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DASpedia

Wireless Technology Evolution
Current & Future Trends

Wireless Training & Social Networking Event
January 11, 2016 1:00PM – 9:30PM
University of California, Irvine

Agenda - Wireless Technology Evolution

1. Introduction
2. Current State of In-Building Tech
3. Future In-Building Tech
4. Wrap-Up
5. Audience Questions

Introduction

Introduction: John K. Bramfeld & Mobilitie

John currently serves as Director of Wireless Solutions in the Central region, where he focuses on acquisition and development of high-value DAS and Wi-Fi networks at high-profile venues. Prior to Mobilitie, John served as the Sales Engineering Manager at ADRF, leading the company's national fiber-DAS engineering projects with the Tier 1 wireless operators and engaged in next generation DAS development. John also was Sales Director for Alcatel-Lucent's Professional Services organization where he managed annual operator accounts in excess of $100M, focused on wireless network integration around DAS, Wi-Fi, and Small Cells. John holds a Bachelor of Arts degree from Wabash College.

Current State of In-Building Tech

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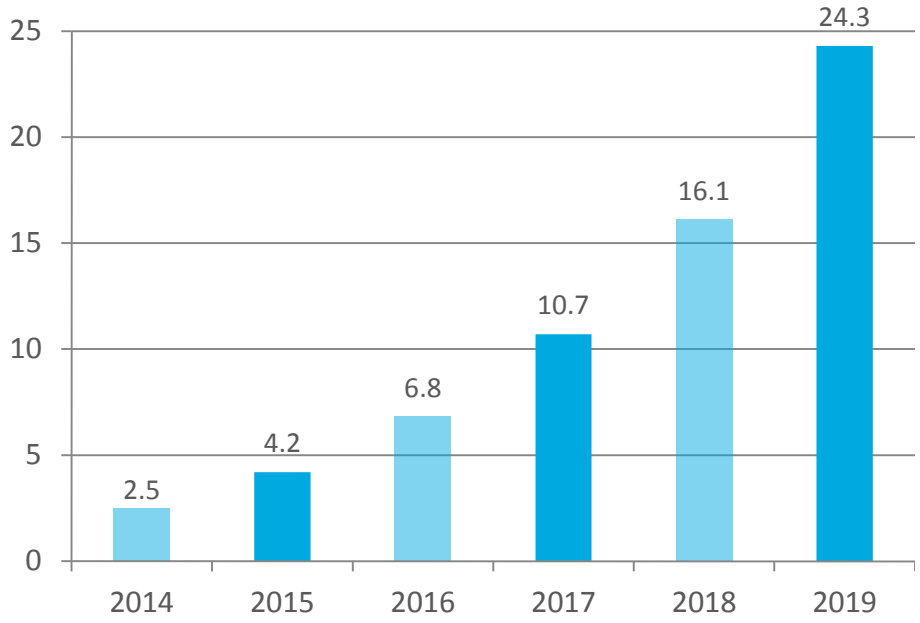
Current State of Wireless: The Fight

MOBILE DATA TRAFFIC (EB/MONTH)



84%
OF TODAY'S SHOPPERS USE THEIR SMARTPHONE TO HELP SHOP IN-STORE

MORE THAN **80%** OF VOICE CALLS ORIGINATE INDOORS

DATA CONSUMPTION
30 MILLION MB OF DATA ARE USED EVERY 5 MINUTES THROUGH MEDIA STREAMING

U.S. MOBILE DATA USAGE

90%
OF HOUSEHOLDS USE WIRELESS SERVICE

650%
INCREASE EXPECTANCY OF MOBILE DATA FROM 2014 TO 2018

44%
OF WIRELESS-ONLY U.S. HOUSEHOLDS (2014), UP FROM 4.2% IN 2003

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Current State of Wireless: The Battlefield

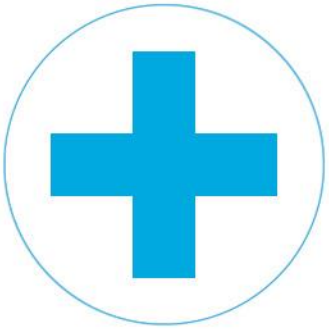
Network planning is shifting from macro-centric to a more inside-out approach.

