An Evaluation of Fault-Tolerant TCP-Splice Based Web Server Architectures

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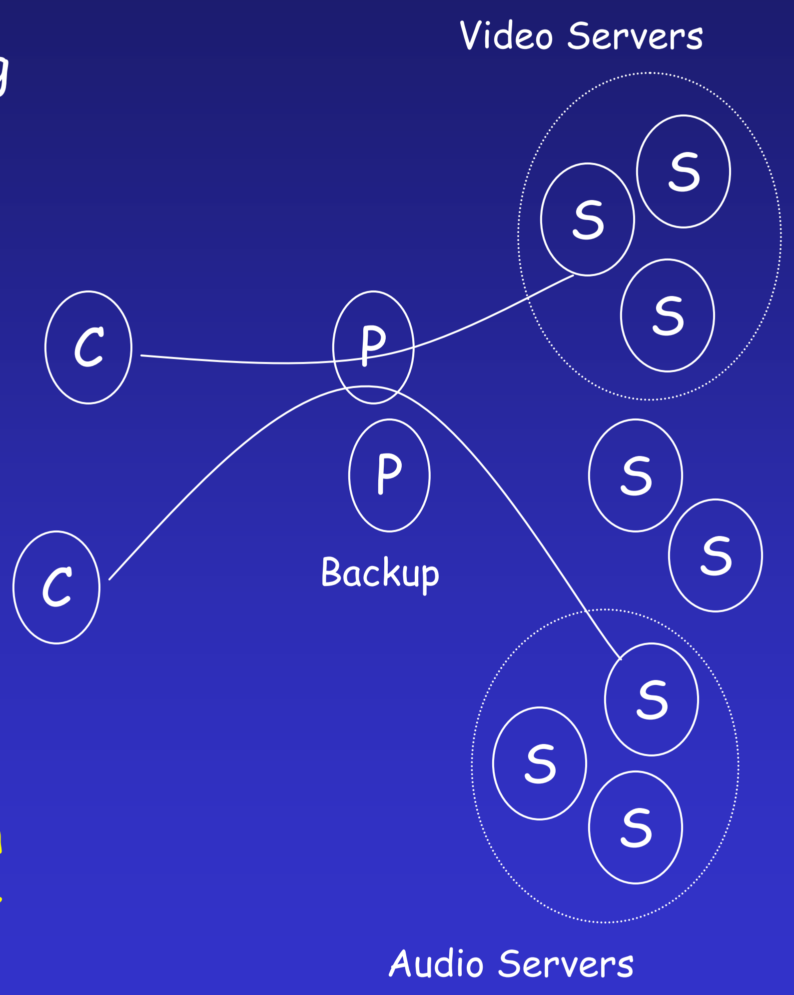
Outline

- Introduction
- Enhancements to TCP Splice
- Our Web Server Architecture
- Simulation Results
- Conclusions

Web Proxies

- Proxies used for
  - Content aware (layer 7) routing
  - Security policies
  - Caching
  - Network management
  - Usage accounting

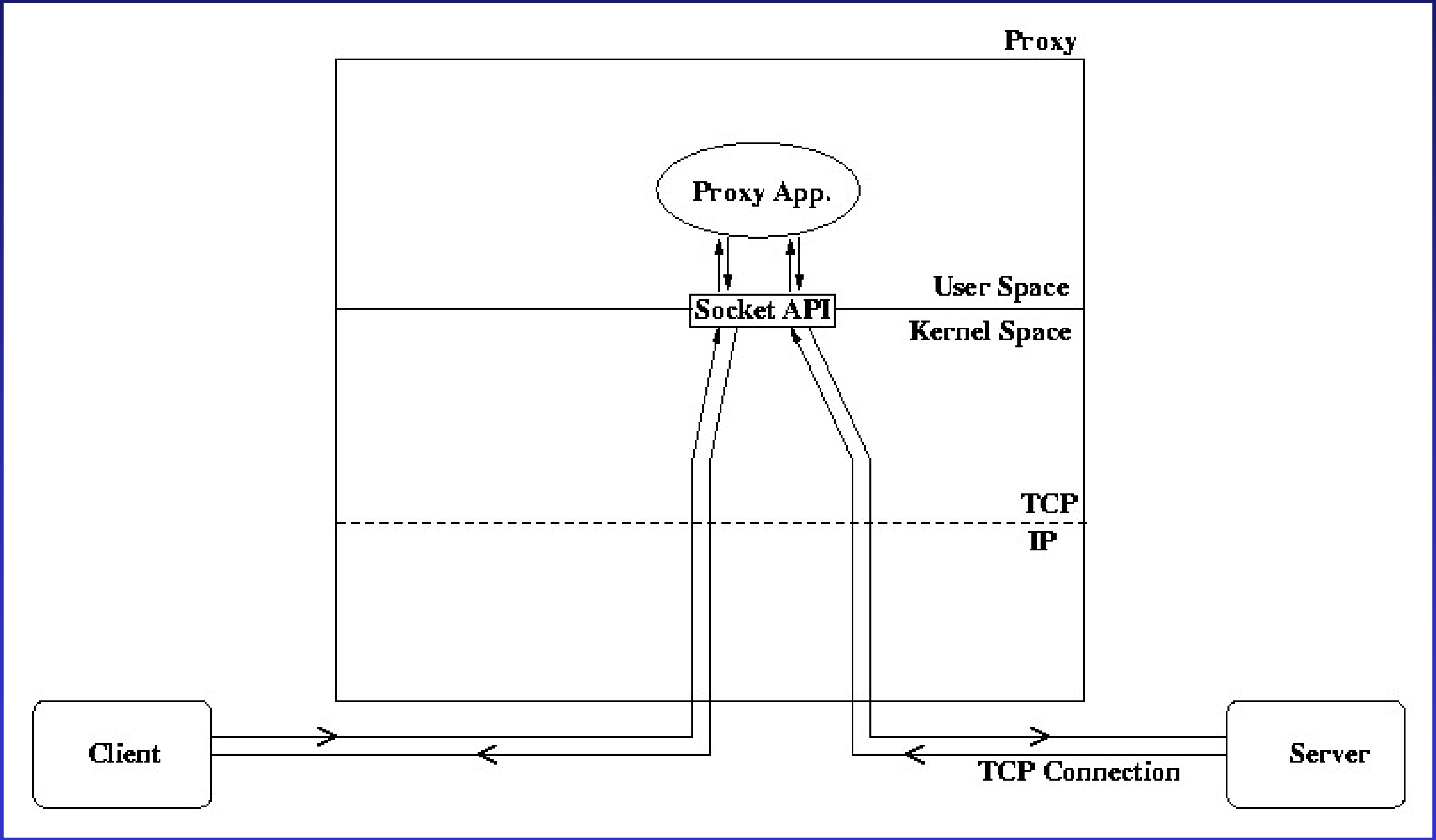
- Drawbacks
  - performance issues
    - kernel <-> user data copying
    - Context switches
  - Single point of failure
    - Even with a backup, connection is broken and would need to be re-established



