Embedding Database System Logic in the Operating System Is Finally a Good Idea

Matthew Butrovich

PARALLEL DATA LABORATORY

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Outline

- User-bypass
- Prior work: User-bypass for DBMS proxies
- Future work: User-bypass DBMS

The OS Is Not Our Friend

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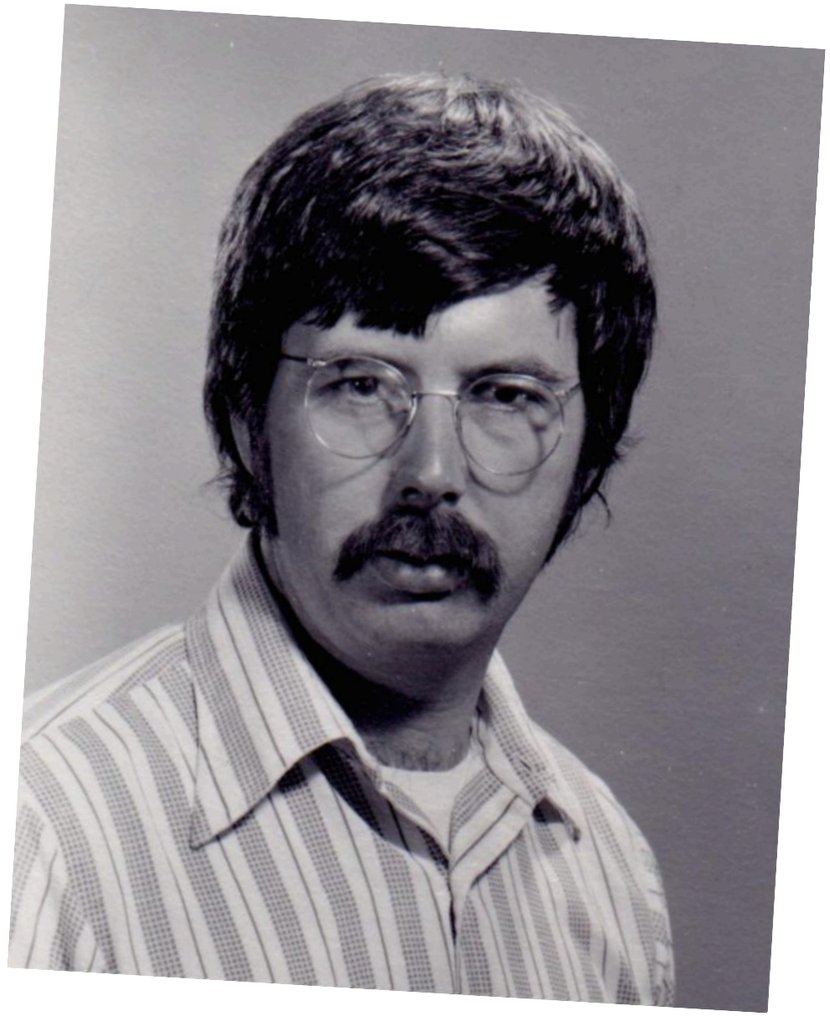
"The bottom line is that operating system services in many existing systems are either too slow or inappropriate."



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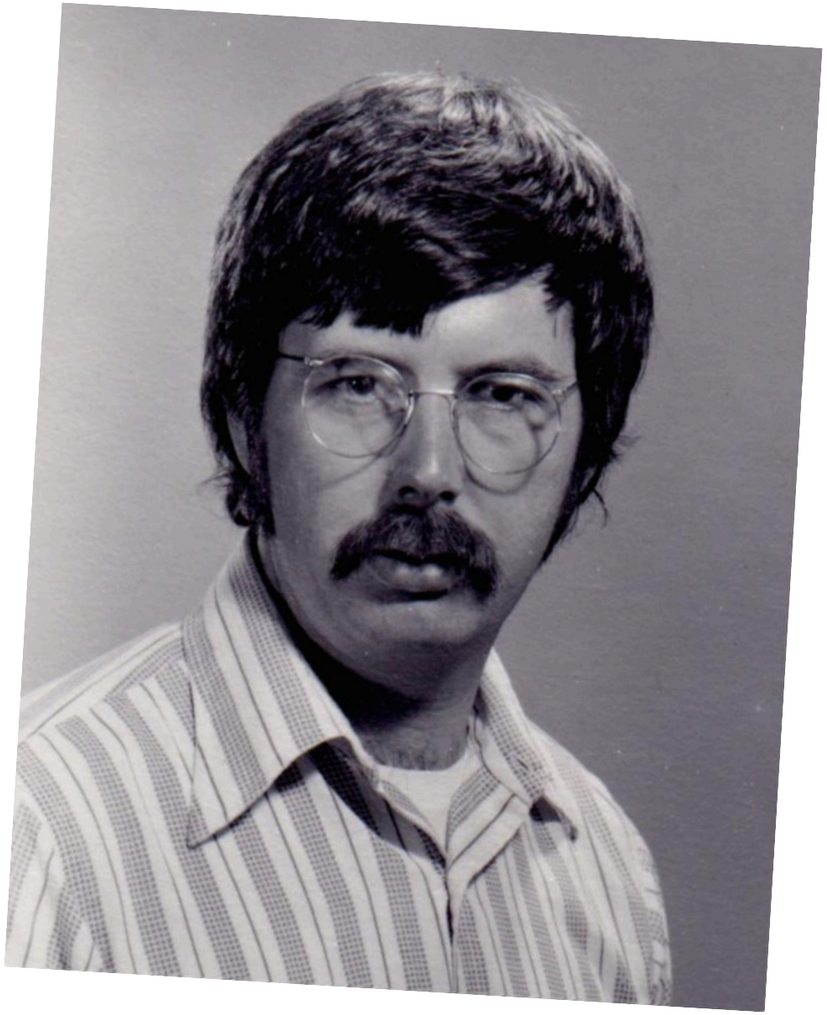

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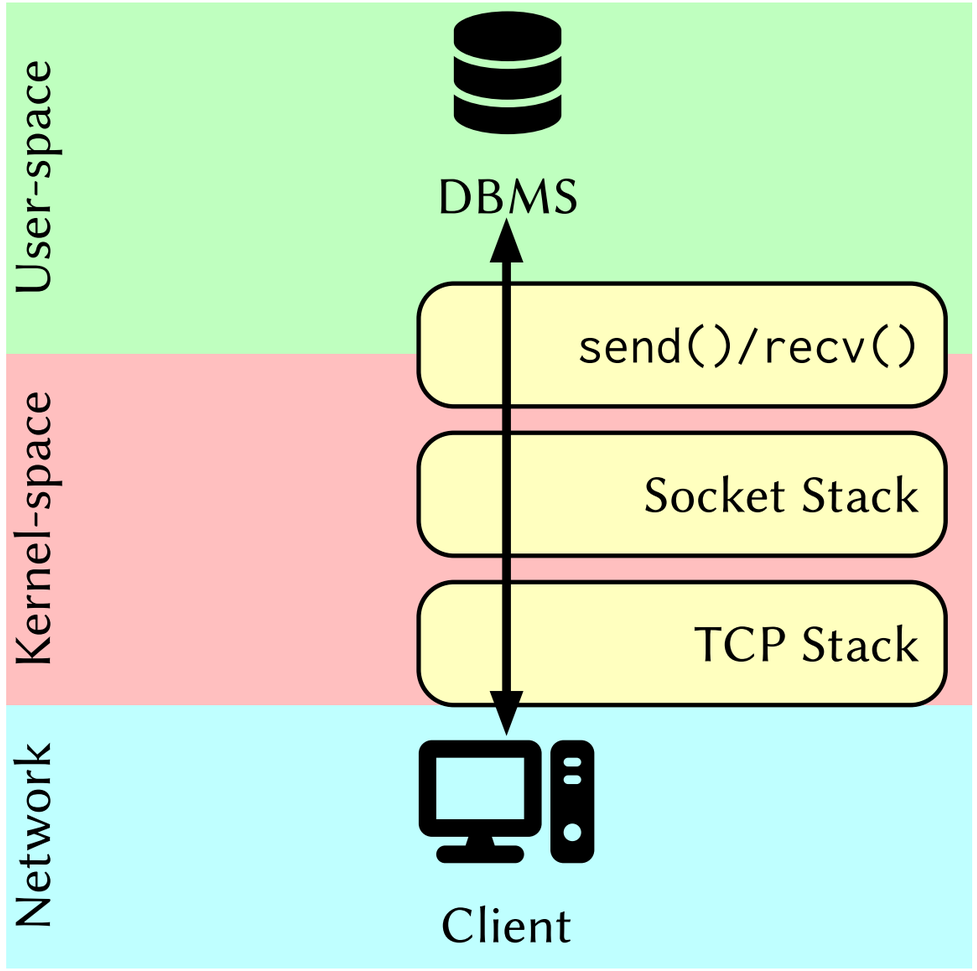

User-space DBMS

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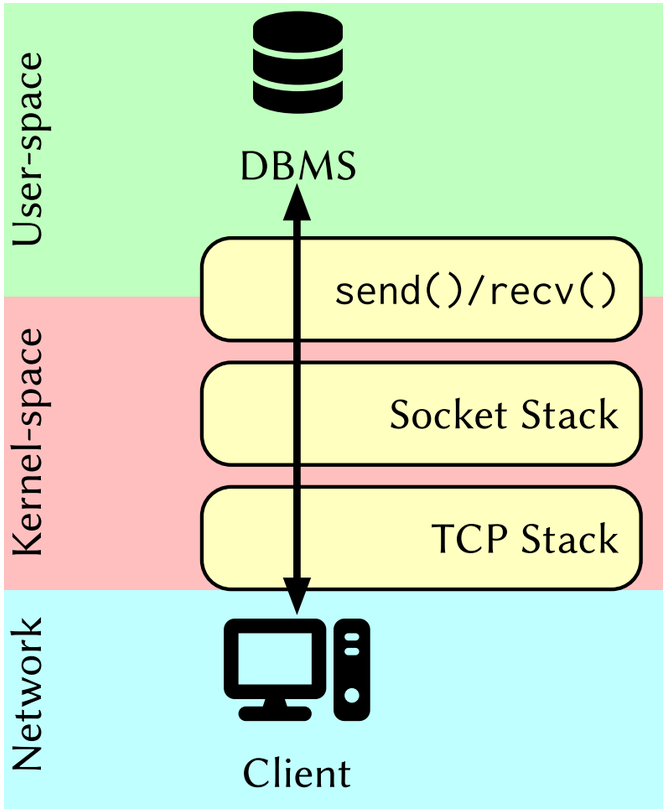

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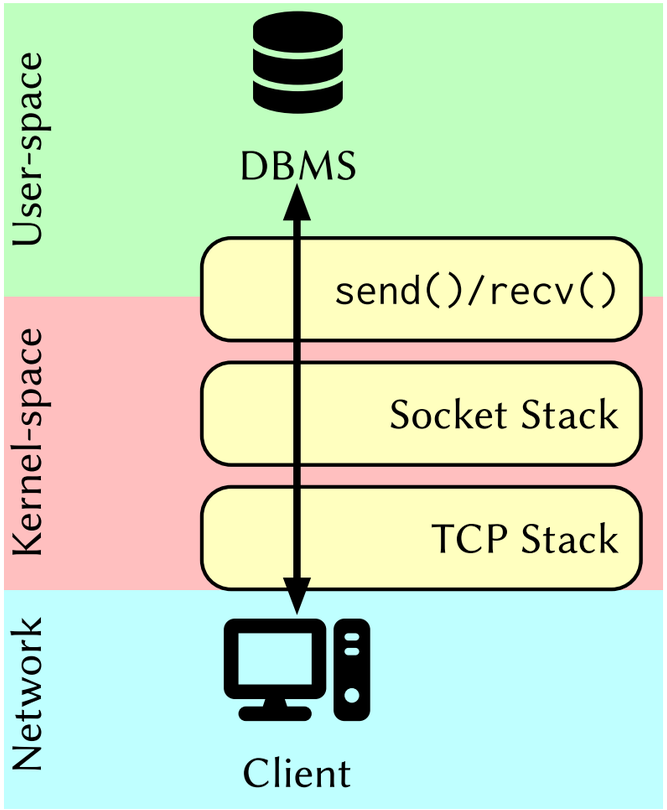

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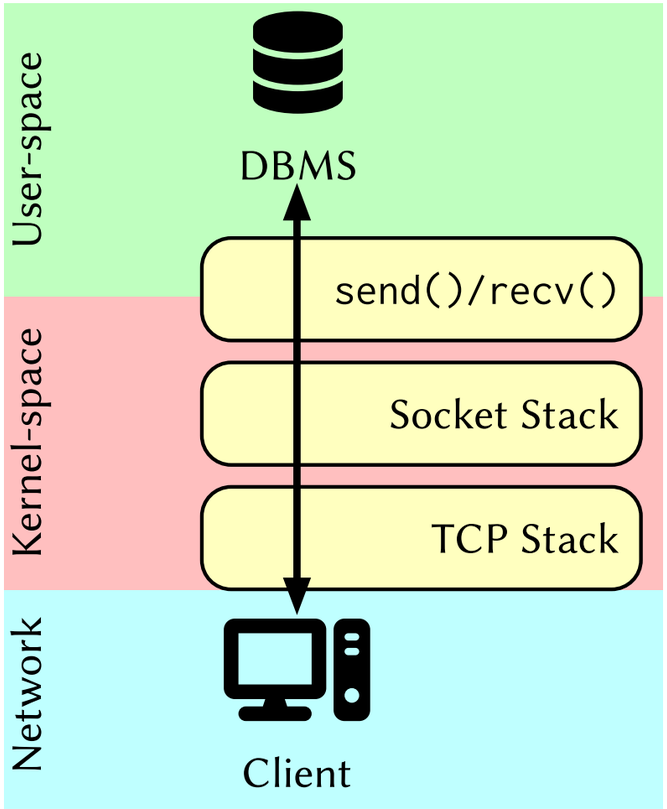

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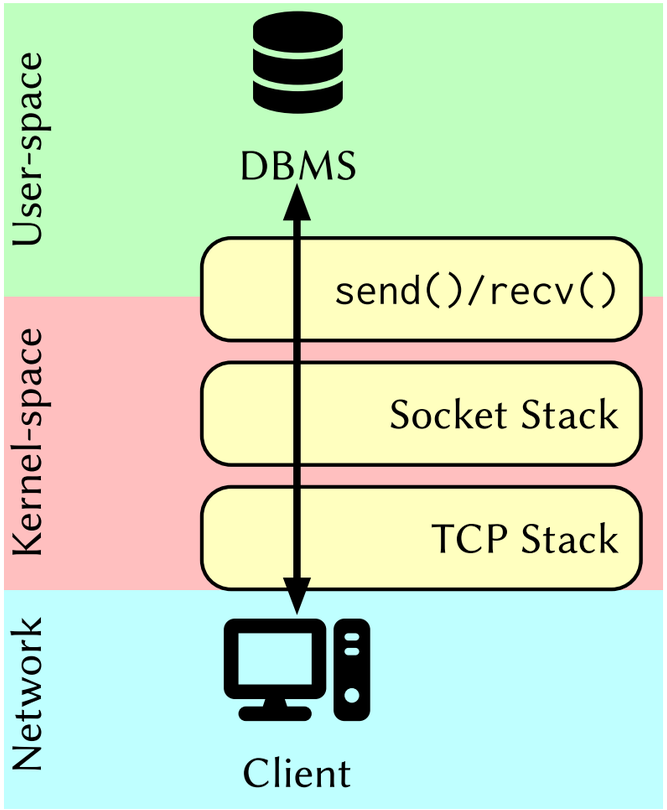

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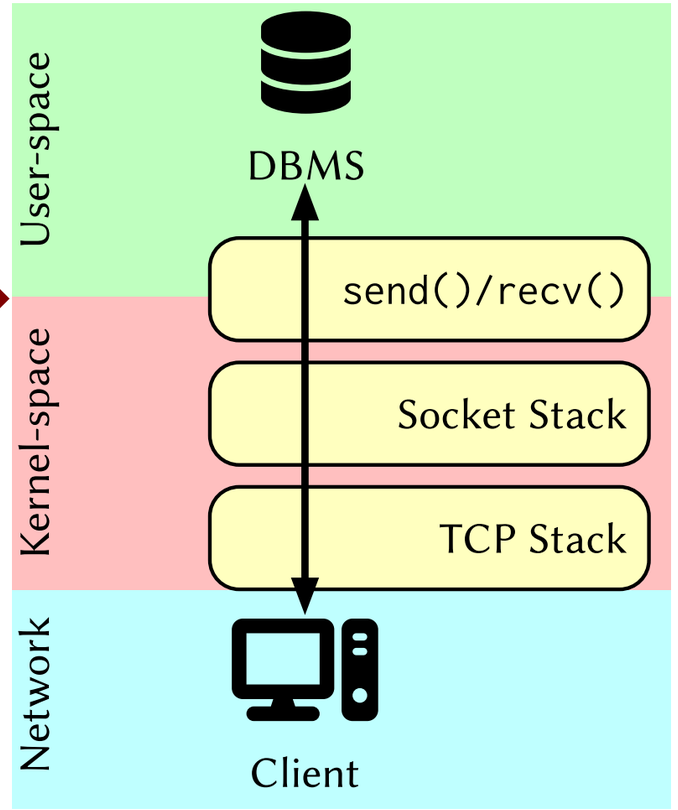
>50% of CPU cycles on memcpy()



