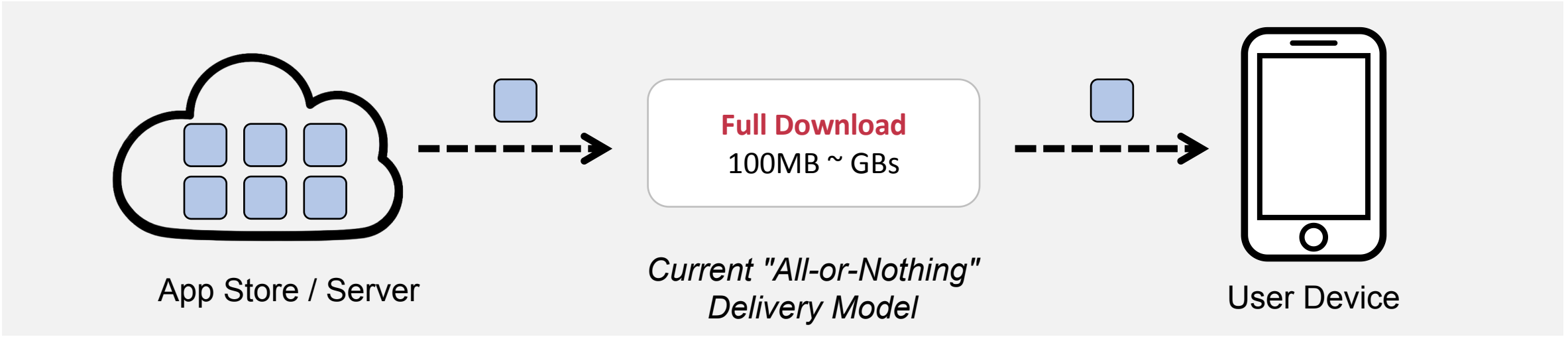
Bridging Storage and Execution: A Semantic Virtual Bus for On-Demand Application Streaming

Jun Lu, Jialin Li, Yaoxue Zhang, Ju Ren

What's wrong with today's app delivery?



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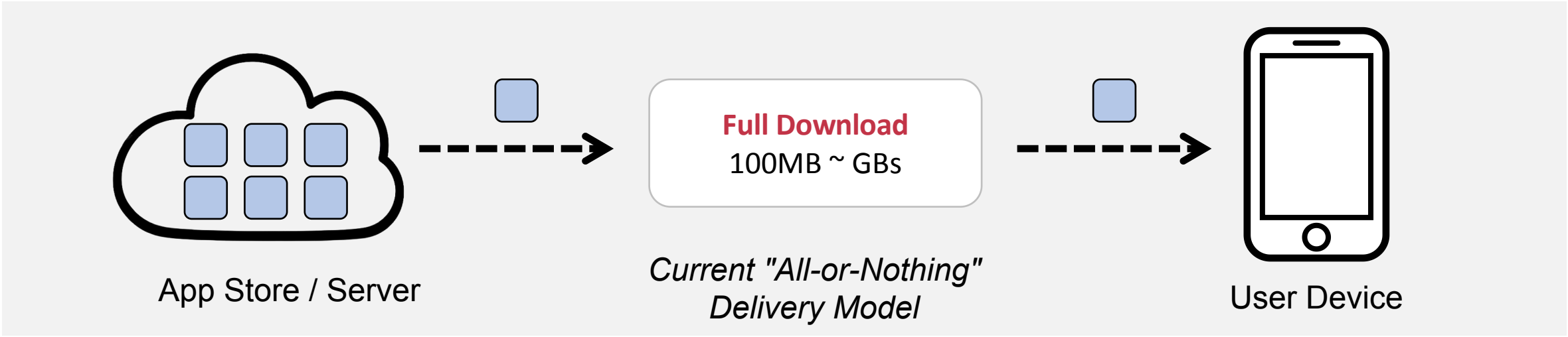

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- **Persistent vulnerabilities**
- **Wasted developer effort**

Application sizes keep growing

- **Long download & installation time**
- **Poor experience for short-term usage**

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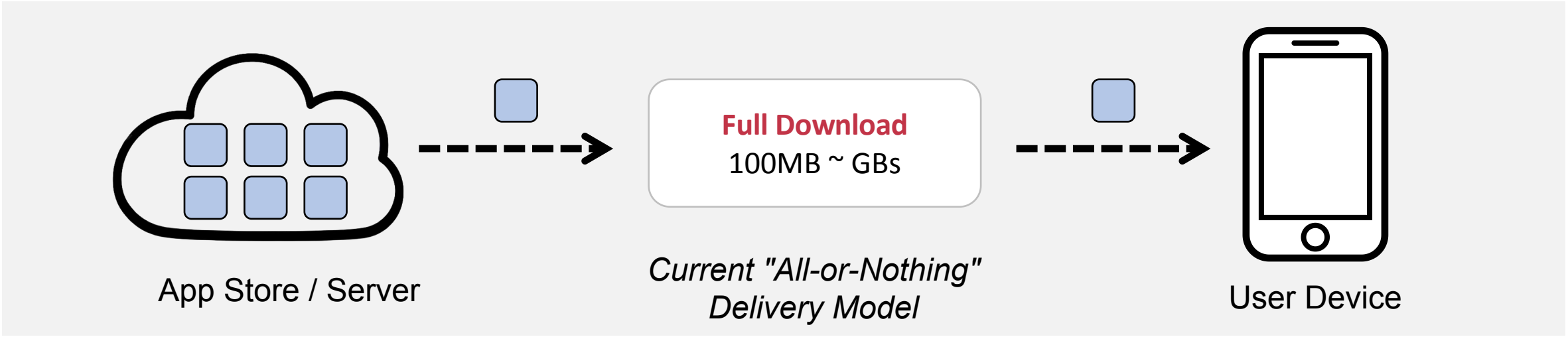

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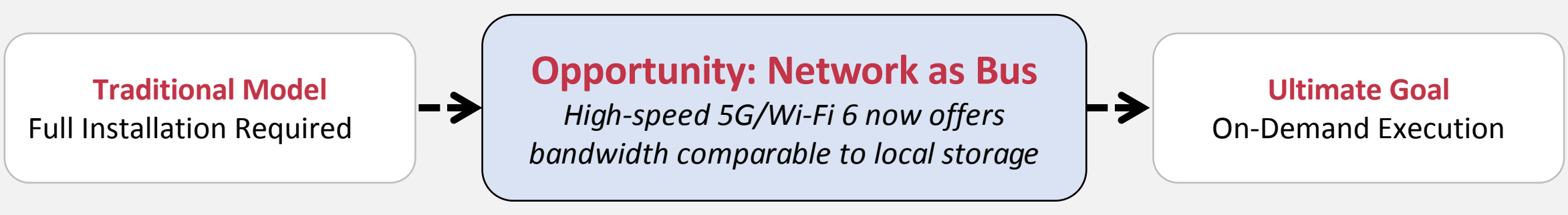
Both problems stem from the same root cause: **full installation before use**

Why existing solutions fall short?

Emerging Paradigm Shift vs. Traditional Model



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Traditional Model
Full Installation Required

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Opportunity: Network as Bus
High-speed 5G/Wi-Fi 6 now offers bandwidth comparable to local storage

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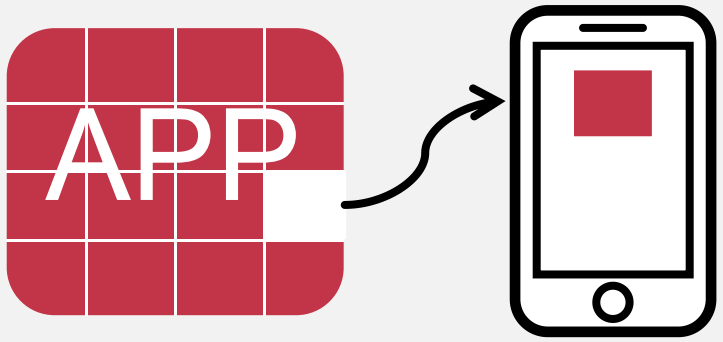
Ultimate Goal
On-Demand Execution



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Intrusive → cannot support existing apps

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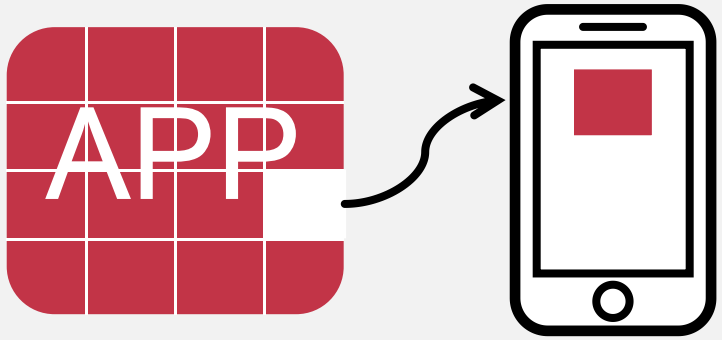

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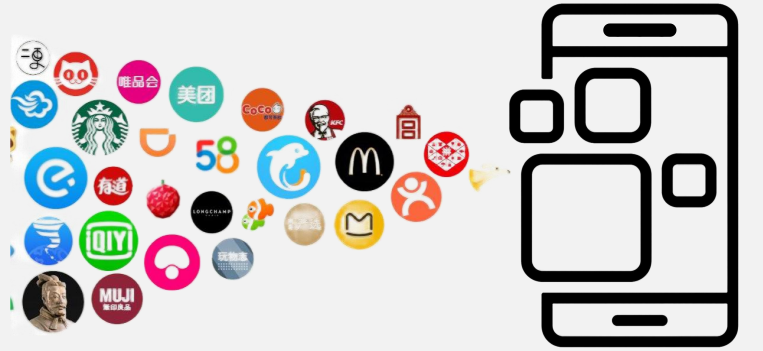

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Non-native runtime → performance loss

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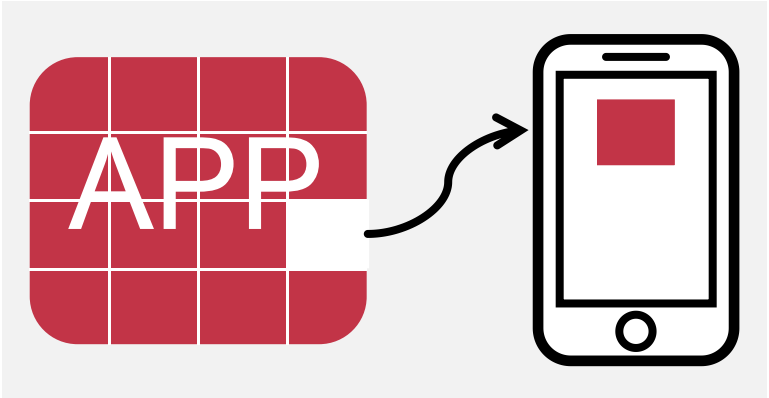

