

Closer to the Live Edge

Client-side Adaptation with Server-side Transport State

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On-demand vs Live Streaming Quality of Experience

- Live latency is the key difference
 - Delta between an event occurring and being viewed
 - Minimise for parity with other broadcasts, consistent to avoid spoilers
- Buffer-based ABR relies on state of playback buffer as input
 - Buffer length is constrained by target live latency, how does ABR perform with limited input?
- **Only the client can know the current live latency at any given time**
 - Can we boost client-side ABR performance with information from the server?

Server-side Transport State for Client-side Adaptation

- We use the Transport-Info HTTP header proposed in an IETF Draft^[1]

```
HTTP/1.1 200 OK
```

```
Host: example.com
```

```
...
```

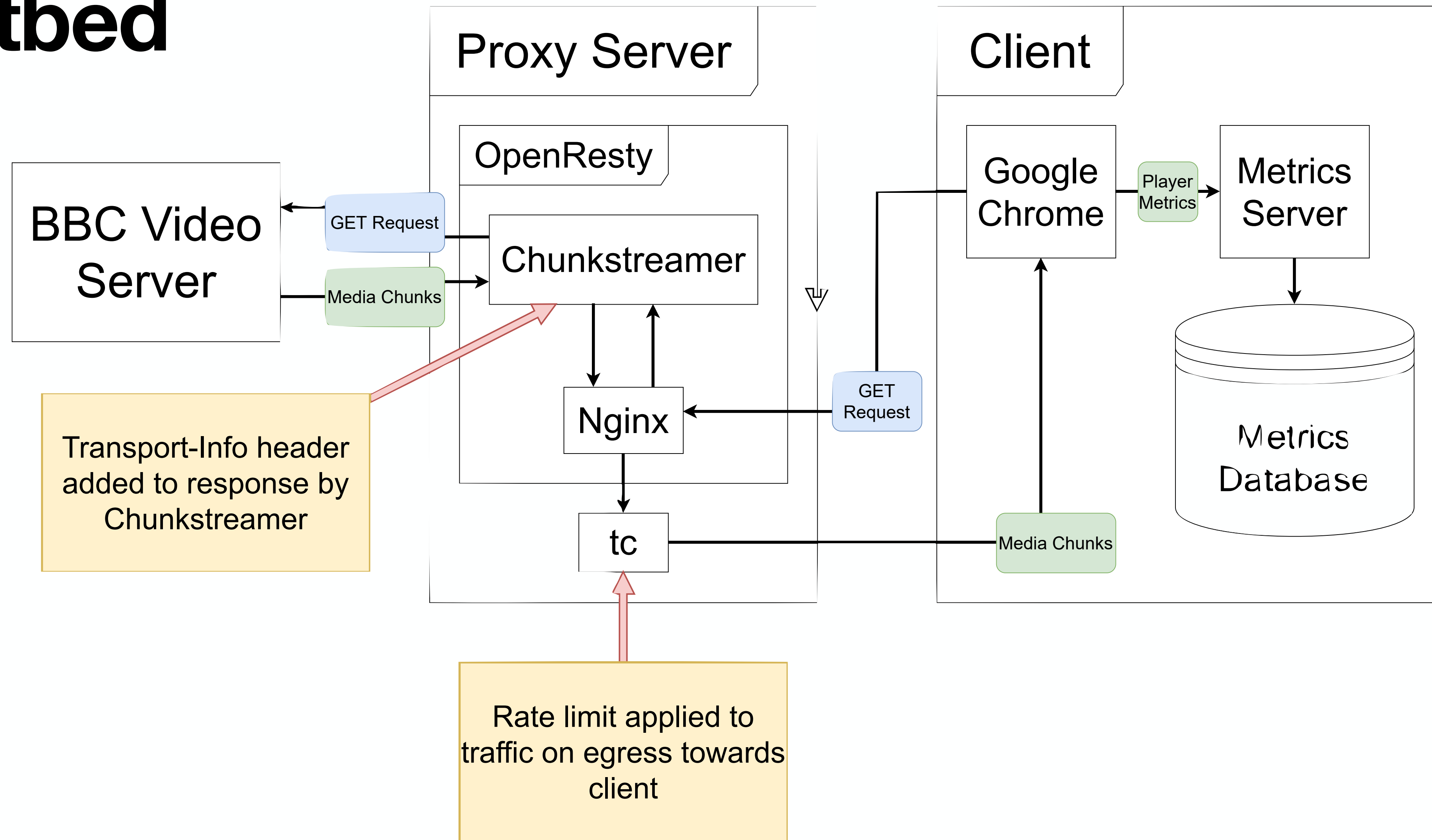
```
Transfer-Encoding: chunked
```

```
Transport-Info: example.com; ts=2021-06-25T15:07:31.123Z; rttvar=512;  
                cwnd=49; mss=1448; rcv_space=14600; dstport=32167;  
                rtt=37133
```

- Transport-Info provides accurate server-side state **but** at the cost of not knowing *where* on the CWND sawtooth the value is from

