中文信息处理实验室-让机器理解语言
Chinese Information Processing Laboratory

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FlashAgents

Accelerating Multi-Agent LLM Systems via Streaming Prefill Overlap

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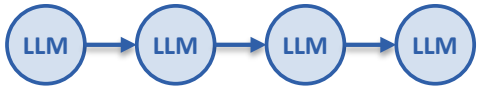
Multi-Agent LLM Workflows Are Now Production

A single user request now triggers **many dependent LLM calls**. What users feel is **workflow latency**, not single-call latency.

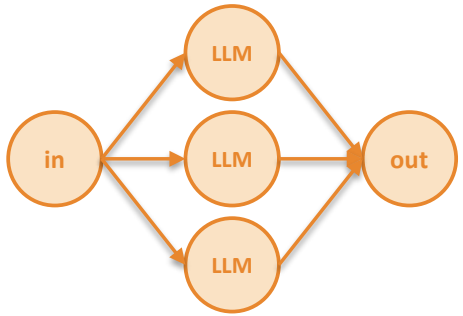
Chain



AutoGen travel planner

→ N – 1 handoffs

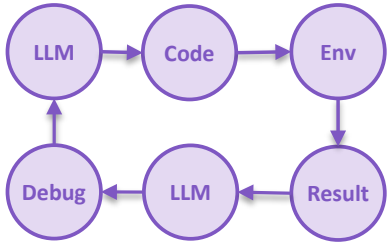
Fan-out / Fan-in



Slides Generation

→ N – 1 handoffs

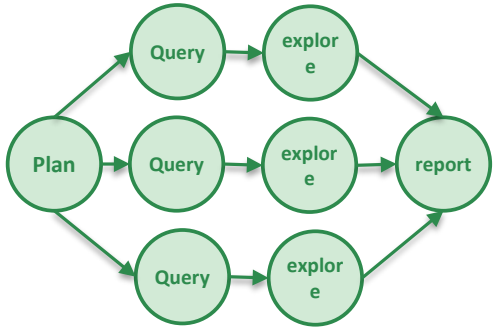
Code Agent



Claude Code w/ subagents

→ N – 1 handoffs

Deep Research

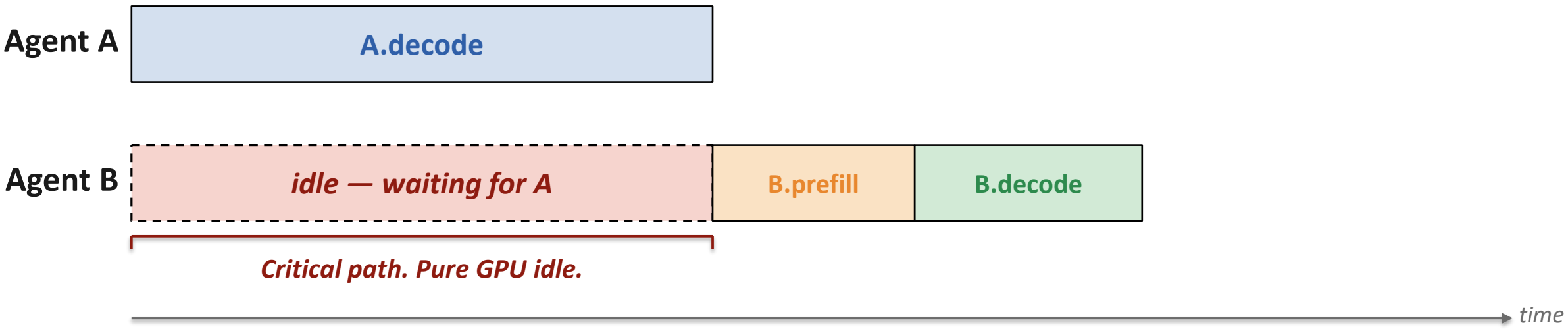


DeepResearch

→ N – 1 handoffs

Every handoff today costs a full prefill on the critical path.

The Hidden Bottleneck: Inter-Agent Idle Time



- Today, B starts prefill **only after A is fully decoded**.
- Existing serving sees **individual requests**, never the **dependency** between them.

