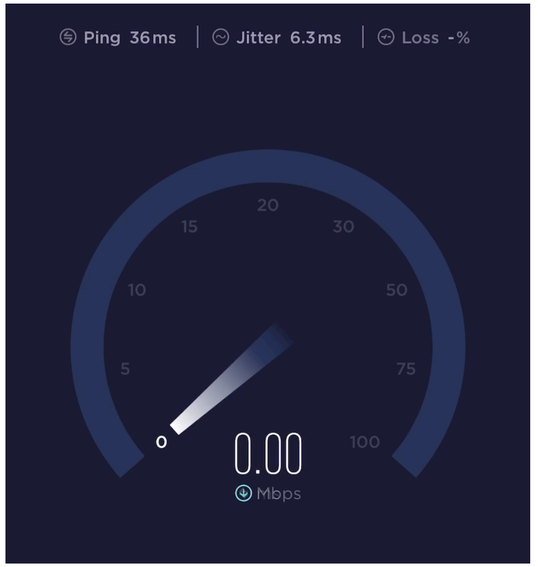
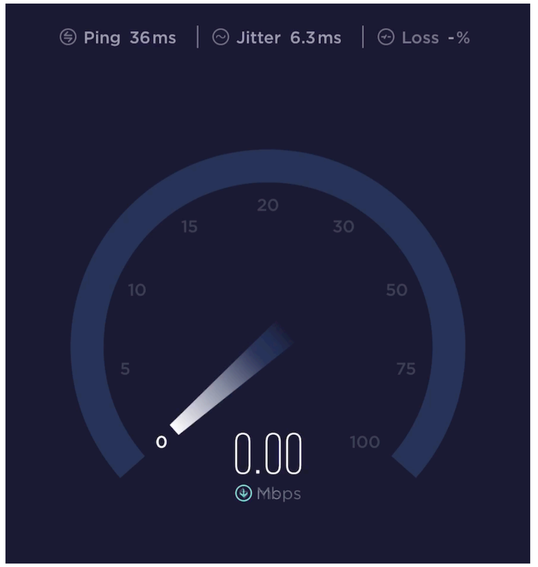
Detecting if LTE is the Bottleneck with BurstTracker

Arjun Balasingam, Manu Bansal, Rakesh Misra,
Kanthi Nagaraj, Rahul Tandra, Sachin Katti, Aaron Schulman

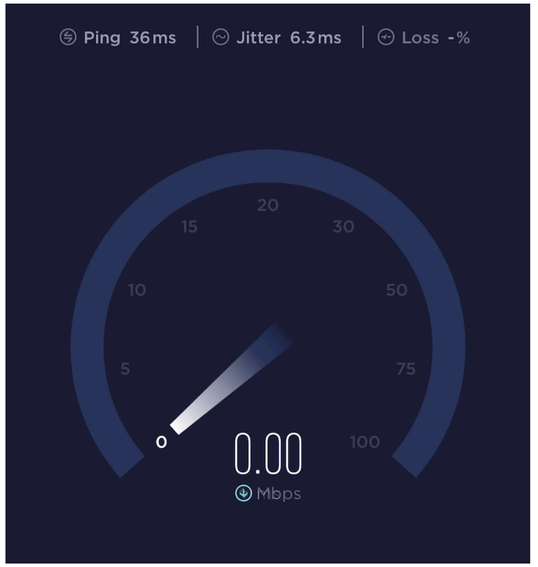
Diagnosing Poor Streaming Quality



Diagnosing Poor Streaming Quality

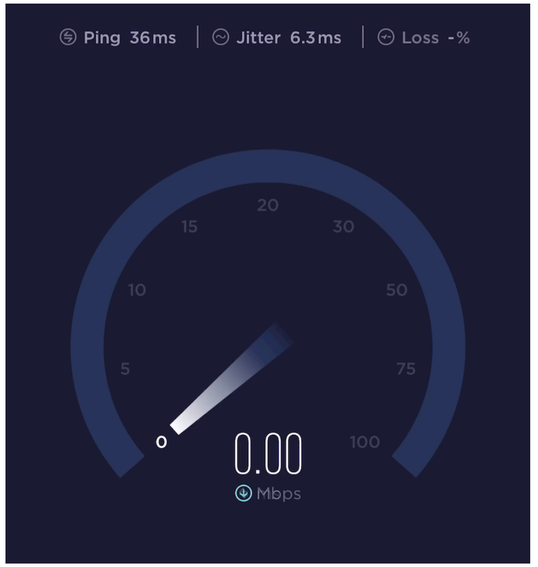


Diagnosing Poor Streaming Quality



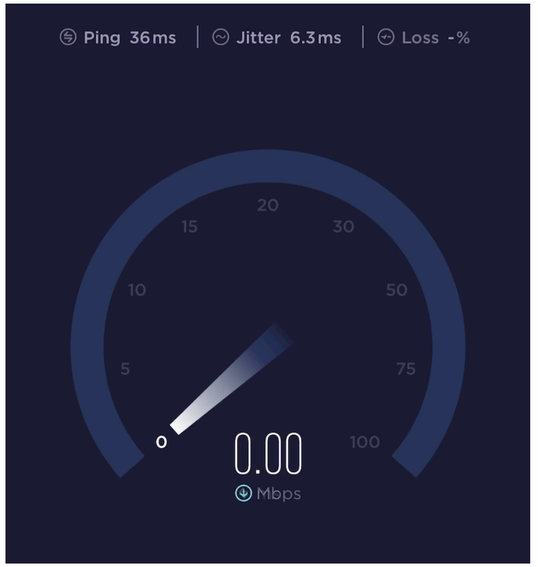
My video quality is only 360p (1.5 Mbps).
The cellular downlink must be slow.

Diagnosing Poor Streaming Quality



My video quality is only 360p (1.5 Mbps).
The cellular downlink must be slow.

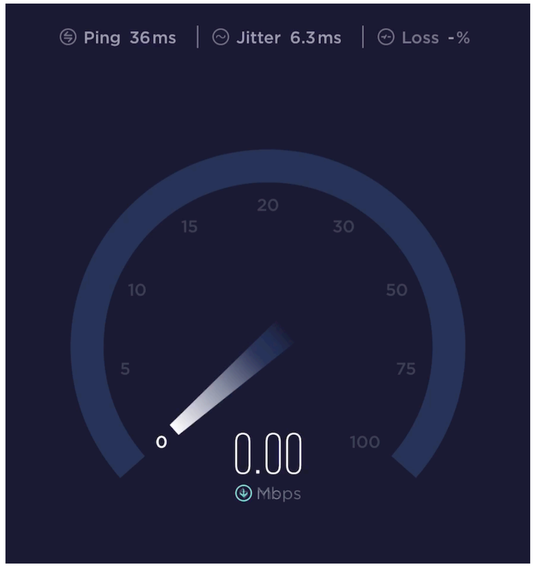
Diagnosing Poor Streaming Quality



My video quality is only 360p (1.5 Mbps).
The cellular downlink must be slow.

But a speed test says the downlink is **10 Mbps.**
What's going on?!

Diagnosing Poor Streaming Quality

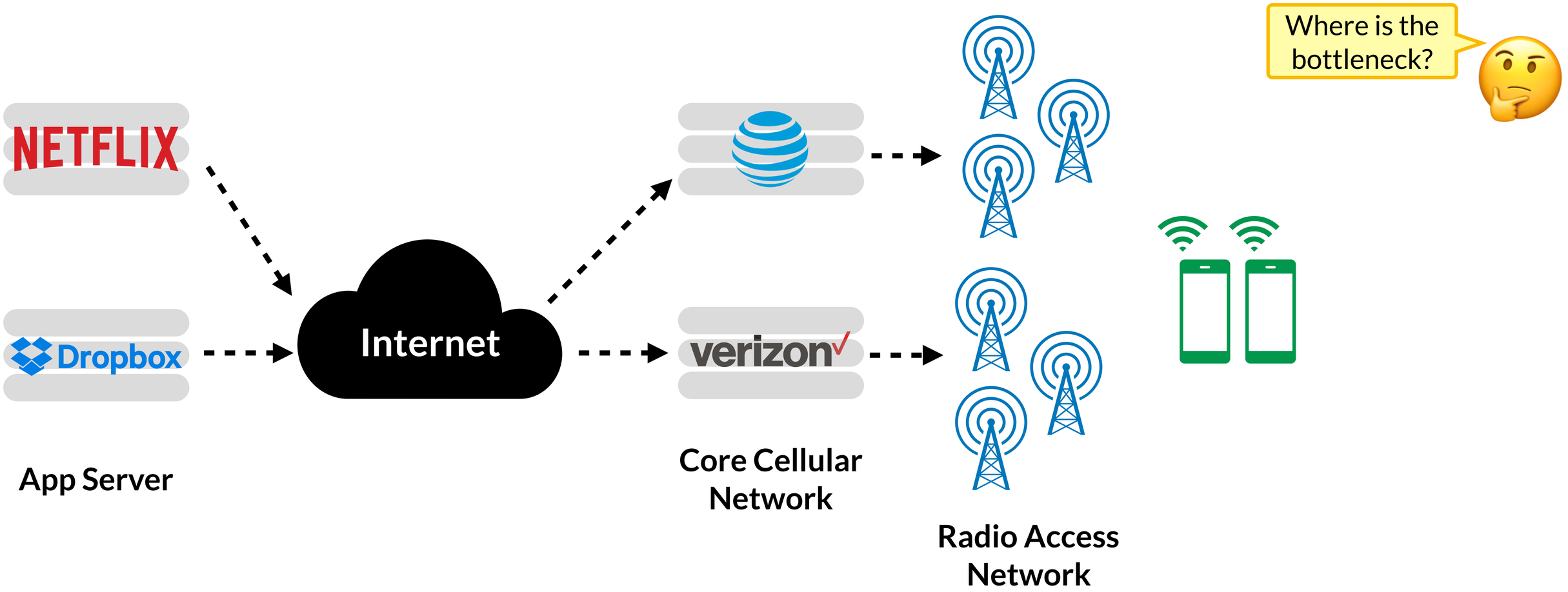


My video quality is only 360p (1.5 Mbps).
The cellular downlink must be slow.

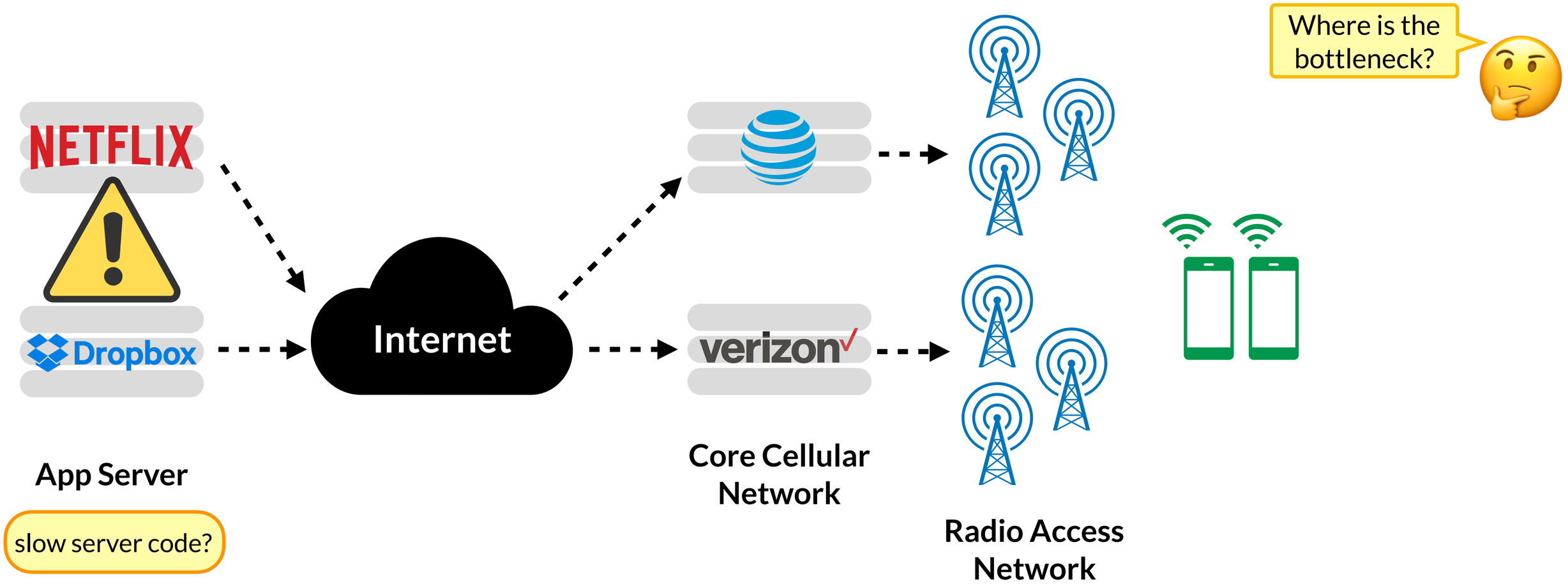
But a speed test says the downlink is **10 Mbps.**
What's going on?!

We can not conclusively determine if the cellular downlink is the bottleneck.