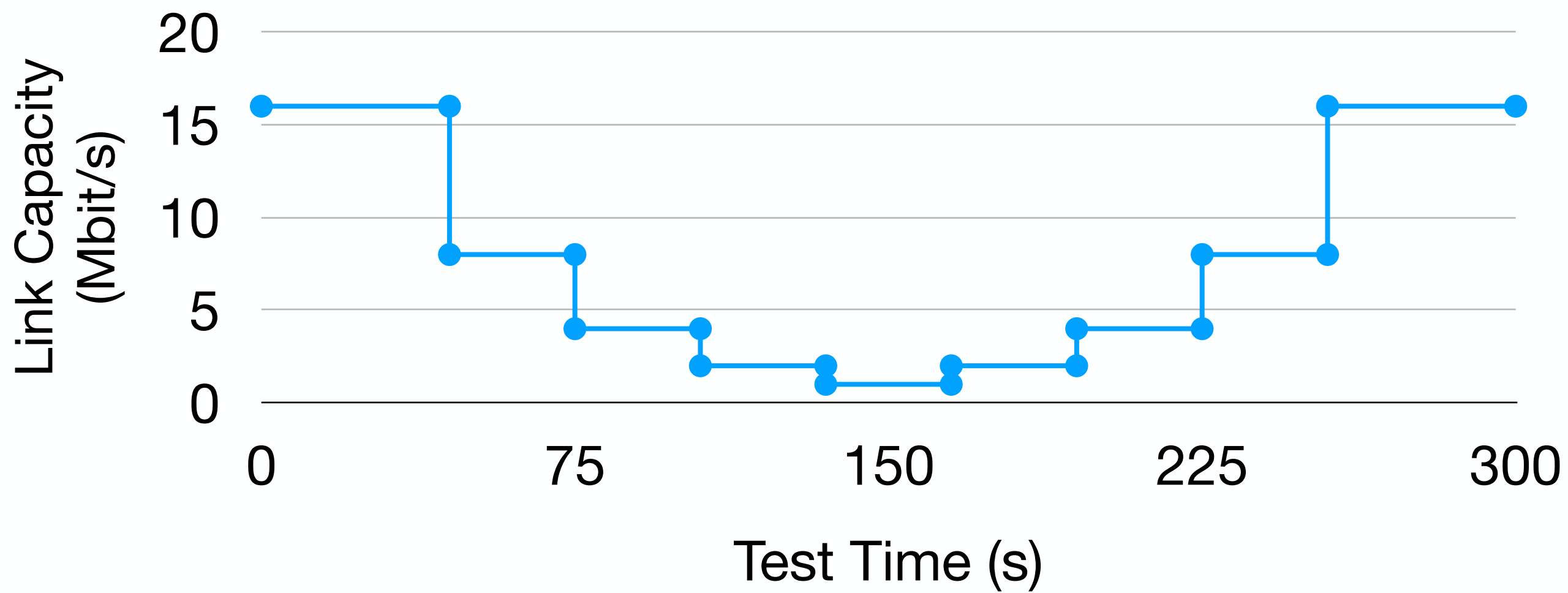
[1] <https://datatracker.ietf.org/doc/html/draft-ohanlon-transport-info-header-01>