SPORTS & ENTERTAINMENT

REAL ESTATE & RETAIL

HOSPITALITY

HIGHER EDUCATION



HEALTHCARE

GOVERNMENT & TRANSPORTATION

Current State of In-Building: D-RAN & C-RAN

Centralized-RAN v. Distributed-RAN

D-RAN (*or Small Cells*)

- Traditional basestation RAN architecture, scaled for capacity distribution
- RF, MAC processing, BB processing all-in-one
- Latency friendly, edge BB processing
- Purest form of spectrum reuse
- Backhaul-only
- Standalone element

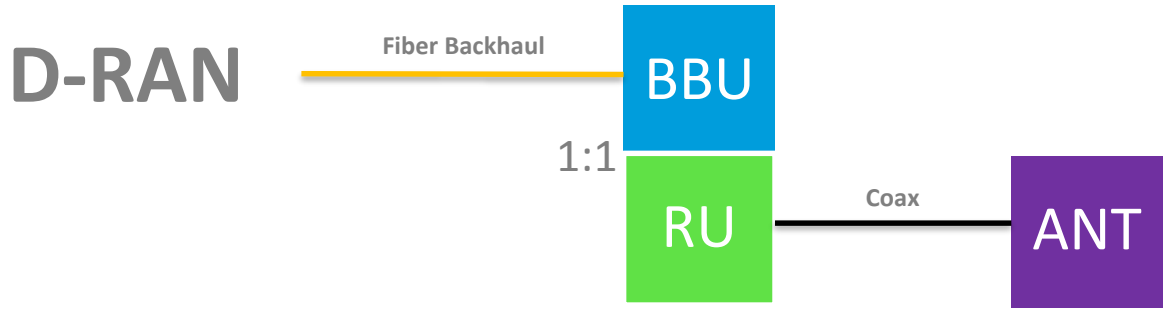
C-RAN

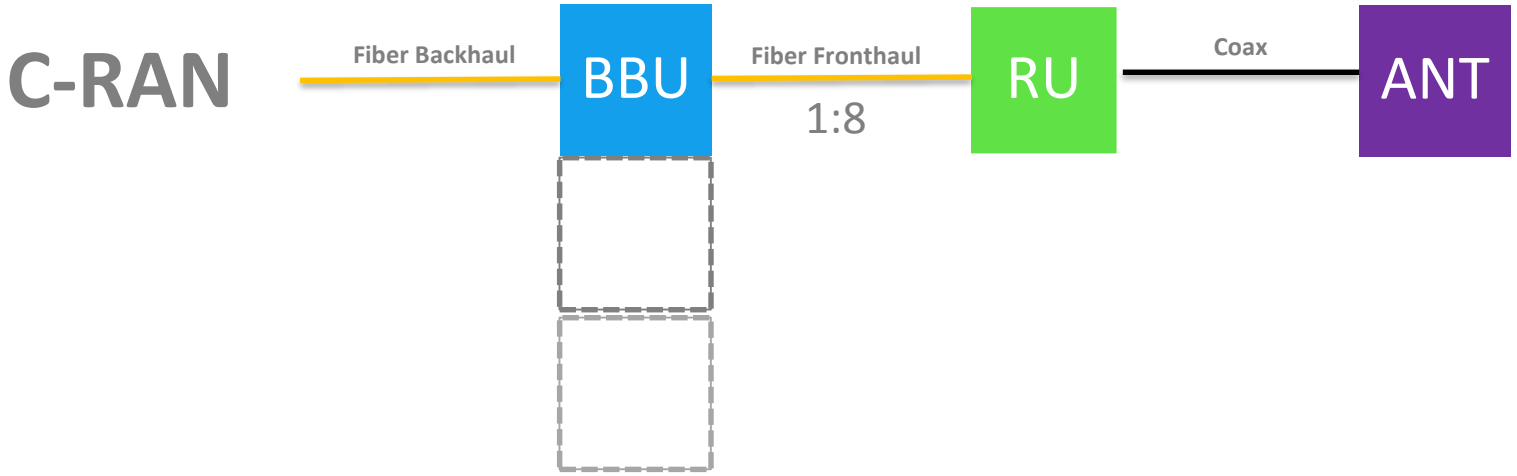
- All about resource management
- Ability to scale capacity broadly
- Baseband pooling
- Backhaul/fronthaul tandem
- Networked elements
- Intended to be deployed at large scale