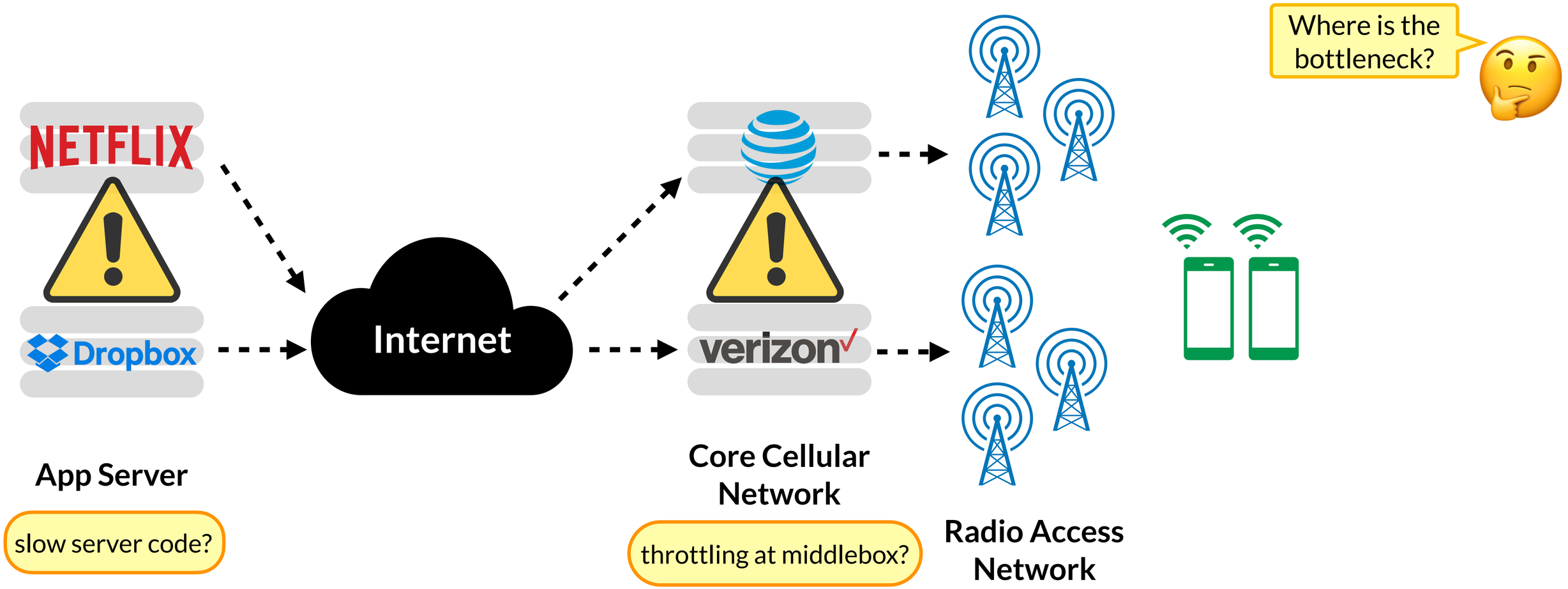
Network Topology of a Mobile App



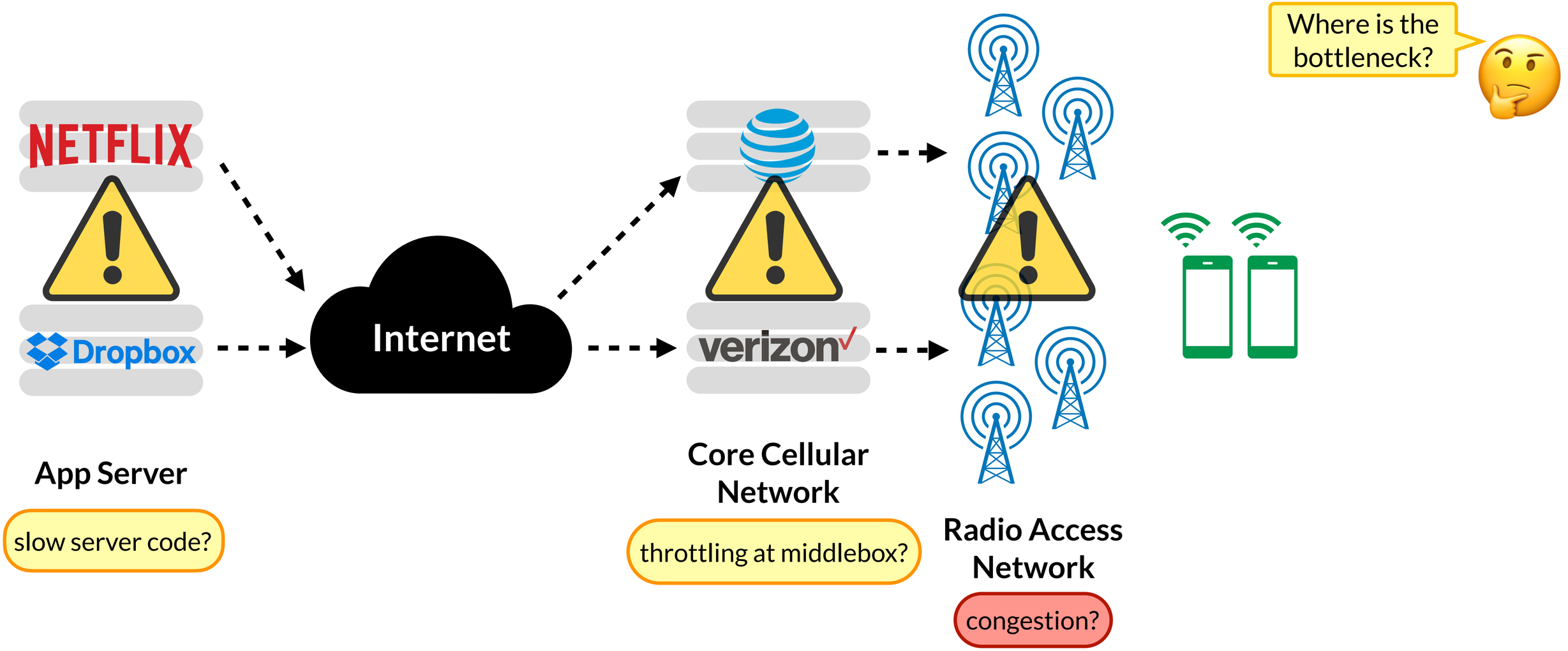
Network Topology of a Mobile App



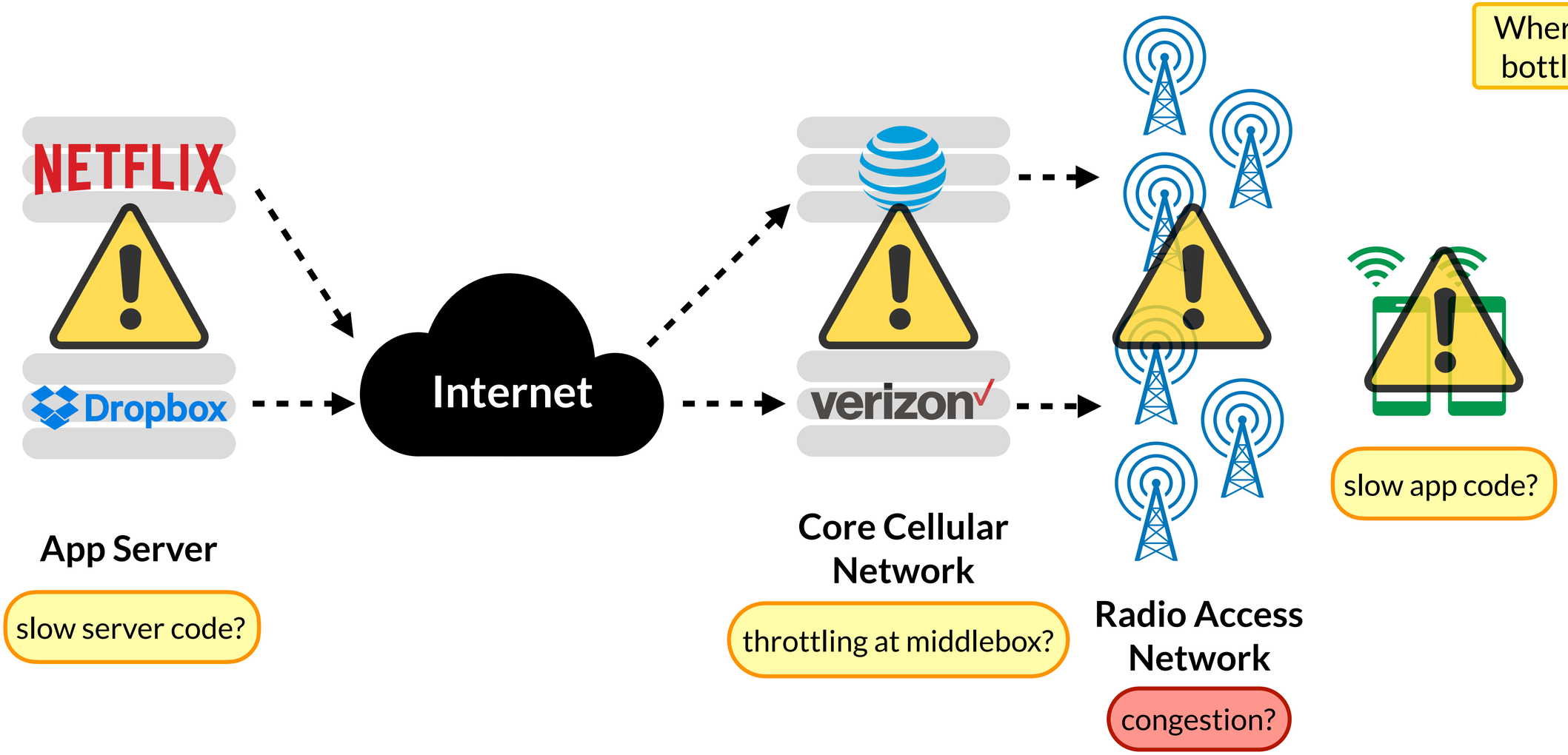
Network Topology of a Mobile App



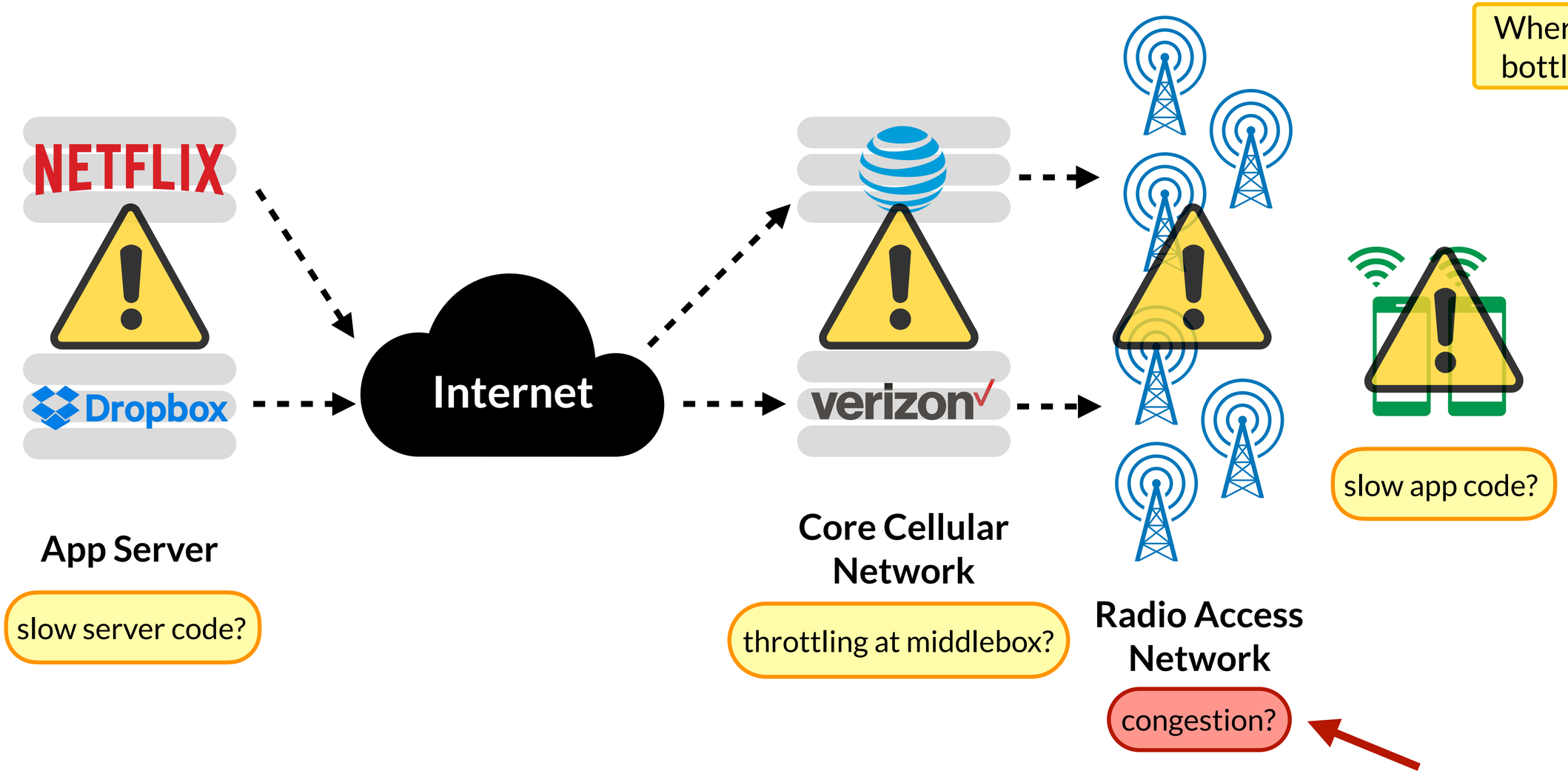
Network Topology of a Mobile App



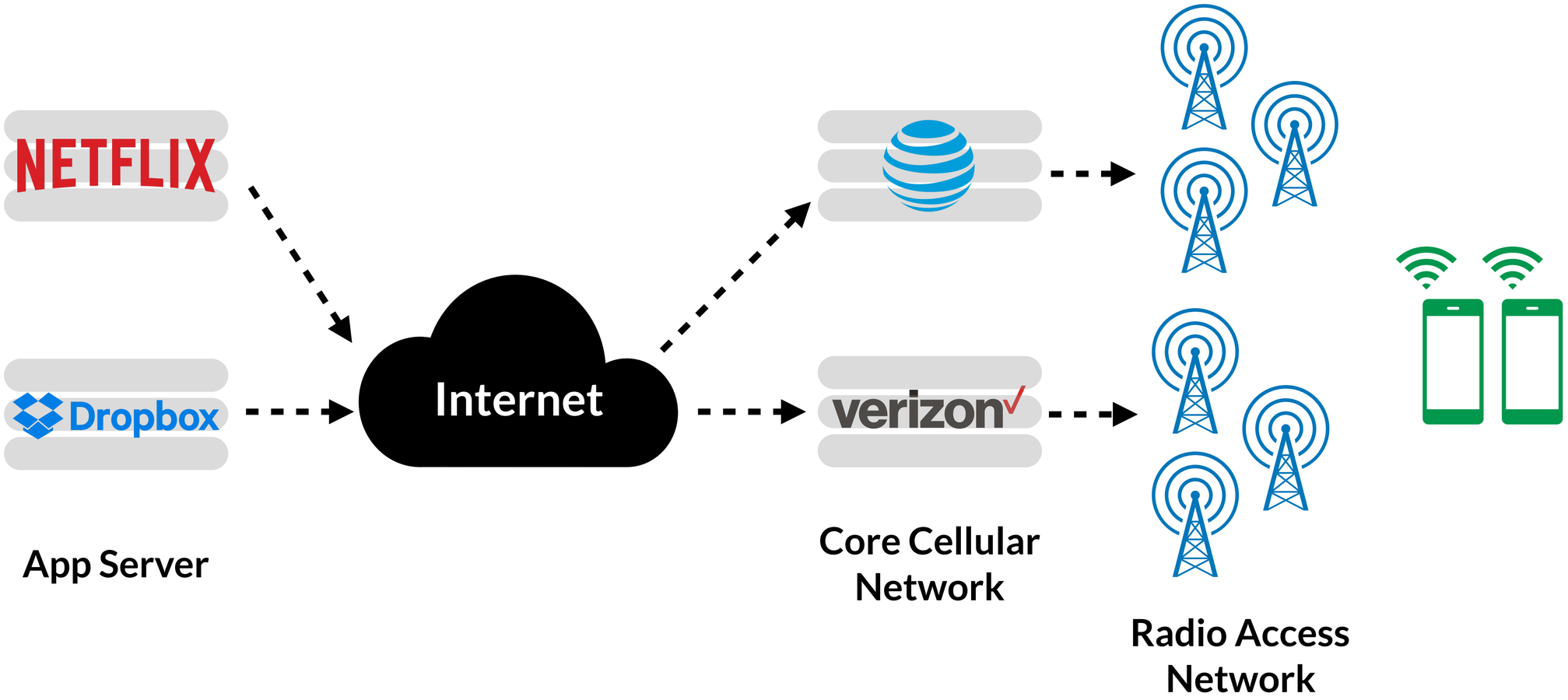
Network Topology of a Mobile App



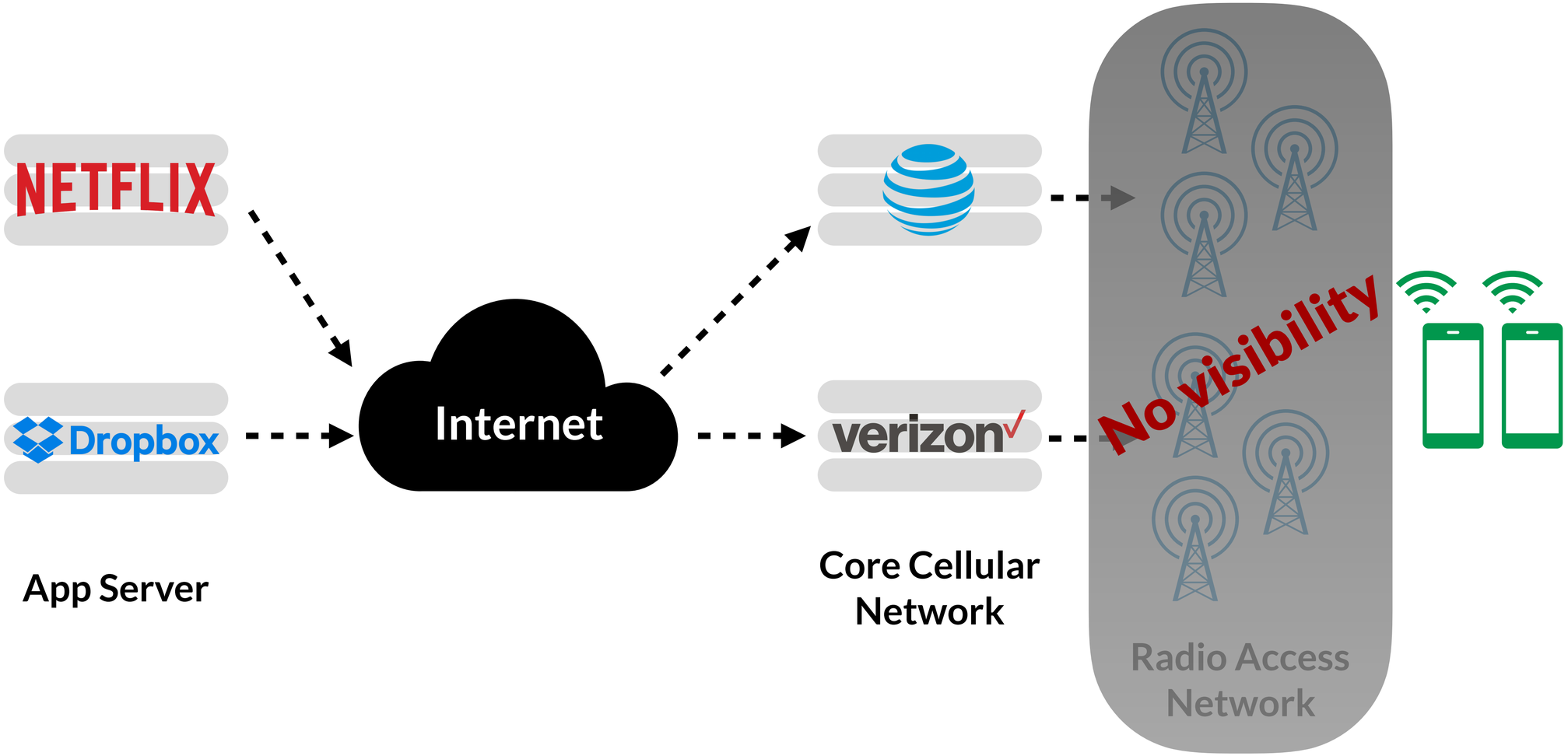
Network Topology of a Mobile App



A Developer's Perspective of Network Bottlenecks

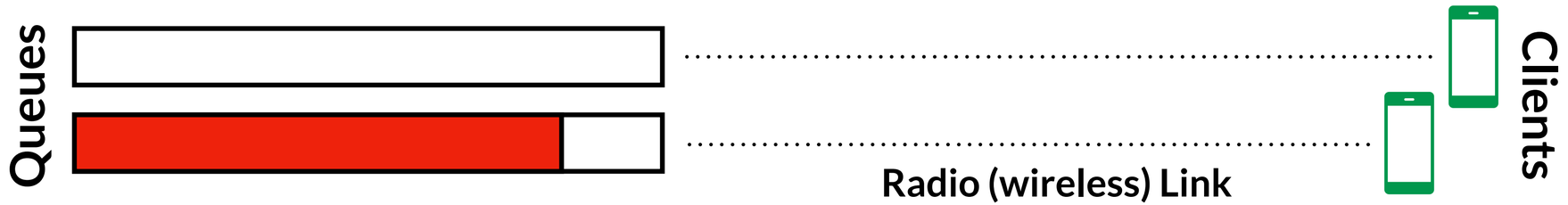


A Developer's Perspective of Network Bottlenecks



The Ideal Metric

Base Station



The Ideal Metric

Base Station

If empty, traffic bottlenecked ***on the way*** to the base station.