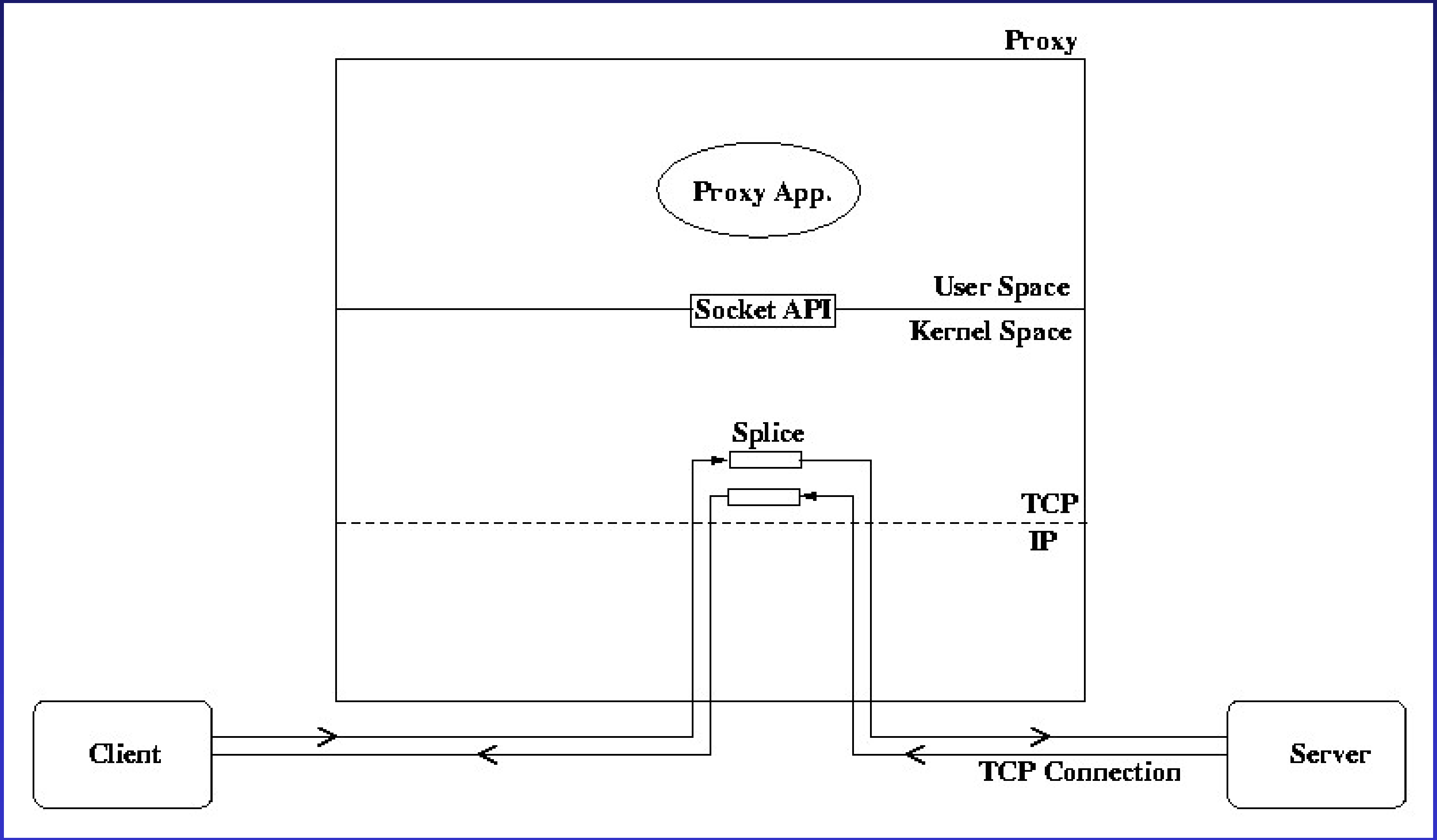
TCP Splice (1)

- Introduced to enhance the performance of web proxies
- Proxy relays data between client and server by manipulating TCP segment headers
- Advantages
  - Done entirely in the kernel
  - Latency and computational cost at proxy only a few times more than IP forwarding
  - End-to-end semantics of the client-server TCP connection preserved
  - No buffering at the proxy

TCP Splice (2)


Proxy
Proxy App.
User Space
Socket API
Kernel Space
TCP
IP
Client
Server
TCP Connection

TCP Splice (3)