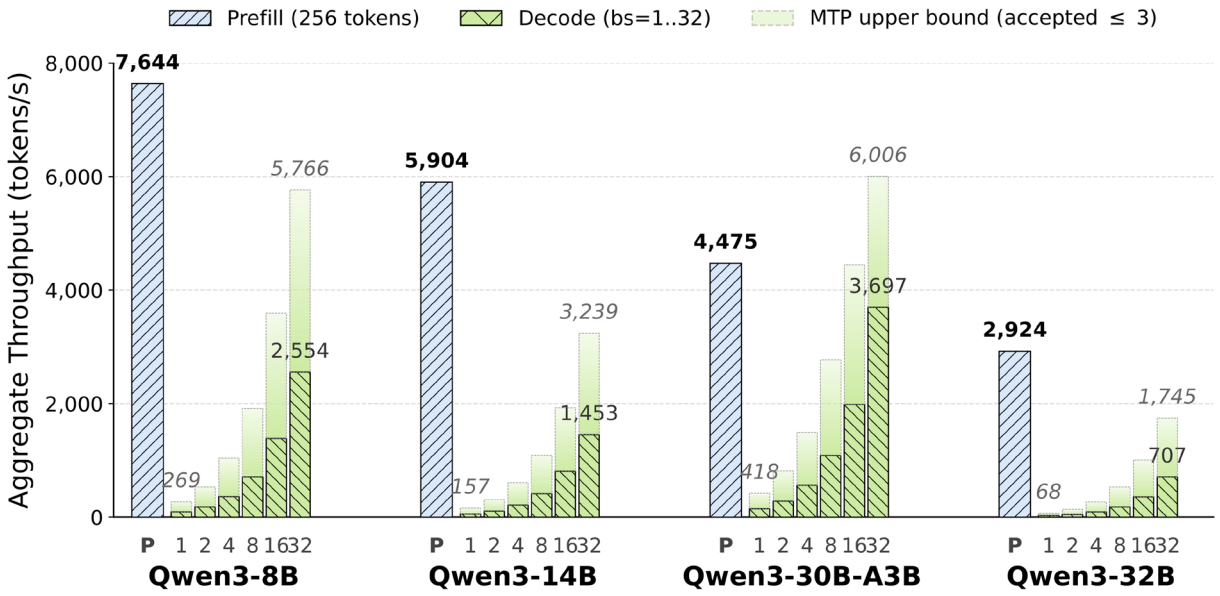
Existing Serving Misses the Inter-Agent Layer

Intra-Request	Cross-Request	Inter-Agent
Within one LLM call	*Across independent calls*	*Between dependent calls*
— FlashAttention — Paged KV cache — Prefill / decode disagg. — Chunked prefill	— Continuous batching — RadixAttention prefix cache — Speculative decoding(n-gram lookup)	— A.decode → B.prefill handoff — Concurrent shared-prefix reuse — Position-stable prefetch
Well solved	**Well solved**	**Unaddressed**

Sequentially dependent requests are nobody's job today.

Decode is Slow, Prefill is Fast?