Testbed

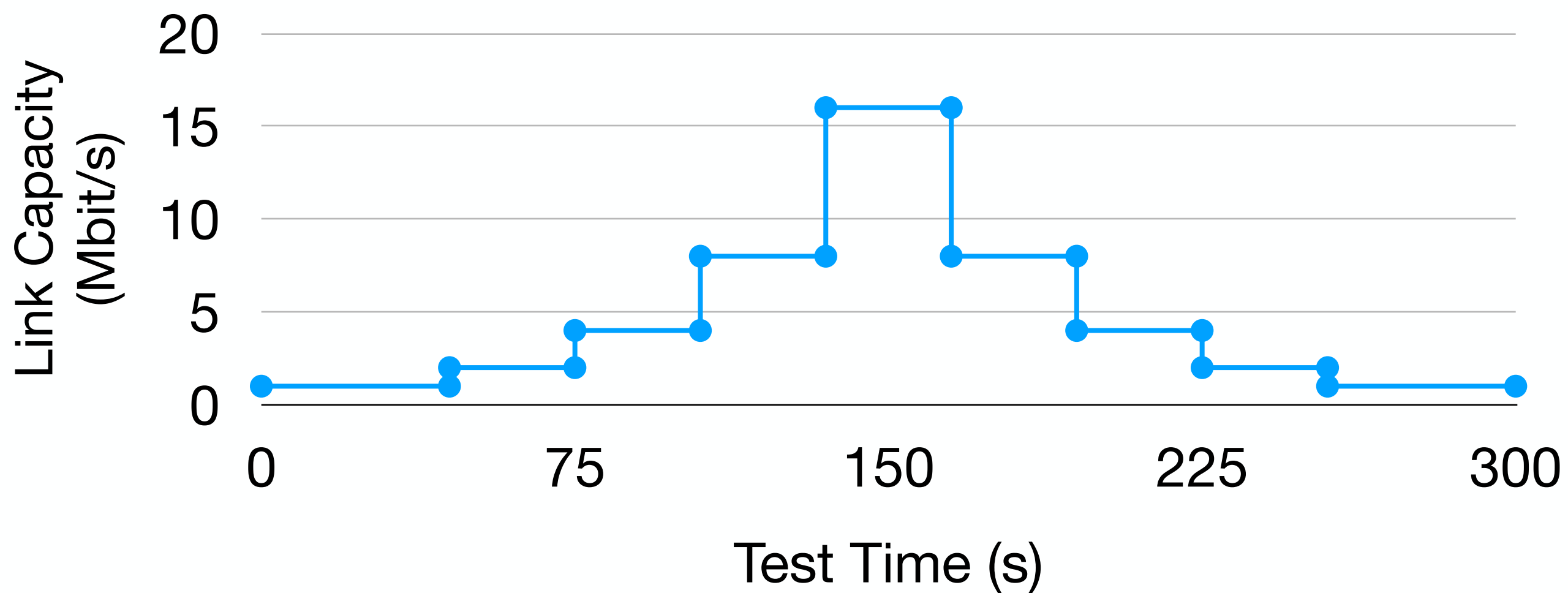


Per-segment Throughput Measurement

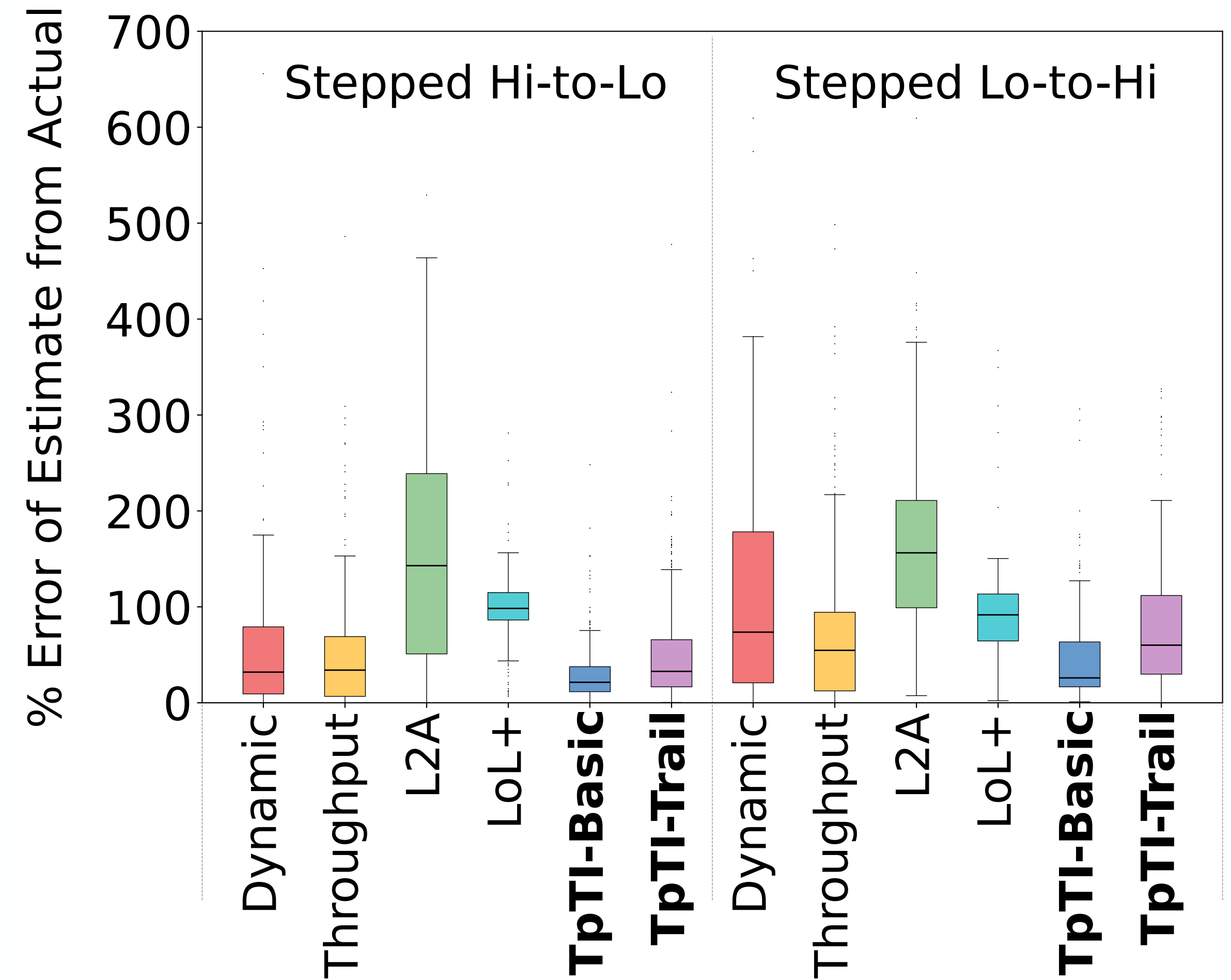
Stepped Hi-to-Lo