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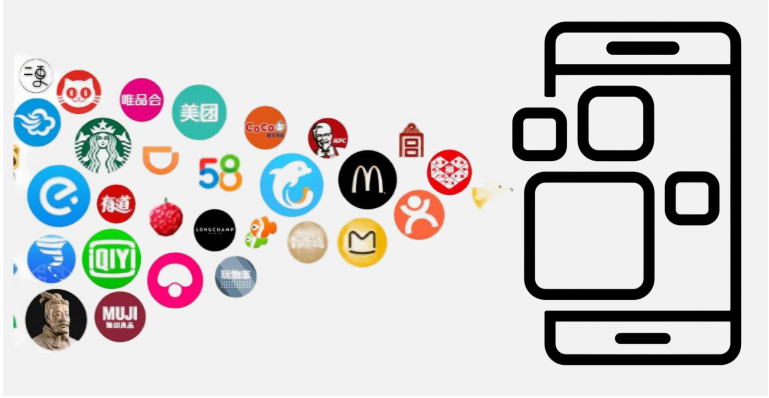

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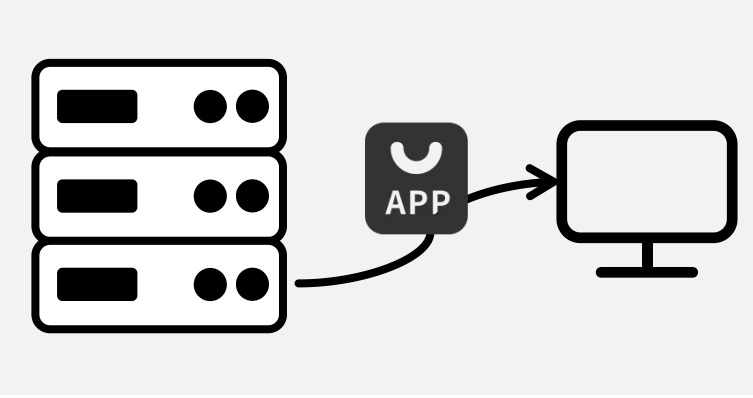

Network FS (NFS)

Stateless for execution → design for data access

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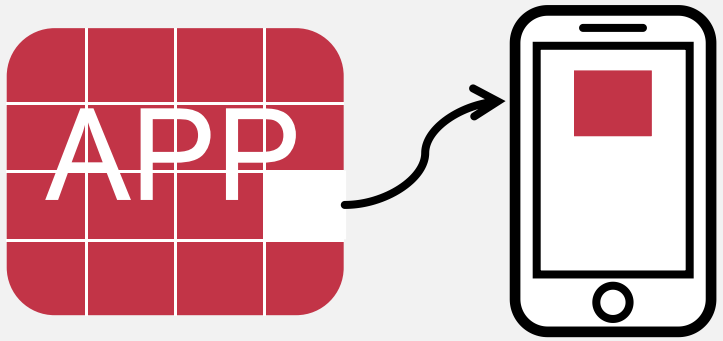

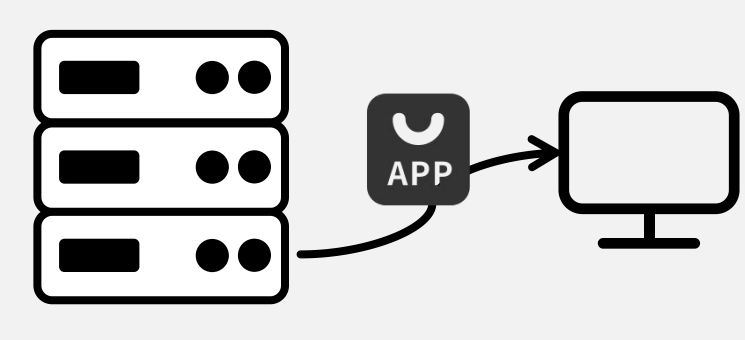

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Existing approaches fail to balance transparency, efficiency, and compatibility.

Key Idea: Semantic Virtual Storage Bus

Goal 1: Transparency

No installation, seamless execution

Goal 2: Efficiency

Hide latency over variable networks

Goal 3: Compatibility

Run unmodified applications

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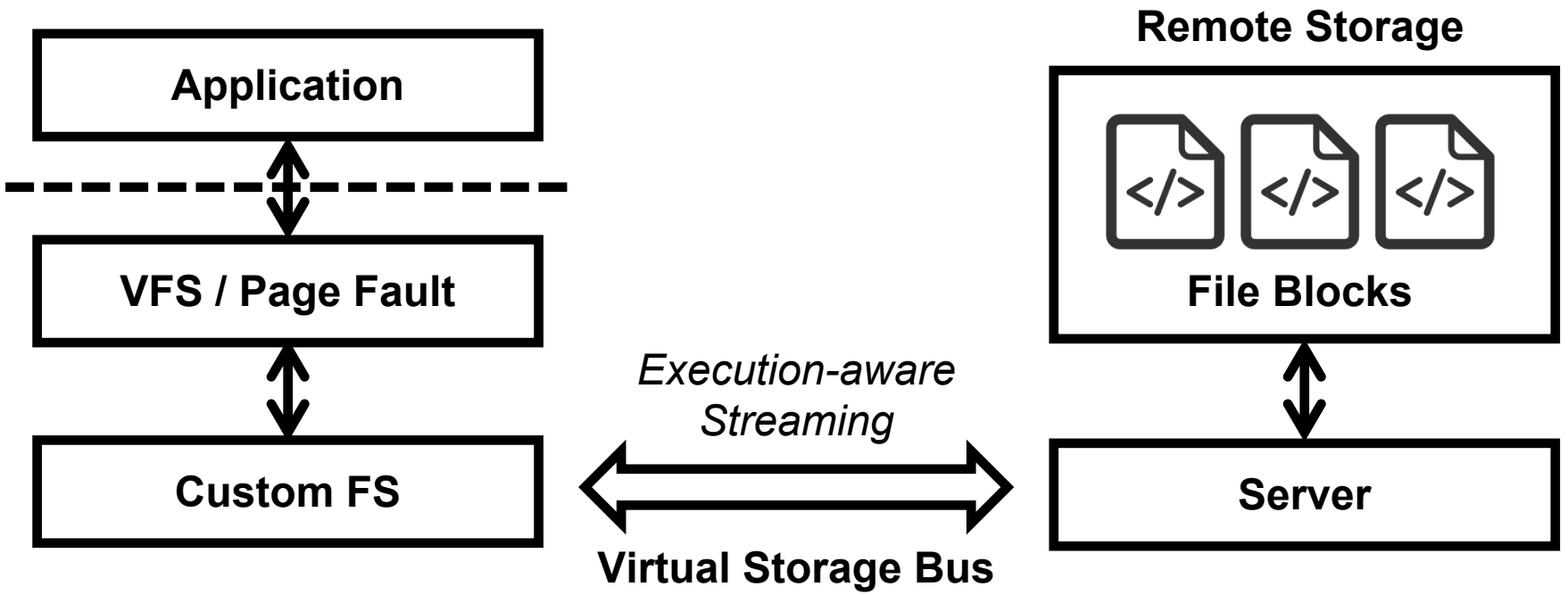

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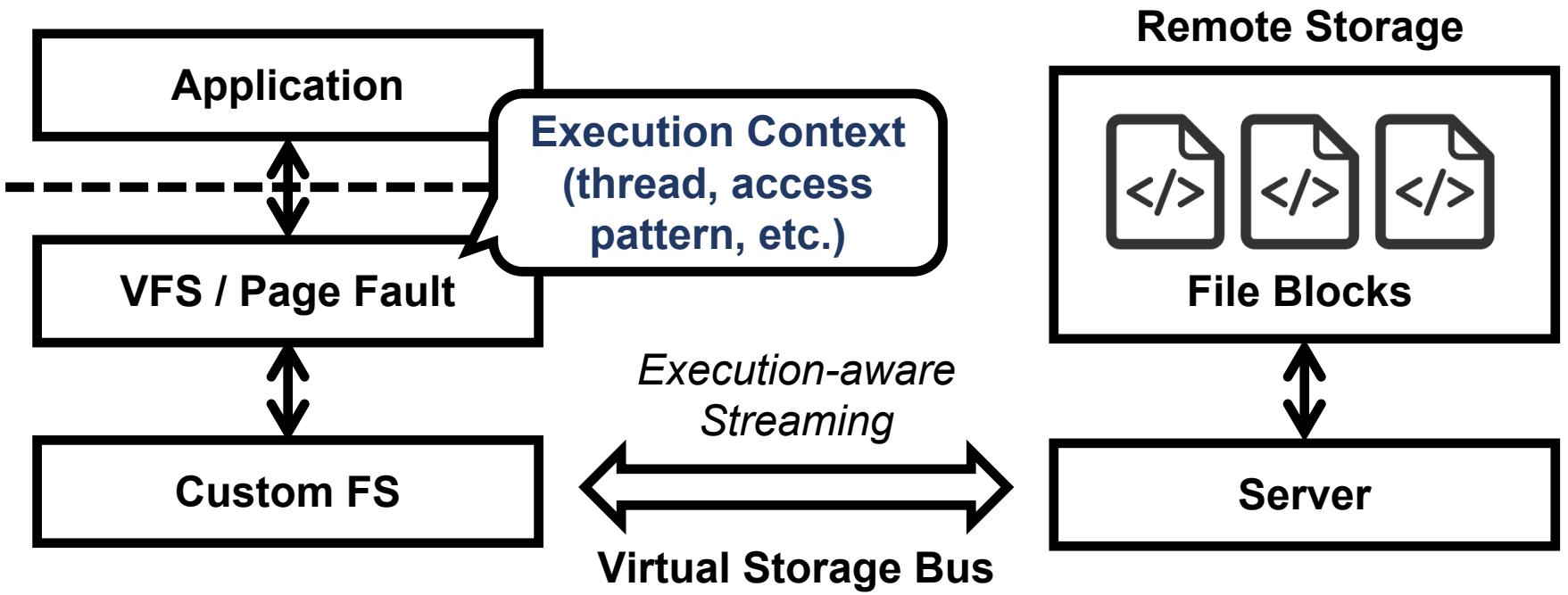

