`accept()`able Strategies for Improving Web Server Performance

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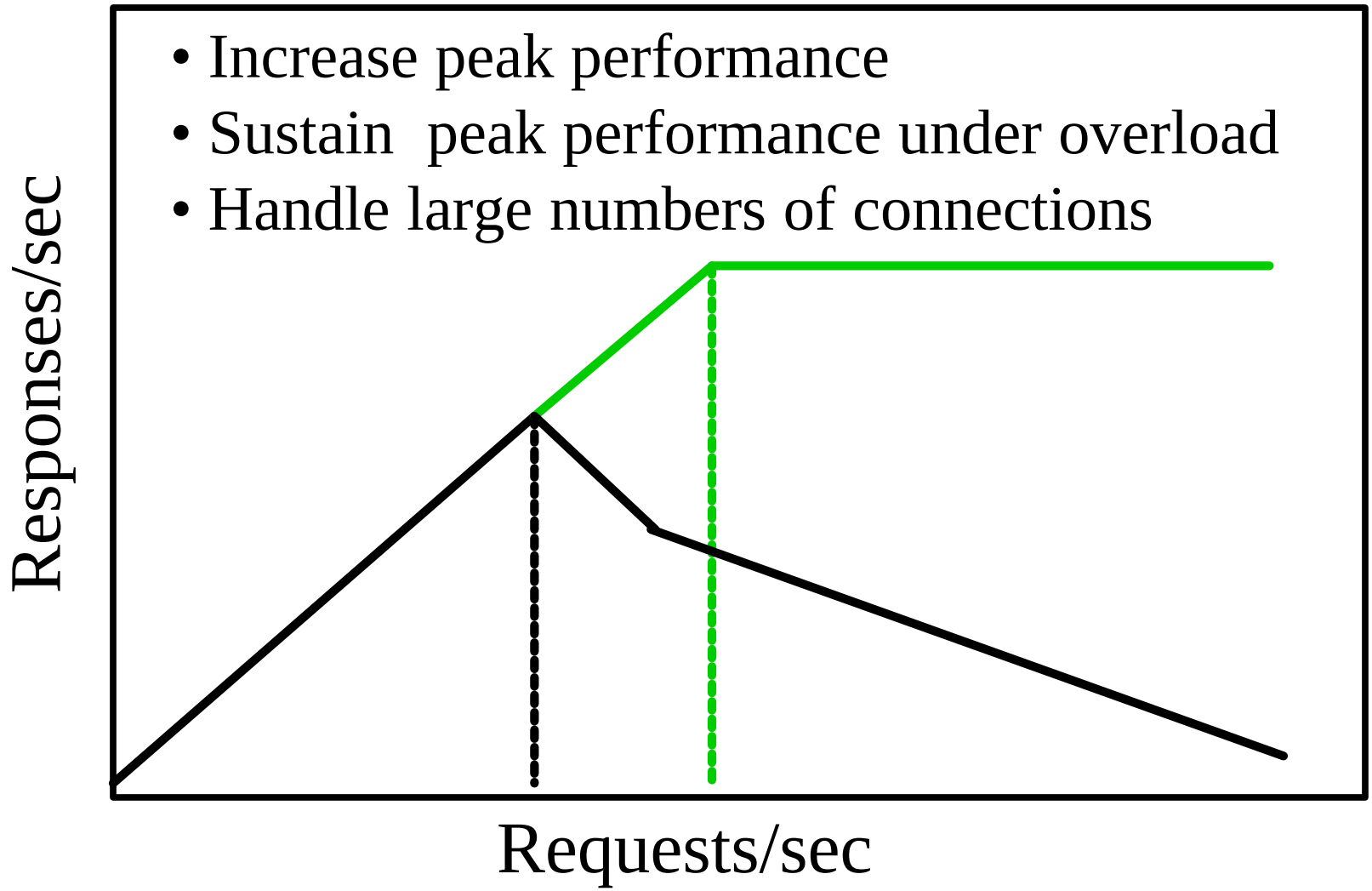
The Problem and Goals



Better understand apps and interaction with kernel

Results

- Examine how different servers **`accept()`** connections
- Increased throughput:
  - **`userver`** **(39-71%)** user-mode, event-driven
  - **`Knot`** **(0-32%)** user-mode, thread-based
  - **`TUX`** **(19-36%)** kernel-mode, event-driven

- **`userver`** performance comparable to **`TUX`**

Some Related Work

- **multi-accept** [Chandra & Mosberger 2001]
  - workload: requesting single 1 byte file
  - call **`accept`** repeatedly until it fails

- **kernel-mode vs user-mode** [Joubert et al. 2001]
  - TUX nearly 2 x best user-mode server

Phases in the Event-Driven userver

Get Events Phase (figure out what to do)

```
get events
  select()
```

Accept Phase

```
get new connections
  n = accept_loop(limit)
```

Work Phase

```
process requests / connections
  read()    write()/sendfile()
```

Phases in the Event-Driven userver

Get Events Phase (figure out what to do)

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get events
  select()
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Accept Phase

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  n = accept_loop(limit)
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Work Phase

```
process requests / connections
  read()    write()/sendfile()
```

Lower Rate 1 10 Inf Higher Rate

Knot (each thread)

```
/* Events are hidden in thread library */
while (1) {
   /* Accept Phase */
   accept_loop(limit);

   /* Work Phase */
   foreach (connection) {
      process_client();
      close();
   }
}
```

Knot (each thread)

```
/* Events are hidden in thread library */
while (1) {
   /* Accept Phase */
   accept_loop(limit);

   /* Work Phase */
   foreach (connection) {
      process_client();
      close();
   }
}
```

Lower Rate 1 10 Inf Higher Rate

TUX

```
/* No get event phase required  (kernel-mode) */
while (1) {
   /* Accept Phase */
   if (accepts_pending()) {
     accept_requests(limit)
   }
   /* Work Phase */
   if (requests_pending()) {
     process_requests()
   }
}
```

TUX

```
/* No get event phase required  (kernel-mode) */
while (1) {
   /* Accept Phase */
   if (accepts_pending()) {
     accept_requests(limit)
   }
   /* Work Phase */
   if (requests_pending()) {
     process_requests()
   }
}
```

Lower Rate **Inf** **10** **1** Higher Rate

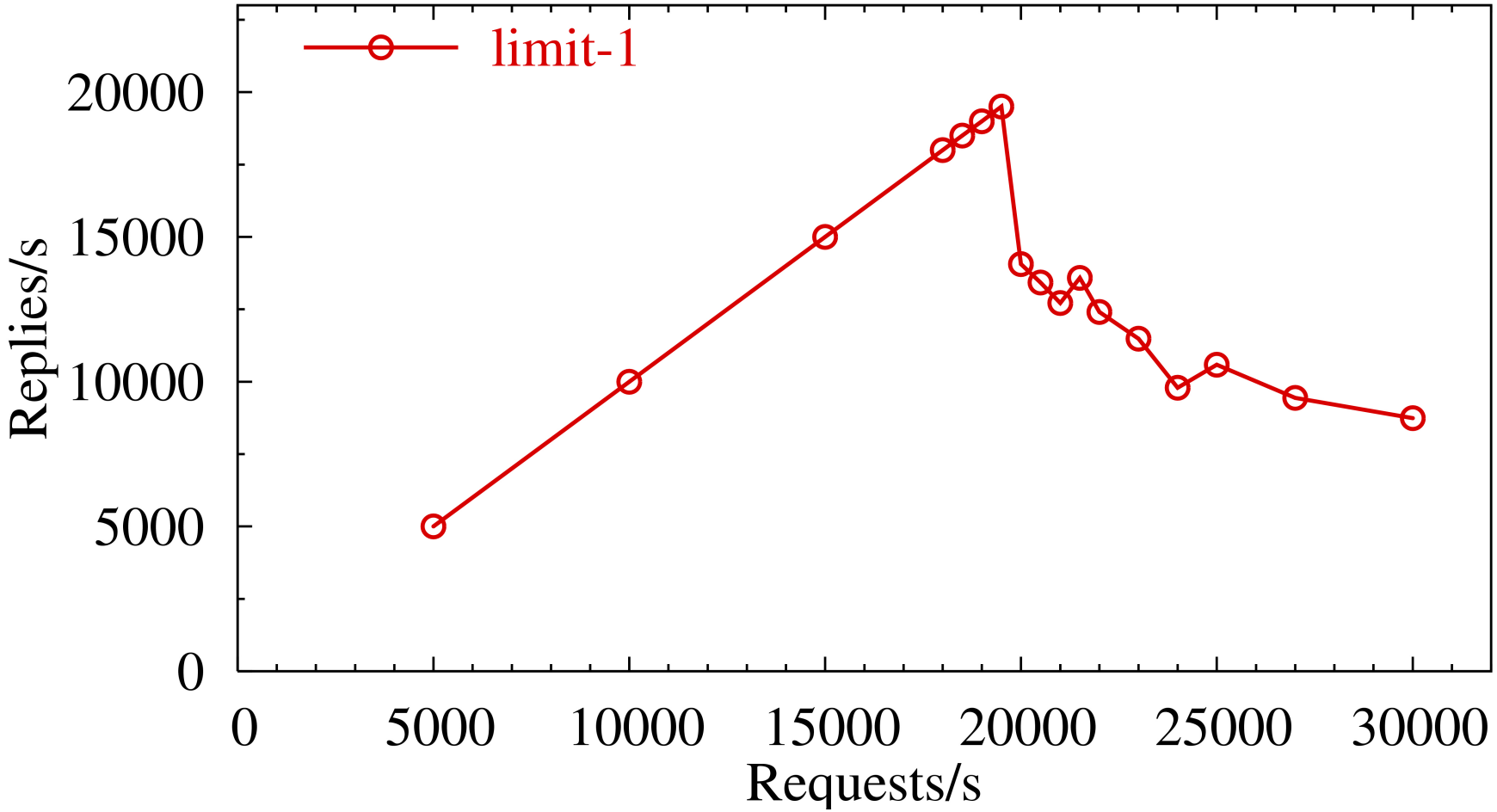
Environment

- **Servers**
  - **`userver, Knot, TUX`**
- **Hardware**
  - 2.4 GHz Xeon, 1 GB RAM, 2 x 1 Gbps Enet
  - 4 clients connected to each 1 Gbps subnet
- **Workload**
  - **One packet workload**

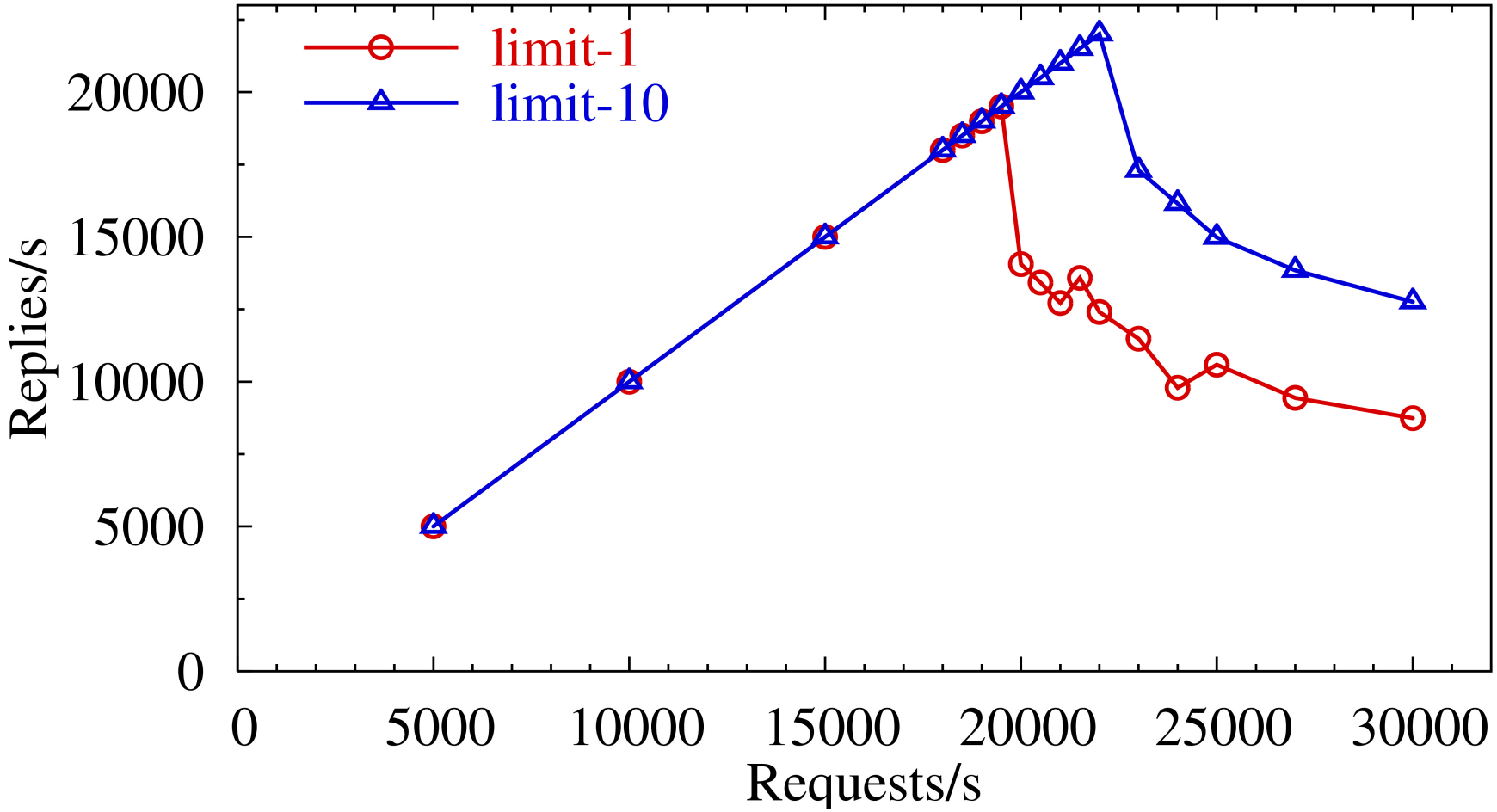
    hammers on OS. CNN.com and upstream on 9/11
  - **Static SPECWeb99-like**

    fits in memory (avoid differences in caching)
  - **`httperf`** can generate overload conditions

Performance of the userver (one packet)



Performance of the userver (one packet)



