# BMC: Accelerating Memcached using Safe In-kernel Caching and Pre-stack Processing

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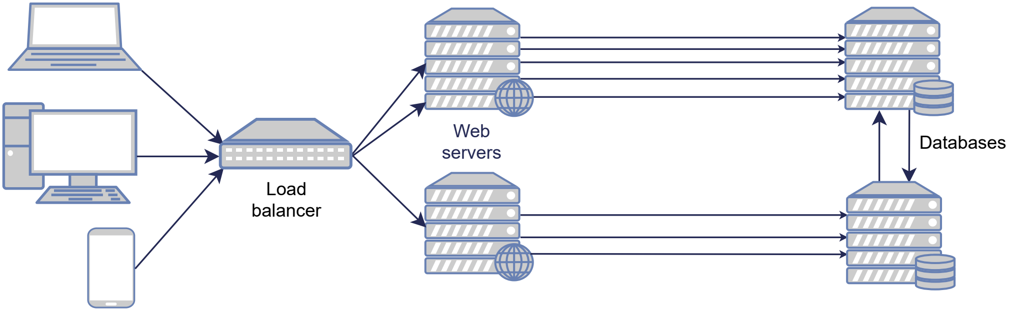
*Networked Systems Design and Implementation, 12–14 April, 2021*

# Memcached



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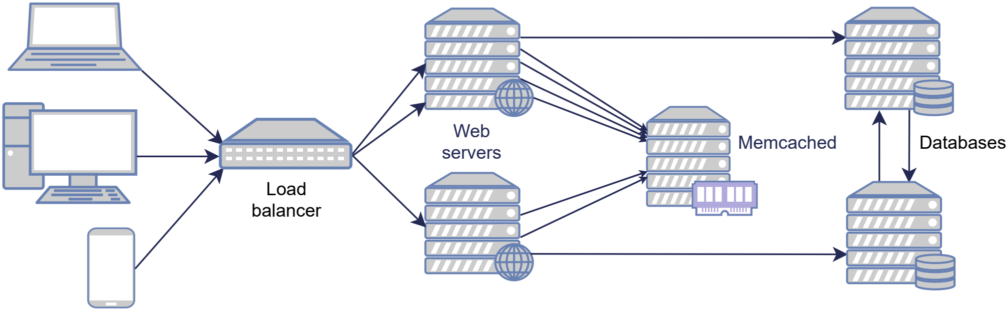
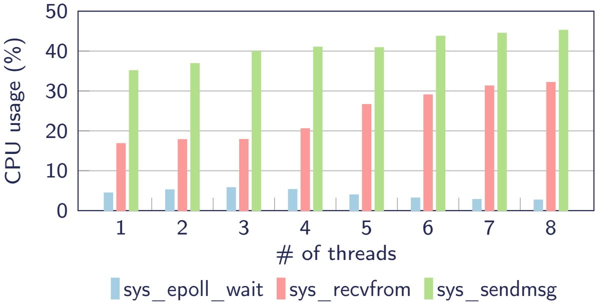



- In-memory key-value store, simple GET/SET interface
- Used by web services to off load work from databases
- Given its crucial role, Memcached must be able to sustain high network load

# Observations

Memcached suffers from known kernel overheads:

- Concurrent data structures (e.g. sockets) used by multiple threads
- System calls



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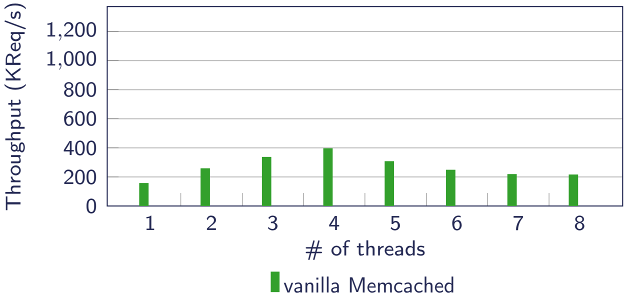