The Ideal Metric

Base Station

If empty, traffic bottlenecked ***on the way*** to the base station.

Queues

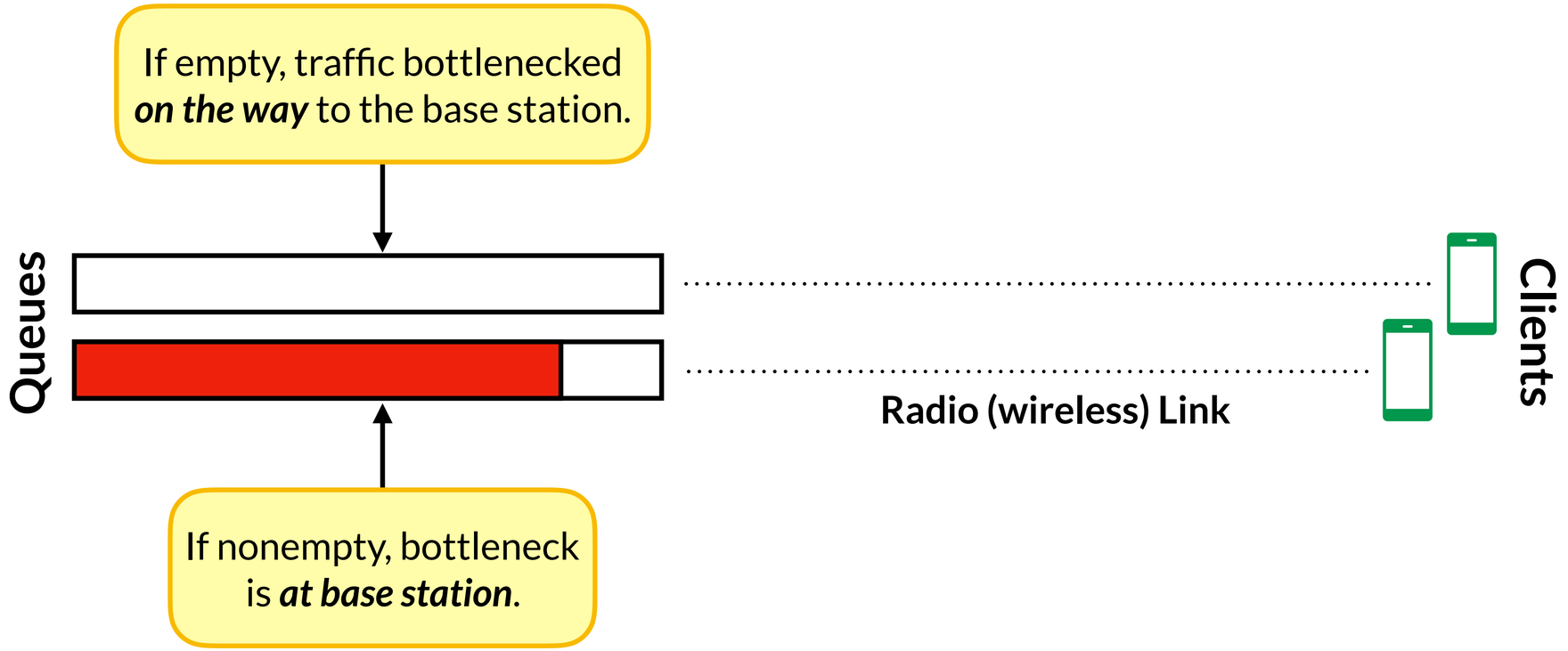
Clients

Radio (wireless) Link

If nonempty, bottleneck is ***at base station***.

The Ideal Metric

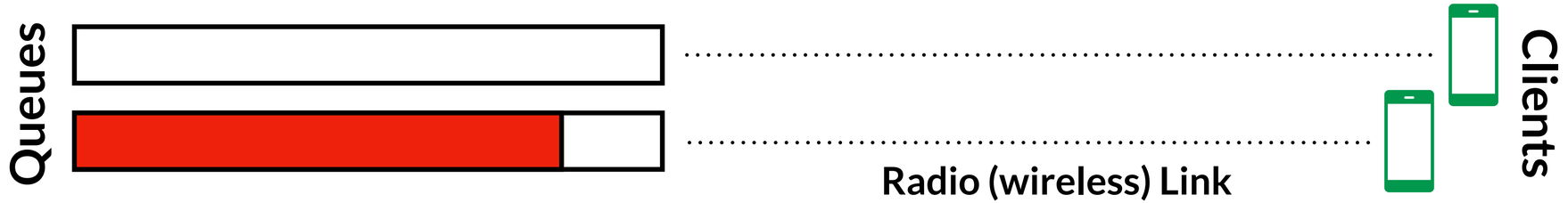
Base Station

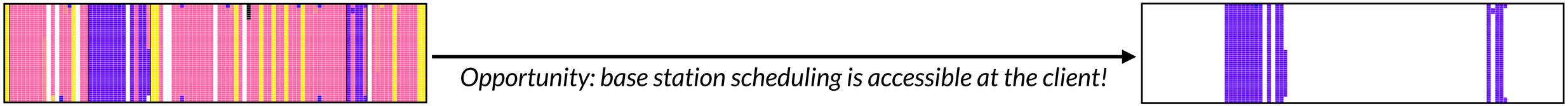


Providers know the status of the queues; but no one else does.
BurstTracker estimates this metric at the client.

The Ideal Metric

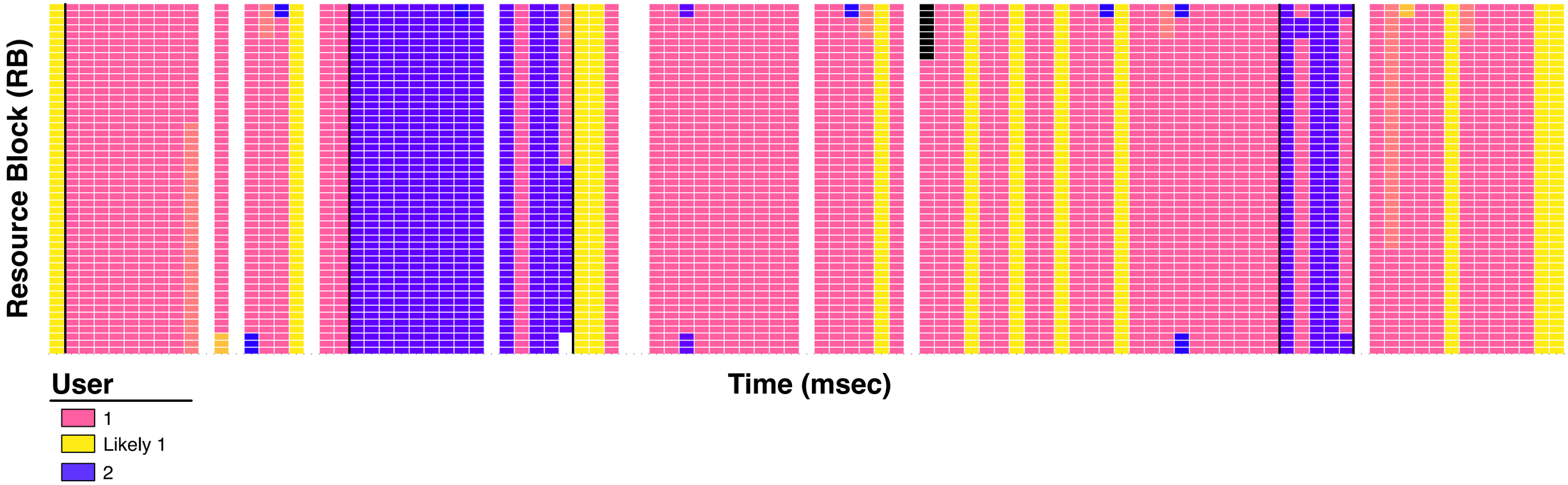
Base Station



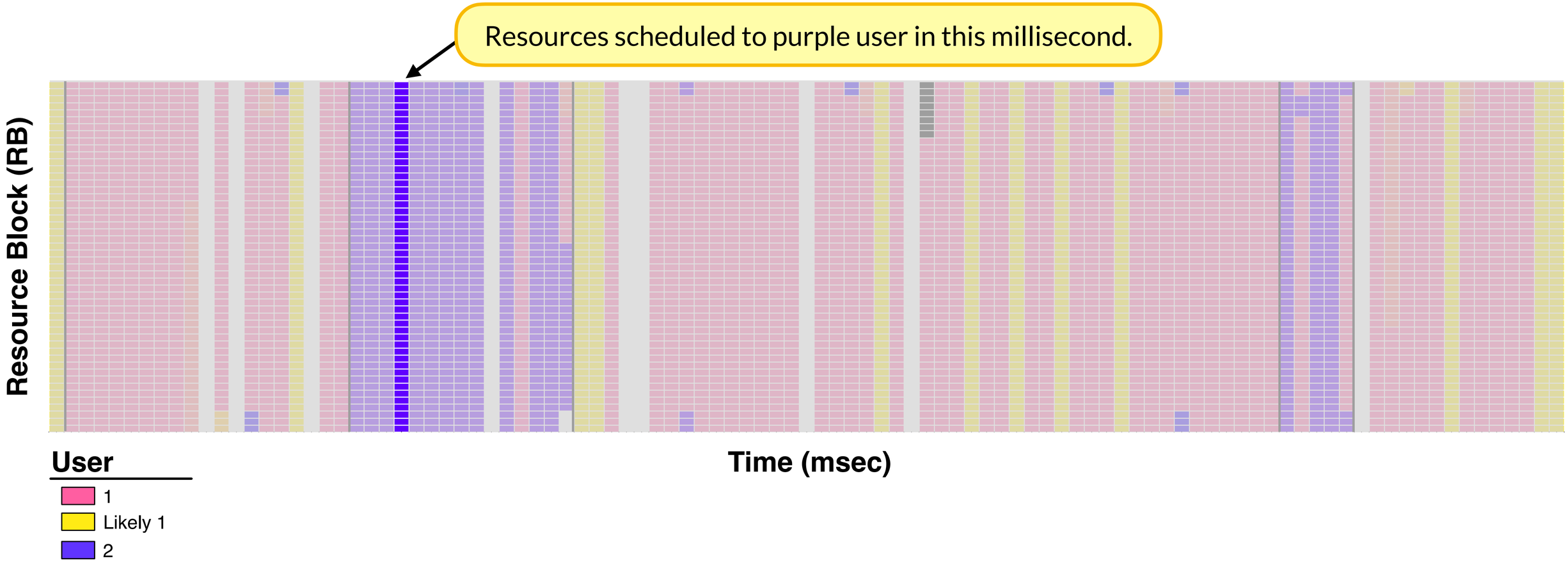


Providers know the status of the queues; but no one else does.
BurstTracker estimates this metric at the client.