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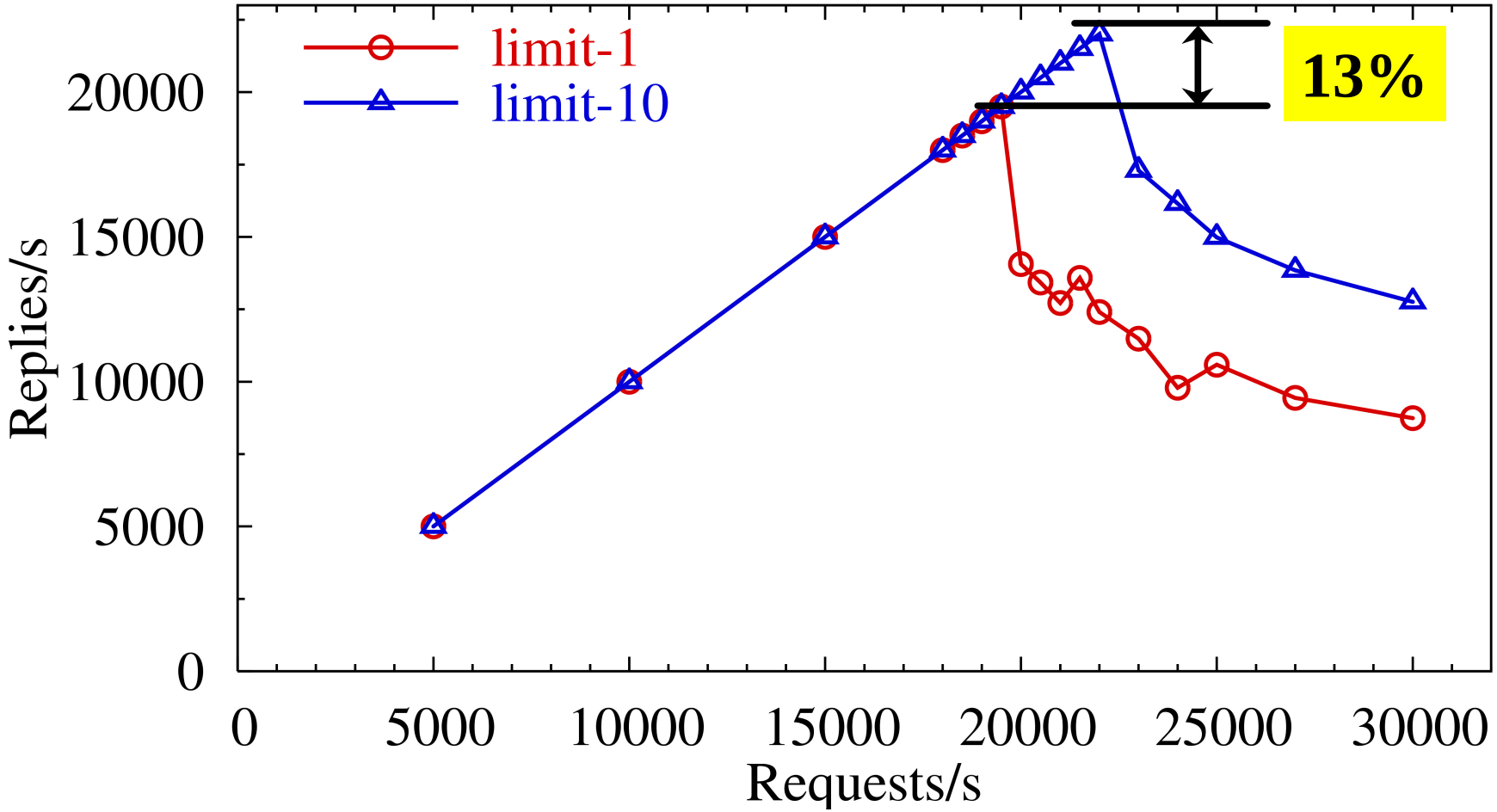

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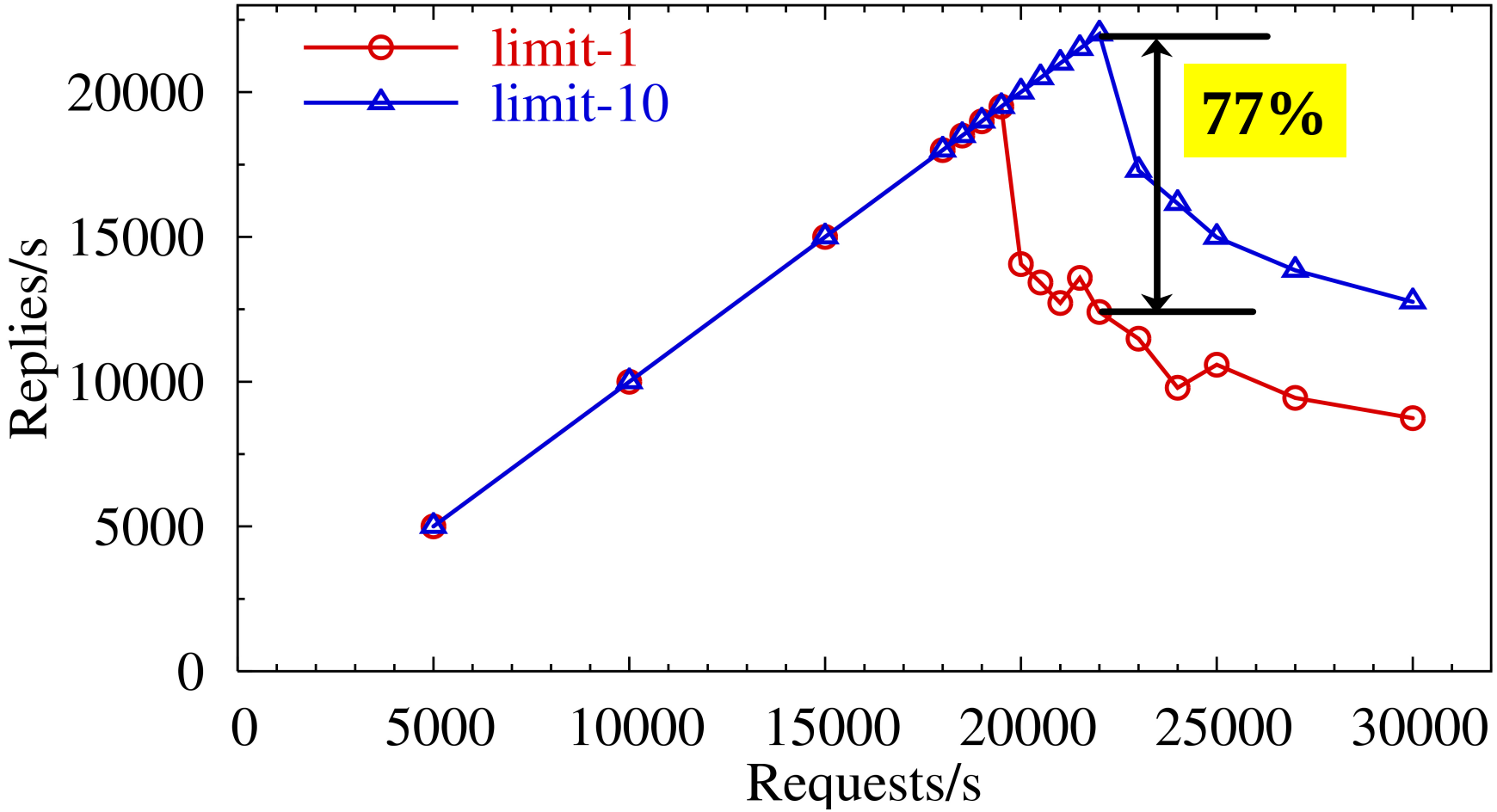
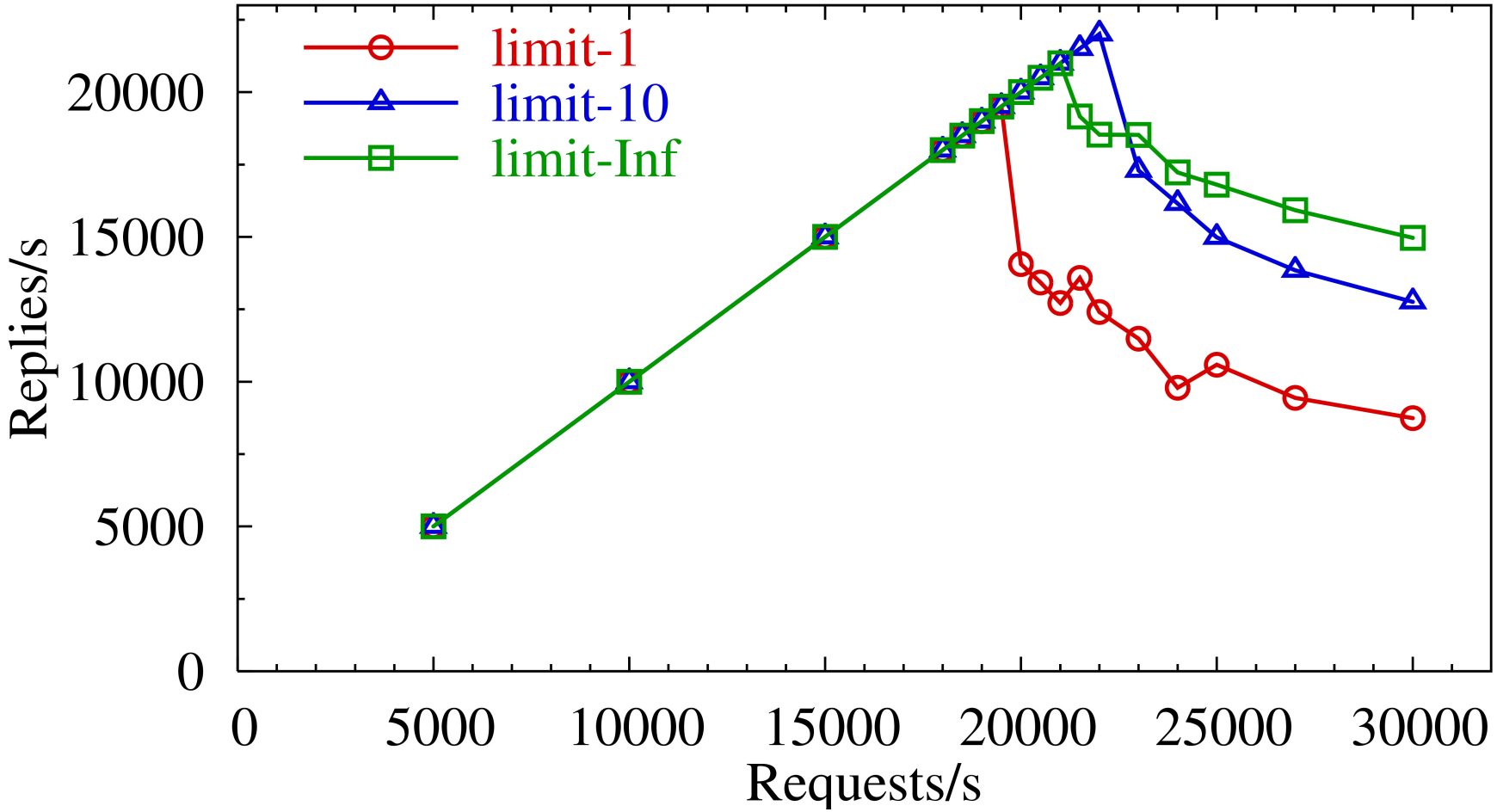
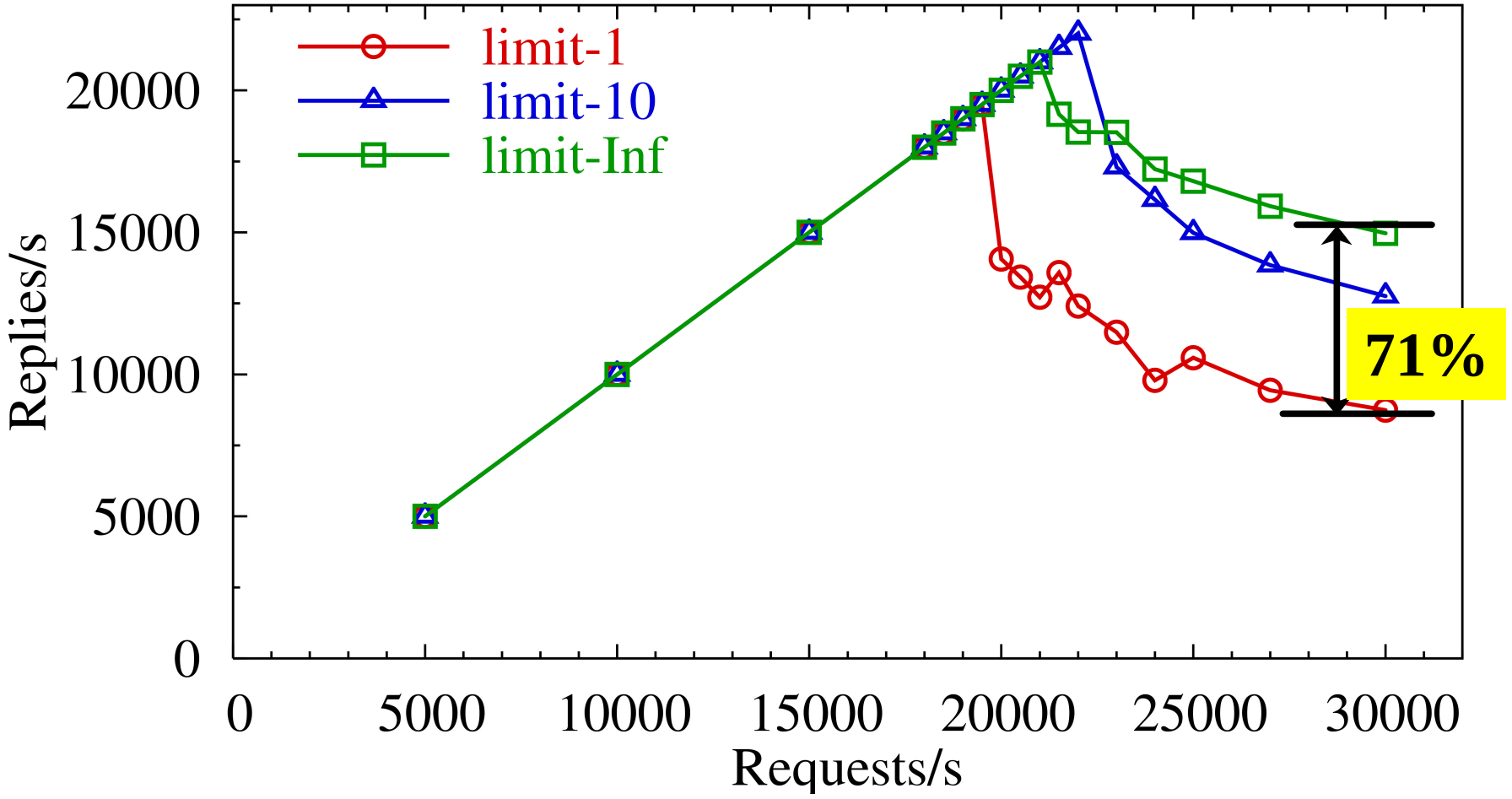