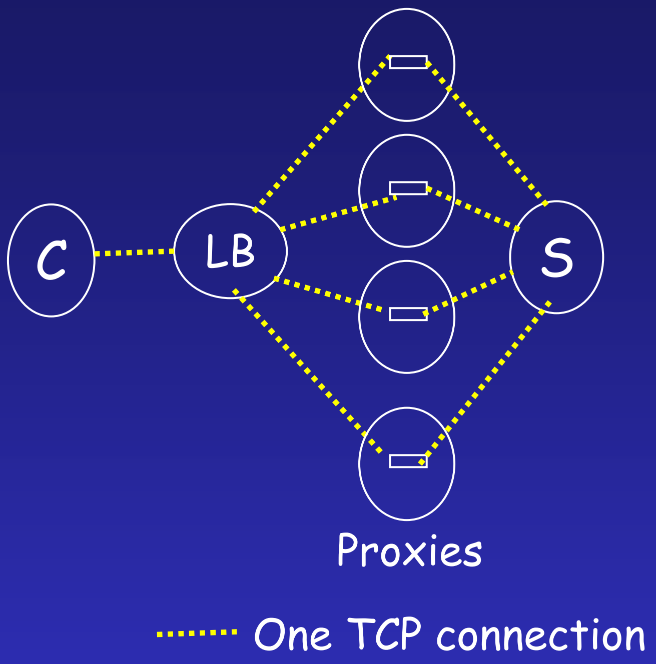


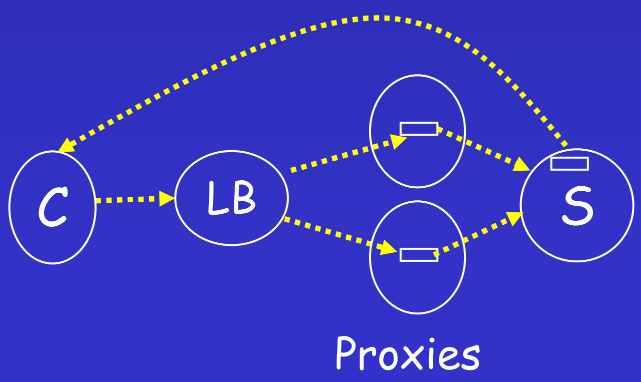
send_seq_num = (recv_seq_num – init_recv_seq_num) + init_send_seq_num

offset

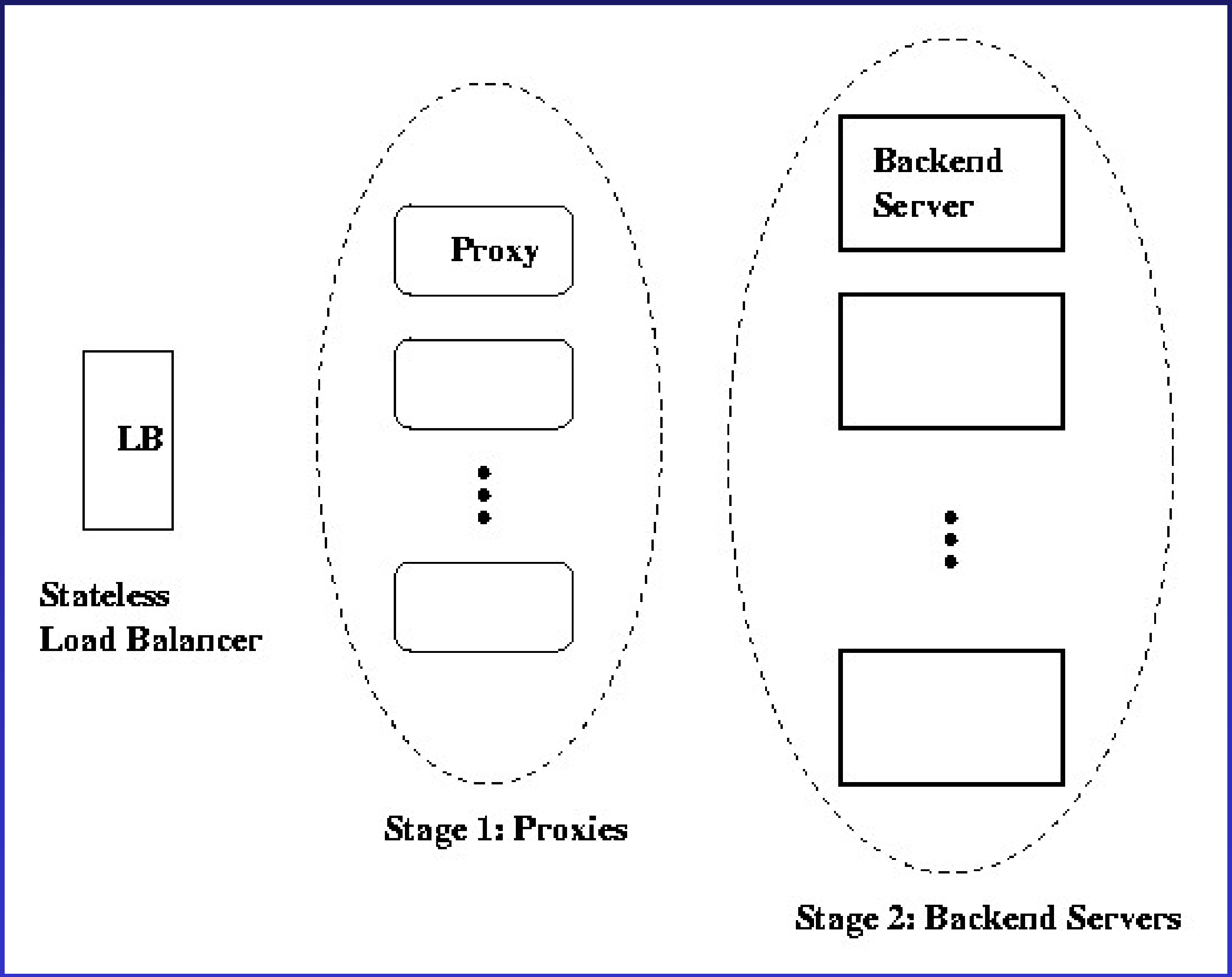
Enhancements to TCP Splice

- Recently, we proposed the following generic enhancements to TCP splice to address
  - Fault tolerance
  - Scalability
- Replicated and Parallel Splice
  - Same connection can be spliced through different machines
- Split-Splice
  - Traffic in the two different directions of the same connection can be spliced at different machines





