The Wireless Session
SIGCOMM 2015

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What are wireless systems?

Systems that primarily use radio frequency signals for:

Communication (LTE, WiFi, Zigbee, DVB, FM/AM)

Localization (GPS, RADAR, VOR)

Tracking and authentication (RFID, Apple Beacon)

Imaging (Body scanners)

There are new applications every few years…
The evolution of devices in wireless systems

<table>
<thead>
<tr>
<th>System</th>
<th>Device size</th>
<th>Device power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telegraph</td>
<td>Large</td>
<td>Mains</td>
</tr>
<tr>
<td>TV/Radio</td>
<td>Medium</td>
<td>Mains</td>
</tr>
<tr>
<td>Handhelds</td>
<td>Small</td>
<td>Battery</td>
</tr>
<tr>
<td>Cellular/WiFi</td>
<td>Small</td>
<td>Battery</td>
</tr>
<tr>
<td>Sensors/RFID</td>
<td>Tiny</td>
<td>Battery or Harvesting</td>
</tr>
</tbody>
</table>

Most of the cutting edge research challenges widely held beliefs about the capability of these constrained devices.
The problems appearing in the wireless session

Communicating efficiently with tiny devices...
...with sufficient range and throughput.
(BackFi)

...in the presence of many other devices.
(Caroke & Laissez-Faire)

Localizing devices indoors using radio signals...
...with 10 meter accuracy using existing infrastructure.
(SpotFi)
The challenges

Communicating efficiently with tiny devices…
  - Devices are low power or energy harvesting

Localizing devices indoors using radio signals…
  - Commercial WiFi chips get confused by reflections
The solutions tend be tricks with the physical layer

Signals constructively and destructively interfere.

Signals reflect off of various materials.

Signals behave like vectors (angle and magnitude).

Signals are imperfect due to variability in radio manufacturing.
Communicating efficiently with tiny devices…

…with sufficient range and throughput.

(BackFi) interfere, reflect

…in the presence of many other devices.

(Caroke & Laissez-Faire) imperfect, interfere

Localizing devices indoors using radio signals…

…with existing infrastructure and sufficient accuracy.

(SpotFi) vector
Trick: Communicating in the presence of many other devices

Frequency of oscillators used to generate radio frequency and for timing can vary significantly.

**Caroke** - *Imperfect* Carrier Frequency

**Laissez-Faire** - *Imperfect* on/off keying timing
Trick: Localizing with commercial wireless cards

SpotFi - CSI (Channel State Information)
Captures the \textit{vectorness} of signals
(Reported by Intel WiFi cards since 2012)

AoA - What angle is the signal coming from.

ToF - How long the signal took to get to the receiver.
Attend and enjoy the session!

Wireless devices are pushing toward tiny and low power.

The solutions to the problems are mostly physical layer tricks.

Warning: Math and terminology ahead:

I/Q = Two dimensional space that is very powerful way of representing wireless signals.

Backscatter = Transmission of data by reflecting an existing transmission (e.g., WiFi).