Beyond Network Latency

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https://github.com/je-clark/sf24eu_latency

About Me

- M.S. in Computer Engineering
  - Focus on networking, protocol design, and security
- Distributed Performance Engineer
  - Using packets to solve complex performance issues

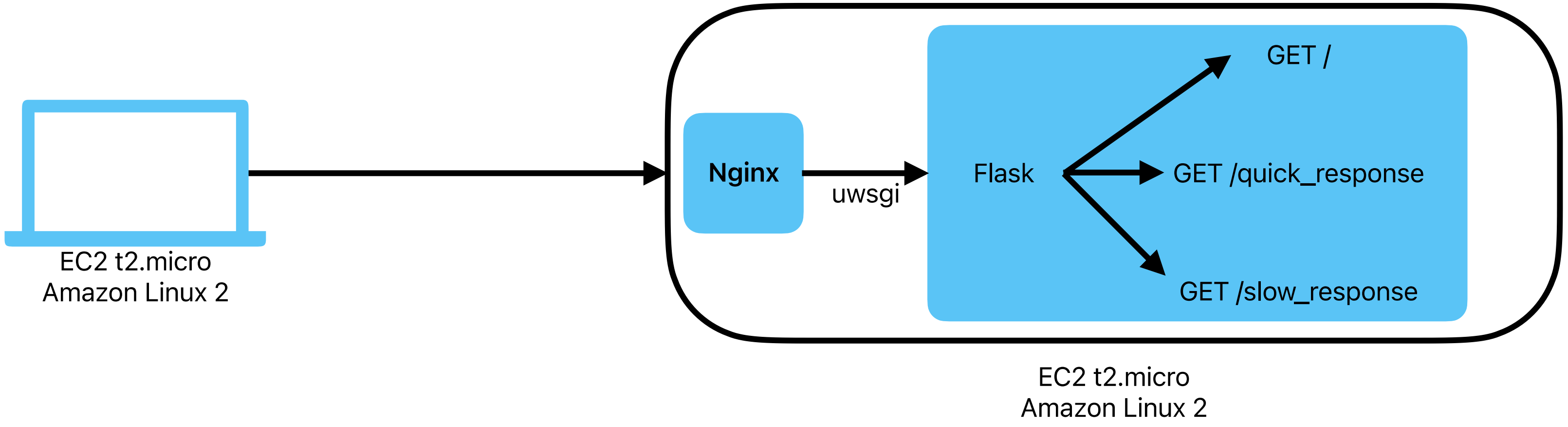
https://www.jeclark.net
https://github.com/je-clark
https://github.com/je-clark/sf24eu_latency

Defining Terms

- **Network Delay** – the time it takes for a packet to travel between client and server, measured as round trip time
- **Application Delay** – the time it takes for an application to respond to a request. This is measured between the application process receiving a message and sending a response to the local server's network stack
- **Server Delay** – the time it takes a server to transfer messages between the NIC and an application process
- **Client Wait Time** - the client's version of server + application delay, usually influenced by user interaction

Latency in Normal Operation

Testing Architecture - AWS



- Normal internet latency of 30ms simulated on client using tc
- Python script (request_code.py) deployed on client to simulate a user
- All packets captured via tcpdump on the client

Capture 1: Fast Response

- 0_normal_fast_clear.pcapng
- 1_normal_fast_cipher.pcapng

THE PATTERN

Δ Conv	Source	Destination	Protocol		
0.005371000	Client	Server	TCP	1448	········A····
0.000015000	Client	Server	TLSv1.2	789	········AP···
0.000506000	Server	Client	TCP	0	········A····
1.002826000	Server	Client	TCP	2896	········AP···
0.000001000	Server	Client	TCP	2896	········AP···

Payload = MSS, no PSH | **client REQ**
Payload < MSS, PSH | **end of REQ**
Payload = 0, ACK | **network delay**
Payload > 0 | **server + app delay**

