802.11ax: Transforming Wi-Fi to bring unprecedented capacity & efficiency

The Wi-Fi landscape is rapidly changing

More devices & data[1]

8 → 24 → 50

2012 2017 2022

Devices per household

Apps & services with diverse needs

Ranging from extremely low traffic to highly bandwidth intensive

[1]Source: Connected devices–GSMA connected living 2015; Number of devices per home in home with a family of 4

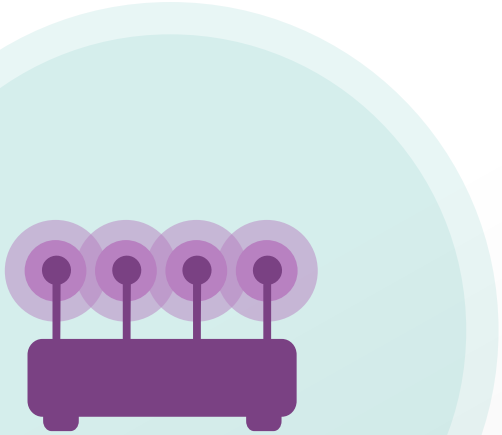
Multiple interfering AP environment

- Shared channel usage

Wi-Fi usage extending to outdoors

- Urban hotspots
- Campus-wide coverage

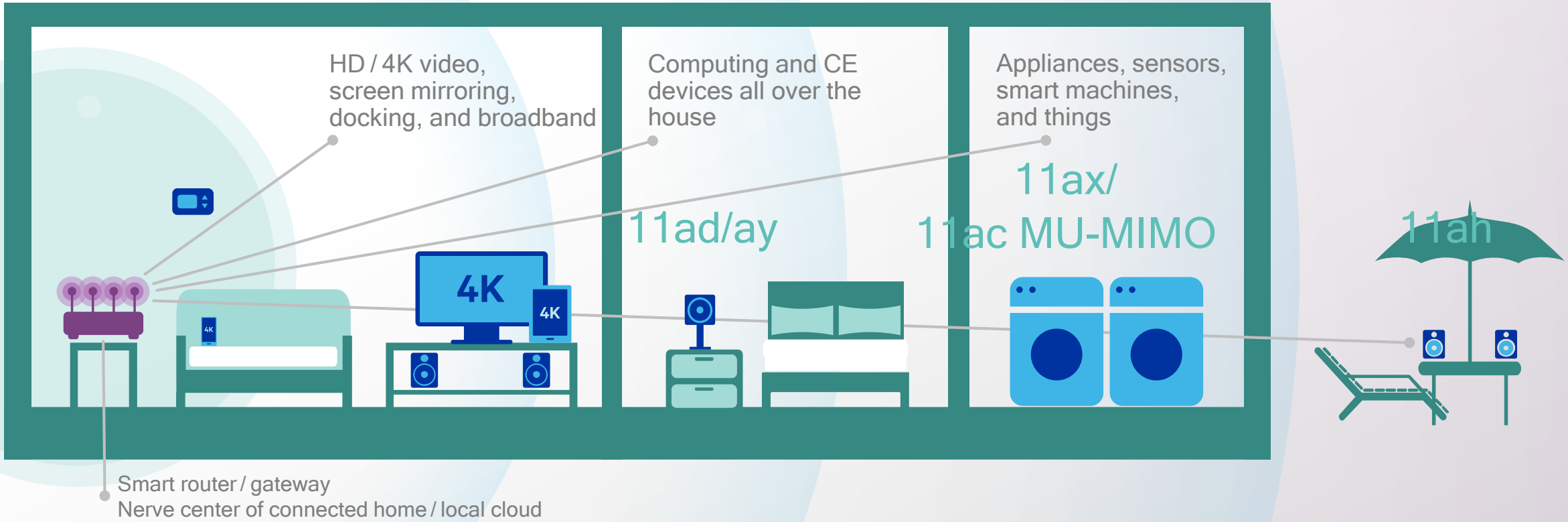
Wi-Fi scales to support wide range connectivity needs



	11ad/ay Extremely high capacity and density	11ax/ 11ac MU-MIMO Foundation for capacity and coverage	11ah Ultra low-power, extended coverage
User speed	Multi-Gigabit	100s of Mbps	100s of kbps - 10s of Mbps
Coverage	In-space	Whole house	Campus
Battery life	Full day	Full day	Months/years

Seamless transition

Wi-Fi powers the smart connected homes



11ad/ay
Consistent Multi-gigabit experience

11ax /11ac MU-MIMO
Broadband for the whole house

11ah
Ultra low-power and extended range

Capacity

(The amount of data delivered to all users with appropriate QoS)

is going to be the defining character of Wi-Fi networks

Capacity is the key metric to measure Wi-Fi performance

Moving away from simplistic theoretical peak speeds

Traditional approach
"theoretical peak speed"

- Works for single AP with few devices

New approach
Overall "capacity"

