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# Converged Wireless Access: The New Normal

Karthik Sundaresan

WNPE, Univ of Washington, June 2016

NEC Laboratories America

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# 5G Services

e network requirements fo

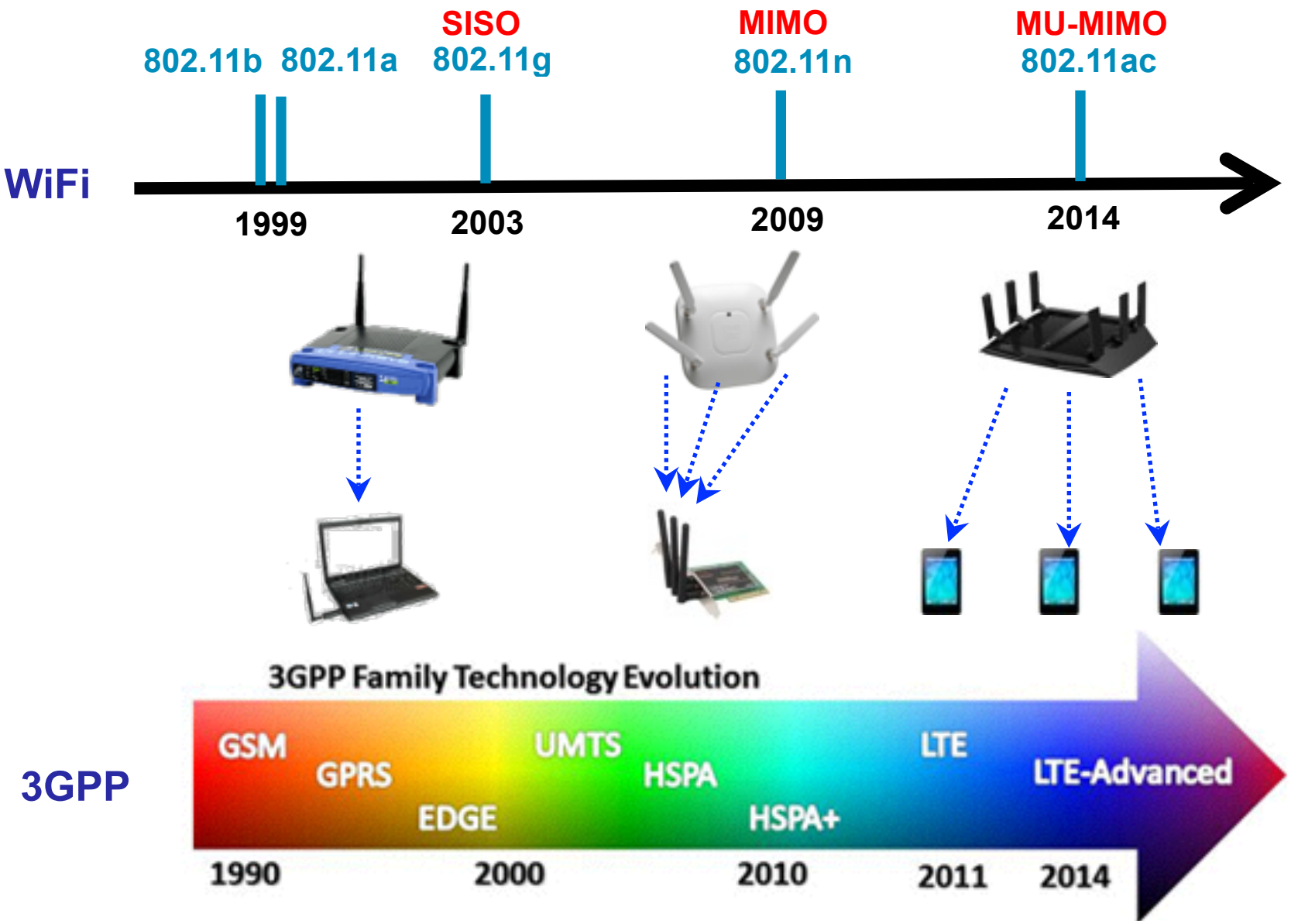

Source: Ericcson

# 5G Services

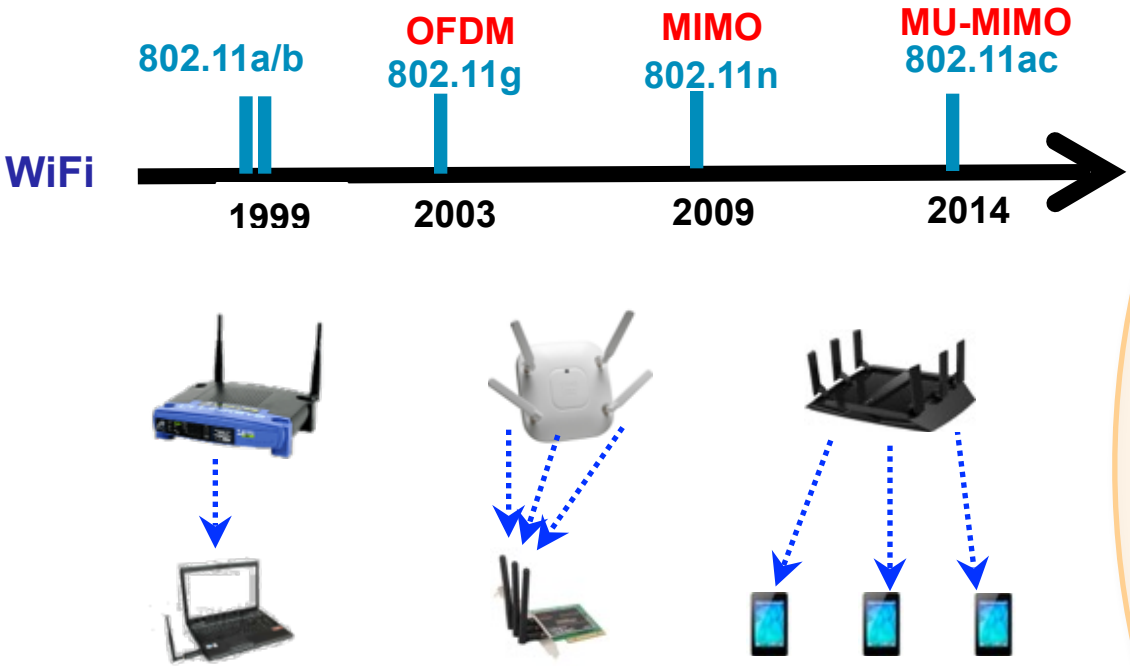
- Services drive network requirements for 5G
- Wireless technology and access plays a critical role in this vision