If you only learn one thing from this talk, let it be the pattern

Capture 2: Network Latency

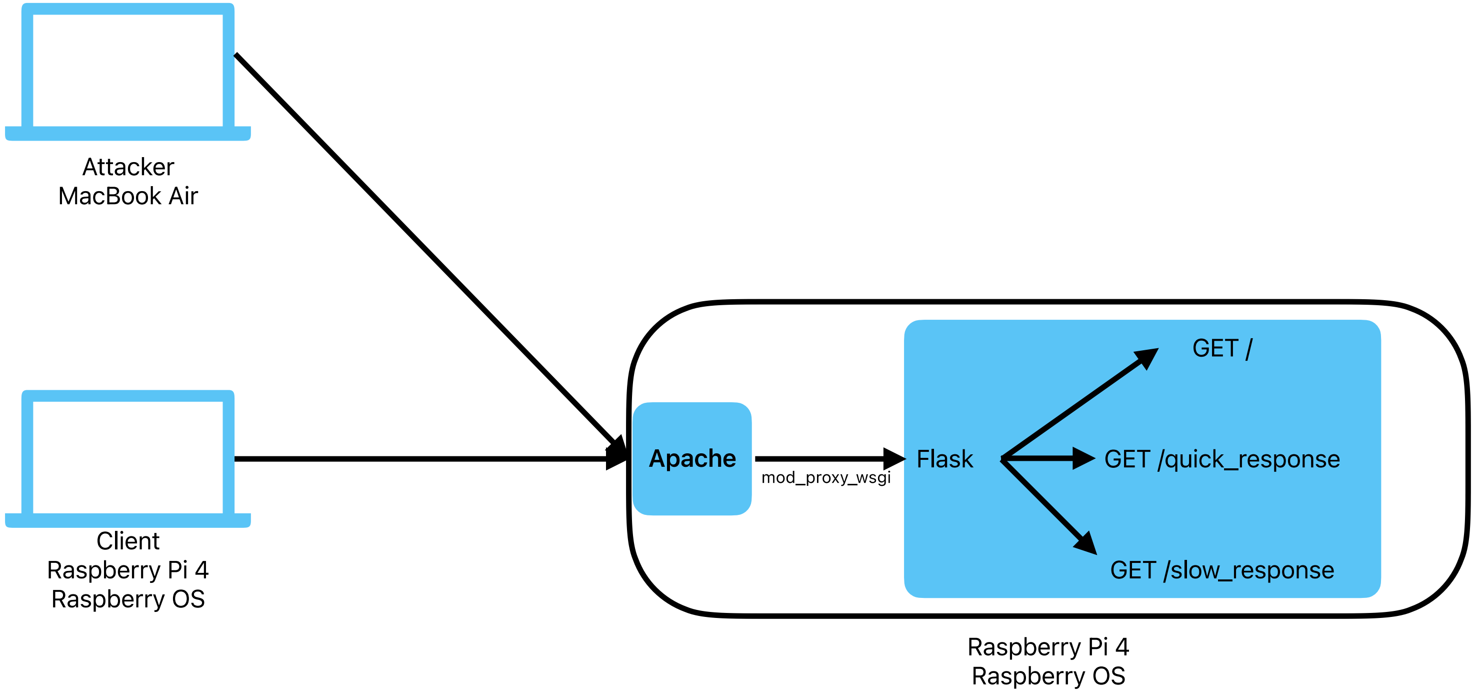
- 2_net_delay_clear.pcapng
- 3_net_delay_cipher.pcapng