Our Web Server Architecture

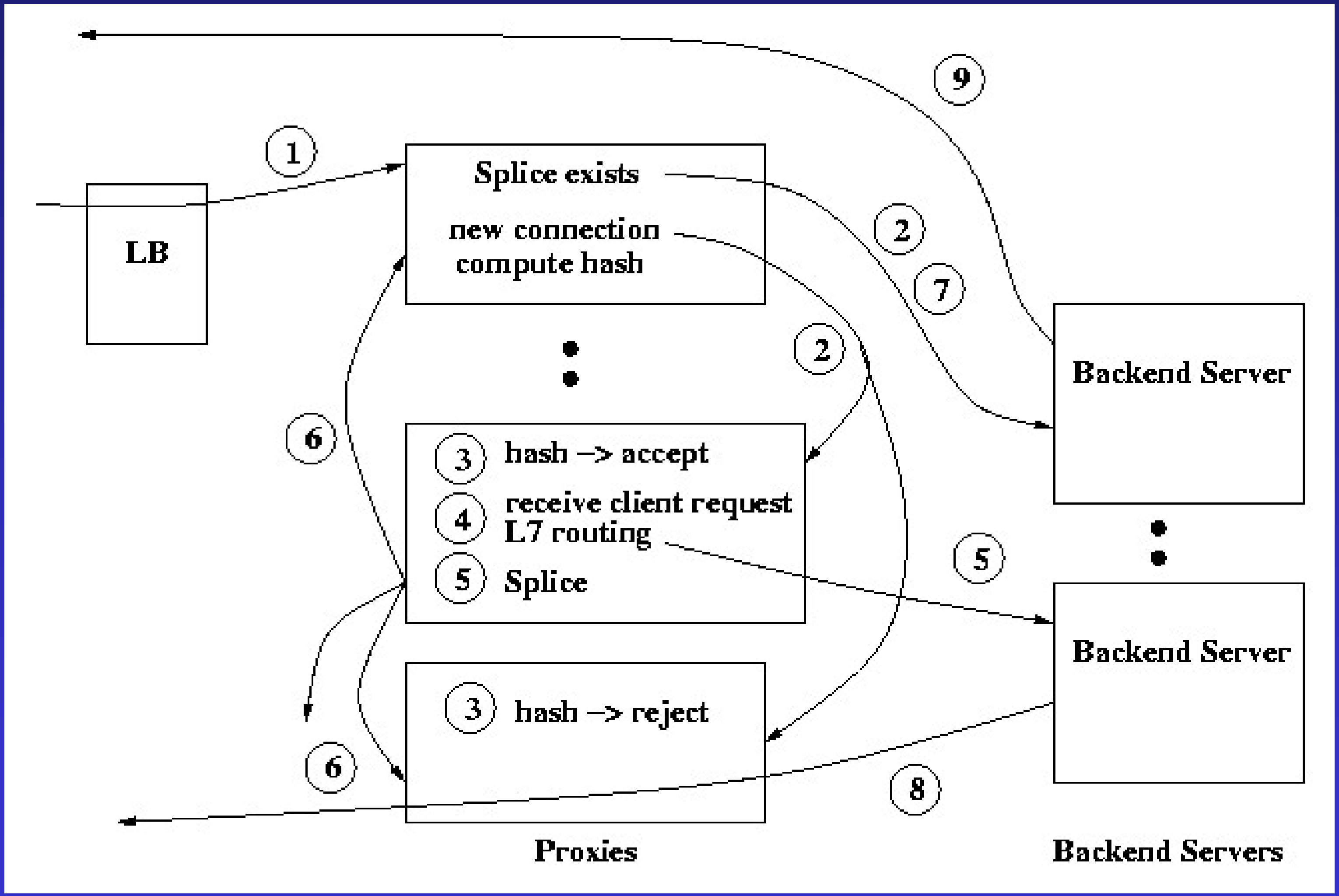


Logical View

Load Balancer

- IP level load balancer (LB)
- No modifications to the packets
- No connection state information is kept
- Completely stateless -> fault tolerance trivial
- Has service IP address
- Right now round-robin algorithm
- Heartbeat mechanism between LB and proxies
  - For failure detection
  - For communicating proxy workload (in future)
- Can be combined with router or proxies