Key

- BB (BBU): **B**ase**b**and (**B**ase**b**and **U**nit)
- BH: **B**ack**h**aul
- RU (RRU): **R**emote **U**nit (aka **R**emote **R**adio **U**nit, Node)
- FH: **F**ront**h**aul
- RAN: **R**adio **A**ccess **N**etwork
- C-RAN: **C**entralized-**R**adio **A**ccess **N**etwork
- D-RAN: **D**istributed-**R**adio **A**ccess **N**etwork

Current State of In-Building: D-RAN & C-RAN Architecture





Current State of In-Building: Distributed Antenna Systems

What DAS *isn't*

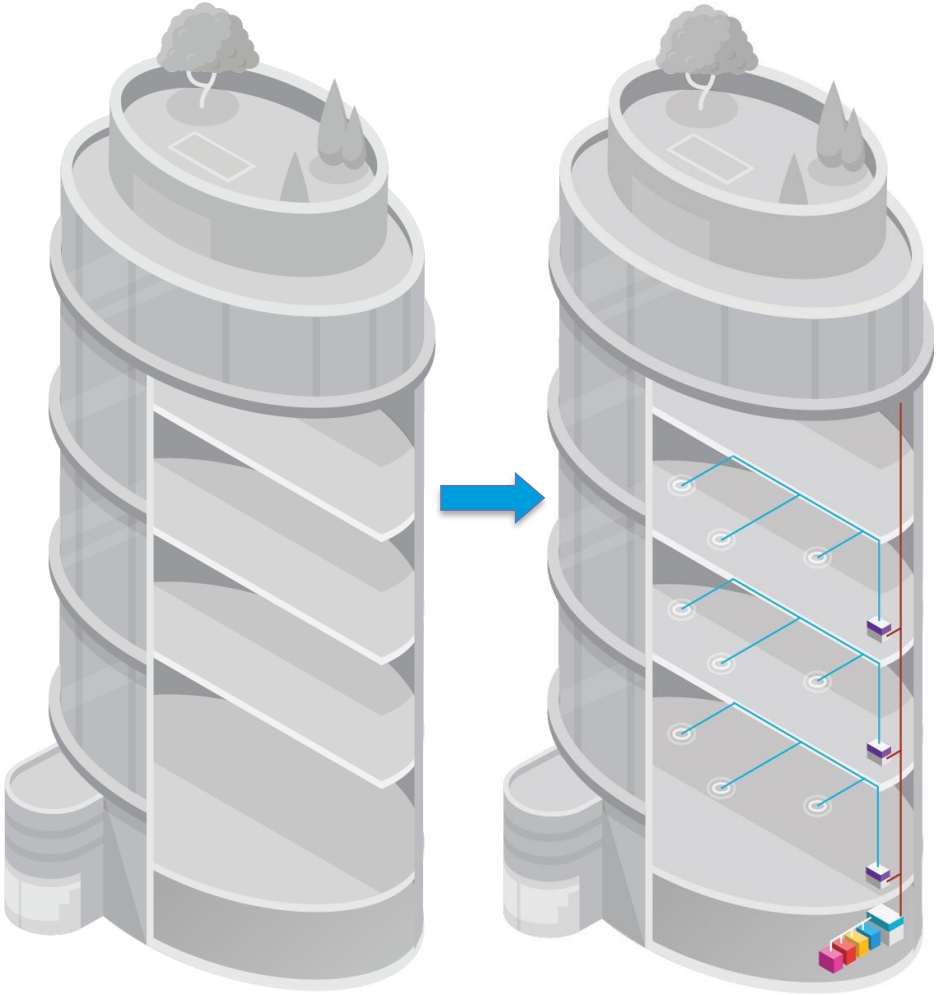
- RAN, or an element of RAN
- Specific/static *type* of technology