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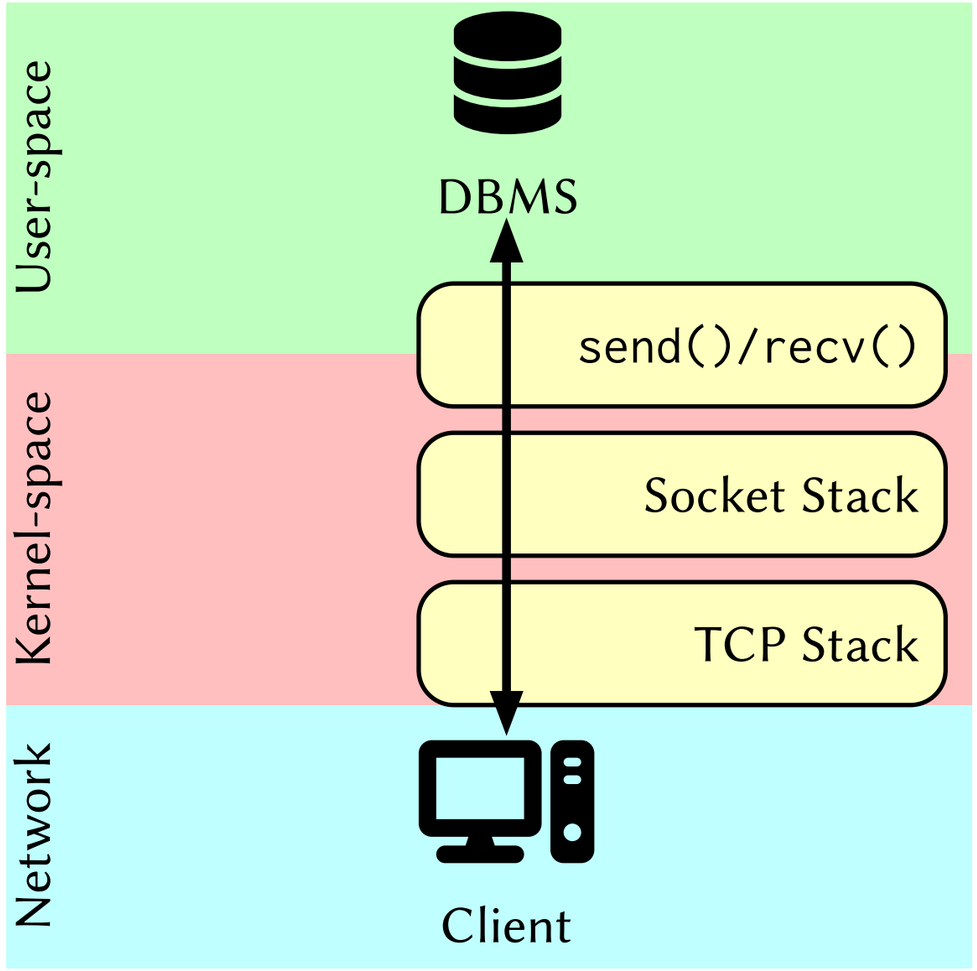

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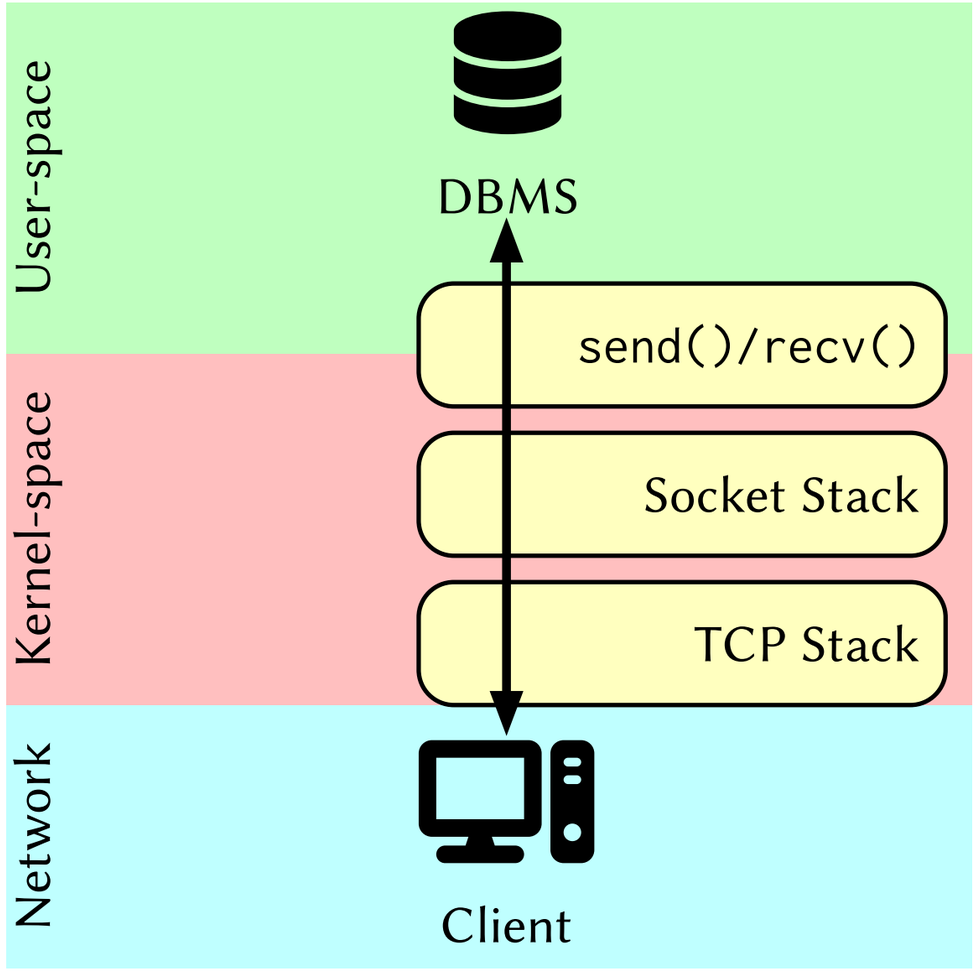

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SPDK

User-space DBMS

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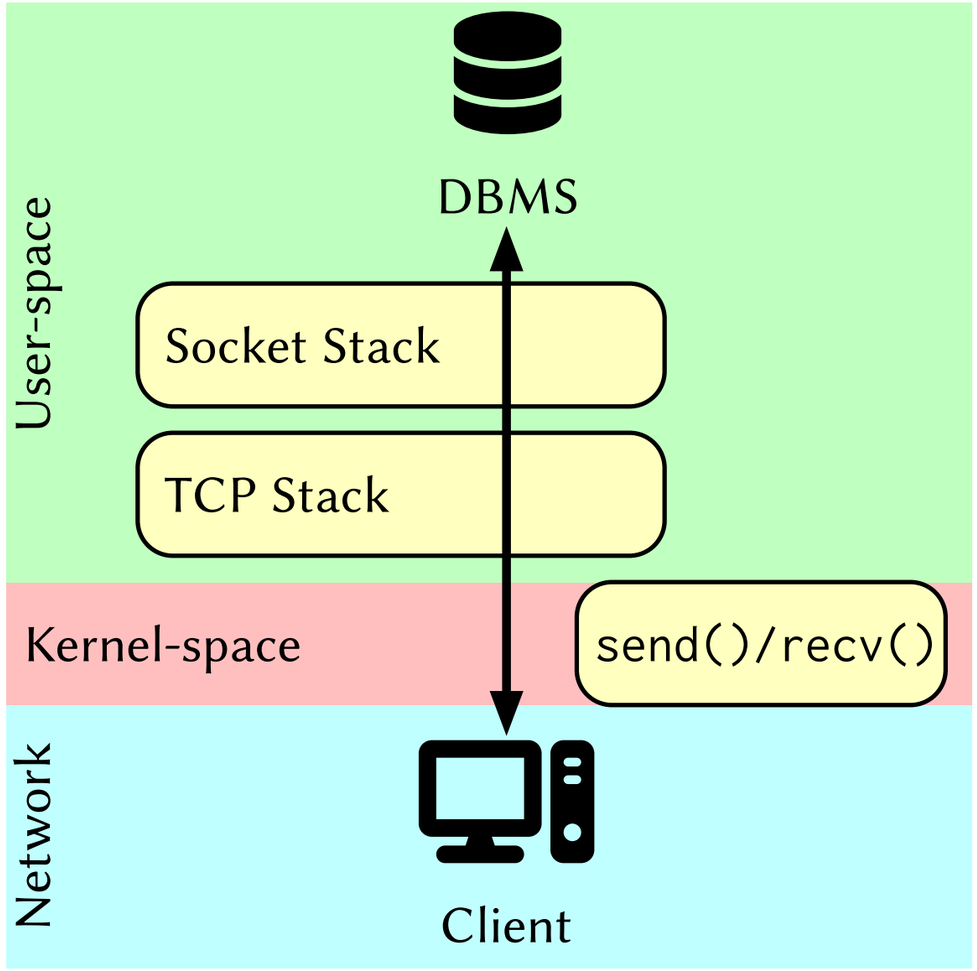

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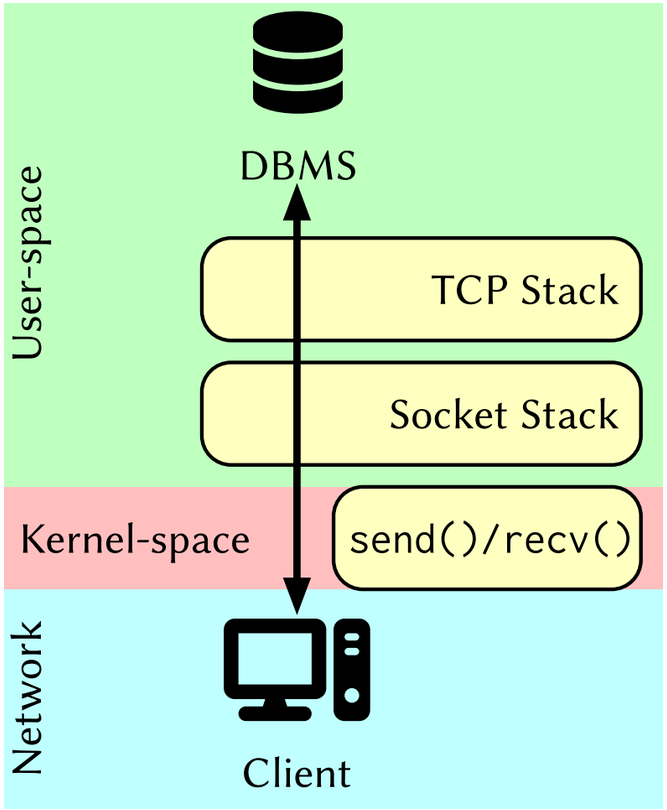

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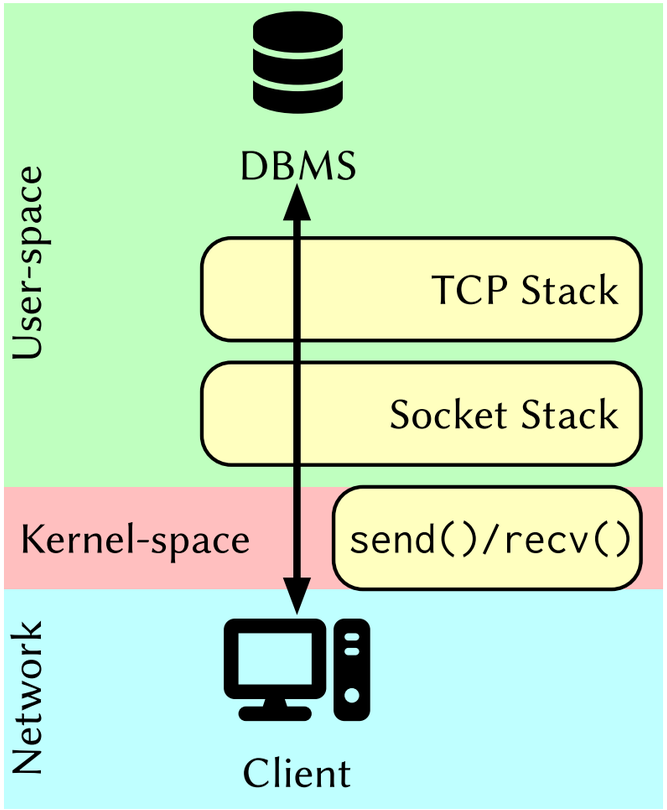

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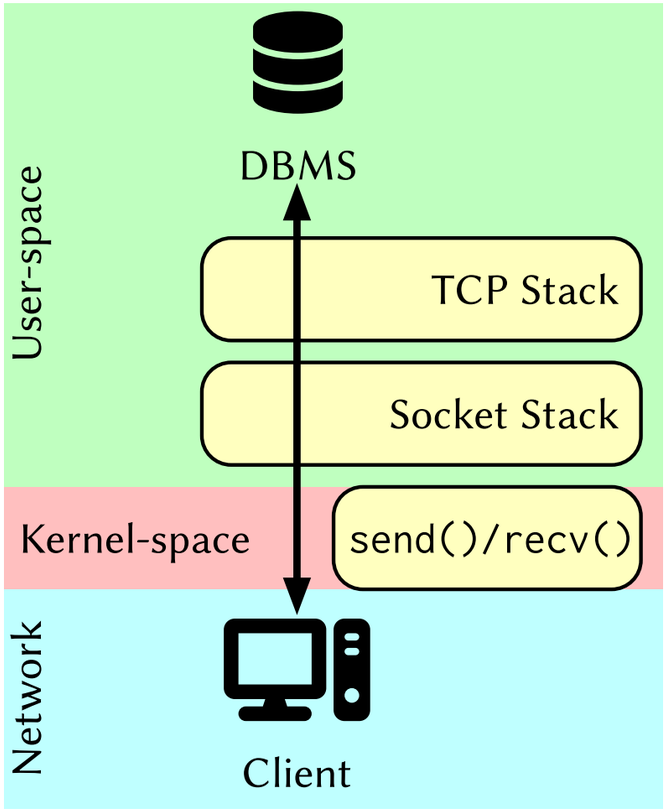

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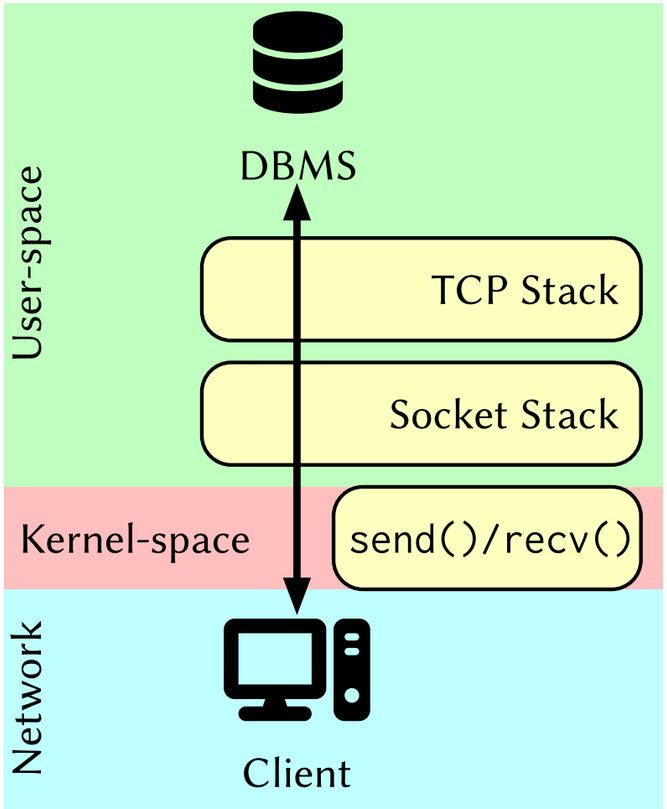

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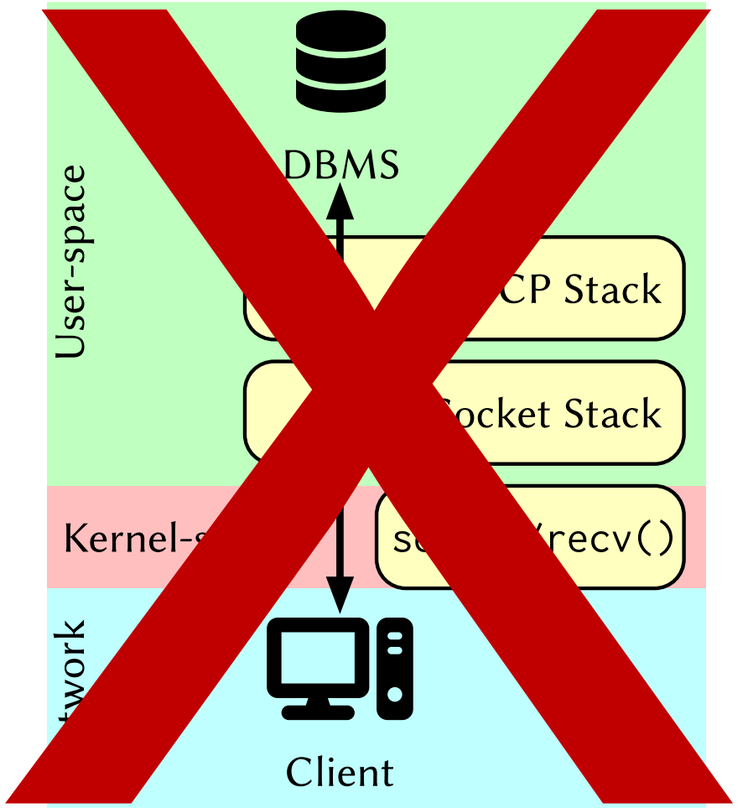