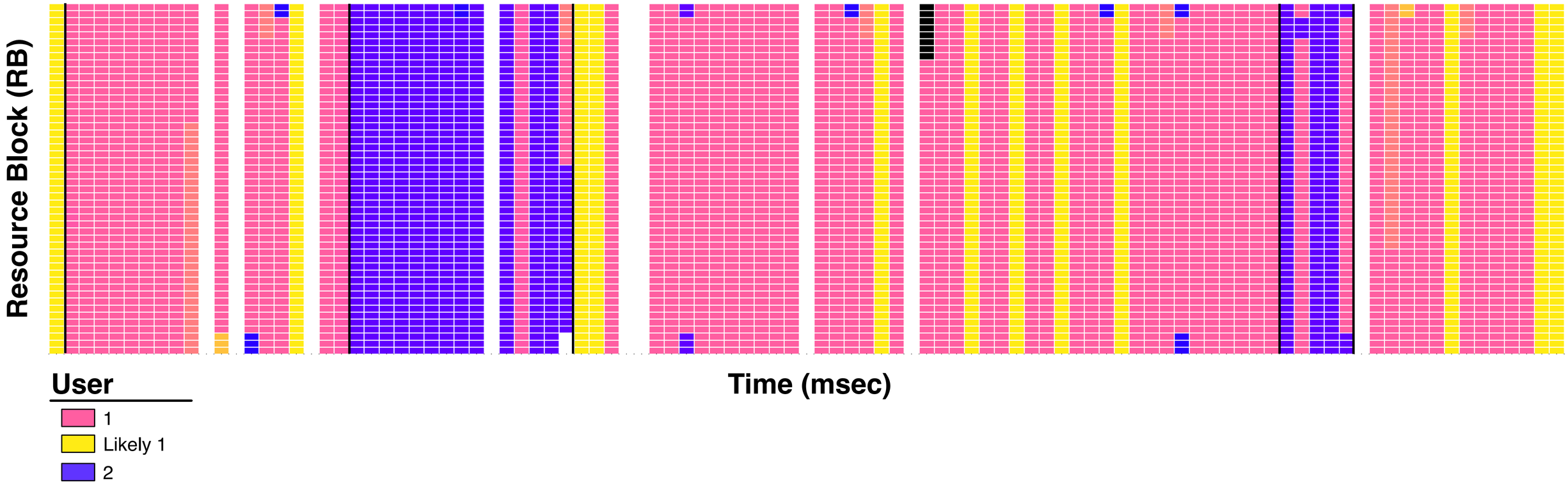
Resource Allocation Reveals Queue Status



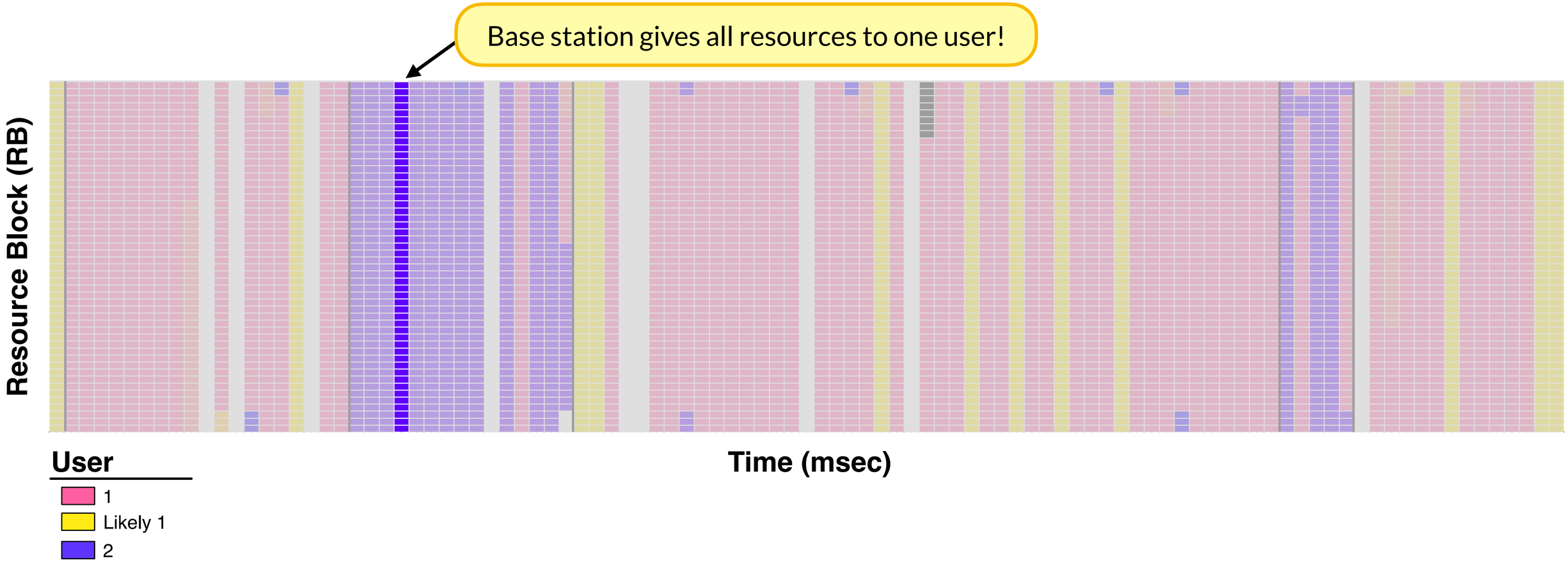
Resource Allocation Reveals Queue Status



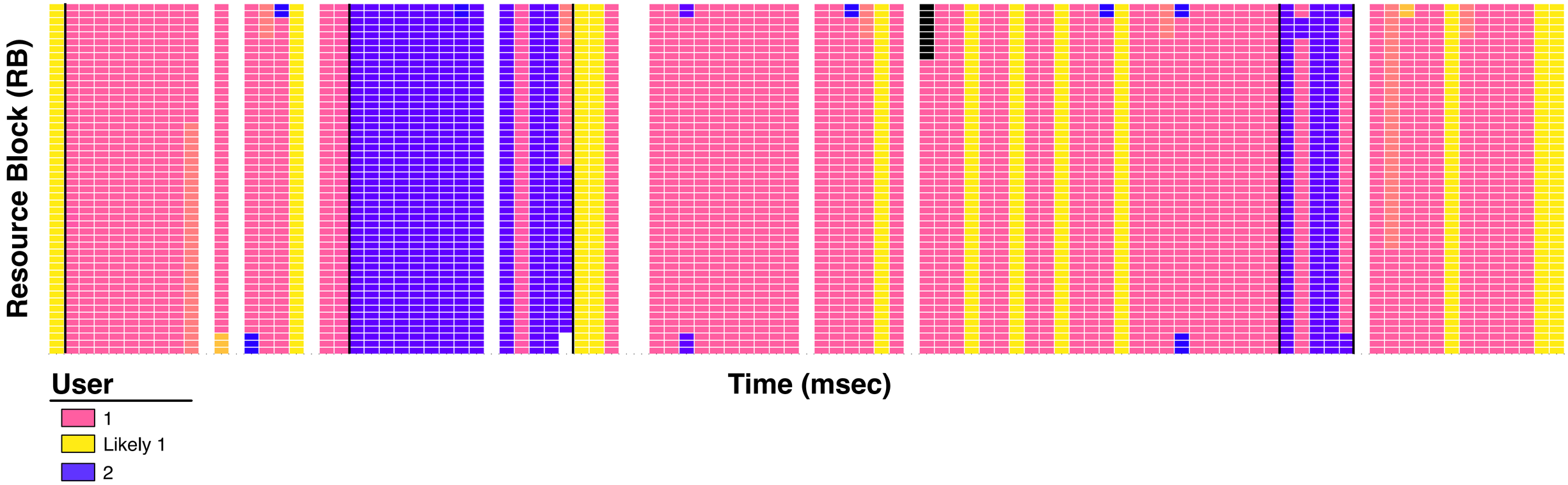
Resource Allocation Reveals Queue Status



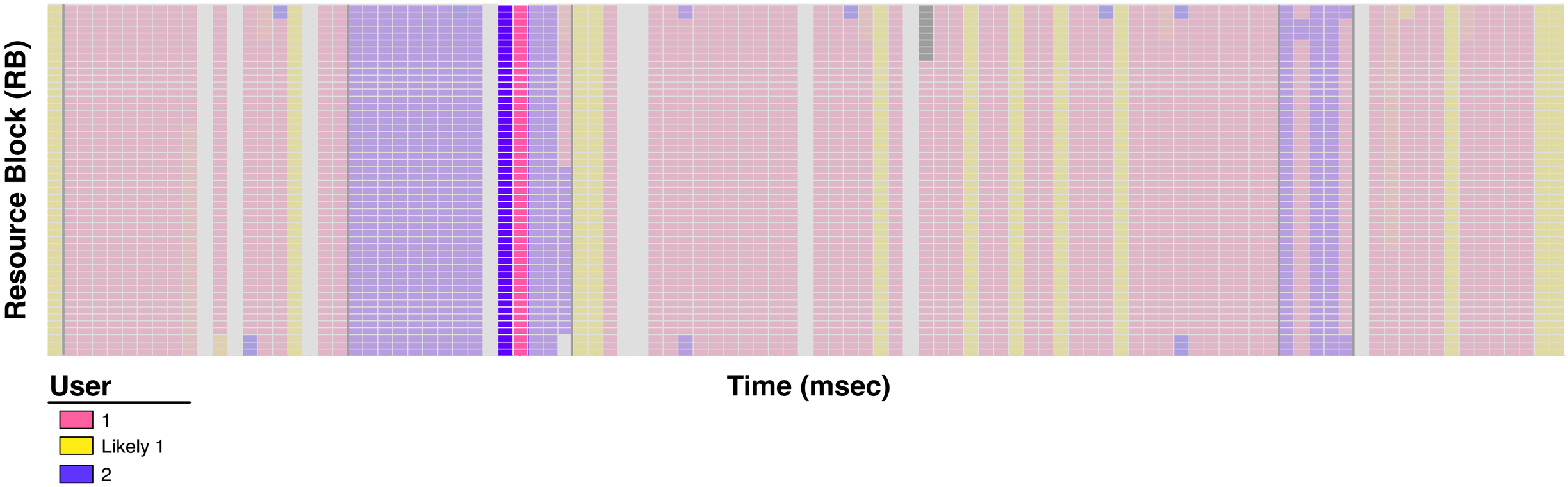
Resource Allocation Reveals Queue Status



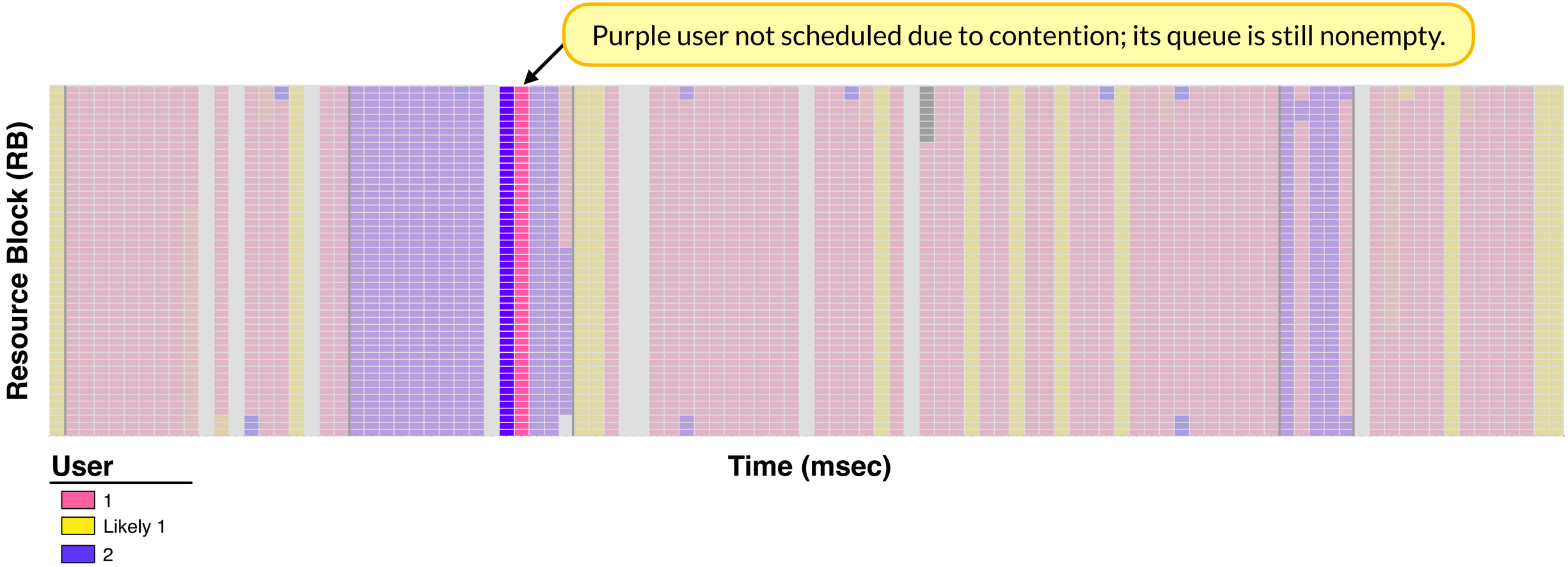
Resource Allocation Reveals Queue Status