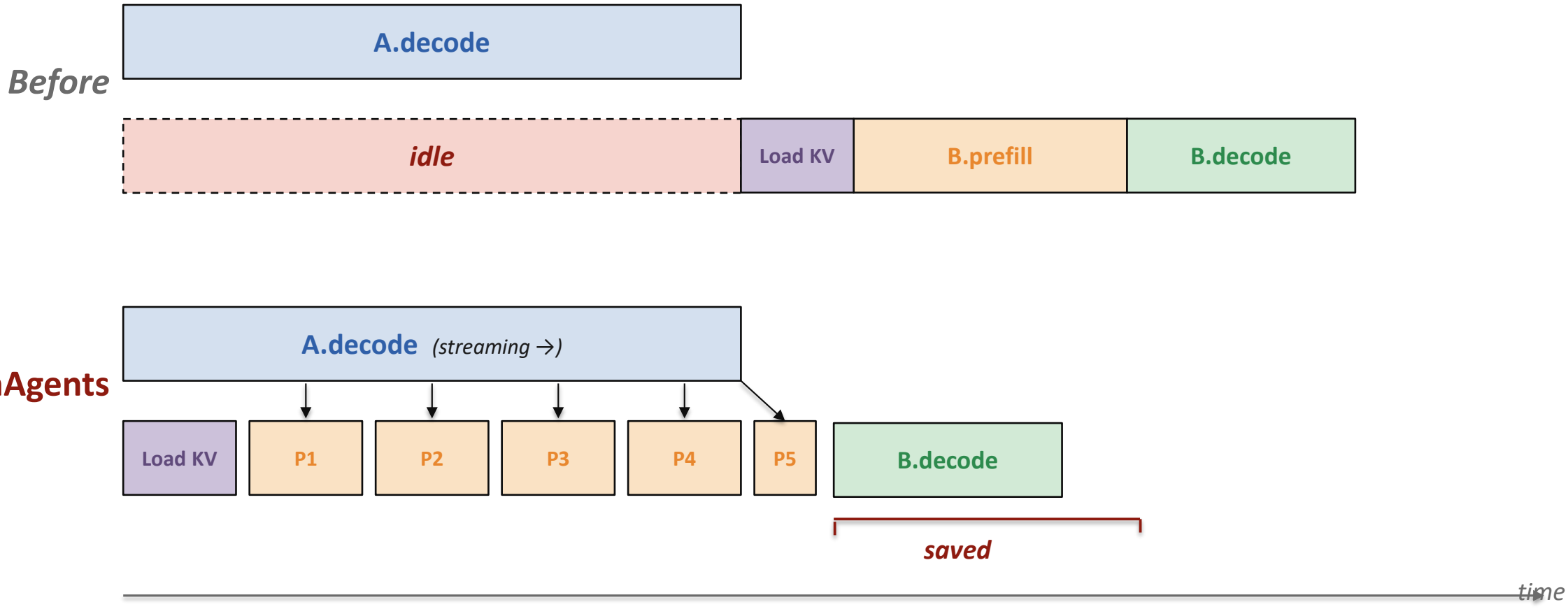
- **Gap is Shrinking:** Advanced decoding (MTP, SpecDec) and heterogeneous setups (SLM as subagent) speed up upstream generation.
- **Prefill isn't "Instant":** Concurrency stretches downstream compute time linearly.
- **Extra Downstream Workload:** B must prefill not just A's output, but extra system prompts, tools, and handle memory-bound KV cache loads.



Prefill vs. decode throughput (Qwen3 family, A100-80GB)

There is plenty of slack to overlap.

FlashAgents at a Glance



$$L = T_{decA} + T_{prefB} - T_{overlap} + T_{decB}$$

with $T_{overlap} \leq \min(T_{decA}, T_{prefB})$

Mechanism 1 — Inter-Agent Streaming and Incremental Prefill

- **Stream** A yields each token → per-pair buffer.
- **Trigger** buffer ≥ chunk size OR end-of-stream.
- **Incremental prefill** append-only KV growth, causal mask preserved.
- **Zero kernel change** — thin layer over SGLang's existing prefill path.