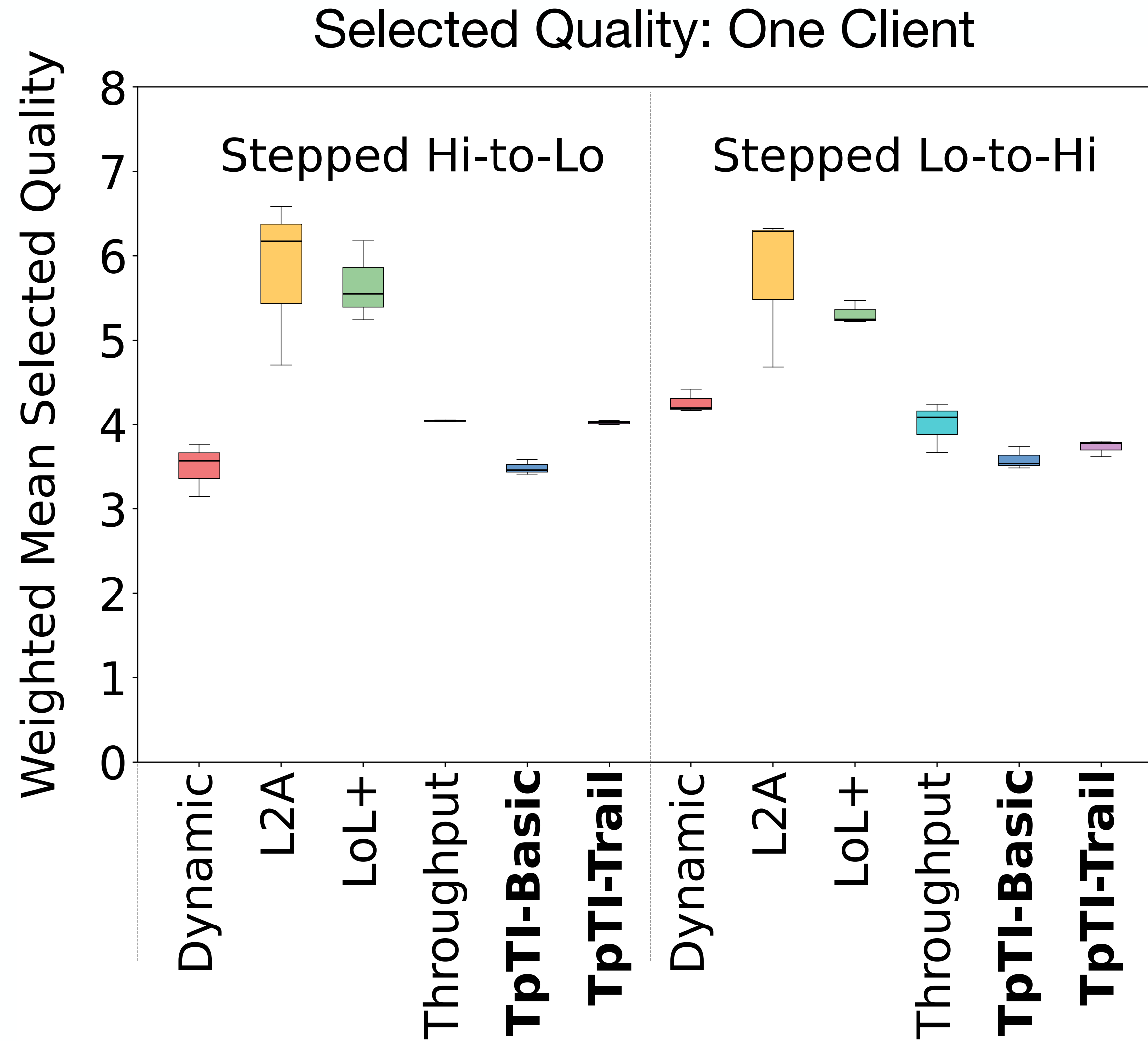
Stepped Lo-to-Hi



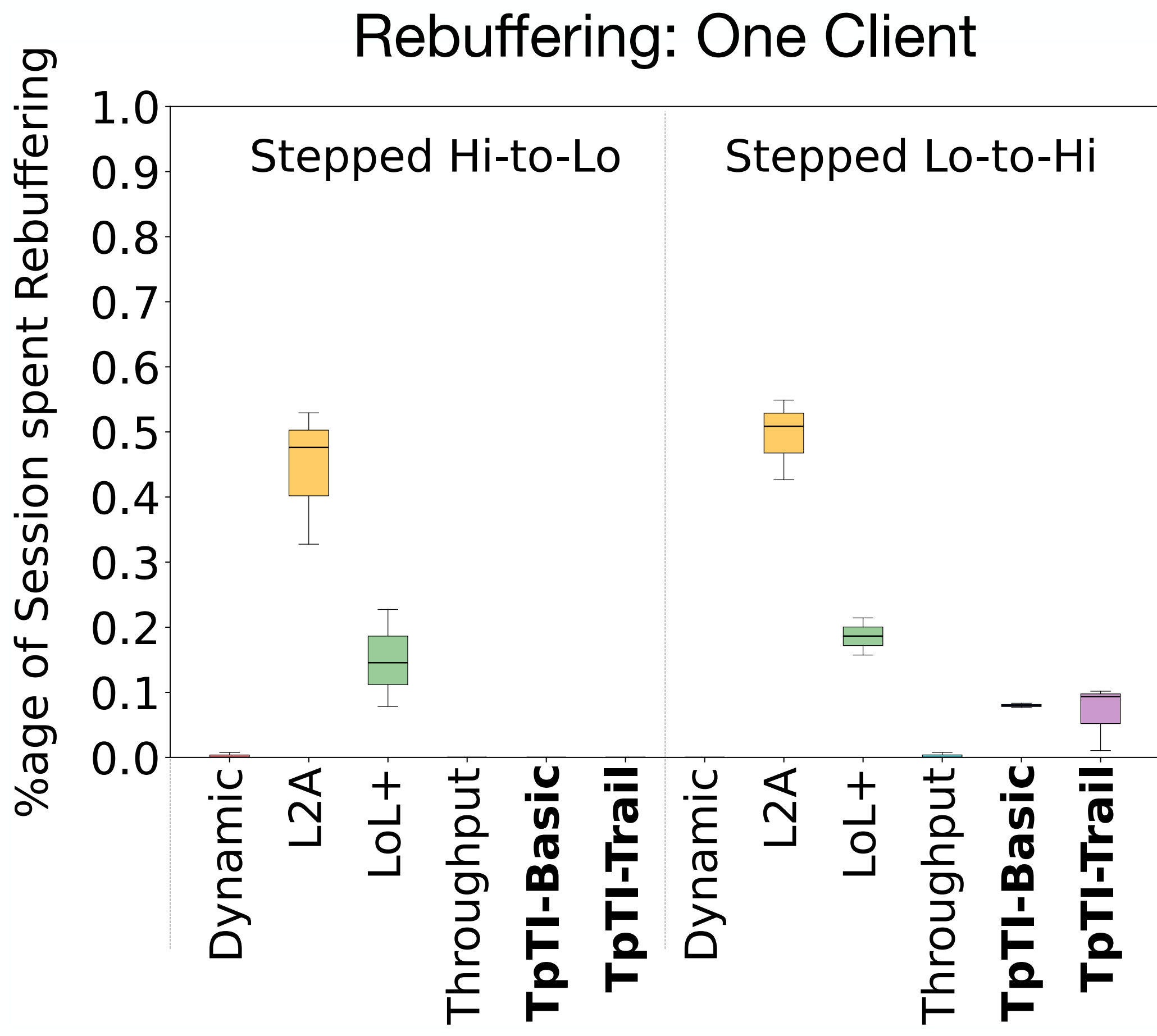
Throughput Estimation Error as Percentage of Actual Bandwidth



