

Adaptive Batching Cuts Queue Delay in Community Sensor Gateways

Trace replay across twelve low-power edge nodes

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Version	Date	Short title
Camera-ready proceedings paper	2026-07-09	Adaptive batching at the edge

ABSTRACT A lightweight queue-aware batching rule reduced median gateway latency in trace replay while keeping radio wake-ups within the baseline energy budget.

Keywords

- edge computing
- sensor gateways
- adaptive batching

HIGHLIGHTS

- The controller uses only local queue depth.
- Trace replay covers bursty and steady workloads.

1. Introduction

Community sensor gateways face bursty uploads but operate under tight wakeup budgets. Fixed batches trade latency for energy; our contribution is a local rule that changes the batch target with queue pressure [1].

2. Method

We replayed 48-hour synthetic traces on twelve low-power nodes. Baseline batches held eight packets; the adaptive controller selected two to eight from the current

queue depth.

$$b_t = \min(8, \max(2, \lceil q_t/3 \rceil))$$

3. Results

Adaptive batching lowered median queue delay by 34% with a 2% increase in radio wakeups, remaining inside the preset 5% budget.

3.1 Gateway benchmark

Policy	Median delay	Wakeup / hour
Fixed batch	820 ms	18.4
Adaptive batch	541 ms	18.8

Gateway performance under burst traffic

Replay of 12 community-sensor gateways; median across five seeded runs

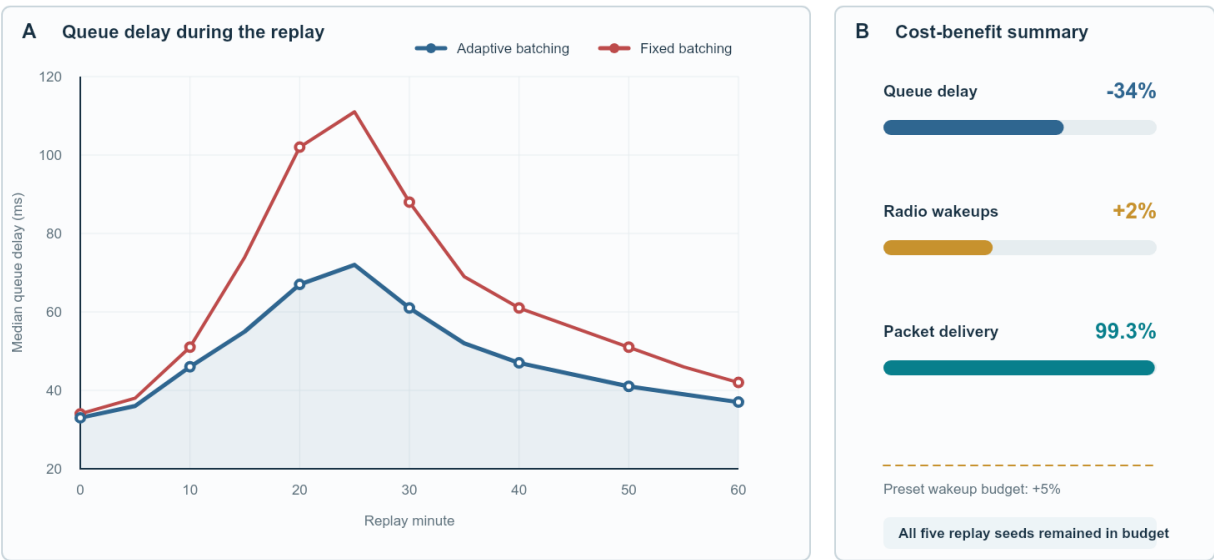


Figure 1 Adaptive batching at the edge



Figure 2 Workflow: Adaptive batching at the edge

The controller uses only local queue depth.^[1]

```
policy,delay_ms,wakeups_h
adaptive,541,18.8
```

4. Discussion

The rule is small enough for constrained gateways and needs no shared state. Future work should test packet loss and seasonal traffic rather than trace replay alone.

5. References

[1] Cedar Ridge Distributed Systems Lab. Gateway trace specification 1.2. Technical Note, 2026.

1. Synthetic gateway traces are included with the proceedings artifact. ↗

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Author contributions

M.O. designed the controller; L.C. ran the replay study; both authors wrote the paper.

Competing interests

The authors declare no competing interests.

Ethics statement

No human participants or personal data were involved.

Data availability

Synthetic gateway traces are included with the proceedings artifact.

Code availability

Controller and replay code are included with the proceedings artifact.

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