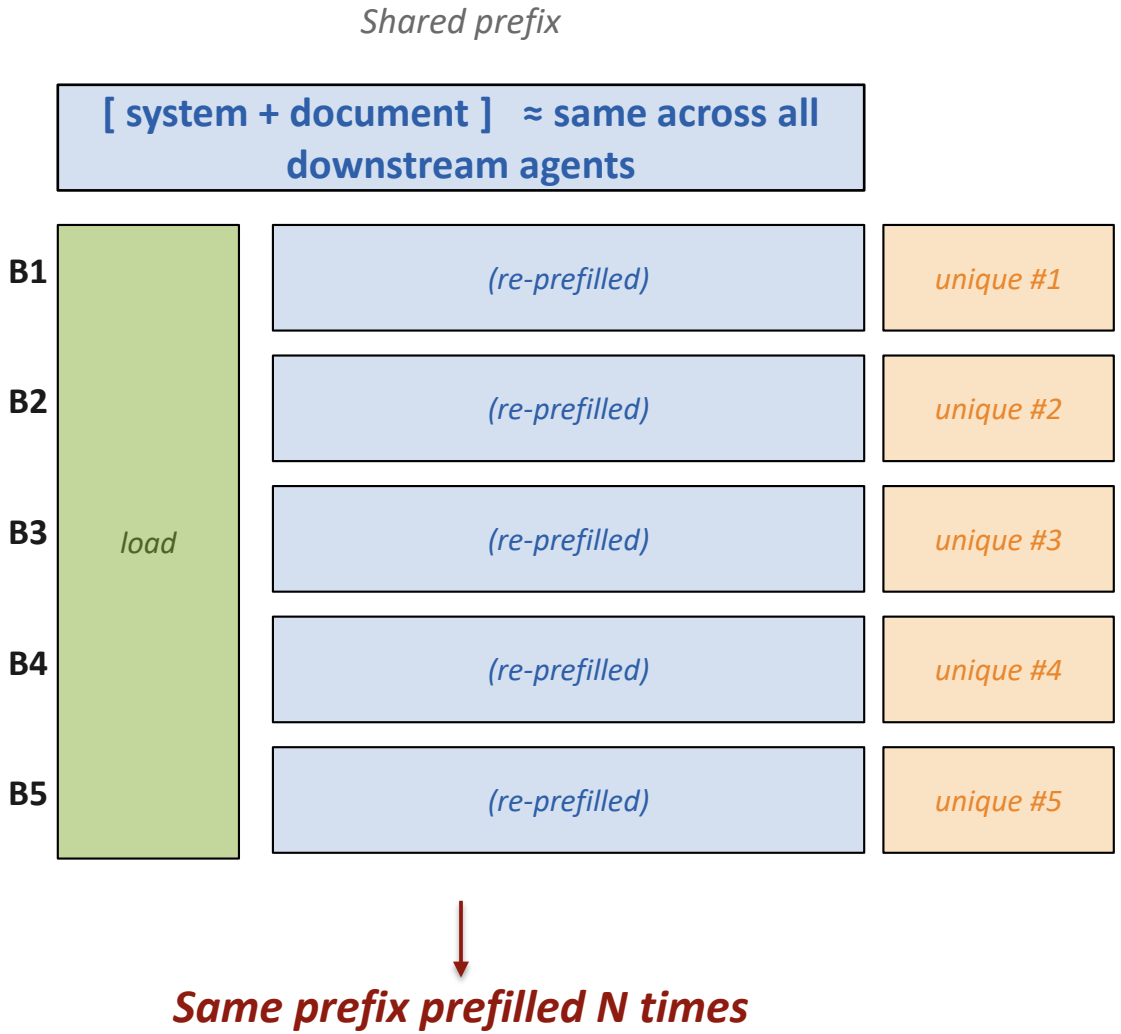
Core loop (per A→B pair)

```
buf, KV_B = [], {}

for tok in A.decode():
    buf.append(tok)
    if len(buf) >= chunk or tok.eos:
        KV_B = incPrefill(buf, KV_B)
        buf = []

return B.decode(KV_B)
```

