The Wireless Session
SIGCOMM 2016

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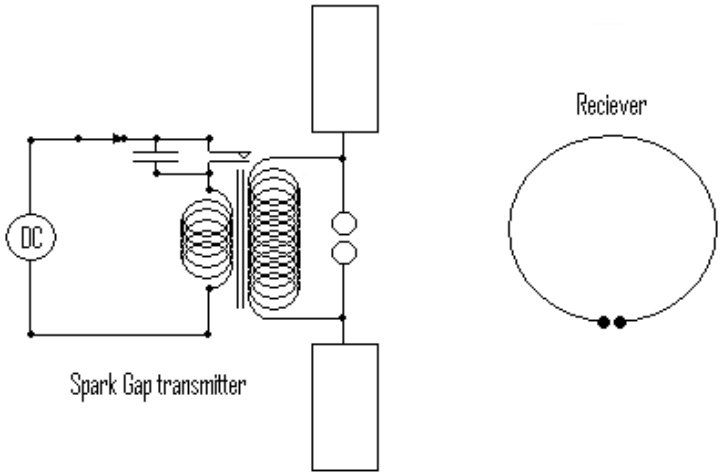
Evolution of Wireless Systems

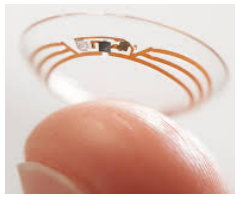
Genesis → Mainstream → Ubiquity



First wireless transmitter:
The spark gap transformer

1G Mobile Phone

Paging Systems



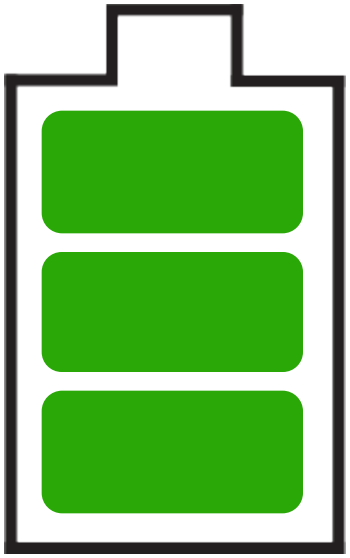
Implantable & IoT

3G, 4G Cellular

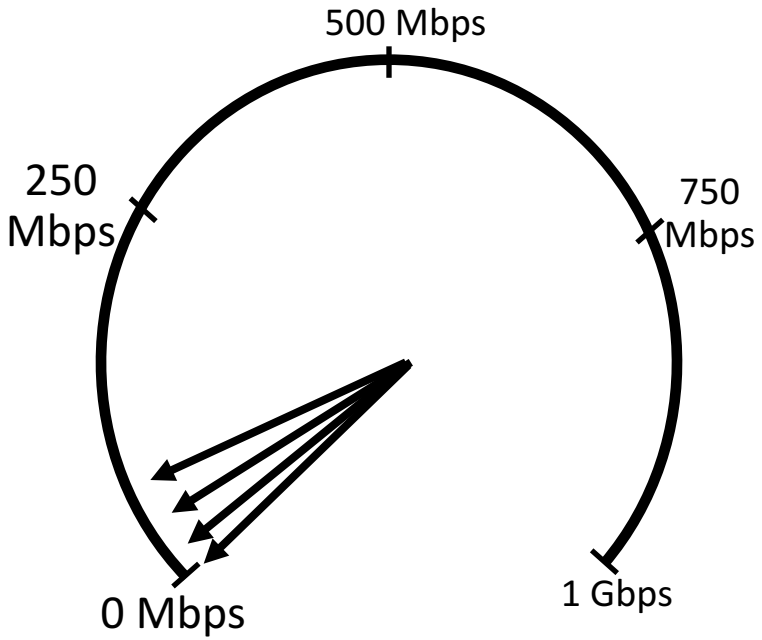
5G: Massive MIMO- Wi-Fi & Millimeter Wave

Hot Research in Wireless

Power Efficiency



High Data Rates



Why is Communication Expensive in Power?