- Relevant for dense usage scenarios

2.4GHz/ 5GHz	802.11 g/n	802.11 ac	11ac MU-MIMO	802.11 ax
60 GHz		802.11 ad		802.11 ay

11ax

High efficiency Wi-Fi for high density connectivity

Up to 4x increase in capacity[1]

Higher efficiency

Improved coverage & performance

[1]Based on Qualcomm Technologies simulations; Up to 4x increase in median throughputs compared to 4x4 11ac Wave-2; Assumptions: 11ax with 8x8 AP and 2x2 clients; UL and DL MU-MIMO; increased OFDM symbol

11ax : Designed for high density connectivity

Simultaneously serving lots of devices per AP

Few vs. dozens of devices

Optimal performance in dense environments with many APs

Multiple APs on shared channels

Uplink resource scheduling

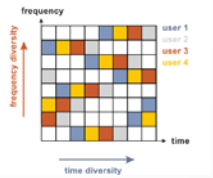
vs. contention

Efficiently serving multiple traffic types

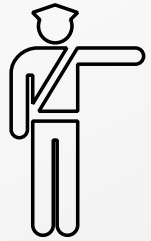
Low traffic IM. IoT vs. 4k streaming/download

Technology building blocks of 11ax

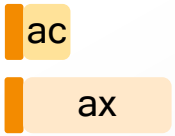
8x8
MU-MIMO