Capture 3: Application Latency

- 4_normal_slow_clear.pcapng
- 5_normal_slow_cipher.pcapng

Latency Under Attack

Testing Architecture – Raspberry Pi

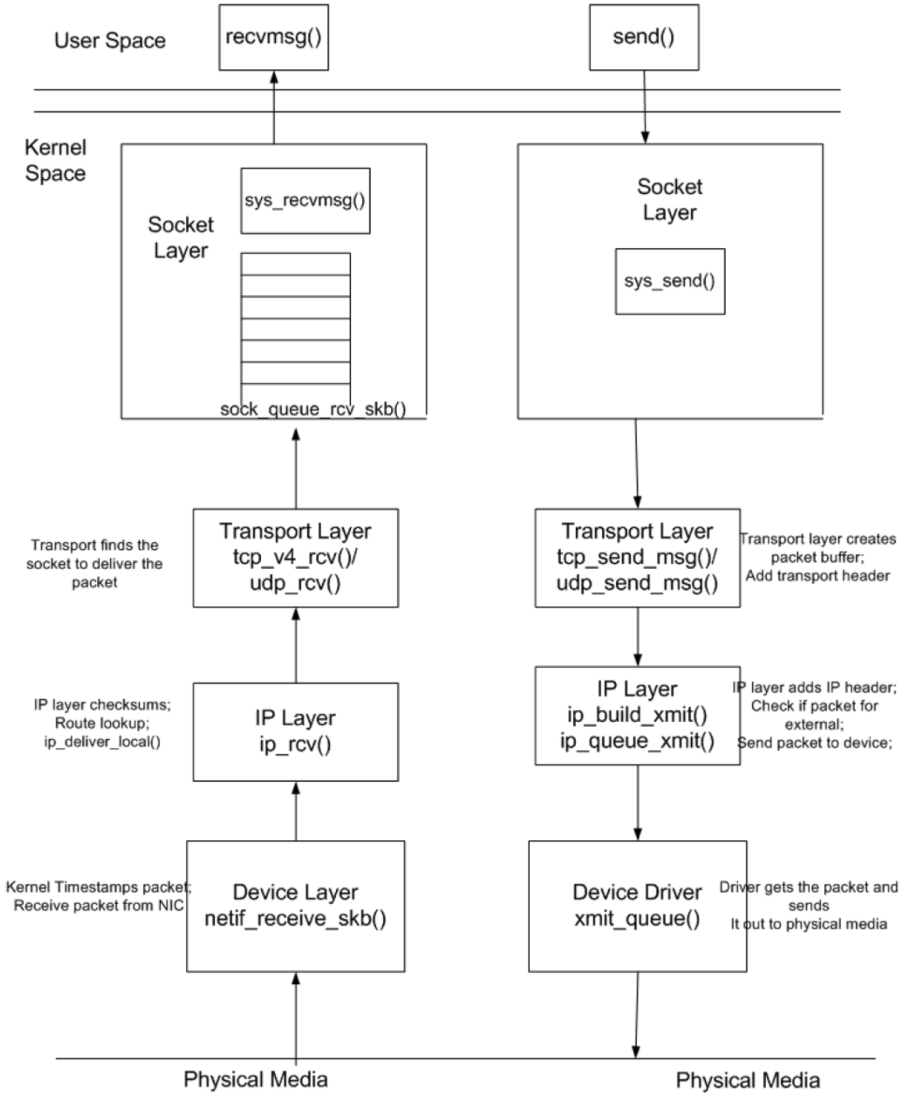


- Switched to Raspberry Pis to reduce overall server capacity
- Switched to Apache because it's less efficient
- Used laptop to add load to the server

Capture 4: HTTP GET Flood

- 6_get_flood_fast_filtered.pcapng

Why This Happened



R. Krishnamurthy, "A Framework for Evaluating Server Performance: Application to SIP Proxy Servers", 2016. Available ramekris.wixsite.com/research

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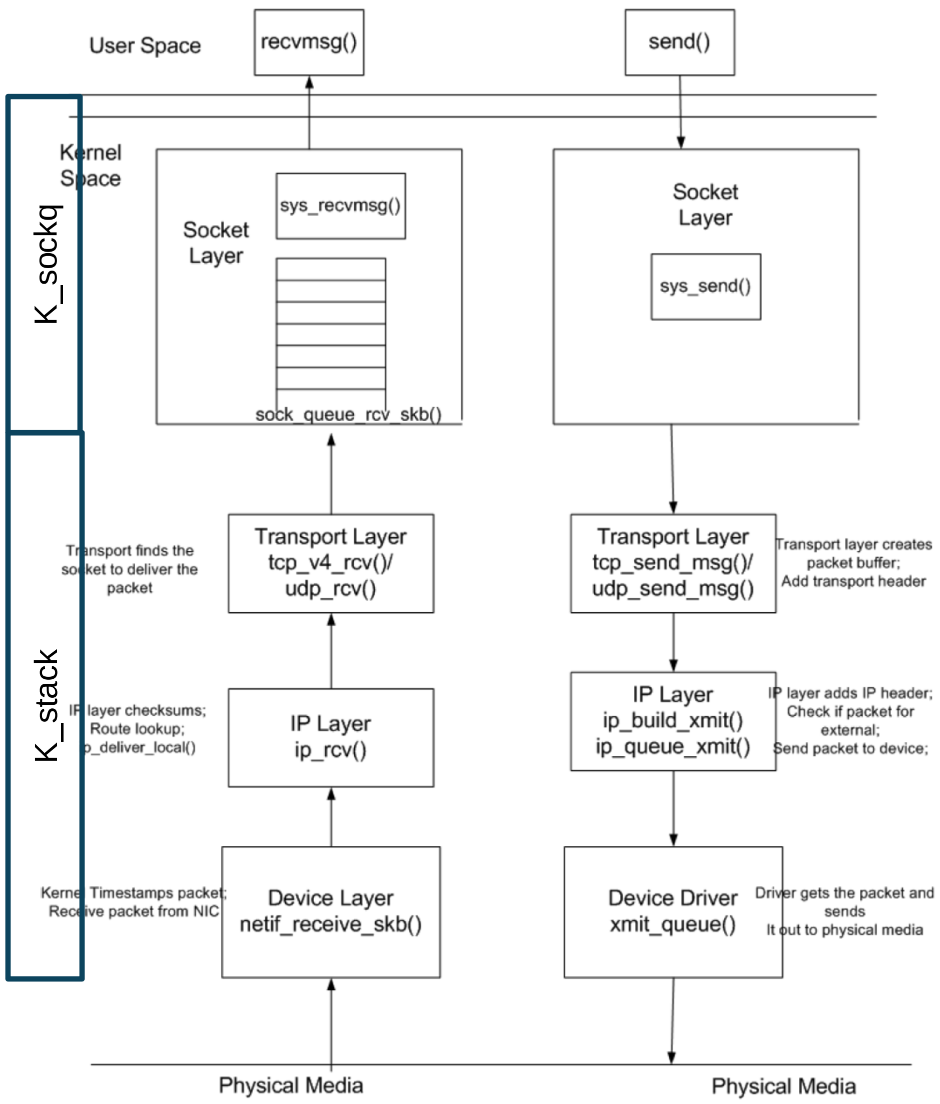