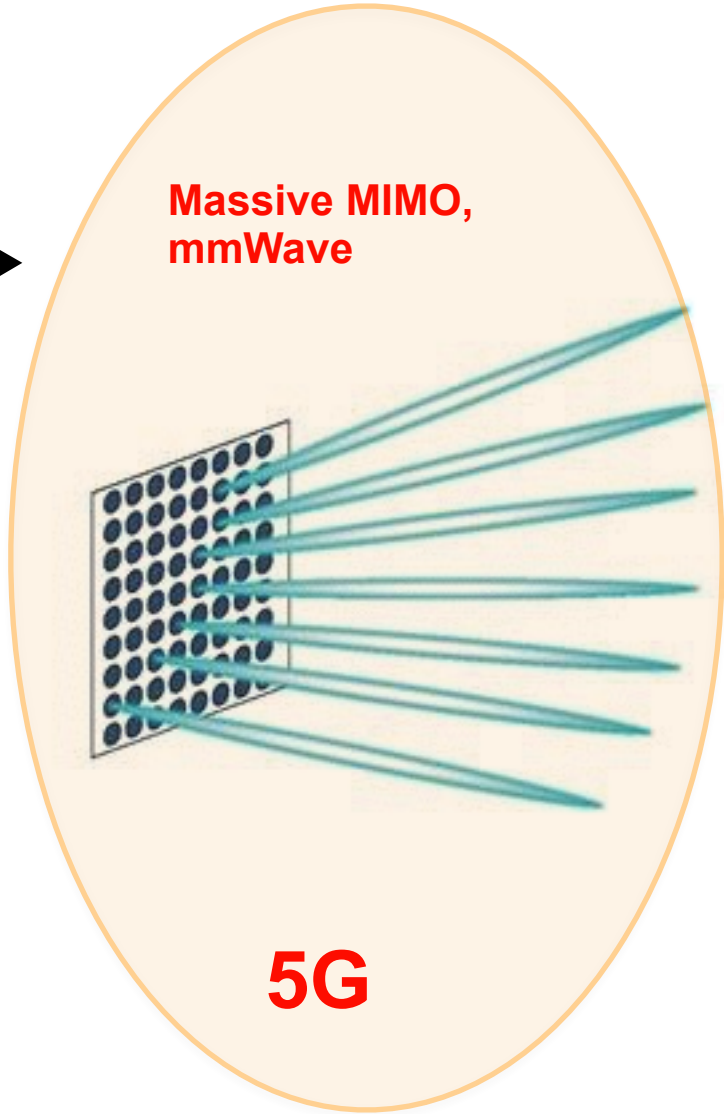

Source: Ericcson

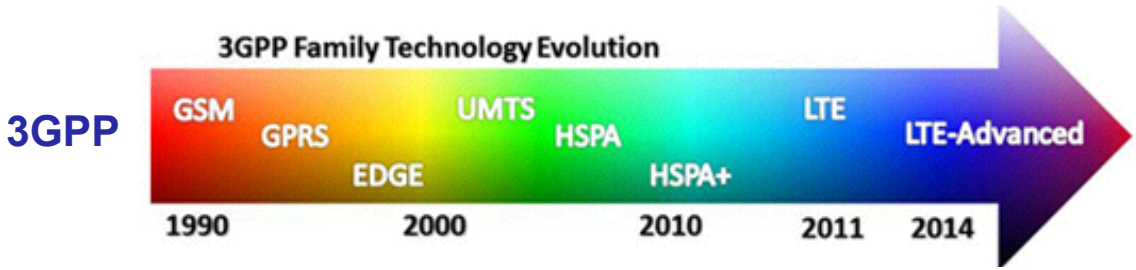
# Wireless Technology Evolution



# Wireless Technology Evolution

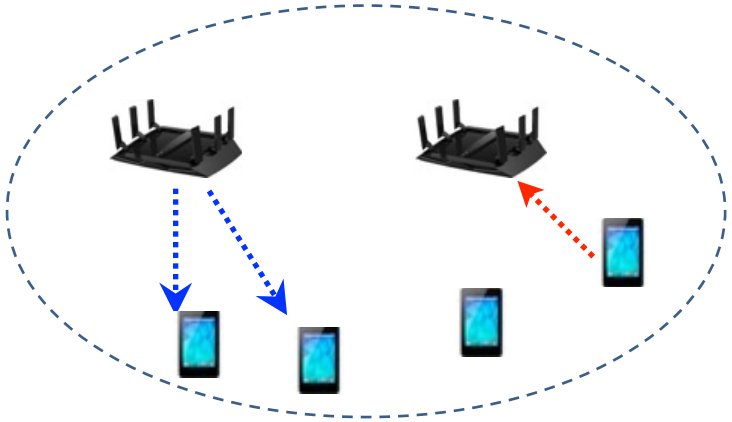


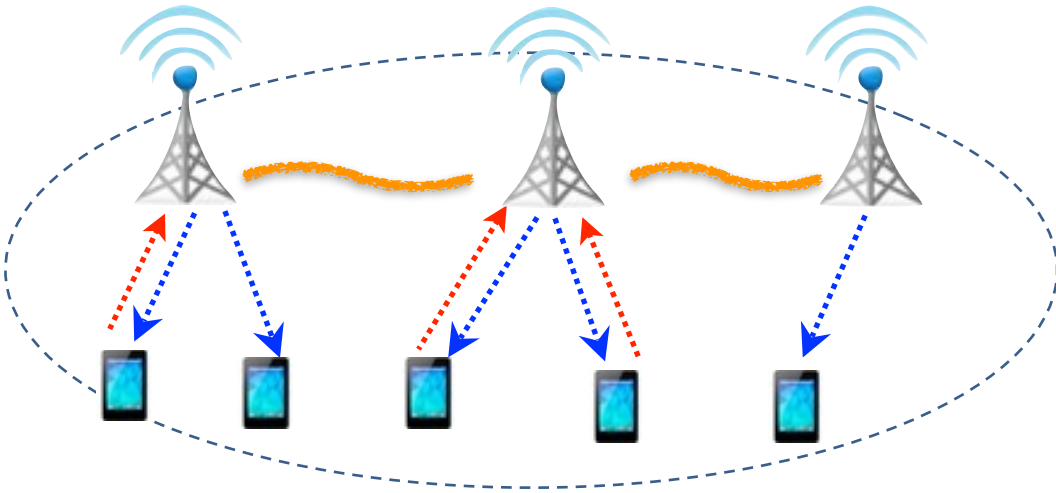



# Access: Two Isolated Worlds

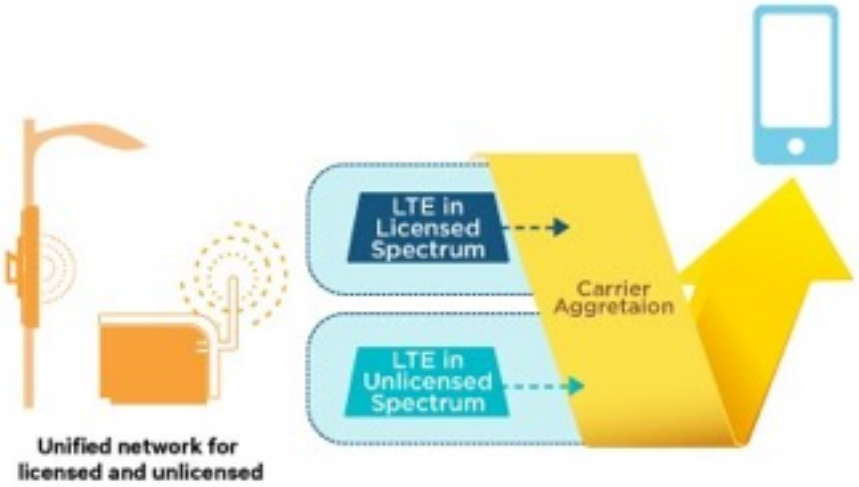
- WiFi
  - Asynchronous, distributed access
  - Asynchronous transmit/ receive
  - De-coupled downlink and uplink
- Cellular (LTE)
  - Synchronous, coordinated access