What DAS *is*

- A concept for network extension
- A sophisticated fiber network
- A signal aggregator/distributor
- The great wireless emulator

The Current State of DAS

- Analog
- RF signal-based
- Fiber transport-based
- Modular-*ish*



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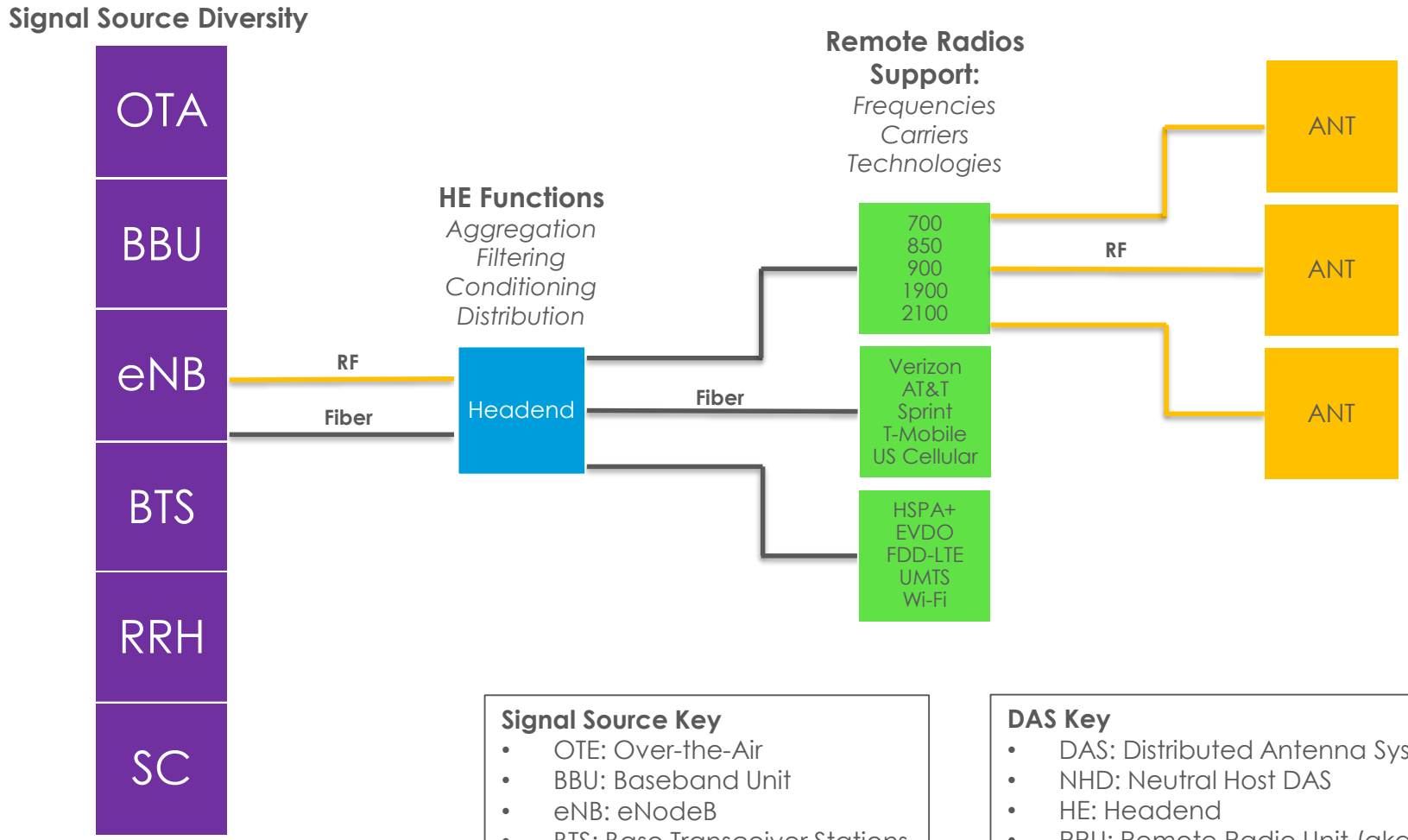
Current State of In-Building: DAS Architecture