Key Reason: Generation of RF signal requires tremendous amount of power

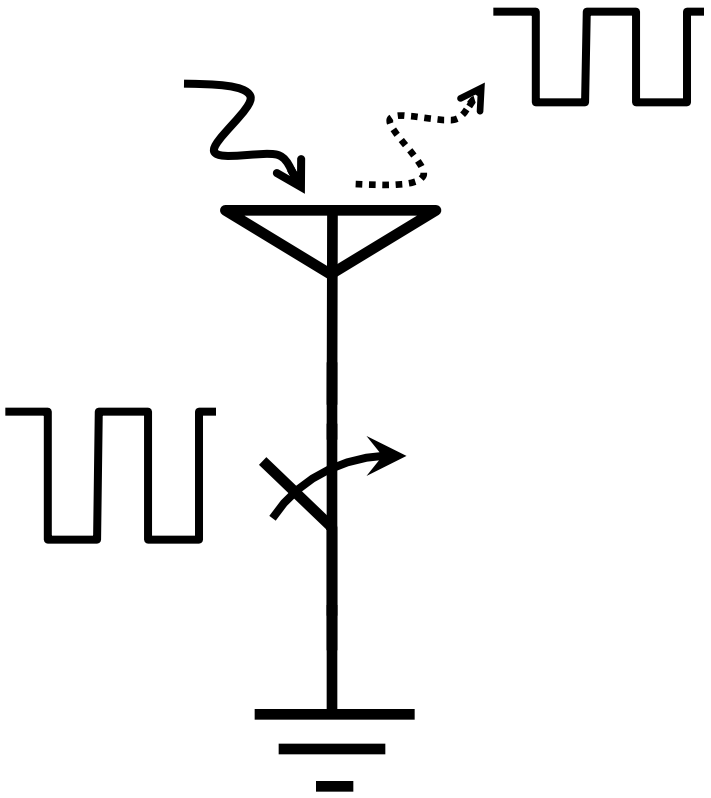
Solution: Don’t generate just reflect!

The Flashlight Analogy

Encode data using reflections

Backscatter in RF

Encode data using reflections



Reflections consume 4-5 orders of magnitude lower power

Evolution of Backscatter

Ambient Backscatter

- Reflect ambient TV signals
- Communicate b/w battery-free devices
- SIG'13: 100 bps-1 kbps @ upto 10 feet
- SIG'14: 10 kbps-1Mbps @ up to 80 feet

Wi-Fi Backscatter

- Communicate with COTS Wi-Fi clients
- Encode data using variations in the Wi-Fi channel
- SIG'14: 100 bps-10kbps @ 10 feet

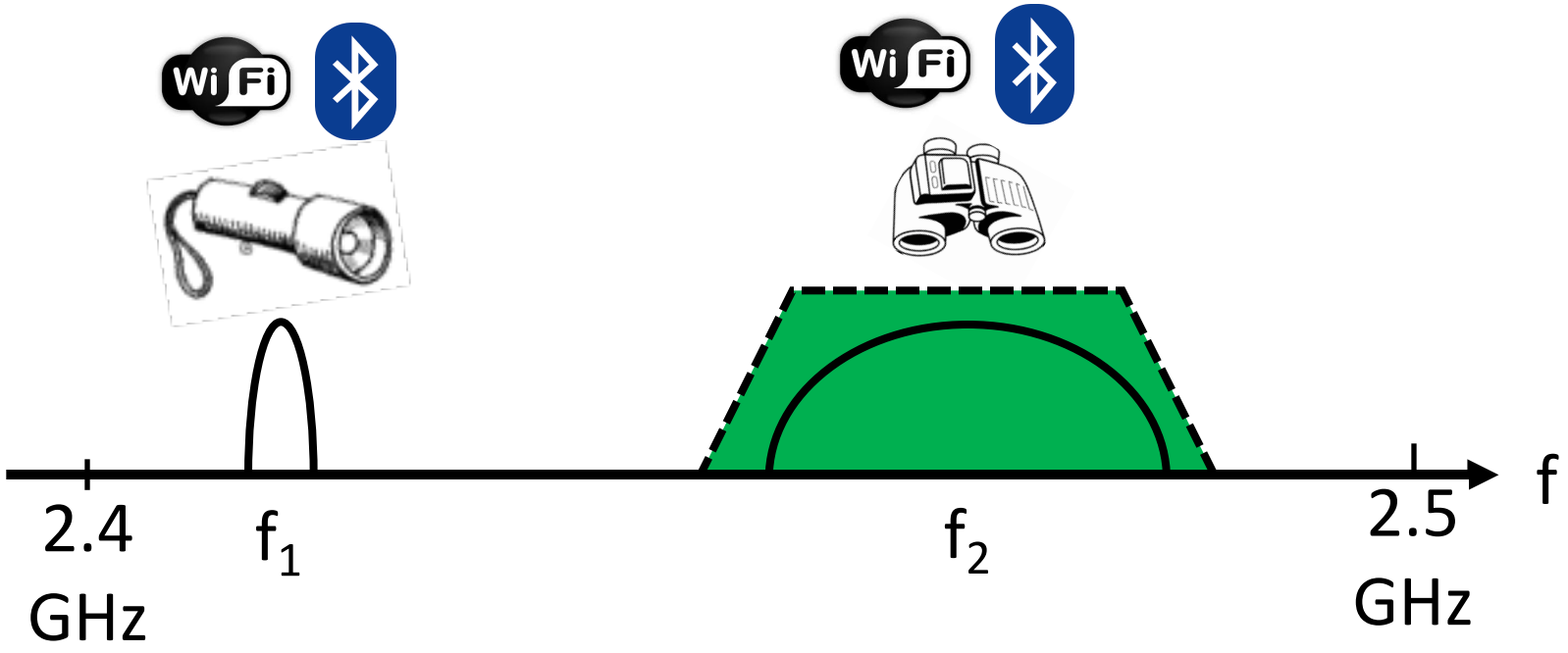
Passive Wi-Fi

- Communicate with unmodified Wi-Fi clients
- Create 802.11b Wi-Fi packets using reflections
- NSDI'16: 1-11 Mbps @ 100 feet