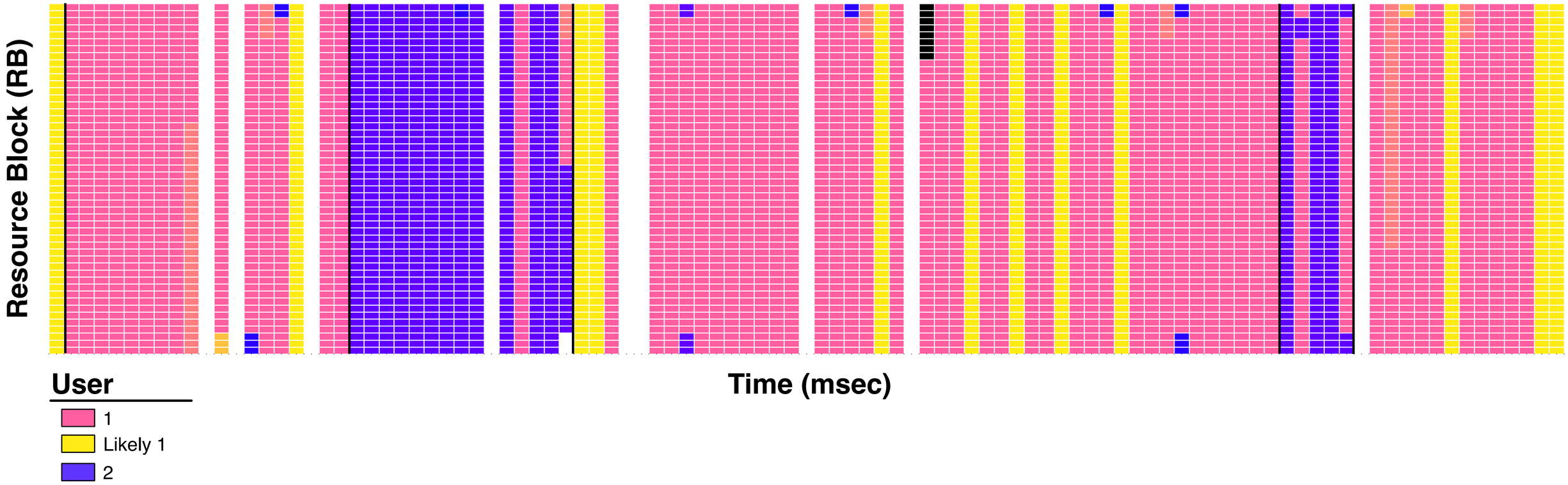
Resource Allocation Reveals Queue Status



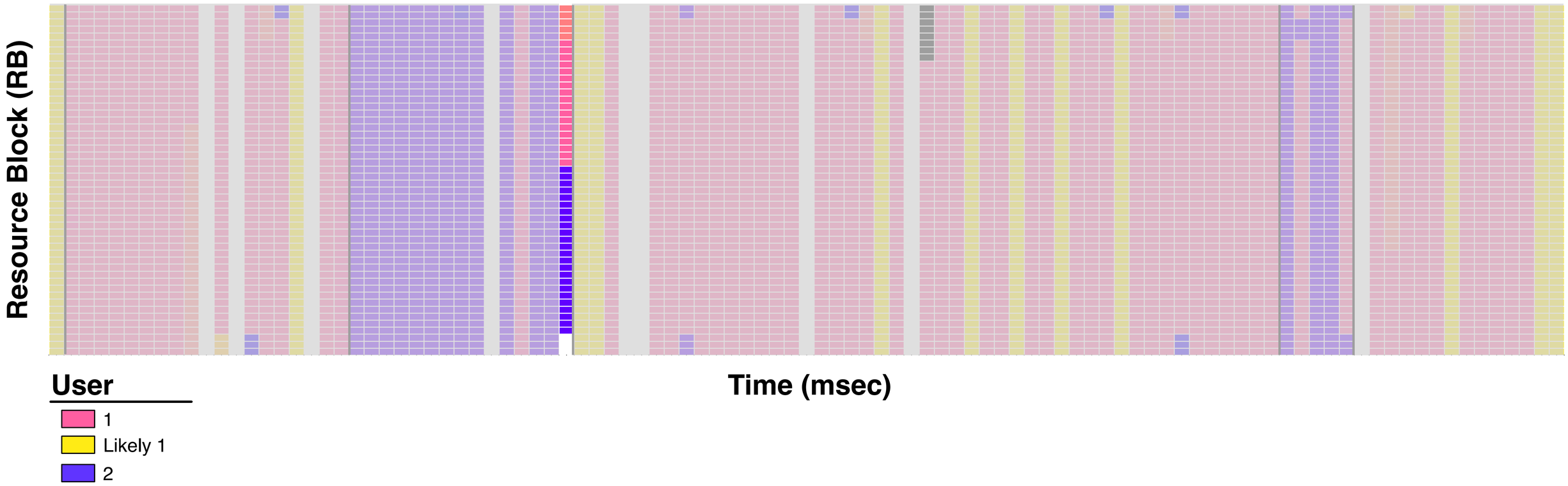
Resource Allocation Reveals Queue Status



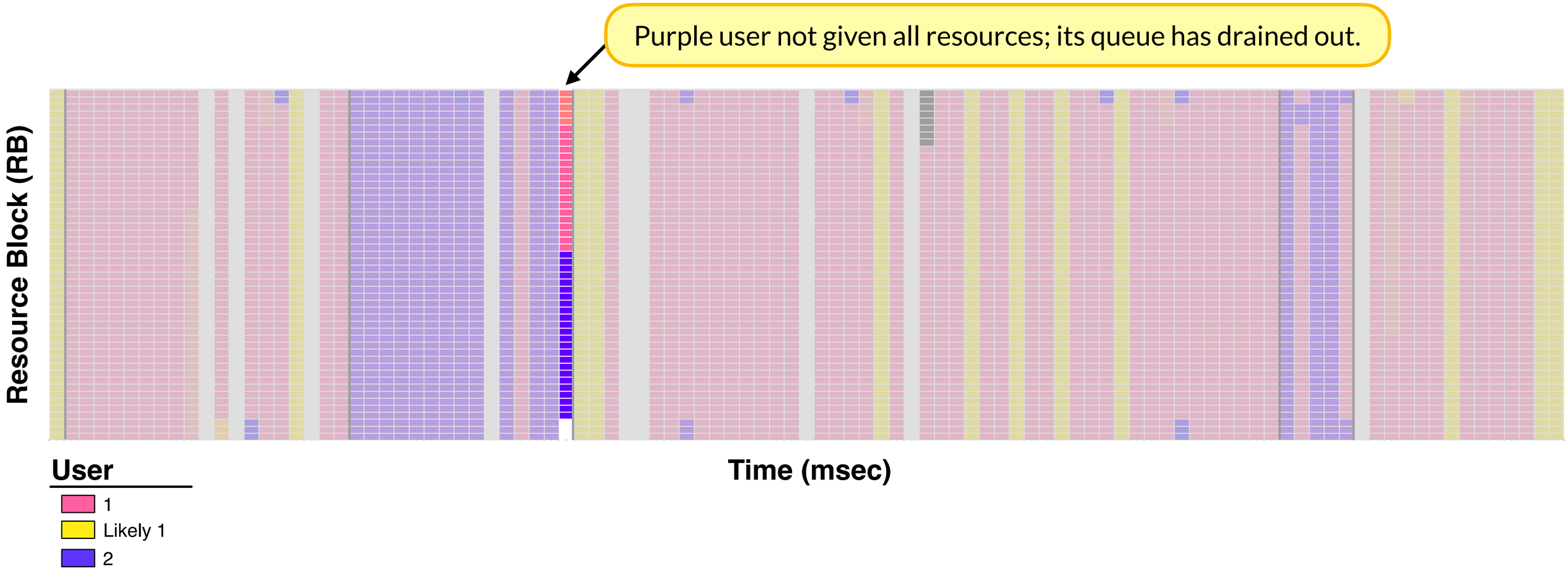
Resource Allocation Reveals Queue Status



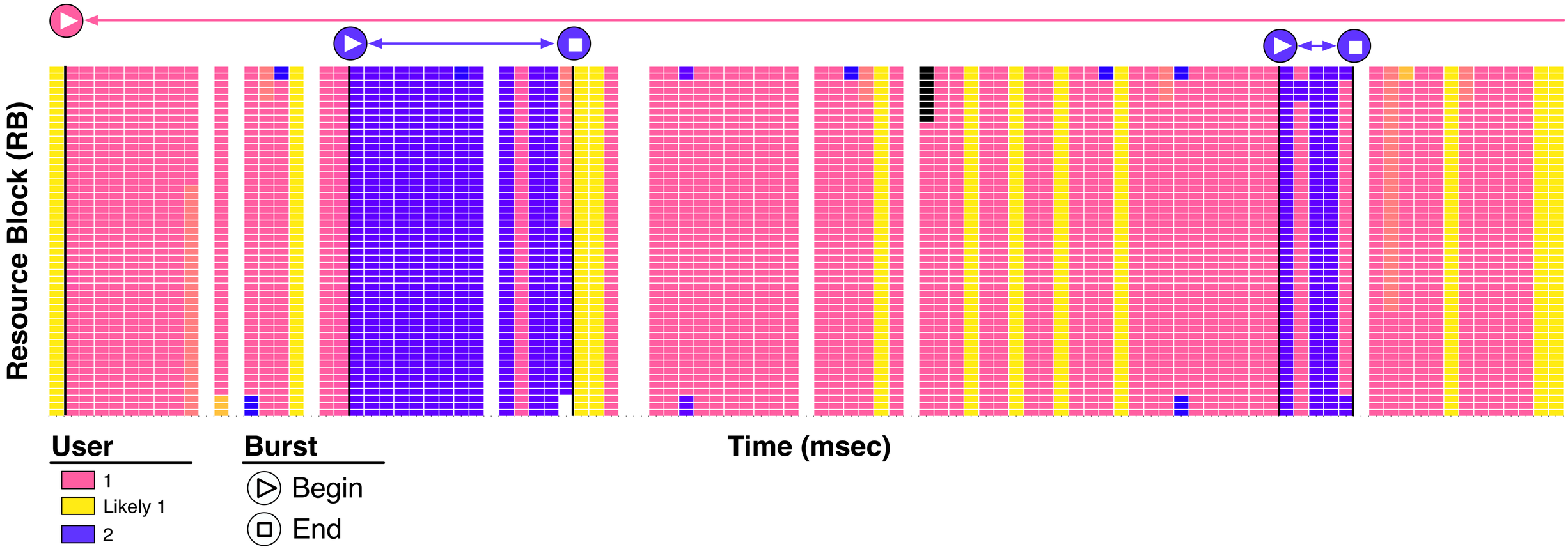
Resource Allocation Reveals Queue Status



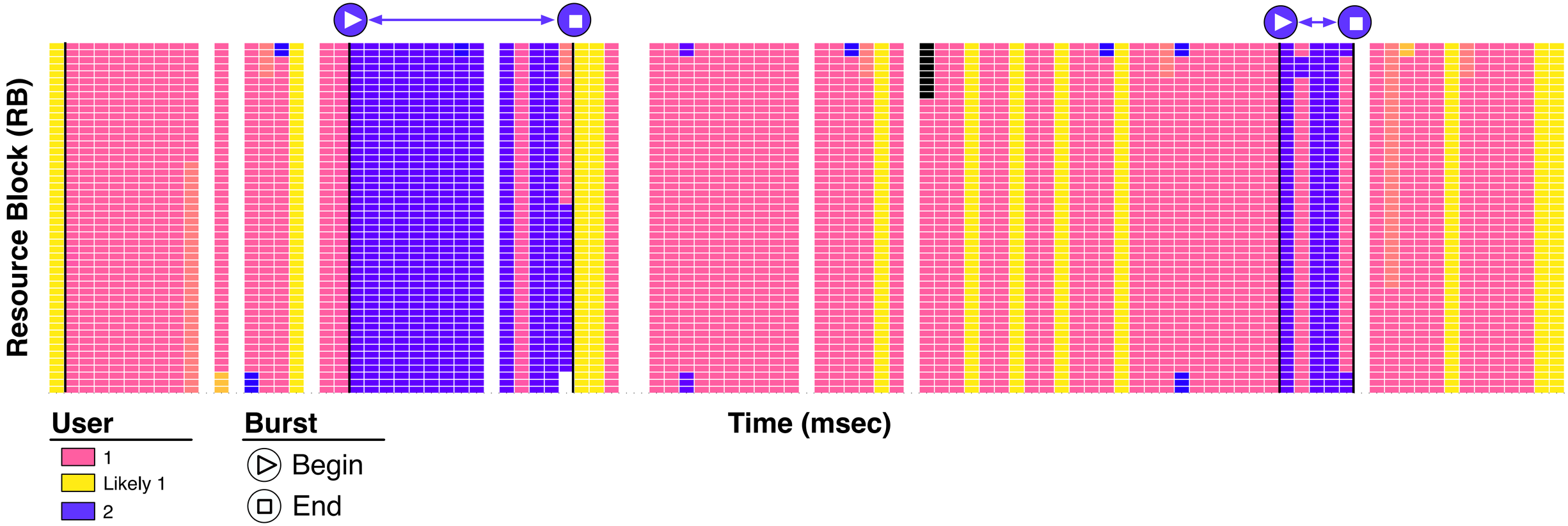
Resource Allocation Reveals Queue Status