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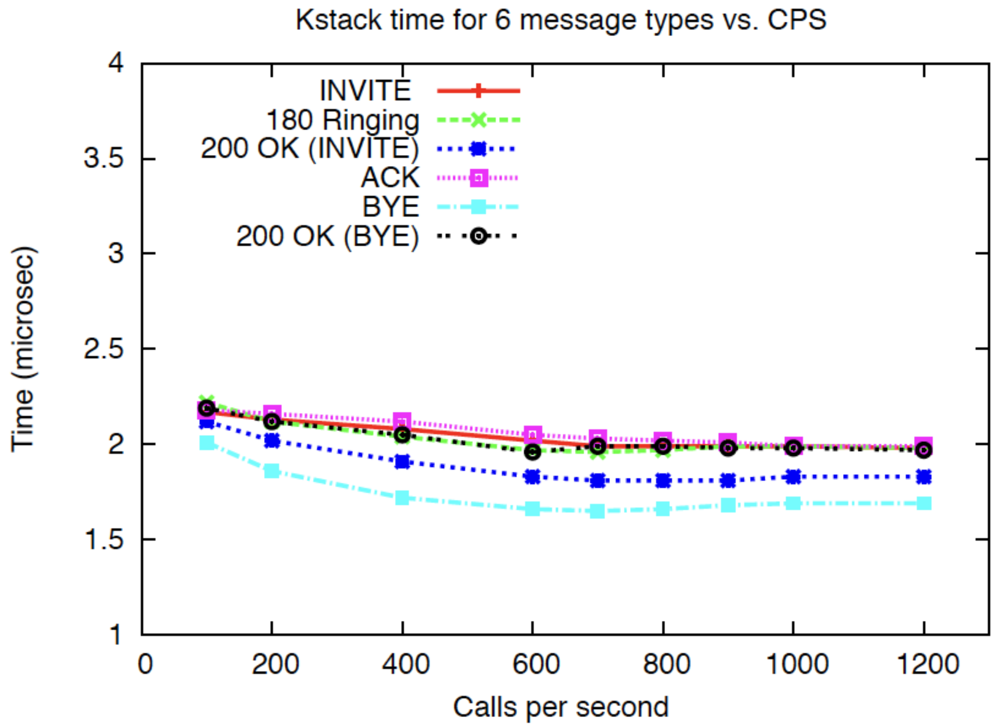