Individual QoE Measurements are Misleading

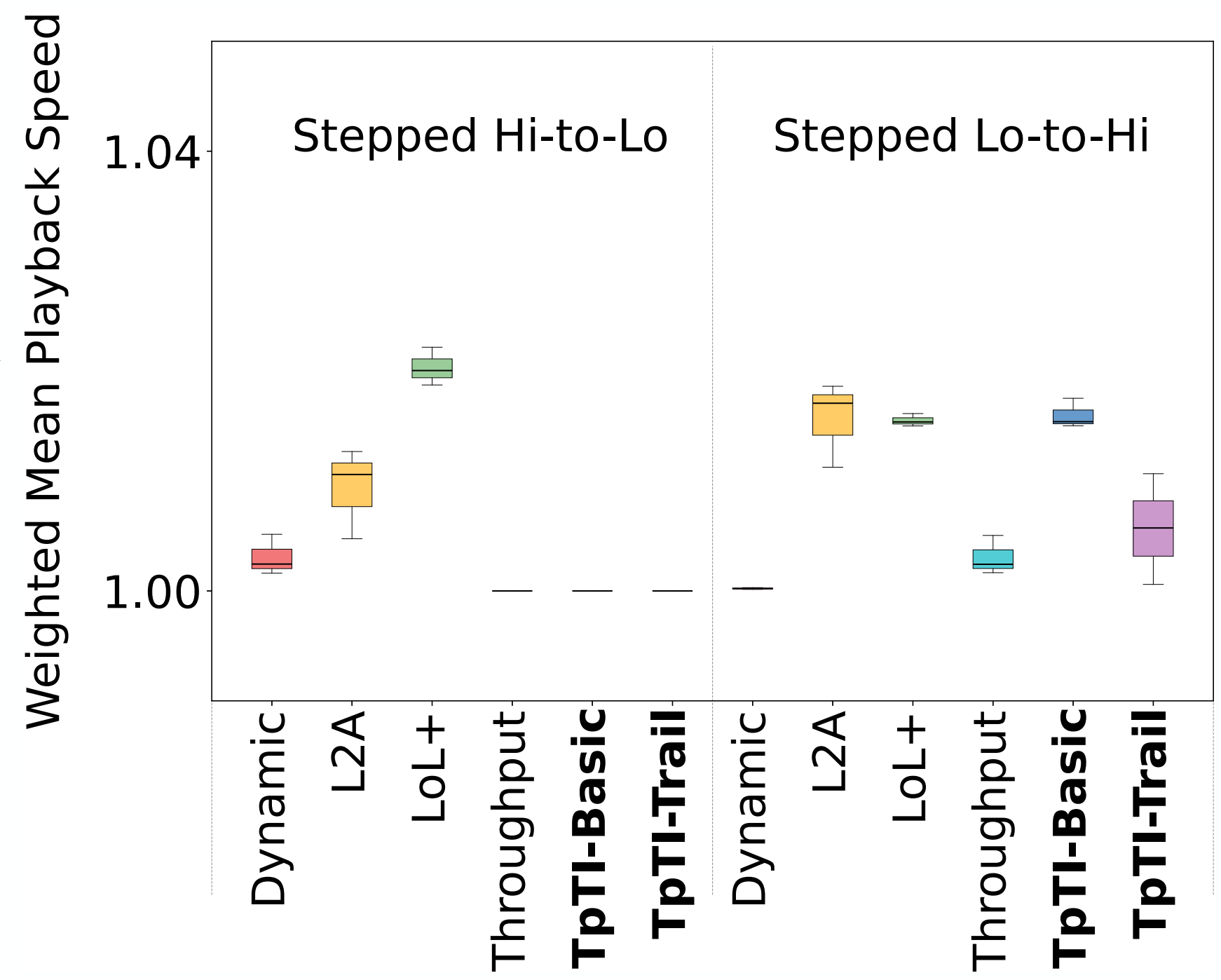
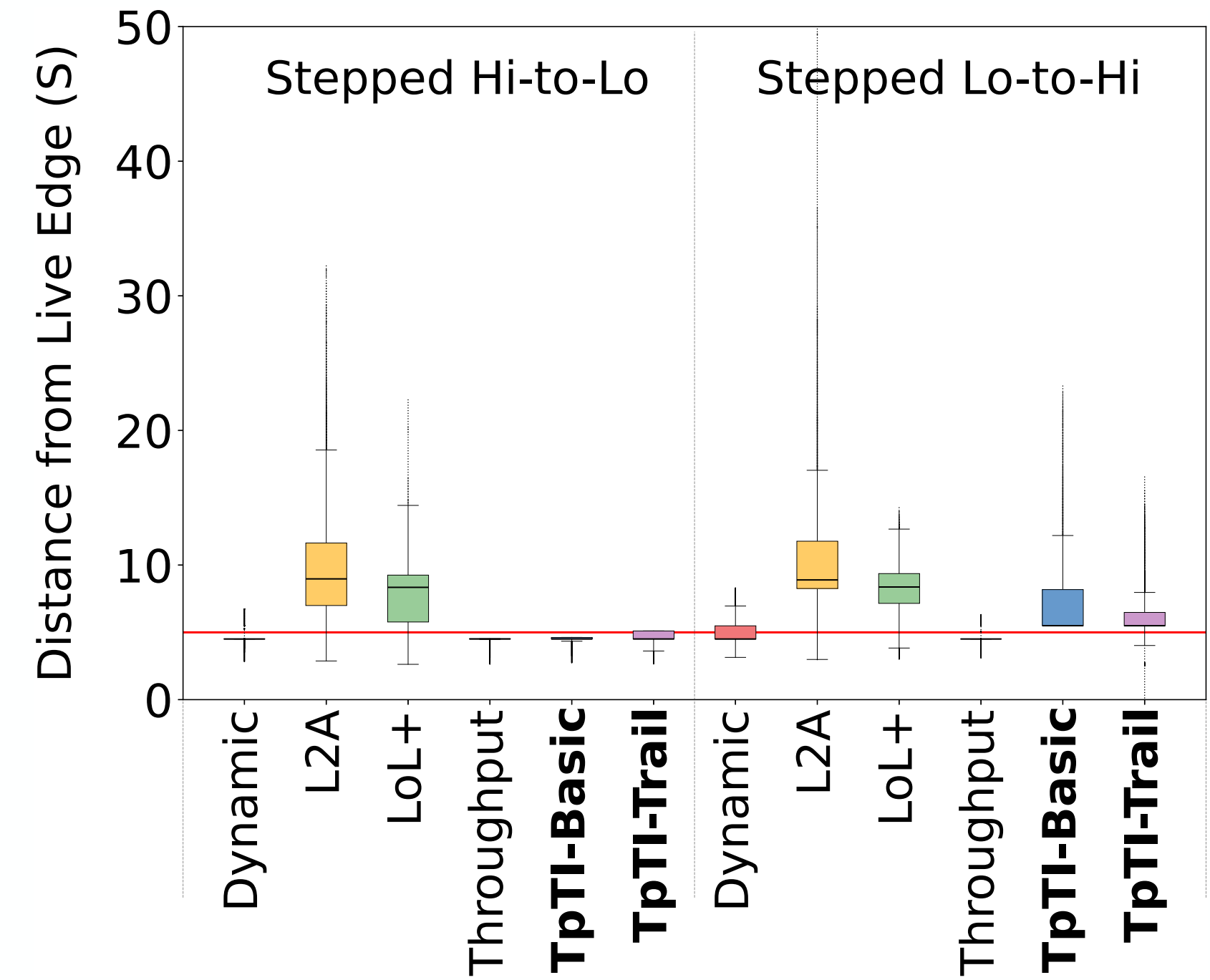