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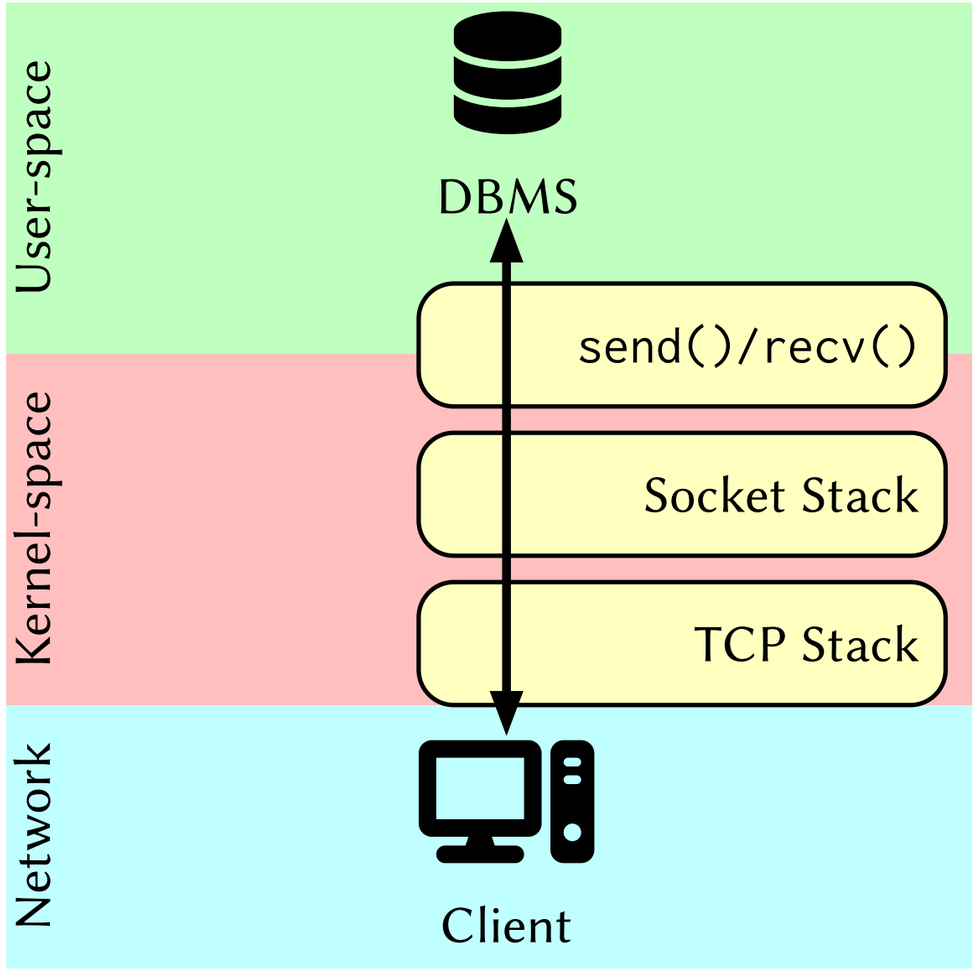

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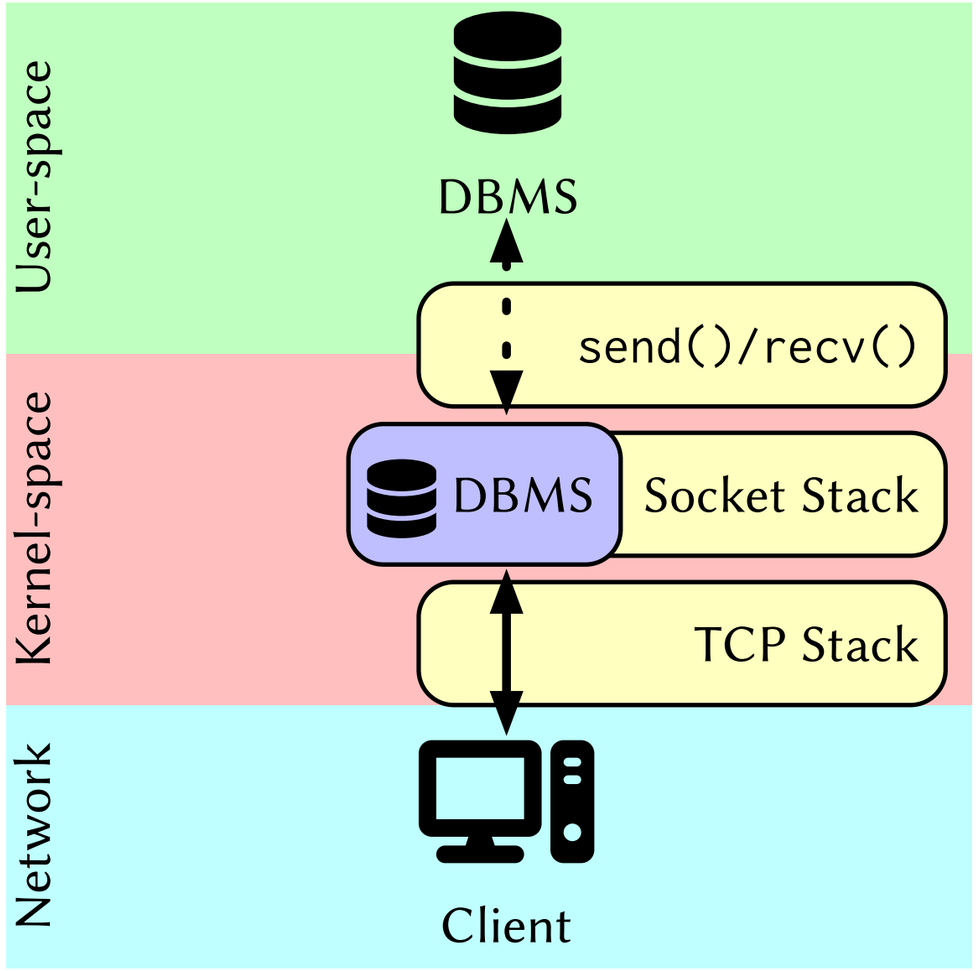

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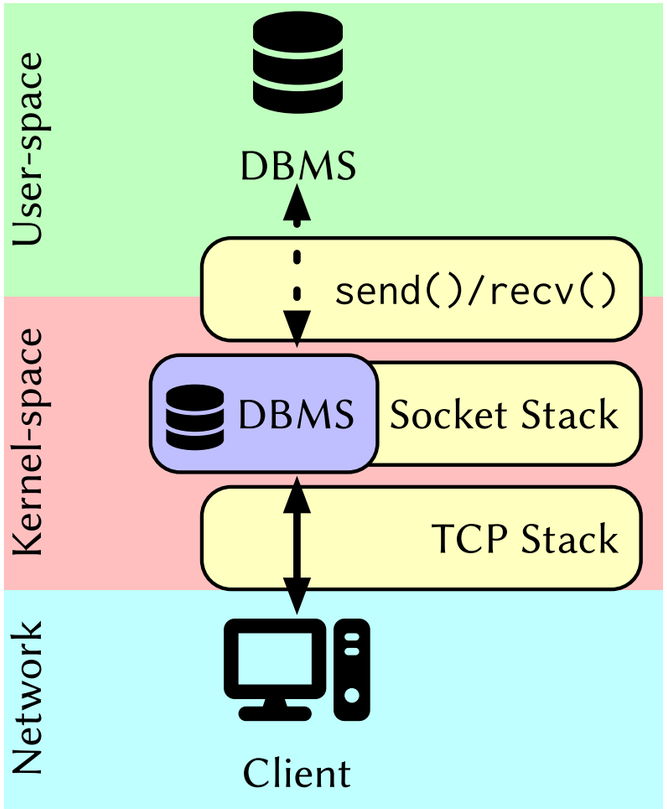

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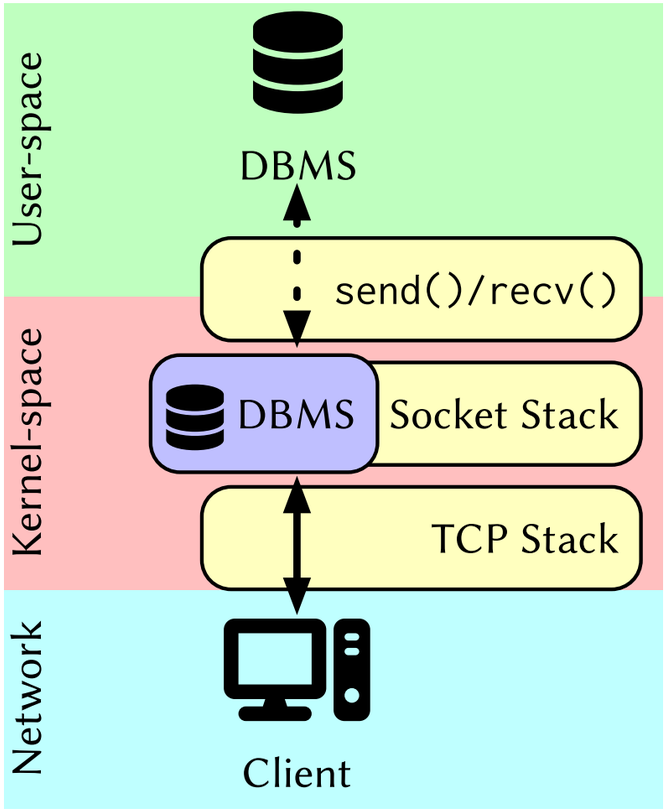

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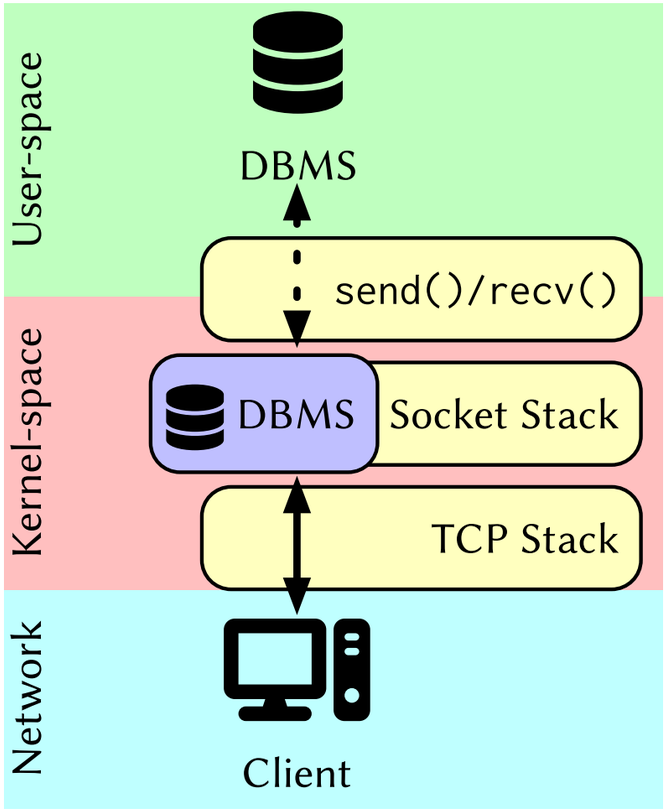

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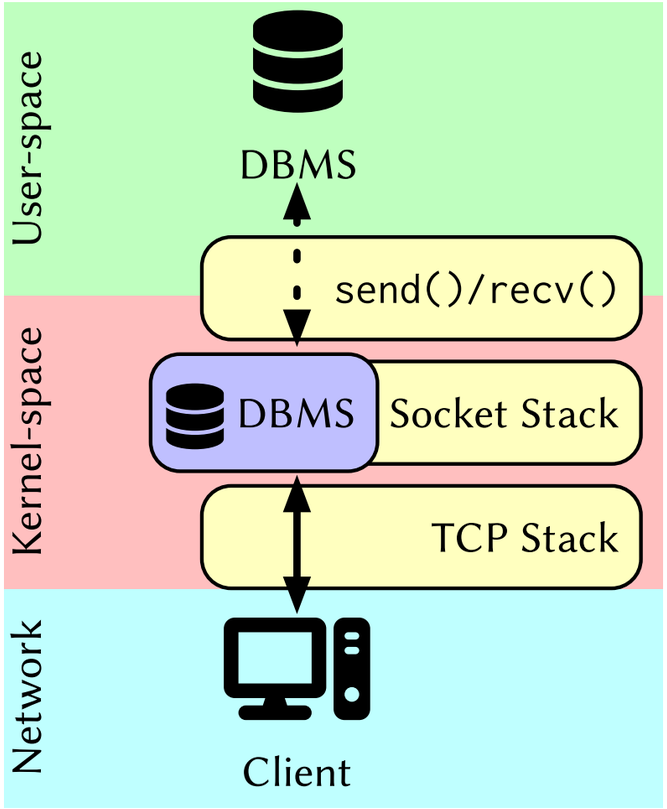

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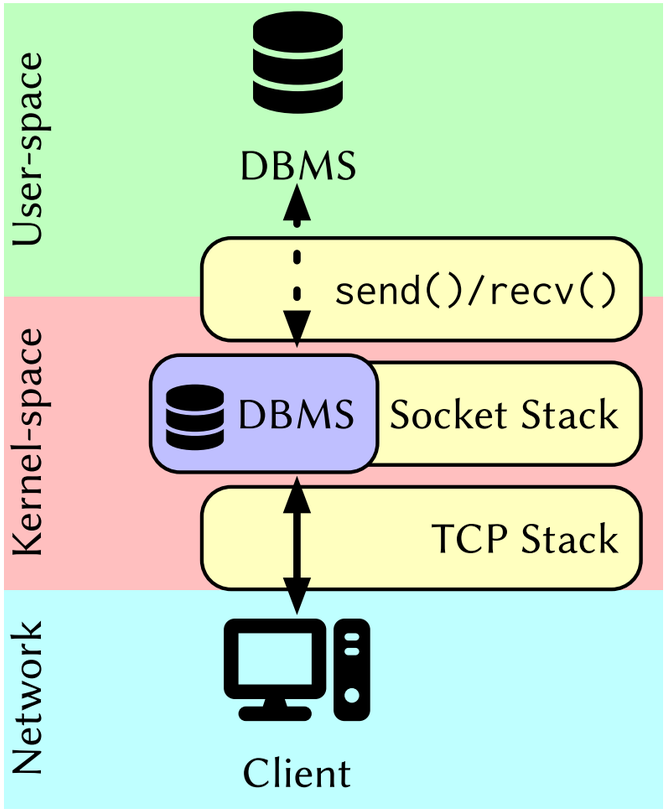

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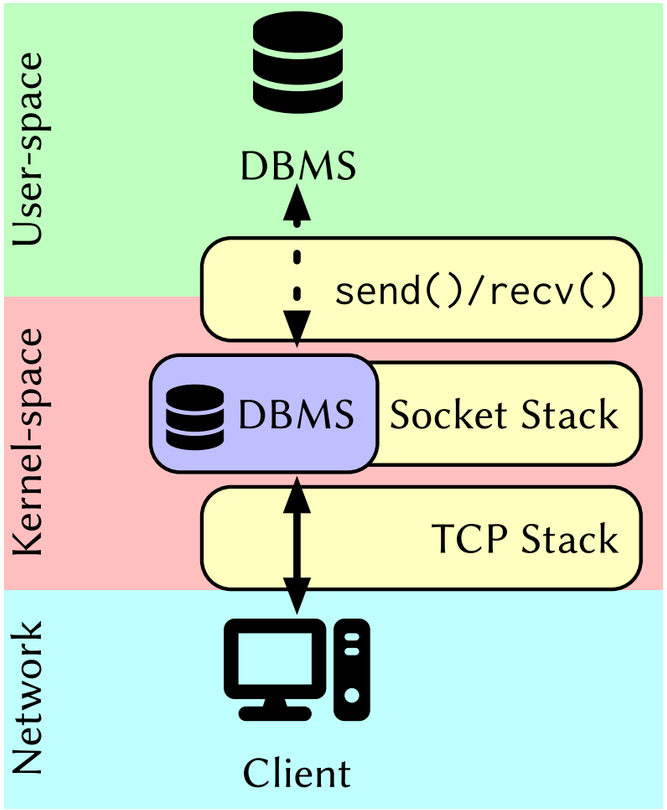

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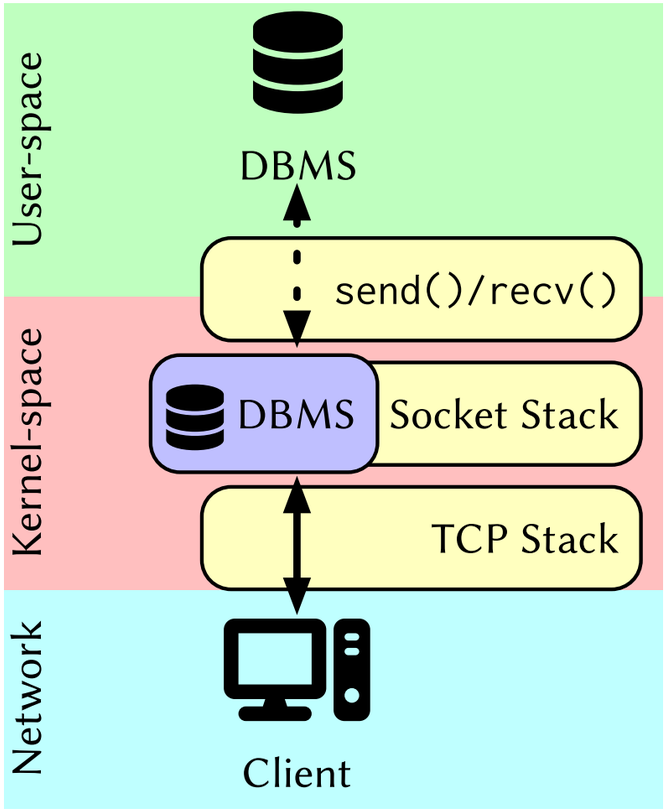

