Investigation of the HTTP-based large-scale data transmission over a long distance

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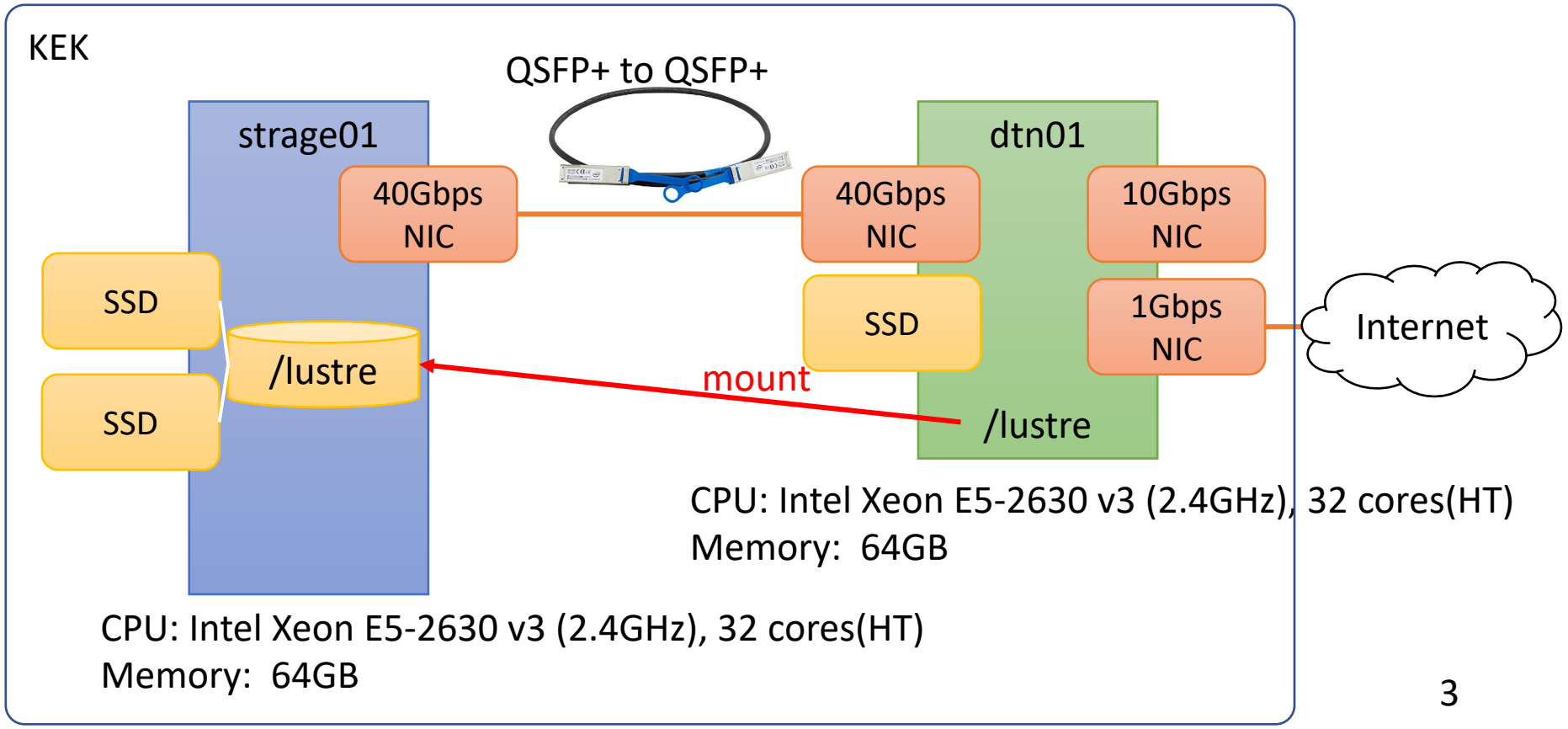
Background: Open Source Globus Toolkit Support Ended

- GridFTP based file transfer has been mainly used in High Energy Physics.
- It's implemented in the Globus Toolkit.
- We have started to investigate alternative way of efficient data transfer.
  - Possible candidates:
    - HTTP, XrootD