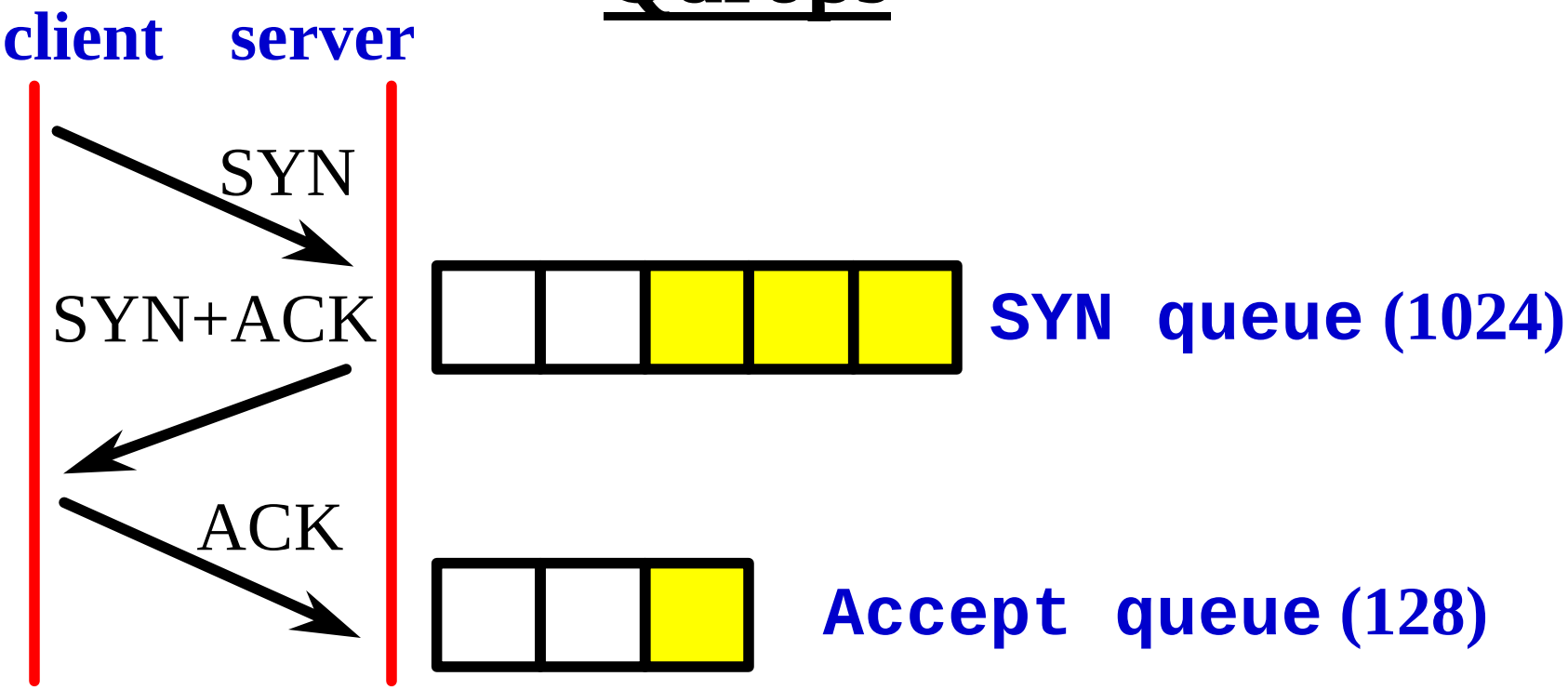
Performance of the userver (one packet)



Performance of the userver (one packet)

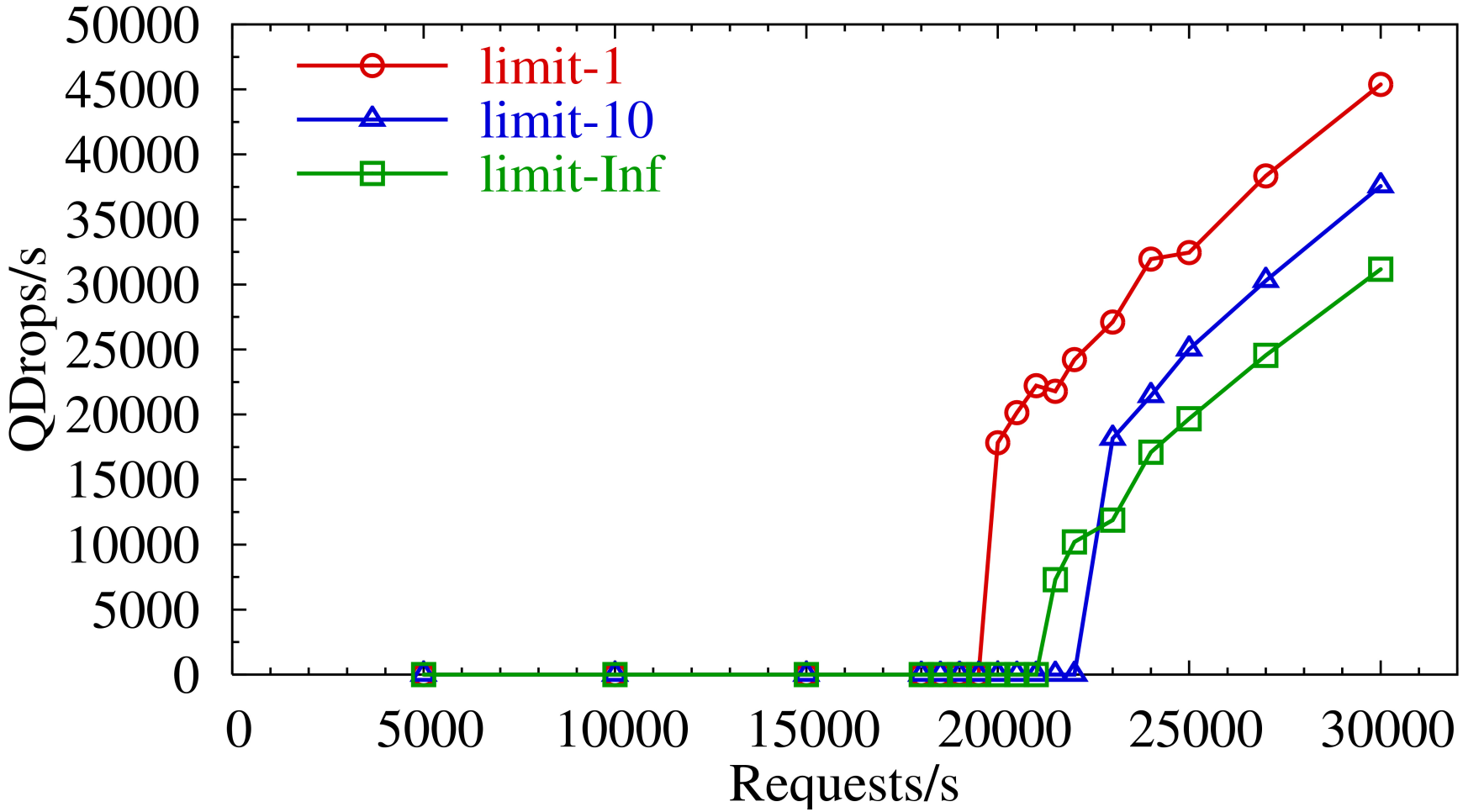


Qdrops

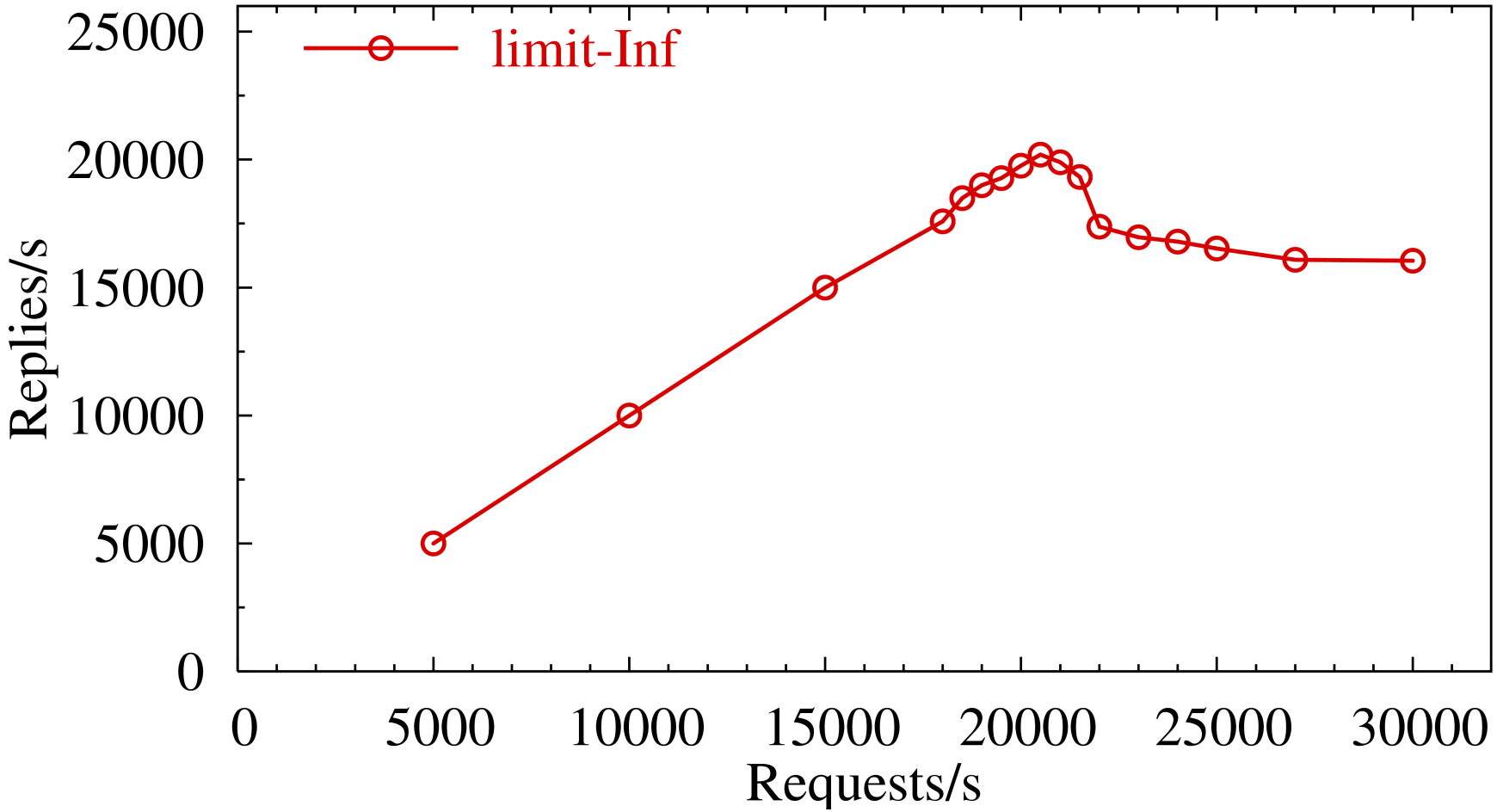


- When SYN arrives **SYN queue** is > 3/4 full
- When SYN arrives **Accept queue** is full
- When ACK arrives **Accept queue** is full

Qdrops for userver (one packet)



Performance of TUX (one packet)



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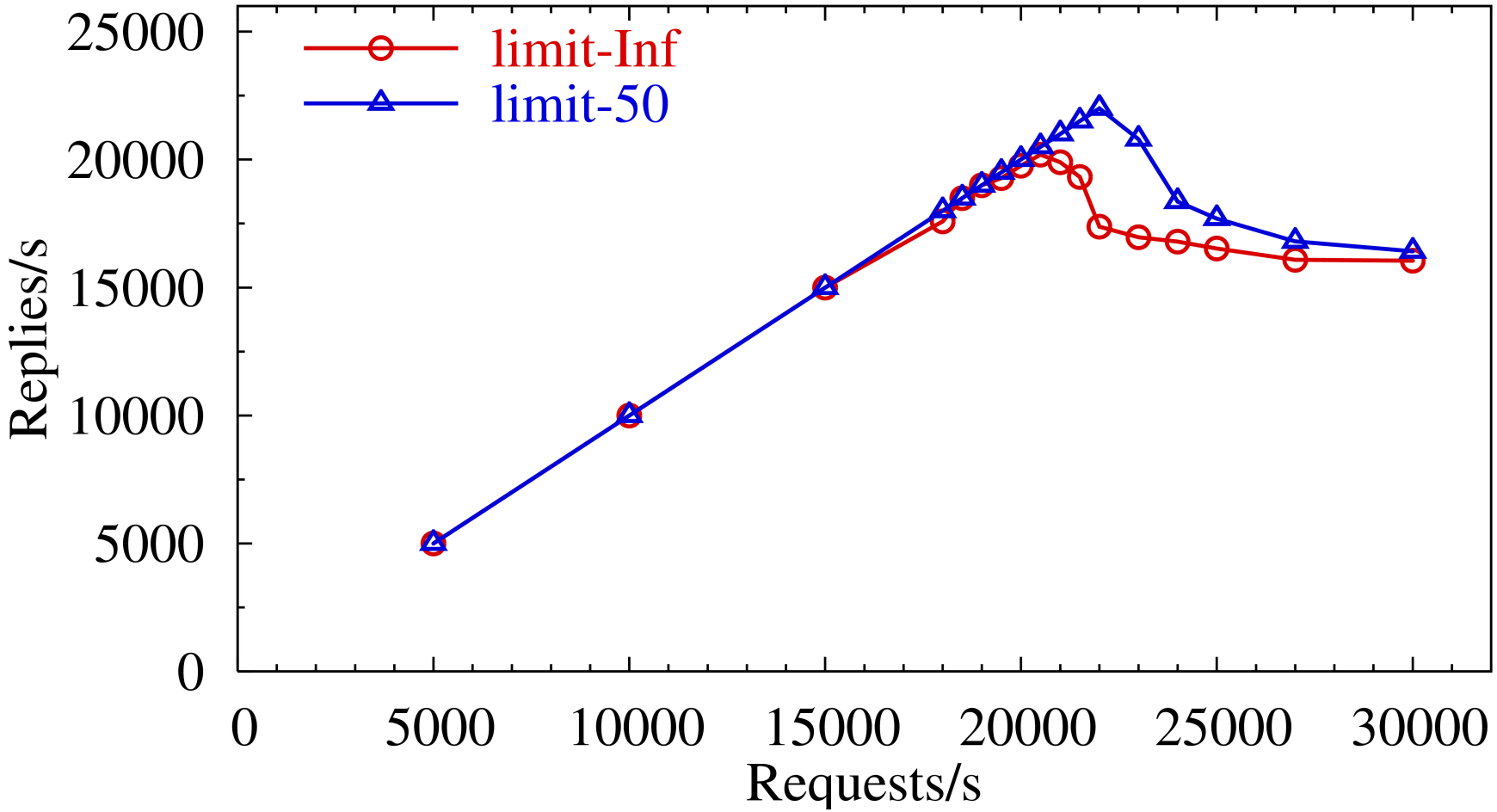