DL/UL



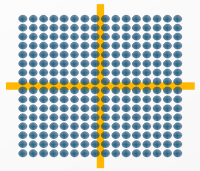
OFDMA
DL/UL



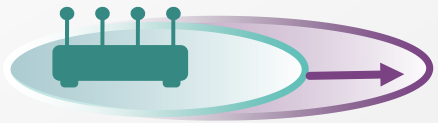
Up link resource
scheduling



Long OFDM
symbol

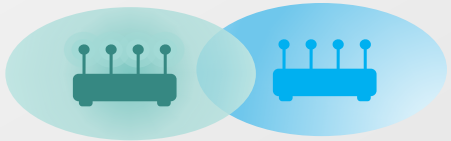


1024 QAM



Extended range

More spatial
streams



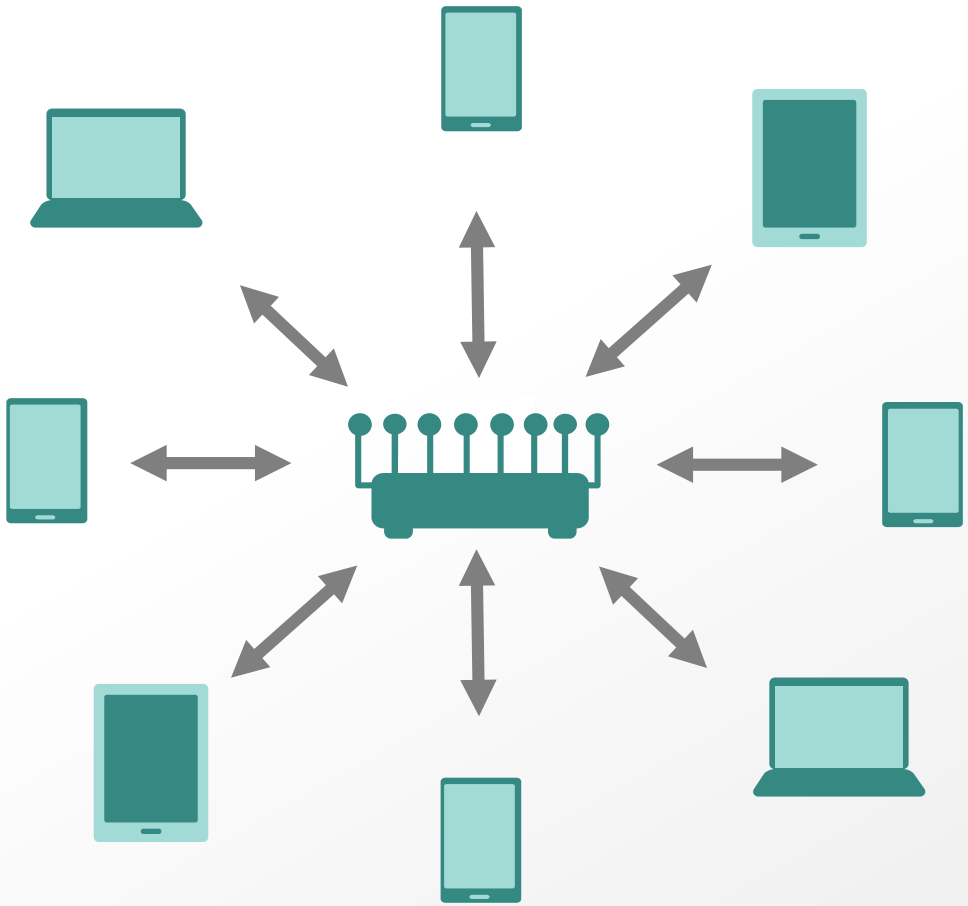
BSS color

MU-MIMO and OFDMA expertise are key for success in 11ax

Up to 4x increase in capacity

Extending the benefits of proven 11ac MU-MIMO

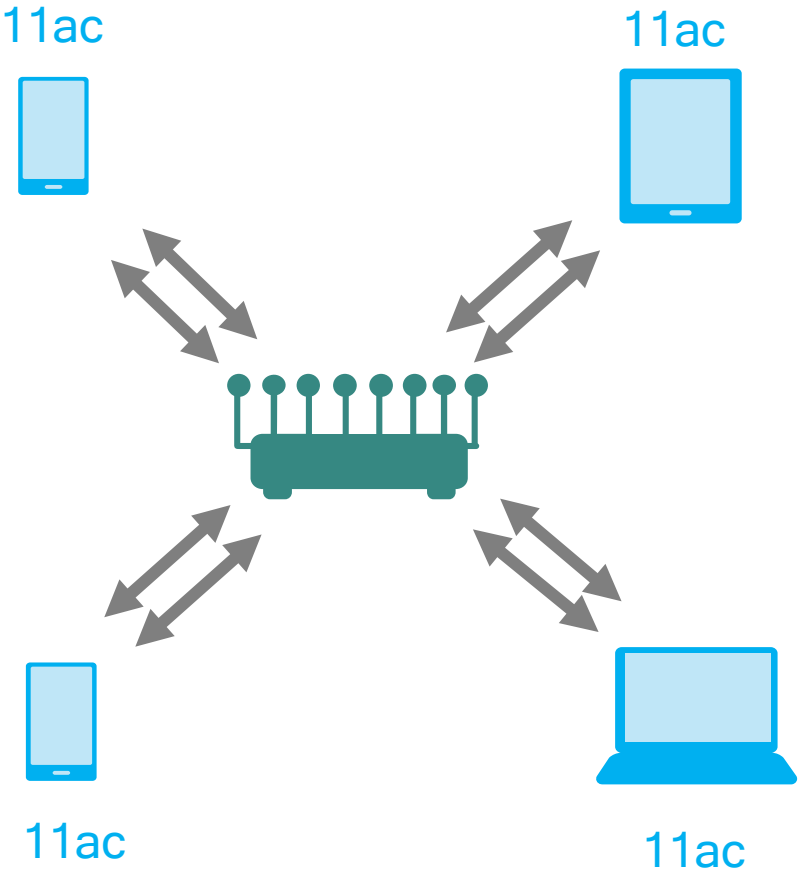
11ac MU-MIMO is already mainstream



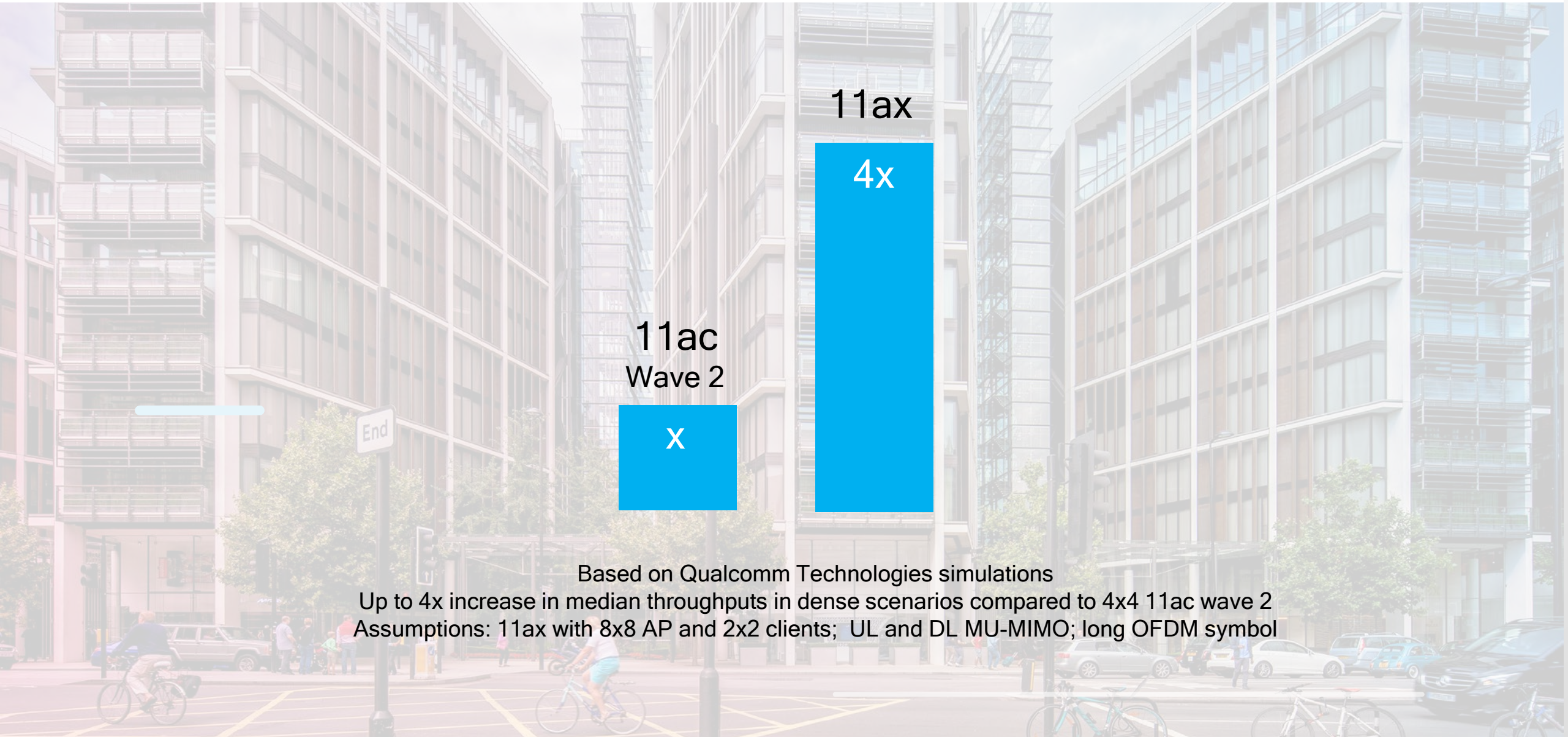
- Up to 8x8 MU-MIMO in the downlink
  - Serving up to 8 simultaneous users (in downlink)
  - Up to 2x increase in capacity vs. 4x4
- Up to 8x8 MU-MIMO in the uplink
  - Serving up to 8 simultaneous users (in uplink)
  - Up to 8x increase in capacity vs. 1x1
  - Extremely useful for uplink heavy apps such as social media, content sharing (video, picture uploads, Periscope, etc)
- Higher MU-MIMO gain with more client devices per AP