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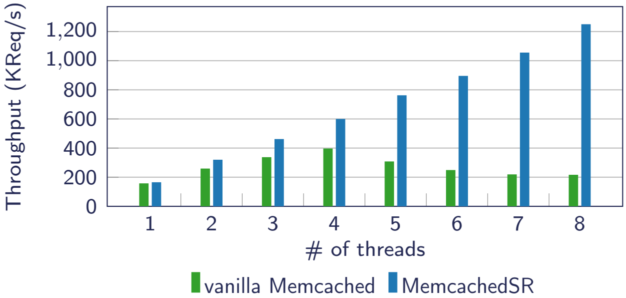

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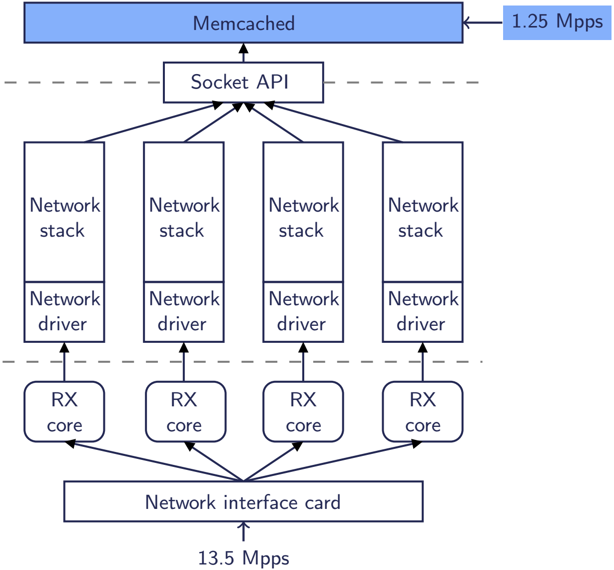

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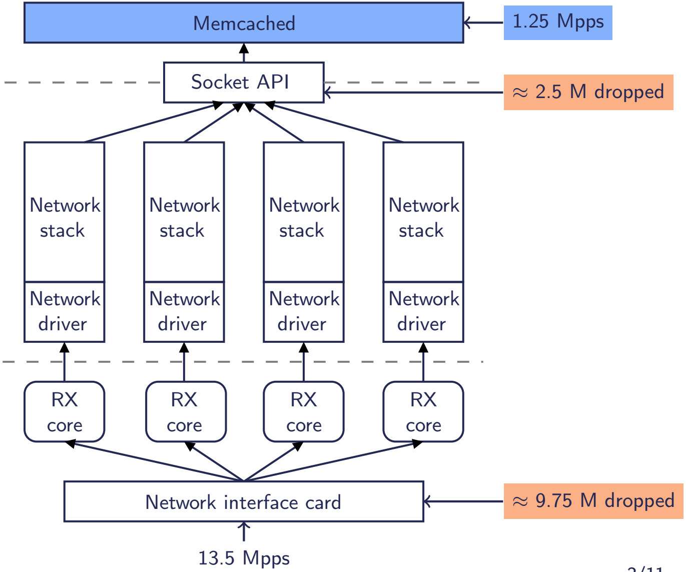
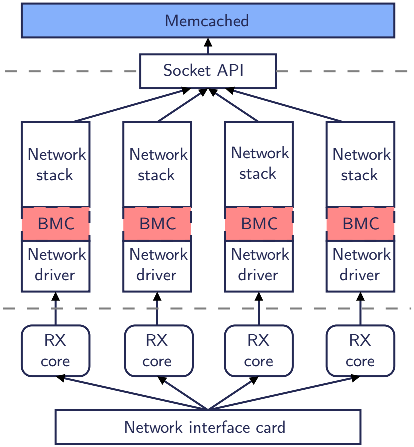


# BMC: Key idea

Enable a Memcached server to respond to *get* requests without executing the whole network stack