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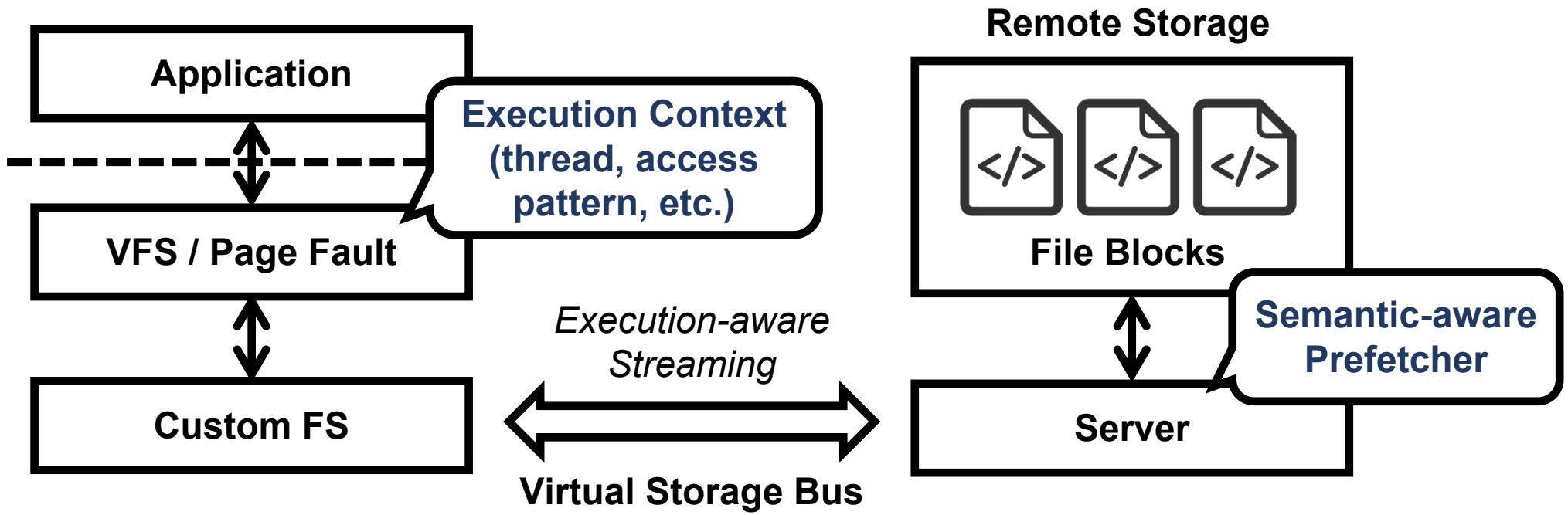

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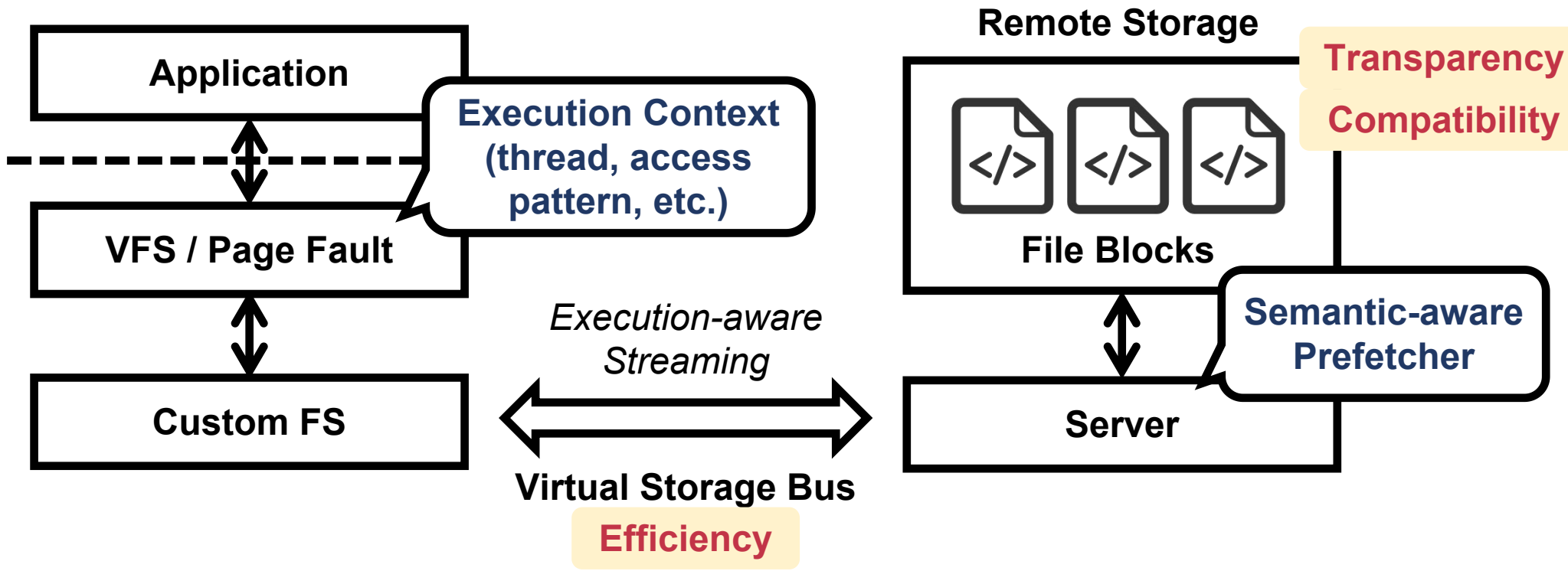
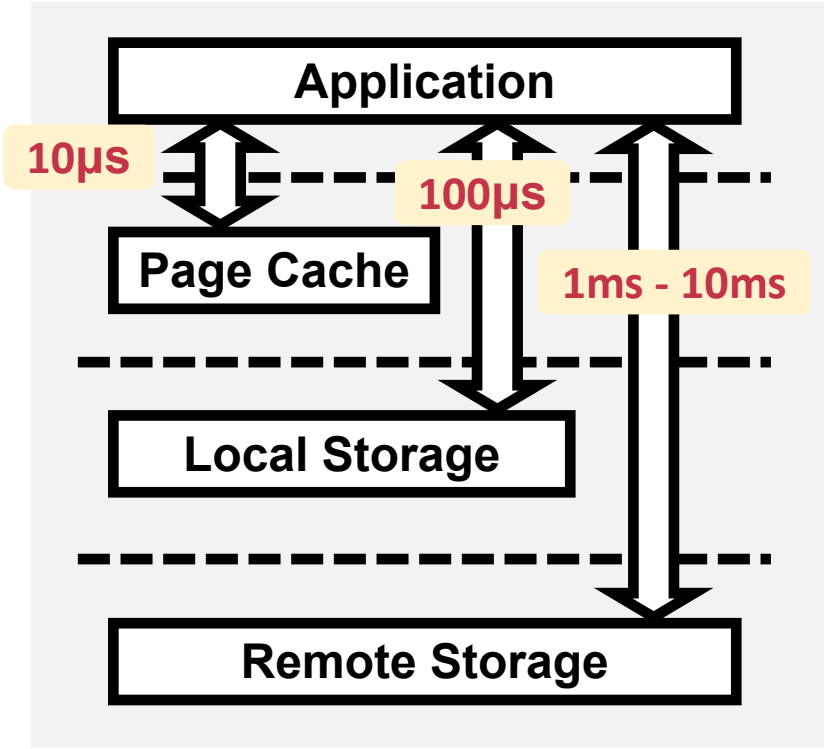


Two Fundamental Challenges



Latency Gap

Execution requires **µs-level** response
Network delivers **ms-level** latency
→ **100×–1000× mismatch**

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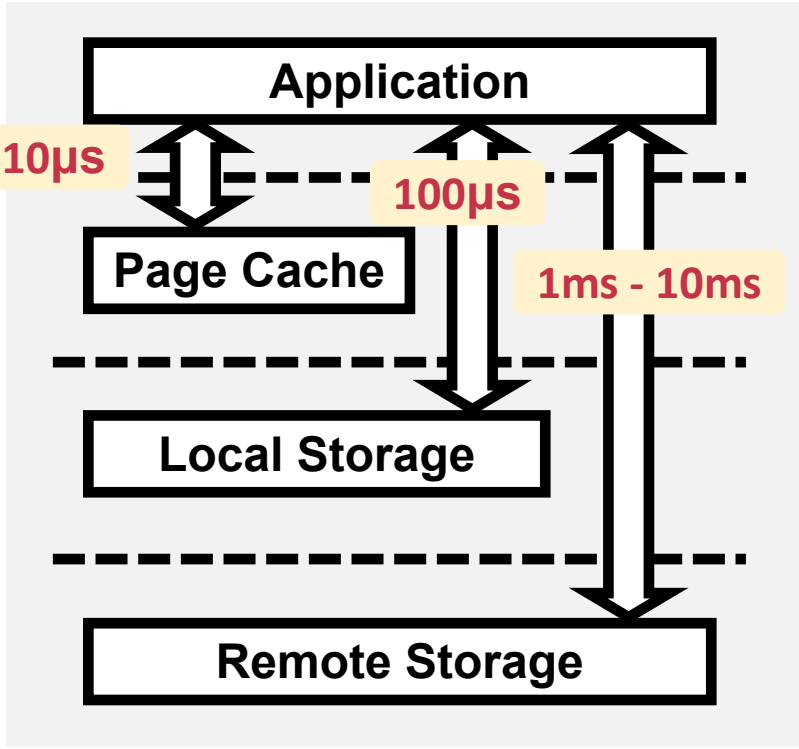