8x8 MU-MIMO: Improved performance for 11ac devices

- Immediate coverage improvement for existing 11ac and legacy client devices
- Up to 4 downlink users with 2x2 configuration served simultaneously
- Realizes the benefits of 11ax during the 11ax client device ramp-up
- Overall capacity scales with the penetration of 11ax client devices



Up to 4x increase in capacity in dense scenarios



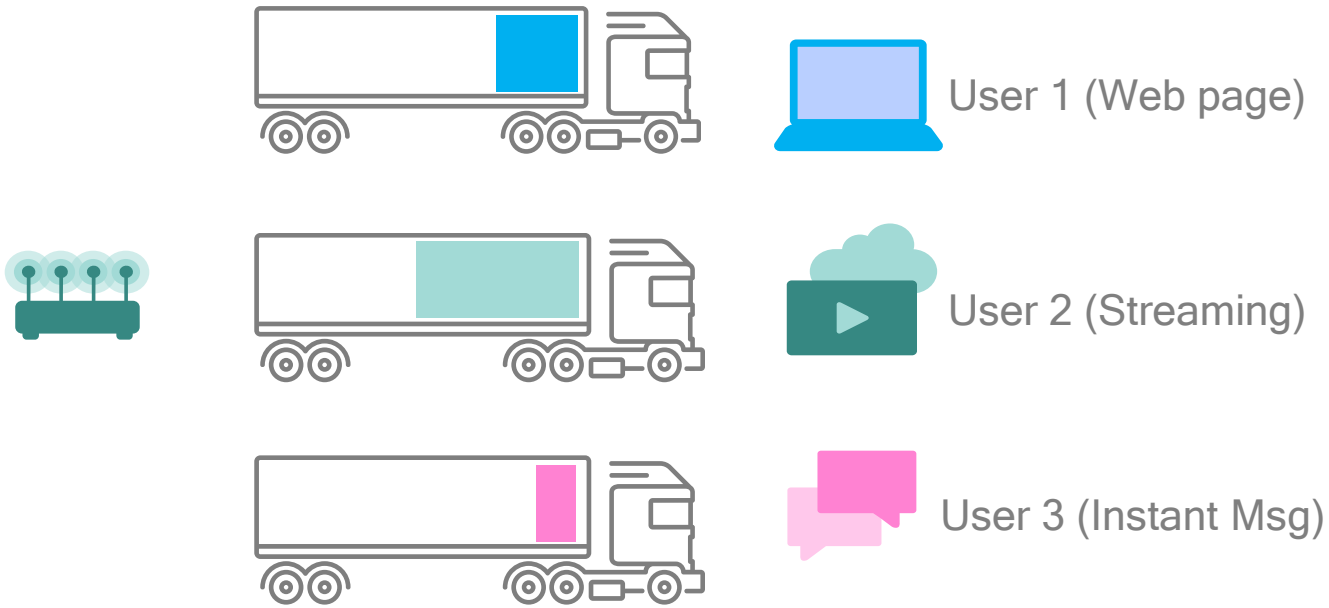
Based on Qualcomm Technologies simulations
Up to 4x increase in median throughputs in dense scenarios compared to 4x4 11ac wave 2
Assumptions: 11ax with 8x8 AP and 2x2 clients; UL and DL MU-MIMO; long OFDM symbol