https://www.globus.org/blog/support-open-source-globus-toolkit-ends-january-2018

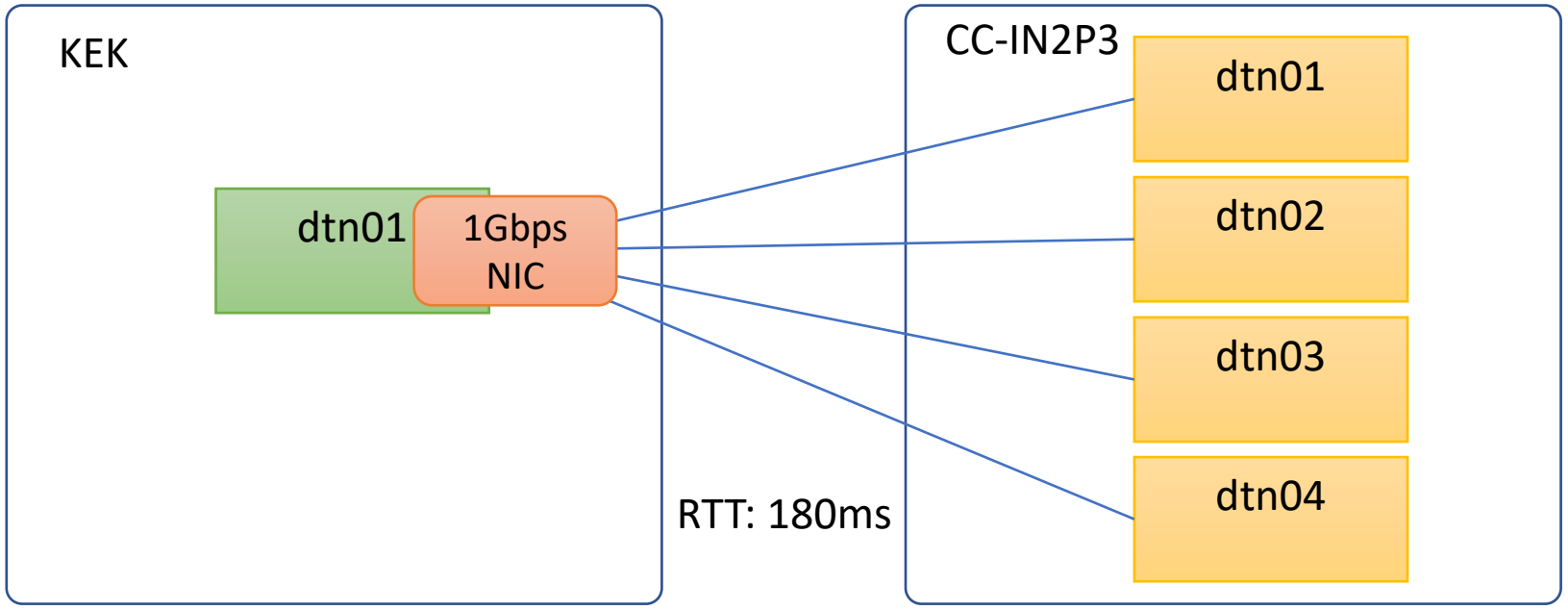
First Test Environment

- Prepare a data transfer node and a backend storage node.
- Use Lustre as a shared file system on top of two SSDs and QSFP+ interconnect
- Internet bandwidth is limited to 1Gbps due to the test environment



HTTP-based File Transfer Test Between CC-IN2P3 and KEK

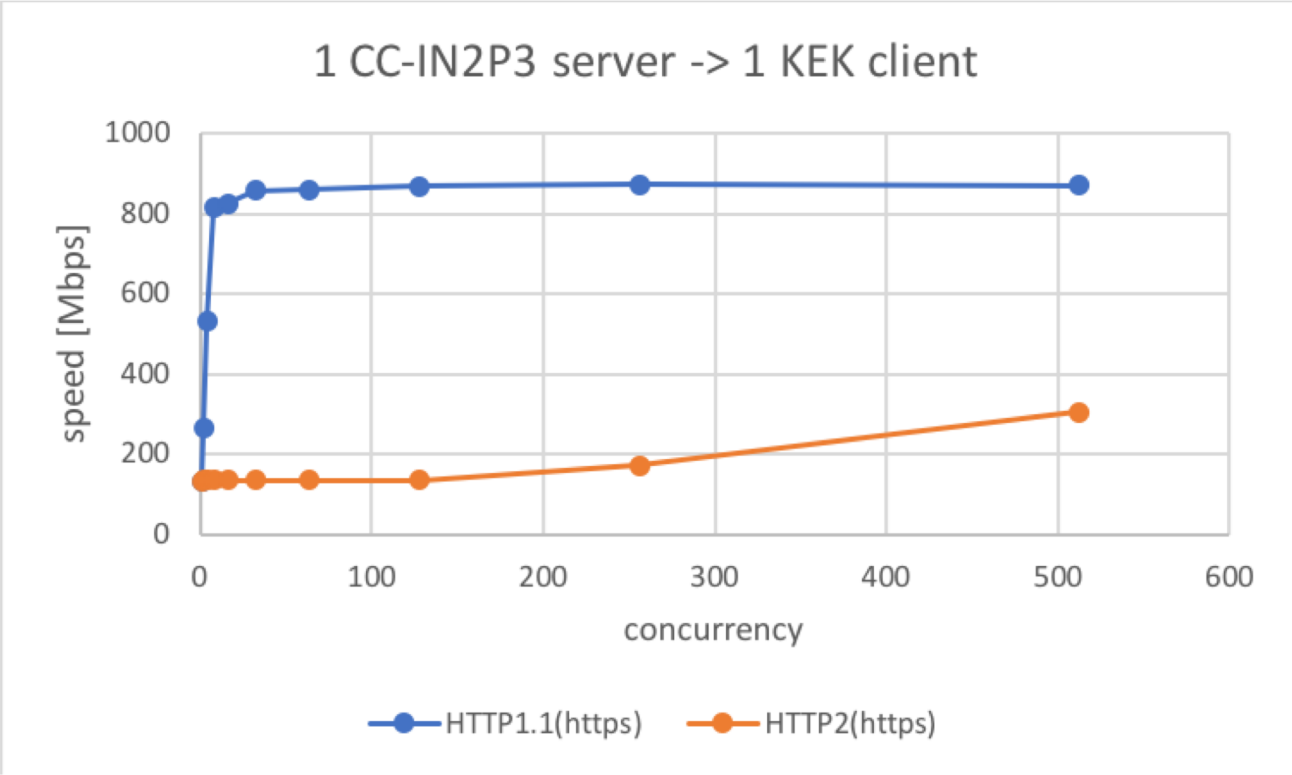
- Use chasqui developed by Fabio.
  - HTTP-based memory-to-memory file transfer tool.
  - It supports HTTP/1.1 and HTTP/2 connection over TLS.
- There are 4 DTN (Data Transfer Node) in CC-IN2P3 and there is 1 DTN in KEK.
- There is a ‘chasqui server’ daemon running on each machine and listening to port 20000.
- There is a ‘chasqui client’ daemon running on each machine and listening to port 20100.
- Download data from the chasqui server(s) by HTTP GET requests.