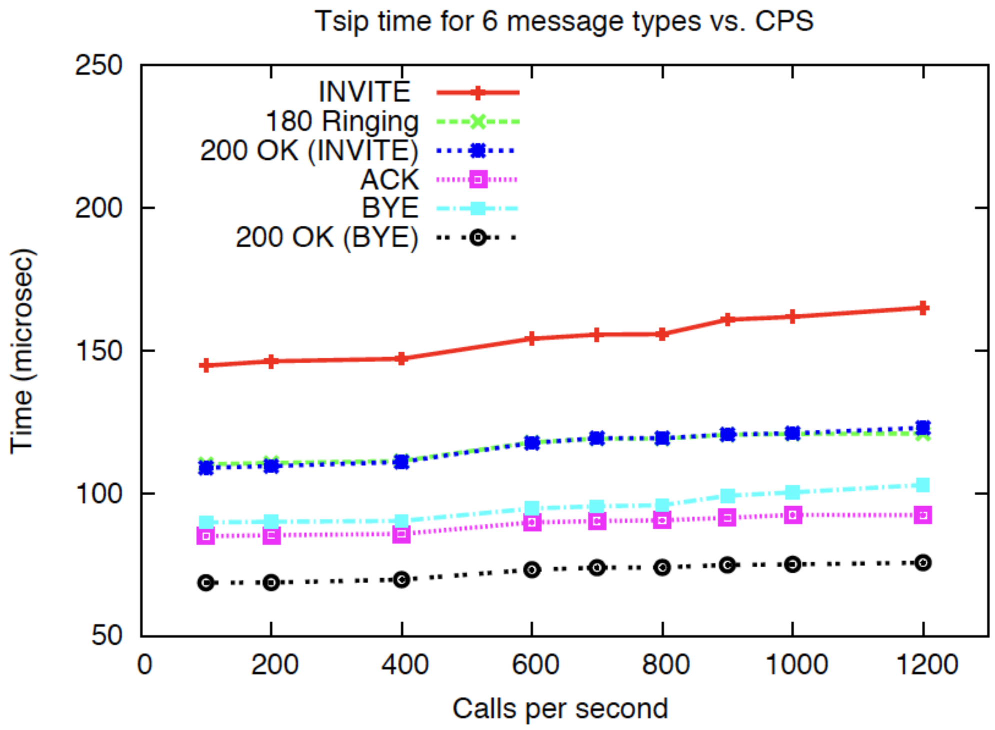

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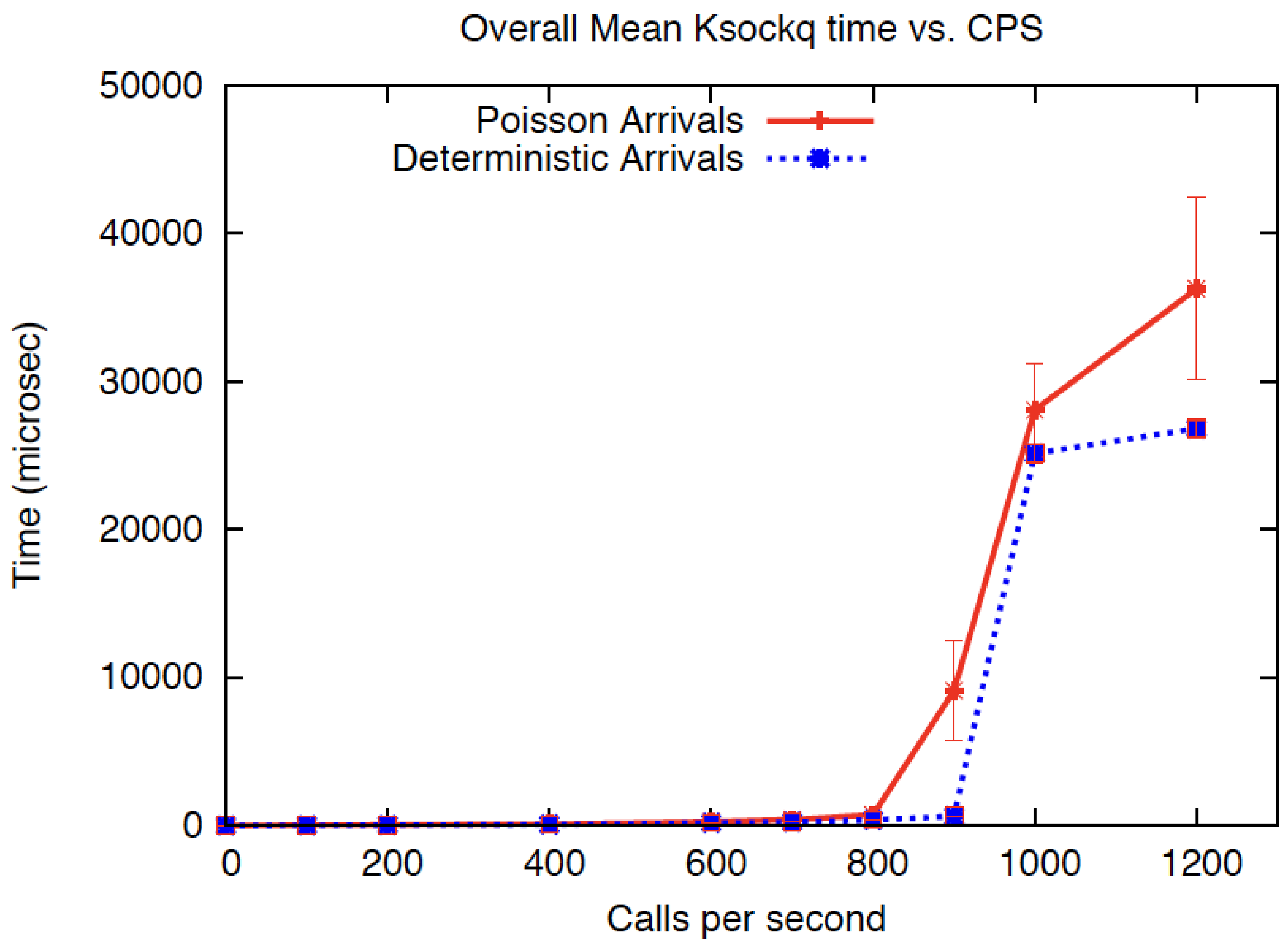