Resource Allocation Reveals Queue Status

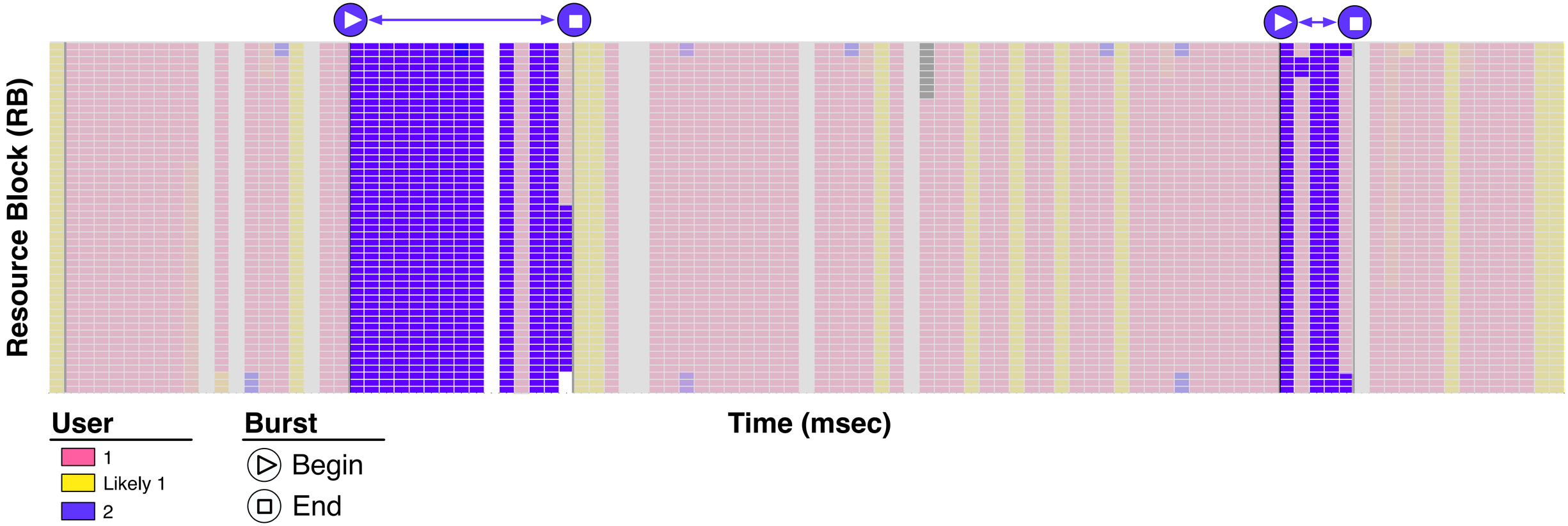


Resource Allocation Reveals Queue Status



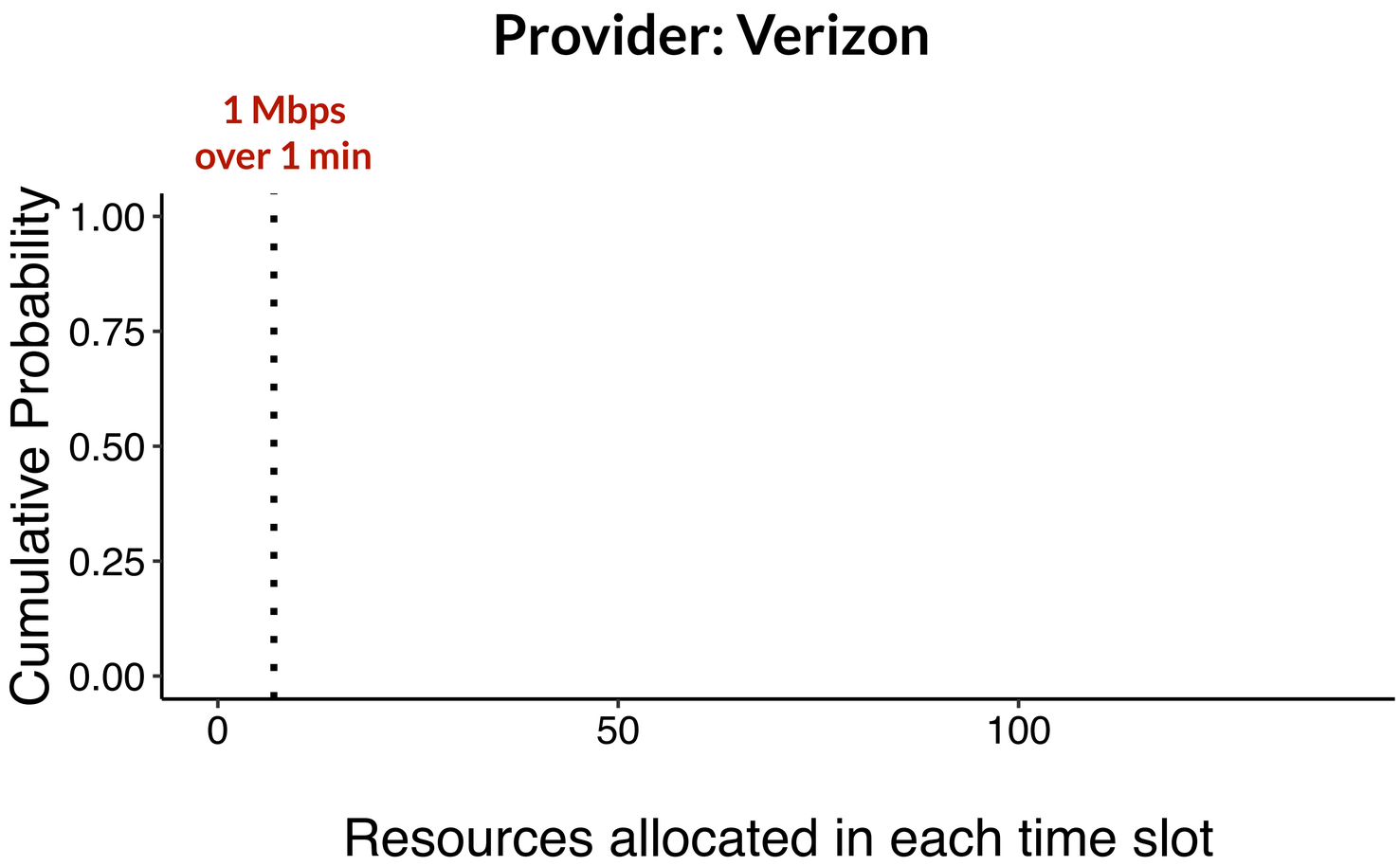
A user only needs to know their resource allocation to infer their queue status.

Resource Allocation Reveals Queue Status

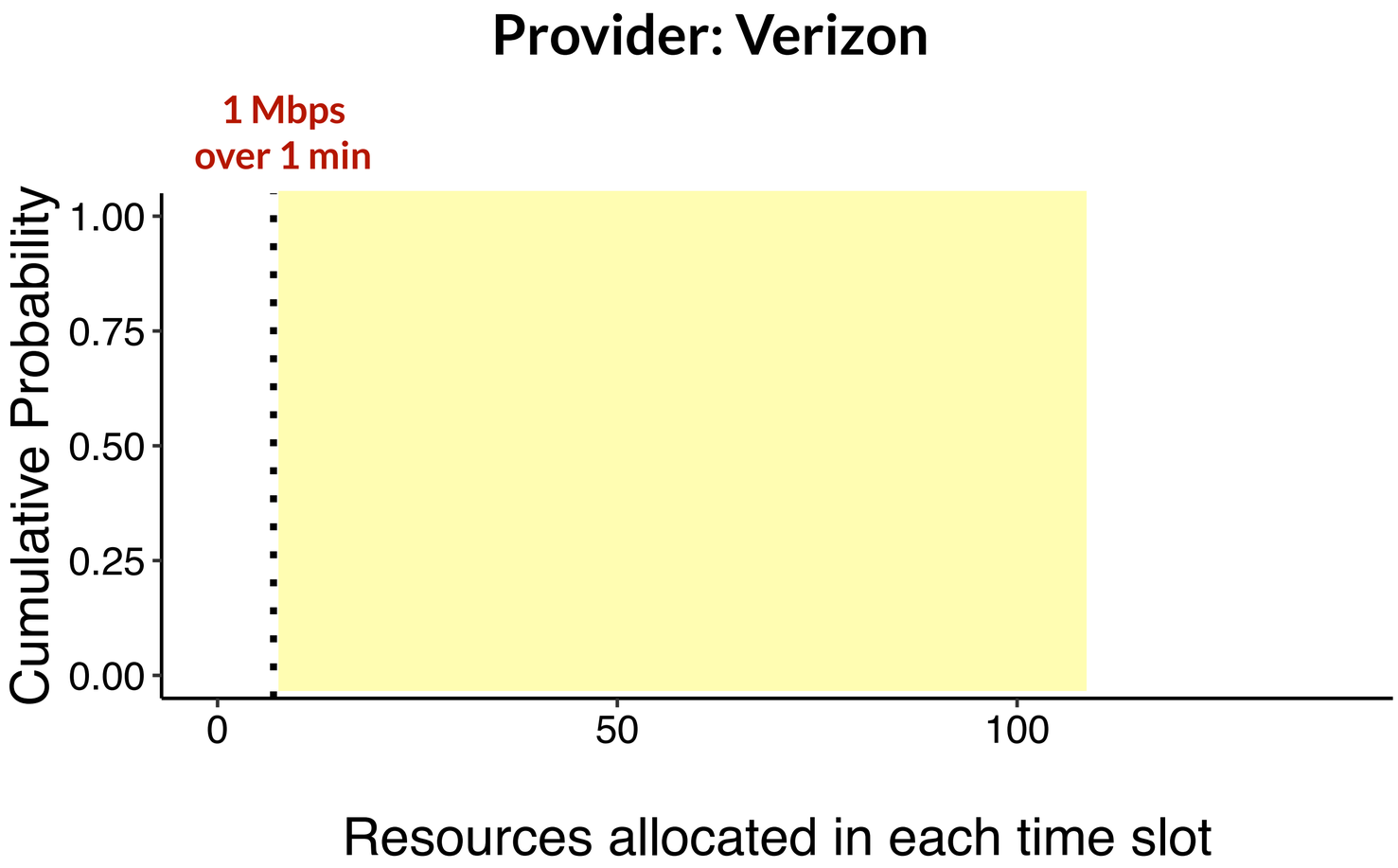


A user only needs to know their resource allocation to infer their queue status.

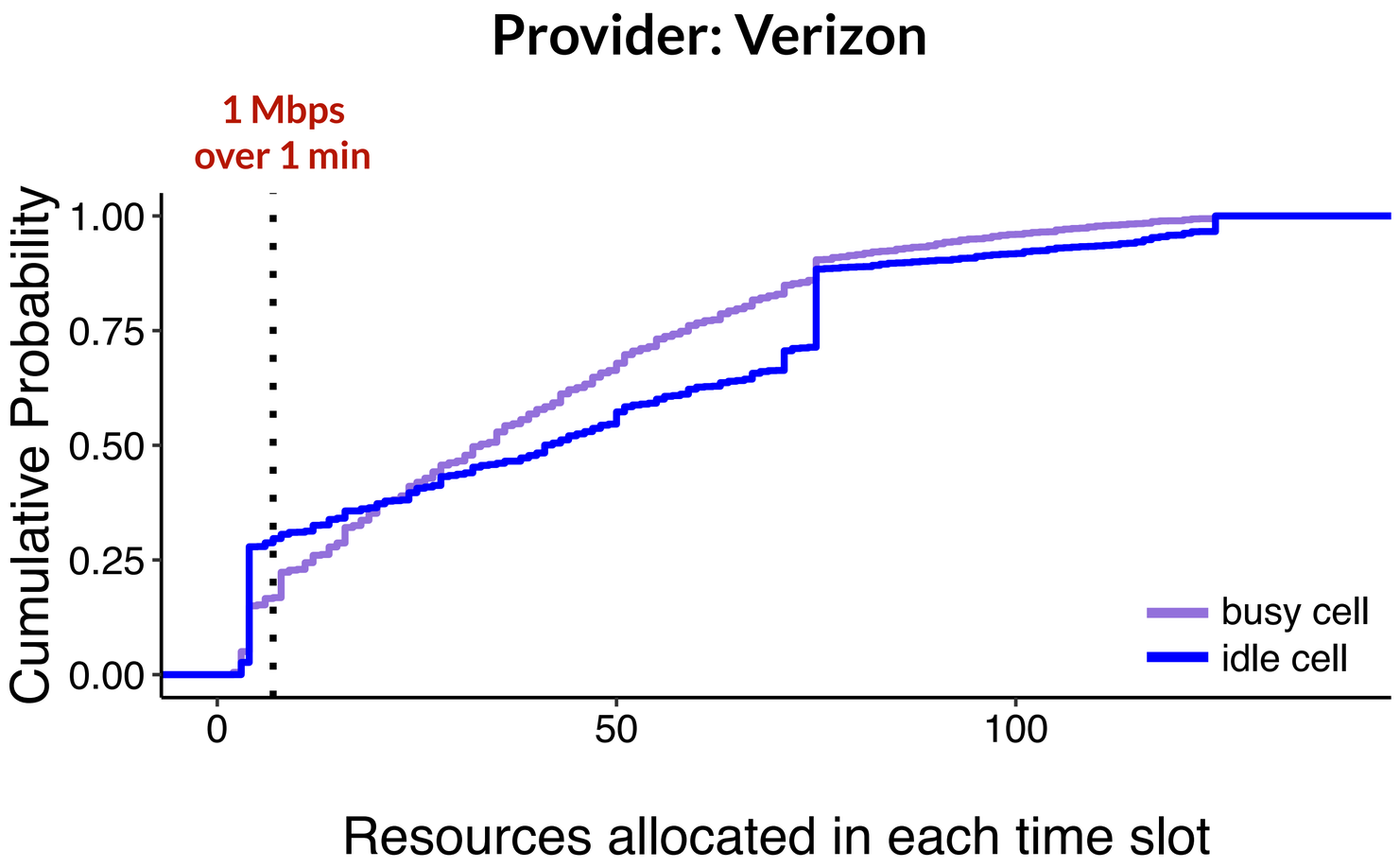
Does BurstTracker Generalize?



Does BurstTracker Generalize?

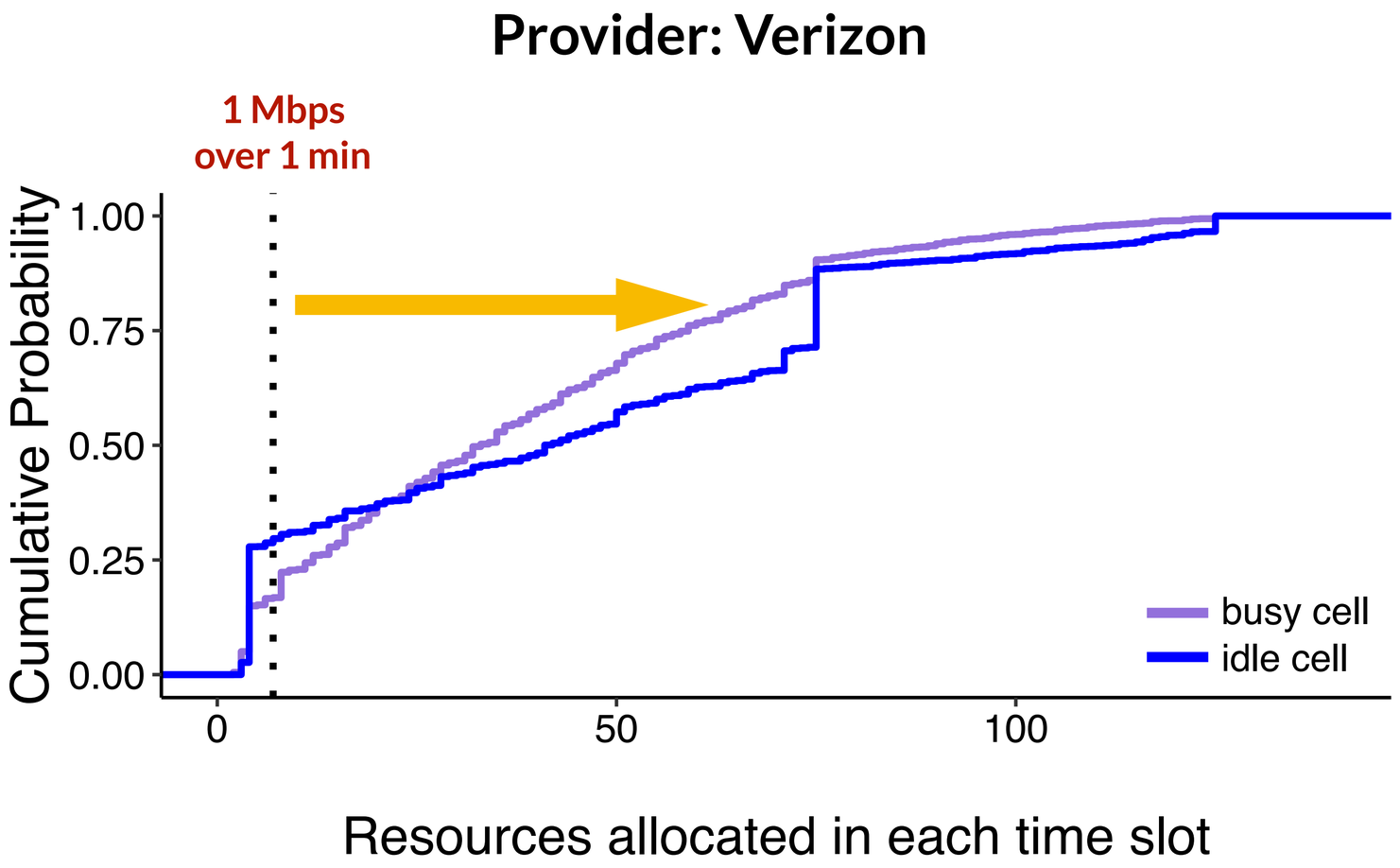


Does BurstTracker Generalize?