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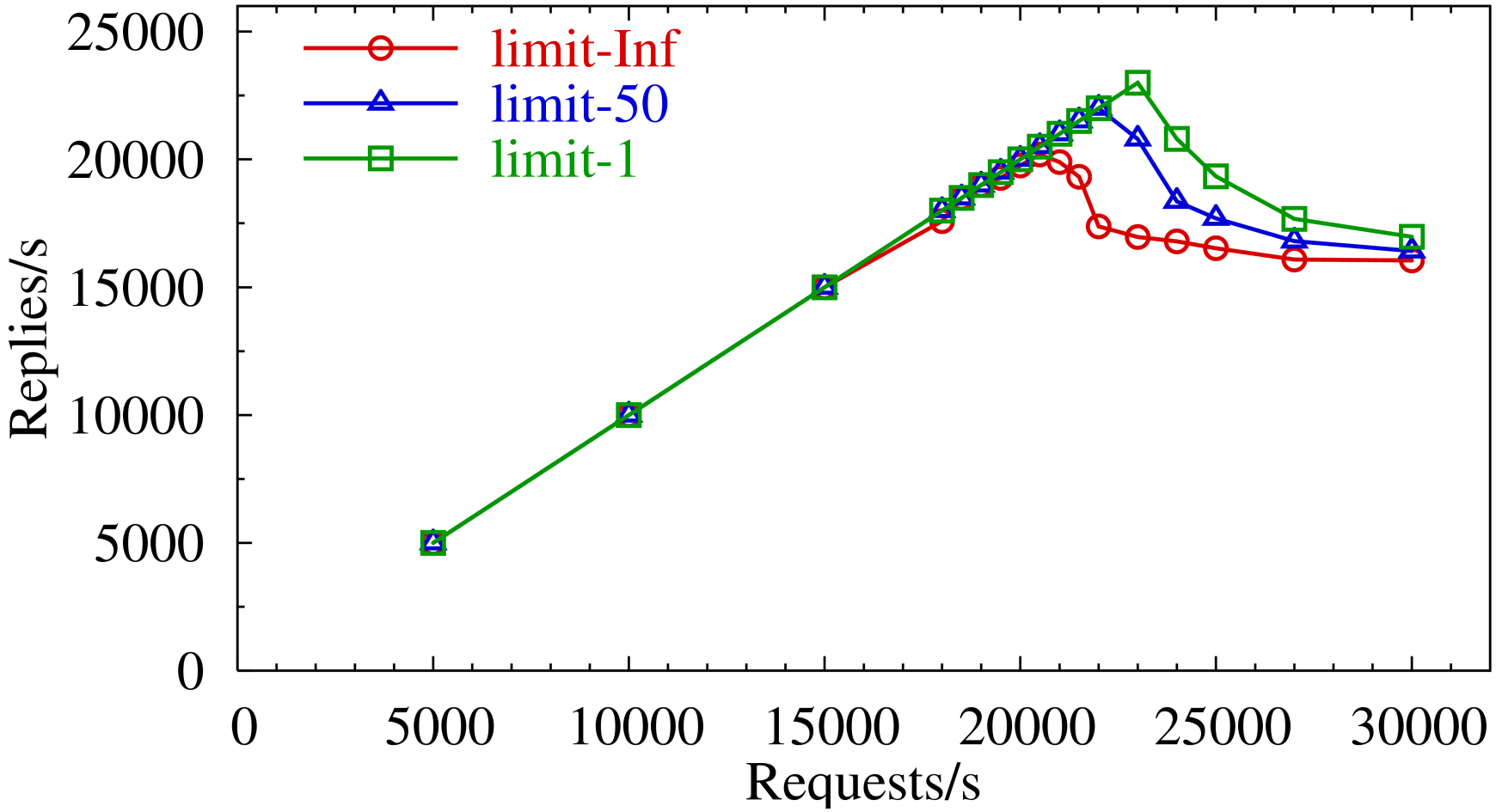

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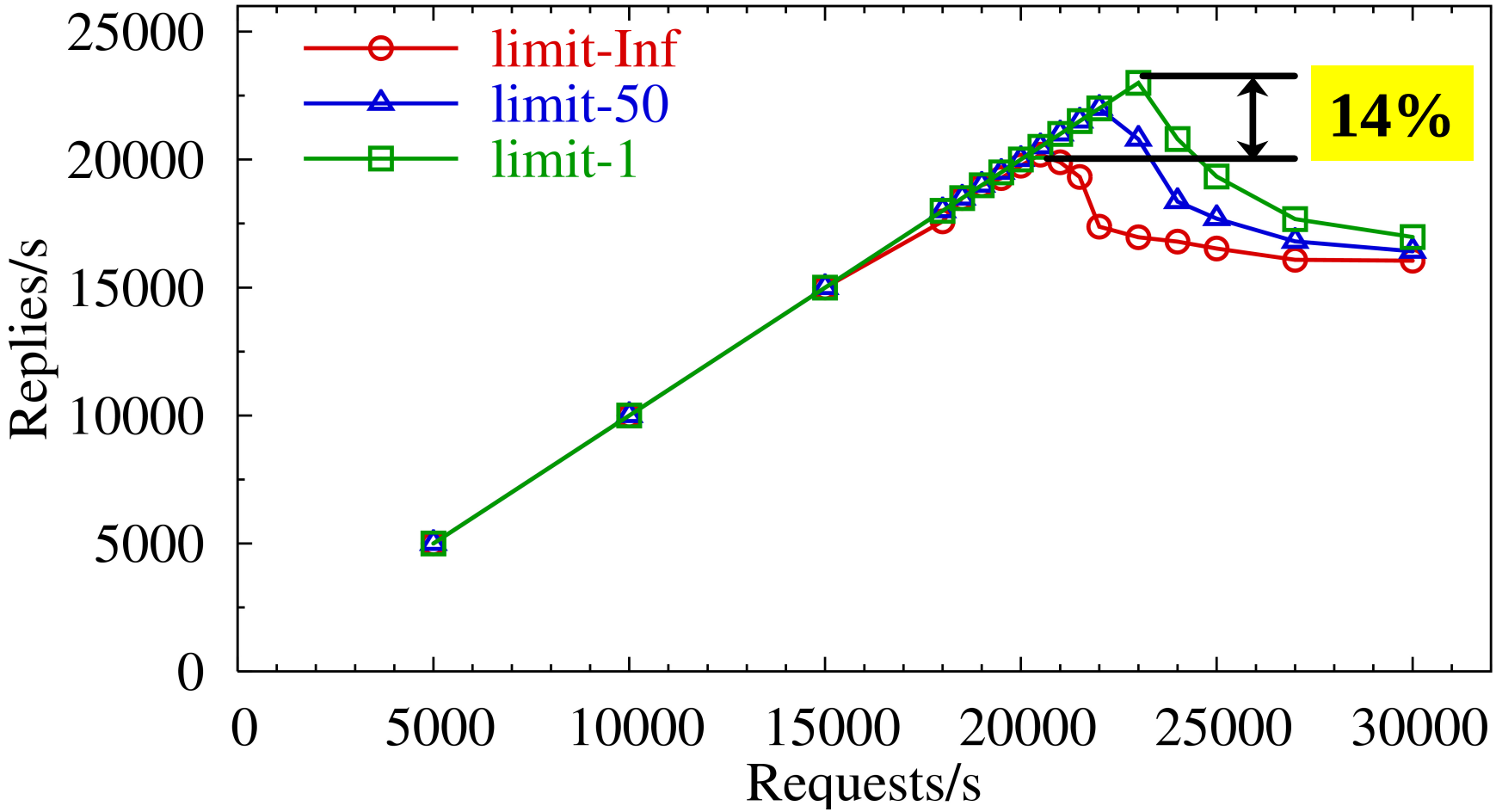
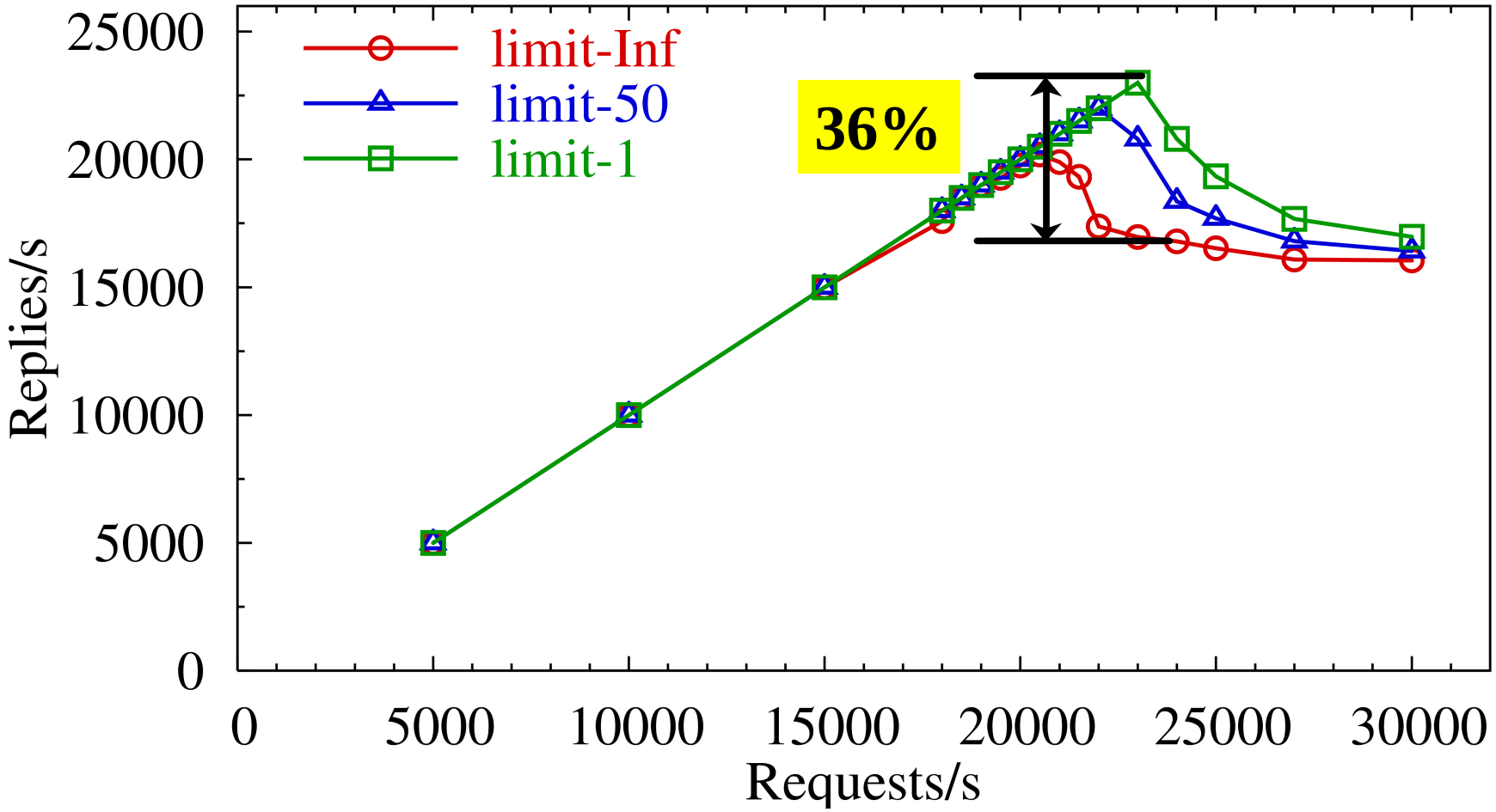
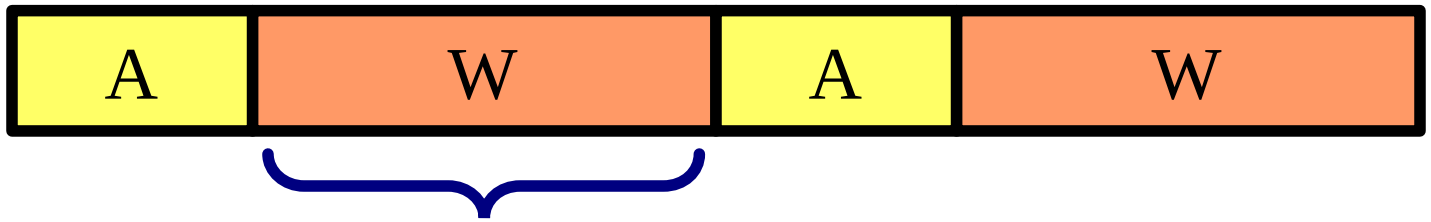


Performance of TUX (one packet)



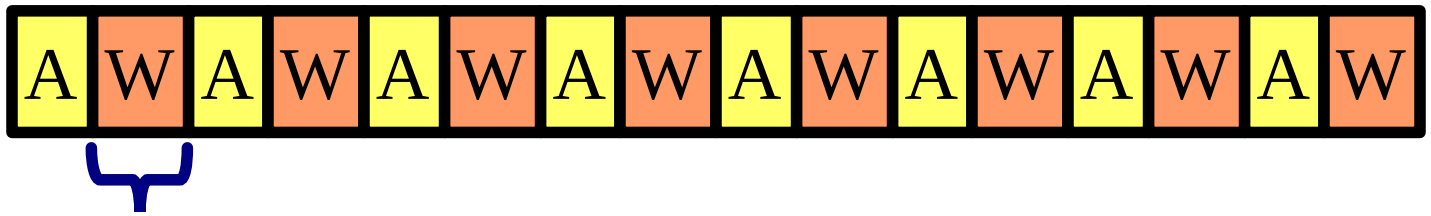
Accept-Limit Impact on TUX

A = 407 W = 10,740 @ 26,000 req/sec



limit-Inf

A = 1 W = 48



limit-1

- **lower limit => more frequent accepts without overhead**
- **lower limit => less opportunity for queues to overflow**