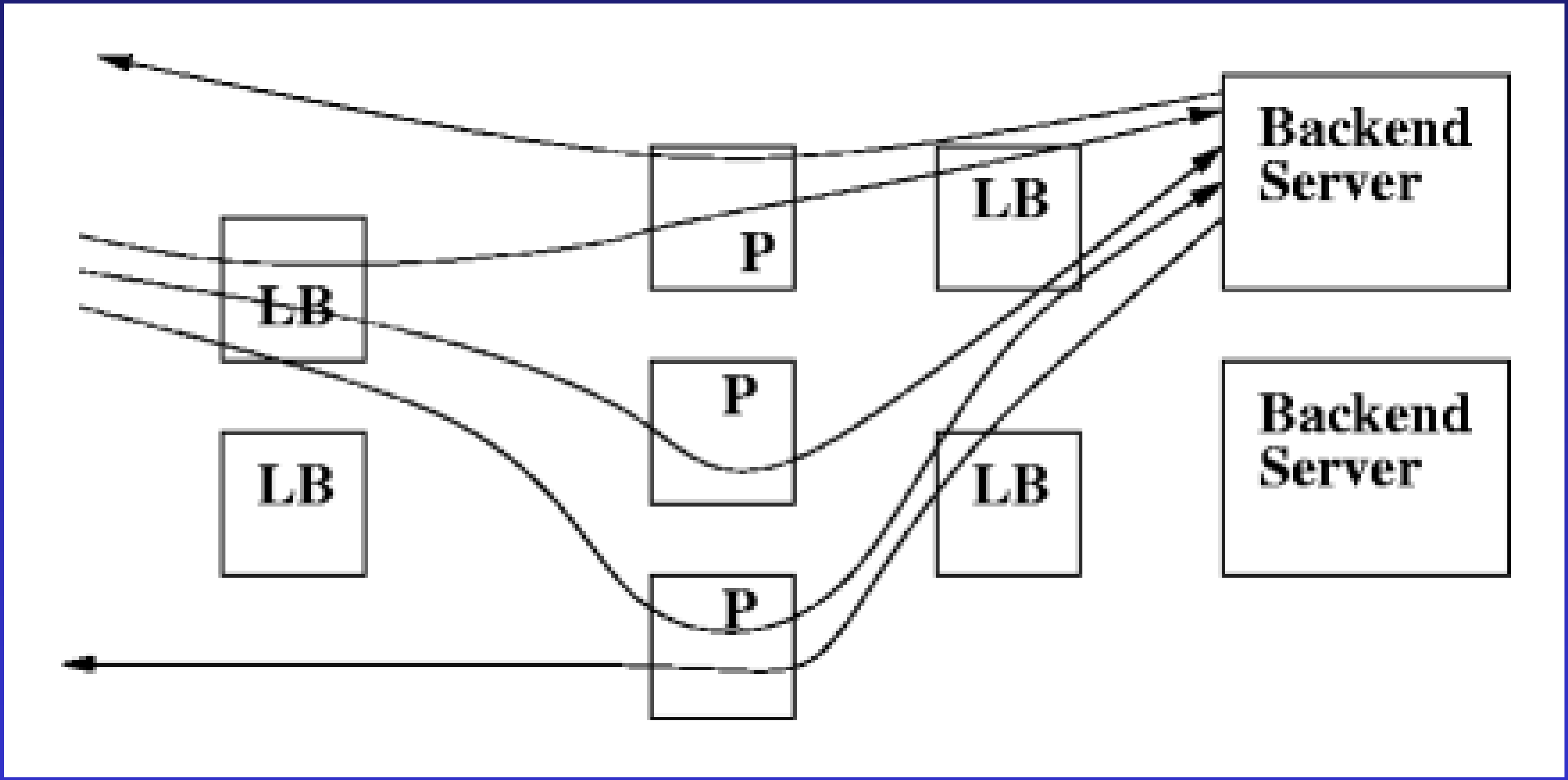
Sequence of Steps involved in Handling a Request



Web Server Configuration 1 (1)

- Separate Proxy and backend server machines
- Traffic in both directions passes through the proxies
- No OS changes required on the backend servers

Web Server Configuration 1 (2)



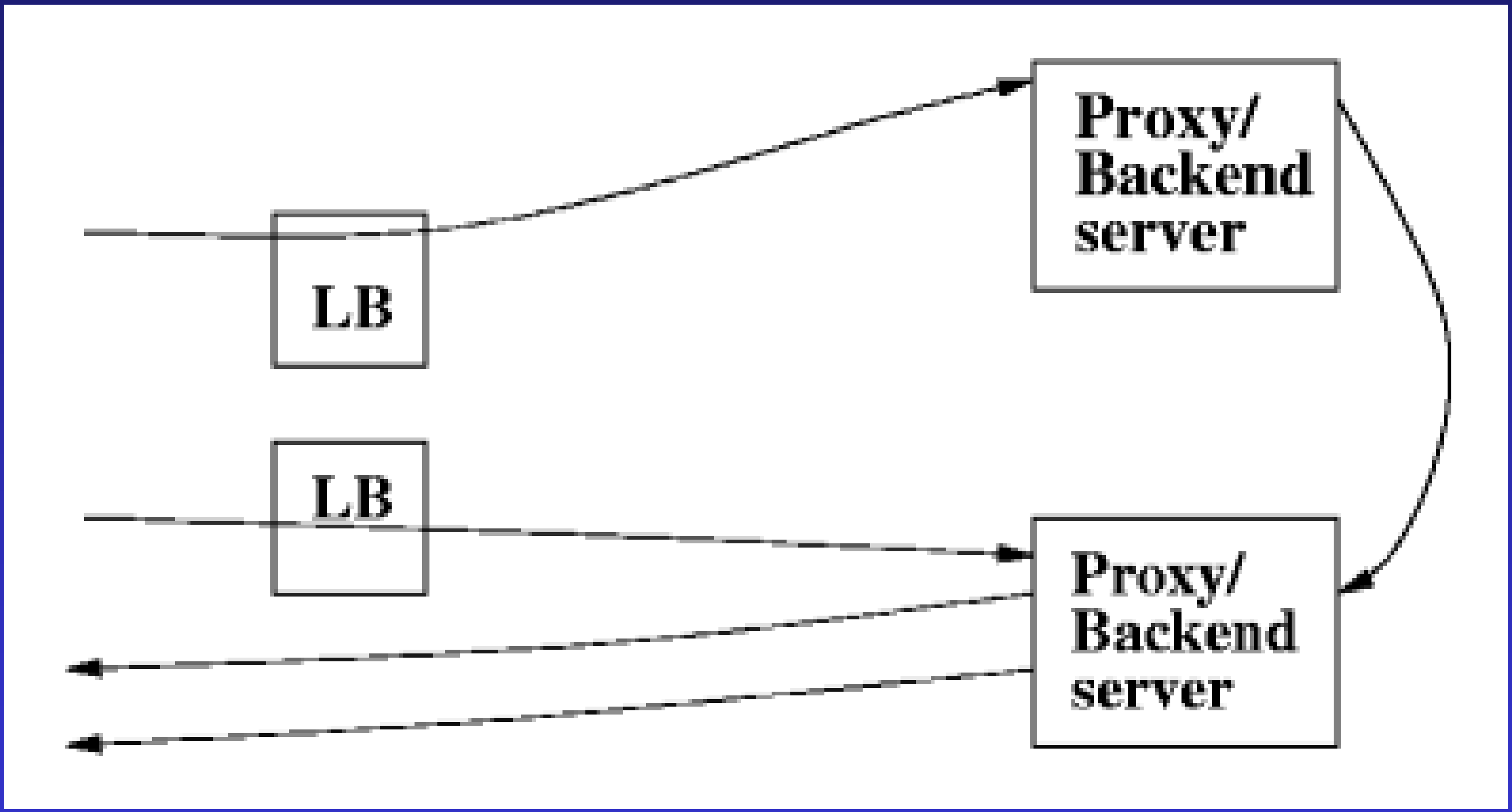
Data Path

One TCP connection

Web Server Configuration 2 (1)

