60GHz Mobile Networking

Heather Zheng
SAND Lab
University of California, Santa Barbara
htzheng@cs.ucsb.edu
http://sandlab.cs.ucsb.edu

The Promise of 60GHz

- Large *unlicensed* spectrum available.
    - E.g. 7GHz unlicensed spectrum

- Compressed arrays create highly directional beams
    - Narrow beams minimize interference

- Leverage 802.11ad as a great start-point
    - 802.11ad: IEEE indoor 60GHz standard
    - Support **three channels**, up to **6.76Gbps** data rate per channel

Single element
2.4GHz antenna
5cm
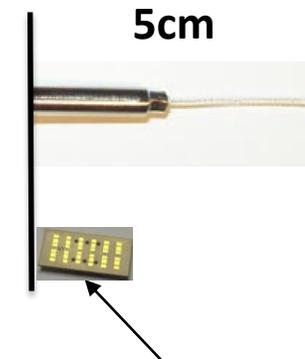
60GHz **32-element** Array[1], **1.8cm × 0.8cm**
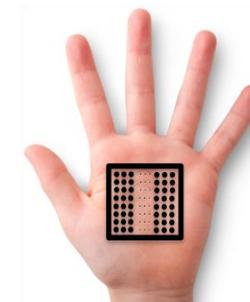
32 x 32 array
in
5.5 x 5.5 cm