When an application is busy, it can take a long time for the kernel to get the application to pull a message from the socket buffer

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Capture 4: TCP SYN Flood

- 7_syn_flood_fast_filtered.pcapng

Why This Happened

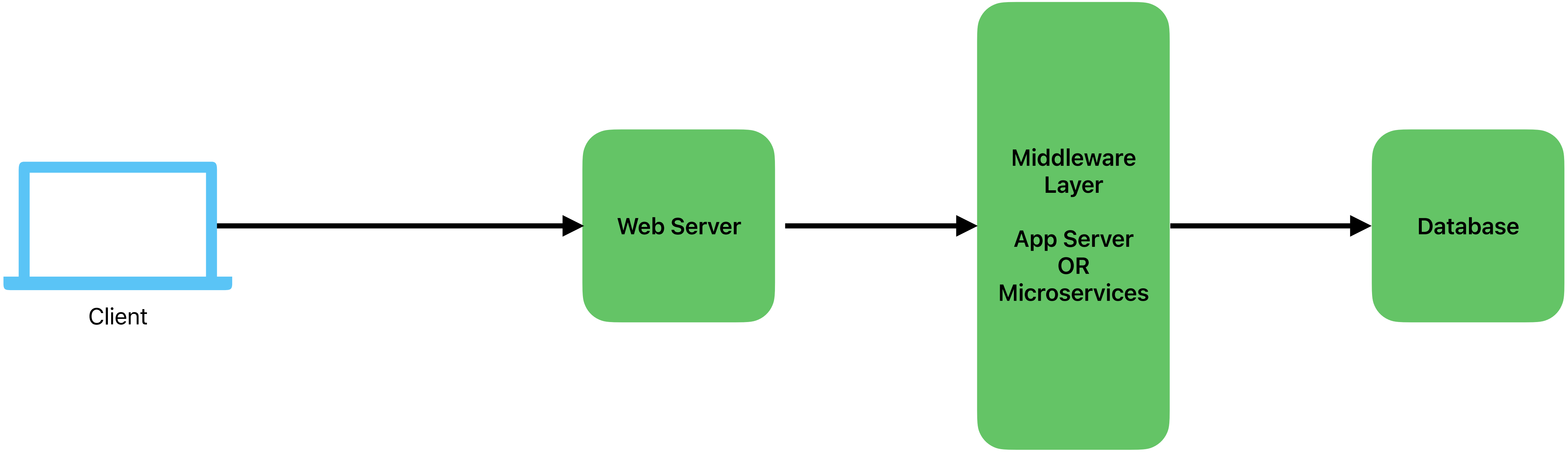
- To get a packet to the kernel, the NIC must send an interrupt to the CPU
- The process that handles that interrupt is ksoftirqd