Backscatter @ SIGCOMM 2016

- Use Commodity devices
  - Repurpose existing Bluetooth and Wi-Fi radios
  - Ease of use and deployment

Key idea behind using Commodity Devices



Physical layer: shift the signal into a different frequency band

Using Commodity Devices

- FS-Backscatter
  - Shifts entire BLE/Wi-Fi packets to adjacent band
  - Requires low level firmware access
  - Inter and Intra packet encoding (up to 50 kbps)

- Interscatter (Best Paper Award)
  - Transforms BLE packet into single tone signal in user space
  - Converts the BLE packet into a Wi-Fi/ZigBee packet
  - Encodes data in 802.11b 2-11 Mbps Wi-Fi packets

Backscatter @ SIGCOMM 2016

- Use Commodity devices
  - Repurpose existing Bluetooth and Wi-Fi radios
  - Ease of use and deployment

- Combine radios with backscatter
  - Radios -> high power but gives long range
  - Backscatter -> Ridiculously low power but shorter range

Bradio: Switch between radio and backscatter

Achieving high data rates

- Cellular: 2G-> 3G -> 4G
- 802.11 Wi-Fi: b-> g-> n-> ac

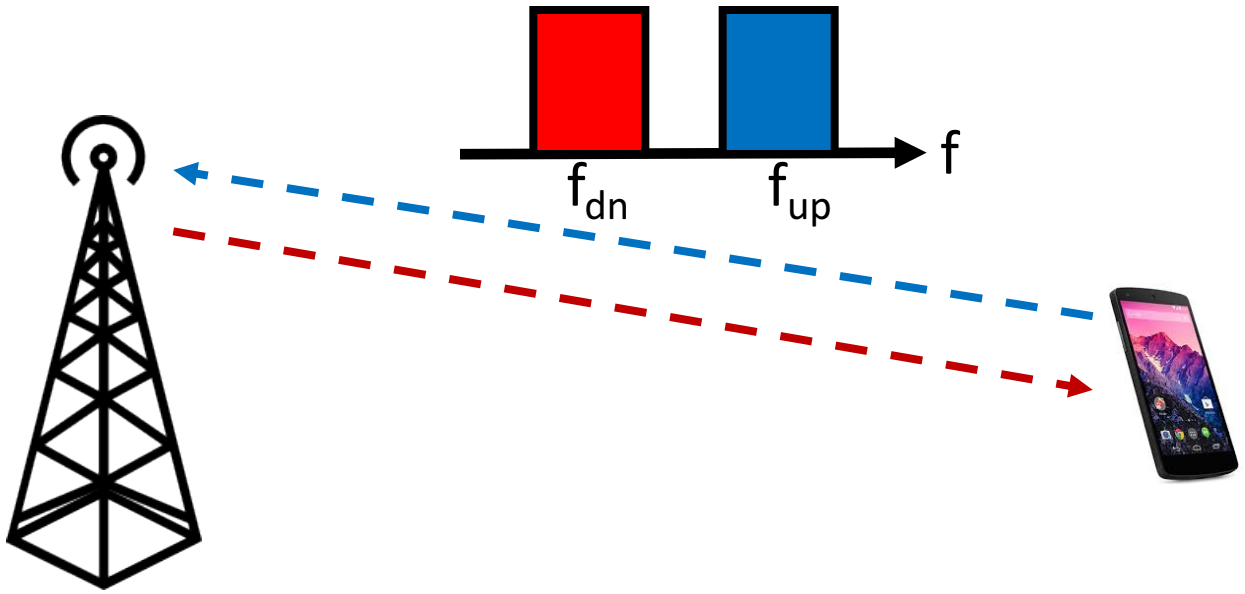
- Next generation (5G) wireless standards
  - Millimeter Wave
  - Large MIMO Systems – Wi-Fi, Cellular, 60 GHz and implement beamforming, nulling, etc.

MIMO requires periodic estimation of channel

Challenge: Channel estimation becomes harder and incurs huge overhead in large MIMO systems

MIMO in Cellular (Best Paper Award)

Cellular Systems use Frequency Division Duplexing



- Model the channel/wireless propagation with frequency independent parameters
- Then use channel reciprocity

Mega MIMO 2.0

- Traditional channel reciprocity methods fail in large MIMO systems
- Software hardware architecture for distributed MIMO

It’s going to be an exciting session!

2 of the 3 Best Papers are in the Wireless Session

- Backscatter Systems
  - Cool physical layer trick - brush up on basic modulation and trig. identities
  - Build MAC and networking layer on top of it
  - RF hardware expertise is required to build these systems!

It’s going to be an exciting session!

- MIMO Systems
  - ➢ It’s all about estimating channel parameters
  - ➢ Brush up on basic wave propagation and matrix operations
  - ➢ Beamforming, nulling and power control techniques in large antenna system

Exponential improvements in coming years in both backscatter and MIMO systems