  - Synchronous transmit/ receive
  - Coupled downlink and uplink (BS schedules)



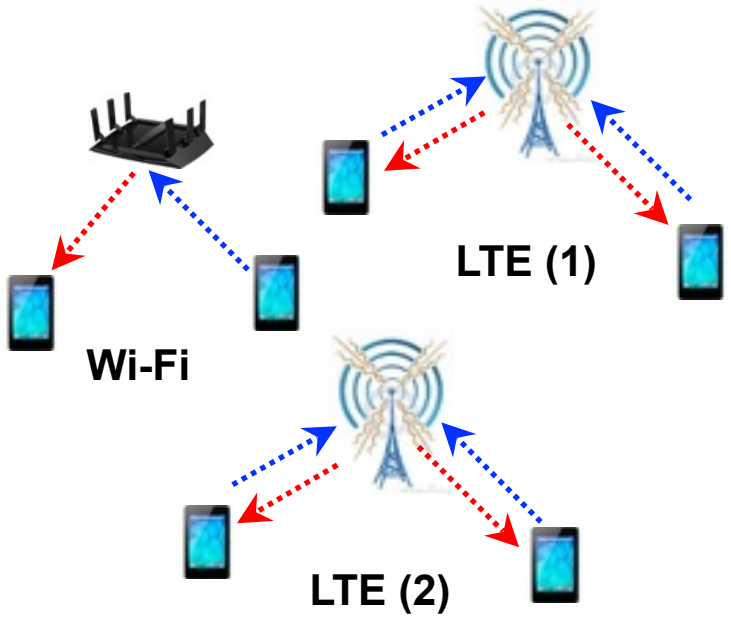


# Convergence in Access?

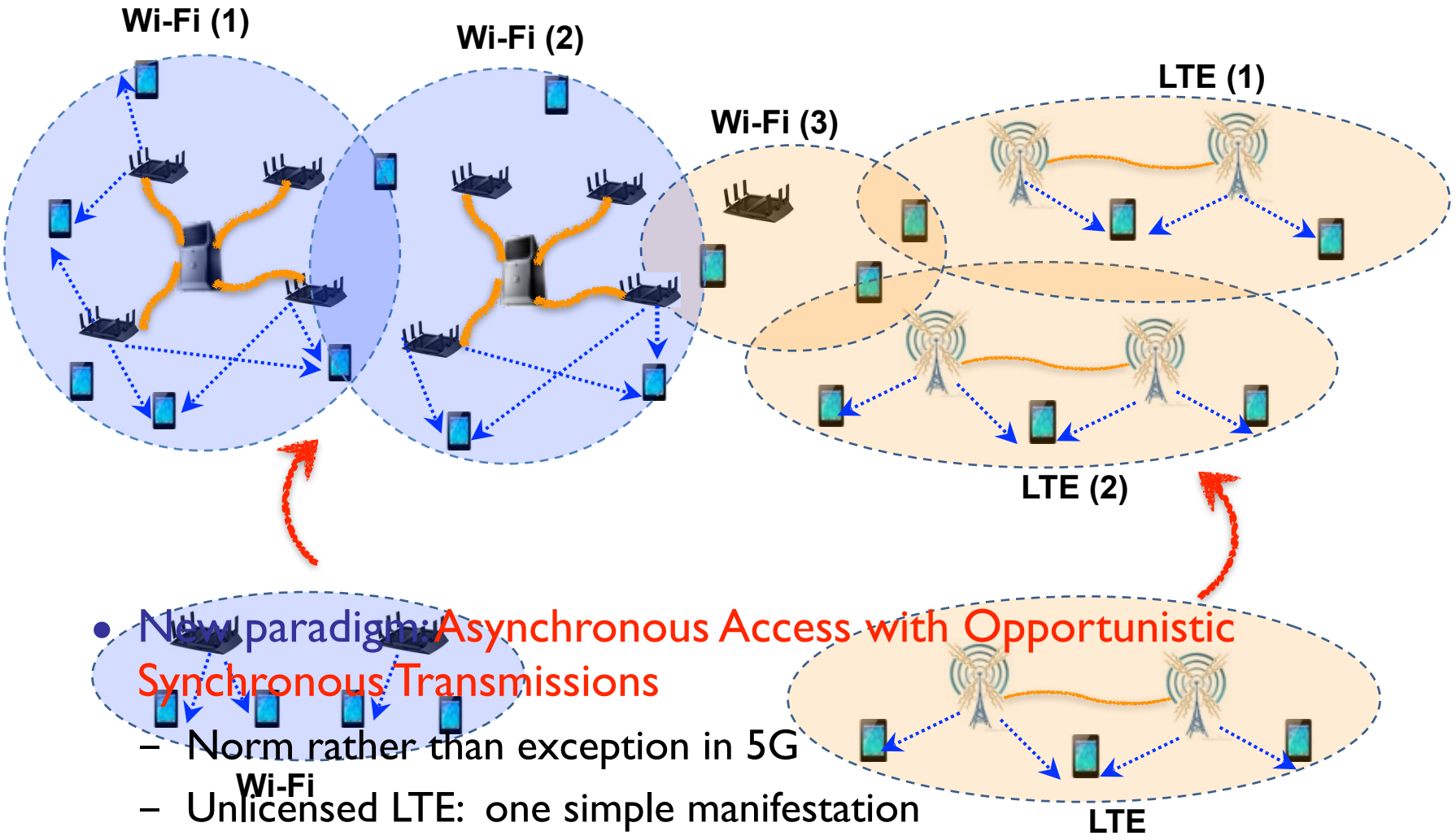
- Licensed spectrum crunch
  - Supplement licensed with unlicensed channels
- Co-existence challenges
  - Co-existence with WiFi and other LTE operators
  - Asynchronous access in traditional synchronous network
- Boundaries of access getting blurred
- Is this a one-off problem?