- Co-located Proxy and backend server machines
- Separate proxy machines not required
- Saves HW
- OS changes required on the servers

Web Server Configuration 2 (2)



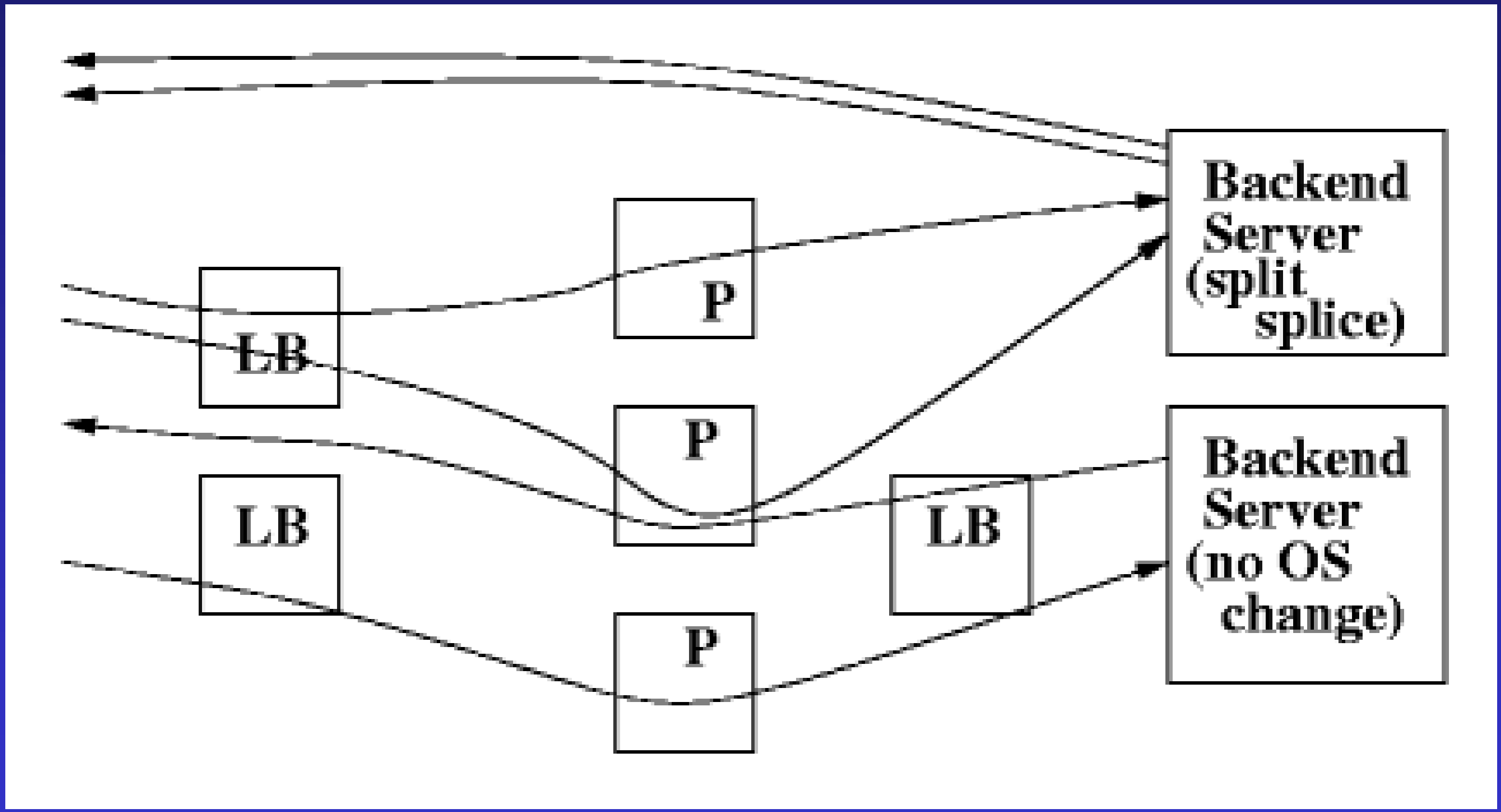
Data Path

One TCP connection

Web Server Configuration 3 (1)

- Mixed configuration: OS changes are required on some machines
- Backend servers where OS can be changed do split-splice

Web Server Configuration 3 (2)