https://github.com/airnandez/chasqui

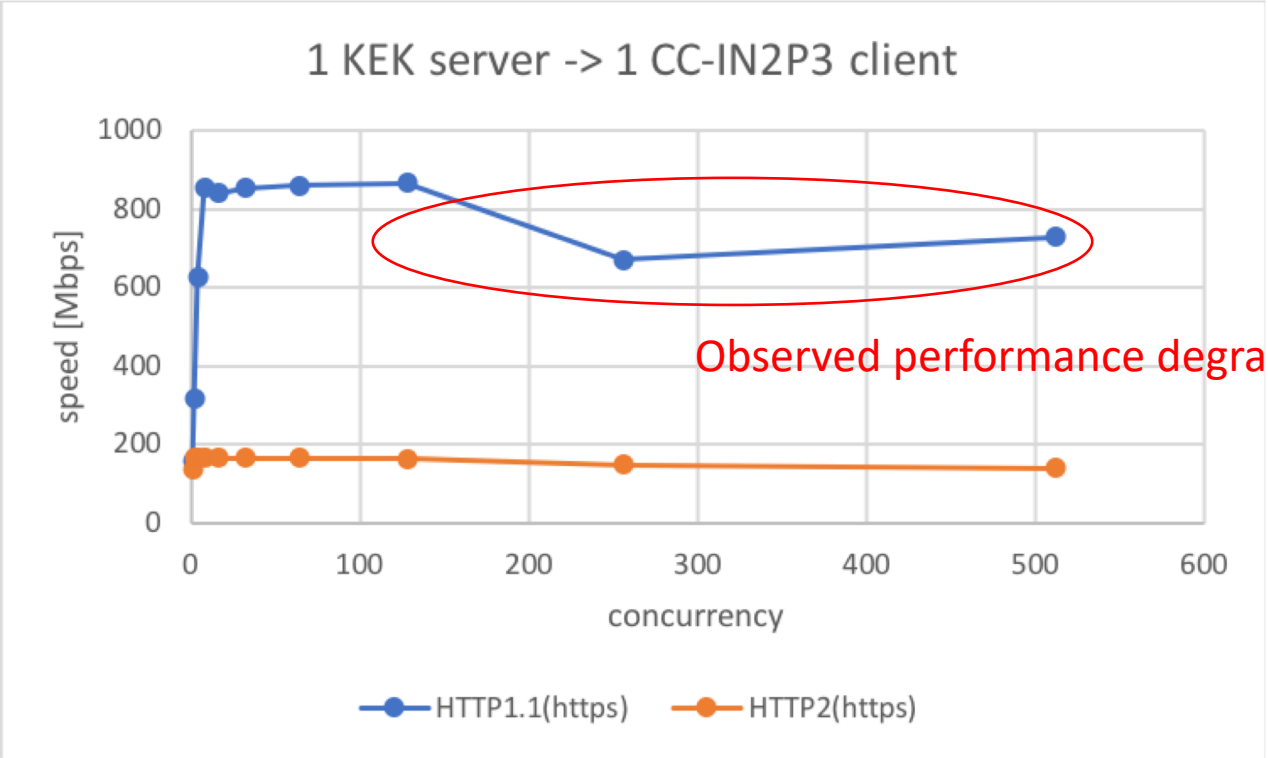
Chasqui Results: Download from CC-IN2P3 to KEK

- HTTP/1.1 downloading speed reached almost 1Gbps with 8 parallel connections from single server.
- HTTP/1.1 performance is much better than HTTP/2.



Chasqui Results: Download from KEK to CC-IN2P3

- HTTP/1.1 downloading speed reached almost 1Gbps with 8 parallel connections from single server.
- We have observed HTTP/1.1 performance degradation with higher parallelism.
- HTTP/1.1 performance is much better than HTTP/2.