Source: Qualcomm



# A Paradigm Shift in Access

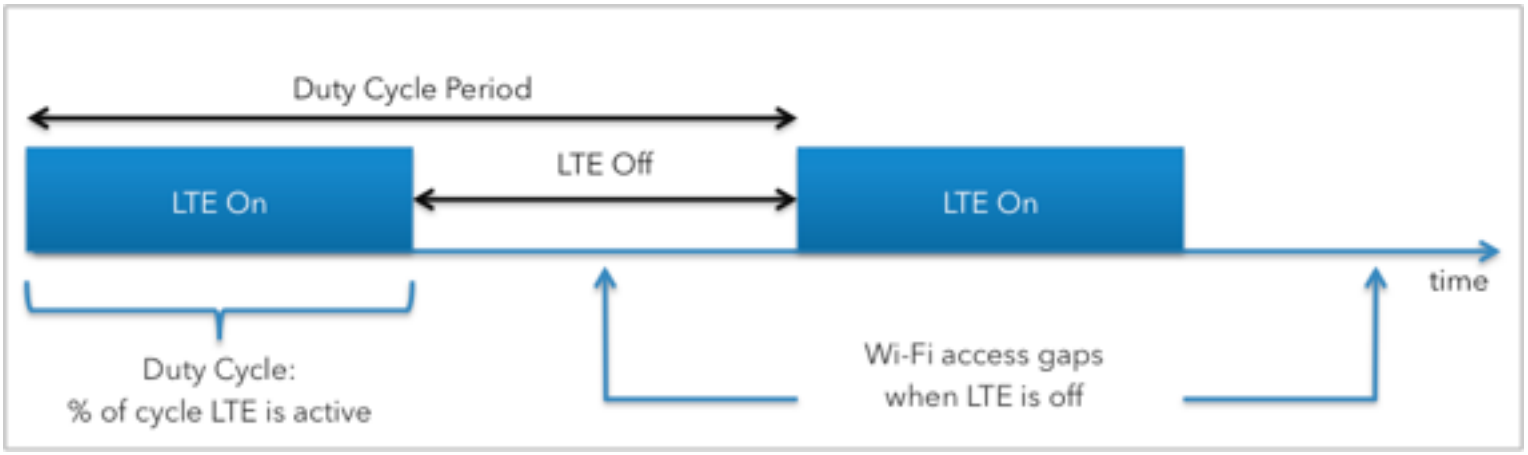



- New paradigm: Asynchronous Access with Opportunistic Synchronous Transmissions
  - Norm rather than exception in 5G
  - Unlicensed LTE: one simple manifestation
- WiFi: synchronous transmissions (network MIMO) for capacity
- LTE: asynchronous access for co-existence, scalability, IoT

"NEMOx: Scalable Network MIMO for Wireless Networks", ACM MobiCom 2013.
"MIDAS: Empowering 802.11ac Networks with Multiple Input Distributed Antenna Systems", ACM CoNEXT 2014.

# LTE-WiFi Co-existence

- Two modes of operation
- LTE-U
  - Duty cycling at time scales of 100 ms
  - Can be realized today: switch on/off unlicensed carriers

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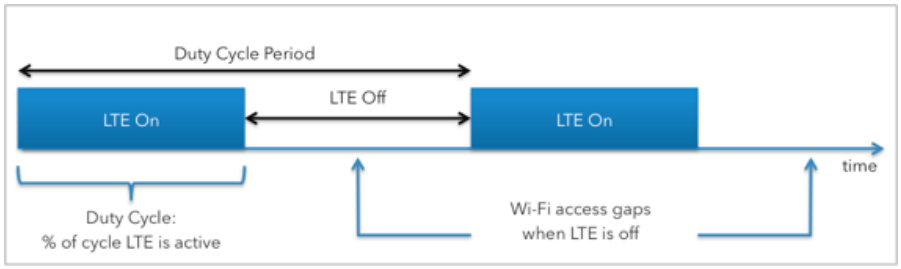
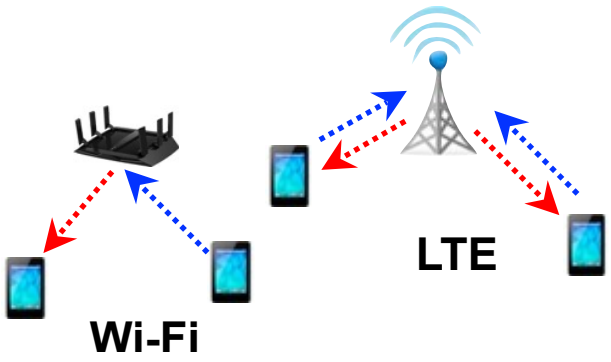
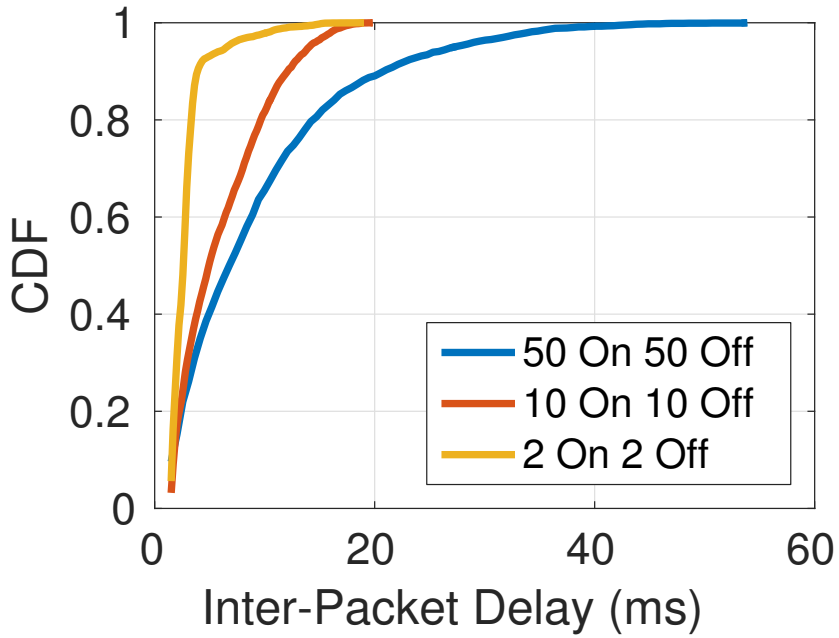
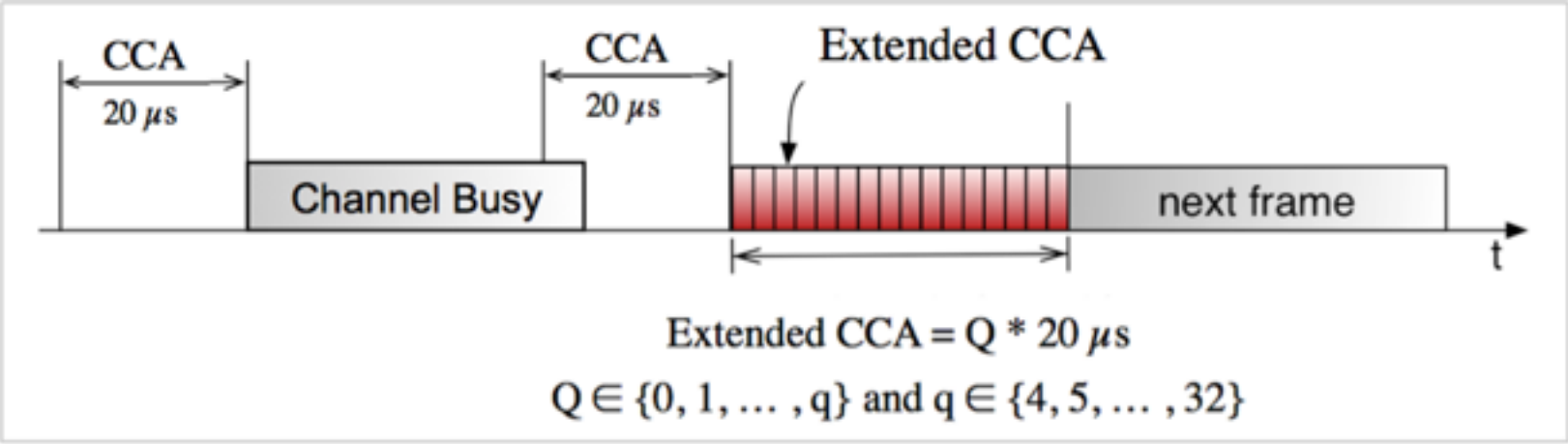


