

Wi-FM

Resolving Neighborhood Wireless Affairs by Listening to Music

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The home network

- Many 802.11 devices.
- Many 802.11 networks!
- Many are poorly configured.
 - Overlapping Wi-Fi channels.
- Controlled by many different “operators.”



An example

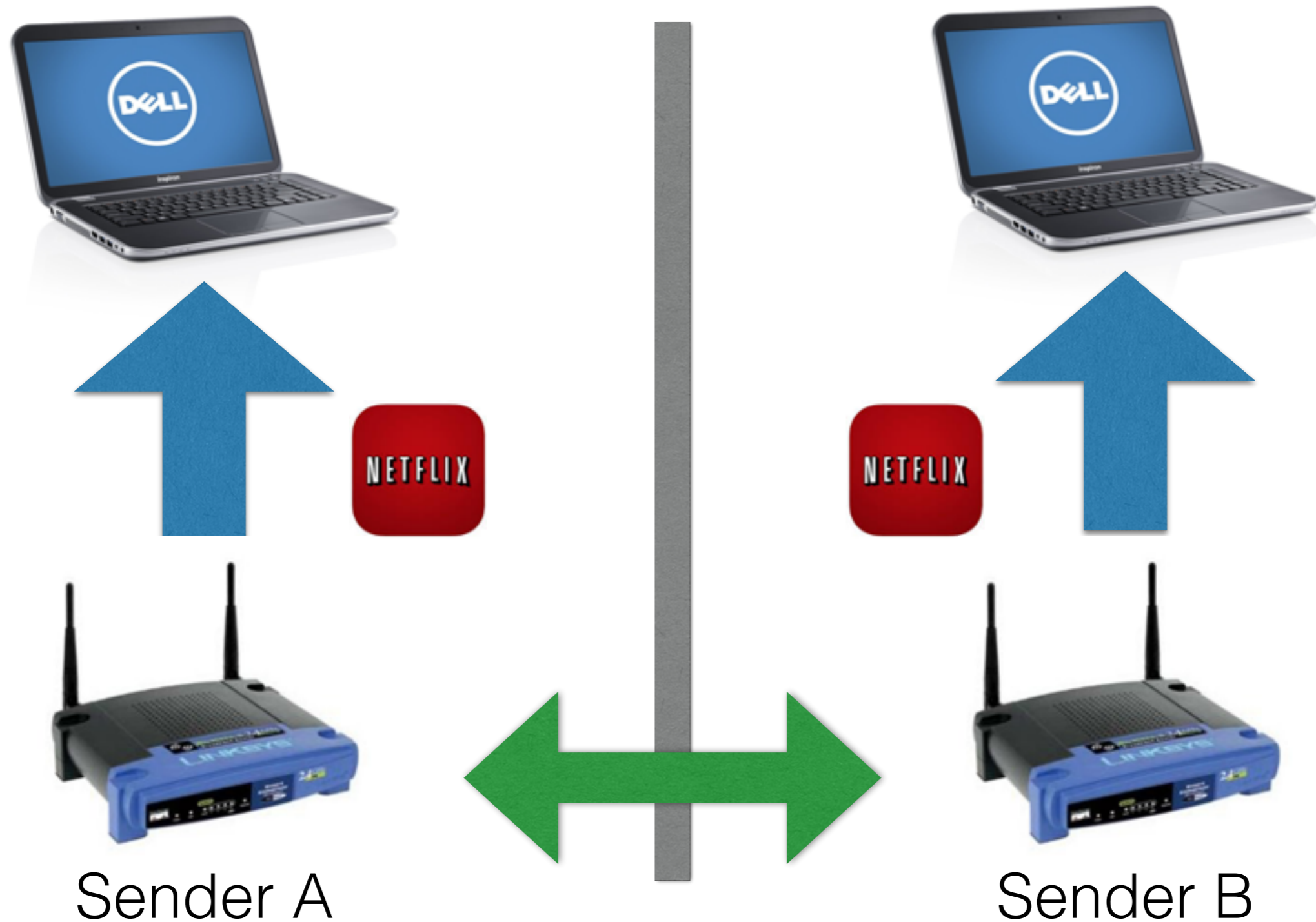


Sender A



Sender B

An example



Crossing the lines...

- How can neighbors interact?
 - Can't require APs to explicitly communicate.
 - Can't depend on any kind of AP based signal.
- We will solve this using an *ambient* radio signal for coordination.

What kind of coordination?

- We are not interested in packet level scheduling.
 - Don't want to alter 802.11 itself.
- Would like an approach that allows efficient sharing when the networks are busy.
- This will be achieved with block scheduling.

FM radio

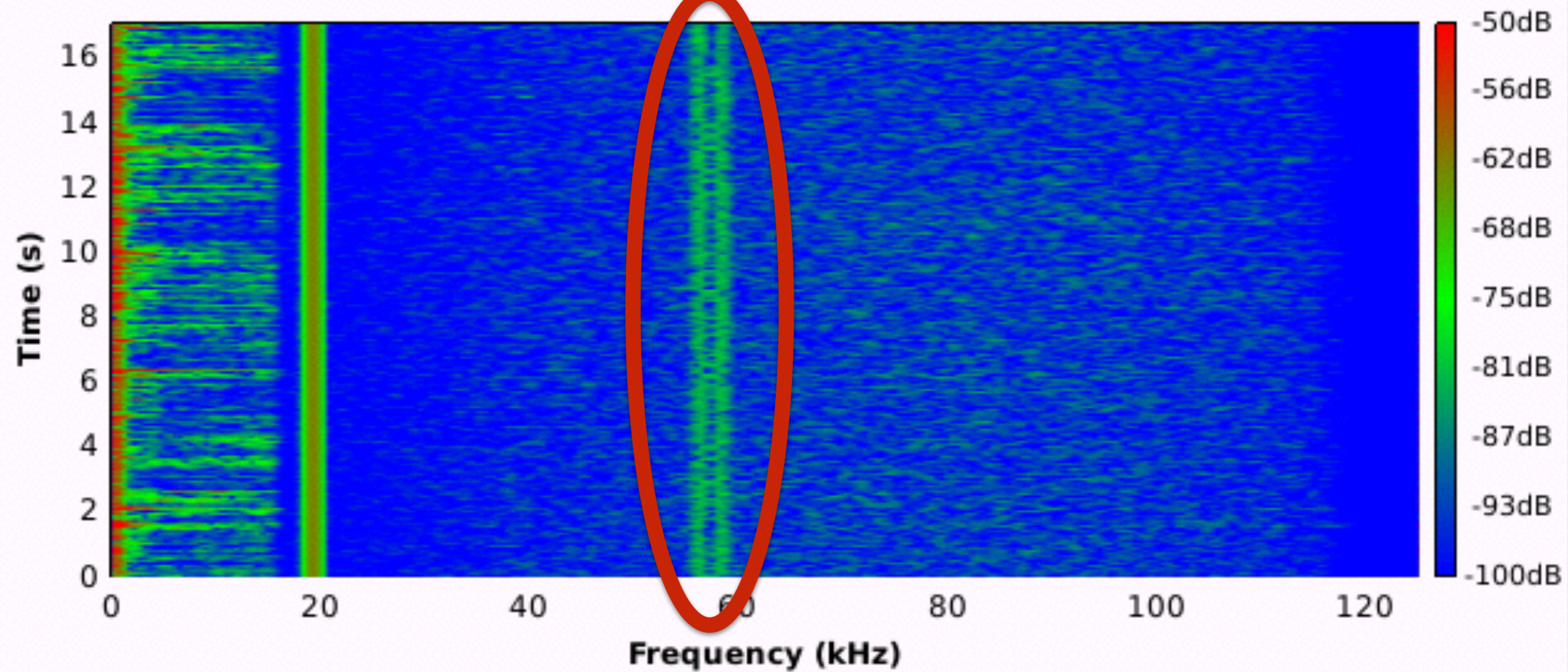
- Ubiquitous in the United States and Europe.
- Penetrates Buildings (unlike GPS).
- Cheap and prevalent antennas.
 - Already included on many Wifi/BT chipsets.
- Comes with included digital signal (RDS).