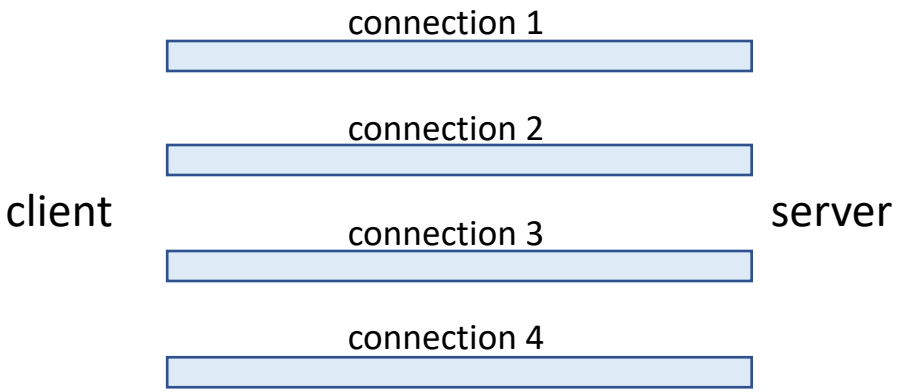


Comparison of the way of Parallel Access from the same client

- Ex. 4 parallel accesses from the same client

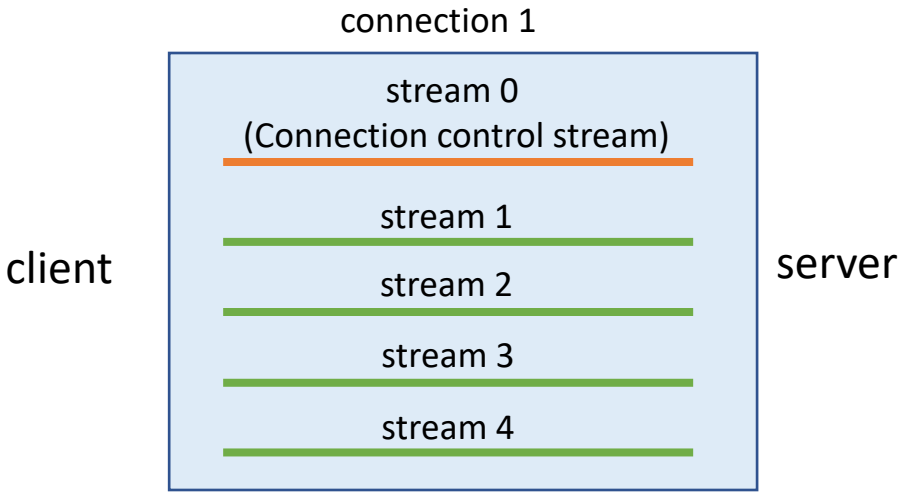
HTTP/1.1

- Establish 4 connections, and each has its own TCP window size.



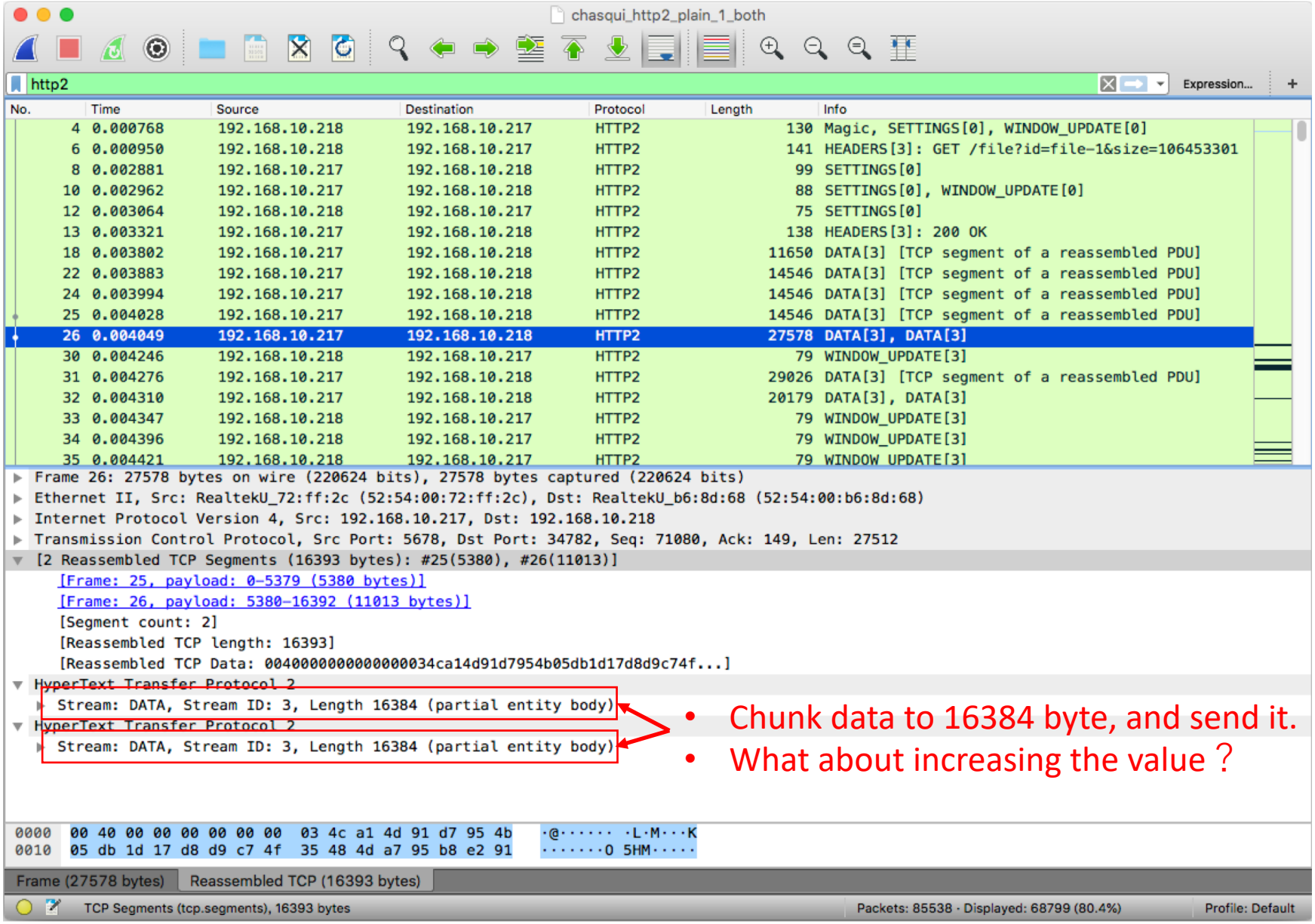
HTTP/2

- Establish only 1 connection, and it has 1 TCP window size.
- Data transfer by using 4 streams in the connection.