Concurrency Reveals a Second Problem

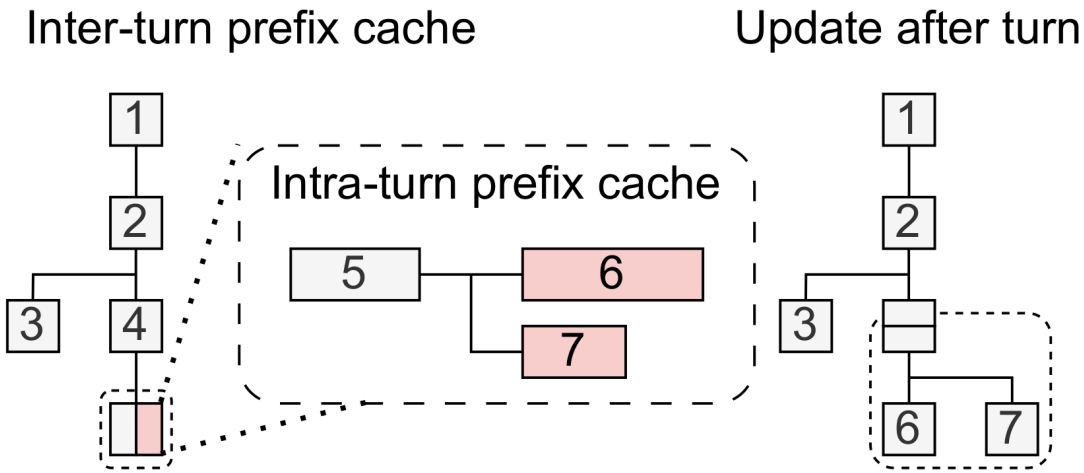


- Many downstream agents share the **same instruction + document**.
- Persistent prefix caches (RadixAttention) update ***after*** engine.step() completes.
- In-flight prefills **cannot reuse each other** within an engine.step() .
  - → *same shared prefix re-computed up to N times.*

Mechanism 2 — Intra-Turn Prefix Cache

- At each trigger, build a **temporary radix tree** over buffered tokens.
- Compute each **unique node once**; share KV across all paths.
- Persistent RadixAttention is **untouched** — we fill its blind spot for *in-flight* requests.

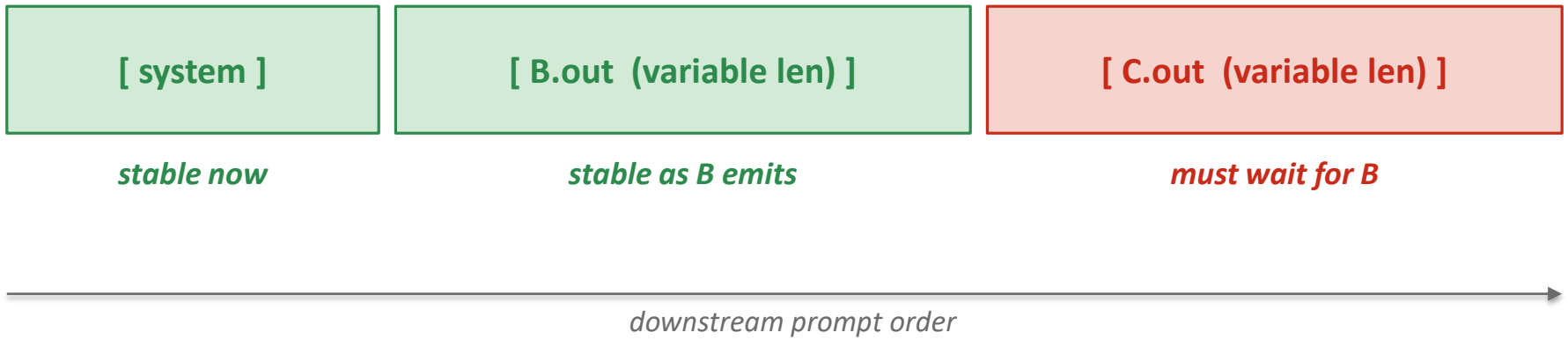
— *Linear time in total unbuffered tokens; bounded memory.*



Radix tree built at the trigger — unique nodes prefilled once, shared by all paths.