# LTE-WiFi Co-existence

- LTE-U
  - Duty cycling at time scales of 100 ms
  - Short-term unfairness to WiFi, higher latency
- LAA-LTE: License assisted access
  - Energy sensing CCA; Operation at 1-10 ms granularity
  - Modification to LTE specification for Listen-before-Talk

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- LTE-U
  - Duty cycling at time scales of 100 ms
  - Short-term unfairness to WiFi, higher latency
- LAA-LTE: License assisted access
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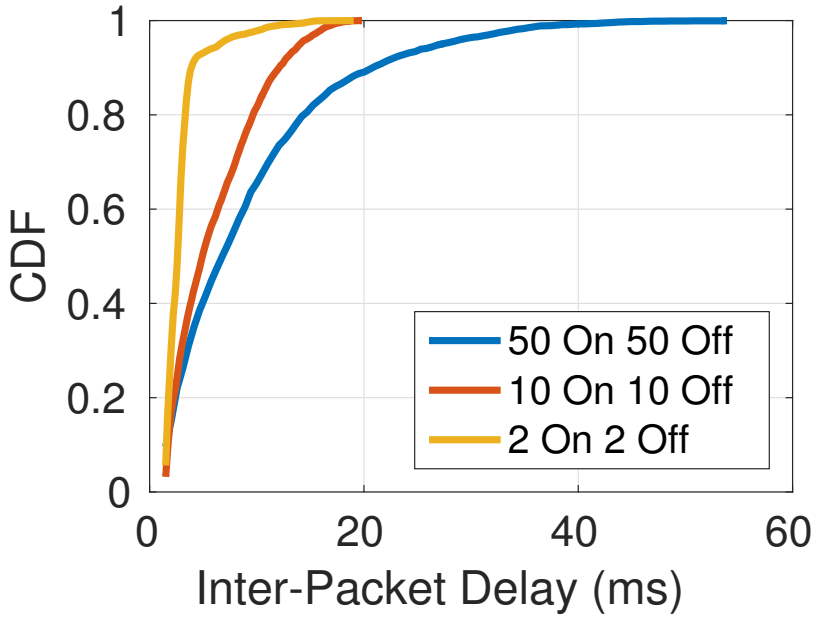
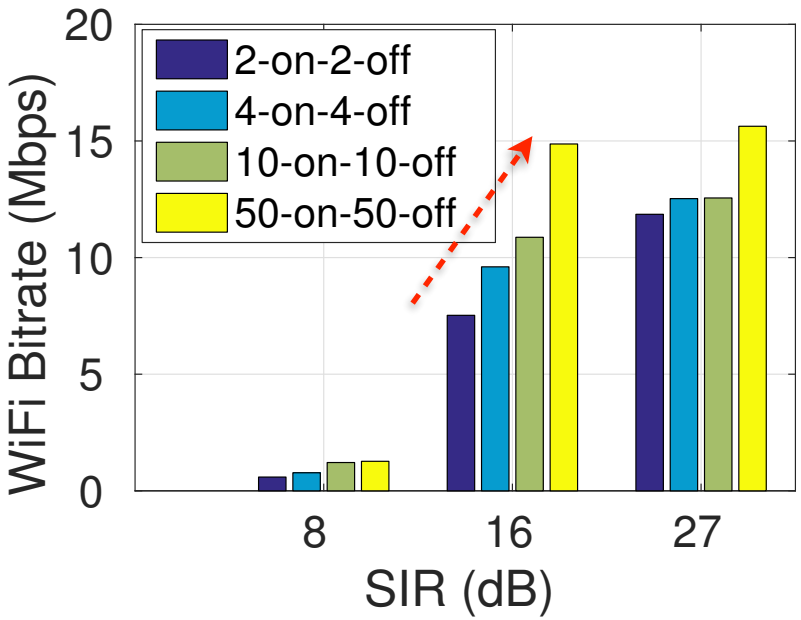
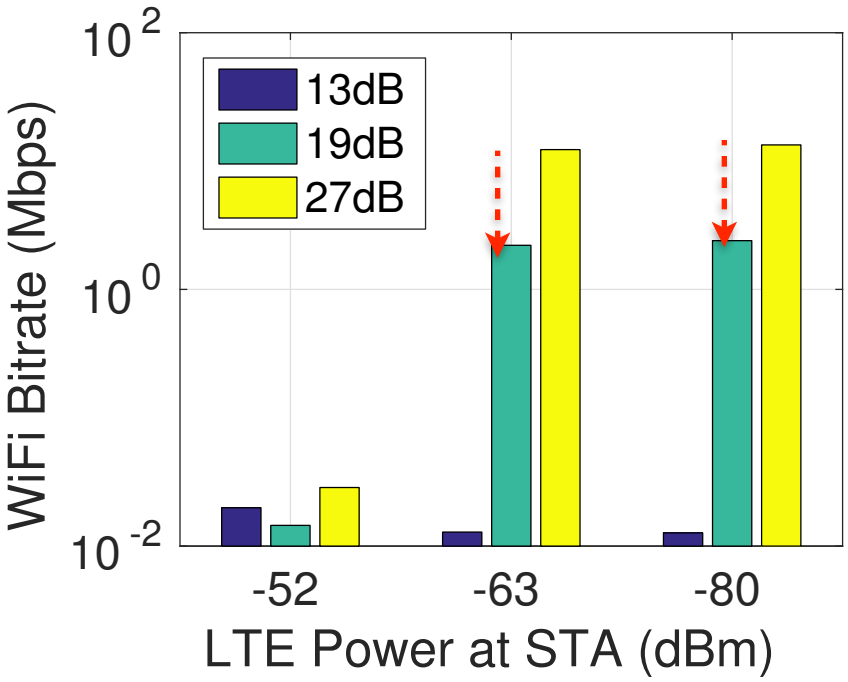
  - Reduced throughput efficiency of smaller TxOP