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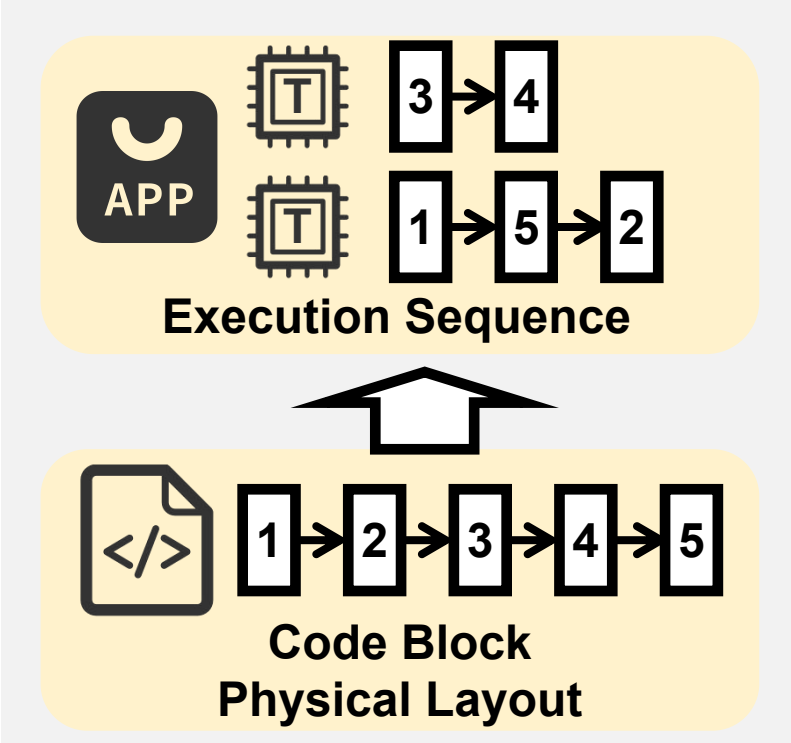
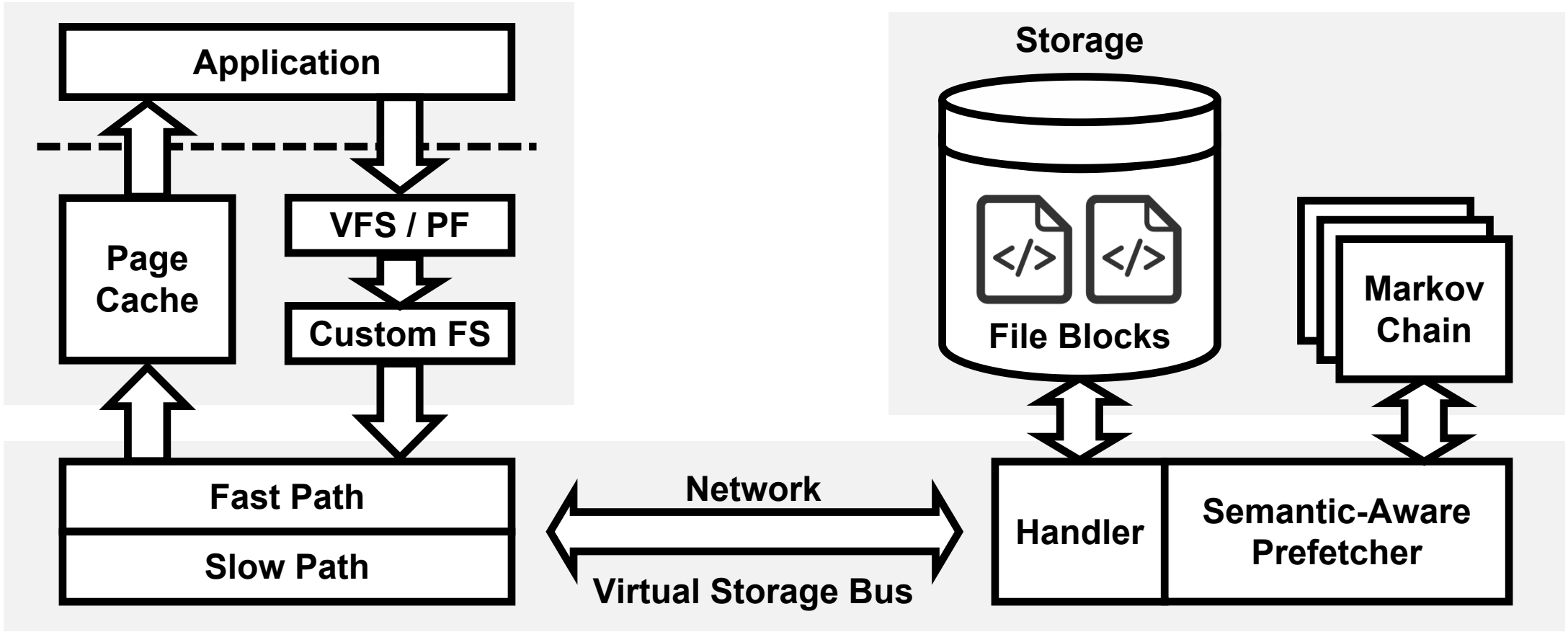


Context Gap

Storage is **stateless**
Execution is **stateful & thread-specific**
→ **generic prefetching is ineffective**

Architecture Overview



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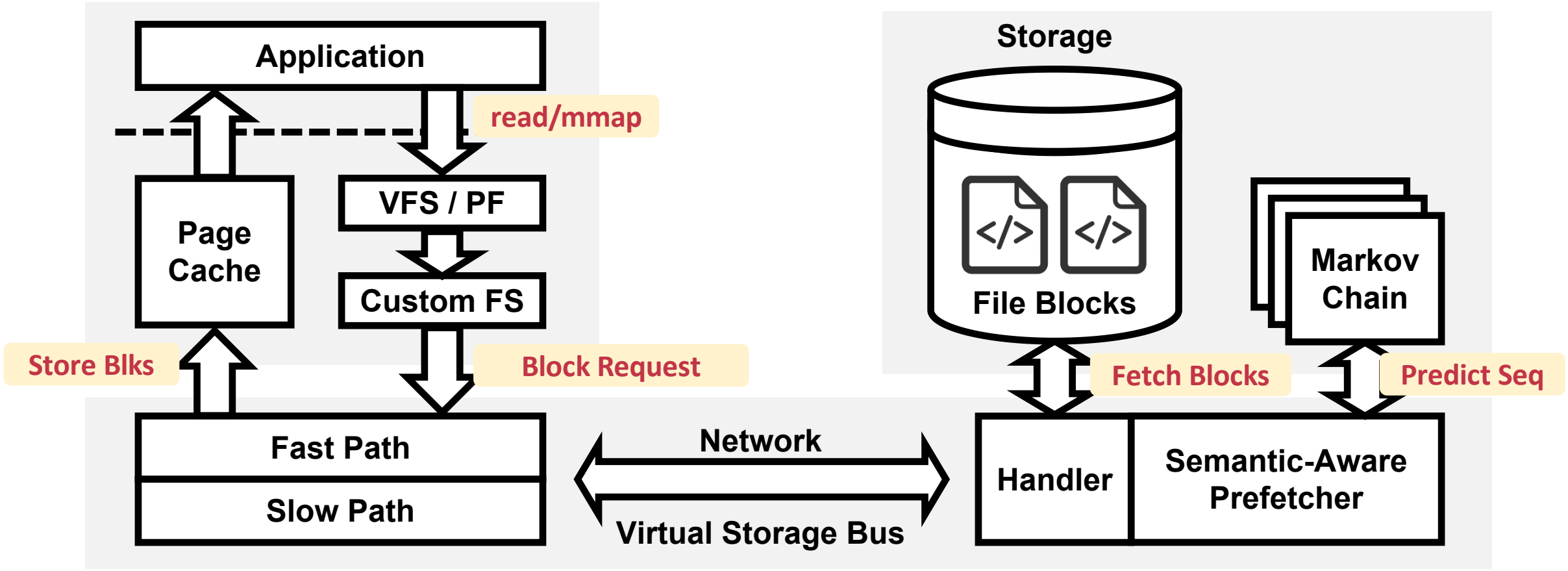

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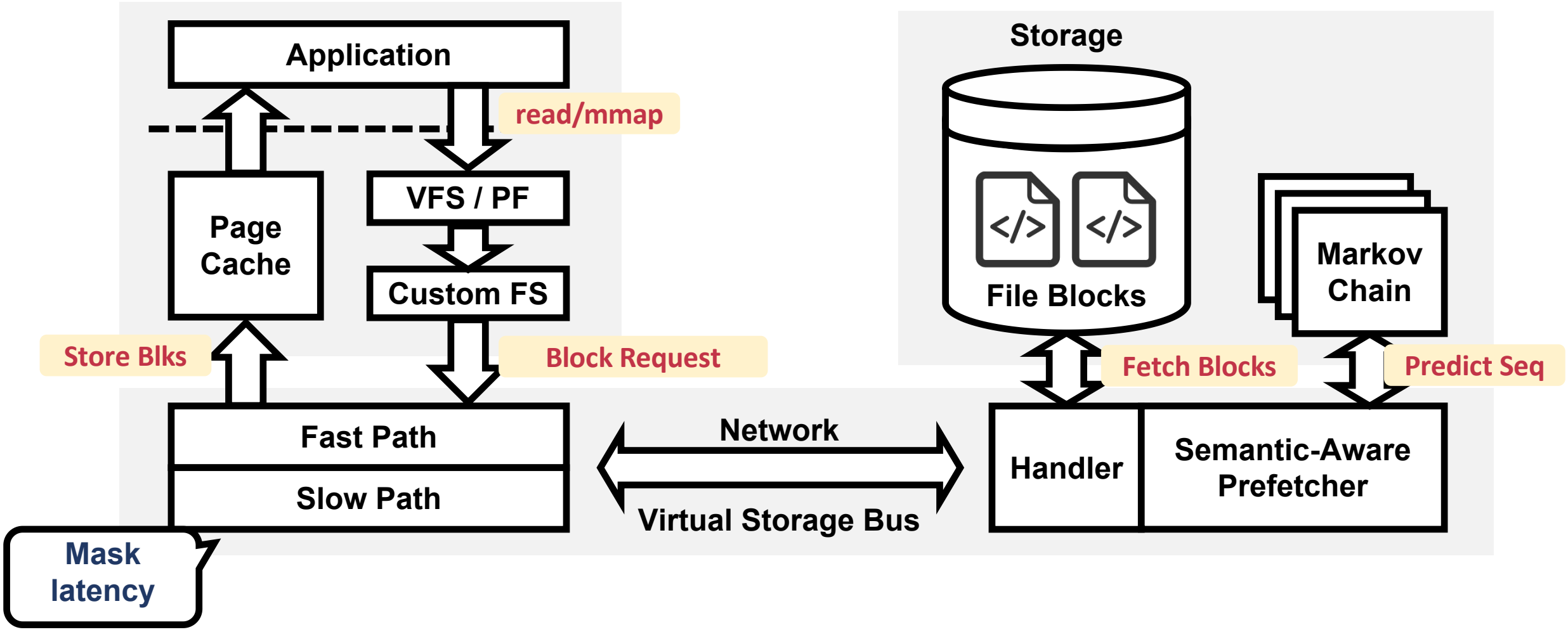