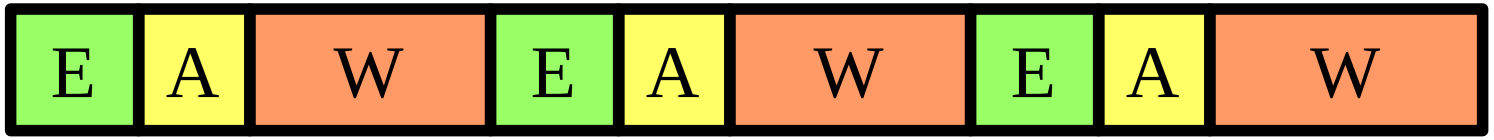
Accept-Limit Impact on the userver

A=1 W=22 @ 26,000 req/sec

Accept-Limit Impact on the userver

A=1 W=22 @ 26,000 req/sec

A=112 W=886

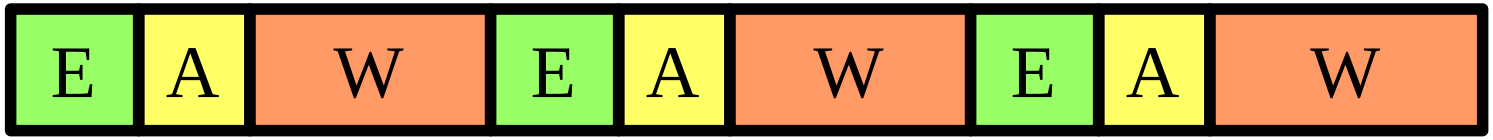


Accept-Limit Impact on the userver

A=1 W=22 @ 26,000 req/sec

limit-1

A=112 W=886



limit-Inf

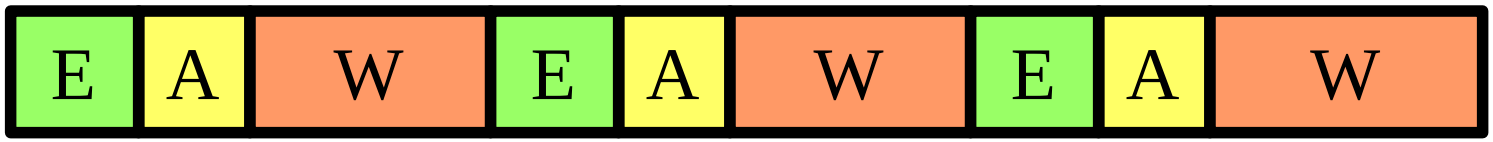
#E's = 184322

limit-1

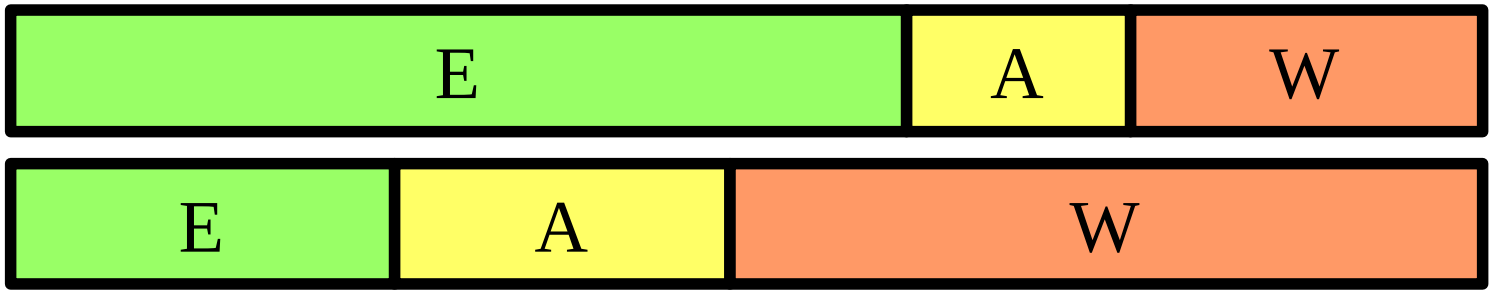
Accept-Limit Impact on the userver

A=1 W=22 @ 26,000 req/sec

A=112 W=886

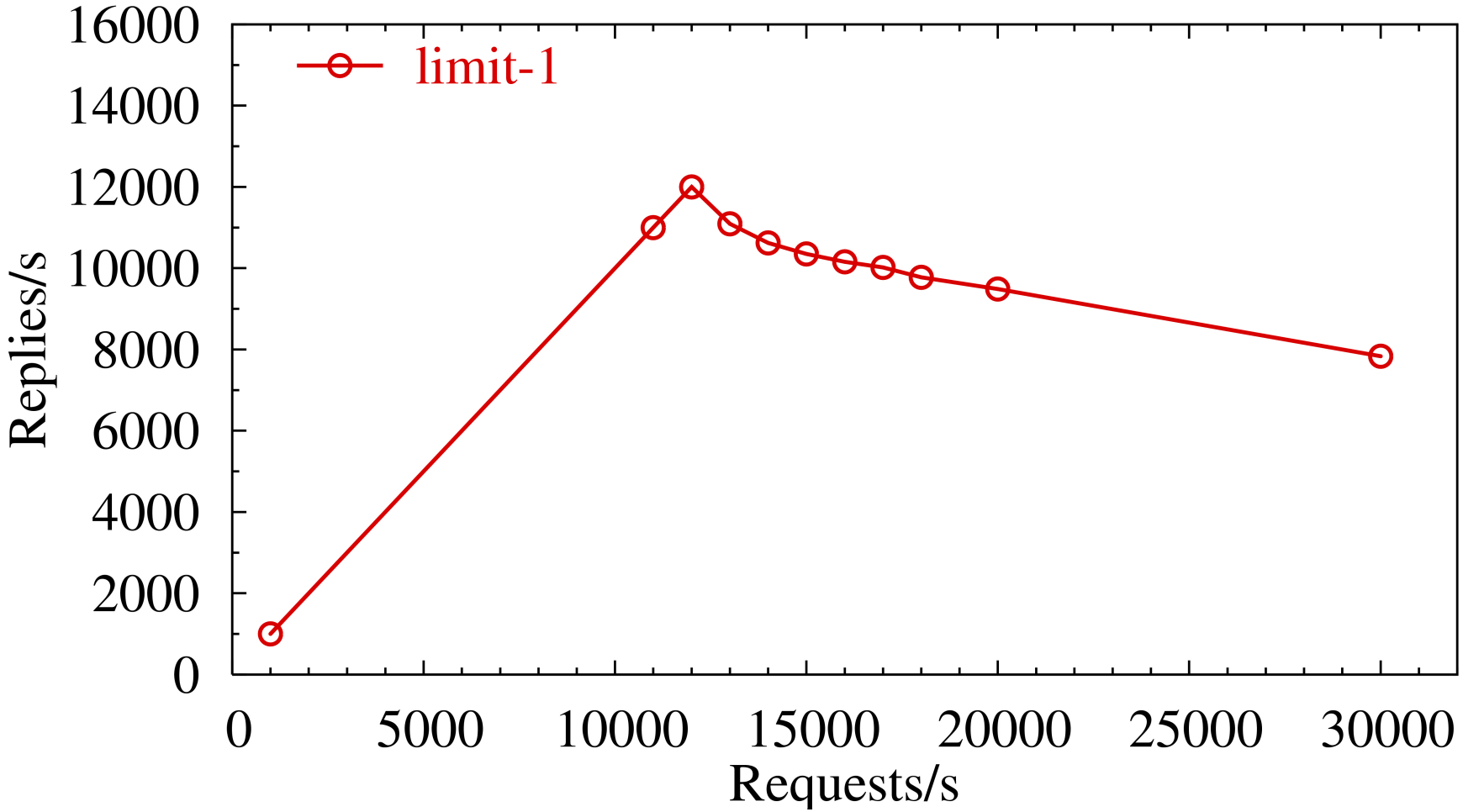


#E's = 184322



#E's = 5201

Performance of Knot (one packet)



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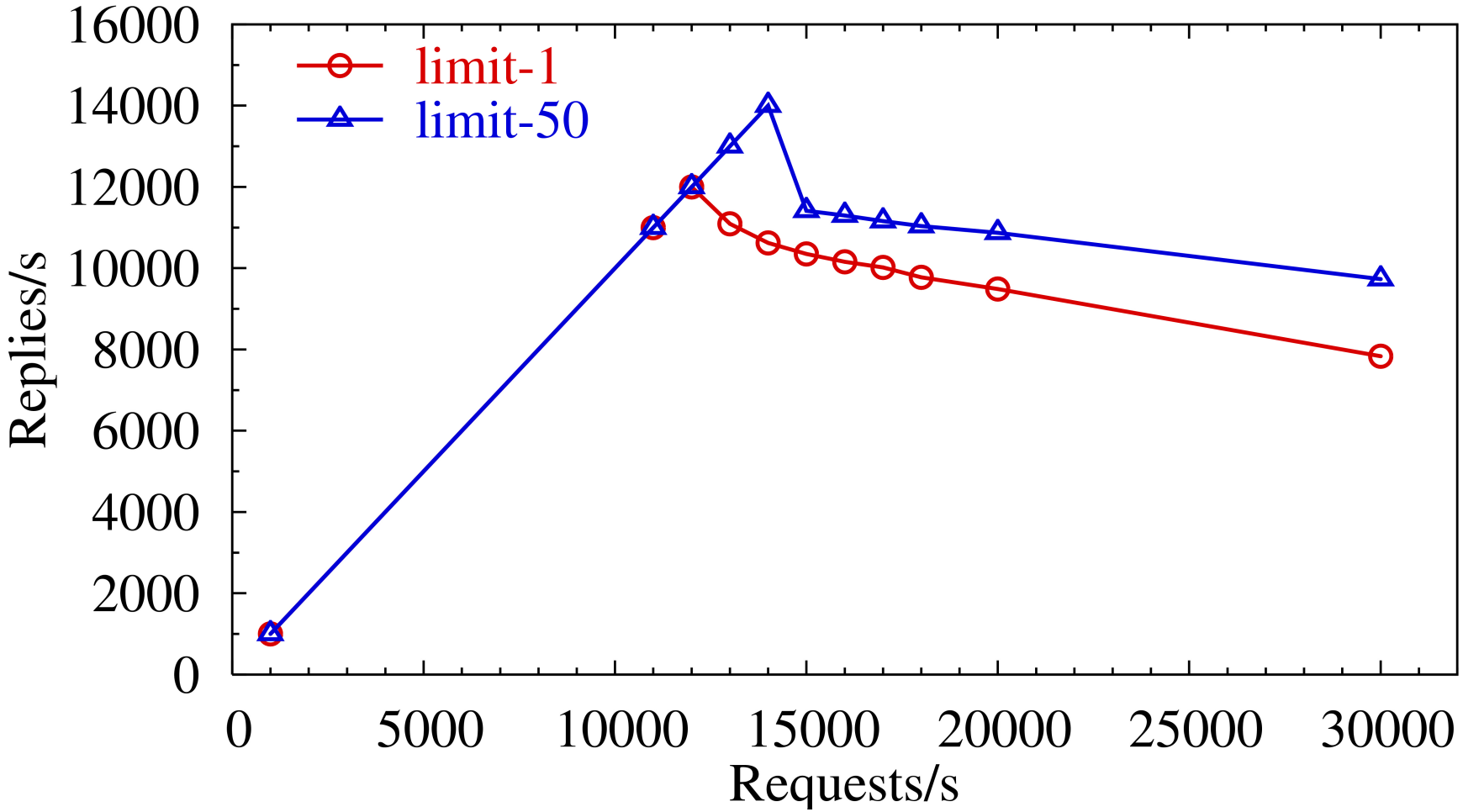

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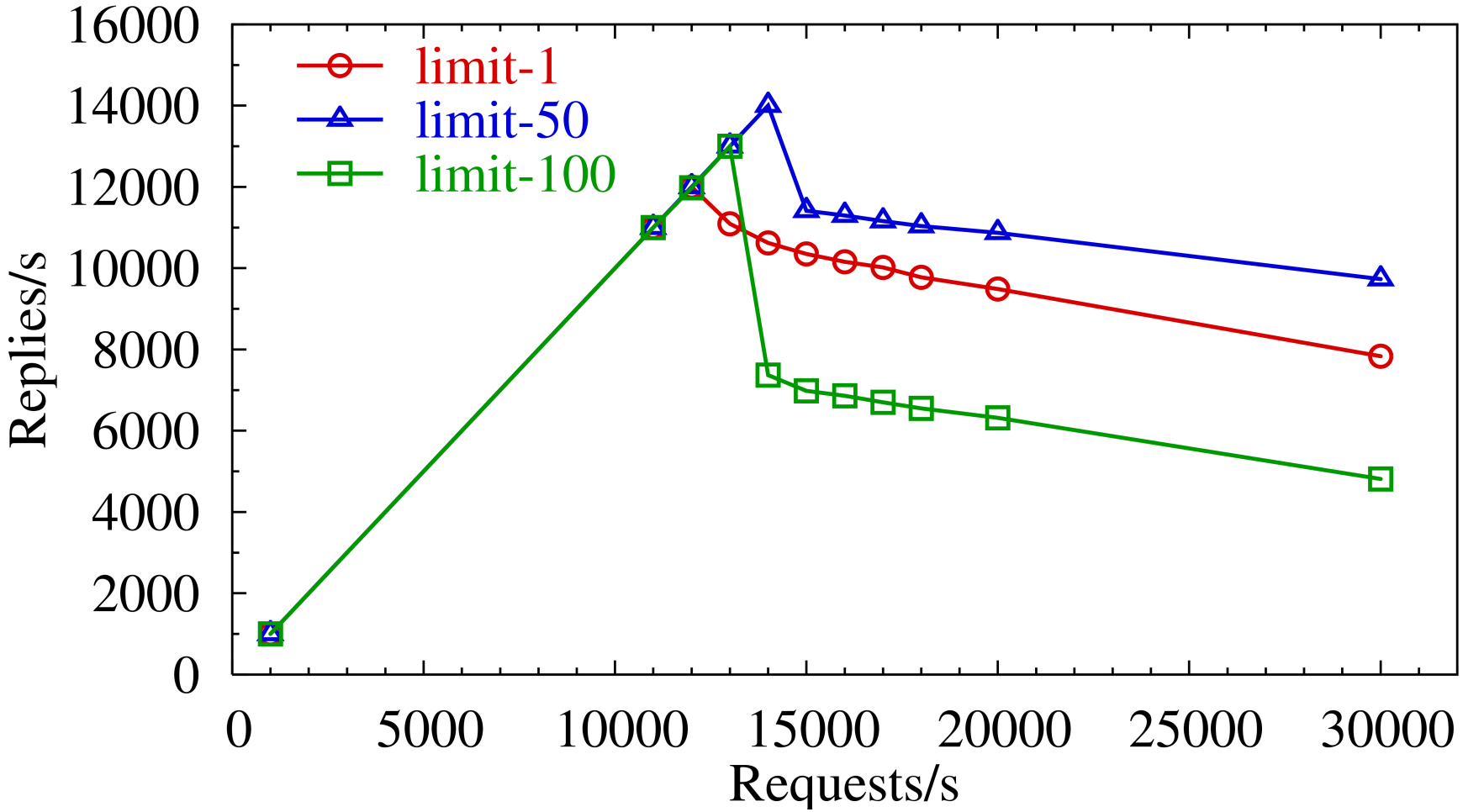