Single TCP connection limits the data transfer speed in HTTP/2?

Dump HTTP/2 Connection: Small Frame Size



- Chunk data to 16384 byte, and send it.
- What about increasing the value ?

HTTP/2 Frame Size: 16384 Bytes

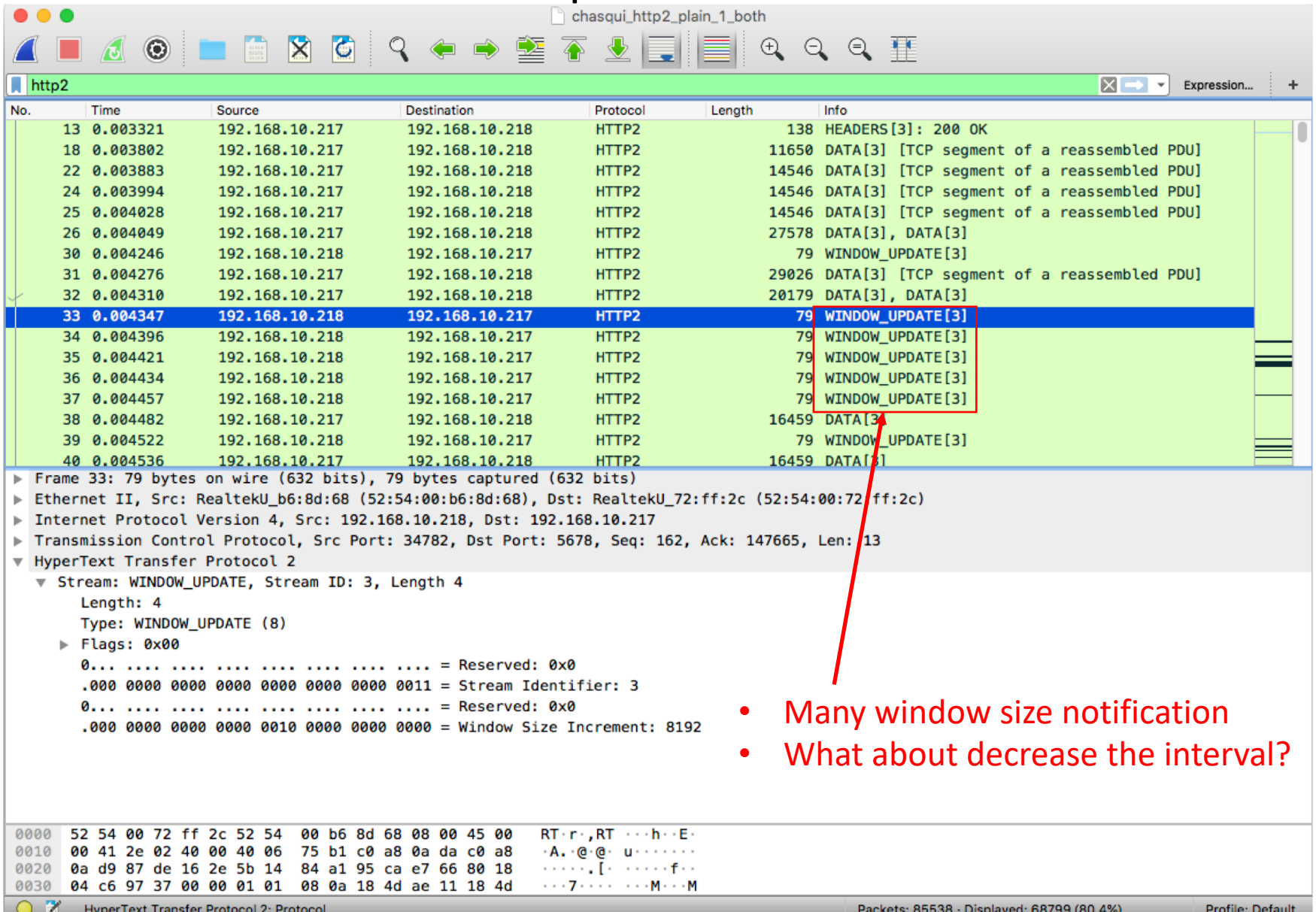
- The value is defined by SETTINGS_MAX_FRAME_SIZE:
  - https://http2.github.io/http2-spec/#SettingValues
  - The default value is 16484 bytes.
- HTTP/2 client of Go doesn't set the above value, so the default value is used.
- I modified the client to set the value:
  - https://github.com/wtakase/net/commit/a9a97aa674f4b9705ad4775e5be164ab4070fd05