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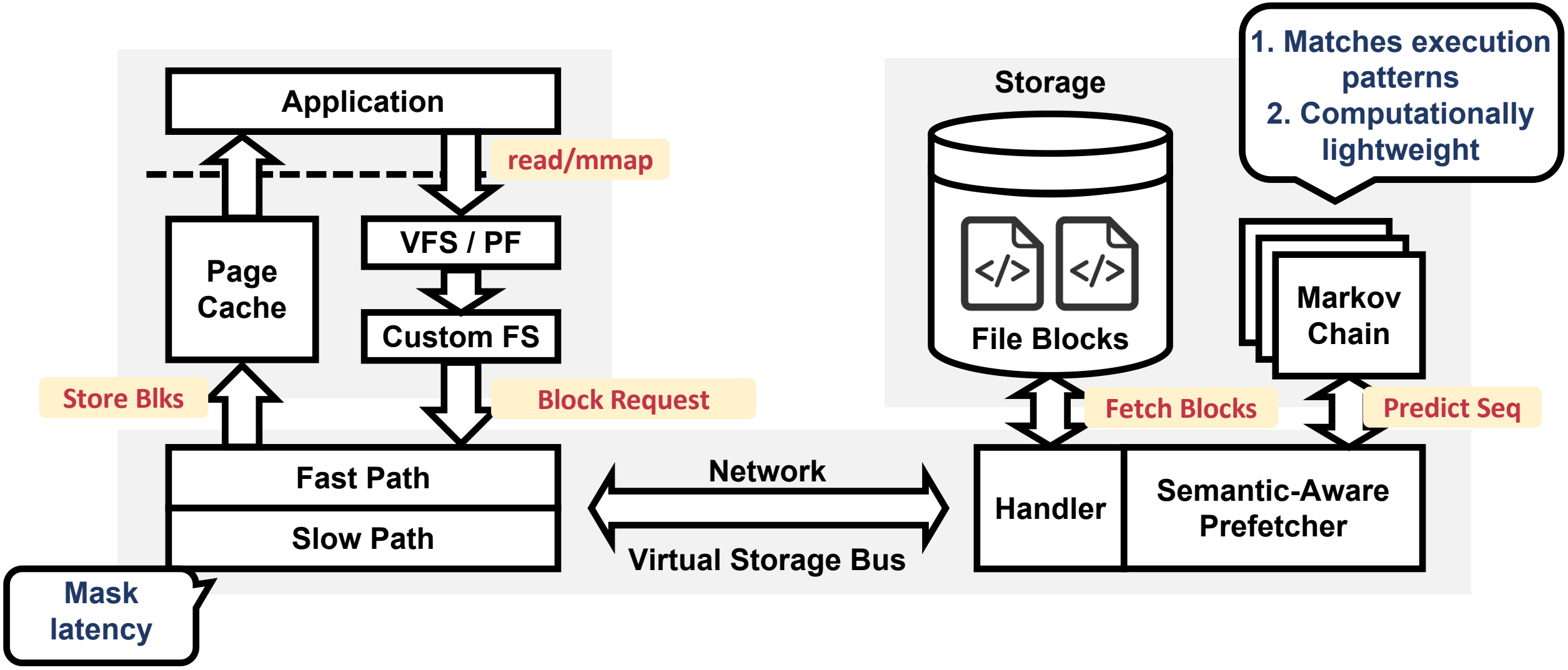
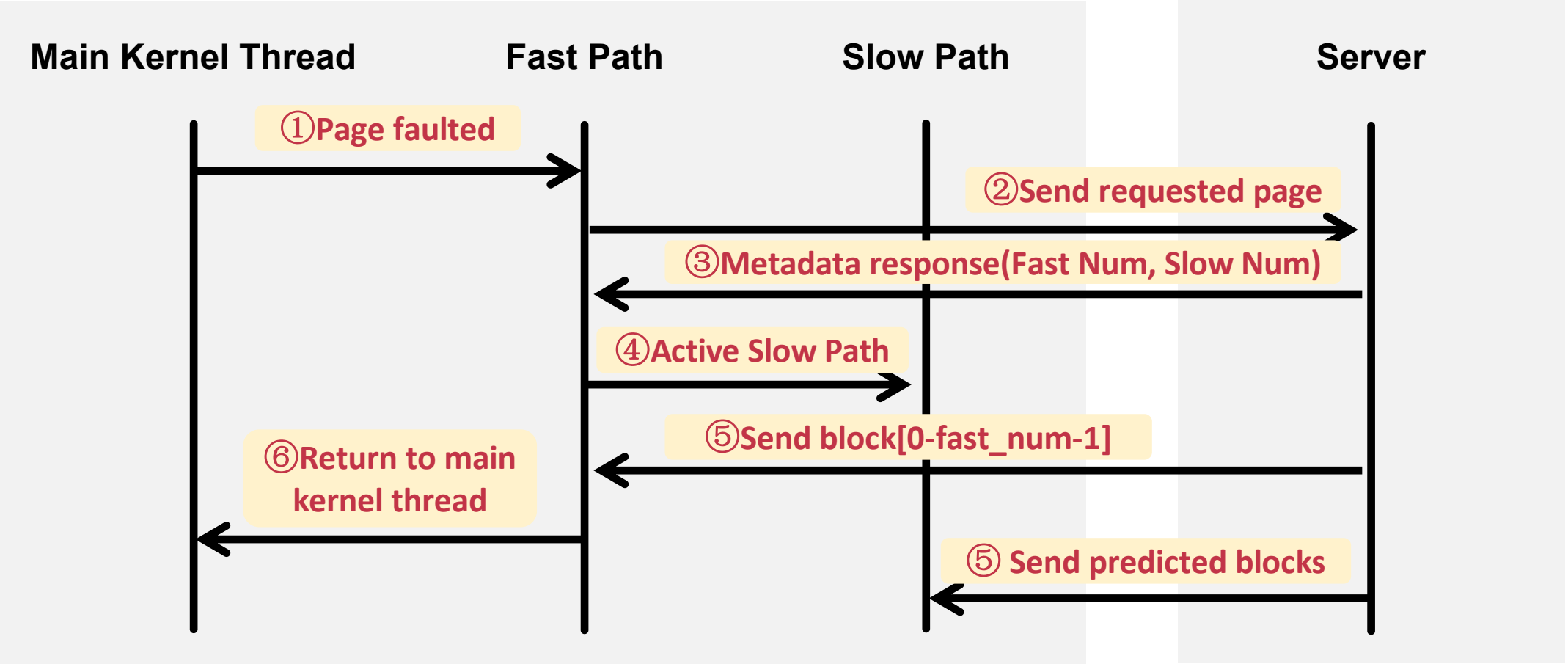


Dual-mode block delivery workflow



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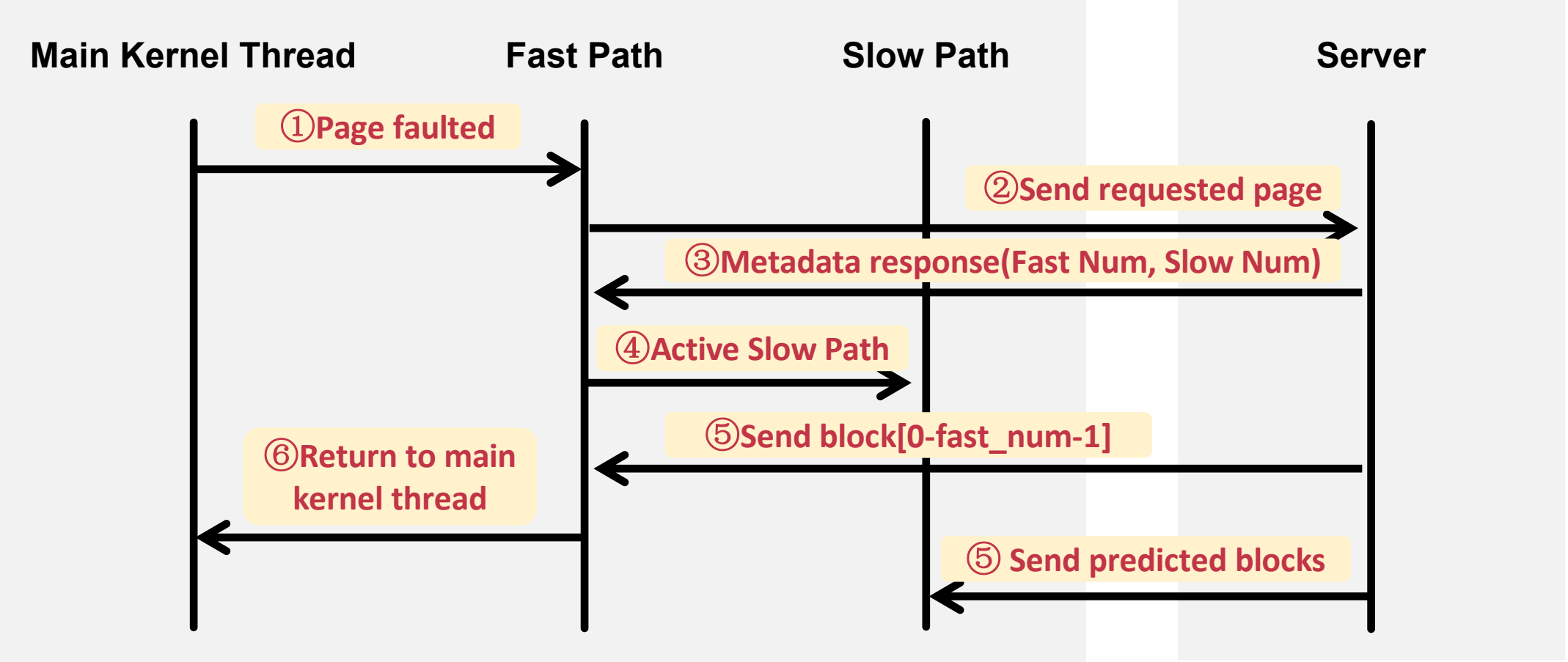
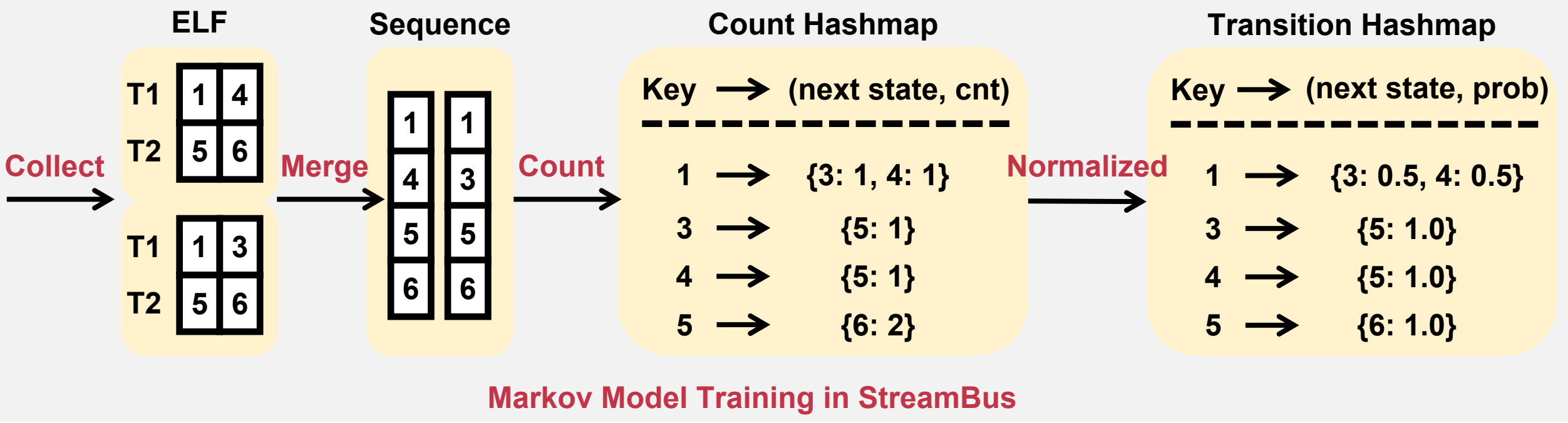


Fast path serves the **current demand**, while **slow path** prepares **future blocks**.