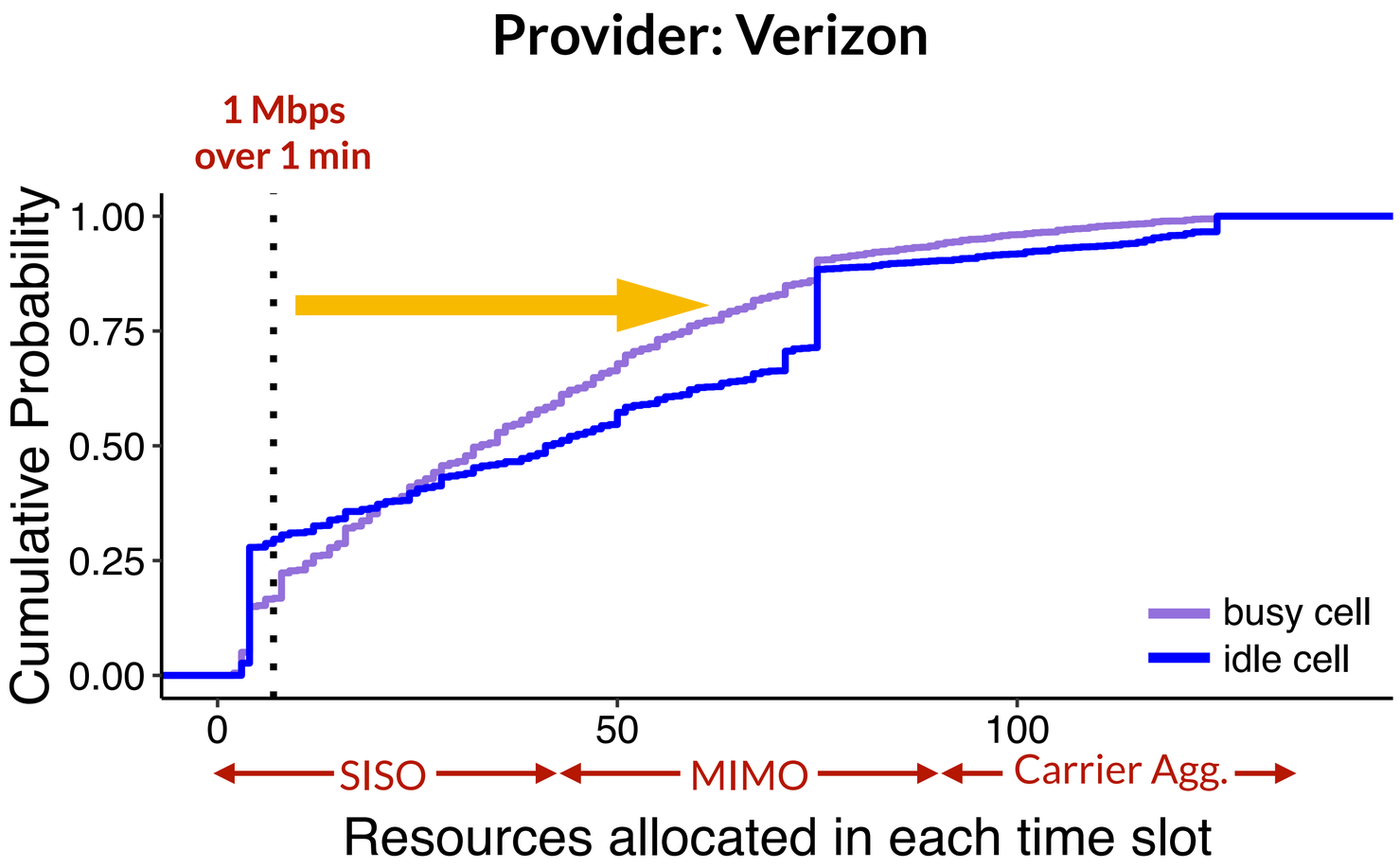
Slow transfer was aggregated into bursts that used most of the resources.

Does BurstTracker Generalize?



Slow transfer was aggregated into bursts that used most of the resources.

Does BurstTracker Generalize?



Slow transfer was aggregated into bursts that used most of the resources.

Is BurstTracker Accurate?

Application	**BurstTracker Median Error** (%)
File Download	7.2
Video Streaming	6.9

Experiment Setup

- 100 runs of each workload
- Network conditions ~ 2–12.5 Mbps

Partnered with Tier-1 provider to get ground-truth queue status measurements.

Is BurstTracker Accurate?

Application	**BurstTracker Median Error** (%)
File Download	7.2
Video Streaming	6.9

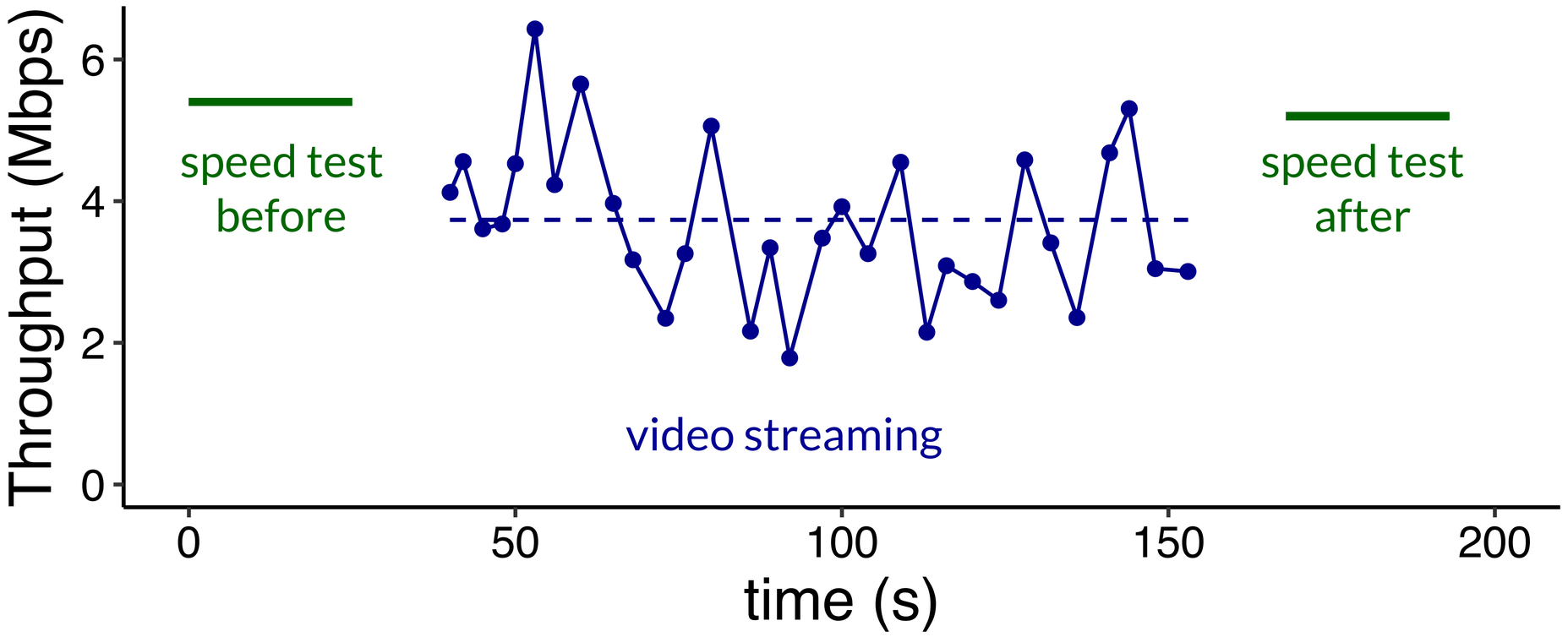
Experiment Setup

- 100 runs of each workload
- Network conditions ~ 2–12.5 Mbps

Partnered with Tier-1 provider to get ground-truth queue status measurements.

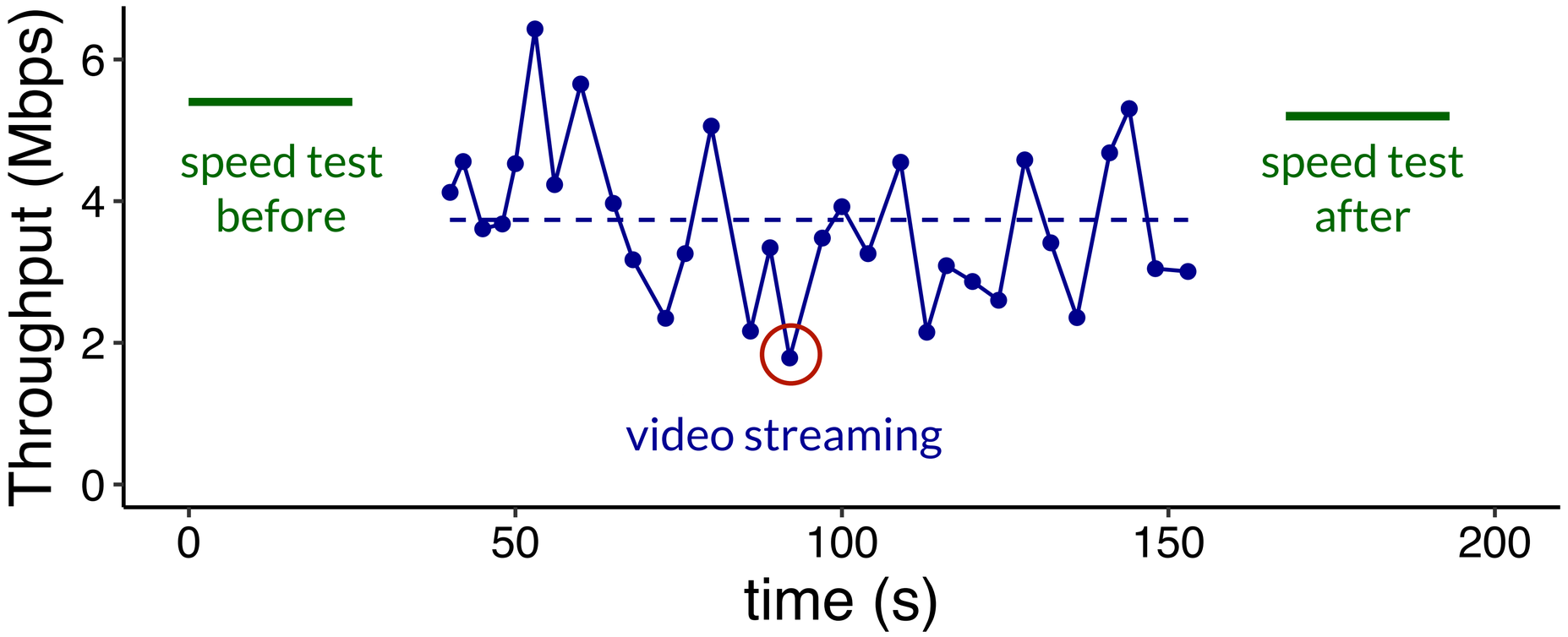
BurstTracker achieves a median error of 7% for different classes of mobile apps.

Case Study: Video Streaming



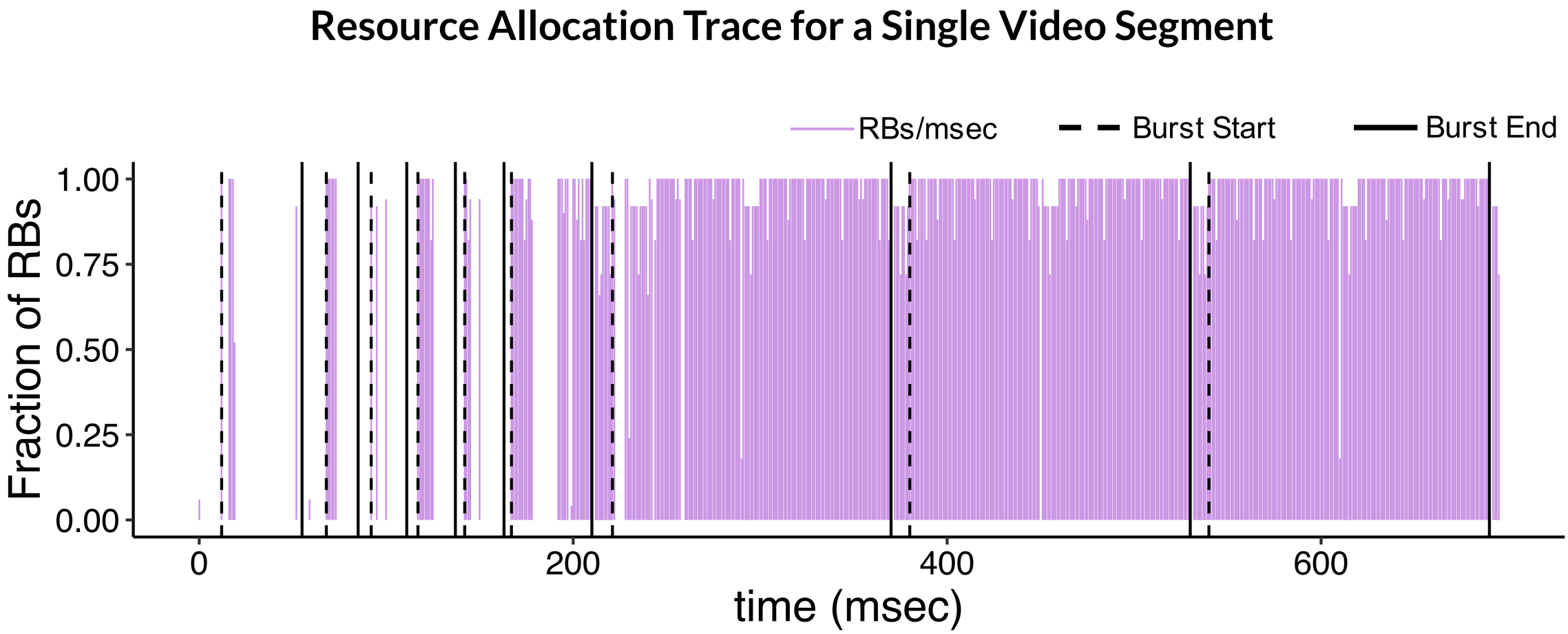
We found that, surprisingly, the LTE downlink was *not* the bottleneck.