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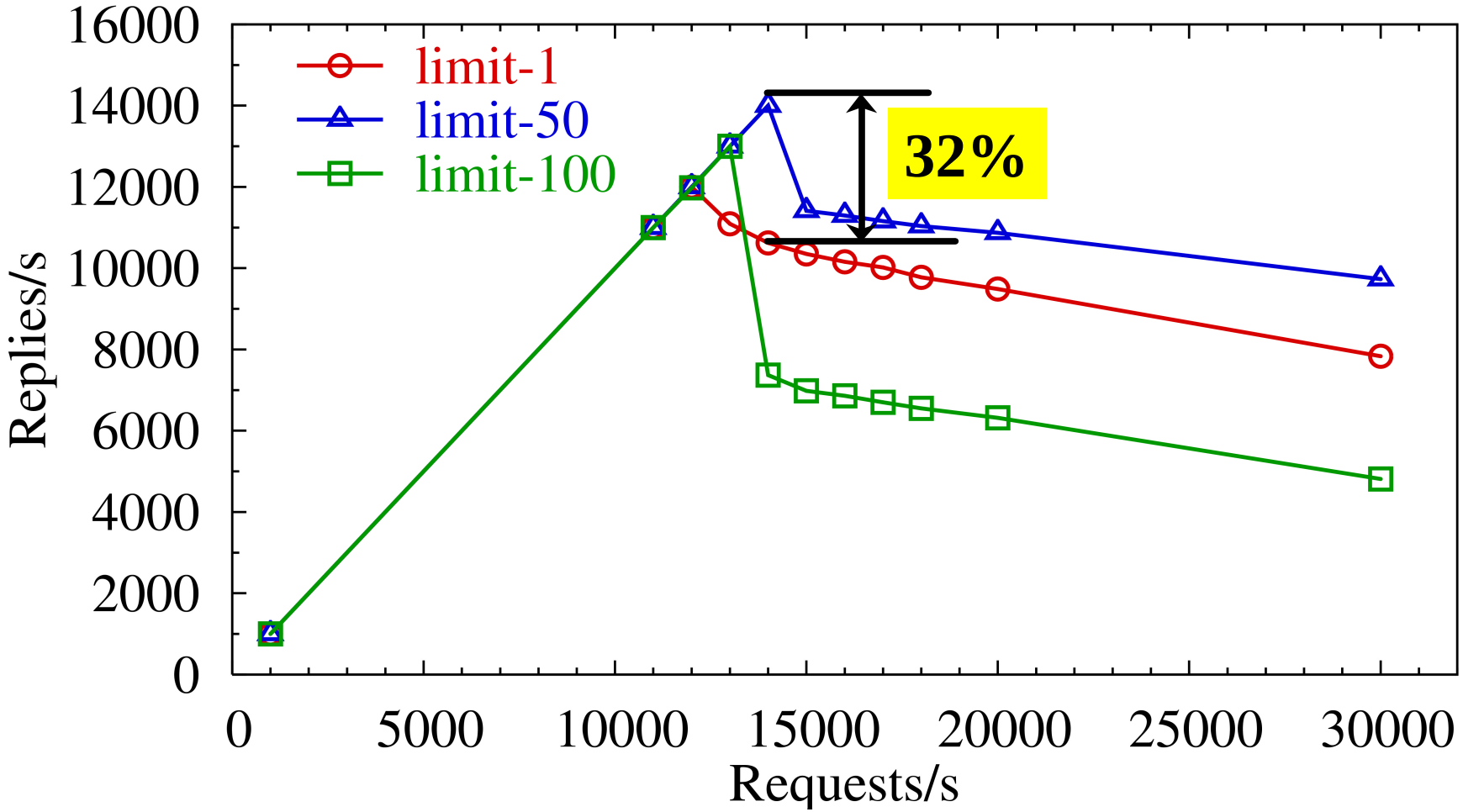

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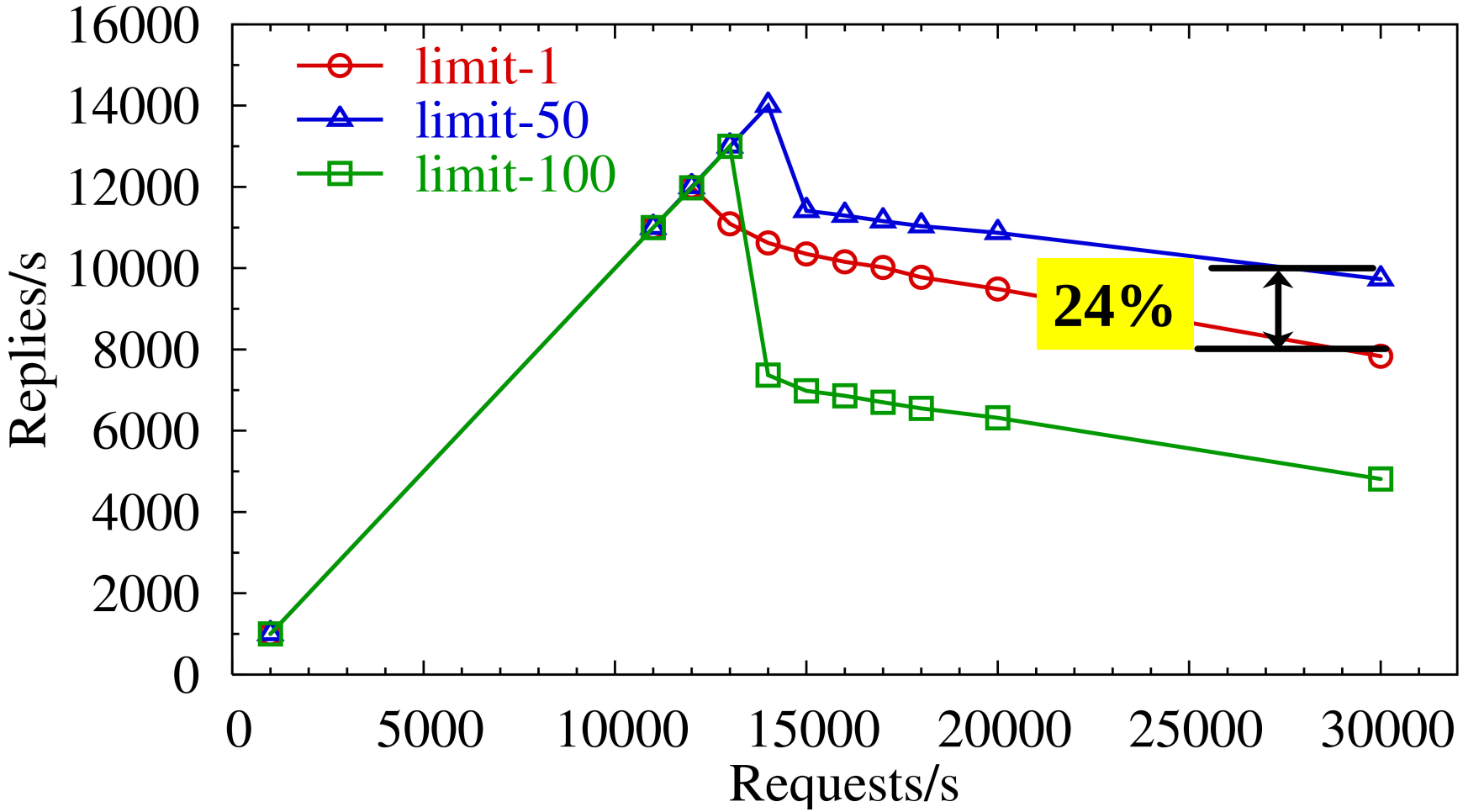
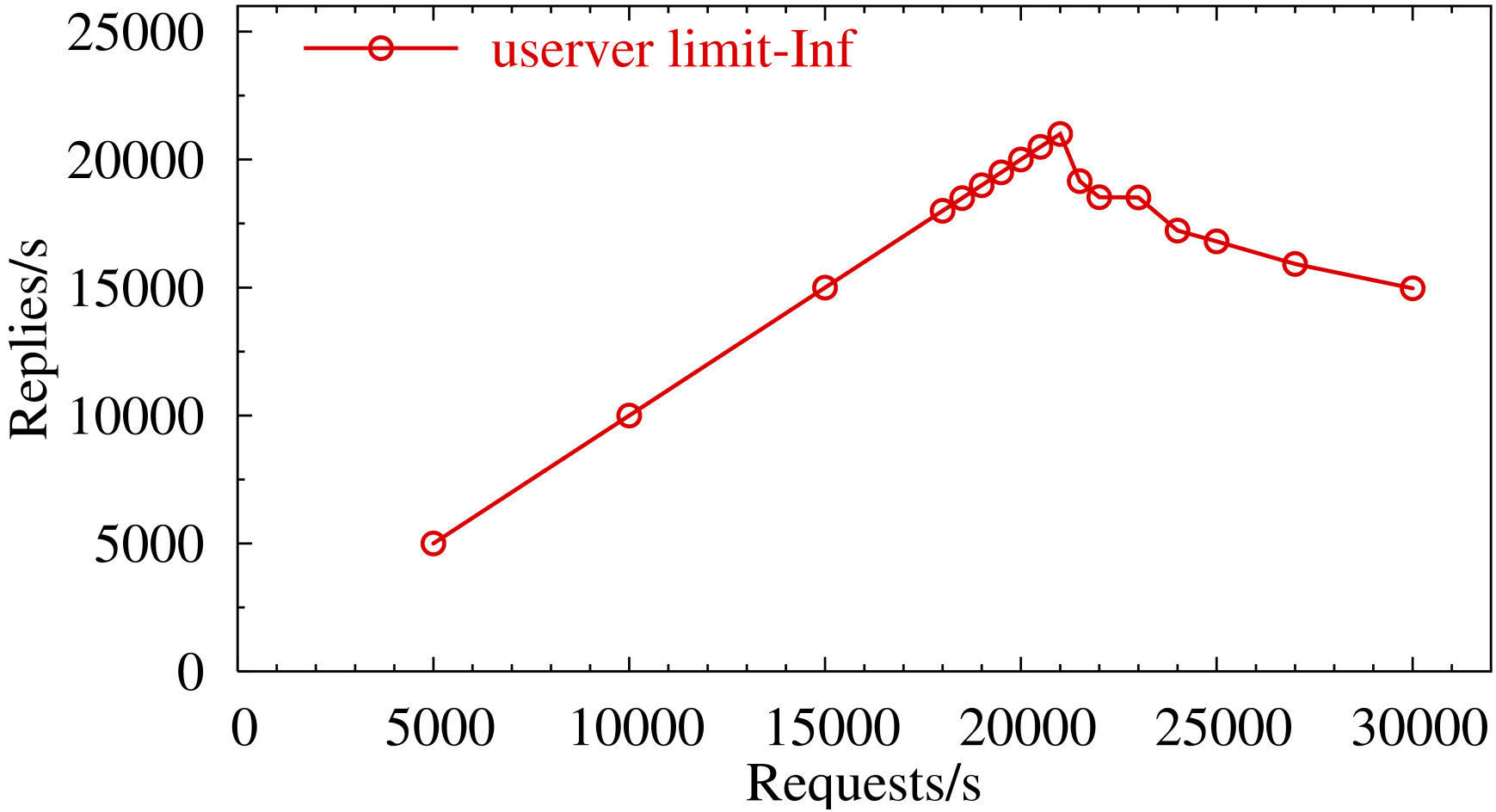


TUX vs the userver (one packet)