→ Data Path

Two TCP connections

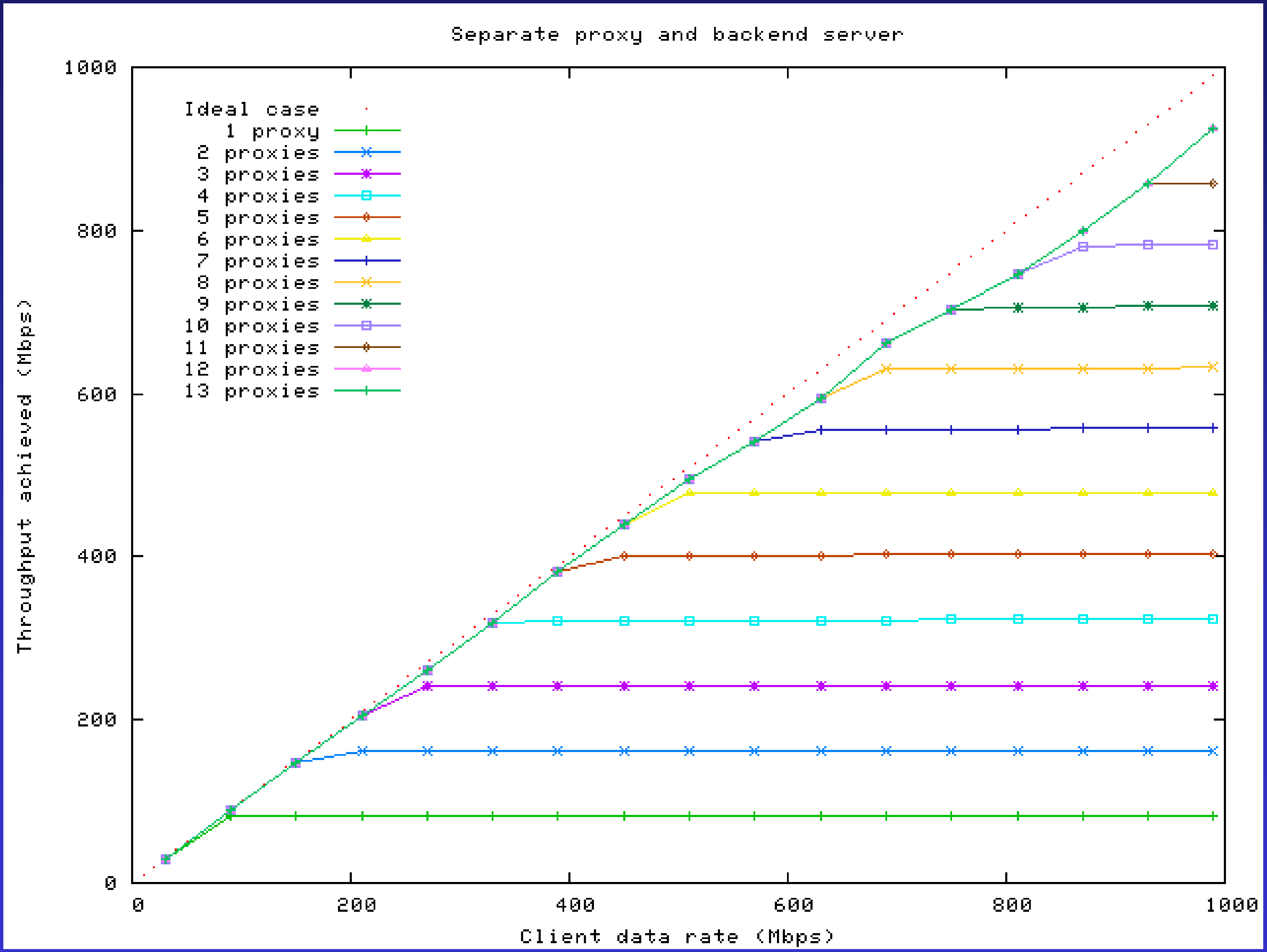
Simulations

- A discrete event simulator was written to simulate the architectures
- Goal of the simulations is to show scalability
- Connections simulated are assumed to be already established and spliced
- Some simulation parameters
  - Splicing Cost: 25 μ sec
  - Client – Proxy link delay: 25 ms
  - Proxy – Server link delay: 0.7 ms
  - TCP buffer: 256kB
  - Packet size: 1460 B
  - Q processing Rate: 1 Gbps

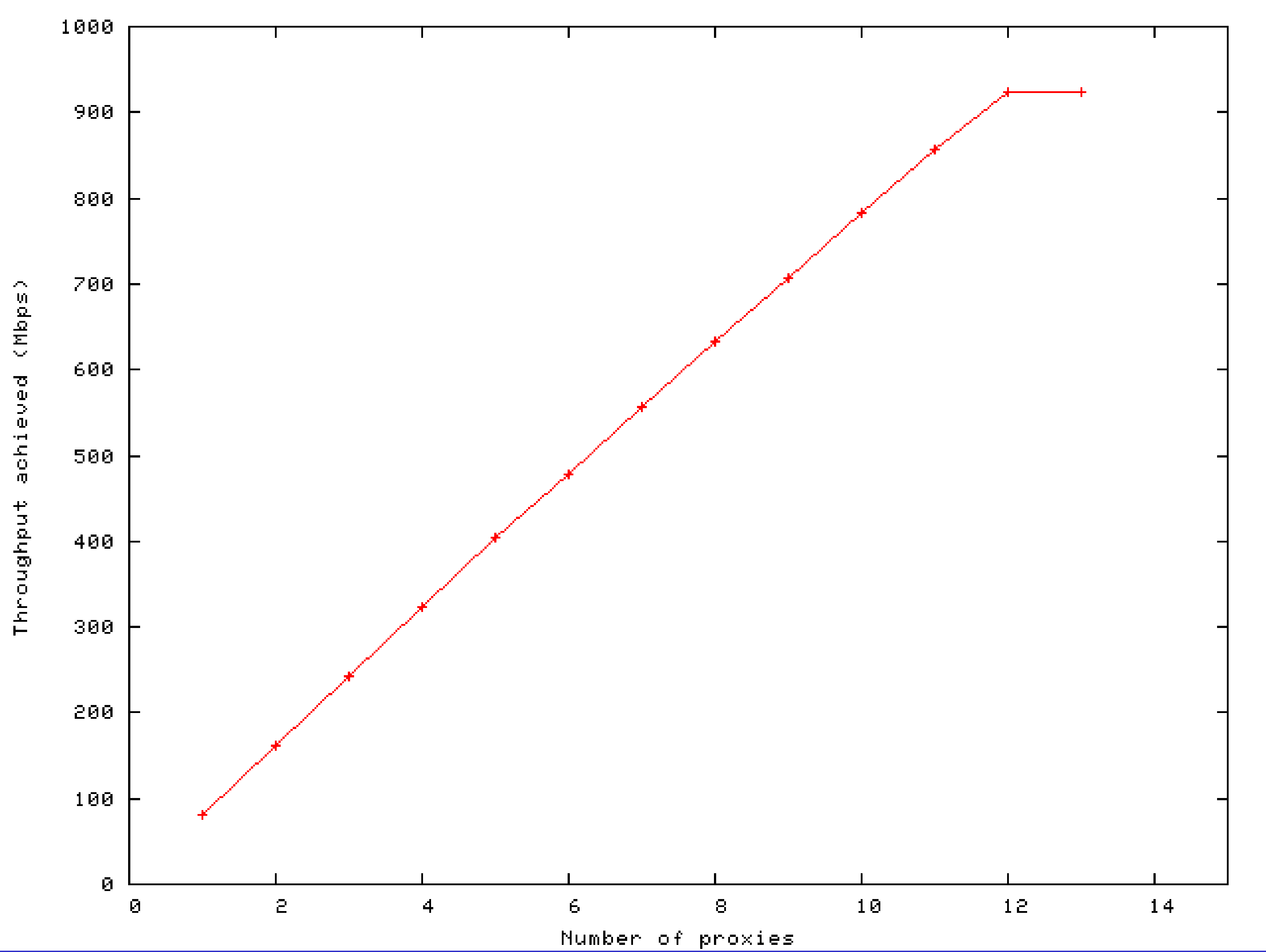
Separate proxy and back-end server (1) (Web Server Configuration 1)

