TCP Encapsulation Considerations

draft-pauly-tsvwg-tcp-encapsulation-00

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Document Motivation

Presented strategy for TCP encapsulation of IKE and ESP in TSVAREA meeting at IETF 101

Interest expressed for having a document to codify the pitfalls and concerns with TCP encapsulation

Document is meant to be an informational reference for other specifications that support tunneling over TCP

Non-Goals

This document is **not** intended to:

- Encourage TCP encapsulation for generic use cases
- Define modifications to TCP to add unreliability, or anything beyond tuning
- Define a specific encapsulation format

Motivations for Encapsulation

Why does anyone want to do this?

- Networks blocking UDP traffic
- NATs timing out UDP mappings

Encapsulation Formats

How should messages be encapsulated over a stream?

Suggests a Length-Value format:

```
 1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                       Datagram Payload                        ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Encapsulation Formats

After length, may add a type or demux value to handle heterogenous datagrams

Format should be generic across stream protocols (TLS/TCP) not just raw TCP

TCP encapsulated protocols will need to allocate a port; suggests parallel port from UDP when available

Performance Concerns

Document discusses **concerns** and **mitigations**

Adding TCP as an encapsulation or tunneling layer can introduce many performance concerns

- UDP-in-TCP adds unneeded reliability
- TCP-in-TCP (for tunnels) adds additional concerns

Performance Concerns

TCP-in-TCP

- “Outer” tunnel
- “Inner” flows

1. Inner TCP experiences Outer losses as delay
2. Congestion window interactions and Bufferbloat
3. Head-of-Line blocking

Performance Concerns

Loss Recovery

Concern

Inner observes loss on Outer as delay

Mitigation

Use delay as input to congestion control

Minor loss is hidden from Inner

Inner TCP often needs to continue beyond tunnel

Performance Concerns

Congestion window interactions and Bufferbloat

Concern

Bursts of packets delivered to other side of tunnel

Multiple layers of slow start

Mitigation

Avoid spurious retransmissions as much as possible

Performance Concerns

Head-of-Line Blocking

Concern

Major timeouts affect all Inner flows

Loss outside tunnel cannot be recovered while the tunnel is blocked

Mitigation

Increased timeouts on Inner flows can give Outer flow time to recover from losses

TCP Encapsulation for IKEv2

RFC 8229

IKEv2 and ESP use UDP port 4500 generally

TCP Encapsulation sends those messages over a TCP stream on 4500 (but others ports can be configured)

TCP stream begins with a “Stream Prefix” of magic bytes to validate the protocol against previous non-standard uses of TCP 4500