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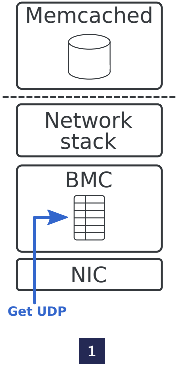


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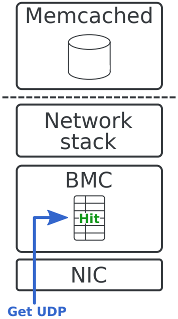


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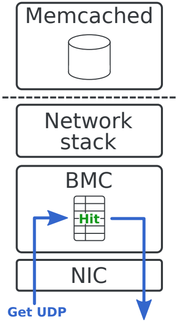


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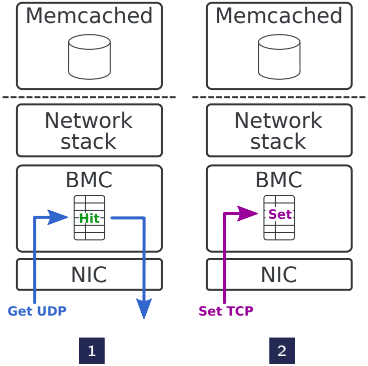


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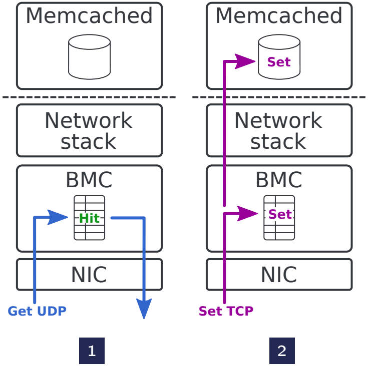


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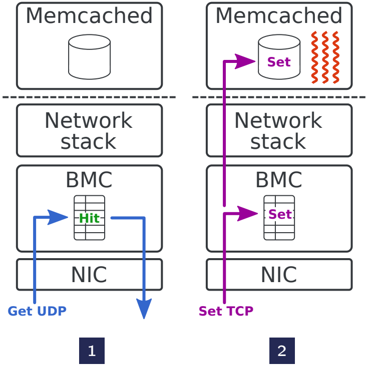


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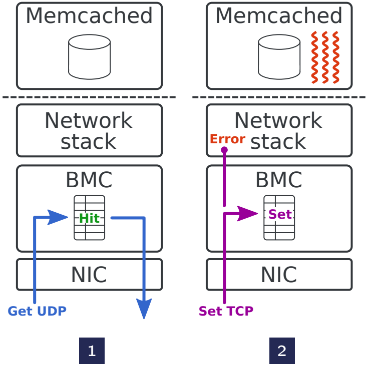


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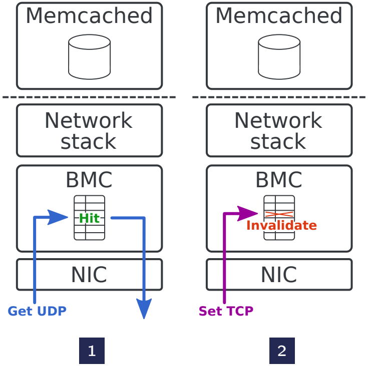


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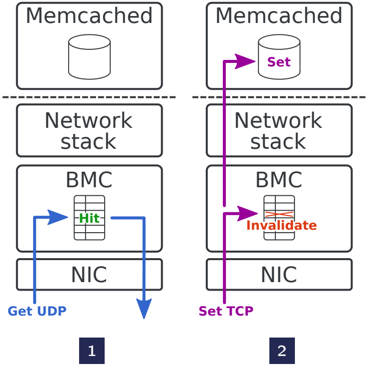