[1]Beyond 802.11ad – Ultra High Capacity and Throughput WLAN, IEEE 11-13/0408r0

60GHz @ Today

© 2010 Wireless Gigabit Alliance

If We Could Bring 60GHz to Outdoor

60GHz 10x10 array

LTE

60GHz basestation

60GHz basestation

LTE macrocell
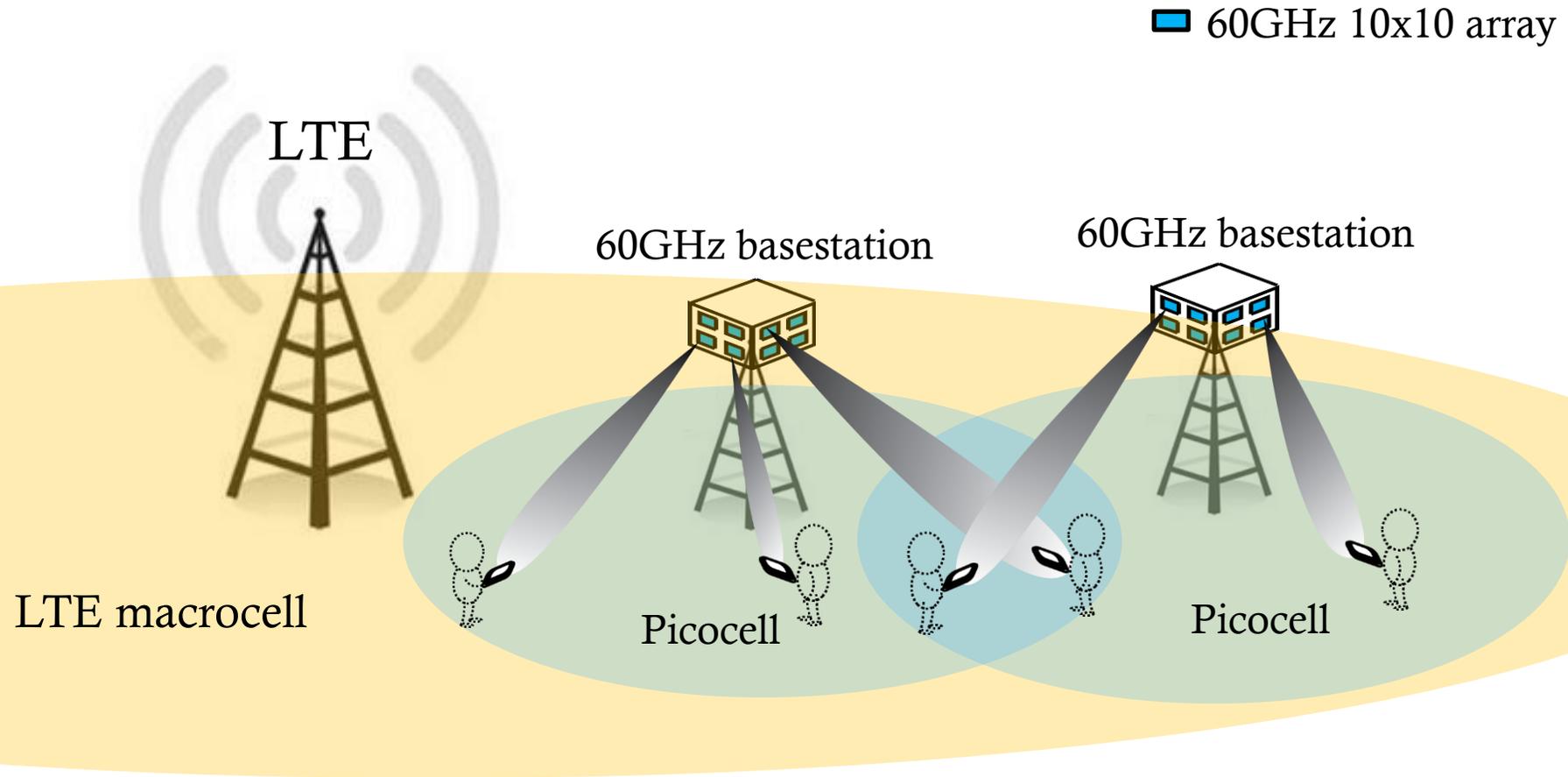
Picocell

Picocell

Real Life Examples
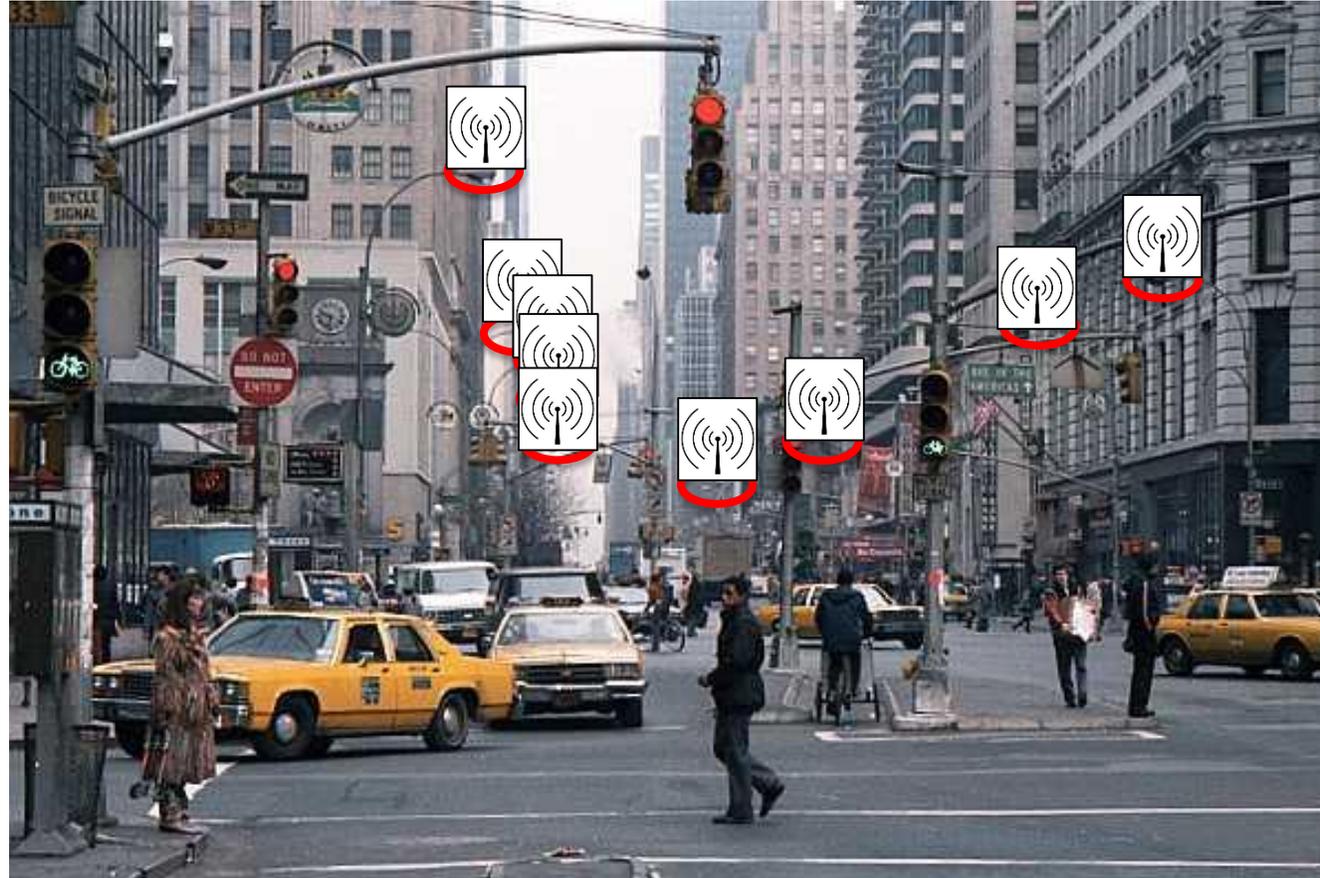
Lamppost-based deployment easily covers downtown streets and intersections.