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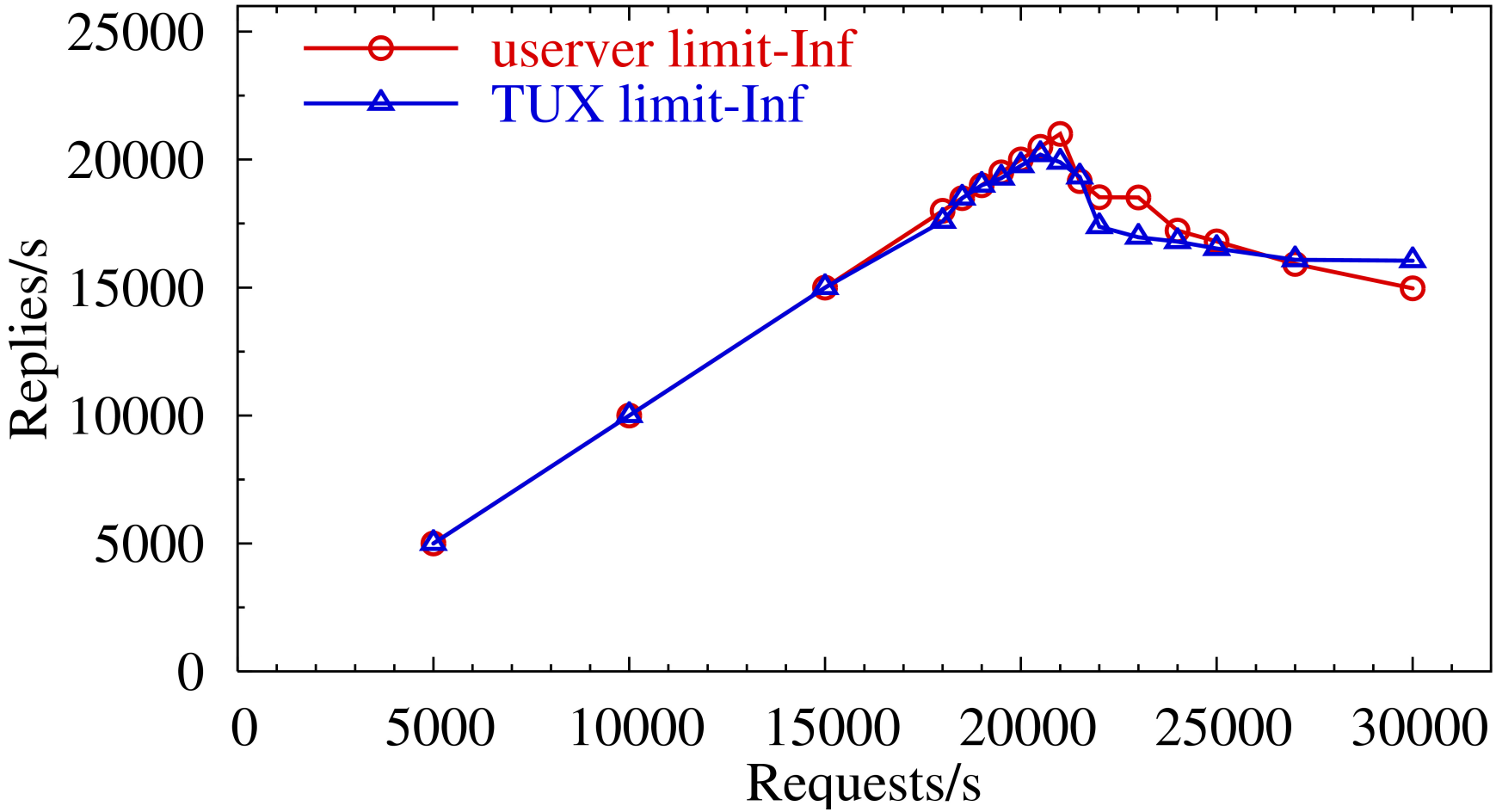
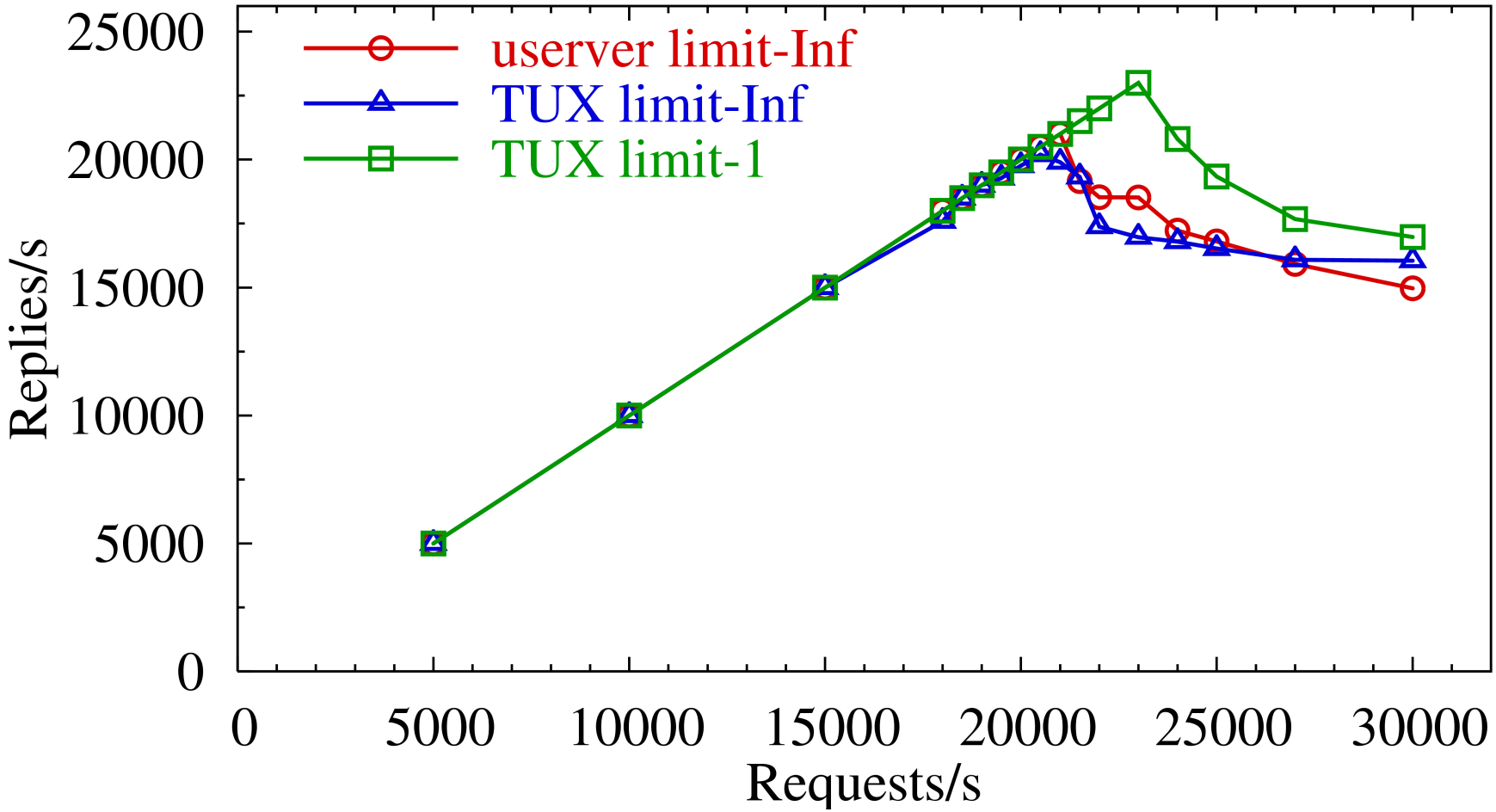
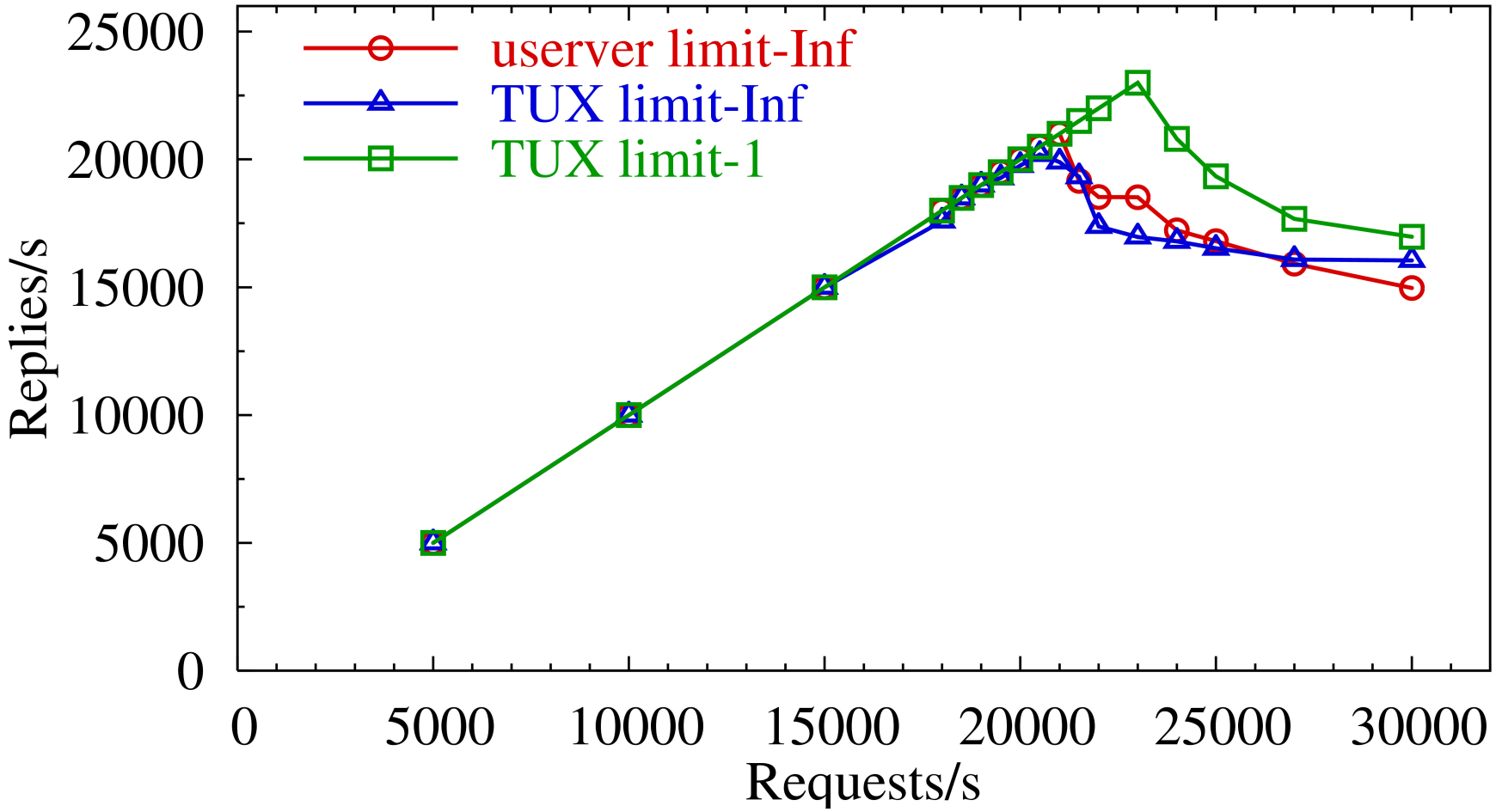


TUX vs the userver (one packet)

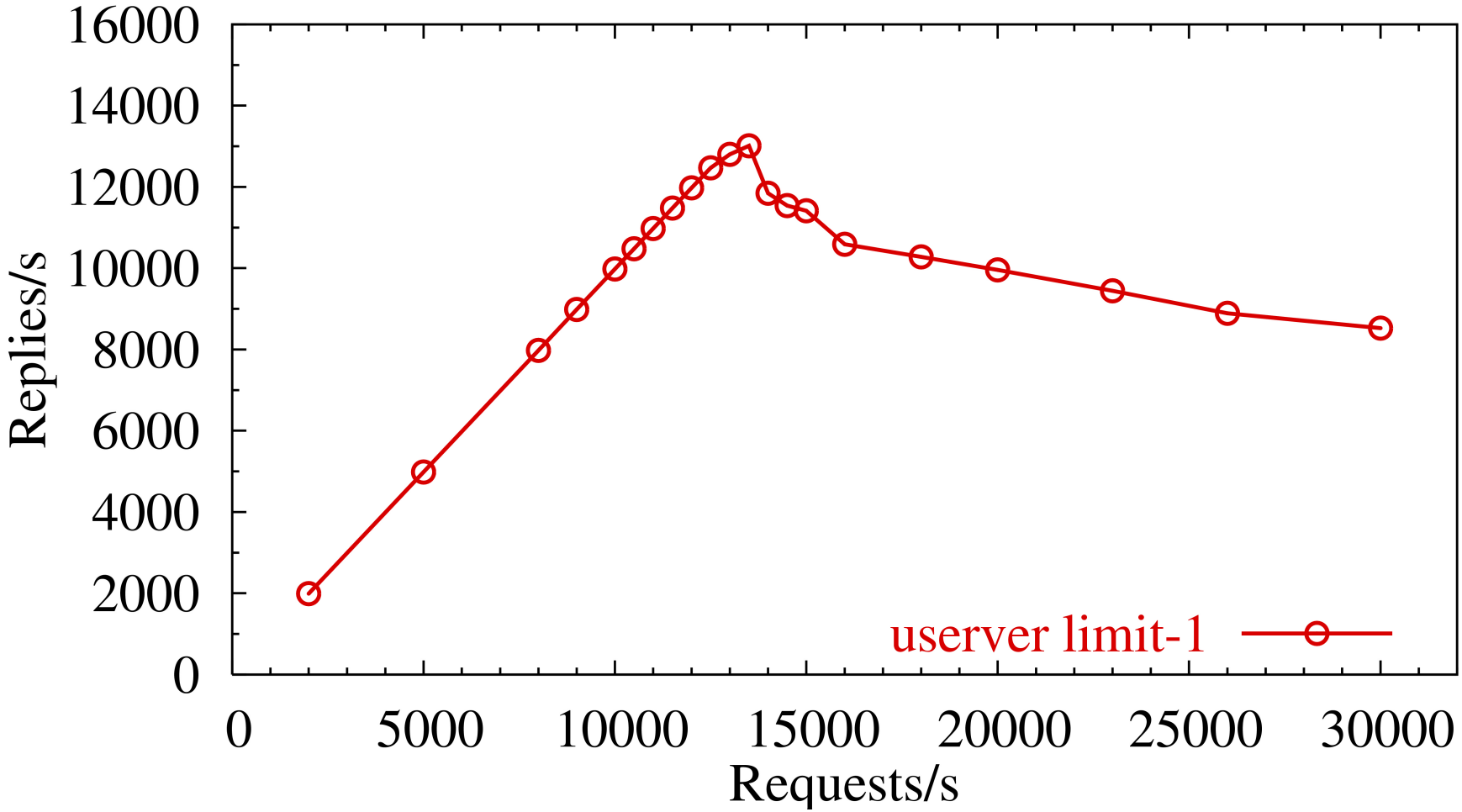


TUX vs the userver (one packet)



Knot was run on different cluster and hasn't been tuned

TUX vs the userver (SPECweb99-like)



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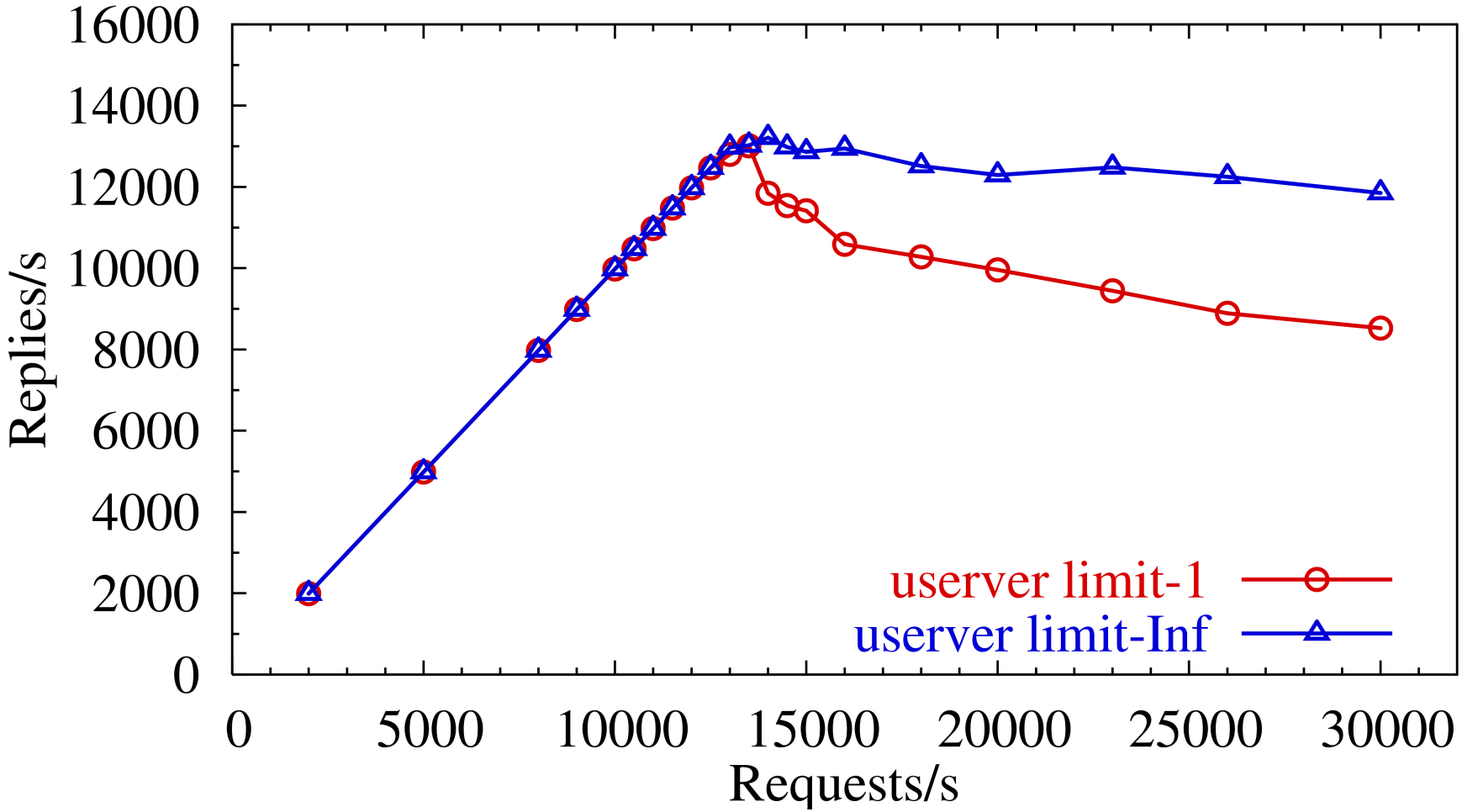