Signal Source Key

- OTE: Over-the-Air
- BBU: Baseband Unit
- eNB: eNodeB
- BTS: Base Transceiver Stations
- RRH: Remote Radio Head
- SC: Small Cell

DAS Key

- DAS: Distributed Antenna System
- NHD: Neutral Host DAS
- HE: Headend
- RRU: Remote Radio Unit (aka Node, Remote, Repeater)

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Current State of In-Building: DAS Advantages

DAS Advantages

- Signal Source Accommodation
- Scalable Physical Footprint
- Future Accommodating Modularity
- Multi-carrier, multi-Technology

DAS Disadvantages

- Cost
- Complexity
- Coordination

Flexibility is the point.

Future of In-Building Tech

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Future of In-Building Tech: The Impending 5G Threshold

Key Requirements (IMT-2020):

- Speed: >Gbps connections
- Latency: 1ms/round trip
- Capacity: 1000x
- Availability: 99.999%
- Coverage: 100%
- MTC, IoT, efficiency, security, etc…

Standards Development

- Europe-Asia: Government/Academia
- U.S: Private sector

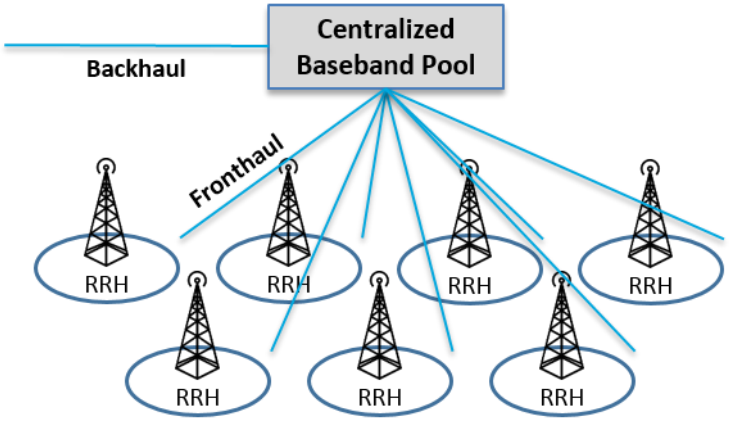
Future of In-Building Tech: C-RAN & D-RAN

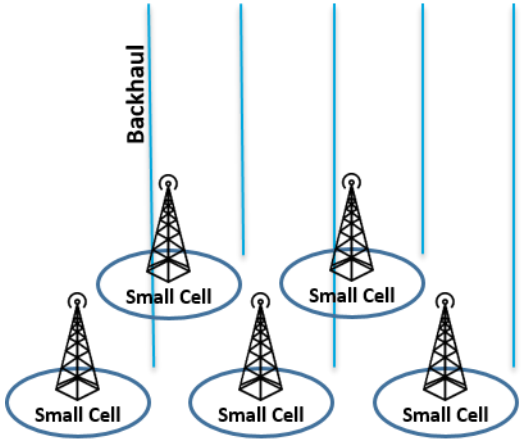
C-RAN
- Best use is wholesale macro-BTS network replacement
- Example of *engineering-perfect, but application flawed* in US siting environment
- *Indoor proliferation*