60GHz Picocell Pros

Many arrays transmit simultaneously
→ ~288Gbps capacity *per basestation*

Spectral Efficiency

Dimensions of Capacity

Very narrow beam
→ Small interference
→ Dense cells (every 20m)

Cell Density

Amount of Spectrum

7GHz unlicensed spectrum
→Up to 6.76Gbps link rate
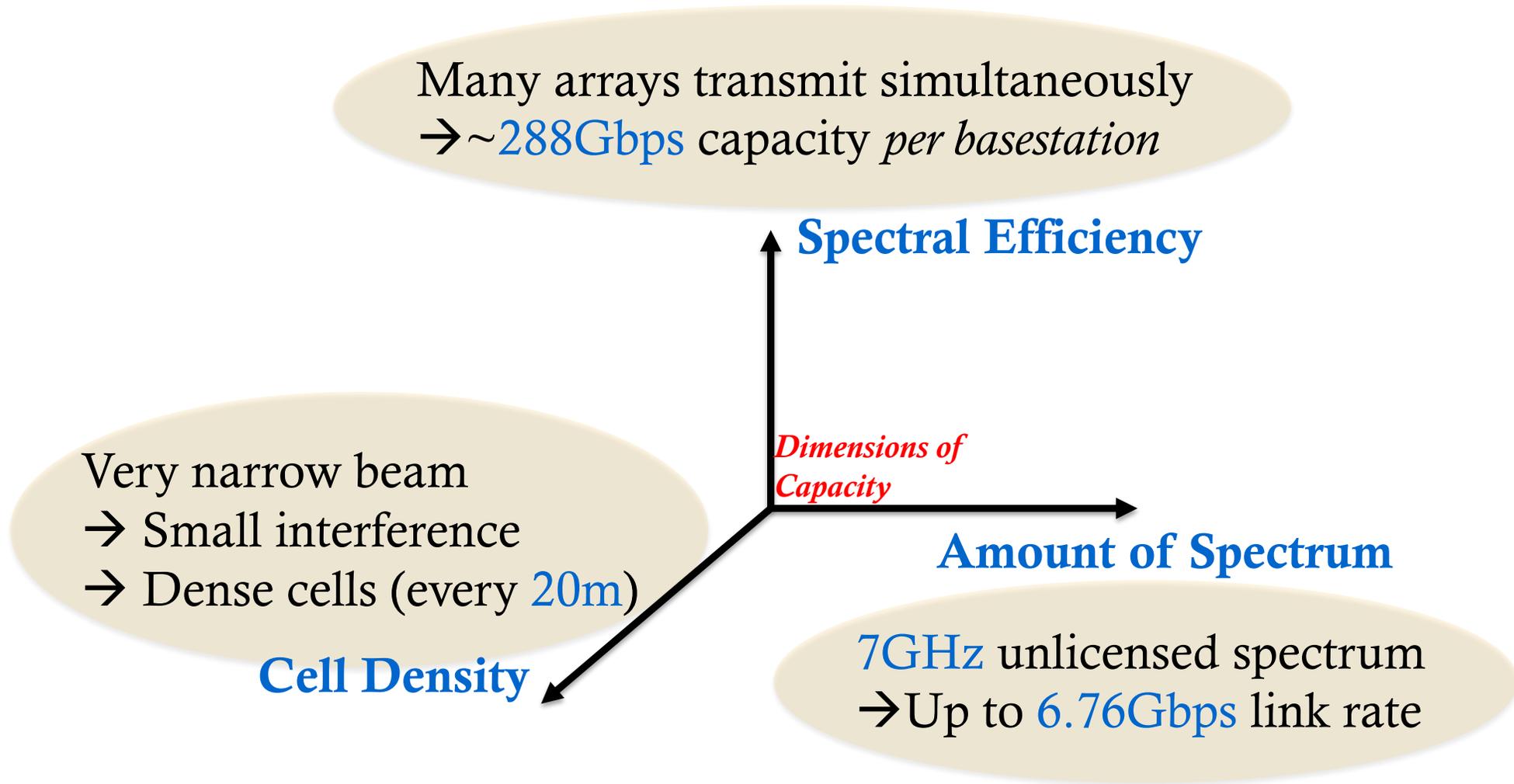
Answers to Common Concerns