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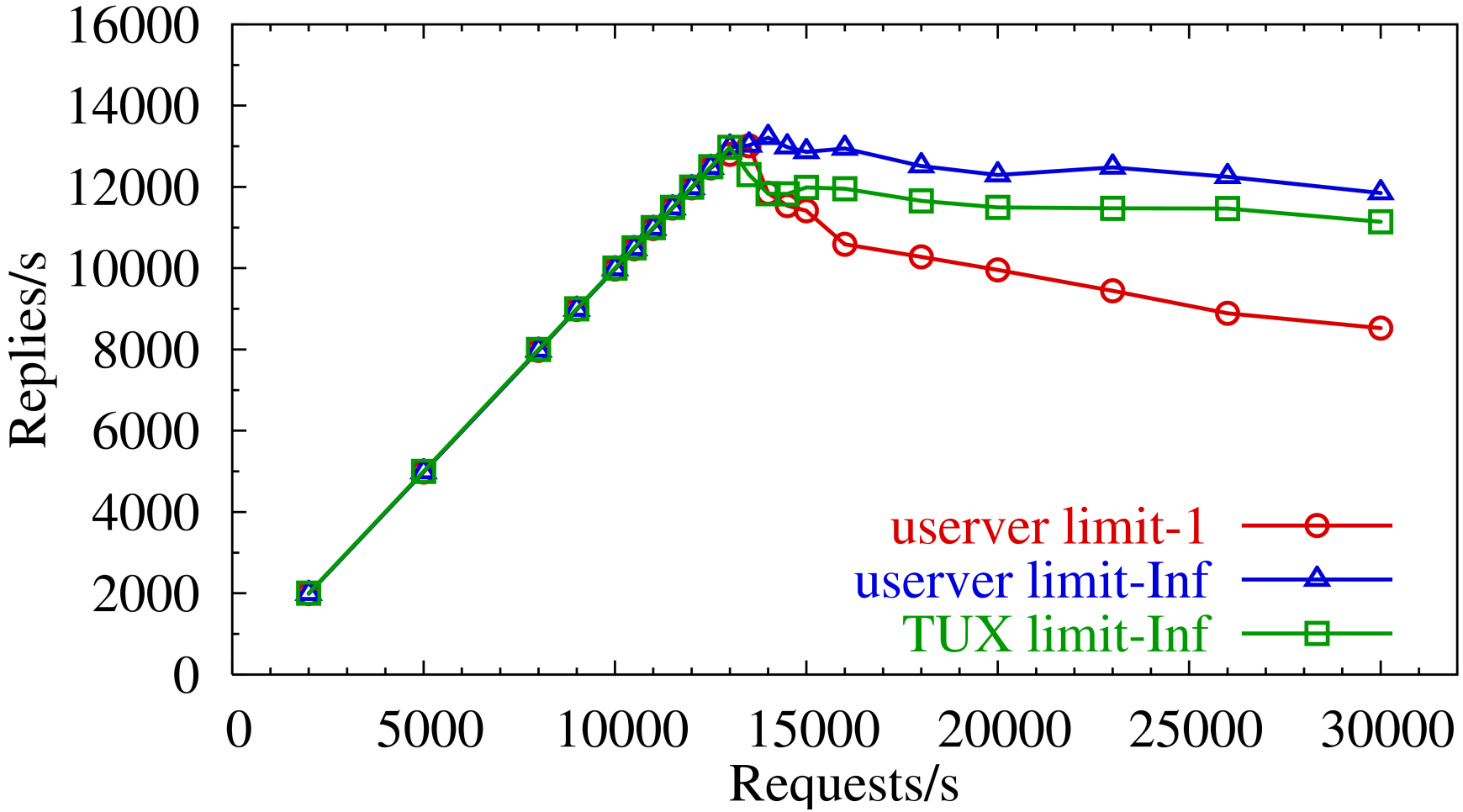

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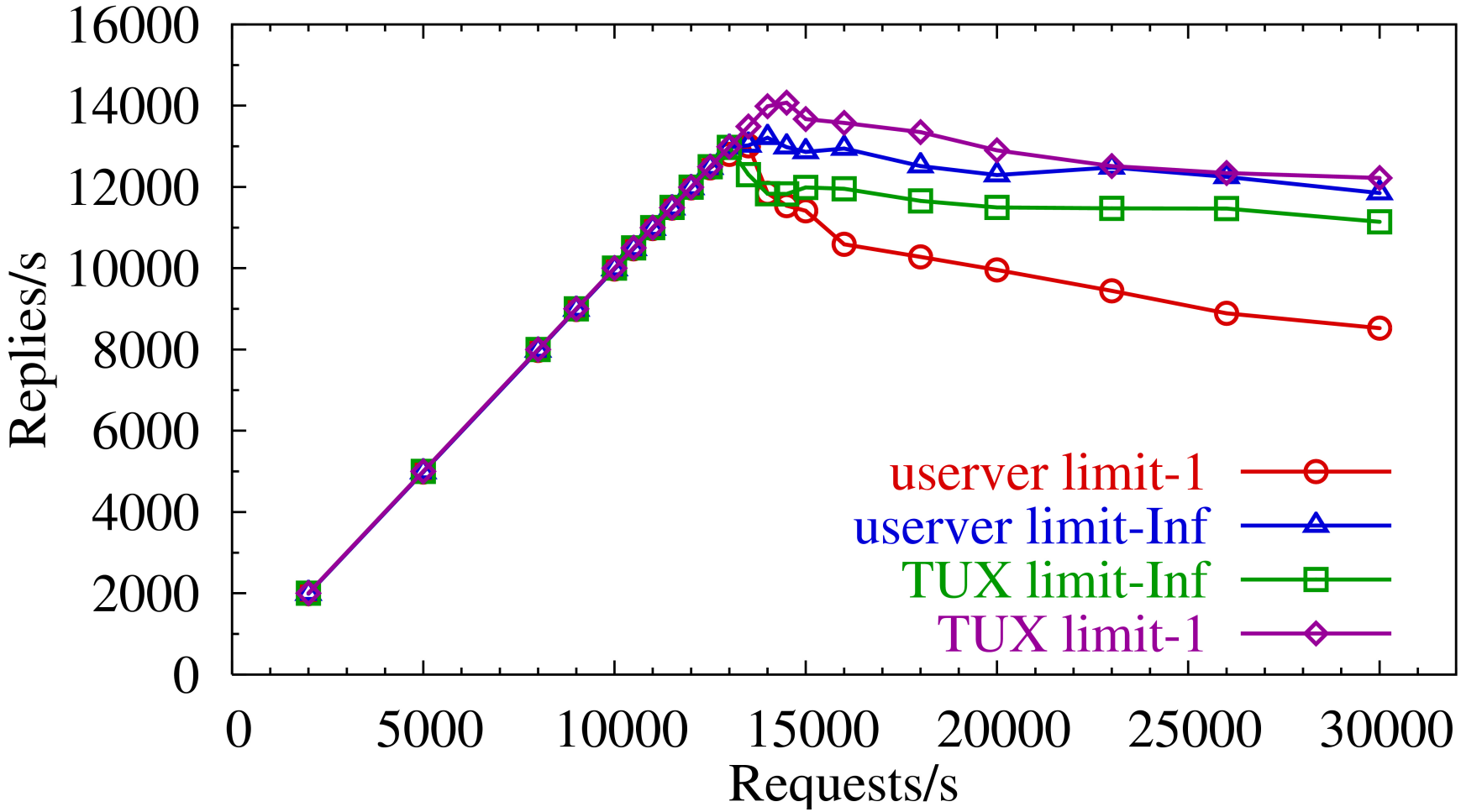

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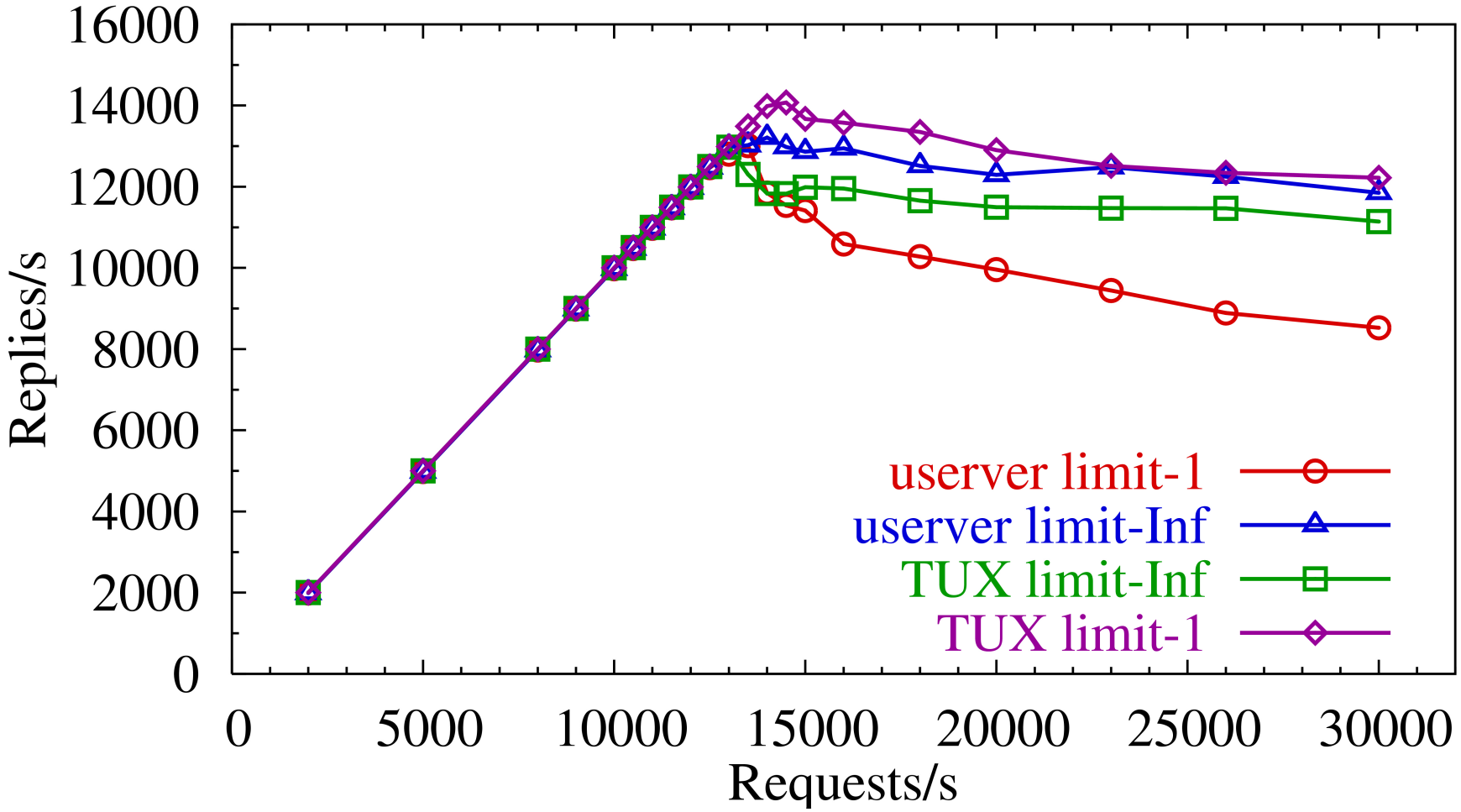
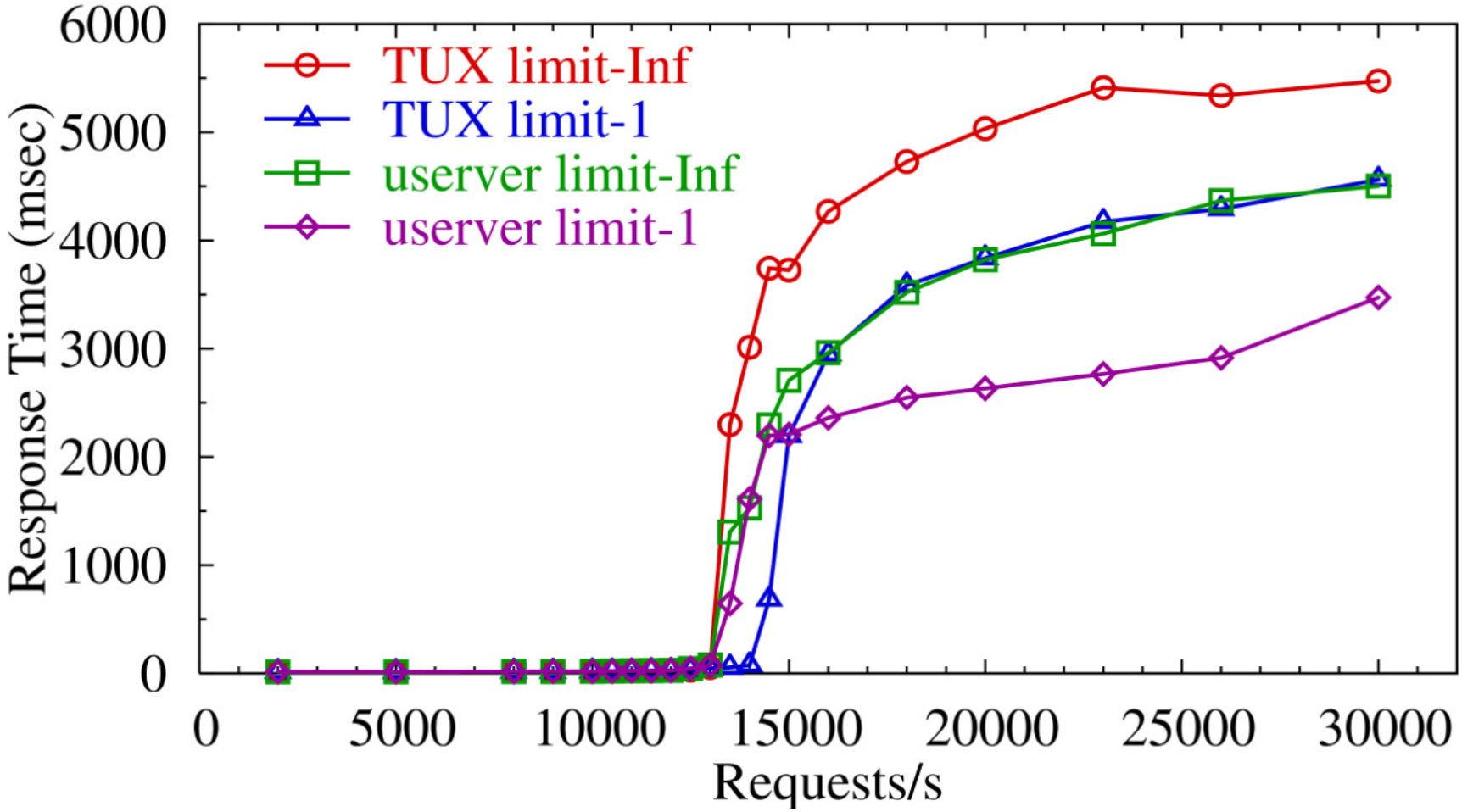


No improvements for Knot with SPECweb99-like wload

Latencies for SPECweb99-like wload



Conclusions

- Ensure accepting at a sufficiently high rate
- Balance accepting with working on existing conns

- Demonstrated performance improvements for:
  - **`userver`** (event-driven user-mode)
  - **`Knot`** (thread-based user-mode)
  - **`TUX`** (event-driven kernel-mode)
- user-mode close to kernel-mode for these workloads

The End