Higher efficiency

OFDMA: Proven technology for efficient access

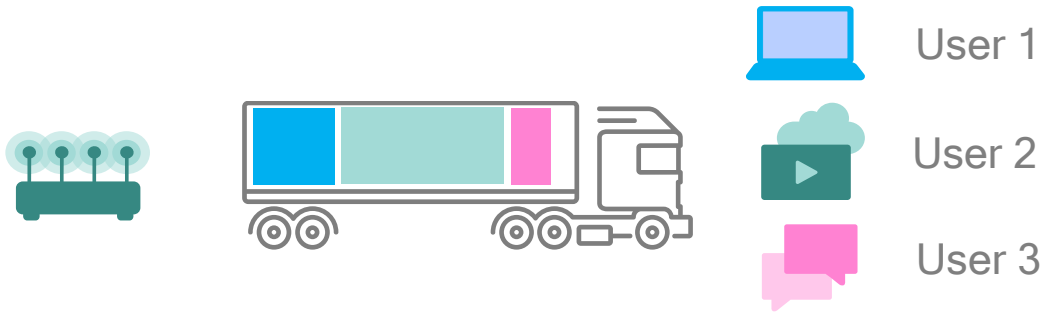
Foundation of global 4G LTE standard

OFDM



- Fixed overhead independent of payload size
- Uses full channel bandwidth per user

OFDMA

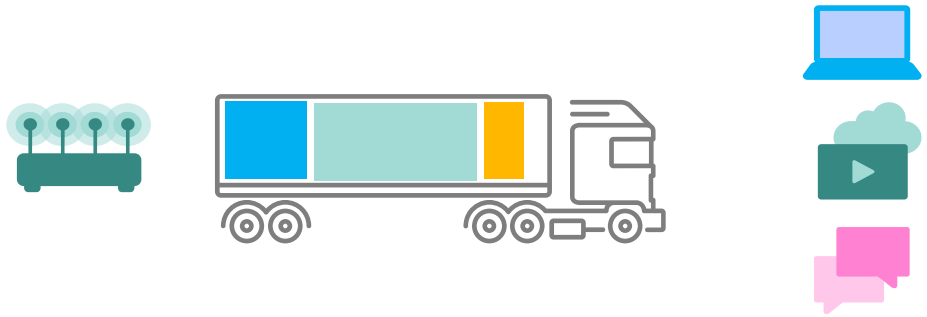


- Overhead amortized among users
- Efficient use of resources
- Scales resources for different types of traffic (e.g. IM vs large download)
- Increases overall efficiency

OFDMA and MU-MIMO are complementary

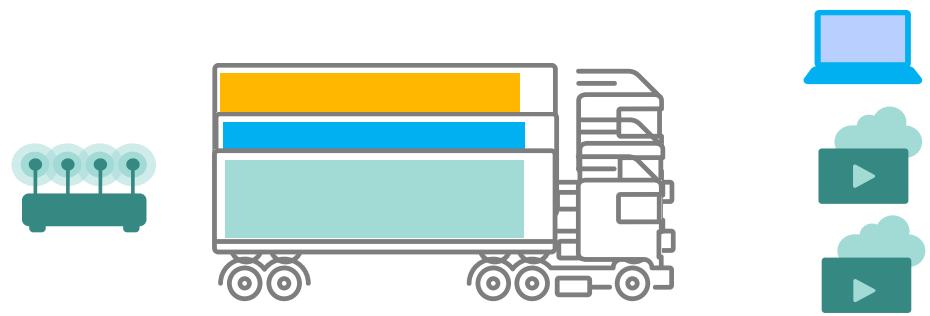
Utilized based on the type of application being served

OFDMA



- OFDMA increases efficiency
- OFDMA reduces latency
- Ideal for low-bandwidth applications

MU-MIMO



- MU-MIMO increases capacity
- MU-MIMO results in higher speeds per user
- Ideal for high-bandwidth applications

MU-MIMO is similar to multiple trucks serving users simultaneously

UL OFDMA & UL MU-MIMO

Scheduled UL access for increased capacity and efficiency

Contention based resource allocation (11ac)

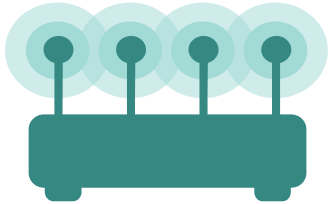
- Un coordinated resource management
- Devices all compete and try to get resource till they succeed
- Works well in single AP scenario