Changed from golang/net/http2/transport.go

```
140       - func configureTransport(t1 *http.Transport) (*Transport, error) {
          202 + func configureTransport(t1 *http.Transport, fct *FlowControlTransport) (*Transport, error) {
141       203         connPool := new(clientConnPool)
142       204         t2 := &Transport{
143       -                 ConnPool: noDialClientConnPool{connPool},
144       -                 t1:       t1,
          205 +                 ConnPool:                      noDialClientConnPool{connPool},
          206 +                 MaxFrameSize:                  fct.MaxFrameSize,
          207 +                 TransportDefaultConnFlow:      fct.TransportDefaultConnFlow,
          208 +                 TransportDefaultStreamFlow:    fct.TransportDefaultStreamFlow,
          209 +                 TransportDefaultStreamMinRefresh: fct.TransportDefaultStreamMinRefresh,
          210 +                 t1:                           t1,
145       211         }
146       212         connPool.t = t2
```

```
606       672   func (t *Transport) newClientConn(c net.Conn, singleUse bool) (*ClientConn, error) {
607       673         cc := &ClientConn{
608       674                 t:                     t,
609       675                 tconn:                 c,
610       676                 readerDone:            make(chan struct{}),
611       677                 nextStreamID:          1,
612       -                 maxFrameSize:          16 << 10,           // spec default
          678 +                 maxFrameSize:          t.maxFrameSize(),   // spec default 16384
613       679                 initialWindowSize:     65535,              // spec default
614       680                 maxConcurrentStreams:  1000,               // "infinite", per spec. 1000 seems good enough.
615       681                 peerMaxHeaderListSize: 0xffffffffffffffff, // "infinite", per spec. Use 2^64-1 instead.
          @@ -652,16 +718,17 @@ func (t *Transport) newClientConn(c net.Conn, singleUse bool) (*ClientConn, erro
652       718
653       719         initialSettings := []Setting{
654       720                 {ID: SettingEnablePush, Val: 0},
655       -                 {ID: SettingInitialWindowSize, Val: transportDefaultStreamFlow},
          721 +                 {ID: SettingInitialWindowSize, Val: t.transportDefaultStreamFlow()},
          722 +                 {ID: SettingMaxFrameSize, Val: t.maxFrameSize()},
656       723         }
```

Dump HTTP/2 Connection: Too many Window Update Notification



- Many window size notification
- What about decrease the interval?

HTTP/2 Window Size Notification Interval

- HTTP/2 client of Go notifies window size when it receives more than 4KB of data.
- I modified the client to change the value:
  - https://github.com/wtakase/net/commit/a9a97aa674f4b9705ad4775e5be164ab4070fd05

Changed from golang/net/http2/transport.go

```
48  48          // transportDefaultStreamMinRefresh is the minimum number of bytes we'll send
49  49          // a stream-level WINDOW_UPDATE for at a time.
50  50          transportDefaultStreamMinRefresh = 4 << 10
```

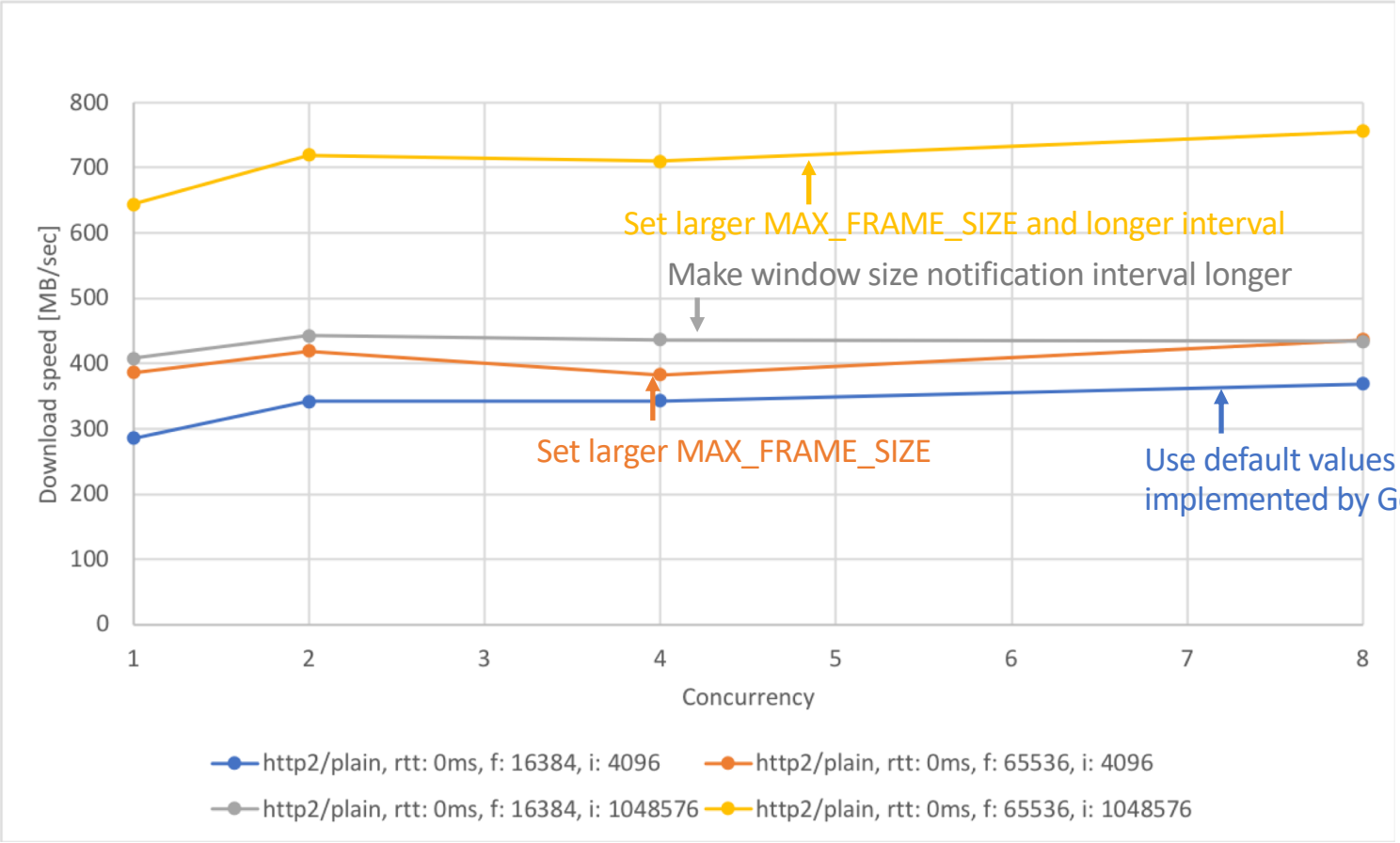
```
140         - func configureTransport(t1 *http.Transport) (*Transport, error) {
        202 + func configureTransport(t1 *http.Transport, fct *FlowControlTransport) (*Transport, error) {
141 203             connPool := new(clientConnPool)
142 204             t2 := &Transport{
143         -               ConnPool: noDialClientConnPool{connPool},
144         -               t1:       t1,
        205 +               ConnPool:                  noDialClientConnPool{connPool},
        206 +               MaxFrameSize:              fct.MaxFrameSize,
        207 +               TransportDefaultConnFlow:  fct.TransportDefaultConnFlow,
        208 +               TransportDefaultStreamFlow: fct.TransportDefaultStreamFlow,
        209 +               TransportDefaultStreamMinRefresh: fct.TransportDefaultStreamMinRefresh,
        210 +               t1:                        t1,
145 211             }
146 212             connPool.t = t2
```