Each datagram is framed with a 16-bit length field.

- IKEv2 packets are distinguished from ESP by the first four bytes being all zeros (from UDP encapsulation)

Concerns with TCP Encapsulation

Packet loss induces large **bursts**, especially for a tunnel that may have inner TCP flows retransmitting

Running TCP within TCP leads to **window size issues**, such as going through slow start both on outer and inner connections. Collaboration between outer and inner TCP would help.

Added **head-of-line blocking** between flows that were independent when using UDP

Performance Tests

Setup:

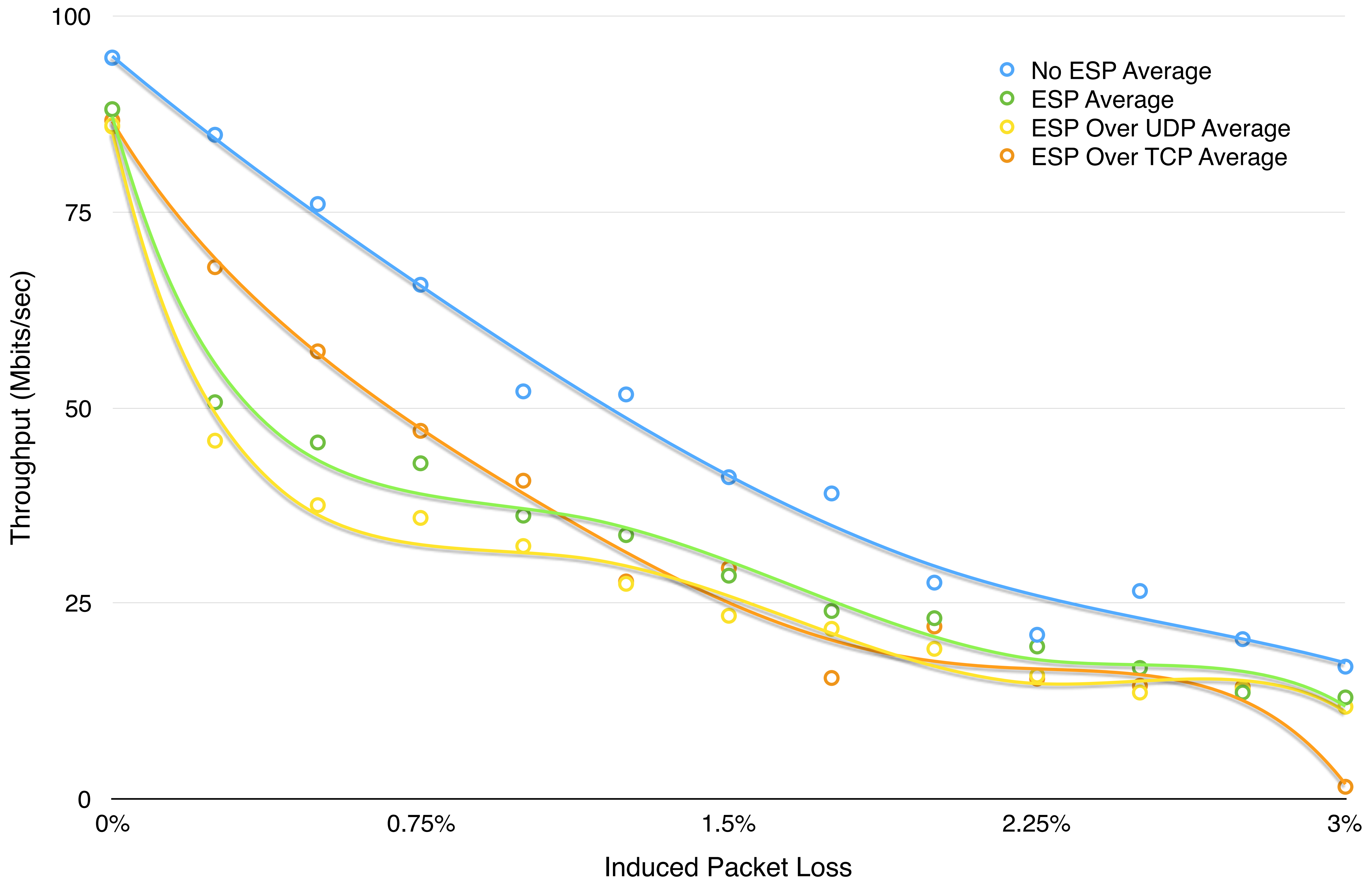
- Standard IKEv2 VPN server
- Relay box in front of server, decapsulating TCP stream
- Client modified to send IKEv2 and ESP packets over the TCP stream
- Run multiple iperf TCP flows within the tunnel

Variables:

- Encapsulation: ESP, ESP over UDP, ESP over TCP
- Fixed random loss (0-3%) induced with Cerowrt router
- Delay (0-500ms) induced with Cerowrt router

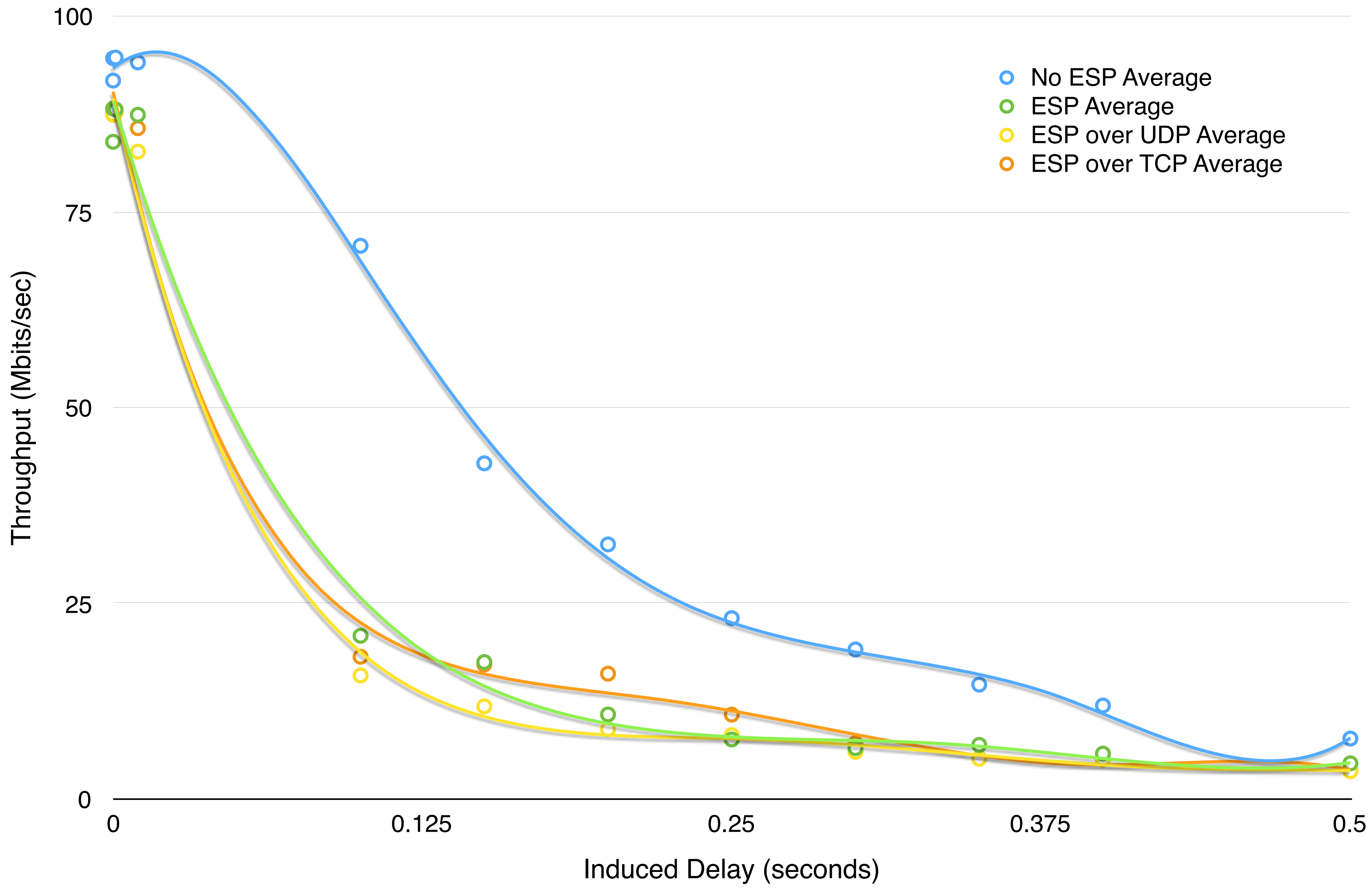
Performance Tests

Loss



Performance Tests

Delay



Conclusions

TCP encapsulation works, and is certainly preferable to no connectivity for UDP-based protocols

Performance is tolerable, and degrades at roughly the same points as other tunnels (may be pathological cases, however)

Tuning the TCP connection used for encapsulation would likely improve its performance