Thread-Aware Prefetching



Markov Model Training in StreamBus

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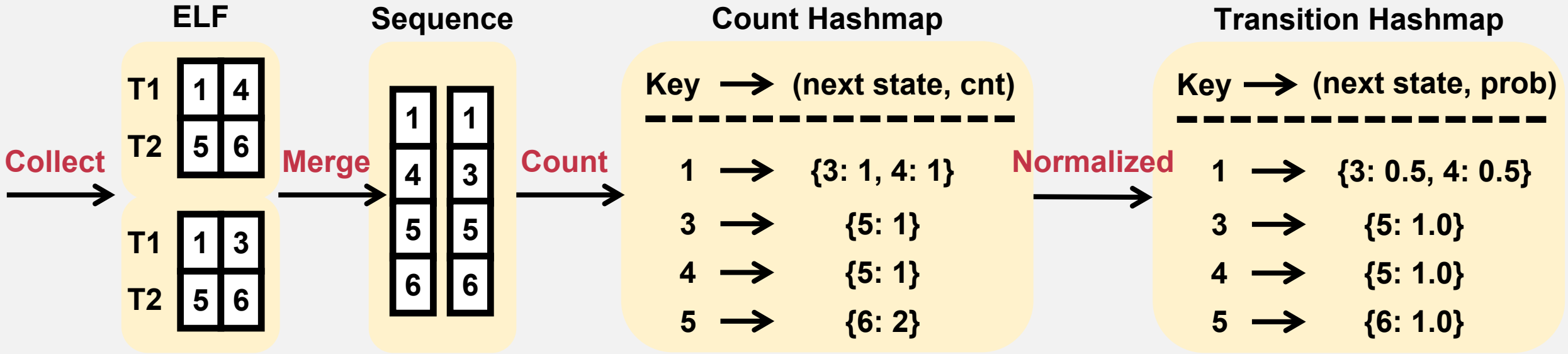

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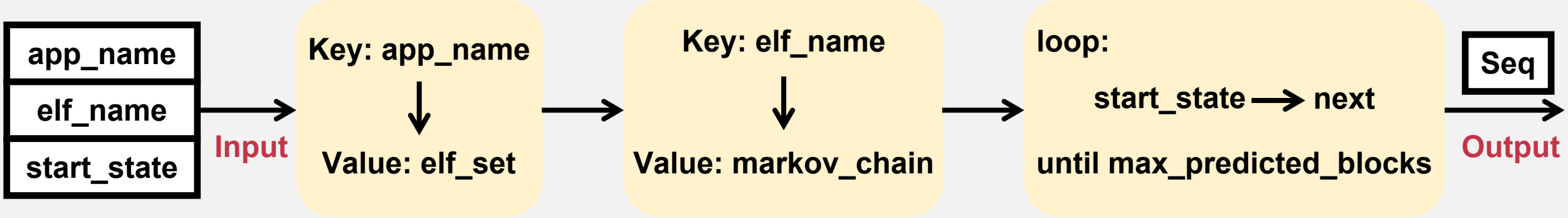

StreamBus Inference Procedure

Evaluation Setup

- **Hardware Setup**
  - **Dell OptiPlex 5070 desktop: 1 TB NVMe SSD**
  - **Google Pixel 6 Pro: 128 GB UFS 3.1 storage**
  - **NETGEAR Router: 1 Gbps Ethernet, 802.11ac (5GHz)**
- **Baseline**
  - **Local: NVMe SSD, UFS 3.1 storage**
  - **Network: NFSv4**

Desktop		Mobile	
Pycharm	3.0GB	Uber	447MB
A. Studio	2.9GB	WPS	377MB
Shotcut	685MB	Spotify	193MB
VSCode	409MB	Whatsapp	126MB
Firefox	260MB	Telegram	122MB

Microbenchmark

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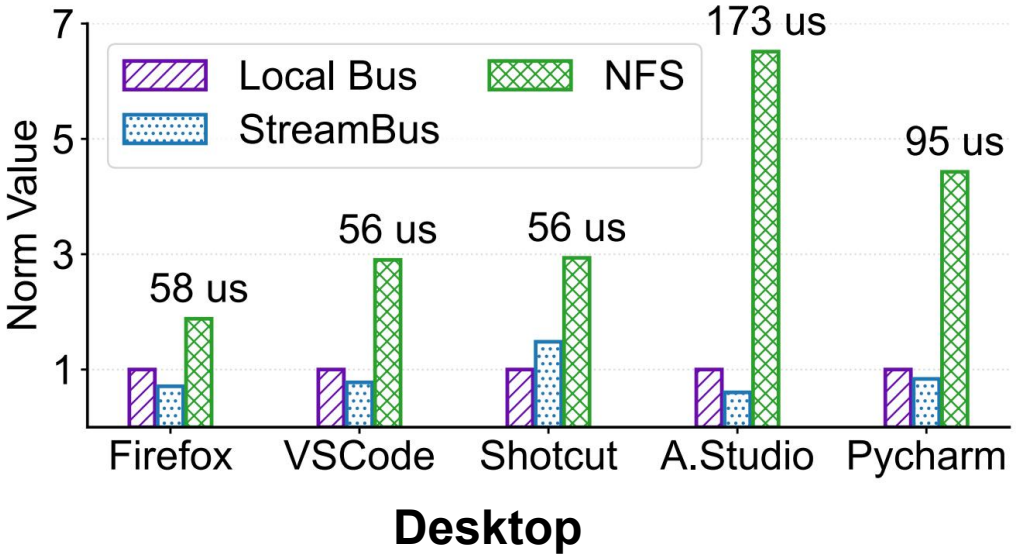

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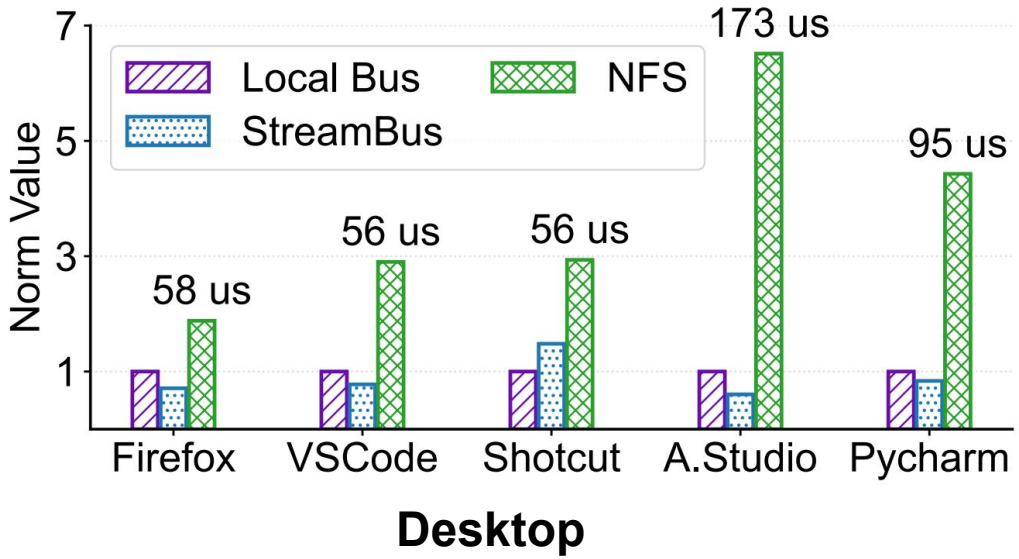

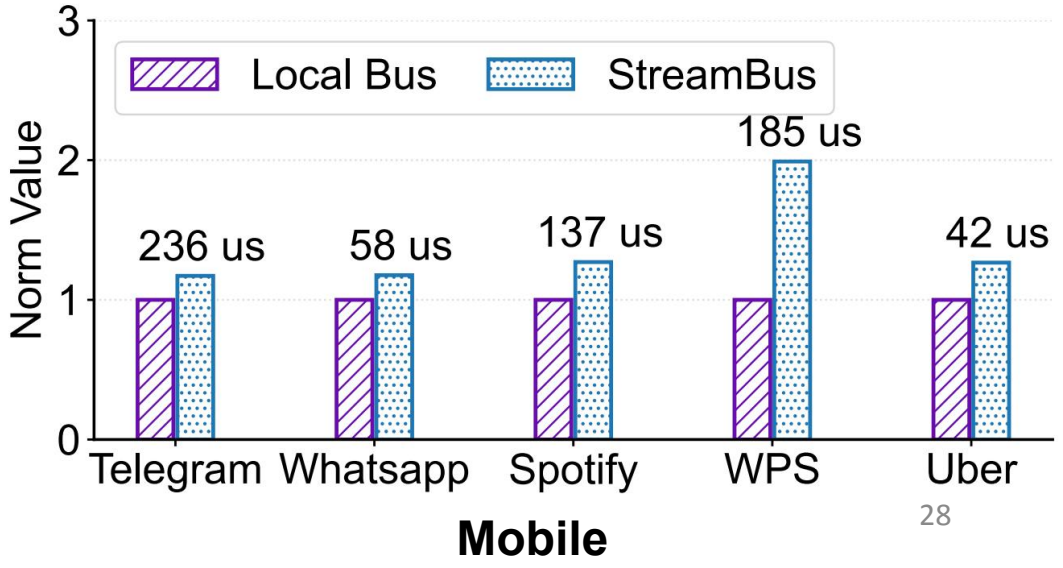

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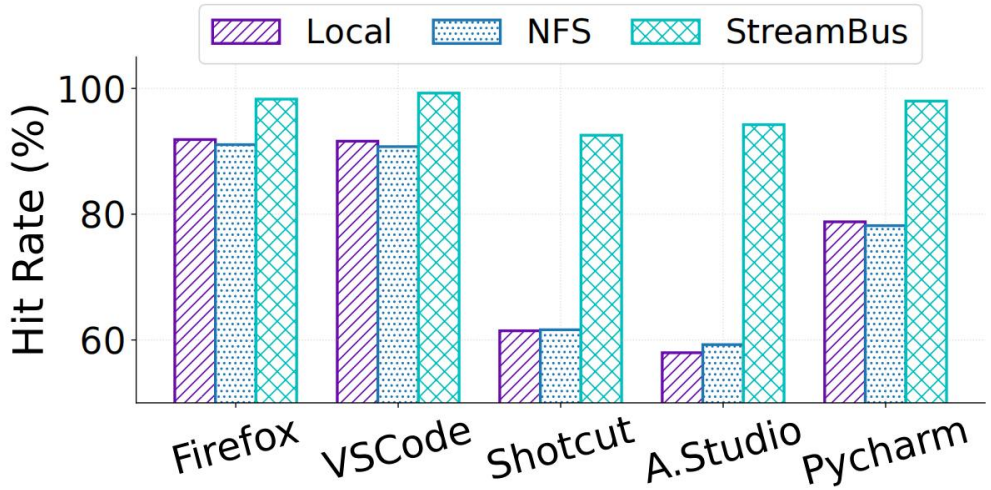