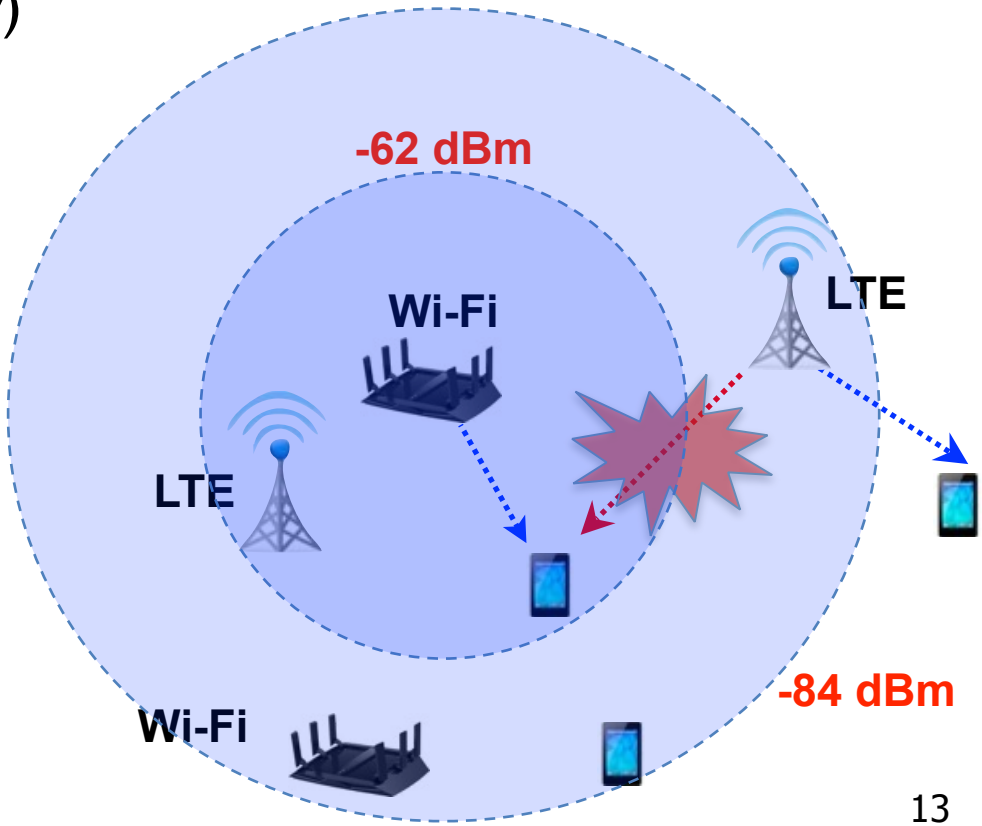


# Challenge

- Im-balanced channel access
  - WiFi detects/notifies other WiFi through "WiFi carrier" sensing/notification (-84 dBm sensitivity)
  - WiFi-LTE detect each other through "energy" sensing alone (-62 dBm sensitivity)