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Applying User-Bypass

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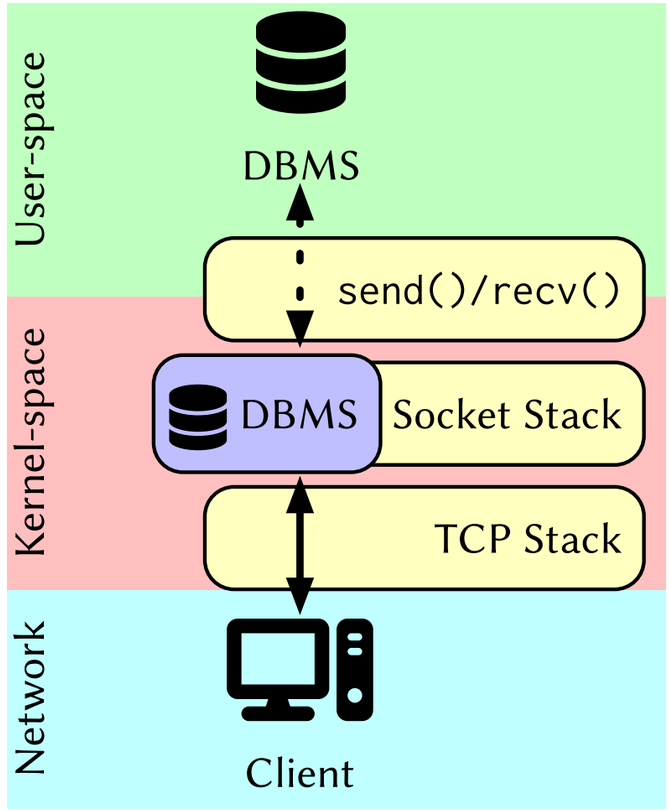

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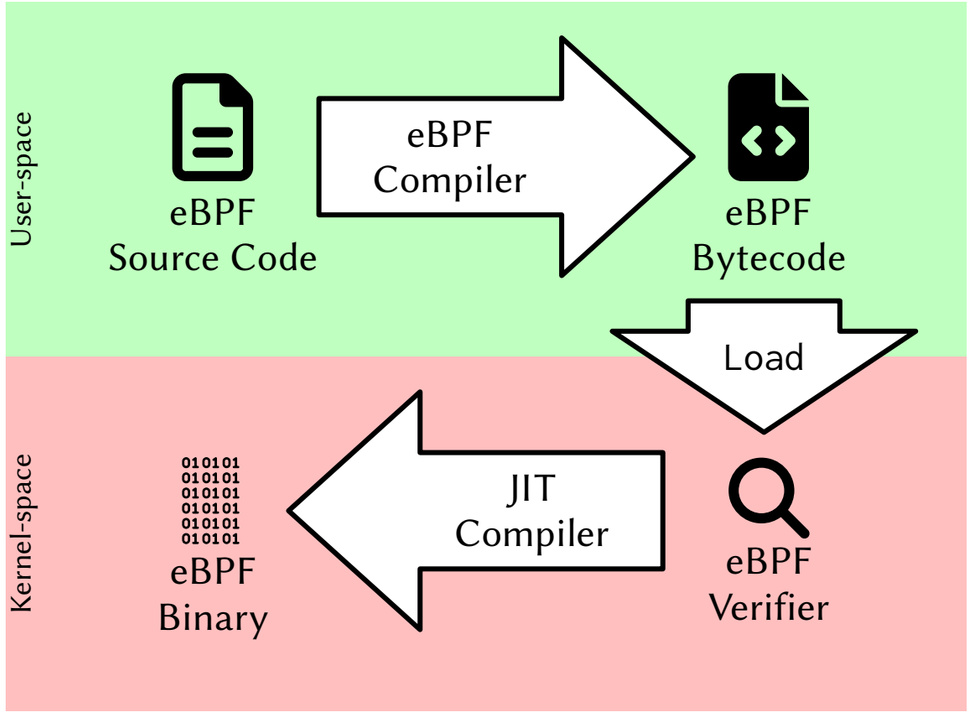

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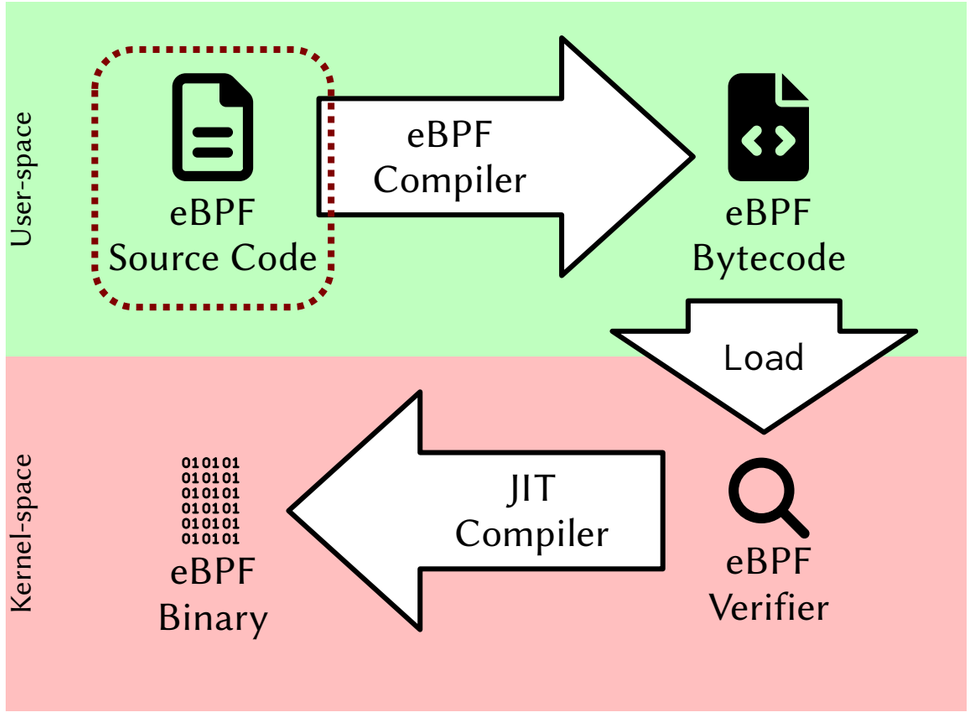

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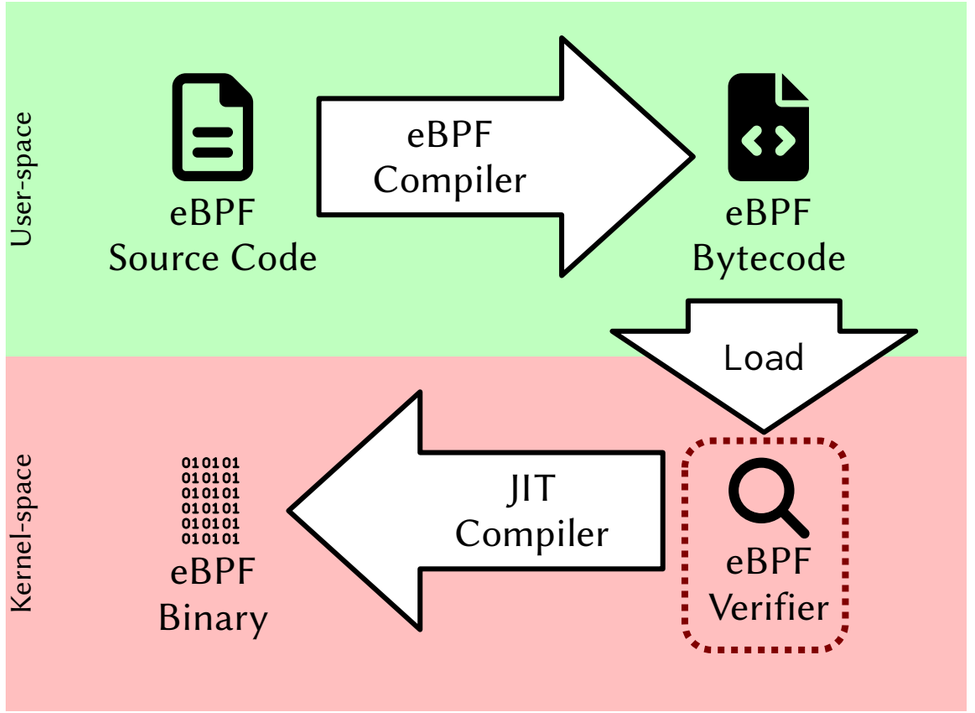

extended Berkeley Packet Filter

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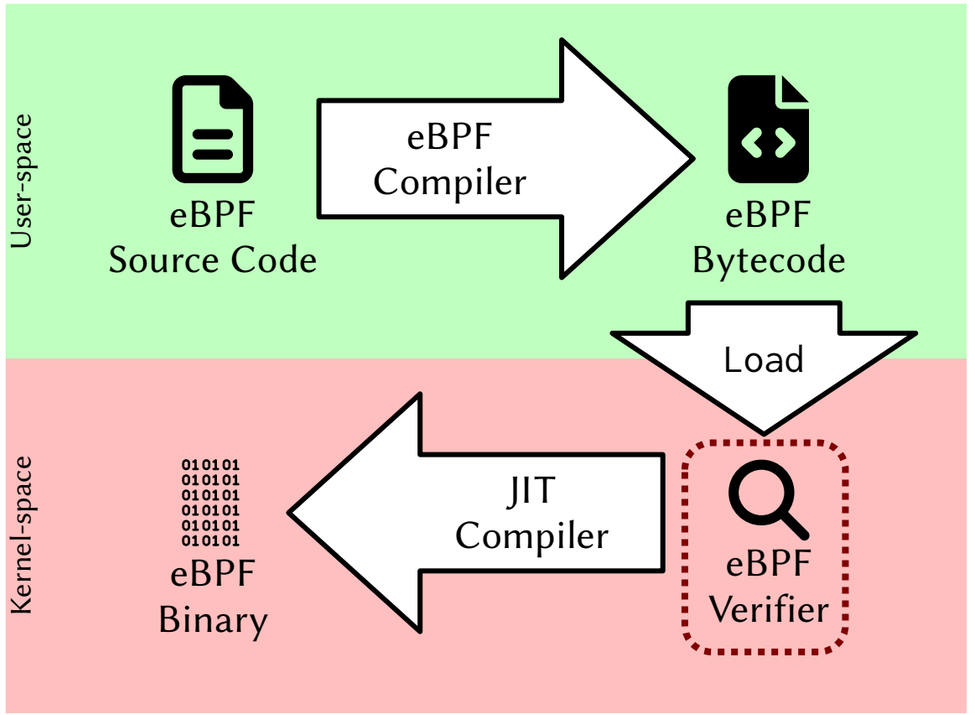
- Write in C and compile to eBPF
- Verifier constraints:
  - # instructions, boundedness, memory safety, limited API



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  - Hash tables, stacks/queues, arrays, etc.

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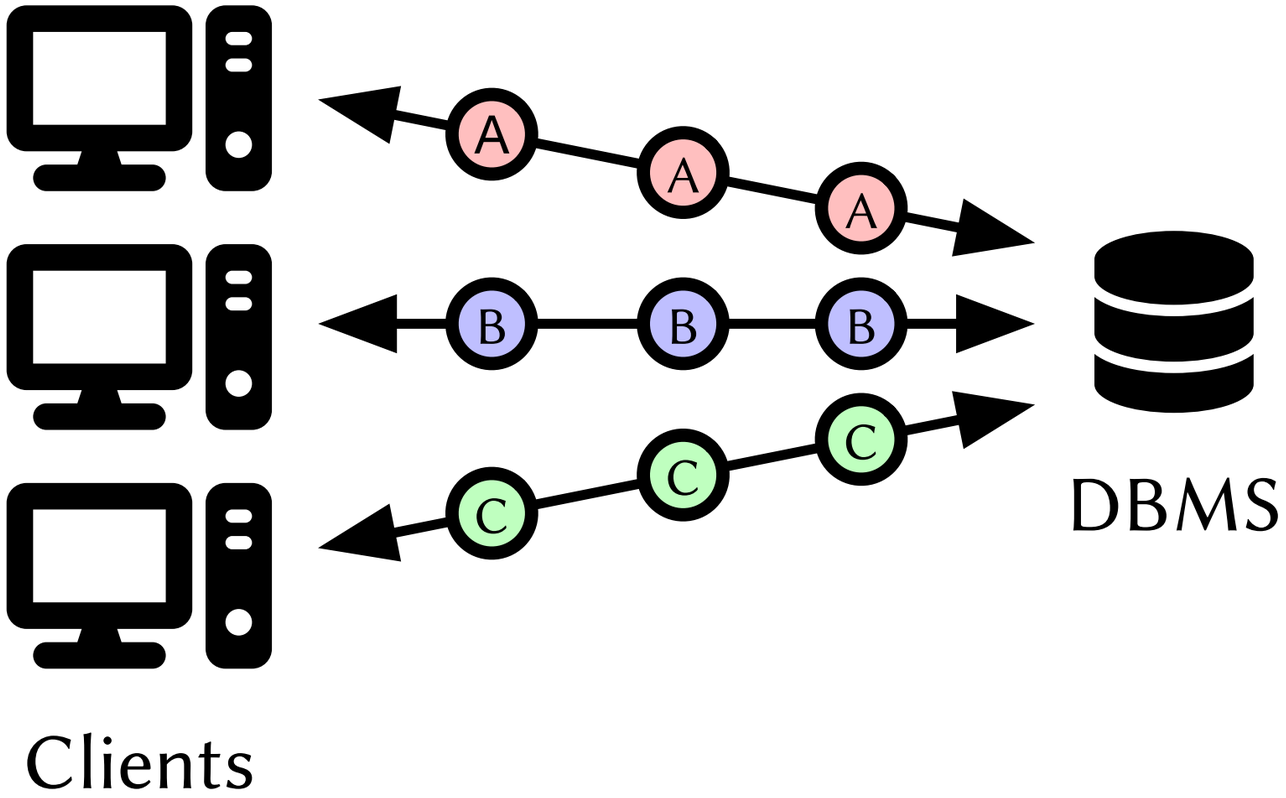
Butrovich et al. Tigger: A Database Proxy That Bounces With User-Bypass. *VLDB*. 2023.

Connection Pooling with DBMS Proxies



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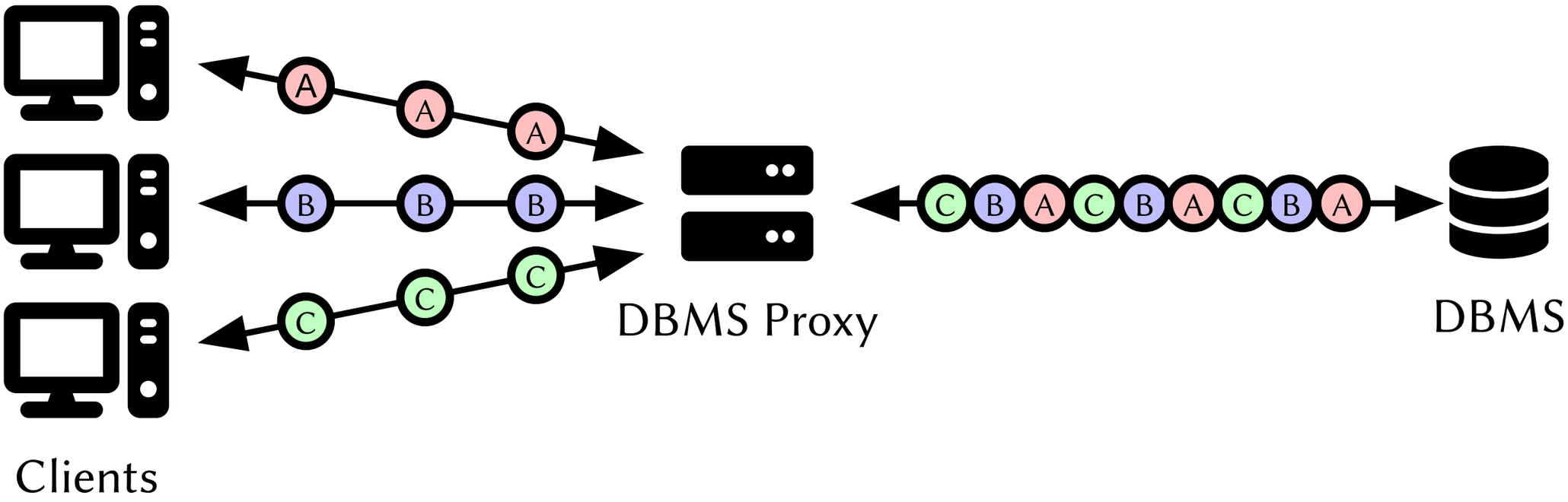
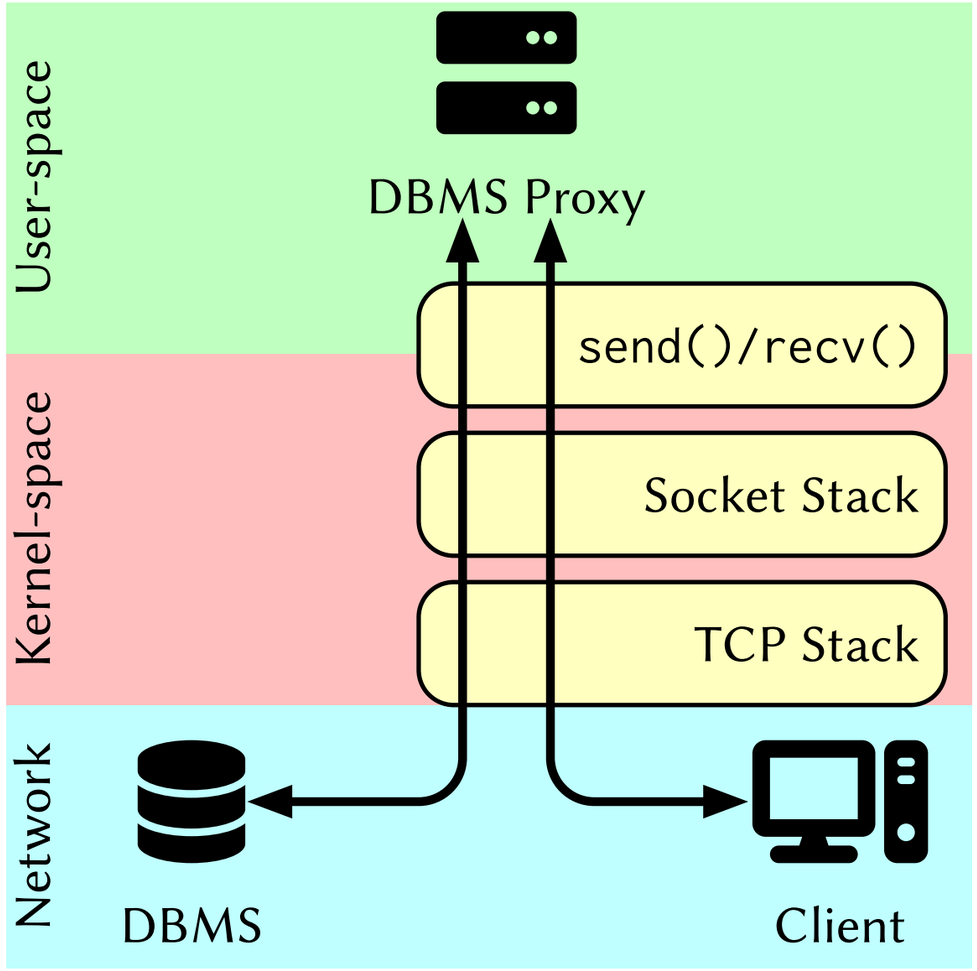