Restraints
- Mono-failure concerns
- Latency
- Fronthaul capex

D-RAN
- Massive, unprecedented utilization in macro
- Independent siting criteria (no FH)
- *Indoor application use-case dependent*

Restraints
- Macro-siting
- Backhaul opex
- Collaborative SON challenges





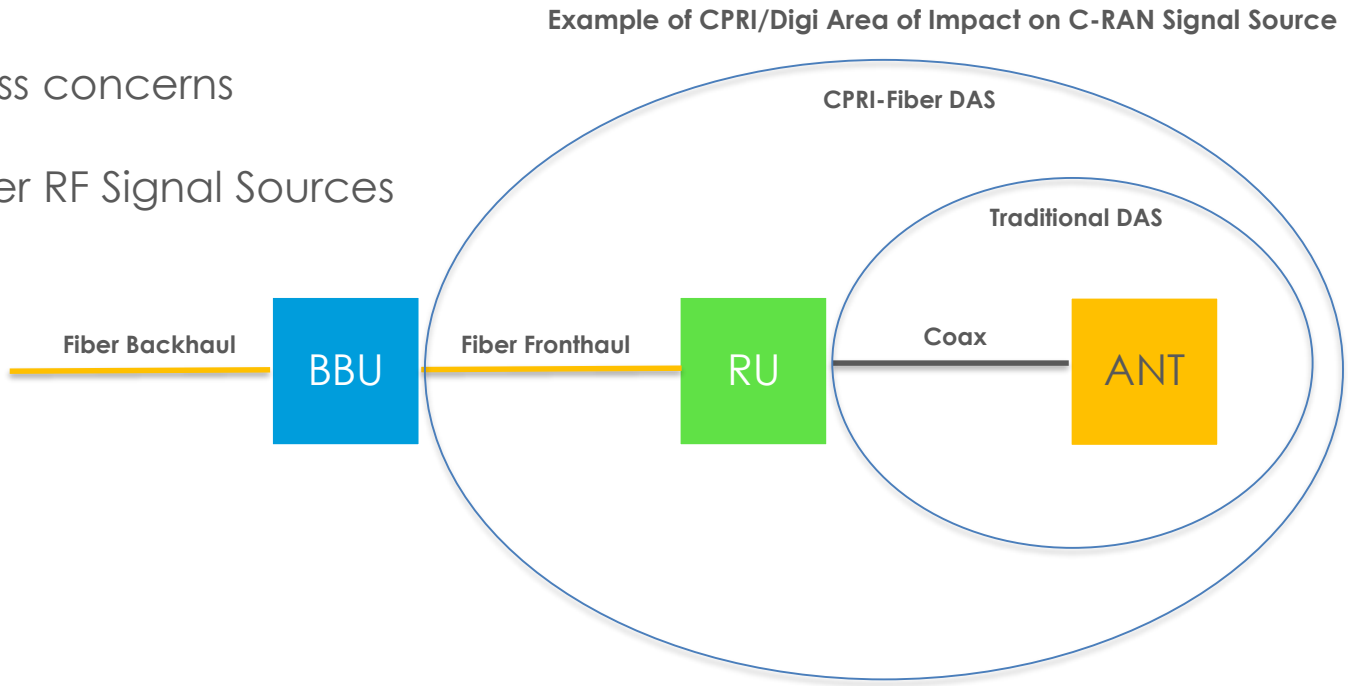
Future of In-Building Tech: Digital DAS Impact

Digital DAS Flexibility
- LTE Timing/Sync
- Eliminates Simulated Multipath Effect