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  - WiFi detects/notifies other WiFi through "WiFi carrier" sensing/notification (-84 dBm sensitivity)
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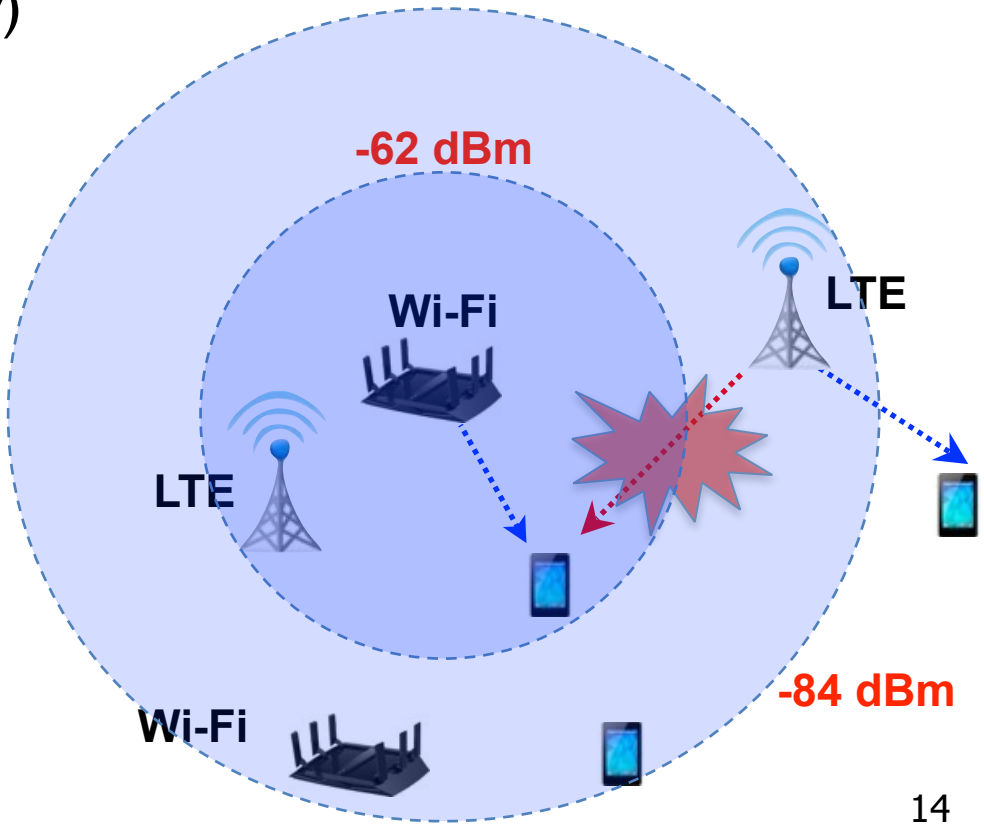
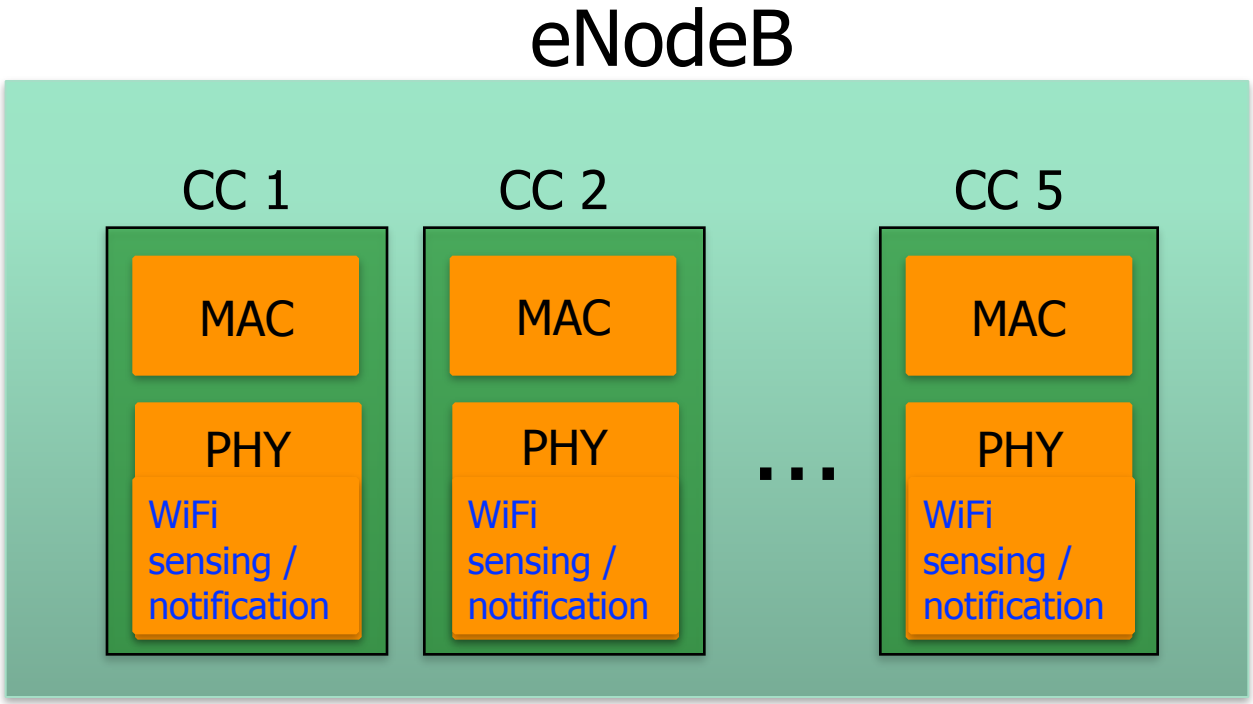
- Can we homogenize channel access policies to deliver better latencies, throughput efficiency?



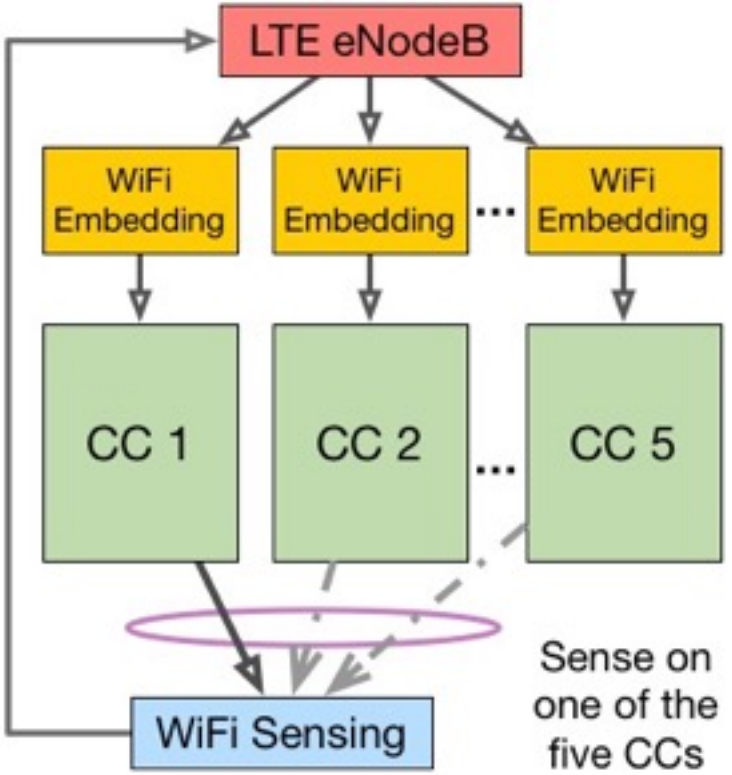
# Ideal Solution

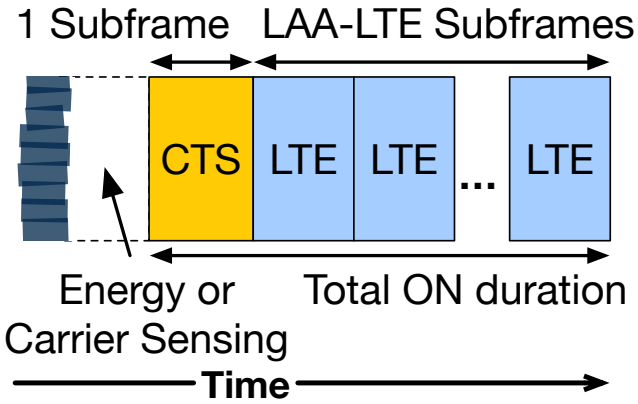



- WiFi sensing and preamble notification on every component carrier
  - Changes to the PHY; technology (WiFi) specific
- Scalable realization without PHY modifications?