User-Space DBMS Proxy



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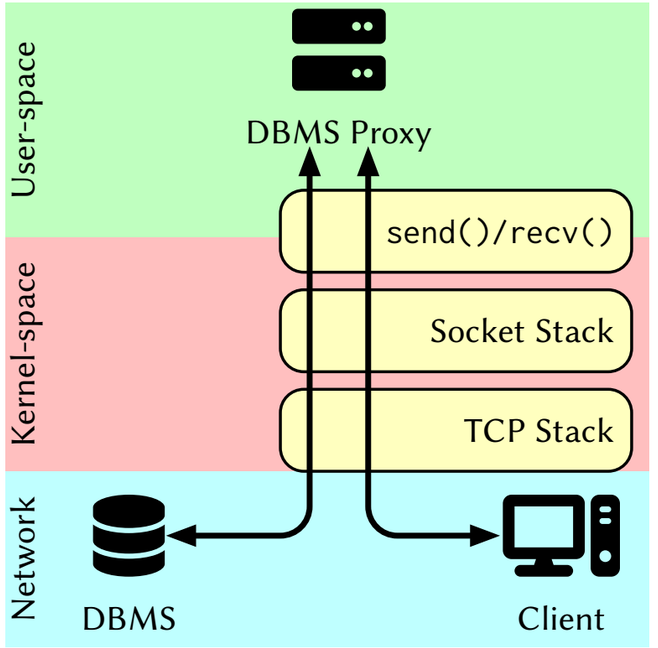

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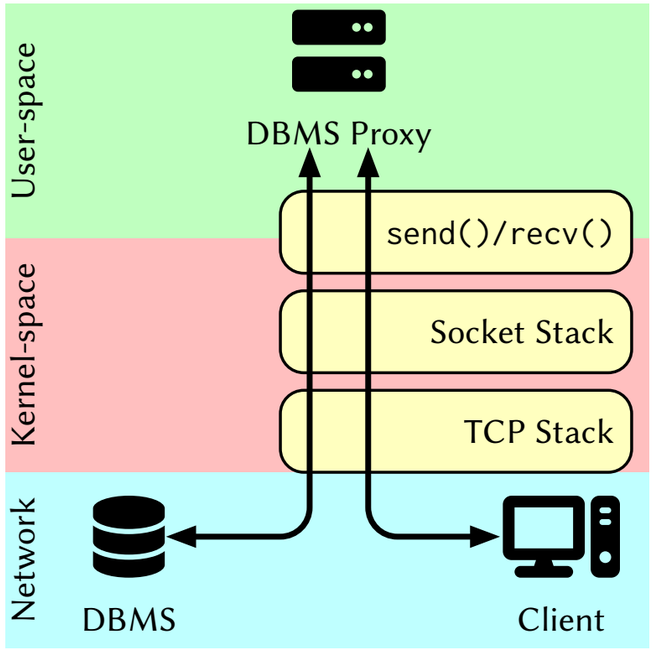

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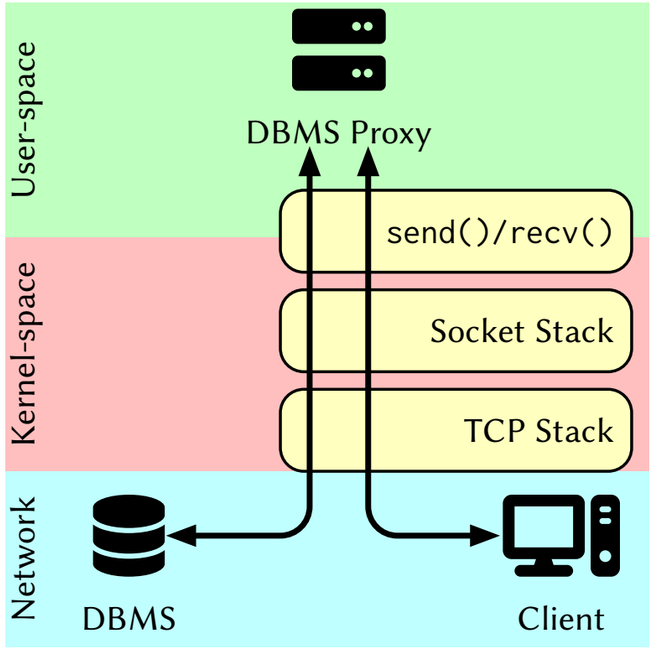

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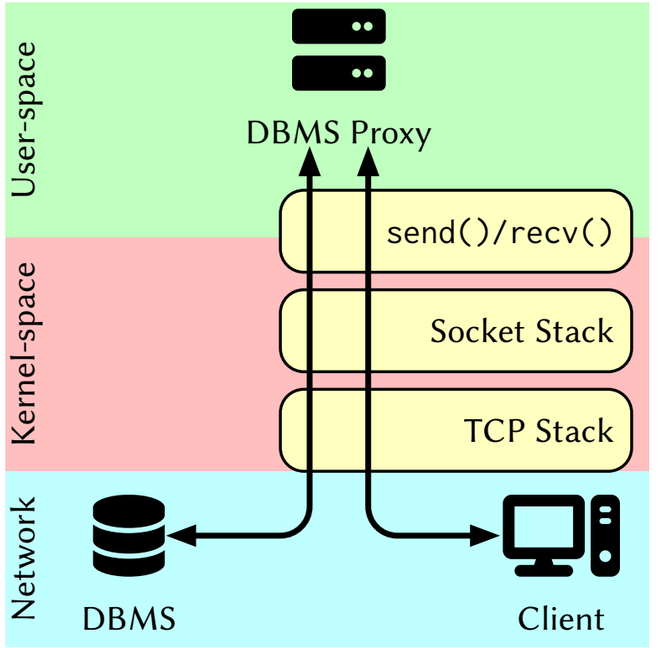
- Coordination mechanisms around `send()` and `recv()` system calls



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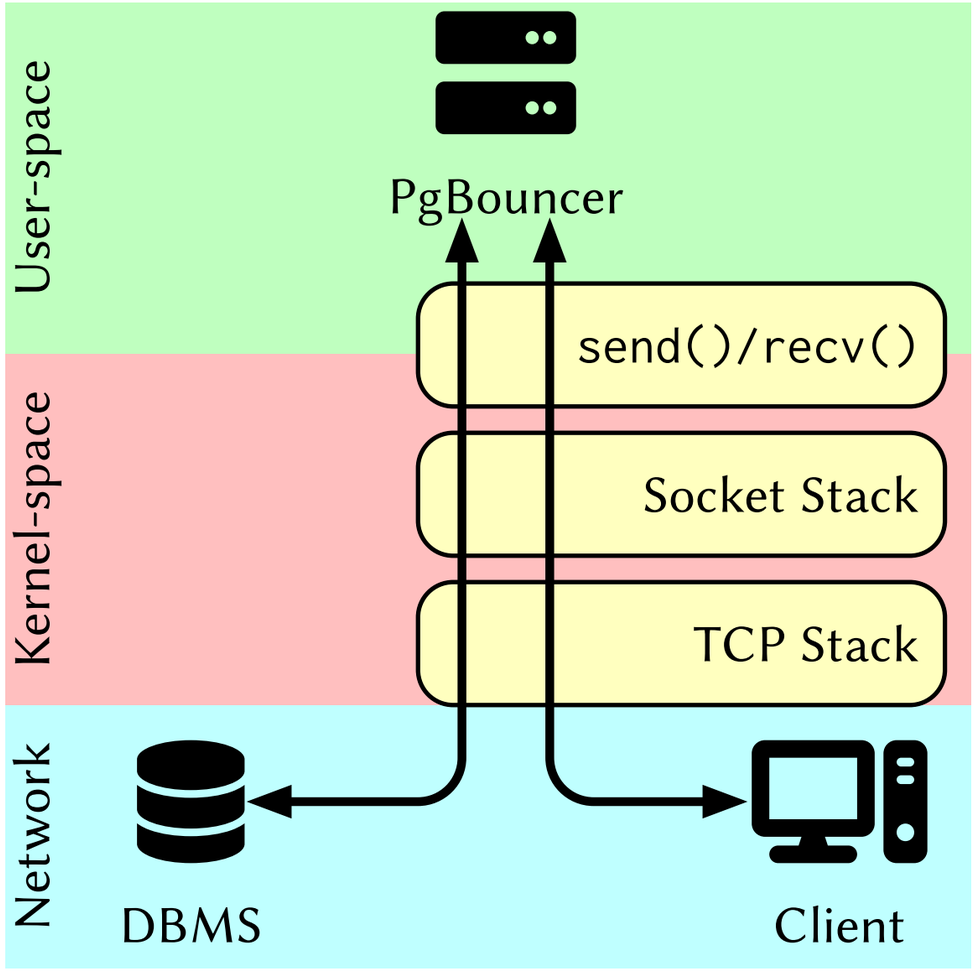

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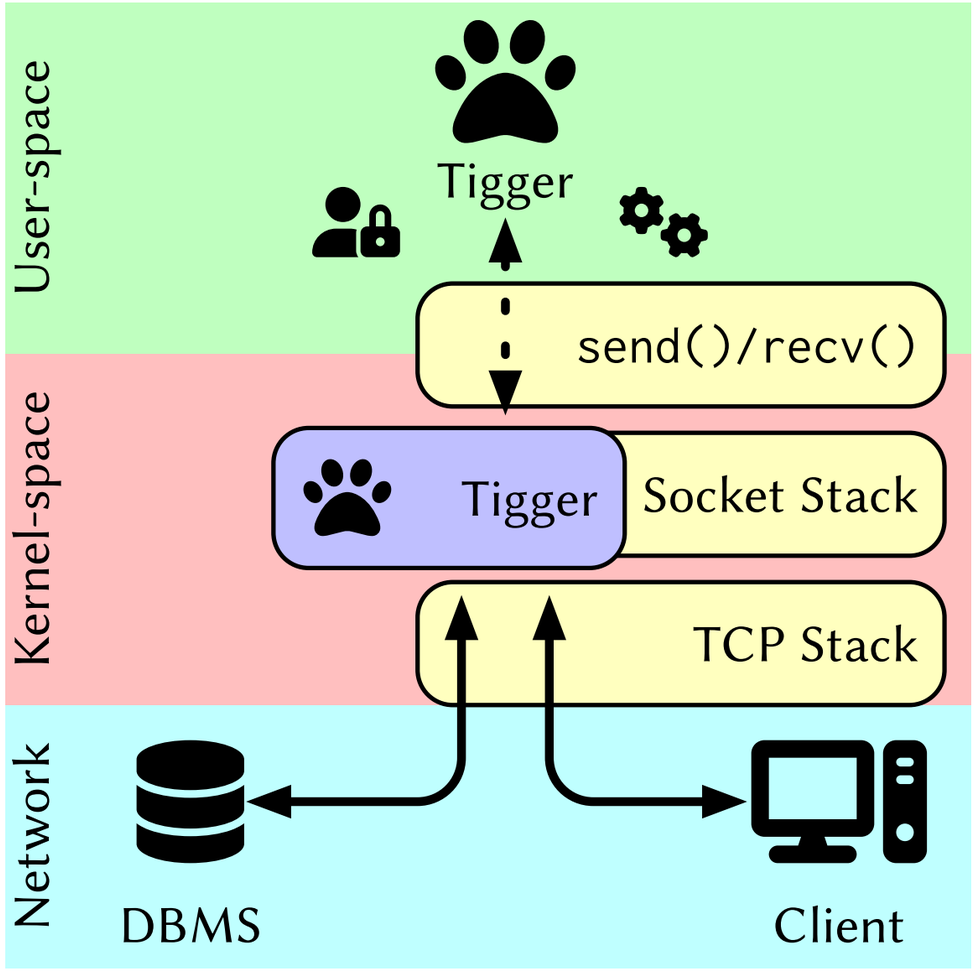

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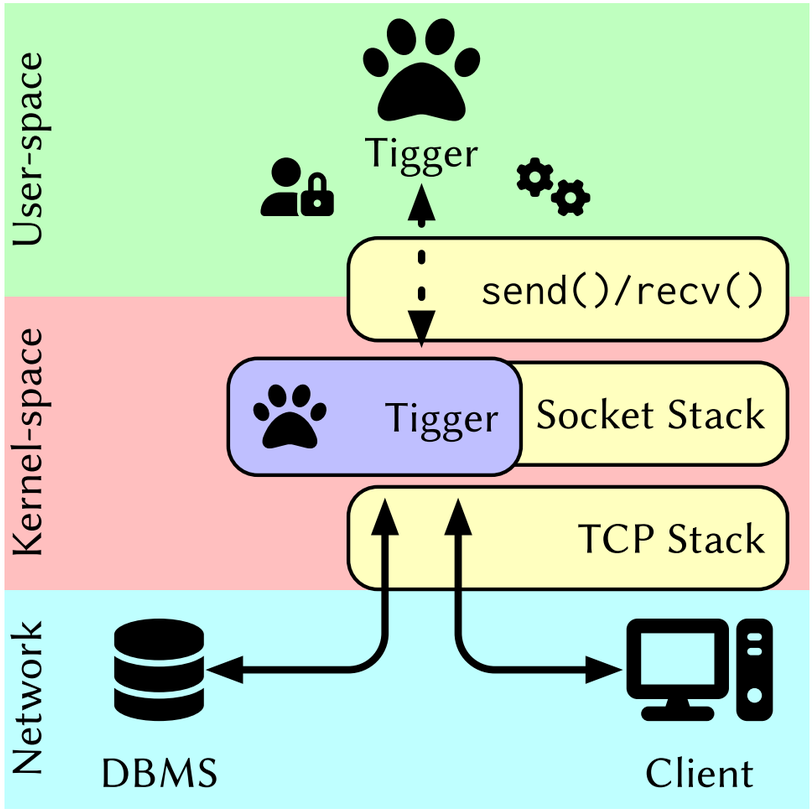

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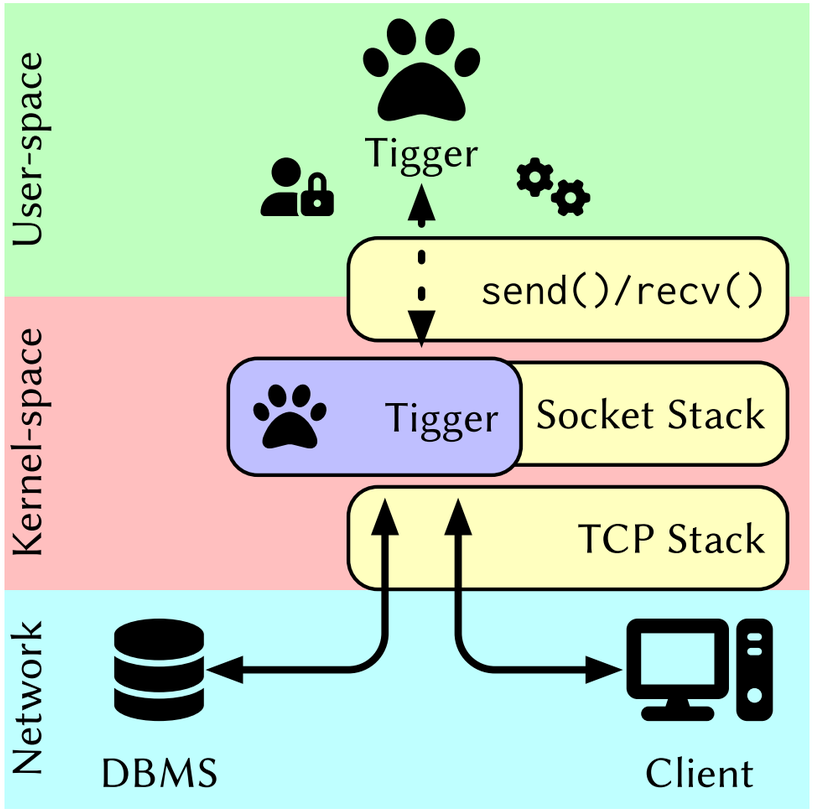