Looking Deeper

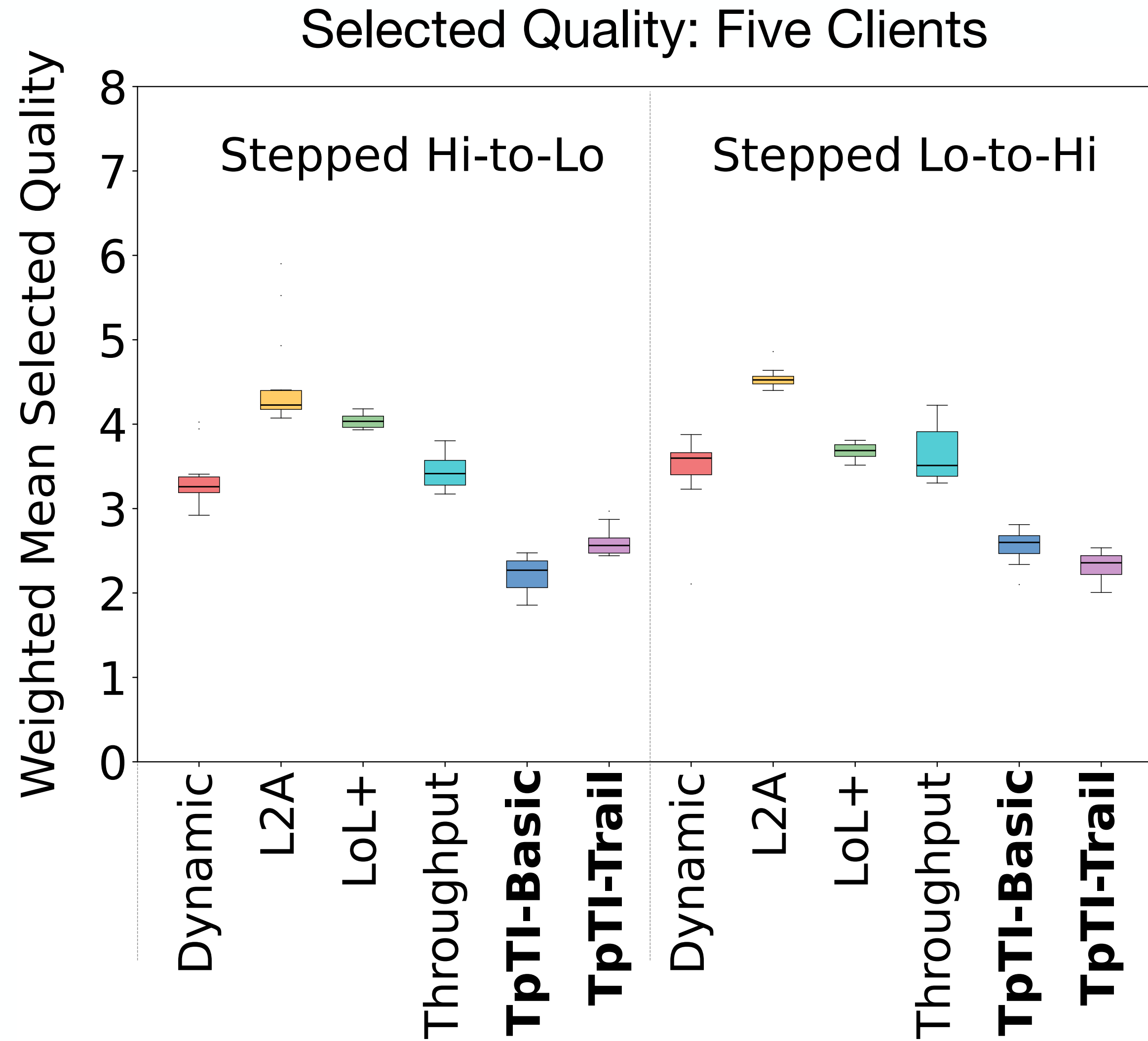


Live Latency

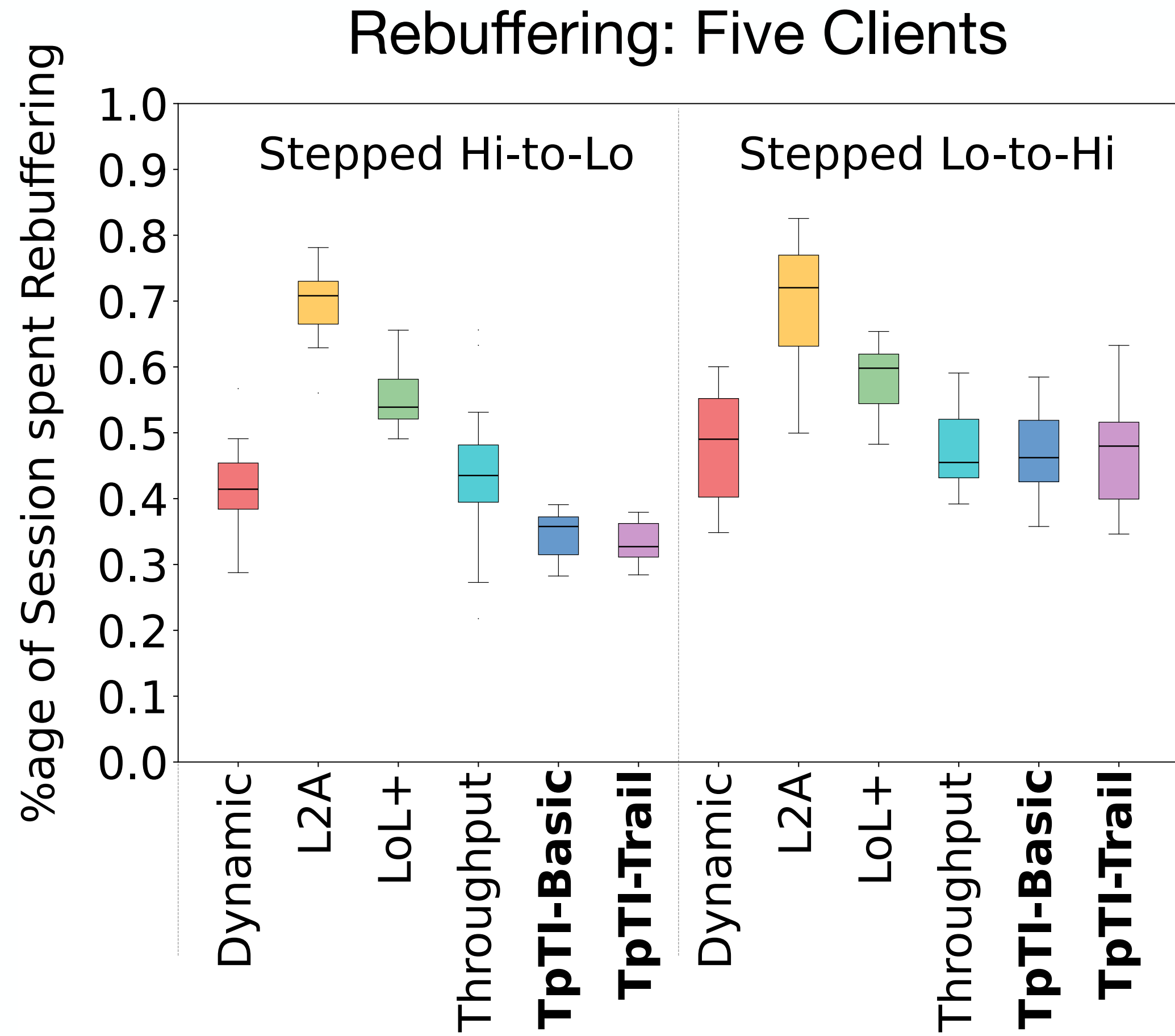
Playback Speed



Similar Problems with Multiple Clients

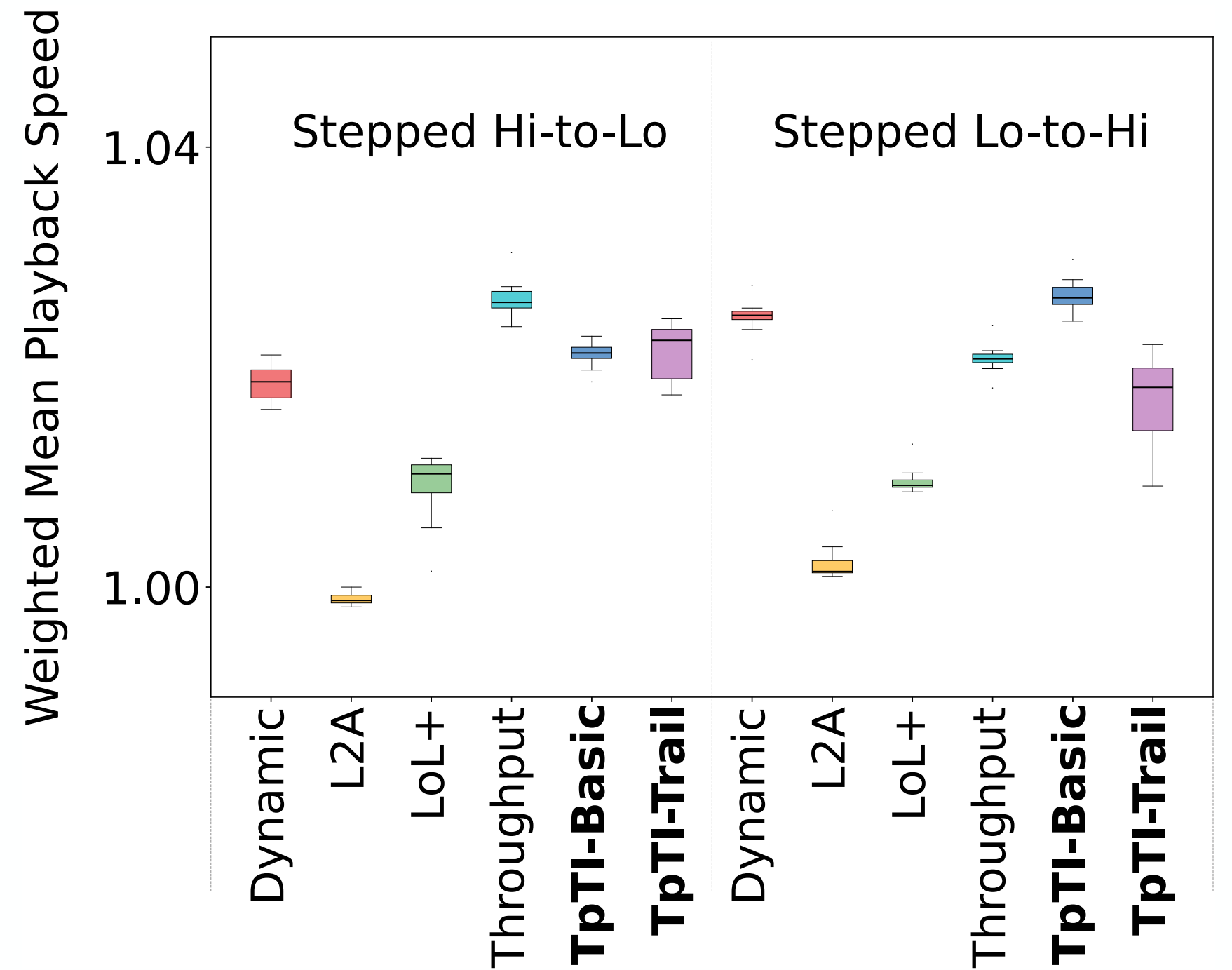
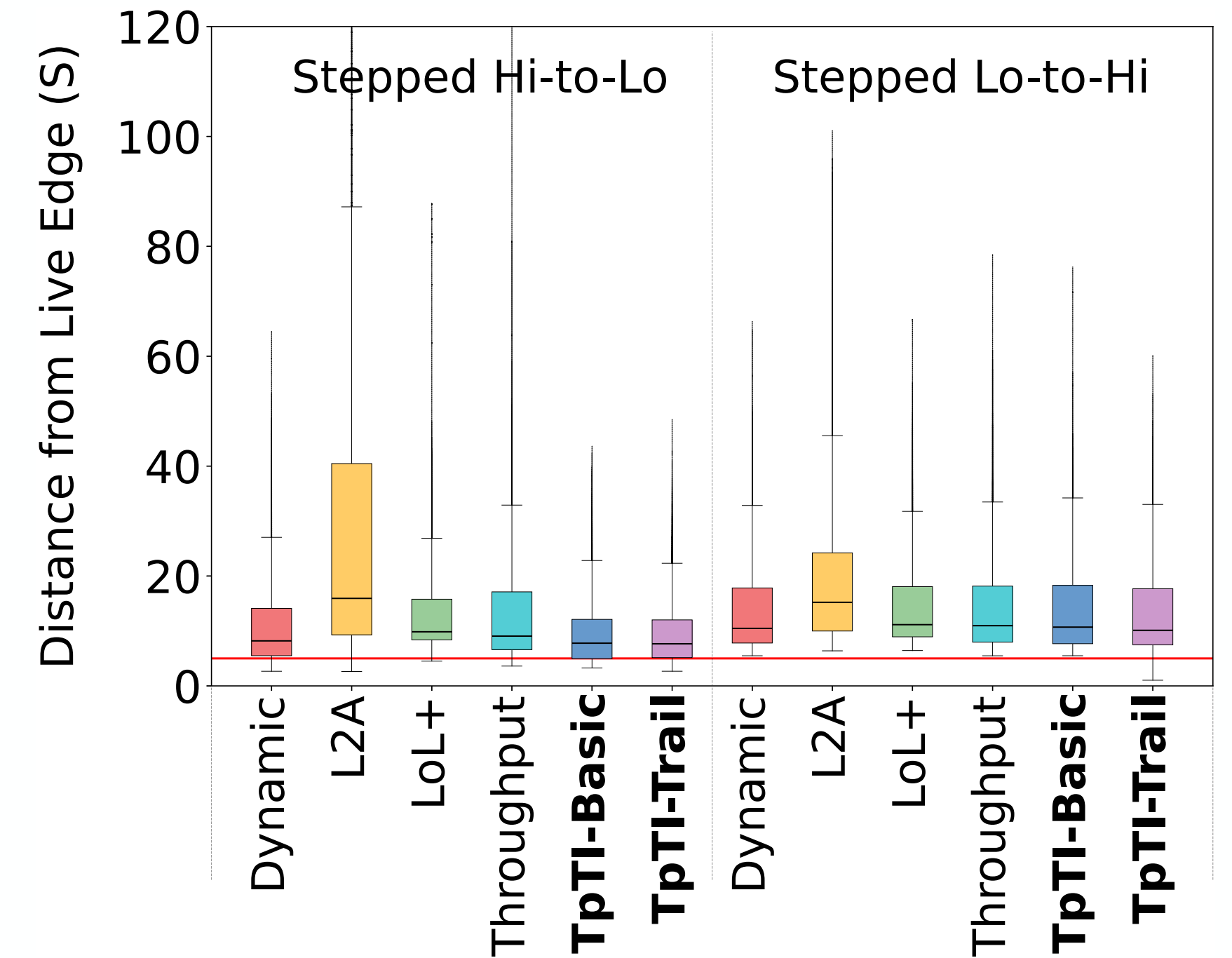


Automated Seek Further Distorts Individual QoE Measures



Live Latency

Playback Speed



Combined QoE Measurements

- Video On-Demand Individual Factors:
 - Selected Bitrate, Rebuffering, Representation Switches
- Live Streaming Individual Factors:
 - Latency, Playback Rate
- **Combined QoE model**
 - Proposed in [2] this model assigns weights to all of the factors listed above to arrive at an overall QoE score

Combined QoE for Tests with Five Clients

ABR	Stepped Hi-to-Lo		Stepped Lo-to-Hi		Legend
	EWMA	SWMA	EWMA	SWMA	
Dynamic	-1,050,816	-1,308,665	-1,236,710	-1,264,220	Best
Throughput	-1,152,297	-1,353,734	-1,239,209	-1,136,539	Second Best
LoL+	-1,388,790	-1,787,691	-1,718,737	-1,756,469	<i>Worst</i>
L2A	-2,348,565	-2,263,878	-2,081,551	1,799,543	
TpTI-Basic	-1,140,901	-1,095,128	-1,153,342	-1,217,570	
TpTI-Trail	-1,021,300	-1,004,095	-1,125,878	-1,201,407	

Conclusions and Open Questions

- Throughput-based ABR can outperform buffer-based ABR in live streaming scenarios when multiple streaming sessions share a bottleneck
- Existing QoE models do not account for the impact of automated-seek behaviours present in modern video clients
- How to enable server-side hints to be communicated to a client in a way that preserves user-privacy?
- What about QUIC?