Radio Data System

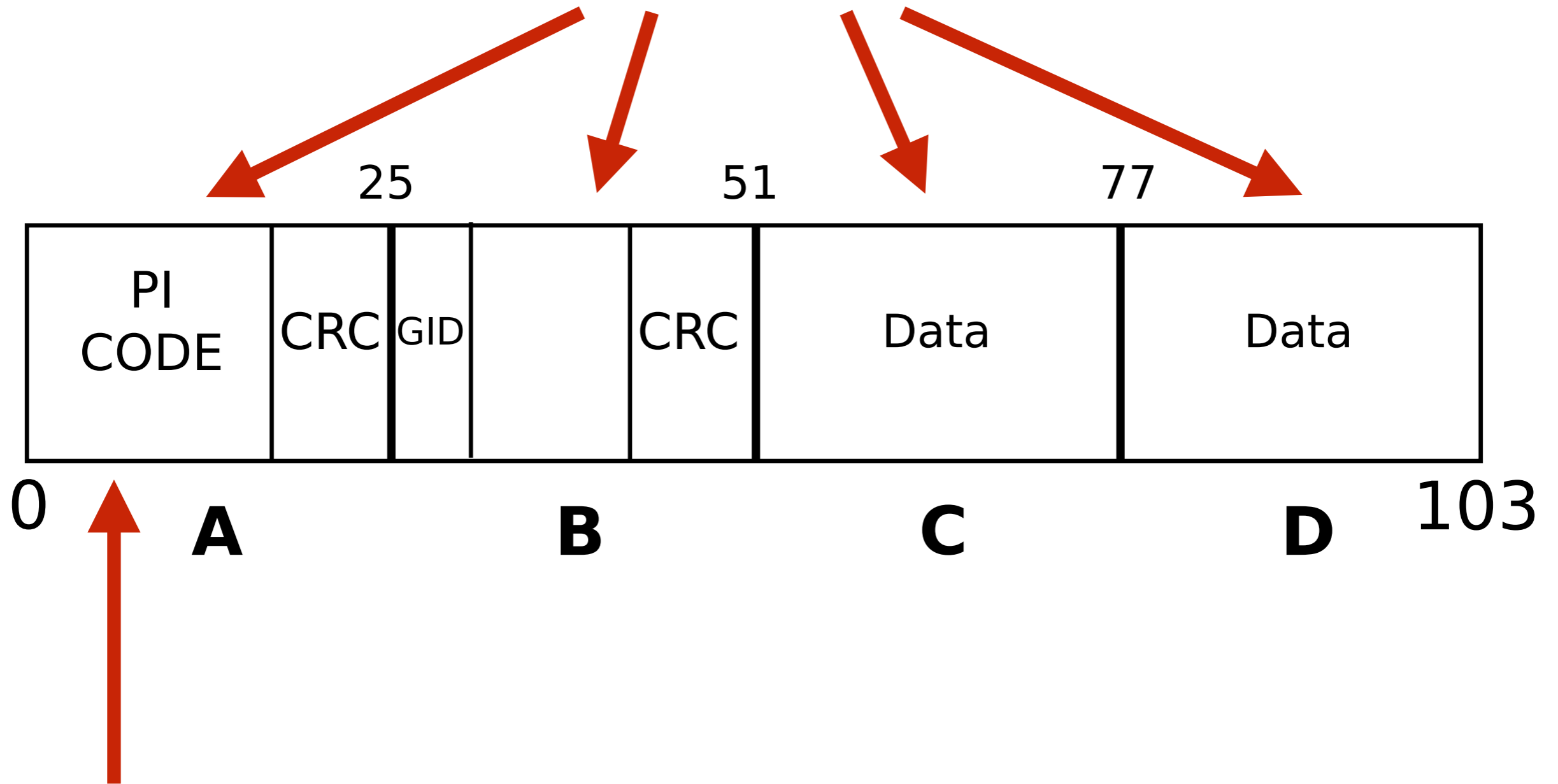
- Designed to provide additional meta-information about a radio broadcast.
 - Program name, alternative frequencies, etc.
- Broadcast alongside FM signal at the 3rd harmonic of 19kHz pilot.
- Includes a well defined structure.



Waterfall Plot



Block layout



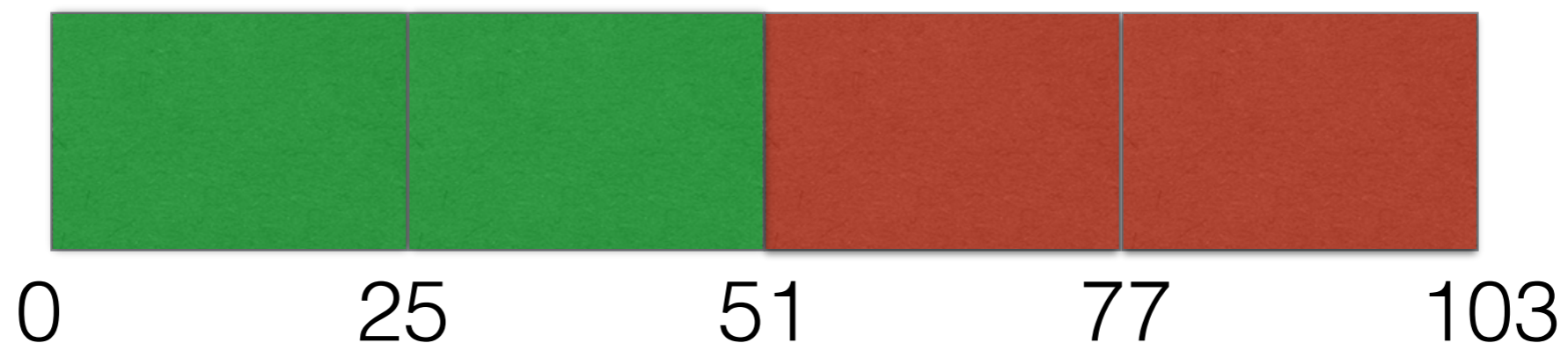
Repeating code

How do we use it?

- Use RDS bits as our base unit of time.
 - Data rate of 1187.5 bps.
- Use structure to *synchronize* to RDS signal.
- Implement non-exclusive scheduling in terms of the blocks.

How do senders schedule?

- Sample the channel, determine which blocks are occupied by other senders.
- Determine a fair share.
- Choose the least contested blocks.
- Repeat process to ensure continued fairness.