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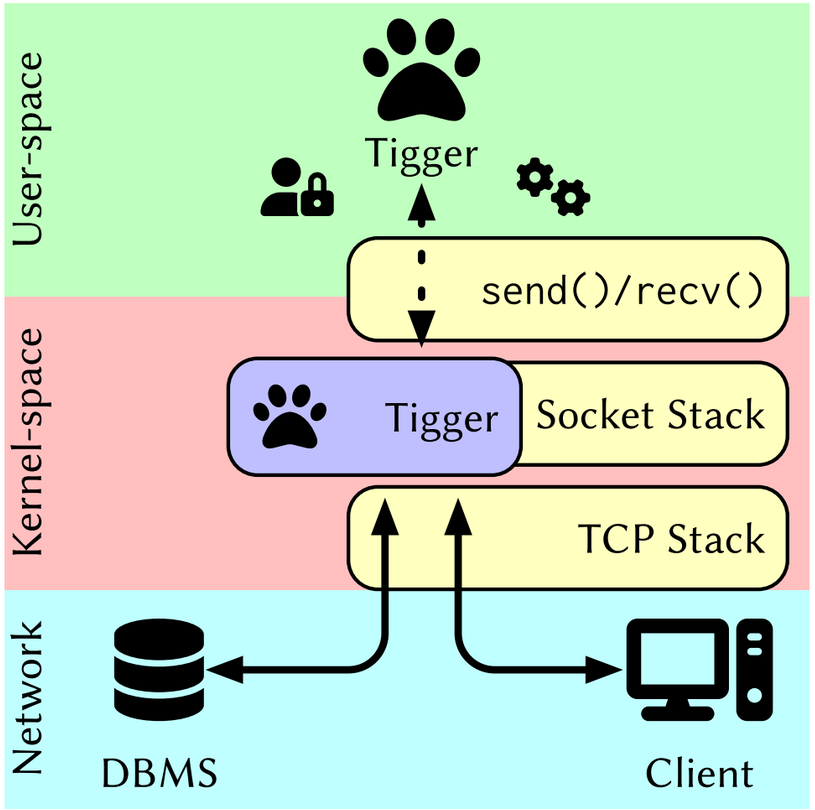
- User-space operations:
  - Authentication
  - Settings



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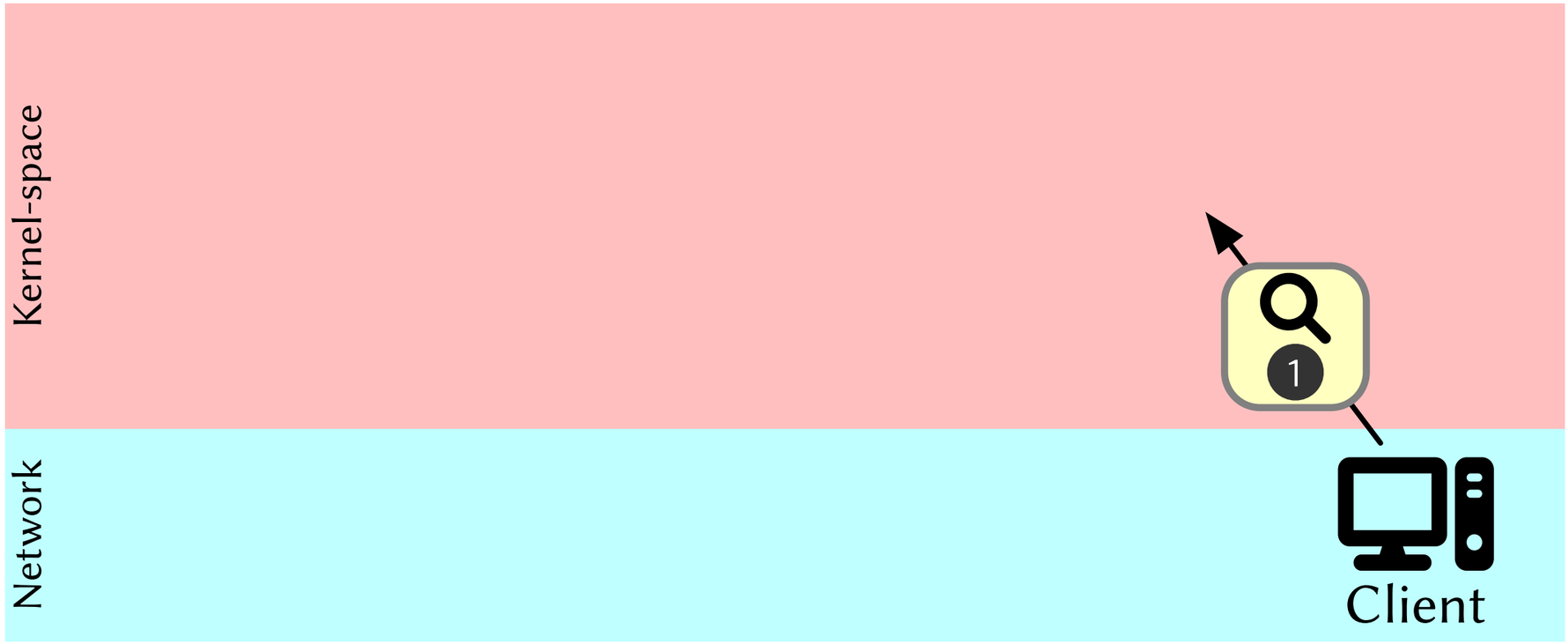

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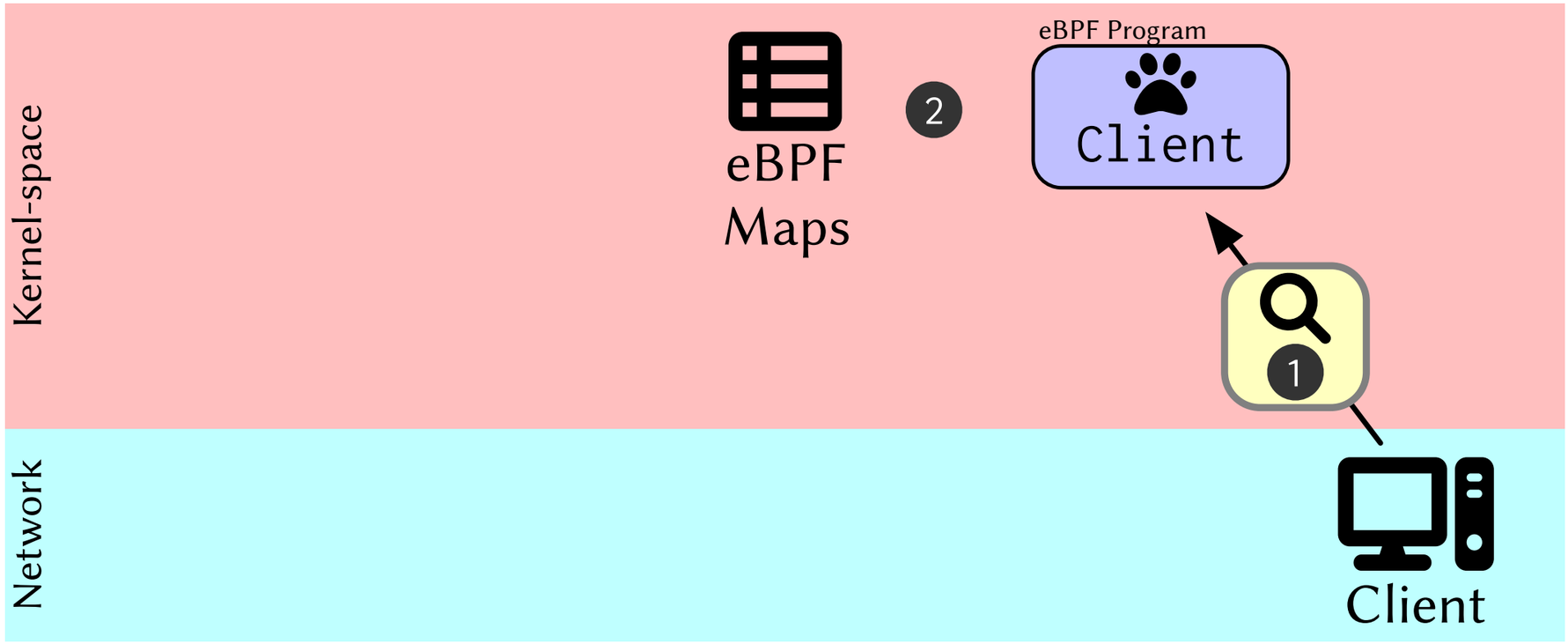

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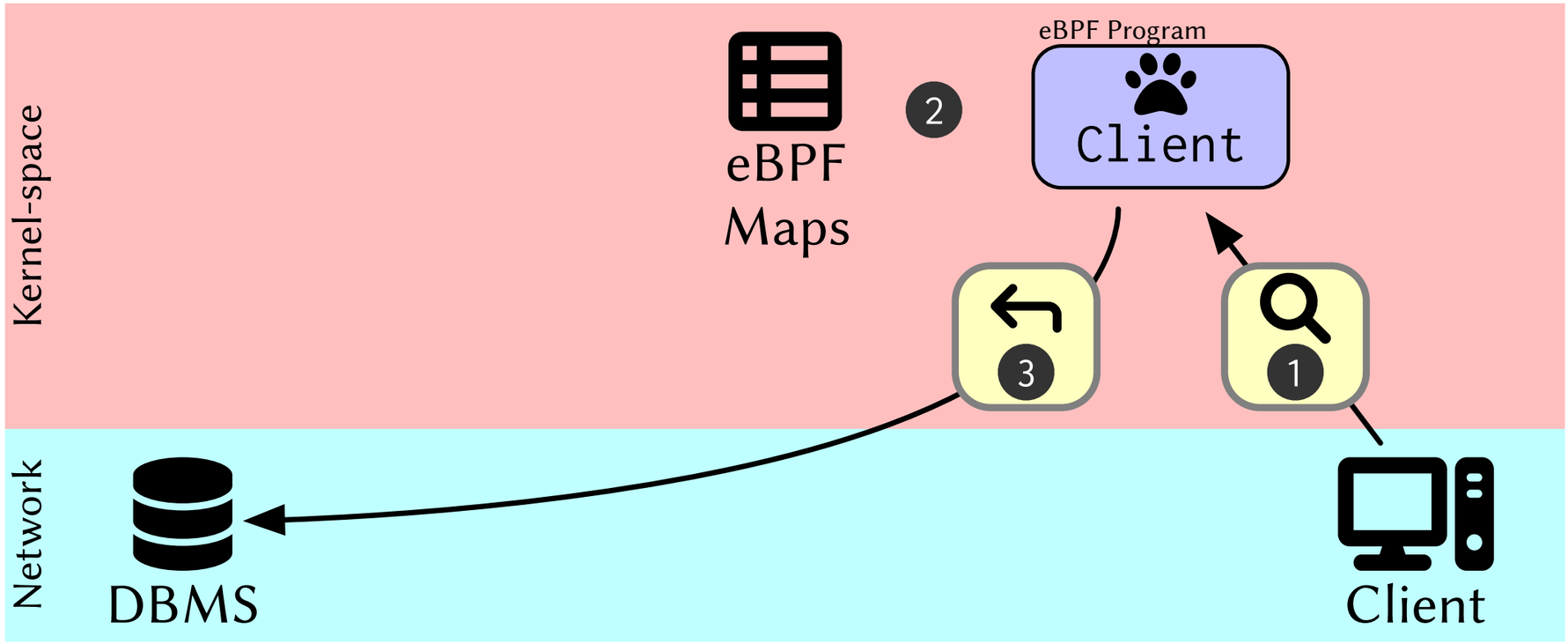

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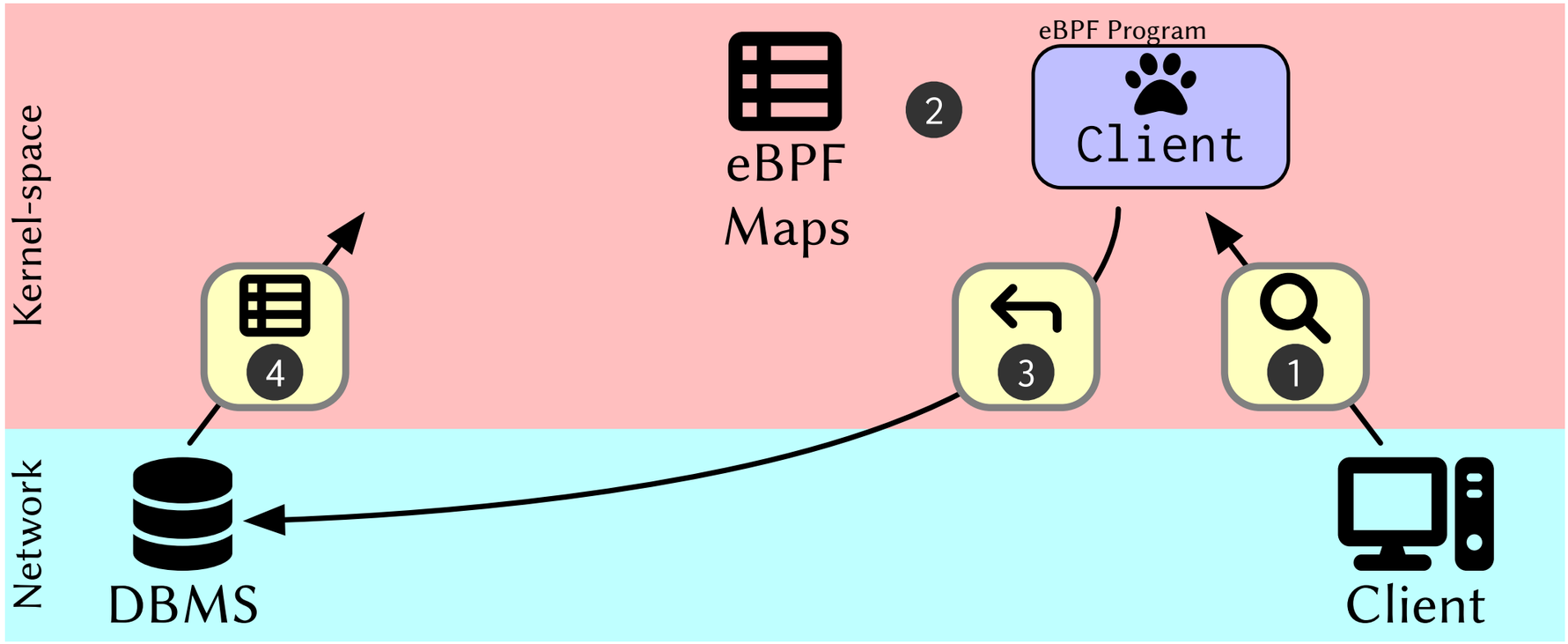

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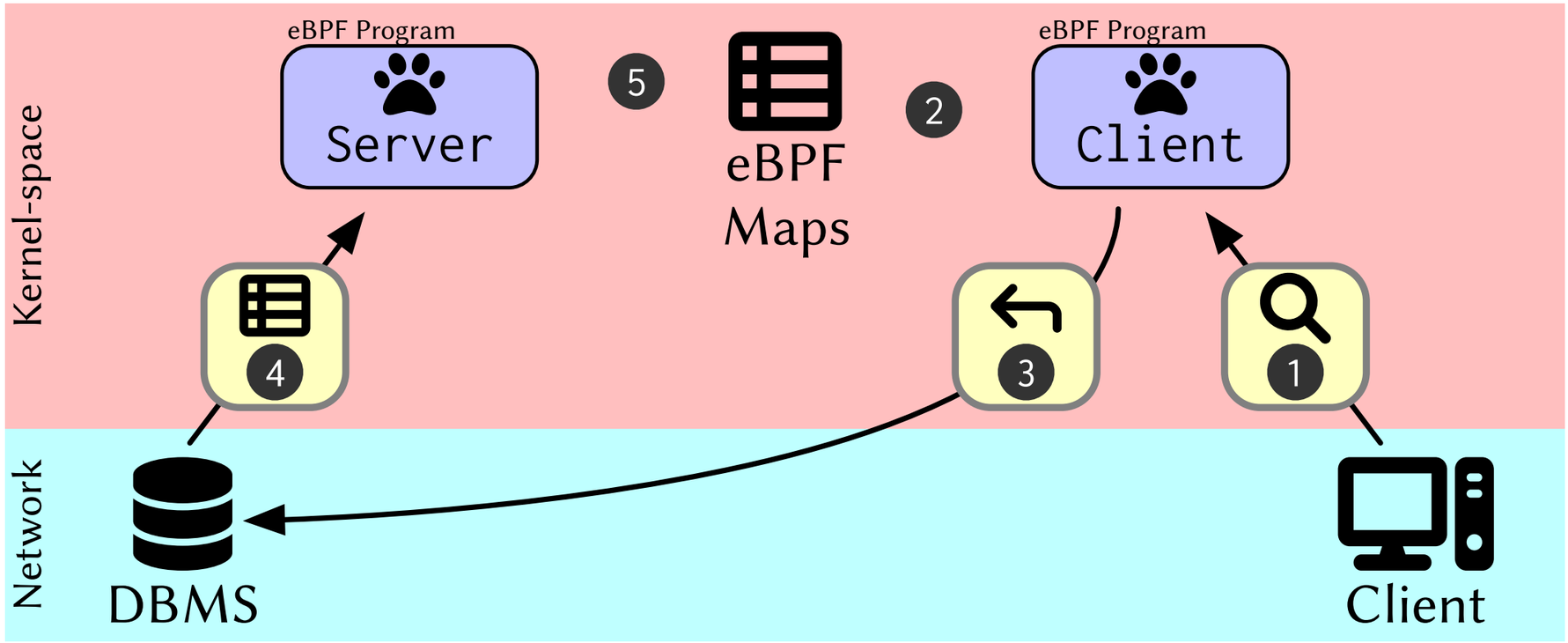