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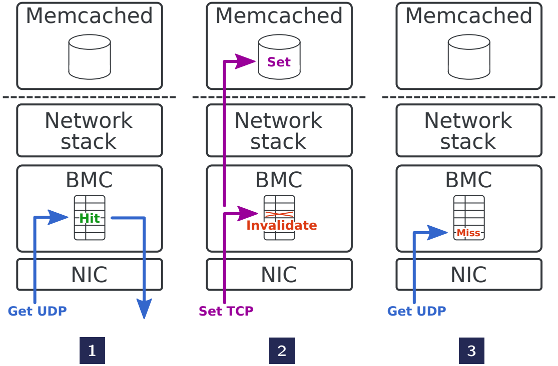


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3 Perform cache updates transparently to the application

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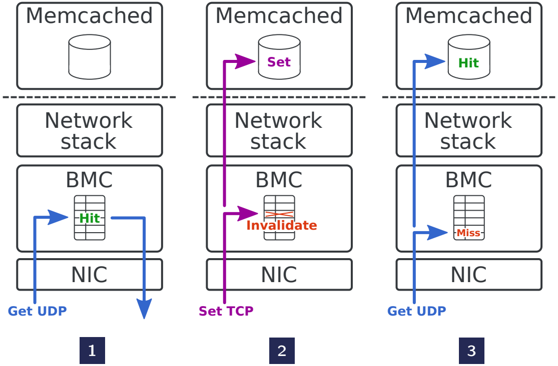


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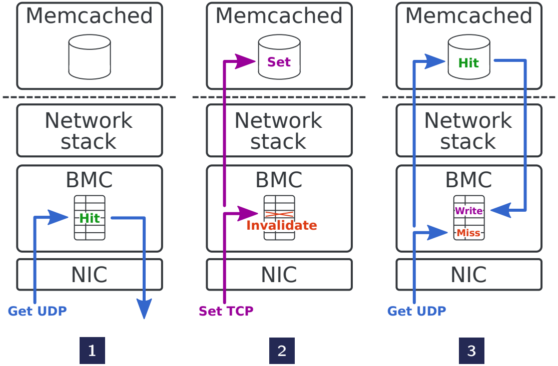


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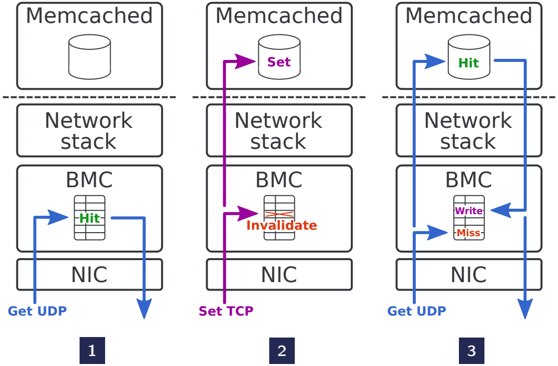


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# Implementation

## eBPF

Linux's extended version of BPF. The eBPF infrastructure offers the ability to run user-supplied programs inside the kernel.

## Benefits of eBPF

- Safety through static analysis
- JIT compilation
- Network driver attach point (XDP)

# Implementation

## eBPF

Linux's extended version of BPF. The eBPF infrastructure offers the ability to run user-supplied programs inside the kernel.

## Limitations of eBPF

Static analysis doesn't scale to complex application logic

- Only a limited number of BPF instructions can be analyzed
- Loops must have static bounds
- No dynamic memory allocation

# Dealing with eBPF's limitations

- Bounding data (memcached keys/data/packets)