Case Study: Video Streaming

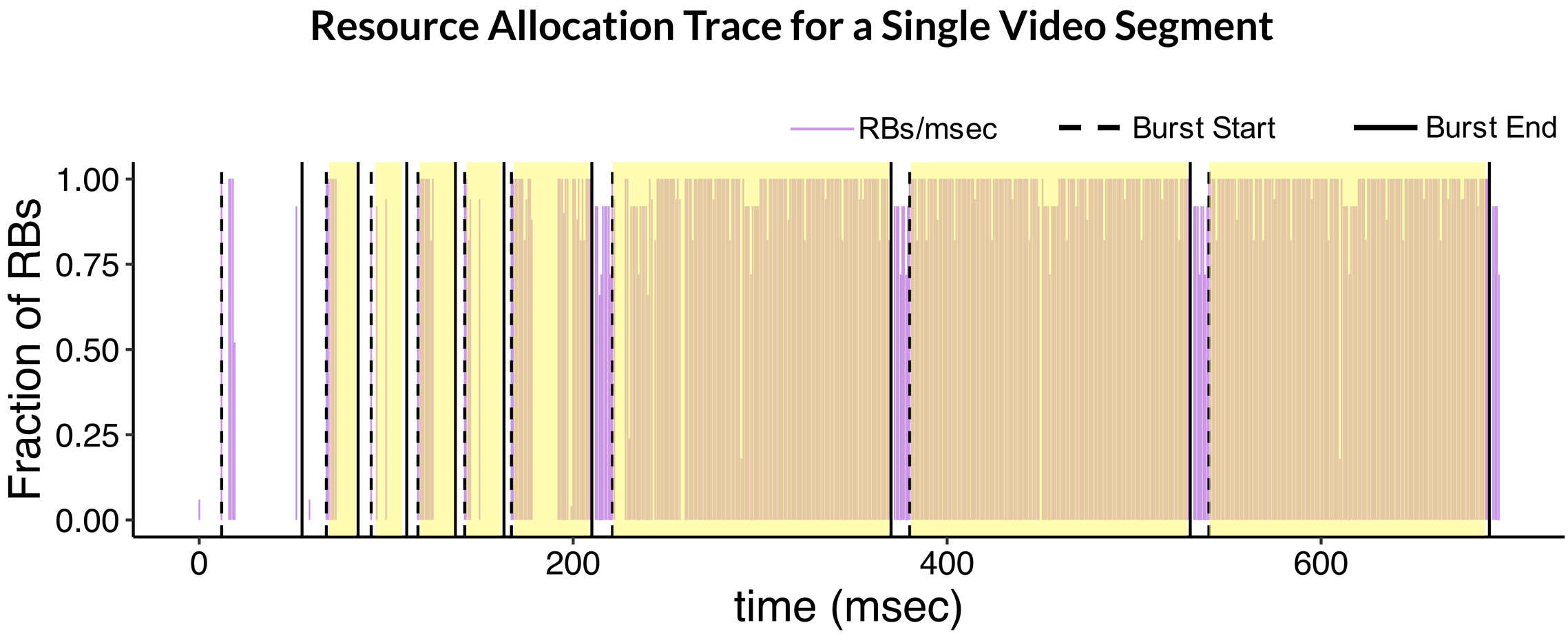


We found that, surprisingly, the LTE downlink was *not* the bottleneck.

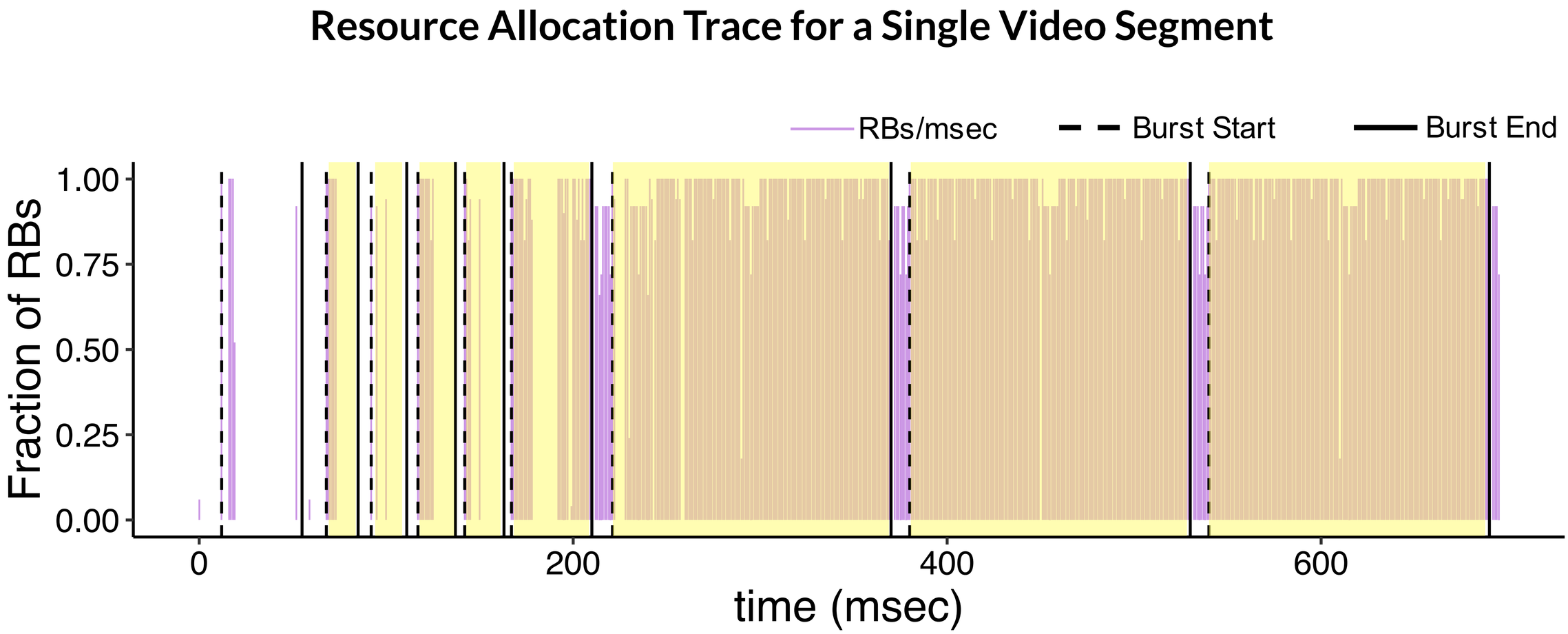
1 Video Segment at the Client



1 Video Segment at the Client

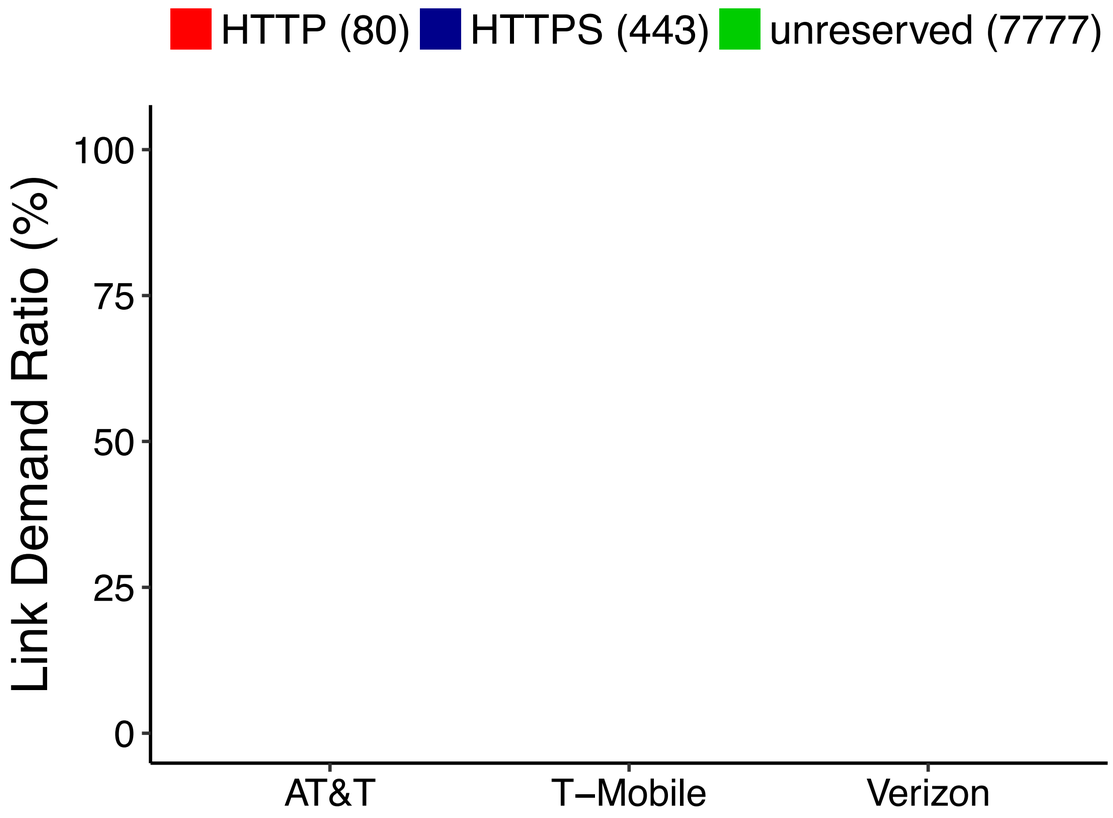


1 Video Segment at the Client



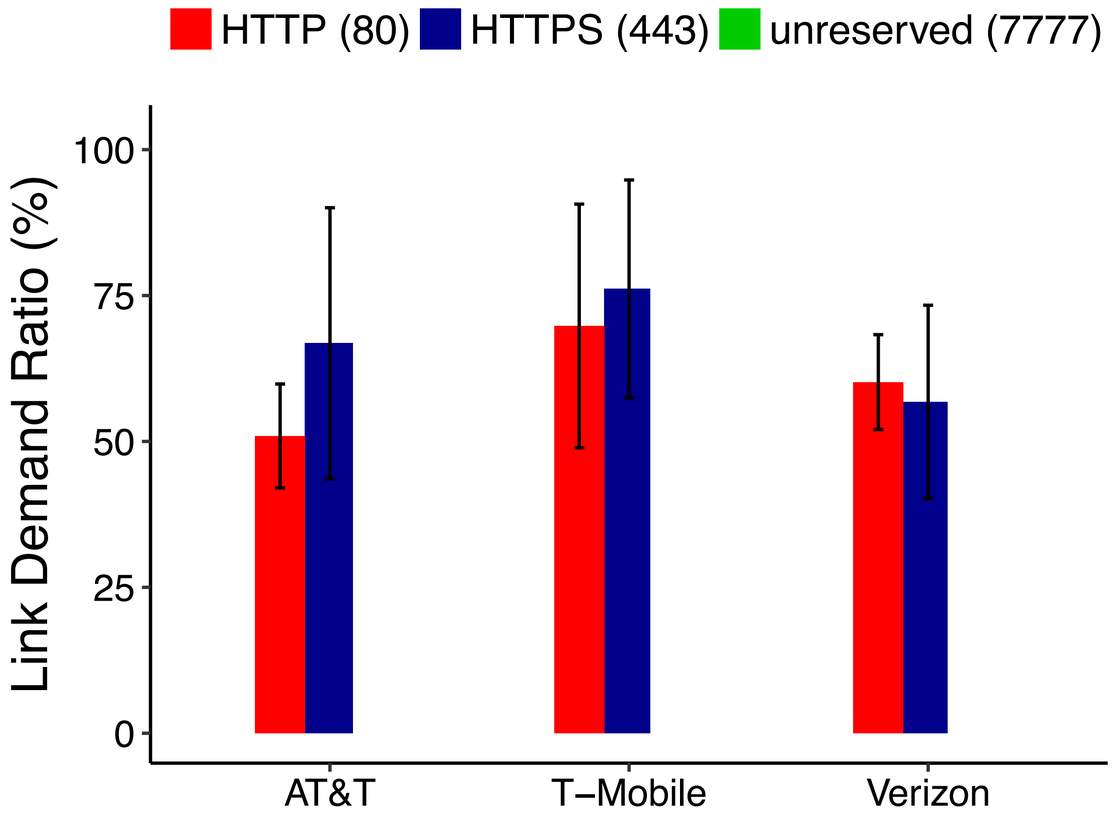
BurstTracker indicates that it might be TCP Slow-Start.

Slow-Start Restart at the Middlebox



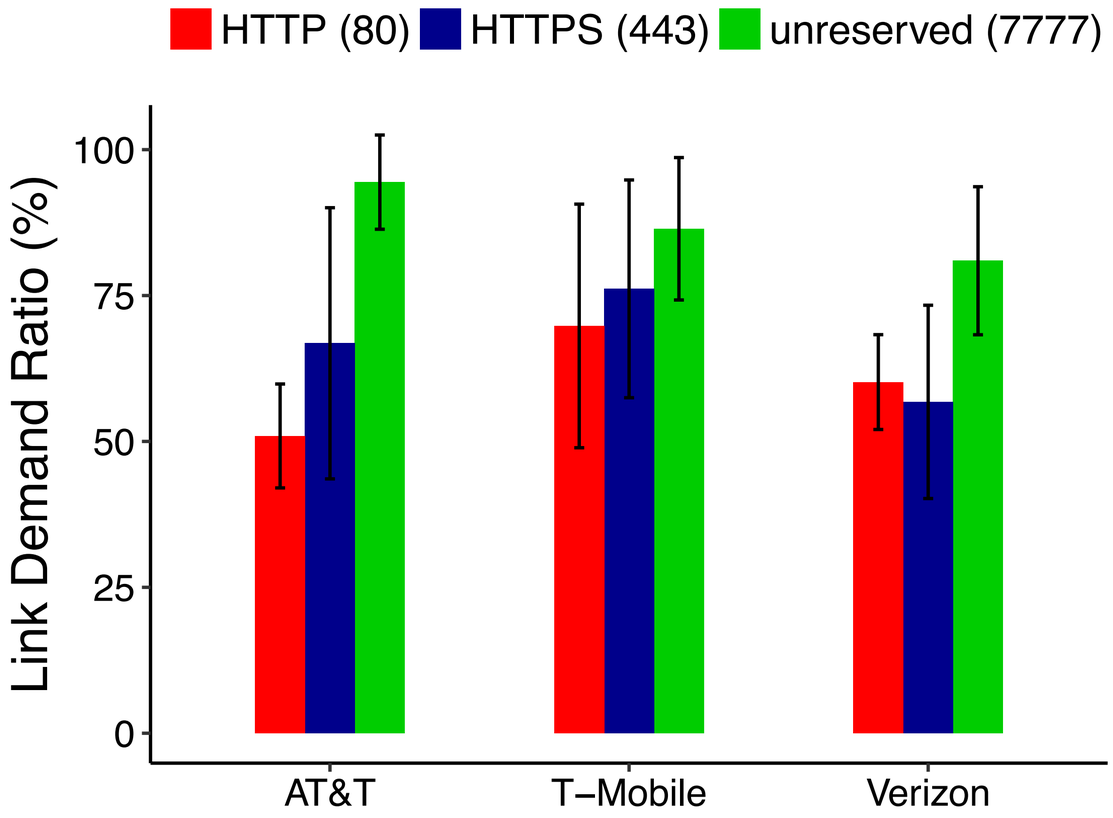
- Only HTTP and HTTPS traffic used middlebox.
- Nonstandard port (7777) bypasses middlebox.

Slow-Start Restart at the Middlebox



- Only HTTP and HTTPS traffic used middlebox.
- Nonstandard port (7777) bypasses middlebox.

Slow-Start Restart at the Middlebox



- Only HTTP and HTTPS traffic uses middlebox.
- Nonstandard port (7777) bypasses middlebox.

Split-TCP proxies were forcing Slow-Start restart.

BurstTracker

- Tool to determine if cellular downlink is the bottleneck
- Showed that we can infer base station queue status from resource allocation
- Discovered that carrier's middlebox was bottleneck for video streaming

github.com/arjunvb/bursttracker