Modification of chasqui

- Uses the modified http2 GO package.
- Supports the following command-line options:
  - Frame size
  - Window size notification interval
- Supports plain-text connection
  - HTTP/1.1 and HTTP/2
- https://github.com/wtakase/chasqui

Test Plain-text HTTP/2 Data Transfer on LAN

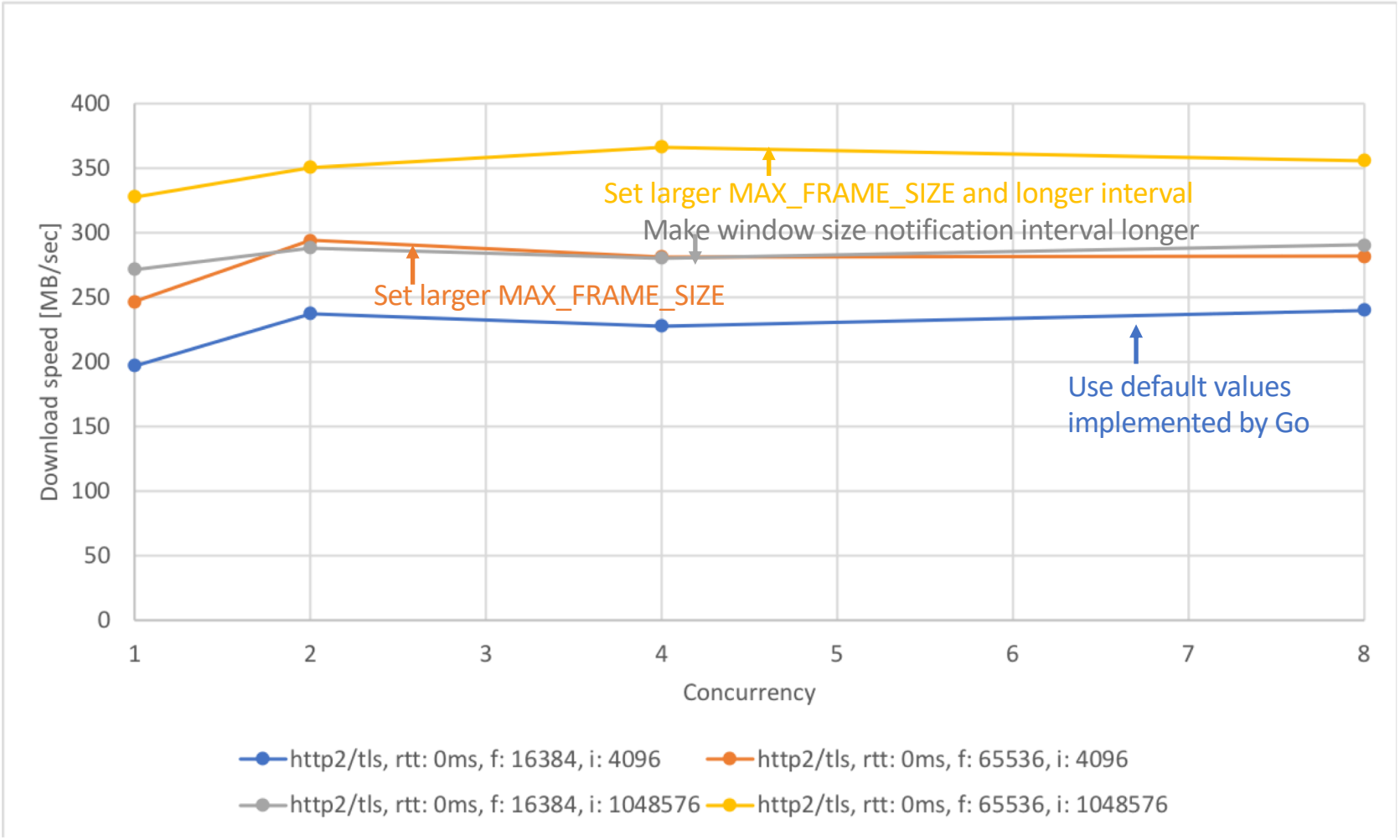
- Prepare 2 DTNs in KEK and connect them directly with QSFP+(40Gbps) and the RTT is 0ms.