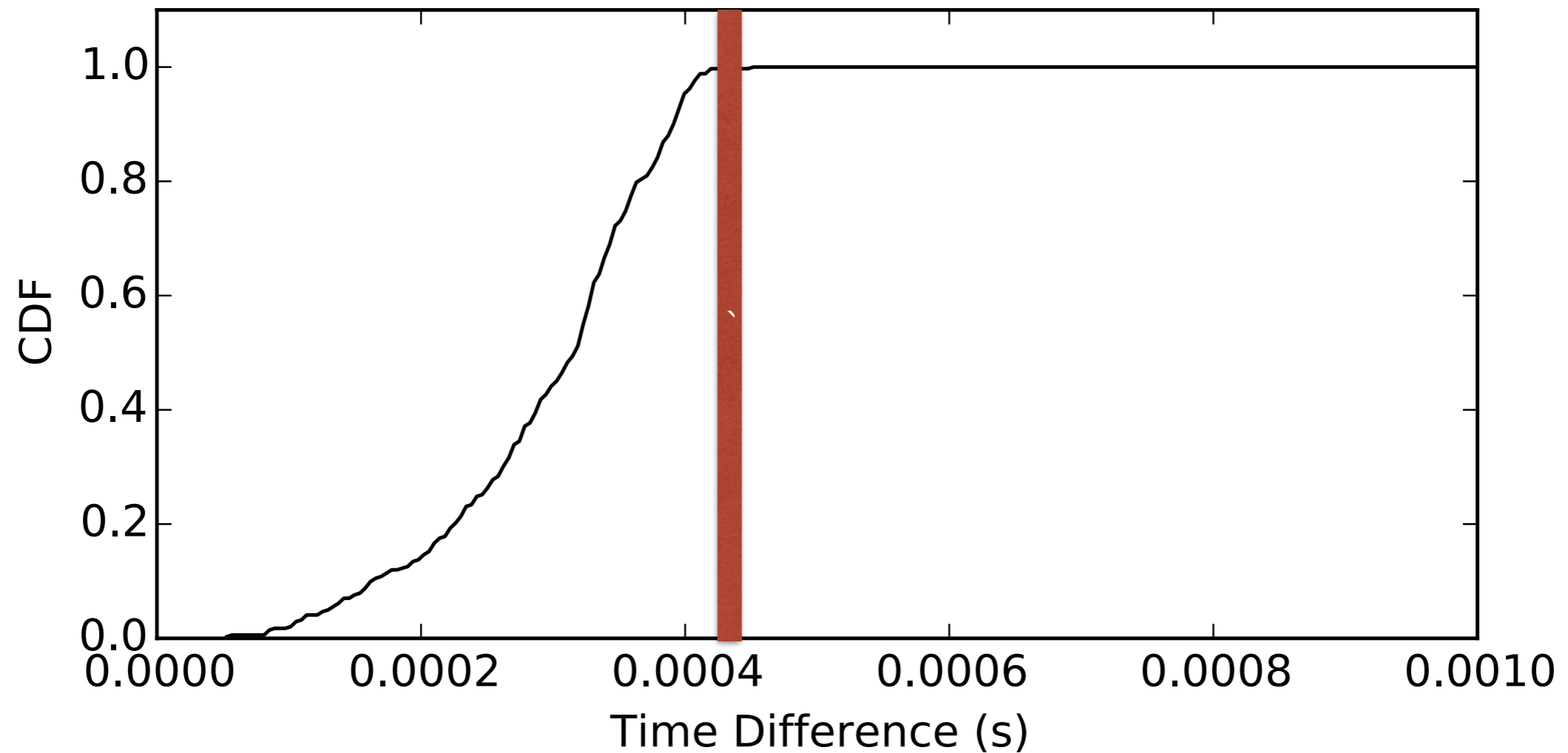


Our implementation

- NooElec DVB-T USB radio.
- GnuRadio using RTL SDR .
- Testbed:
 - Arch Linux 3.17.3, on 3.3 Ghz Intel i5 processor.
 - TP Link TL-WDN3800 802.11n card, Ath9k driver.
 - Modified “plug” qdisc to control traffic.

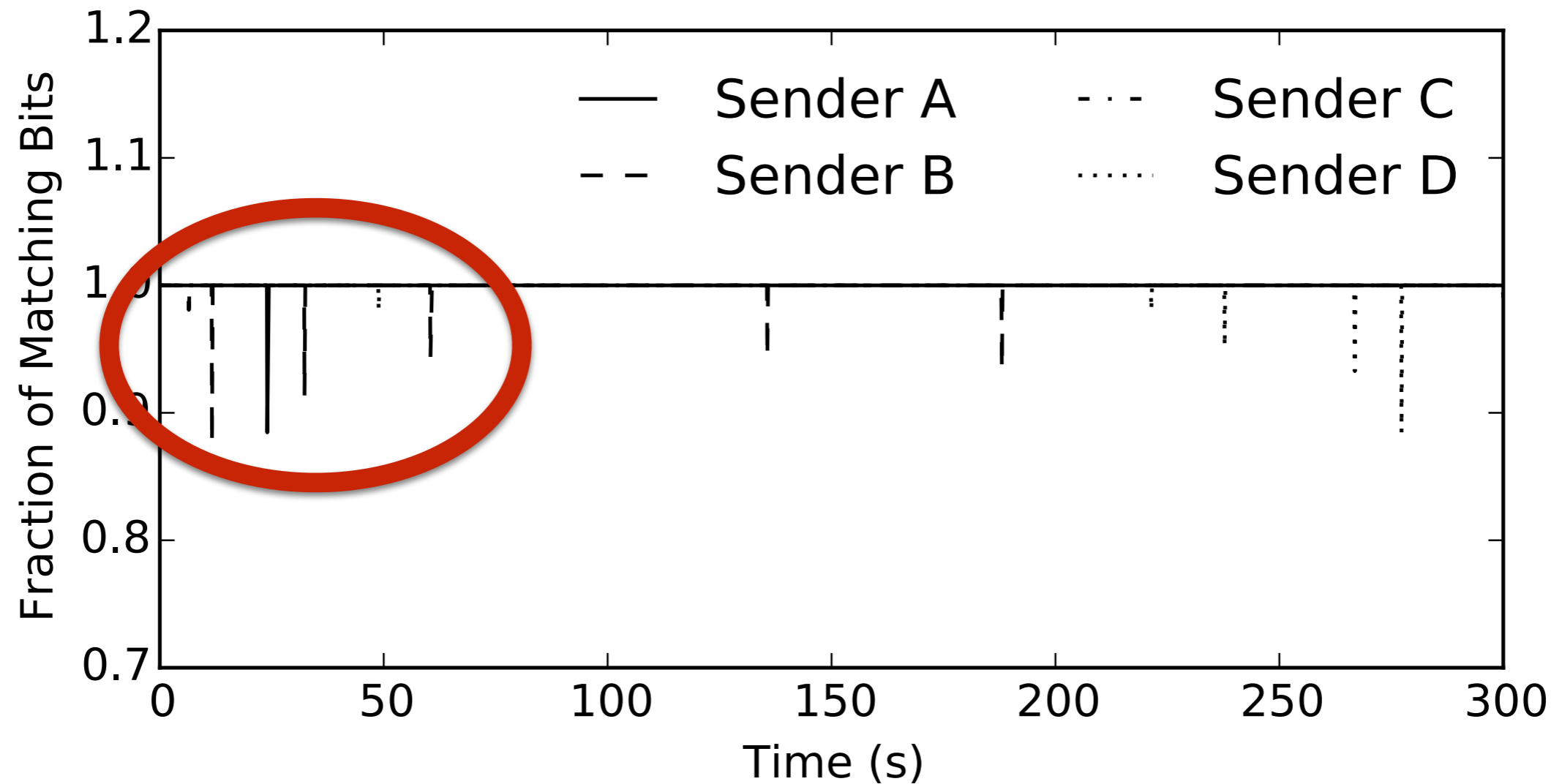


Delay between nodes



Delay between nodes is well under 1ms.