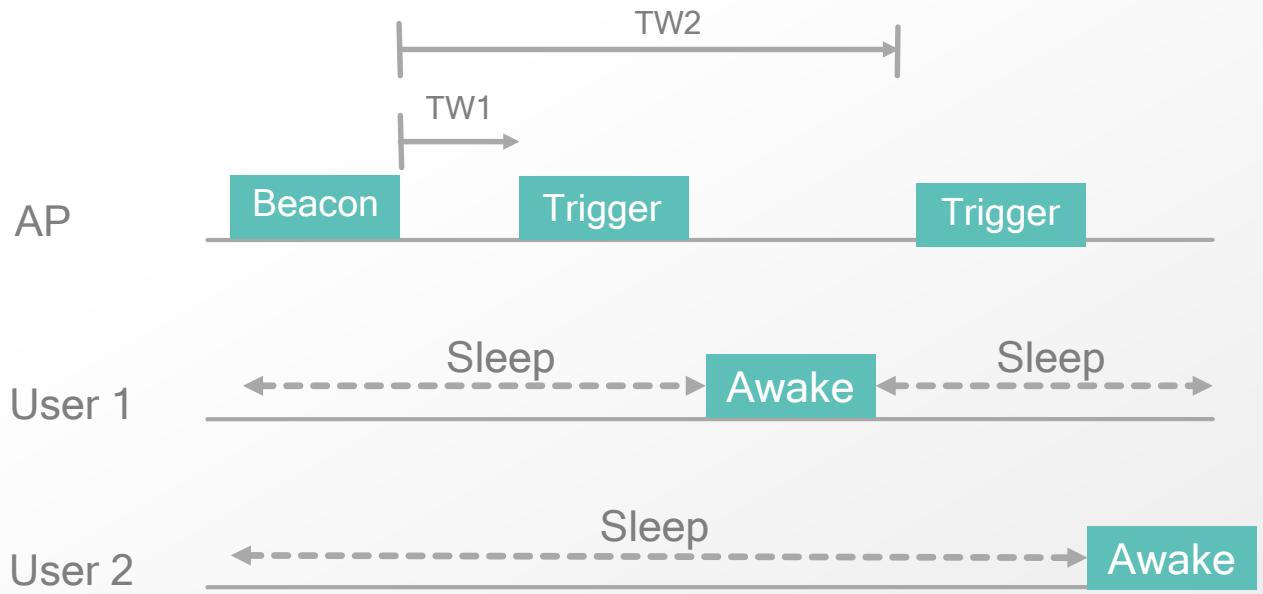
Scheduling based resource allocation (11ax)

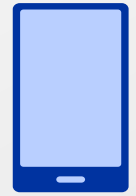
- Up link resource allocation managed by AP
- A must for dense scenarios
- Increased capacity and better user experience

Resource scheduling significantly improves device battery life

TWT : Target Wake Time





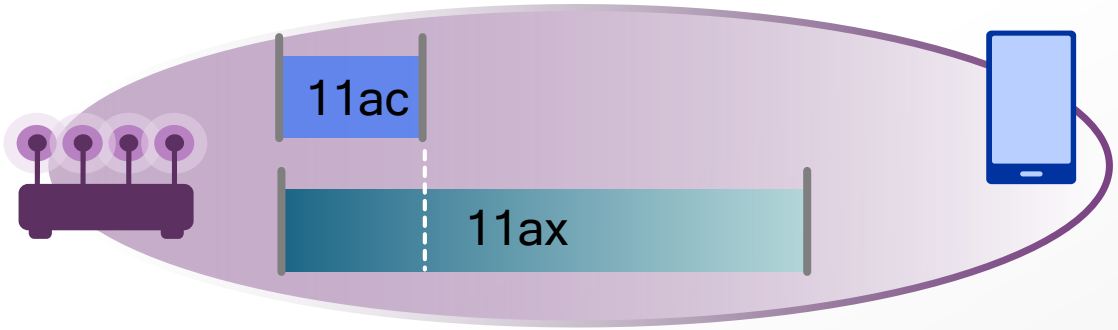


- AP and devices negotiate and define a specific times to access the medium
- Reduced contention and overlap between users
- Significantly increases the device sleep time to reduce power consumption

Improved coverage & performance

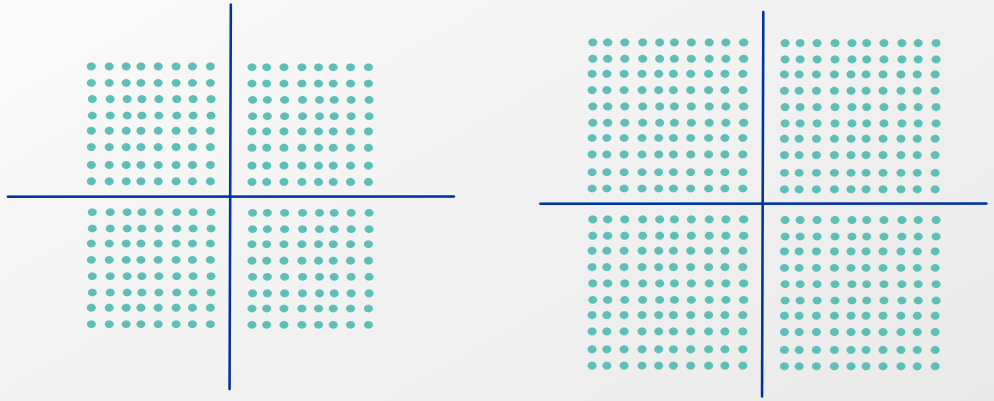
Enhancements that further improve capacity & efficiency