- Goal: show scalability of architecture
- Client
  - data is generated from 30 Mbps to 990 Mbps in intervals of 60 Mbps
  - 50 MB is transferred at each data rate
- Proxies
  - Varied from 1 to 13
- 1 Backend server used

Separate proxy and back-end server (2)



Separate proxy and back-end server (3)



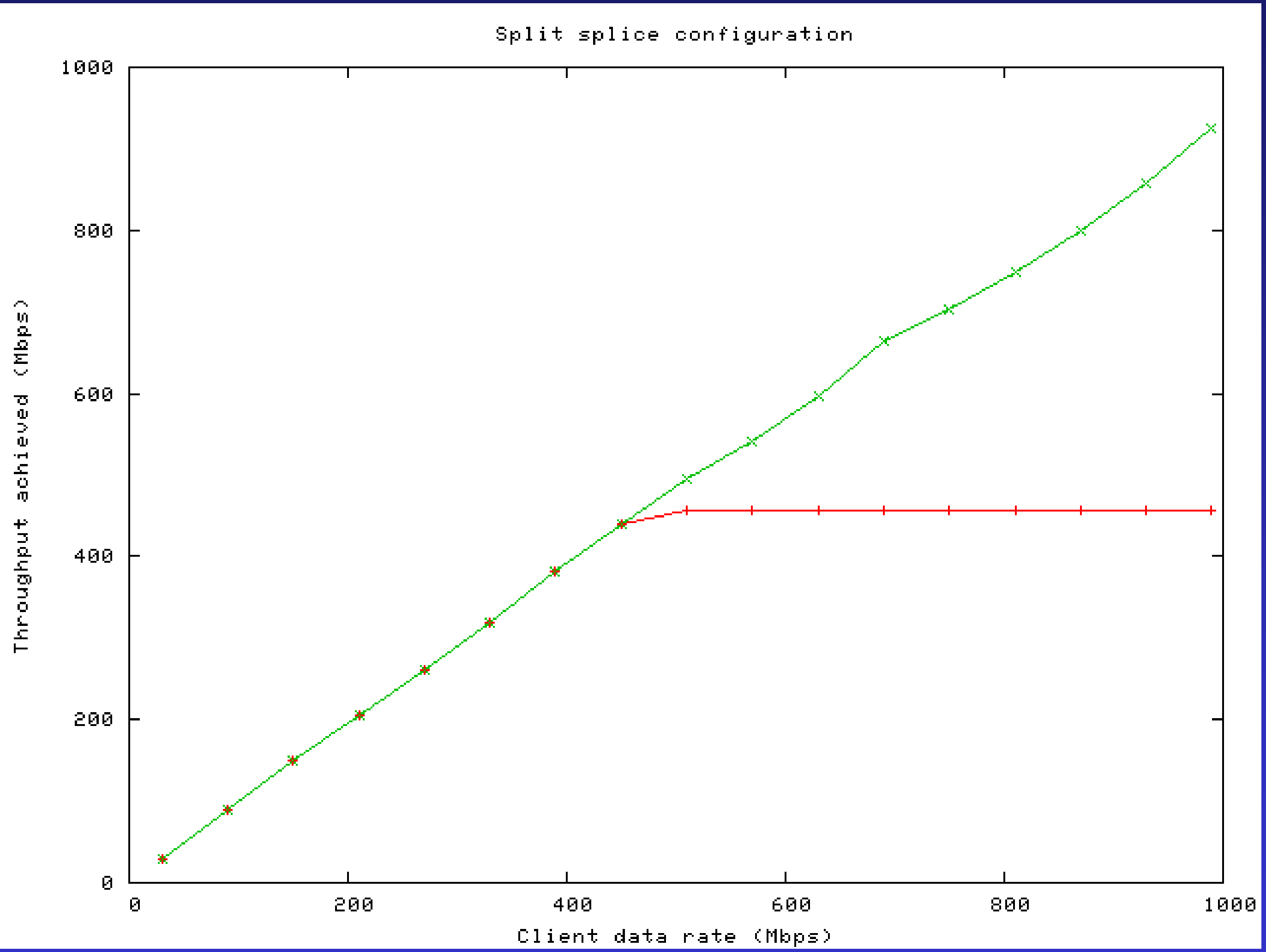
Co-located proxy and back-end server (Web Server Configuration 2)

- The same experiments were repeated for this scenario
- Proxy – Backend server link delay was made zero
- Almost identical to separate proxy and backend server scenario since link delay was already small

Split Splice (1)

- Same experiments were repeated for split splice
- Data generated at a backend server, spliced and sent directly to client

Split-Splice (2)



Splicing cost: 25 μ sec

Splicing cost: 2 μ sec

Conclusions and Future Work

- Presented web server architectures based on enhanced TCP splice
- Used simulations to evaluate these architectures
- In particular, simulated three different configurations
  - Scale well
  - Connections preserved even on proxy failure
  - Proxy not a bottleneck
- Linux prototype implementation paper to be presented at SRDS '06
- In future, make architecture tolerate backend server failures while preserving client connection

Backup Slides

Proxies

- Perform TCP splicing
- Before a connection is spliced, all packets of a particular connection are received by the same proxy through use of hashing and multicast groups (details in SRDS '06 paper)
- Proxy establishing splice distributes splicing state info to other proxies
- Once a connection is spliced, a packet of that connection can be spliced at *any* proxy