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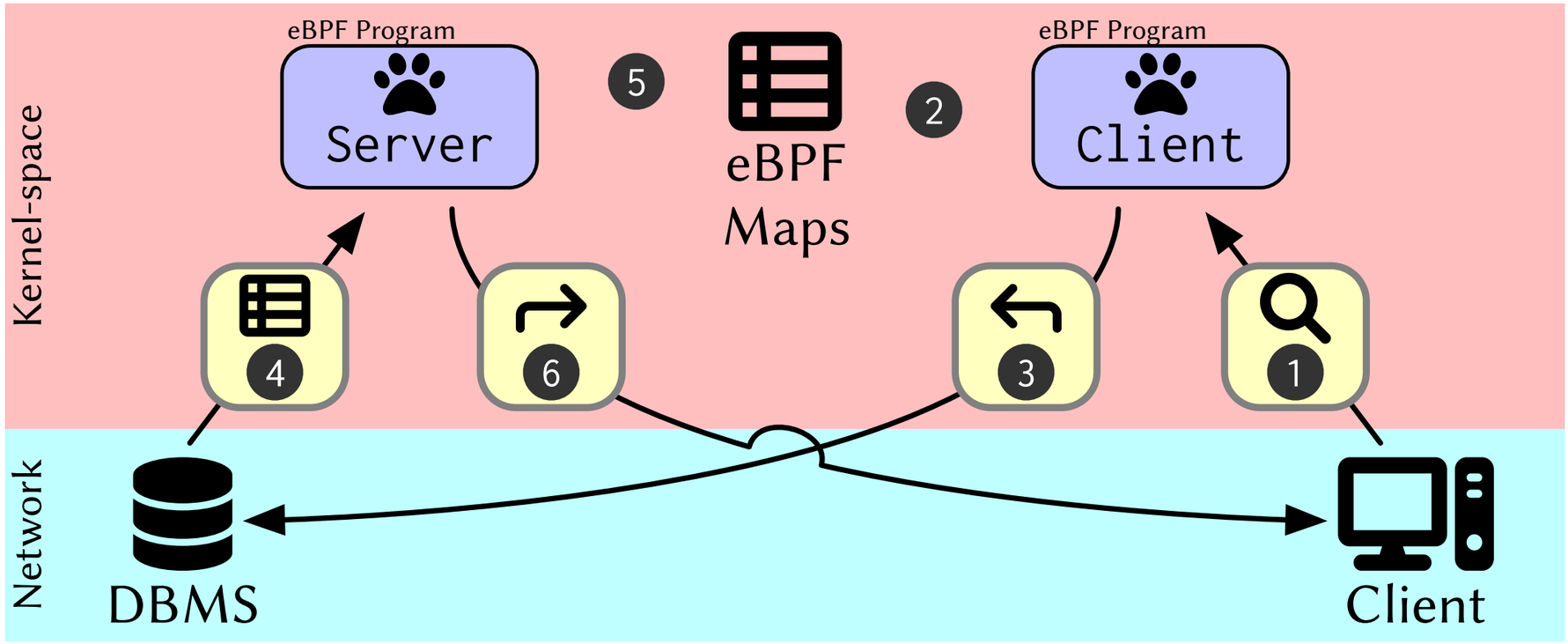

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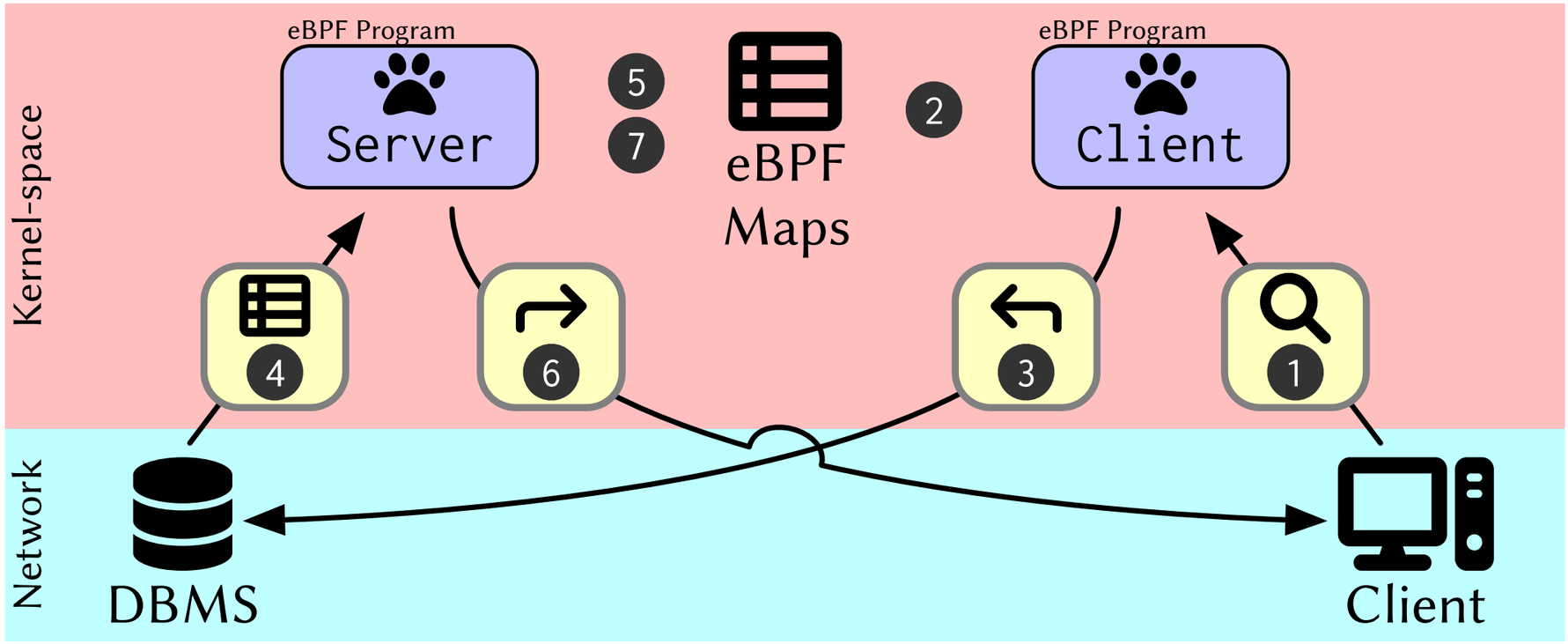

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Connection Pooling Throughput

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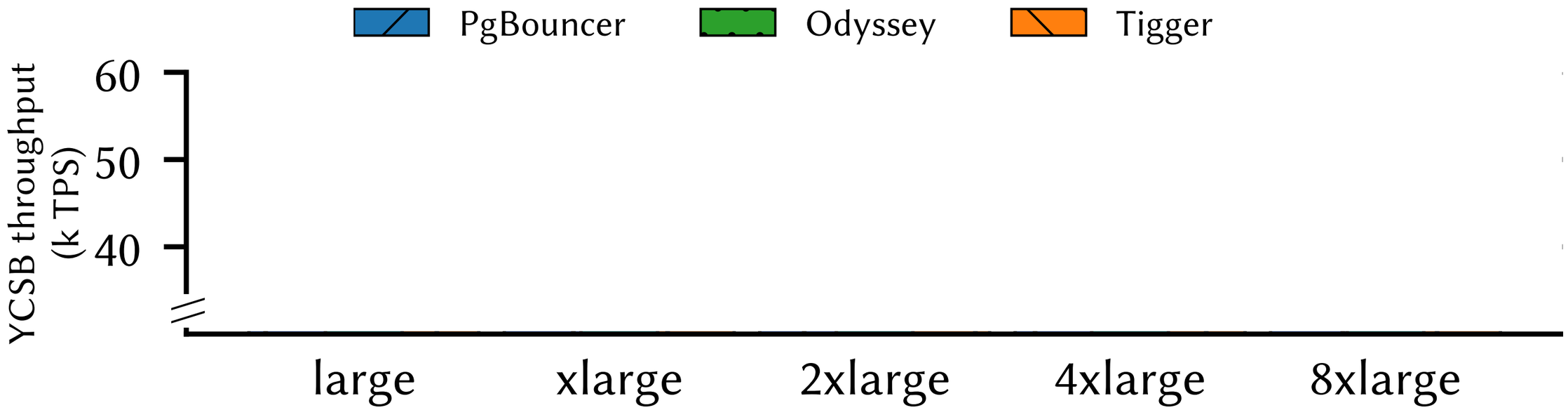

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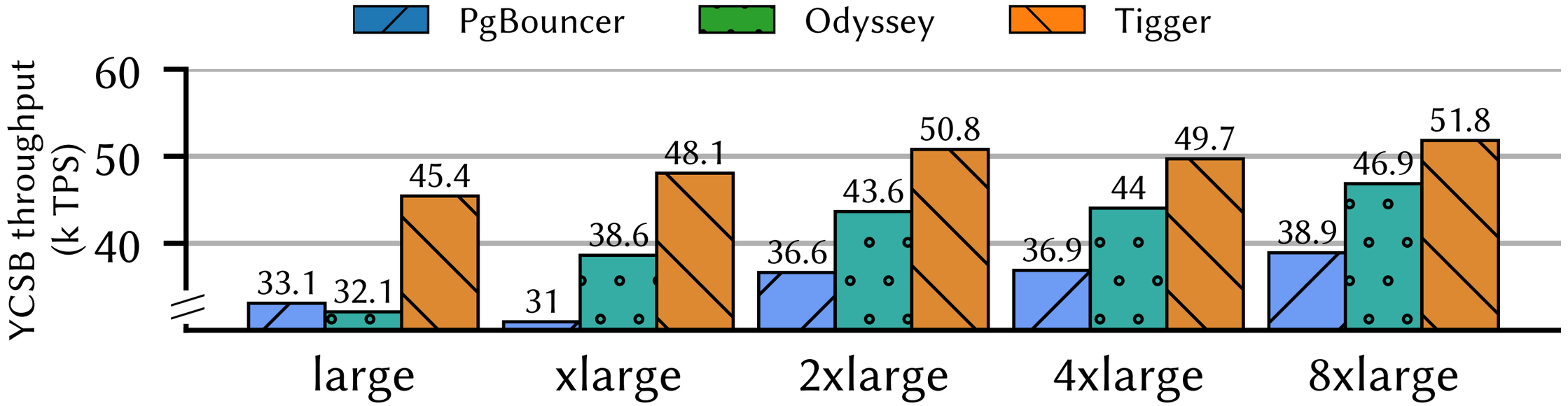

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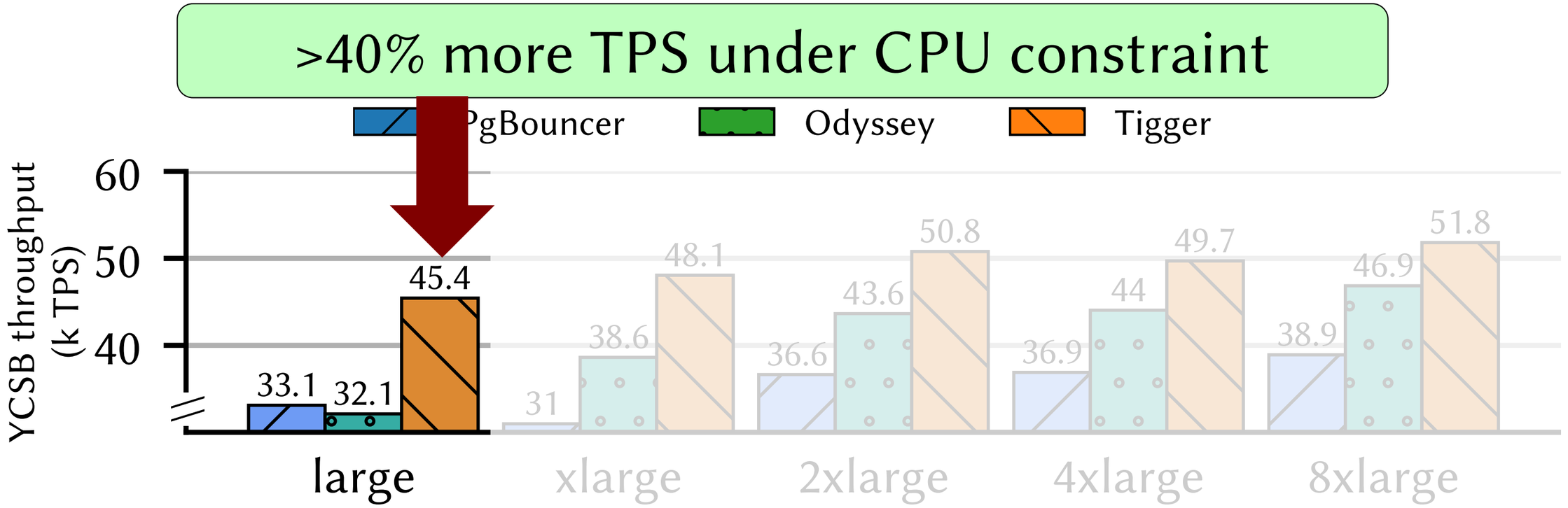
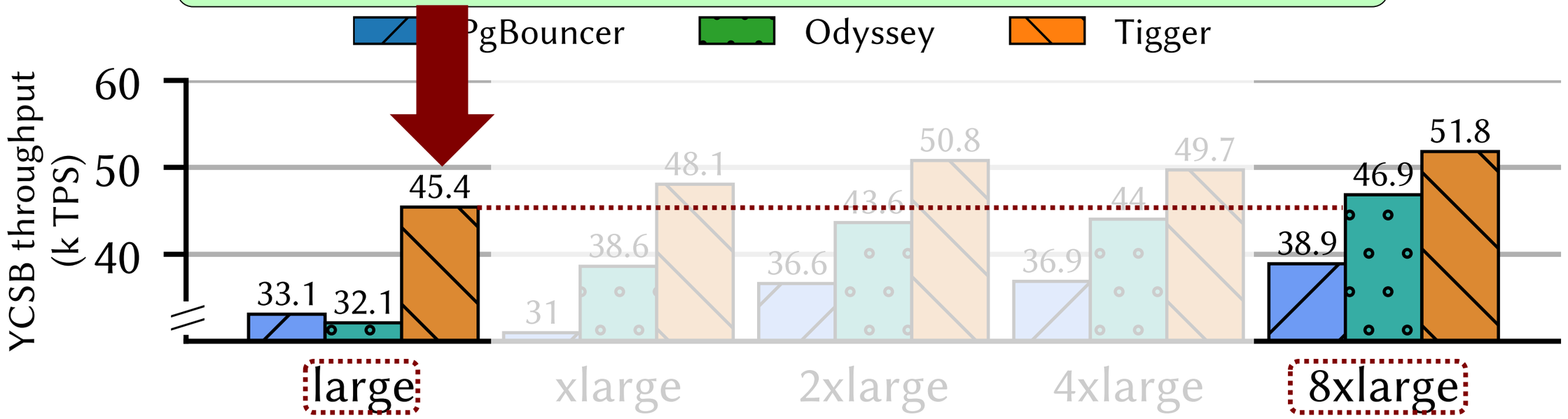


Connection Pooling Throughput

>40% more TPS under CPU constraint

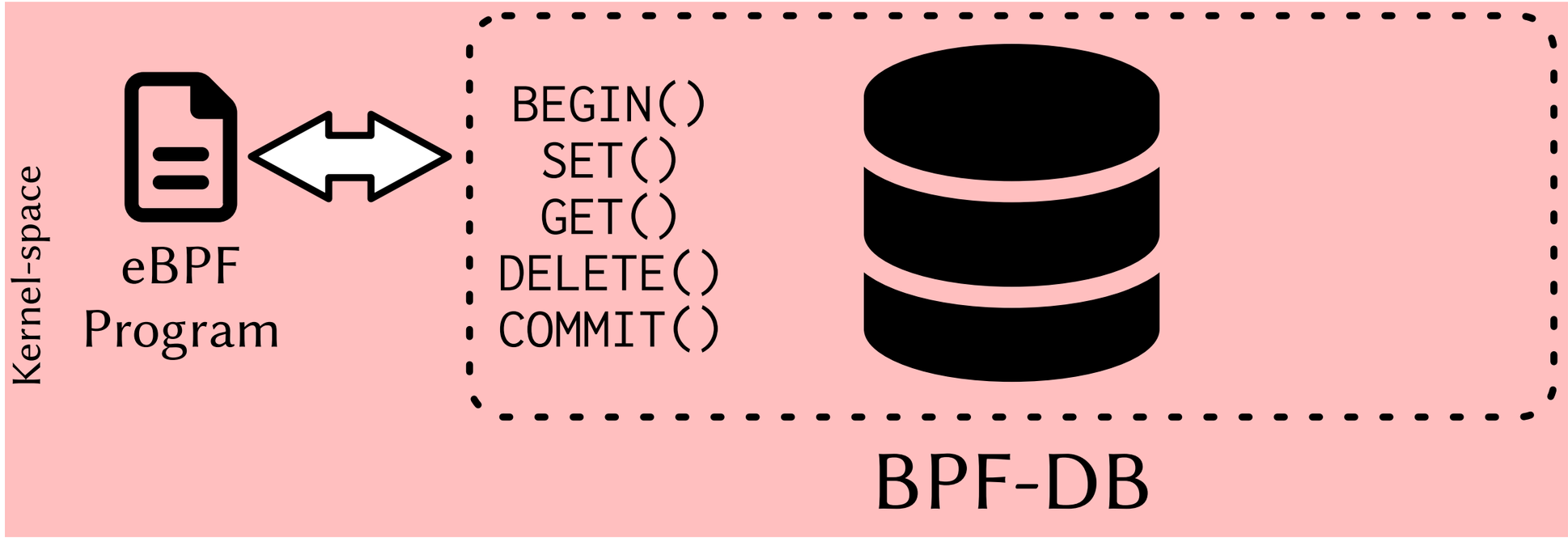


8x cost for Odyssey to match Tigger's performance

Outline

- User-bypass
- Prior work: User-bypass for DBMS proxies
- Future work: User-bypass DBMS