Long OFDM symbol



- 4x longer OFDM symbol
- Increased efficiency and higher rates
- Address outdoor use cases such as colleague campus and public venues

1024 QAM



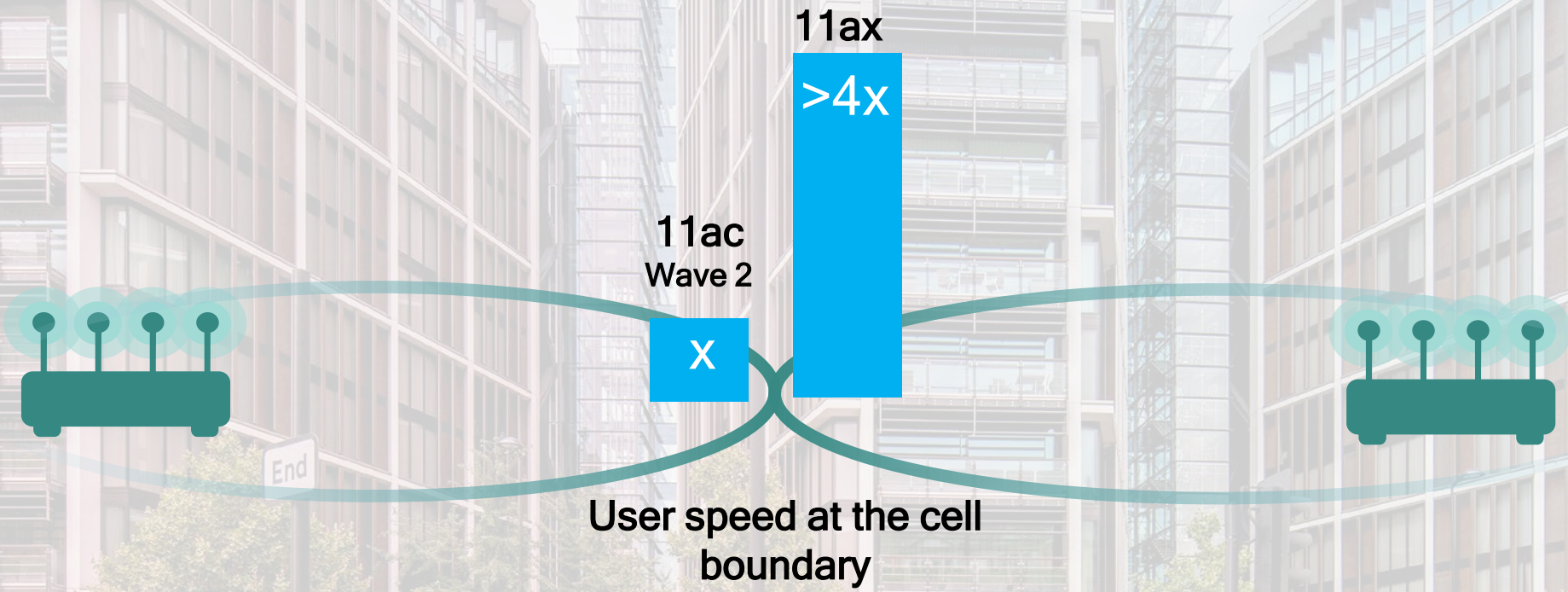
256 QAM

1024 QAM

- 10 bits per symbol vs. 8
- Gigabit Wi-Fi with only 2x2
- Up to 25% higher capacity vs. 256QAM

[1]In certain conditions

>4x increase in speeds for users on the cell boundary



Based on Qualcomm Technologies simulations
> 4x increase in worst 5 percentile throughput in dense scenarios compared to 4x4 11ac Wave 2
Assumptions: 11ax with 8x8 AP and 2x2 clients; UL and DL MU-MIMO; long OFDM symbol

[1]Up to 4x increase in median throughputs in dense scenarios; Projected value for 8 AP antennas with 2 STA antennas based on 4x1 simulations, UL/DL MU-MIMO and improved numerology; IEEE Enterprise scenario with Full buffer traffic 50:50 DL:UL; ; IEEE enterprise scenario (