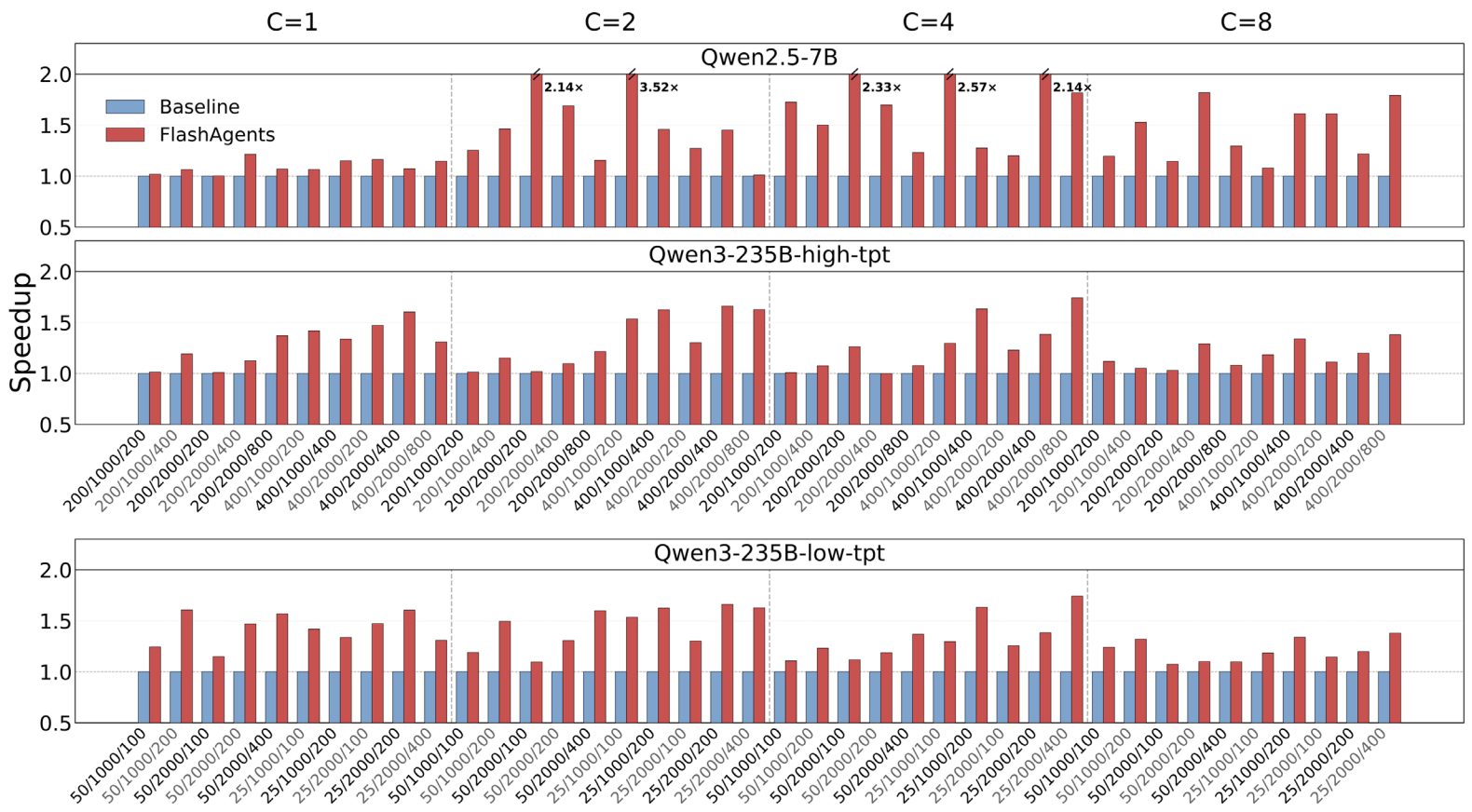
Reuse before requests finish — not after.

Correctness — Only Prefill Position-Stable Tokens



- RoPE / absolute positions: a token's KV depends on its **final index**.
- In fan-in, the tail of variable-length B-output **must wait** until B finishes — *then* we prefill it.
- FlashAgents is **conservative** — overlap is opportunistic, correctness is not.

Microbenchmark — Up to 3.52× Speedup



Sequential baseline vs. FlashAgents across 240 configurations.

3.52×

Peak speedup
(Qwen2.5-7B, C=2)