CPRI-Digital DAS Flexibility
- Elimination of RF from pre-RU

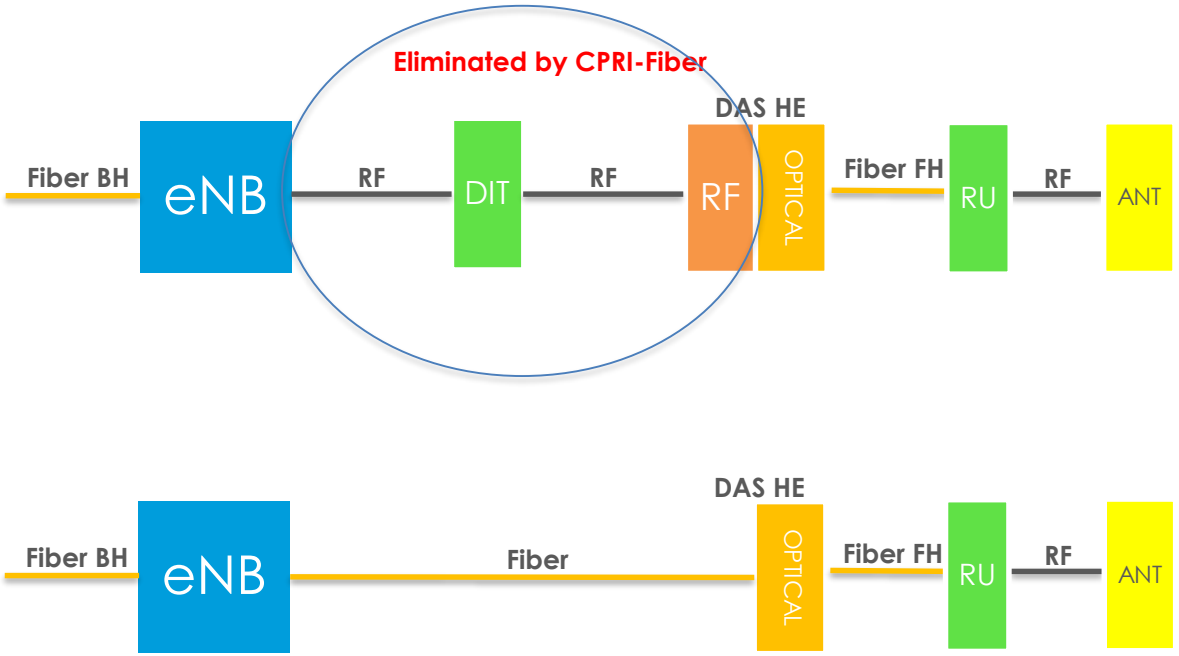
Digital Drawbacks
- Expense
- Robustness concerns