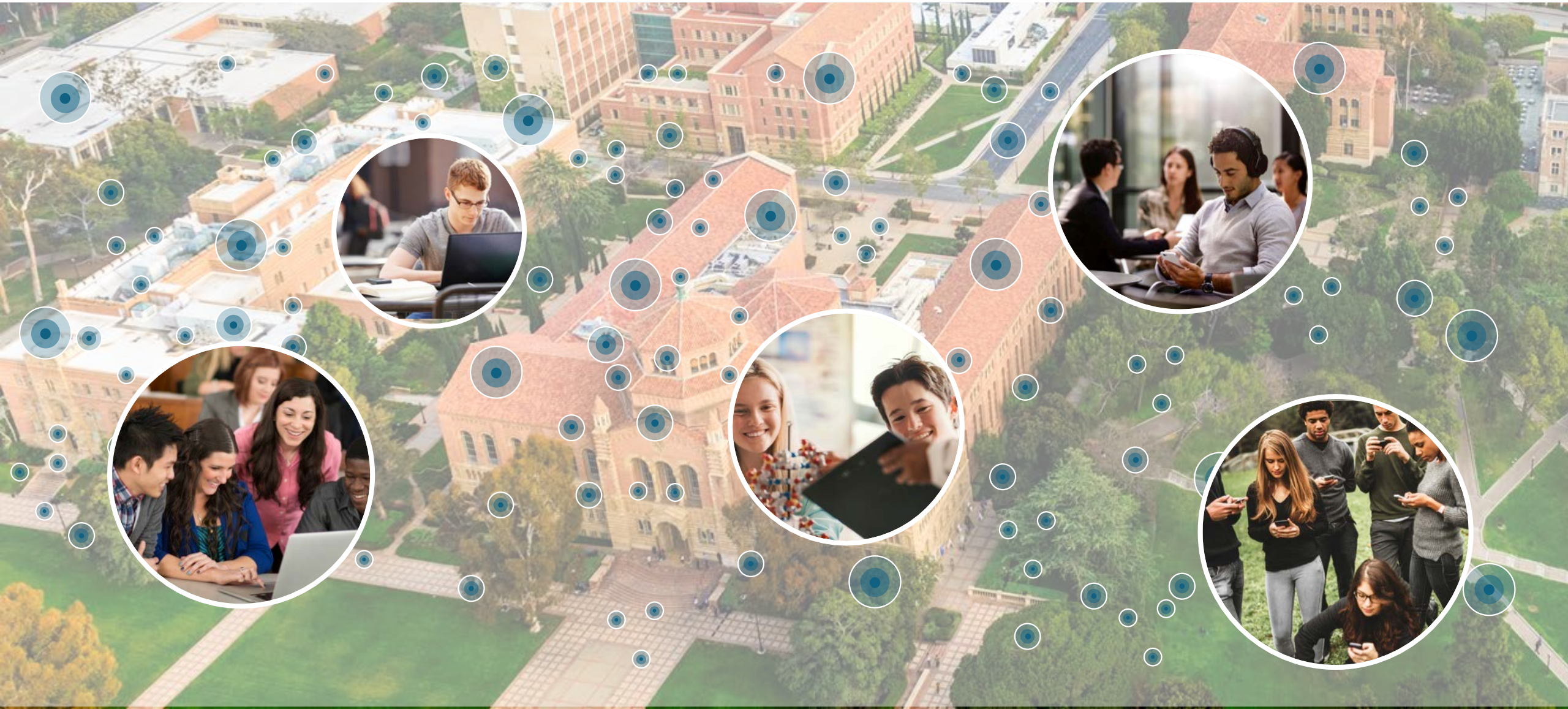
11ax use cases

11ax is a necessity for dense urban usage scenarios

E.g.: Apartment complexes, condominiums, and multi-dwelling buildings

11ax is key to enterprise-class use cases

E.g.: Next-gen e-classrooms, colleges and school campuses



11ax is critical for carrier networks for LTE traffic offload

Qualcomm Technologies is leading the Wi-Fi evolution

OFDMA and 11ac Wave-2 experience key to 11ax success

Wi-Fi leadership across segments[1]

First with MU-MIMO and 11ad

LTE/LTE Advanced technology & product leadership

>30 years of industry leadership in cellular

[1]Source: from IHS WLAN IC Extract Nov. 2016. Reflects shipments from 802.11X ICs (Baseband, RF / IF, but not PA) used in handsets, tablets, PCs (mobile and desktop), Enterprise and Consumer Access points, Carrier Gateways and Clients, Gaming devices/consoles, and other devices.

802.11ax: Next Gen Wi-Fi for the transformed landscape

1
- Designed for high density usage scenarios
  - Unprecedented increase in capacity to support more devices, more data and diverse needs

2
- A must to meet capacity needs in homes
  - Capacity to support connected homes.

3
- Critical upgrade for enterprise and carrier networks
  - Higher capacity and coverage enables new use cases and improve existing ones

4
- Qualcomm Technologies Wi-Fi leadership
  - Leadership in MU-MIMO, 11ad, OFDMA & strong proven heritage of cellular technology

Capacity is going to be the defining character of Wi-Fi performance

Thank you

Follow us on:

For more information, visit us at:

www.qualcomm.com & www.qualcomm.com/blog