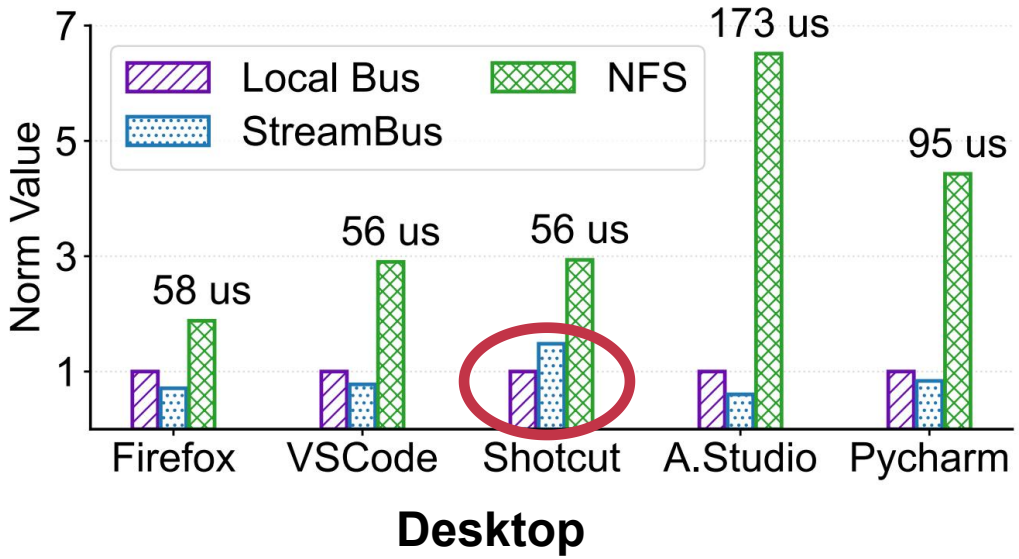

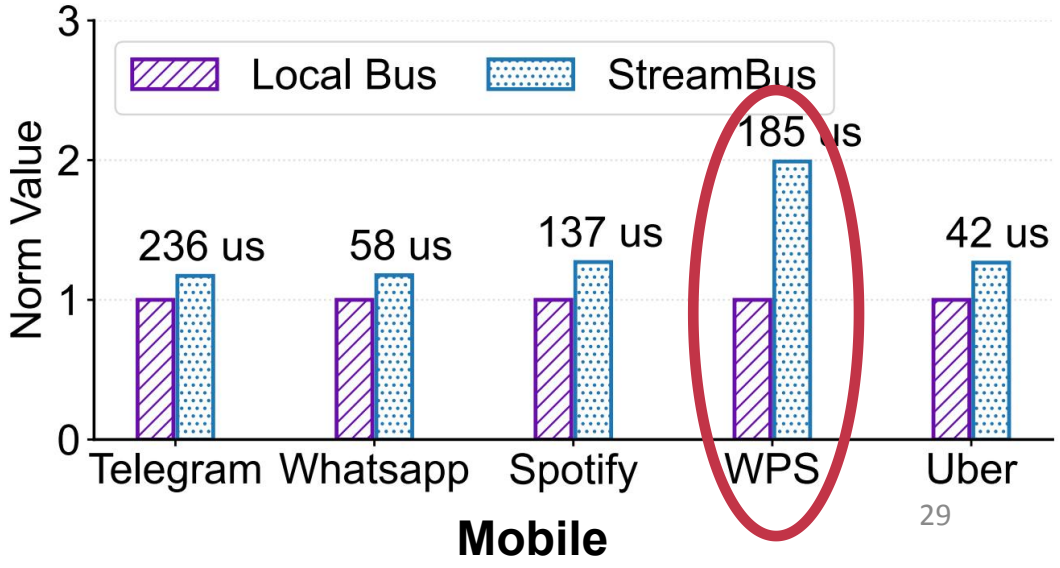

End-to-End Performance

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- **↓ 20–55% startup latency vs. NFS**
- **≈ NVMe-level startup on desktop**
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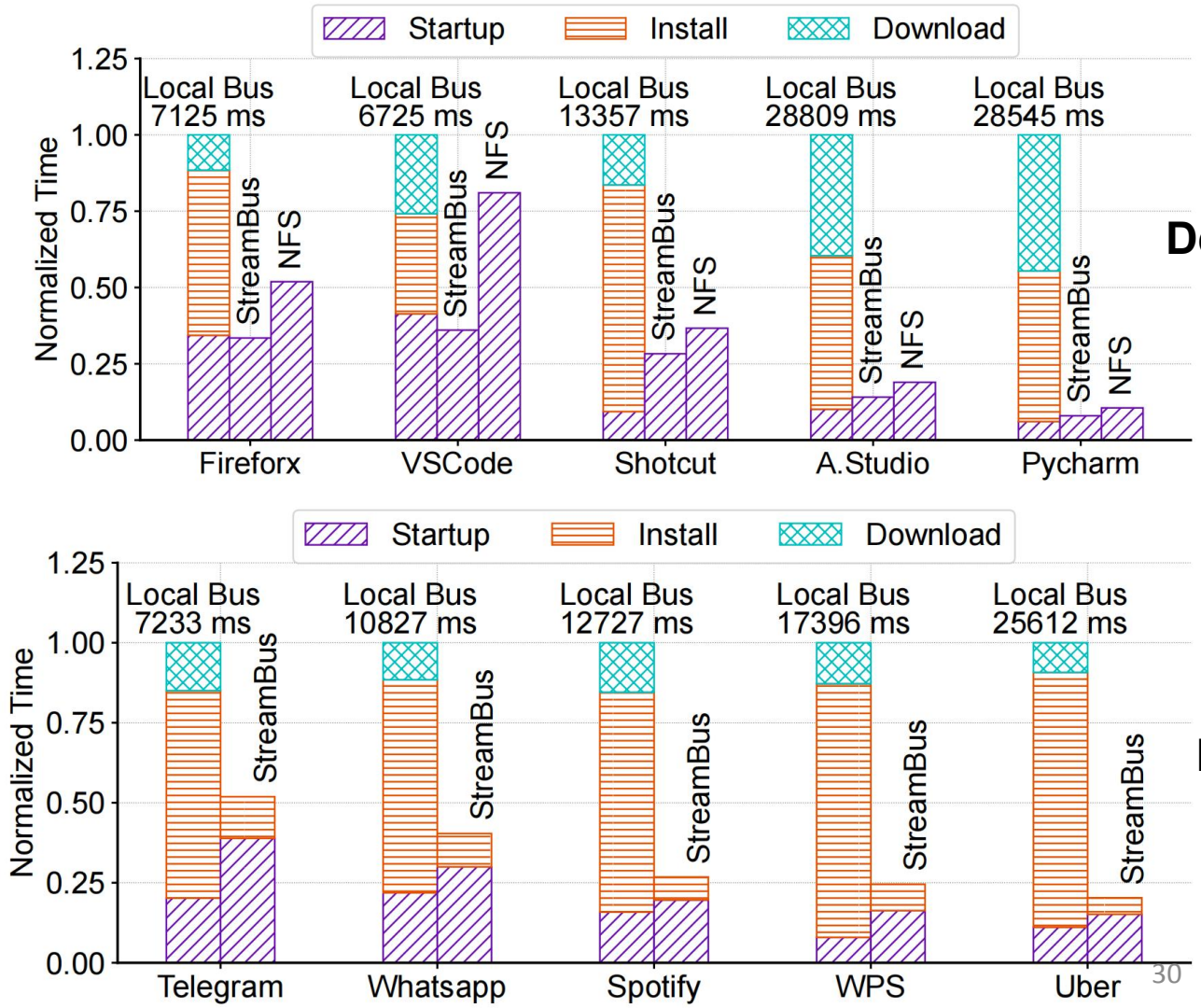

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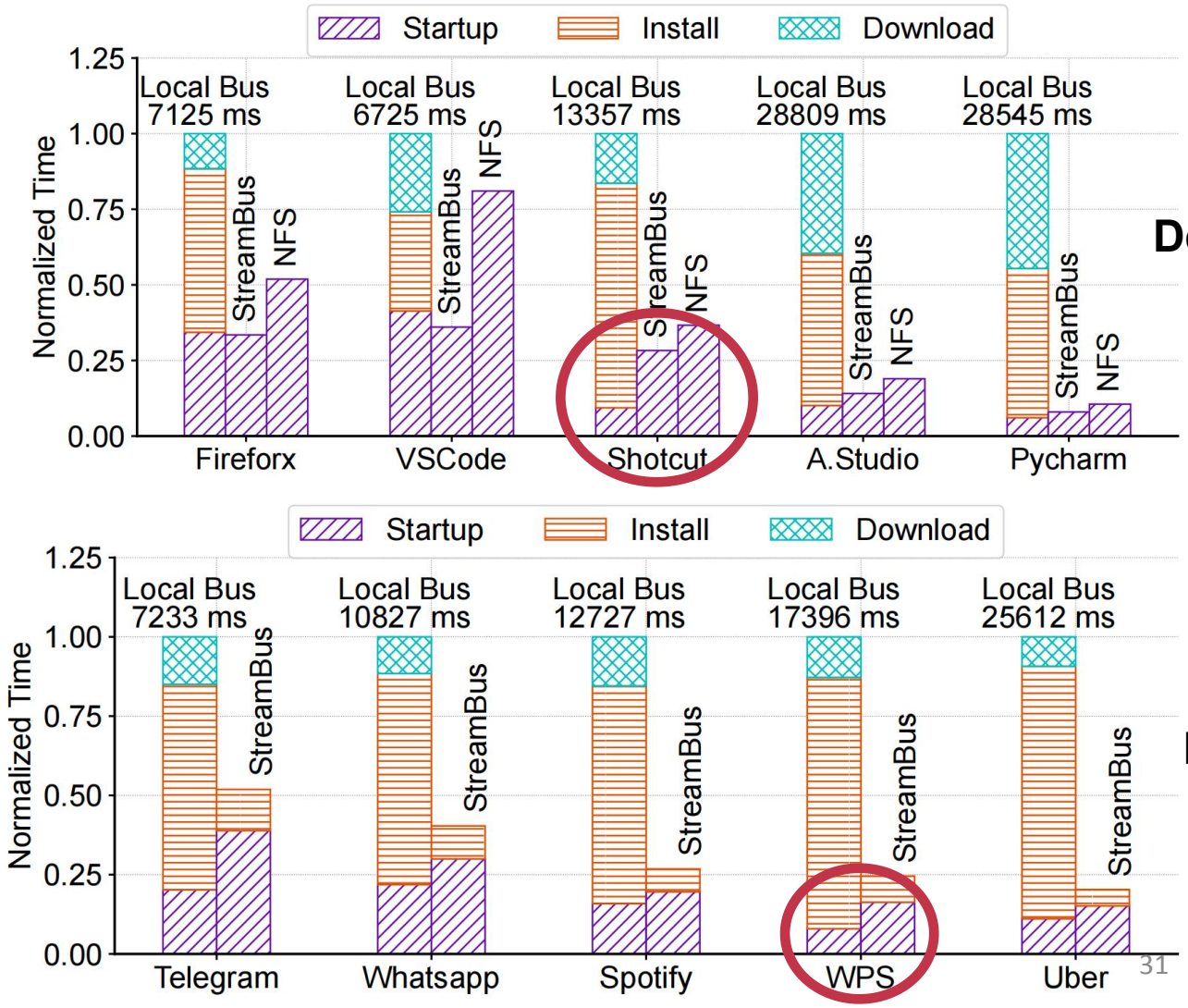