Sync time

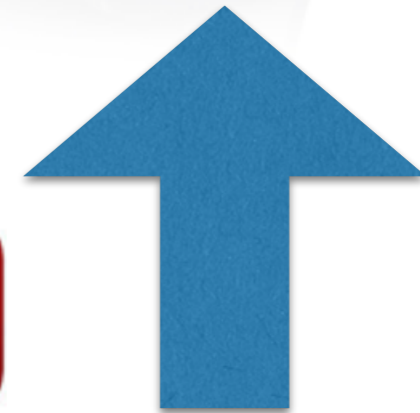


WiFM maintains a near perfect sync rate

Neighborhood coordination

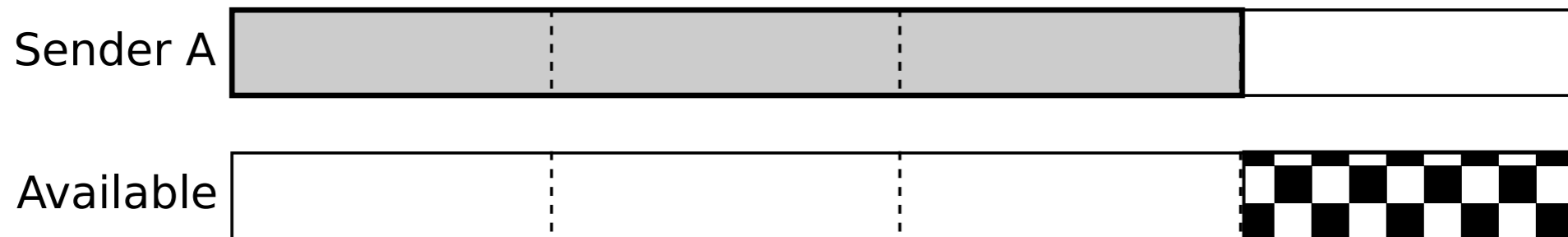
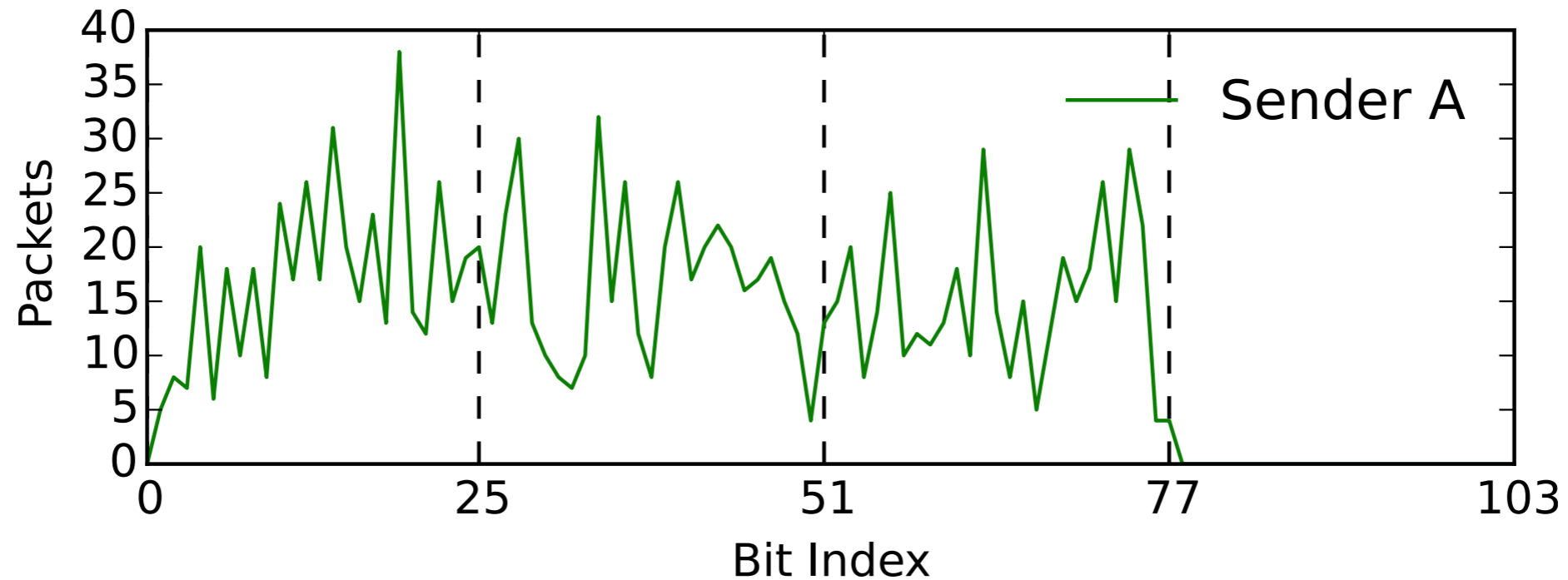


Sender A

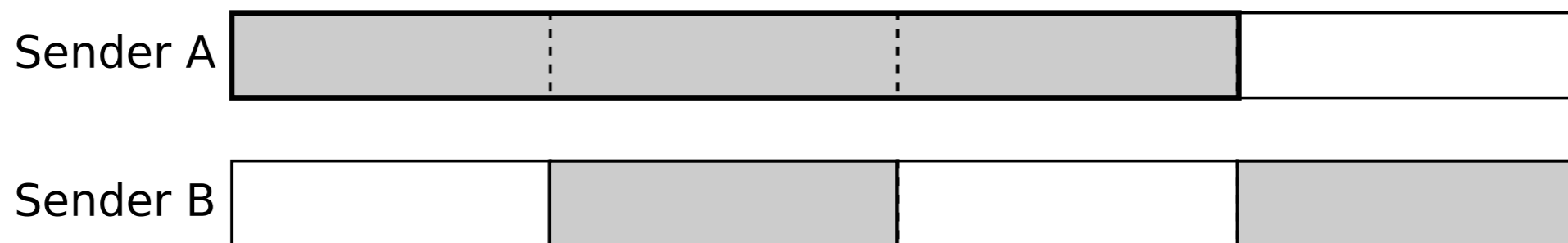
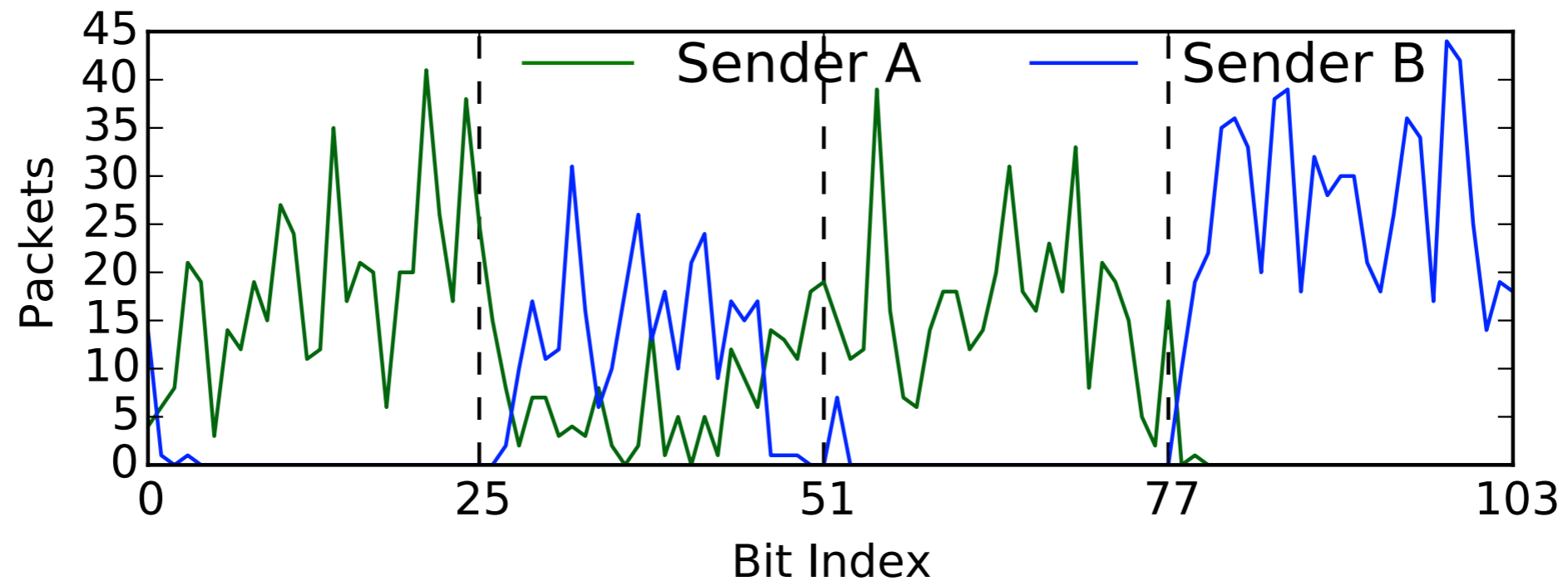