- <u>60GHz oxygen absorption → range too small?</u>

  100+m range (@1Gbps) for 802.11ad devices

- <u>High frequency → sensitive to blockage ?</u>

  Yes but reflection provides ample alternative paths

- <u>Narrow beam → user motion breaks connection?</u>

  Realign every 2s is sufficient for pedestrian

Basestation

Client

Real-life environment

Key Challenges

- **User tracking**: build a path inventory for each user
  - Compressive array adaptation vs. scanning

- **Picocloud** architecture
  - Base station coordination
  - Control plane for a multi-Gbps data plane

- Hardware: **array of steerable subarrays**
  - Programmable antenna array
  - Spatial multiplexing

Ongoing teamwork at UCSB, Stanford, U Wisconsin

Reusing 60GHz Radios for Mobile Imaging

- Identify object location, orientation, shape, curvature & material
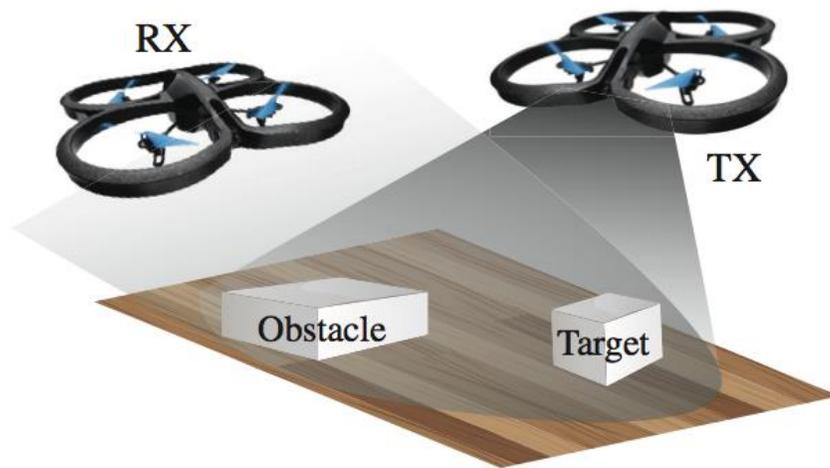
(a) Scenario setup
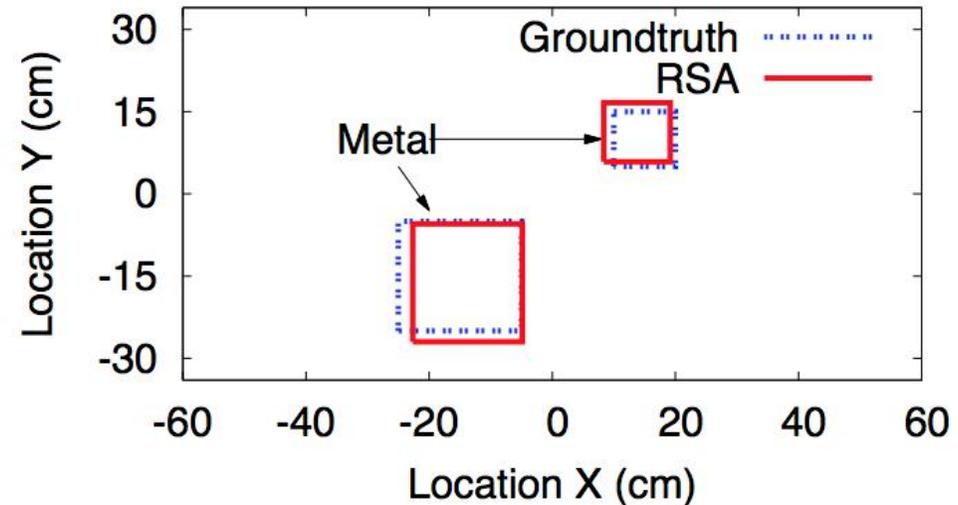
(b) Imaging result (top view)

Reusing 60GHz radios for Mobile Radar Imaging,
Yanzi Zhu, Yibo Zhu, Ben Y. Zhao and Haitao Zheng, MobiCom'15

Demystifying 60GHz Outdoor Picocells

Yibo Zhu, Zengbin Zhang, Zhinus Marzi, Chris Nelson, Upamanyu Madhow, Ben Y. Zhao, Haitao Zheng

MobiCom'14

THANK YOU!