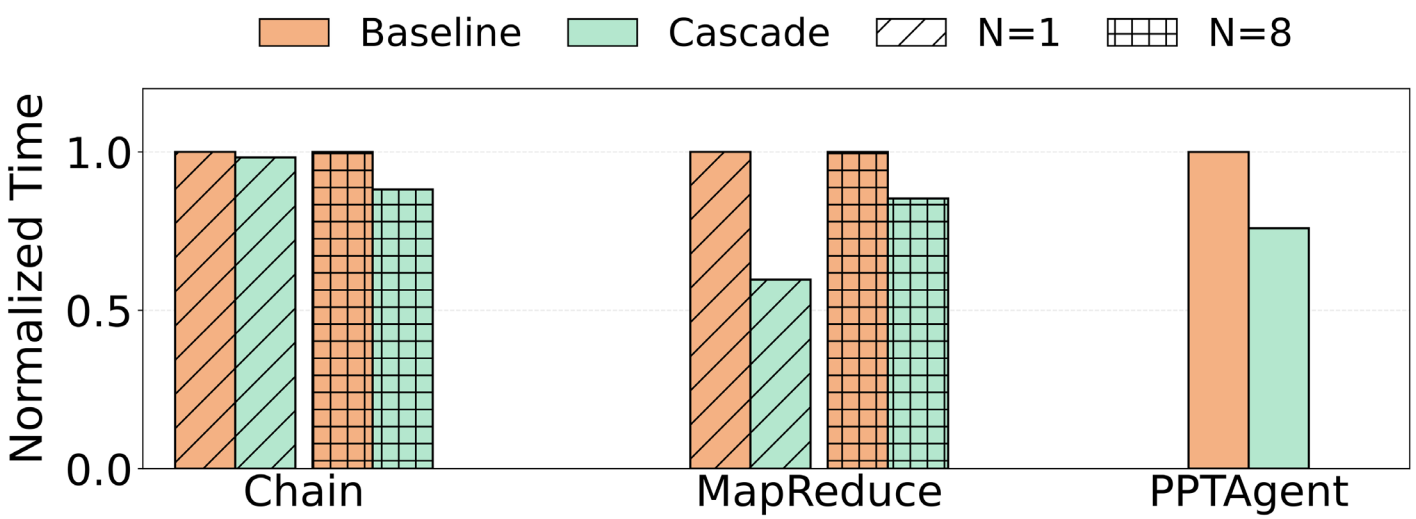
240/240

Configurations where
FlashAgents wins

1.05–3.5×

Speedup range across
models and concurrency

Real Workflows — Up to 40% Latency Reduction



Normalized latency on three end-to-end workflows.

Chain

4 agents · AutoGen

11.9% at N=8

MapReduce

3 reviewers + meta

40.3% (N=1) · 14.7% (N=8)

PPTAgent

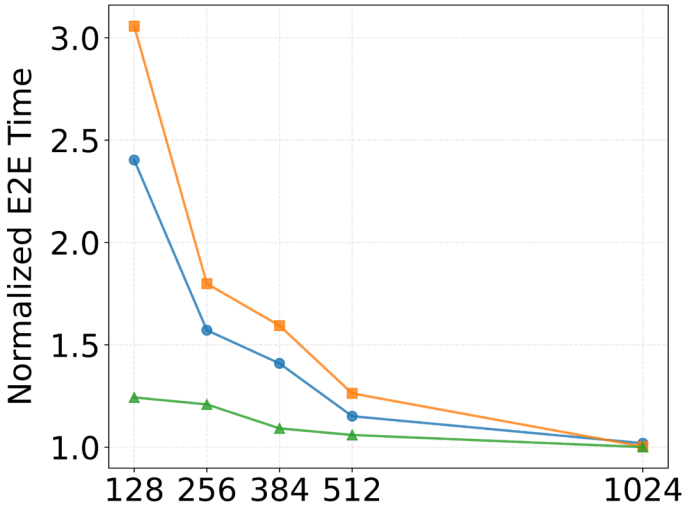
VL-7B → 14B · 2 GPUs

24.1% (1.32×)

Mechanism: pre-warm shared system+document prefix during upstream decode → hide most downstream prefill before the user-facing decode starts.

Take-aways

1. Multi-agent serving has a **new bottleneck — inter-agent idle time**.
2. **Streaming + incremental prefill** moves downstream state preparation (prefilling, KV cache loading) into upstream decode.
3. **Intra-turn prefix cache** scales the idea under concurrency.



Overhead vs. chunk size (1024-token context)

1.2× at chunk=512
KV-history alone: 4.6 – 7.9%

Schedule across agent boundaries — not just within requests.

THANKS