Sender B

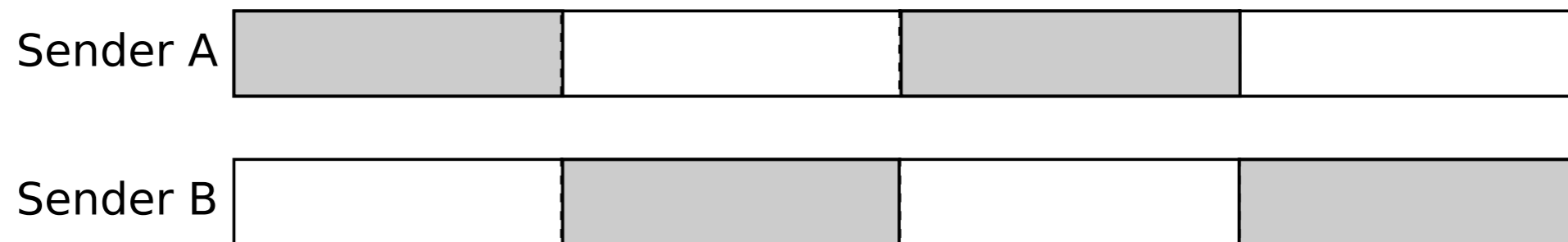
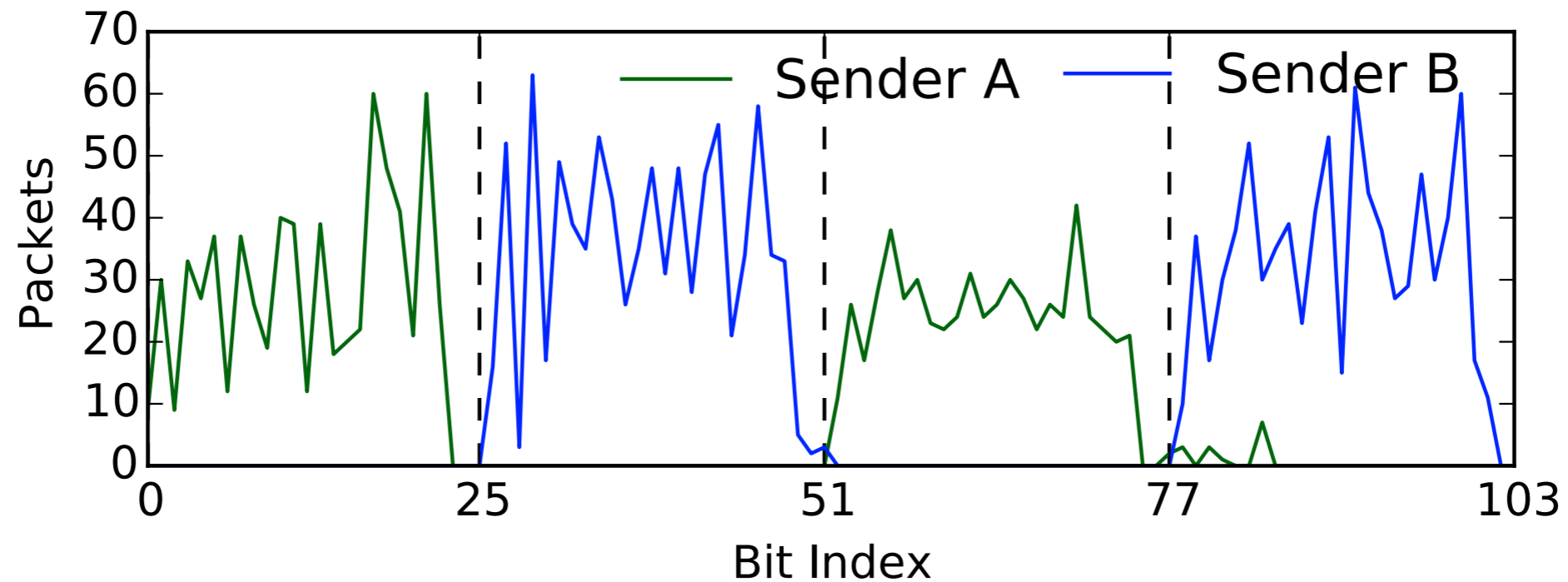
Neighborhood coordination



Neighborhood coordination

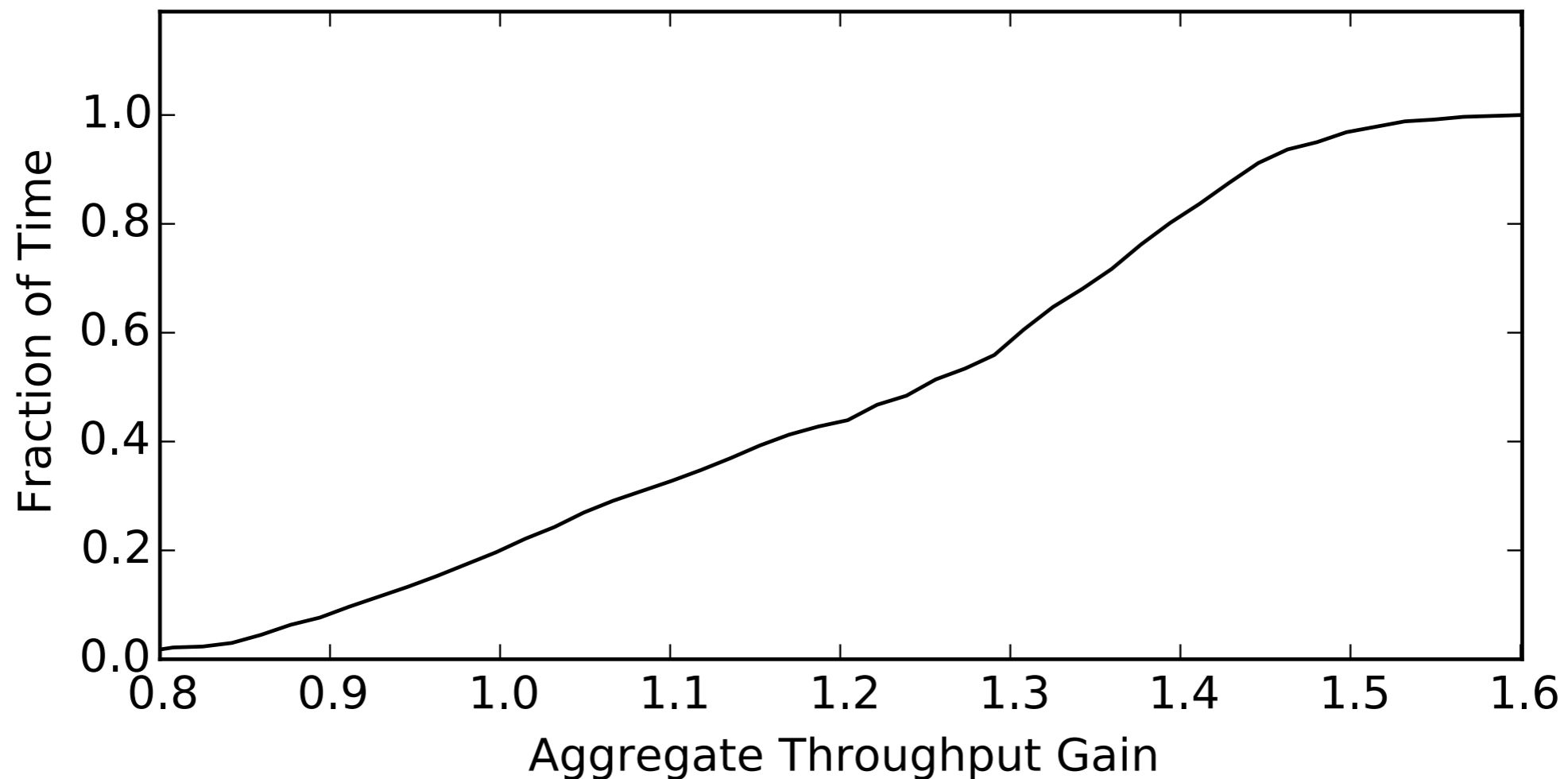


Neighborhood coordination



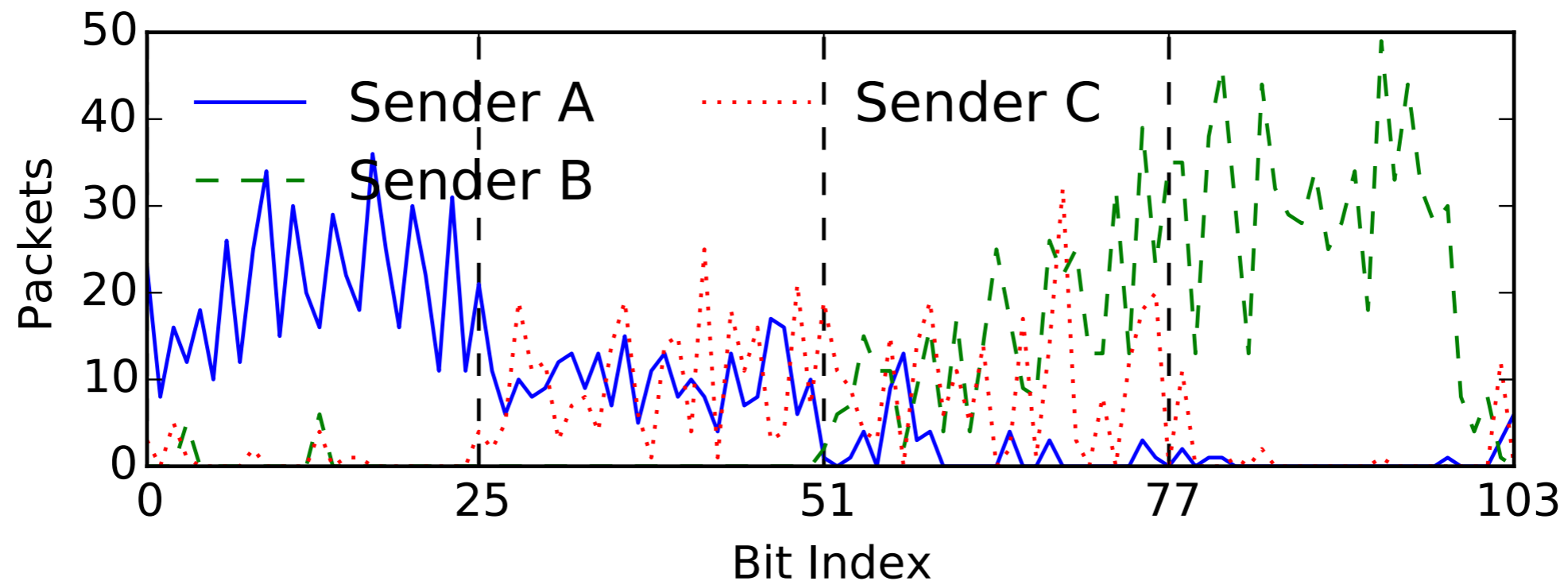
All nodes are scheduled on non-overlapping blocks.

