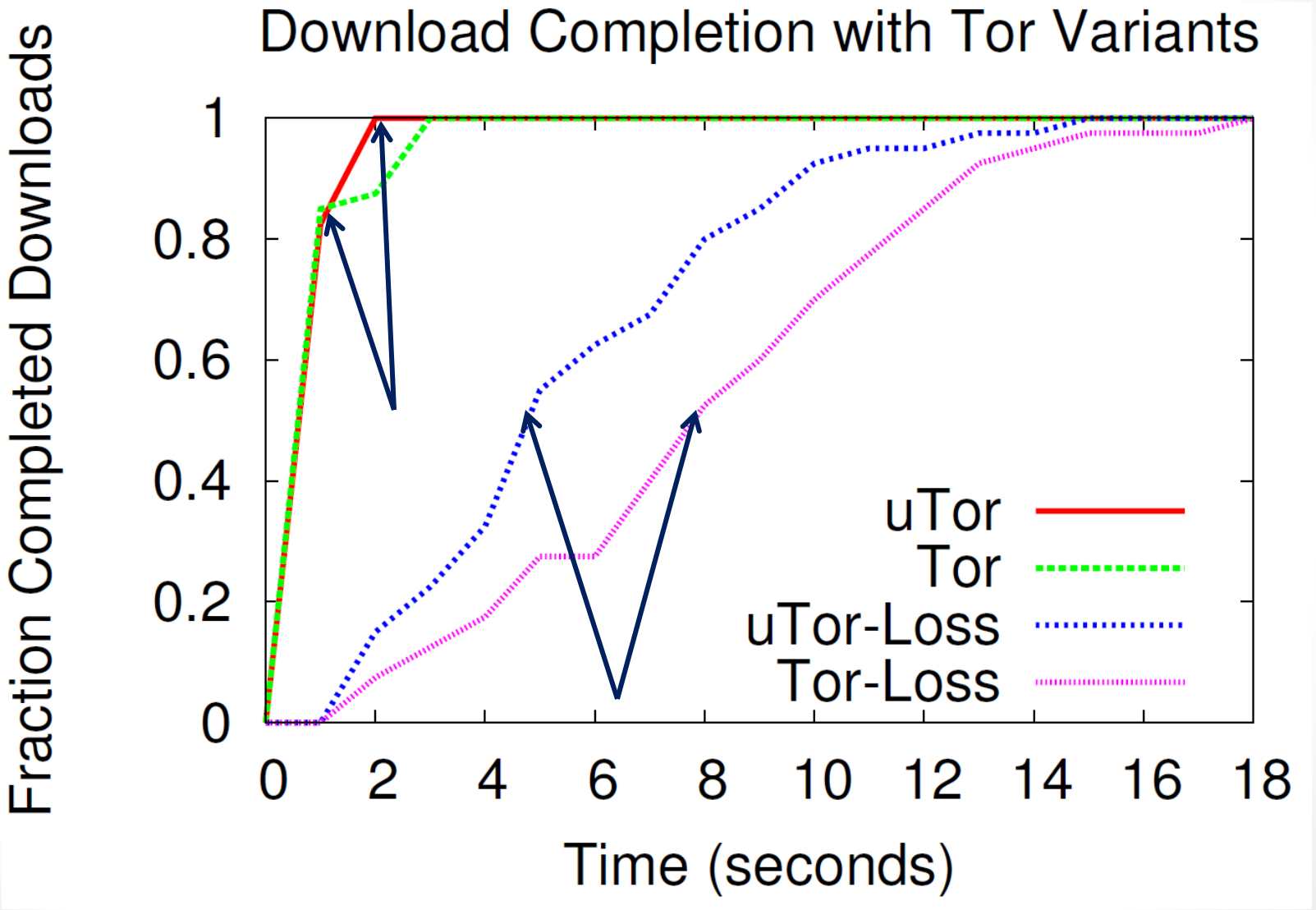

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# Future Work

- uTor shows promise
  - Removes head-of-line blocking
  - No userspace networking libraries (DTLS/TCP Tor)
  - No need to change Tor to use UDP
- We can do more
  - Investigate improved congestion control algorithms
  - Priority sending – Similar to Torchestra
  - Impact of head-of-line blocking on congestion control
- Out of order circuits interesting but dangerous
  - Processing a destroy before receiving all packets
  - Assumed in order nature

Thank you for your attention

http://dedis.cs.yale.edu/2009/tng/

# The Challenges with TCP

- Overlays multiplex a single TCP link for multiple streams
- A missed packet in one stream causes delays in all streams
  - Logically the streams are not blocked
  - TCP blocks until all packets are received in order
- Unable to perform priority sending
  - Cannot insert into TCP buffer
- Layered congestion control
  - TOR runs TCP between end points as well as hop by hop
  - Receiving a dropped packet in the hop by hop could result in a burst between the end points causing undesirable ramping up