# ULTRON: Unlicensed LTE Radio Node

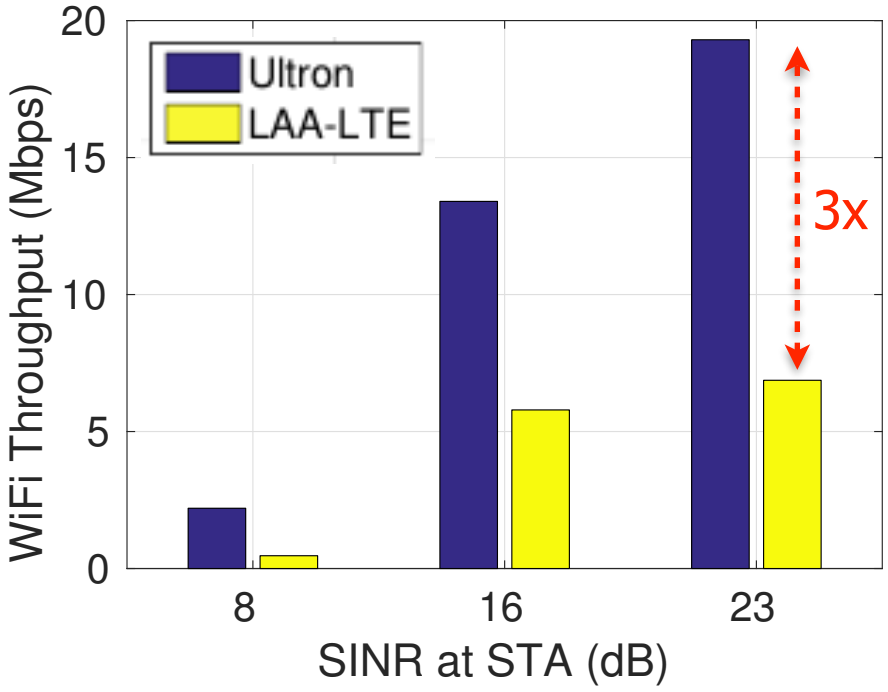
- Homogenized channel access
- WiFi Embedding
  - Embeds Tx notification (CTS-to-Self) in LTE transmissions
- WiFi Sensing
  - Detects WiFi signals to realize -84 dBm sensitivity
  - Single WiFi sensing module spans multiple CCs; LTE scheduler balances traffic

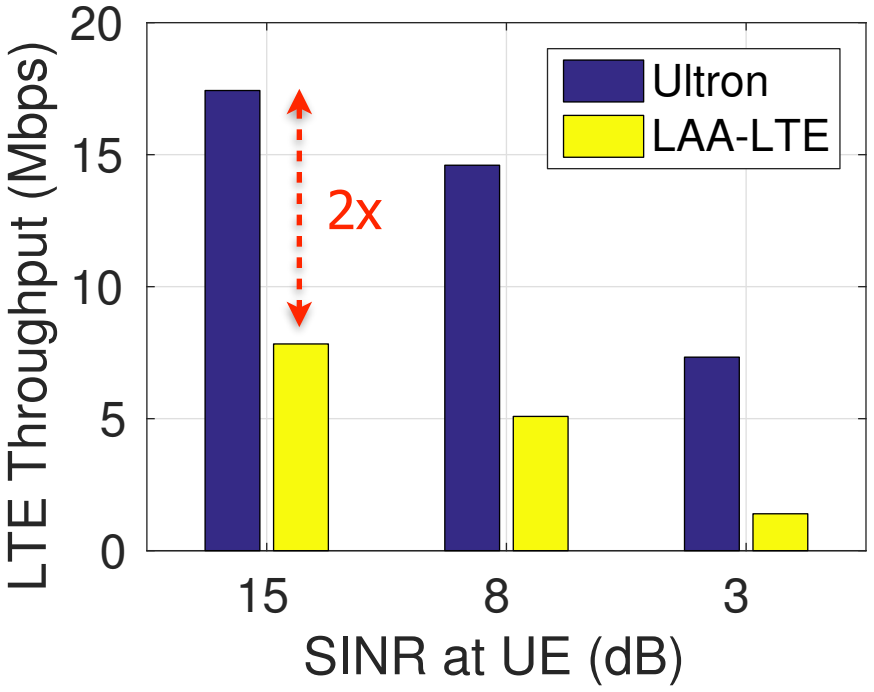


# ULTRON: Unlicensed LTE Radio Node

- Homogenized channel access
  - Detects WiFi signals to realize -84 dBm sensitivity
  - Embeds Tx notification to WiFi in LTE transmissions
- Efficient and fair LTE-WiFi co-existence (2x-3x gain)



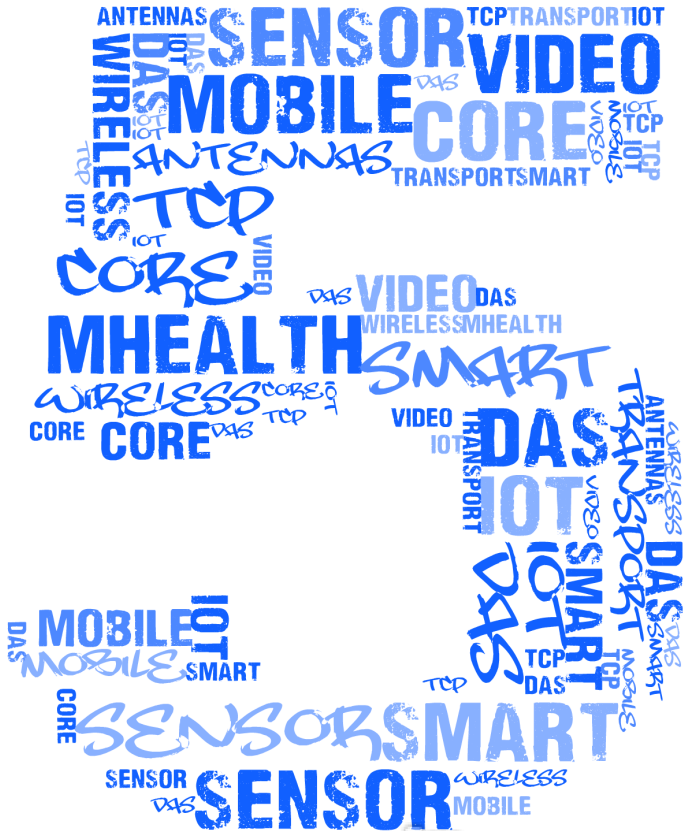



# Summary

- Boundaries between synchronous and asynchronous access models will get blurred in 5G
- Need a deeper understanding of how to realize converged access
  - Several interesting and important problems
  - Critical for innovation in unlicensed spectrum: new operators and business models
- LTE-WiFi co-existence barely scratches the surface
  - Both technical and policy challenges
- Right time to get involved!

# Thanks!

## Questions/Comments?

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