User-Bypass DBMS



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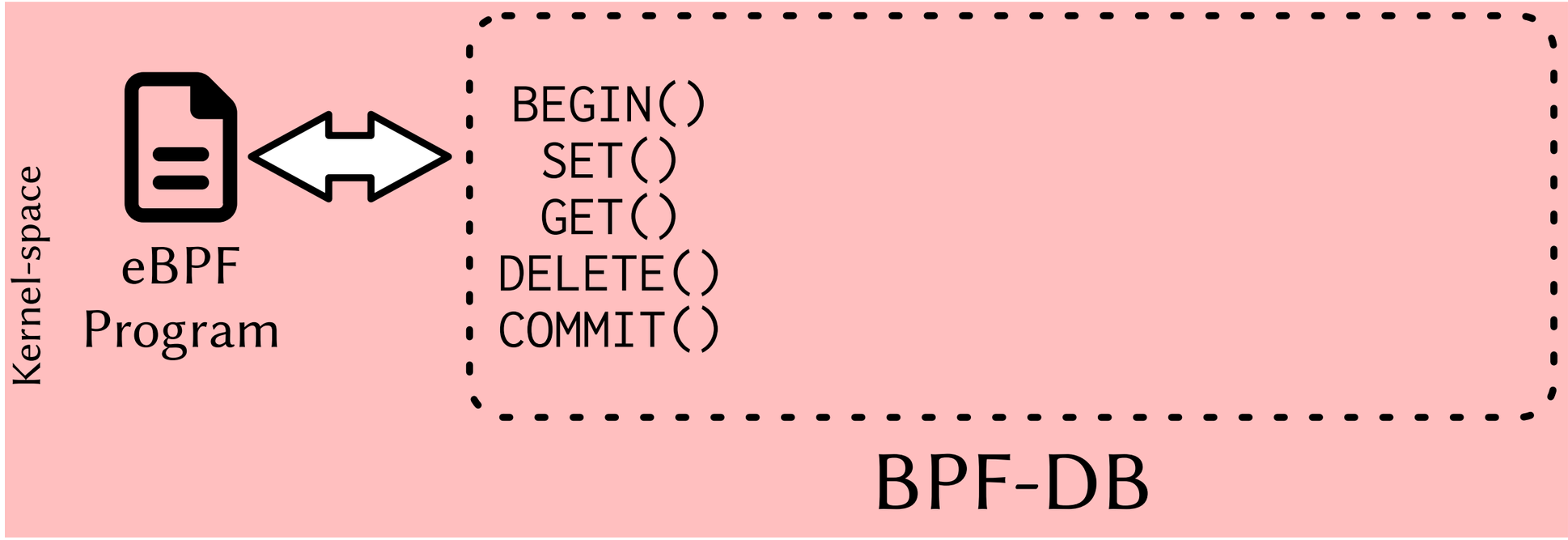

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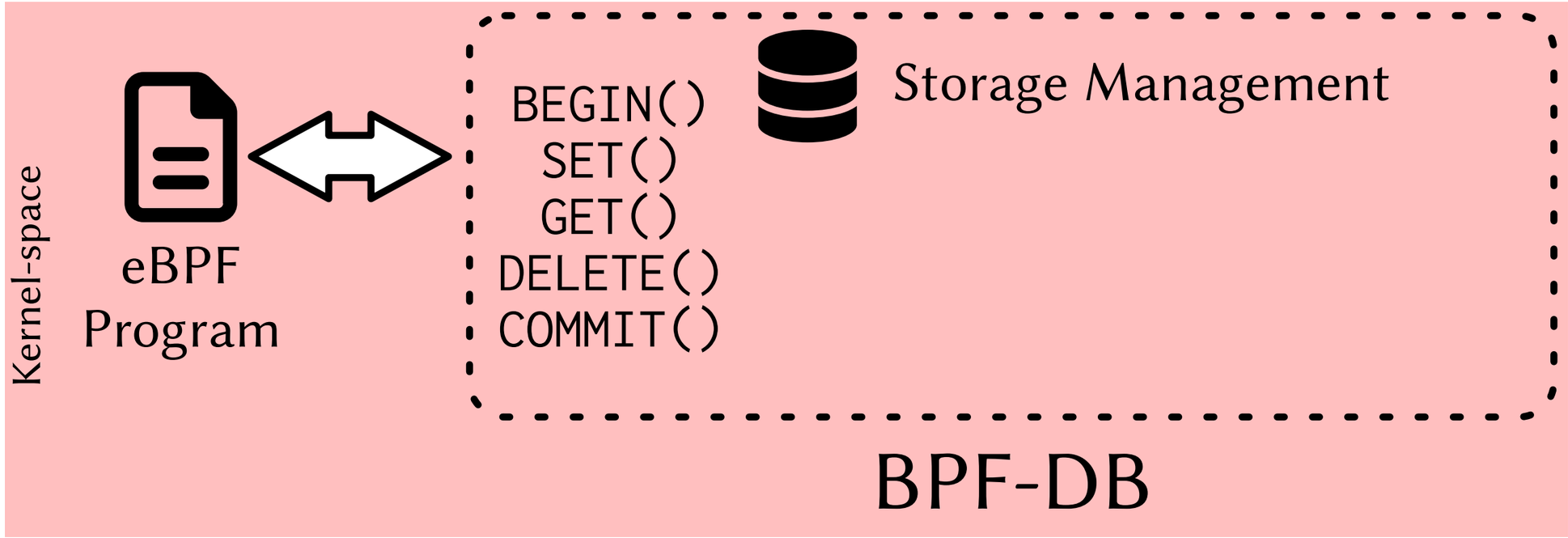

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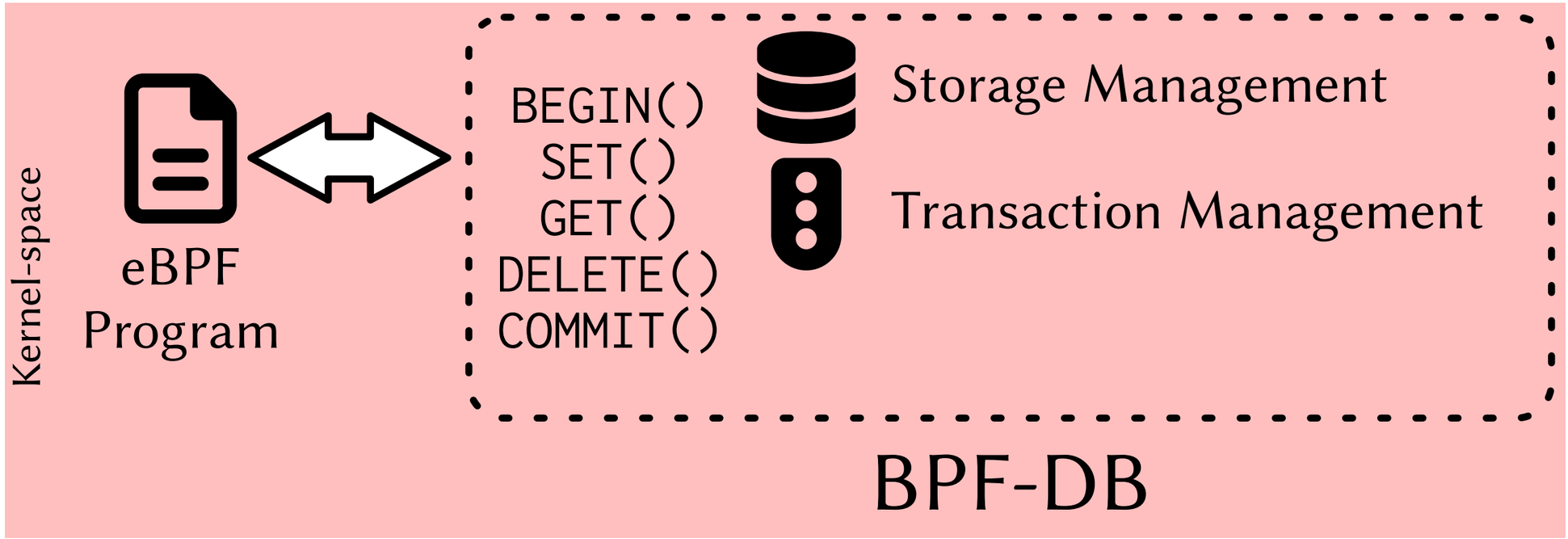

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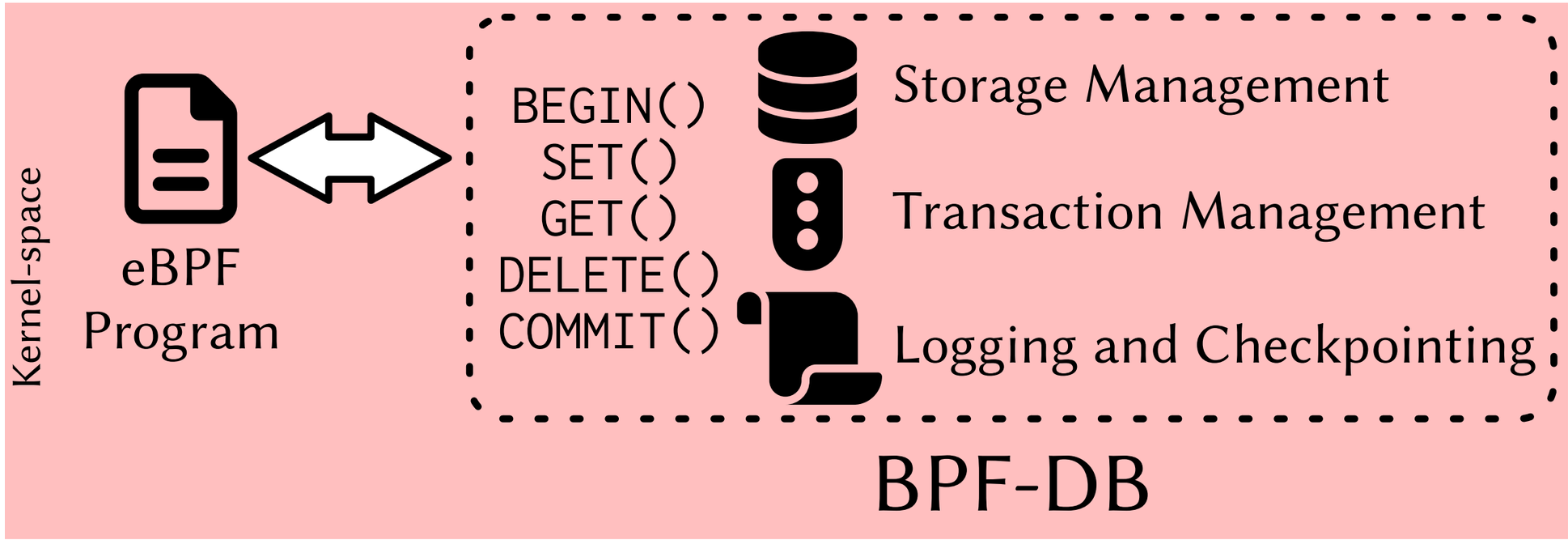

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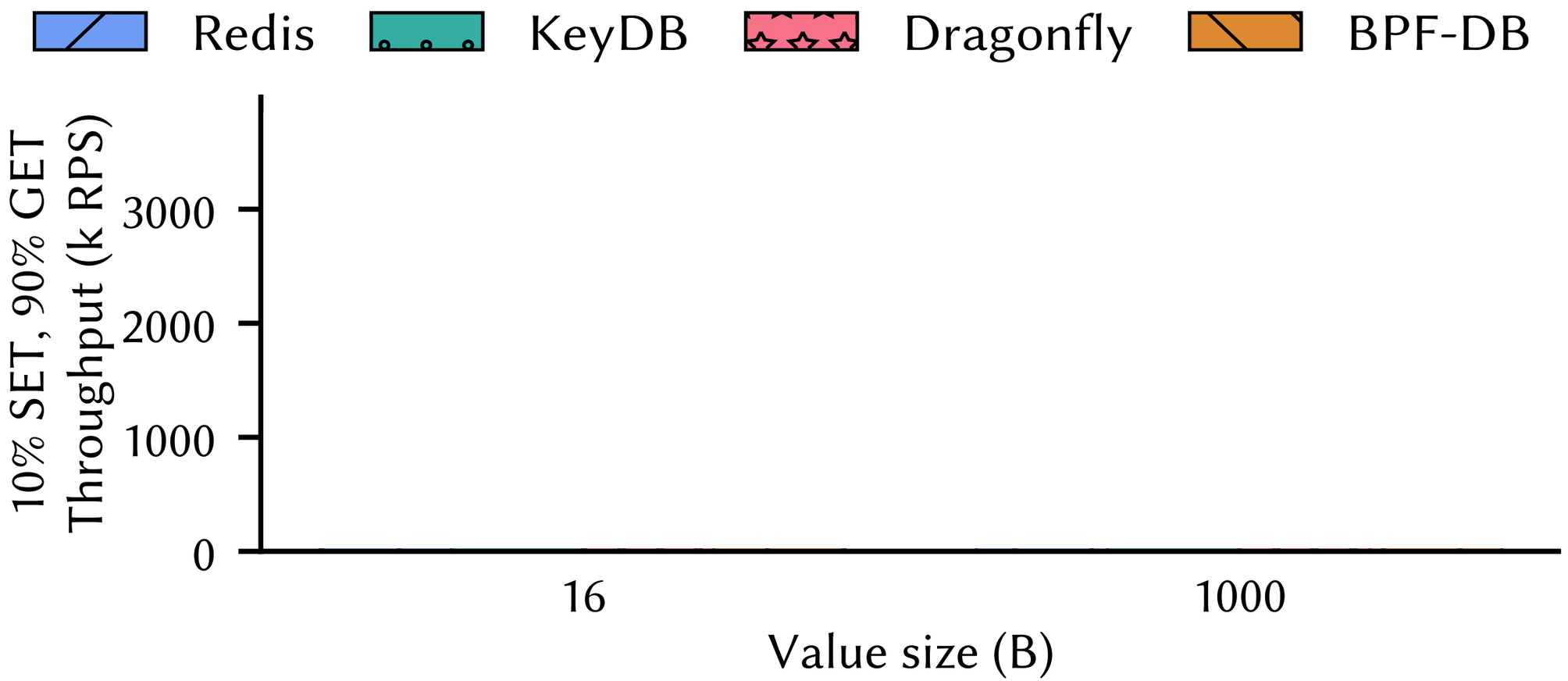

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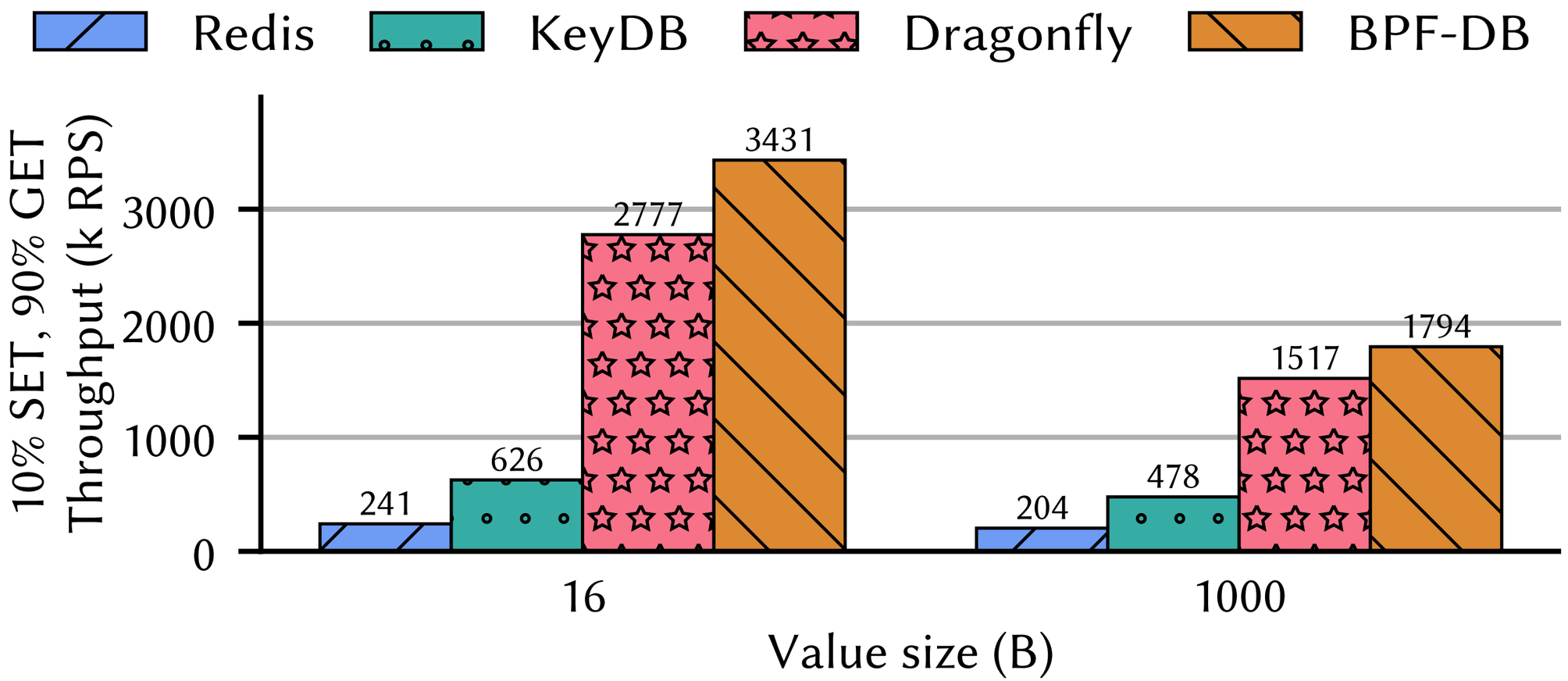

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- User-bypass is already feasible for multiple applications including DBMS proxies
- Our proposed user-bypass DBMS will benefit from storing database contents in kernel-resident data structures and enable new classes of eBPF applications