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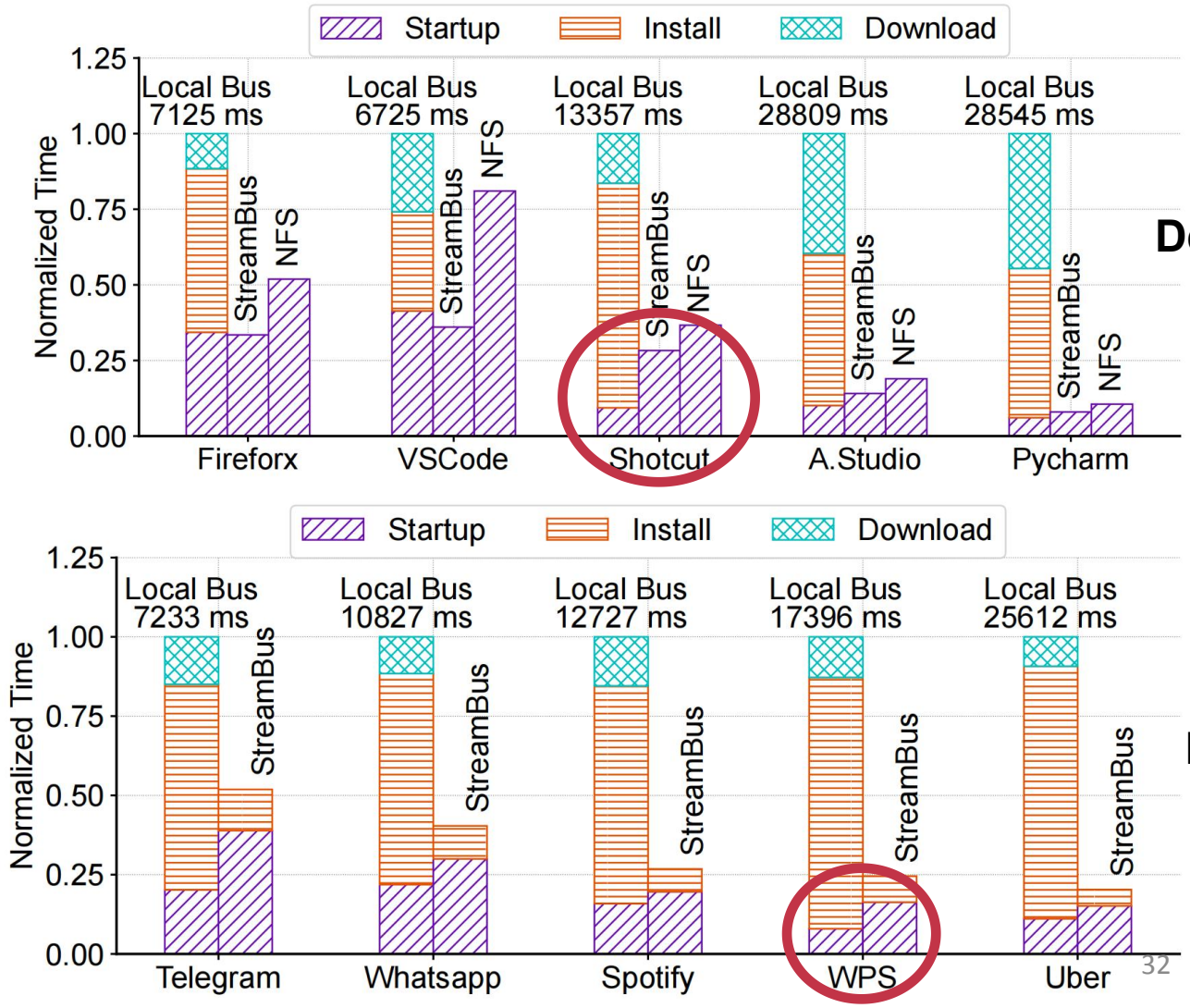
- **↓ 36–80% end-to-end time (mobile)**



Robustness Under Network Variability

- **Set up: Inject RTT: 2–100 ms (+ loss & jitter)**
- **Metric: End-to-end delay**
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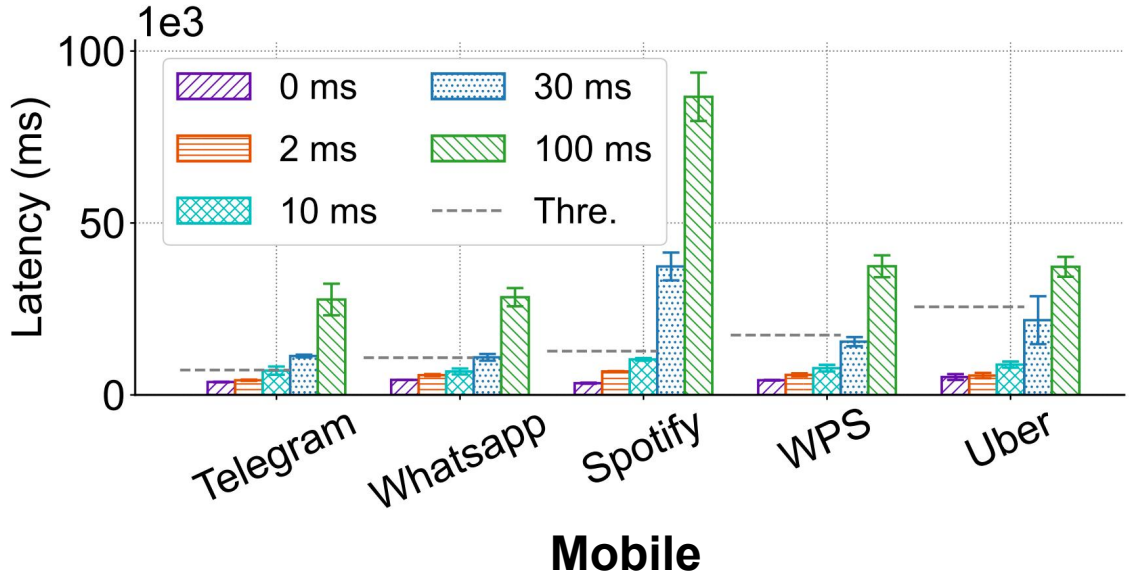

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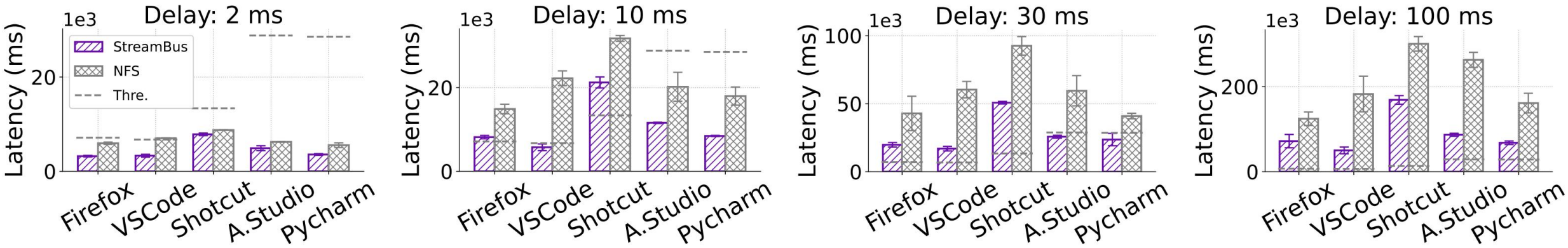

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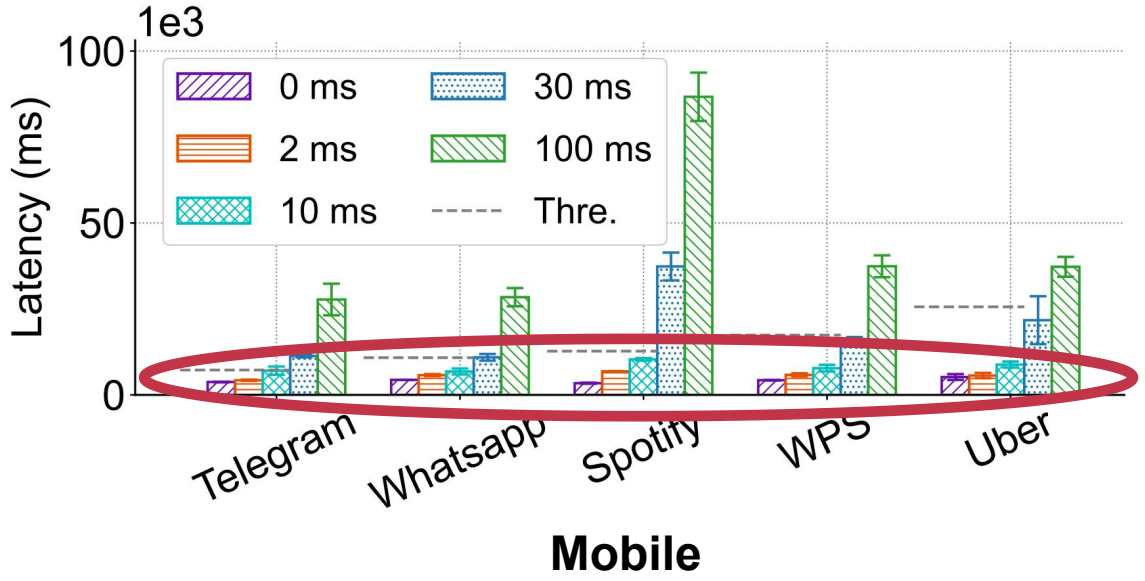

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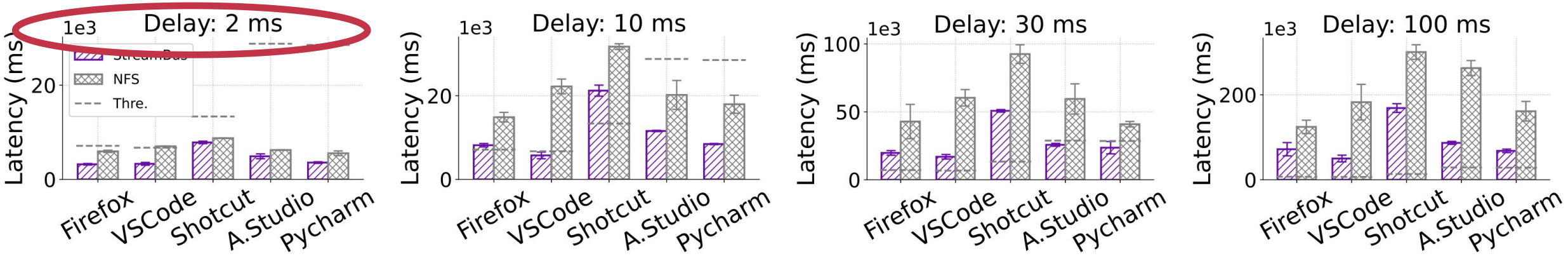

Desktop

Conclusion

- **StreamBus: Enables on-demand execution without installation via a semantic virtual storage bus.**
- **Performance: Masks network latency, achieving near-local responsiveness**
- **Future: Towards zero-install applications and edge-cloud execution.**

Q & A