Throughput gain



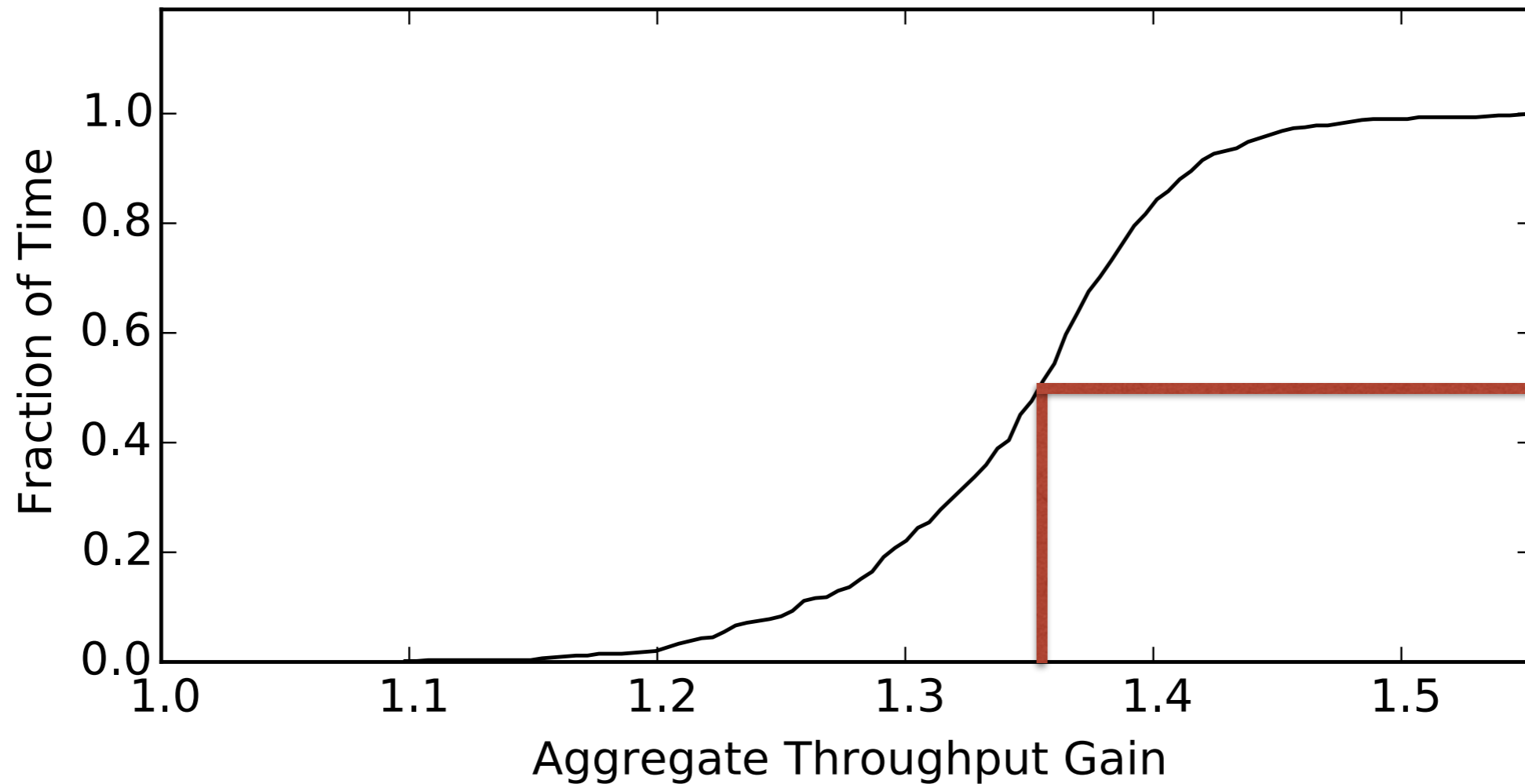
Throughput gains achieved 80% of the time.

Neighborhood coordination



More complex arrangements are possible.

Throughput gain



Greater gains are achieved.

Summary

- Used FM Radio as an external coordination mechanism.
- First to provide a neighborhood coordination mechanism for use across networks.
- Demonstrated implementation which relies on straightforward coordination process.
- Showed throughput gains in testbed experiments.

Thank you!