Why This Happened

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
14	**root**	**20**	**0**	**0**	**0**	**0**	**R**	**90.7**	**0.0**	**0:18.56**	**ksoftirqd/0**
1074	**root**	**20**	**0**	**0**	**0**	**0**	**R**	**9.3**	**0.0**	**0:01.33**	**kworker/0:2+events**
709	root	20	0	3116	1840	1420	S	0.7	0.0	0:00.56	dhcpcd
850	root	20	0	0	0	0	I	0.3	0.0	0:00.15	kworker/2:1-events
1069	**pi**	**20**	**0**	**9860**	**3248**	**2716**	**R**	**0.3**	**0.1**	**0:05.46**	**top**
1	root	20	0	166824	10172	7436	S	0.0	0.3	0:02.86	systemd
2	root	20	0	0	0	0	S	0.0	0.0	0:00.03	kthreadd
3	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	rcu_gp

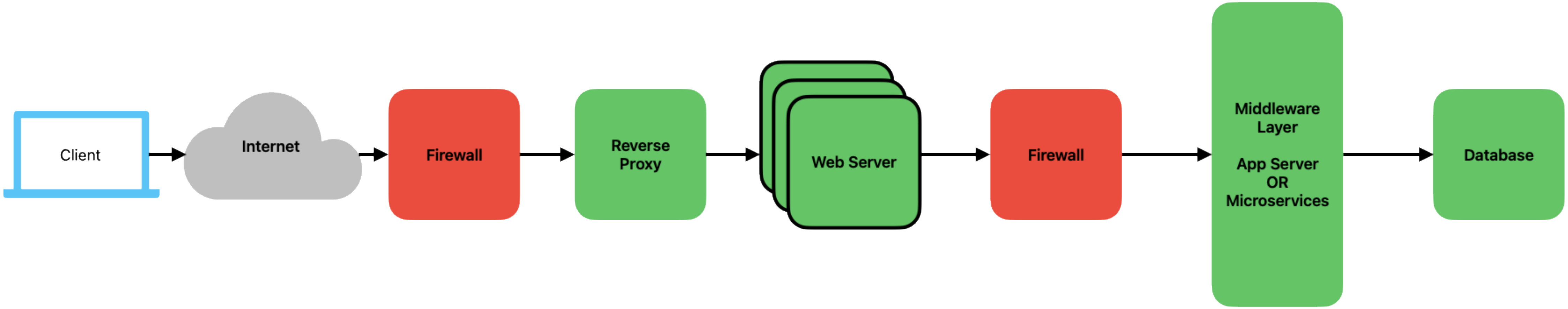
Real World Application

Three Tier Application



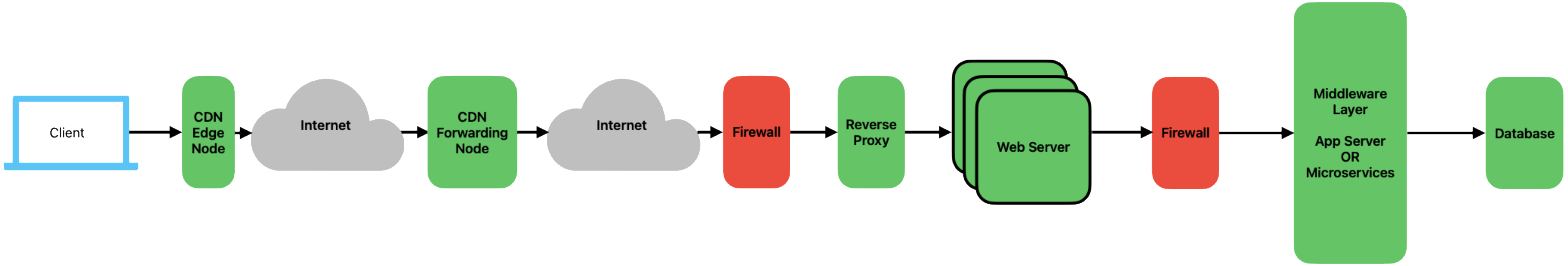
Packet captures from a given layer let us perform latency analysis on both sides of that layer

Modern Application



In a modern internet-facing application, any one of these devices can be causing latency, including devices deployed as appliances. Getting packet captures at multiple layers is critical to isolating a problematic layer.

CDN Fronted Application



With a CDN in the mix, it's difficult to determine any latency at the client. Because CDNs operate at Layer 7, we don't even get a good understanding of network latency.

Feedback