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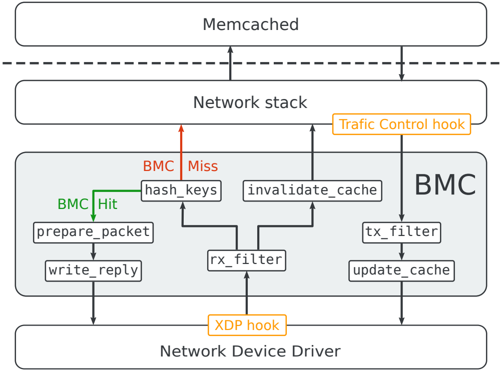
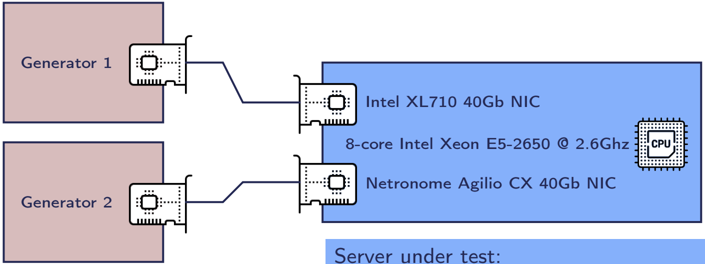
- Using a rolling hash function (*FNV-1a*)
- Partitioning complex functions



# Experimental setup

Two clients generate memcached worload:

- 100 million distinct memcached keys
- Zipf key distribution
- 16-byte keys and 32-byte values
- 30:1 GET/SET ratio

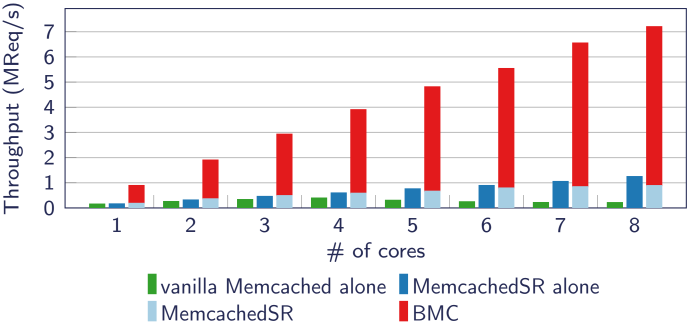



Server under test:

- Linux 5.3.0
- Memcached 1.5.19 with 10 GB of memory
- BMC with 2.5 GB of memory

# Throughput

- Up to 18x compared to vanilla Memcached
- Up to 6x compared to MemcachedSR



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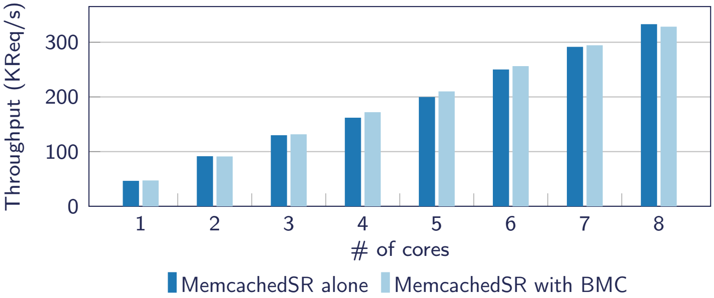
- No observable deterioration with a worst-case workload



# Receive-Process-Reply latency

- Median of memcached hits and misses with BMC is respectively 21.8 and 21.6 µs
- 2.11 µs for a BMC cache hit
- Memcached operations are about 1 µs faster when not running BMC