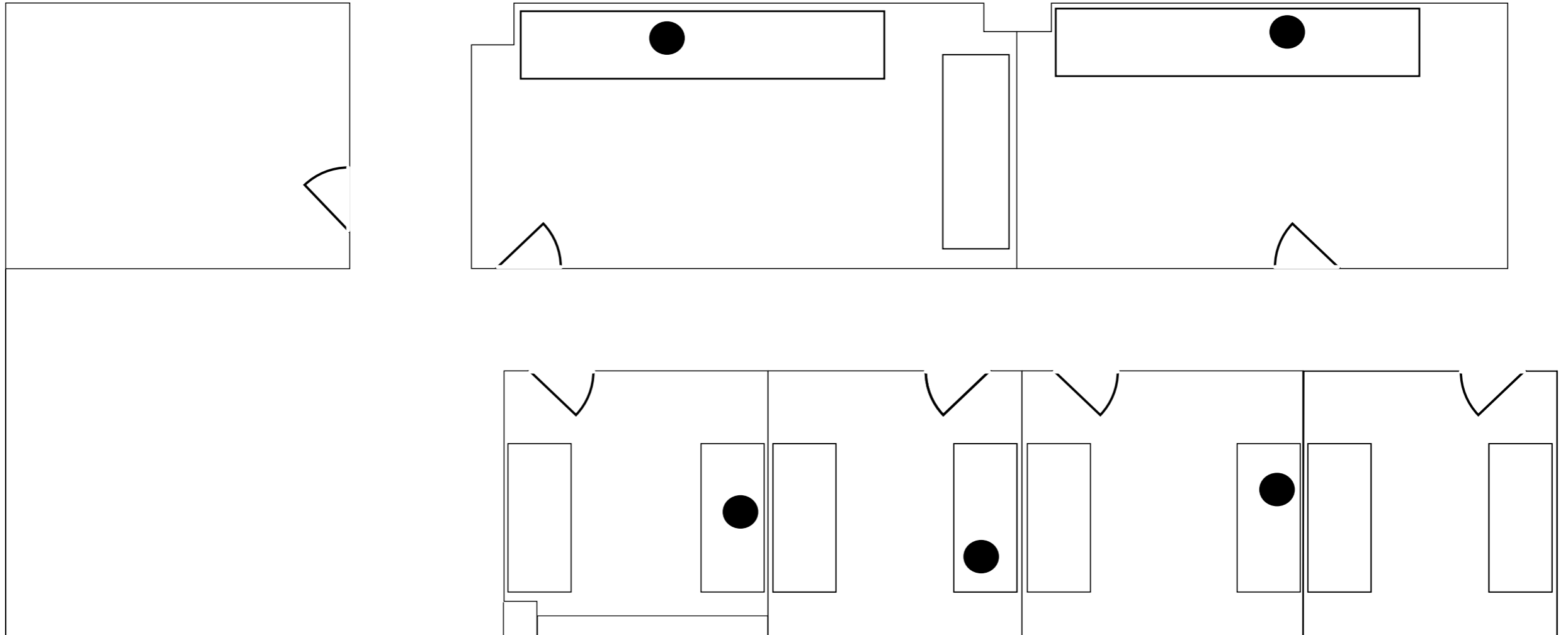
Extras



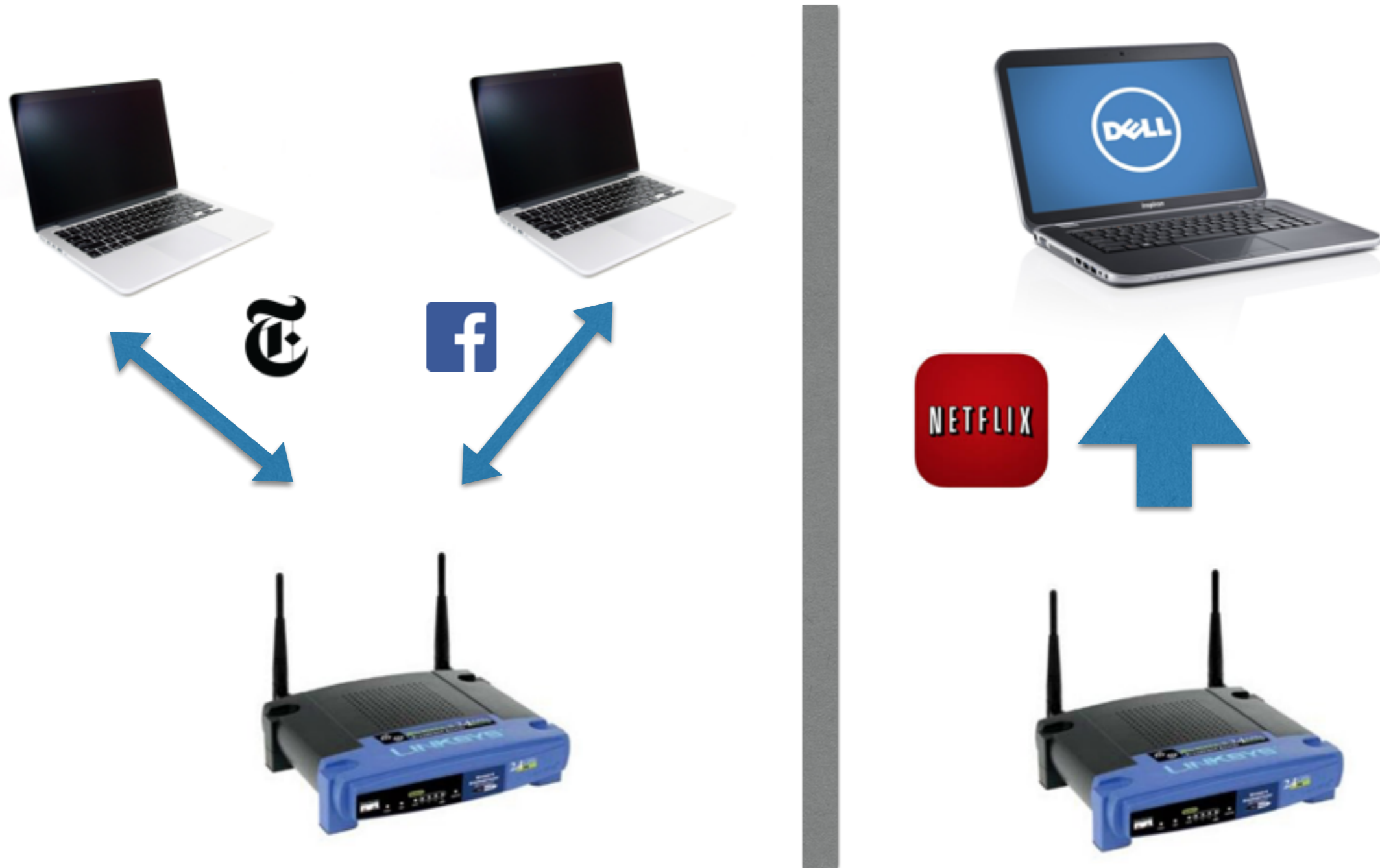
Related work

- A large body of work exists on performing TDMA with 802.11 networks.
- In the realm of enterprise/managed networks, don't apply to home networks.
- Significant work in general synchronization.
 - Including the use of RDS.
- We are the first to consider neighborhood setting.

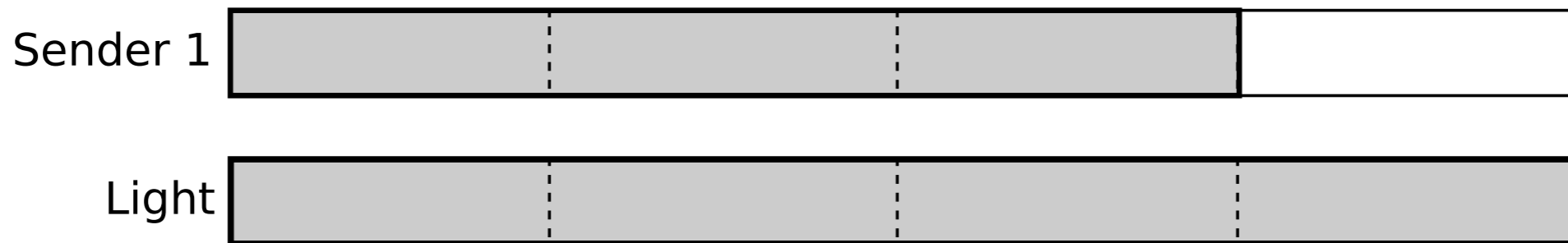
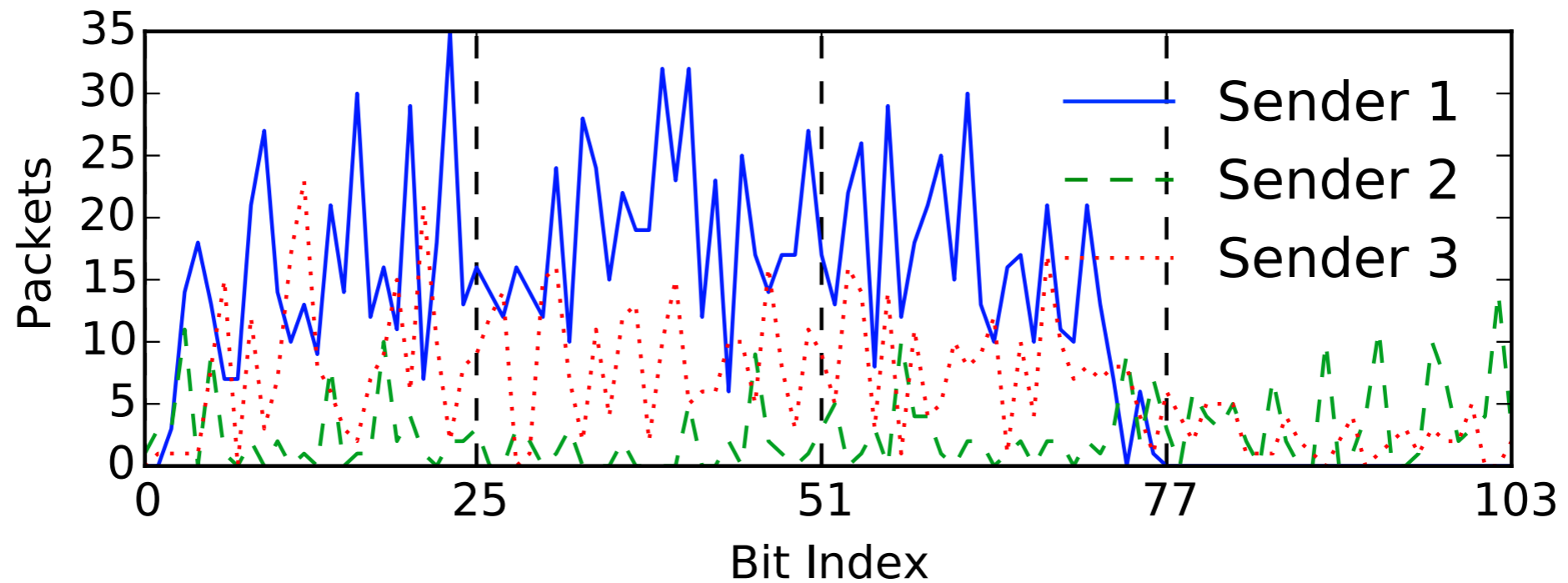
Testbed arrangement