RTT: 0ms, Measuring times: 1, Duration: 60 sec

```
$ chasqui driver -clients caddy02:9443 -servers caddy01:5678 -duration 60s -concurrency X ⇒
-max-frame-size Y -win-update-interval Z -plain-http
```

Test TLS HTTP/2 Data Transfer on LAN

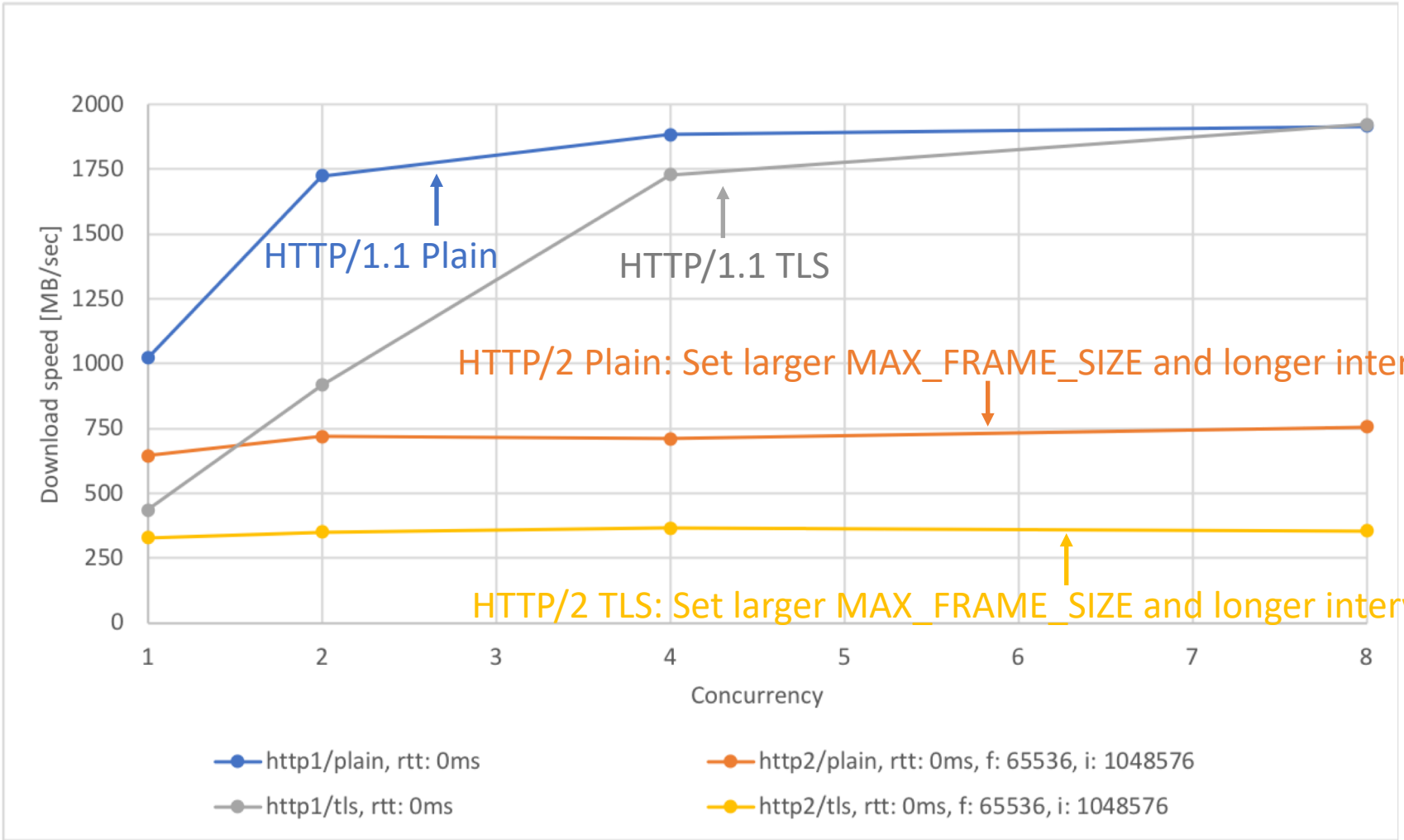


RTT: 0ms, Measuring times: 1, Duration: 60 sec

```
$ chasqui driver -clients caddy02:9443 -servers caddy01:5678 -duration 60s -concurrency X ⇒
-max-frame-size Y -win-update-interval Z
```

Comparison of HTTP/1.1 and improved HTTP/2

- Still HTTP/1.1 got better results.
  - Single TCP connection limits the data transfer speed in HTTP/2?
- Download performances over TLS are slower than the plain-text because of encryption/decryption overhead.



Next Step: Test with 10 Gbps network: Current Status

- CC-IN2P3:
  - The DTNs have already been connected to 10 Gbps network.
  - The firewall has been configured to allow connection from the DTN in KEK.
- KEK:
  - The DTN have already been connected to 10 Gbps network.
  - The firewall was configured to allow connection from the DTNs in CC-IN2P3 on 28th November.

Summary and Future work

- We have started data transfer test between CC-IN2P3 and KEK.
- We got the first result of memory-to-memory data transfer over 1Gbps.
  - HTTP/1.1 got better performance.
- We investigated the cause of HTTP/2 performance degradation.
  - Frame size, interval of window size notification
- Future work:
  - Test with multi-servers and multi-clients
  - Test with CC-IN2P3 over 10Gbps network
  - Test with modified chasqui
  - Test with larger Kernel TCP buffer sizes
  - Disk-to-disk data transfer test