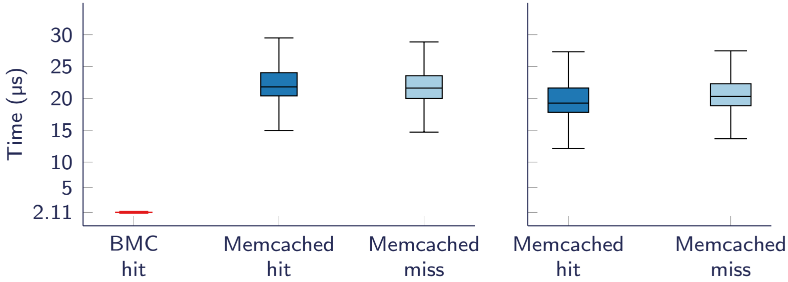
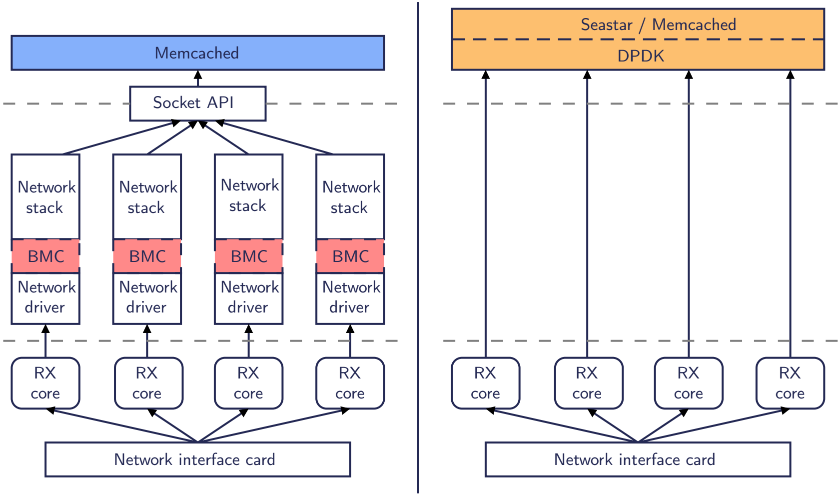



Fig 1: with BMC

Fig 2: without BMC

# Comparison to kernel-bypass: Seastar



# Comparison to kernel-bypass: throughput

- Up to 5x higher throughput on favorable workload
- Better performance scaling on mixed workload

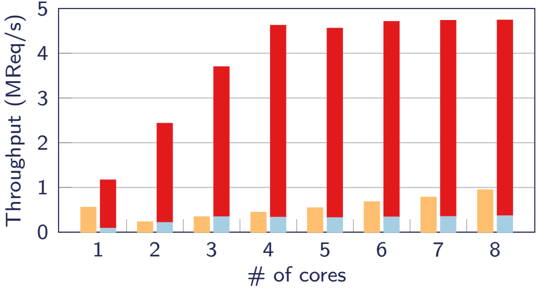



Fig 1: UDP only

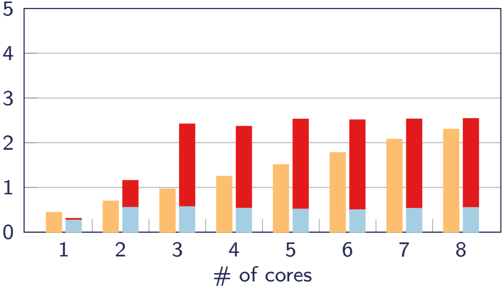
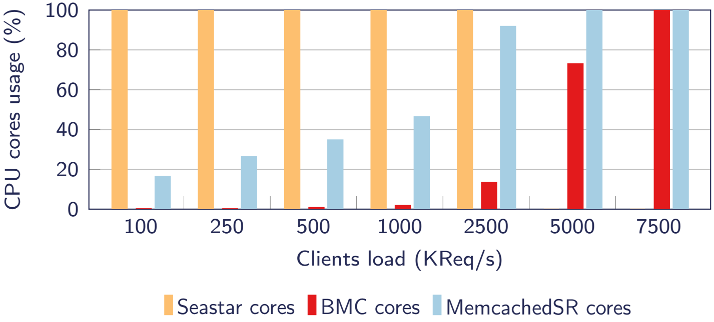



Fig 2: UDP and TCP

Seastar MemcachedSR BMC

# Comparison to kernel-bypass: CPU usage

- Up to 5x higher throughput on favorable workload
- Better performance scaling on mixed workload
- 3x times less CPU resources to achieve similar throughput



# Conclusion

BMC

- uses in-kernel caching to serve Memcached requests after they have been received by the network driver
- works with unmodified software on commodity hardware
- offers significant throughput improvement
- introduces negligible overhead

**On-going work:** Optimized eviction algorithm

# Thank you

For more questions:

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