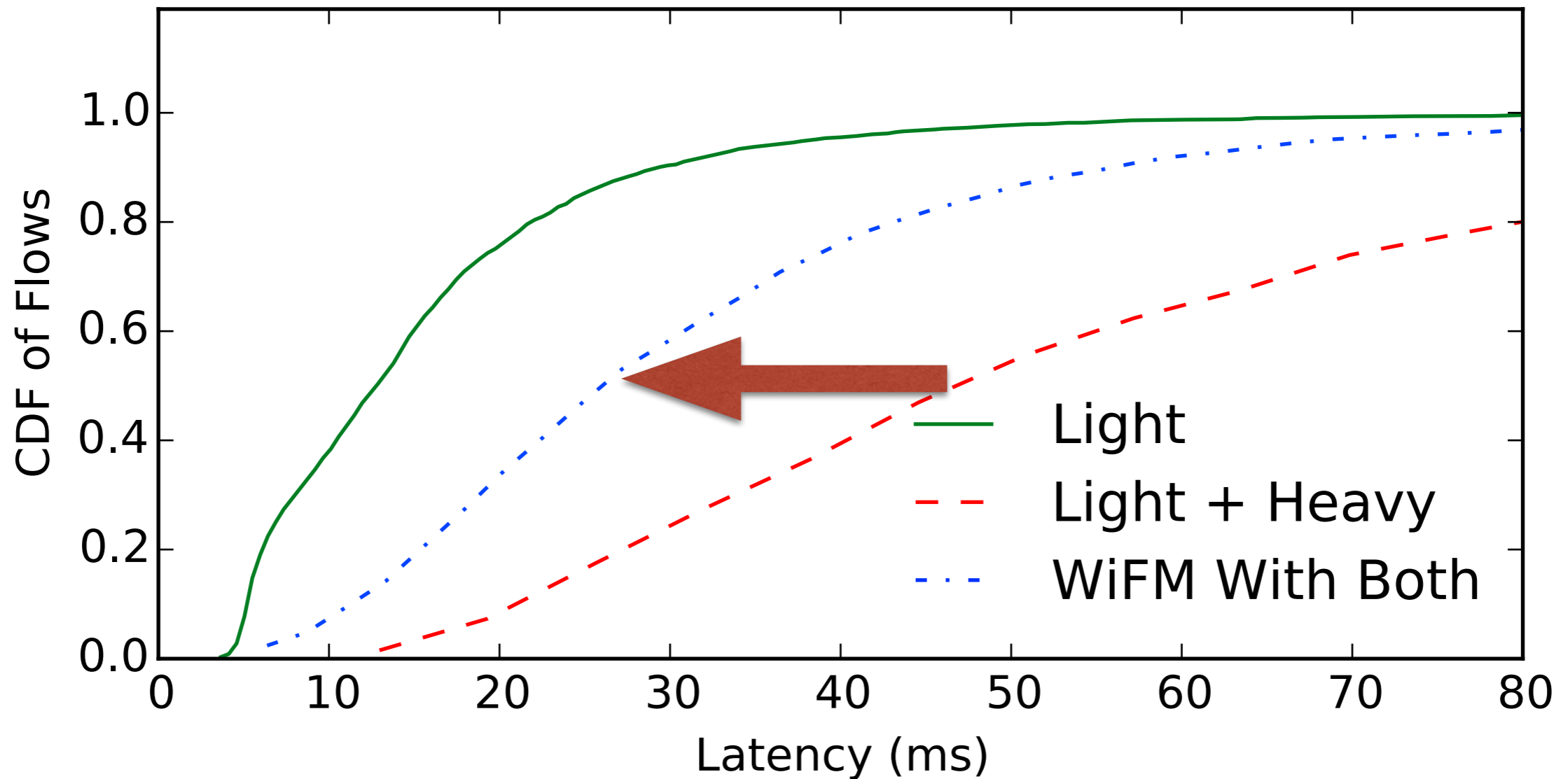
Negative schedules



Negative schedules

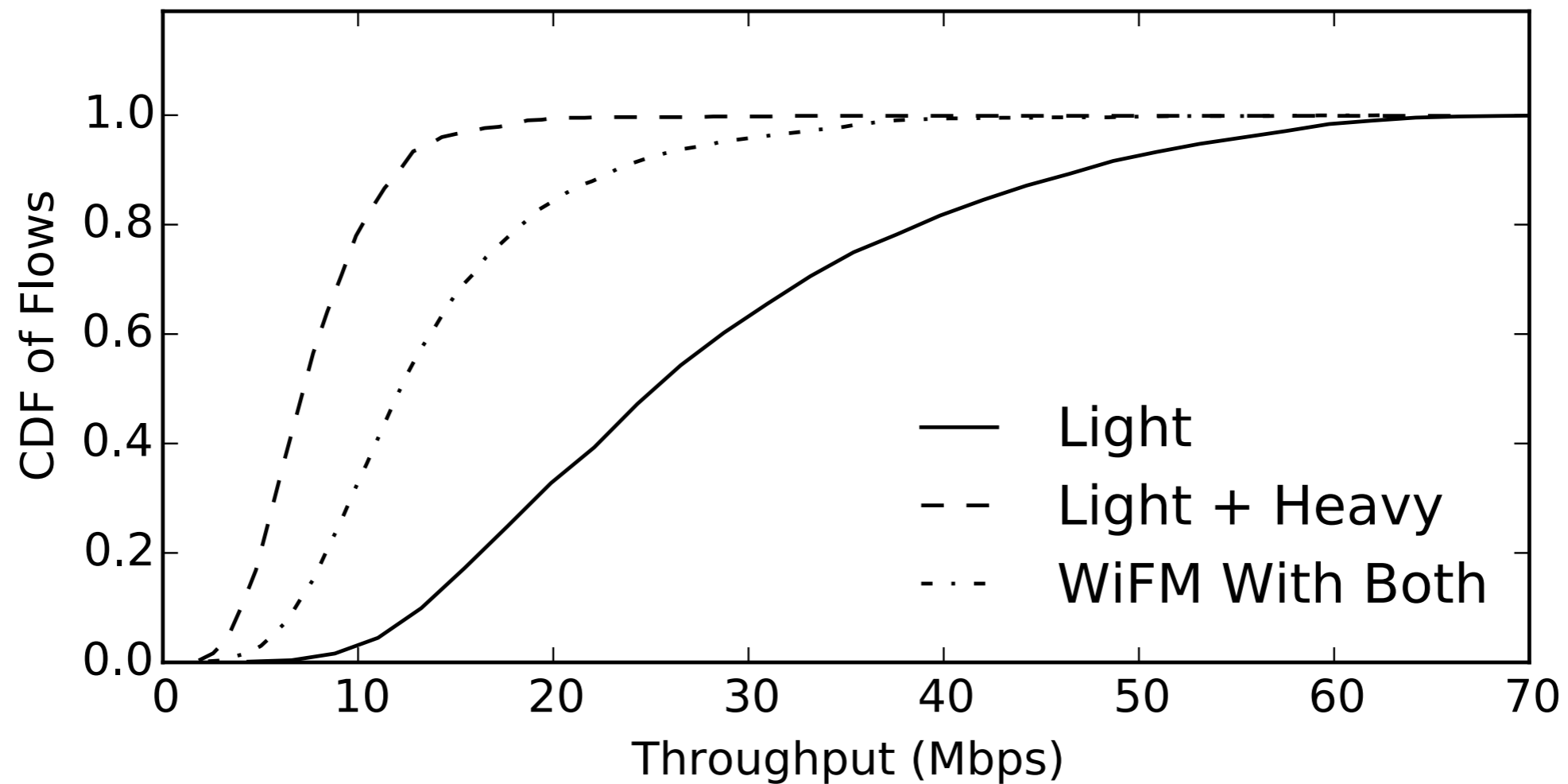


Negative schedules



Latency improved by nearly 40ms

Negative schedules



Negative schedules