Alternatives
- Low power RF Signal Sources



Future of In-Building Tech: Digital DAS Impact

Example of CPRI-fed DAS Area of Impact on eNB Signal Source



Future of In-Building Tech: Wireless Fronthaul

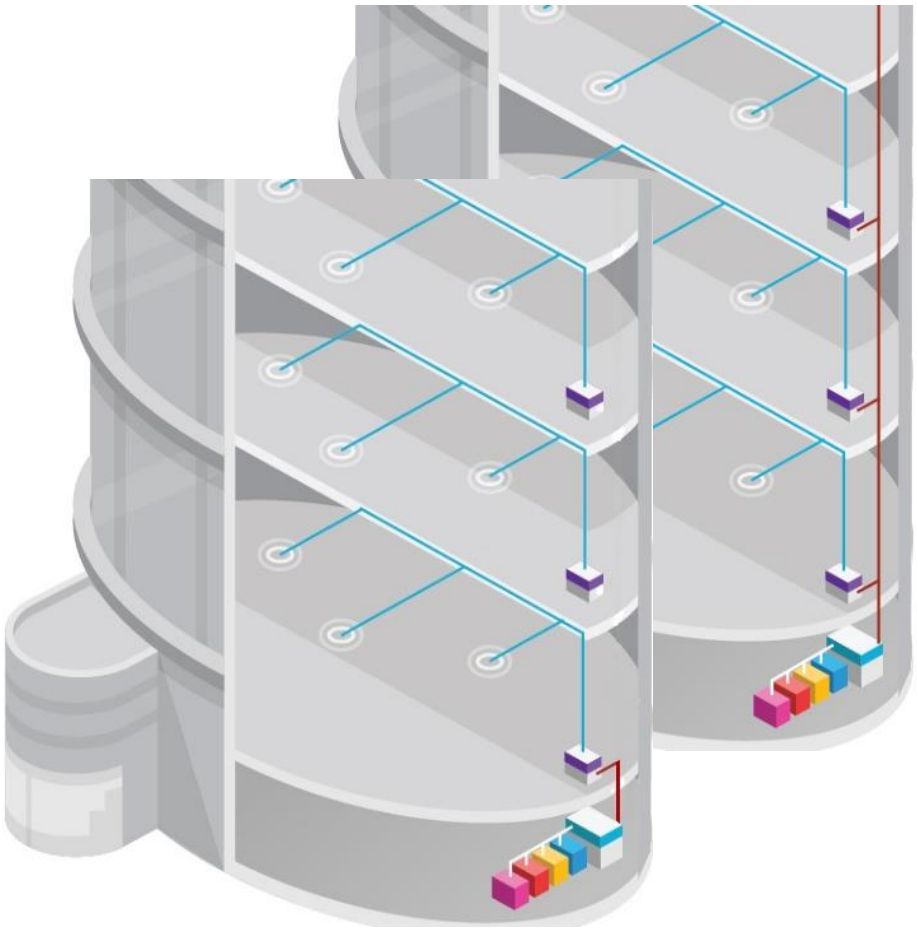
Wireless Fronthaul DAS

- May see attempts in next few years at RU-to-RU wireless FH
- Capex reduction – labor/conduit
- Growing availability of unlicensed spectrum
  - 3.5GHz
  - 5GHz (ad hoc, perhaps)
  - **mmW** (mesh or primary FH)

Concerns

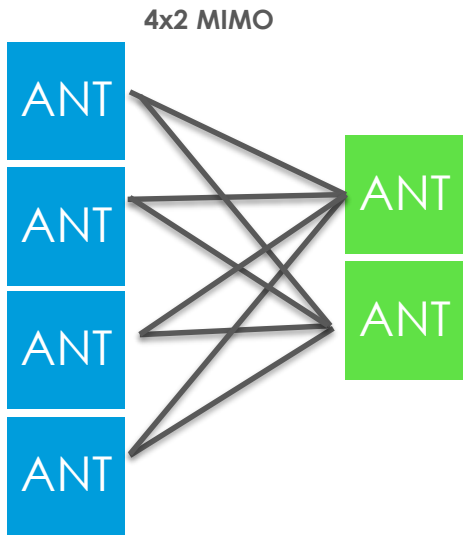
- Unlicensed to carry licensed frequency signals
- Protocol or tech to protect against interference

Just remember: *Fiber Always Works*



Future of In-Building Tech: DAS MIMO-Type Expansion

MIMO increases capacity of a link by increasing the number of Tx and Rx antennas using multipath.



Current Design Standards

- SISO is dominant
- Limited multipath
- Exceptions typically 2x2 C-MIMO
- Cross-polarized antennas are prevalent
- Performance need has not yet outweighed additional cost

Future MIMO Expansion

- 4x2, 4x4 C-MIMO
- D-MIMO likely utilized for orders beyond 4x4
- Massive-MIMO, beamforming applications in typical indoor morphologies will be limited

MIMO Key

- SISO: **S**ingle-**I**nput, **S**ingle-**O**utput (pr. SIGH-SOH)
- MIMO: **M**ultiple-**I**nput, **M**ultiple-**O**utput (pr. MY-MOH)
- C-MIMO: **C**o-located **MIMO**
- D-MIMO: **D**istributed **MIMO**
- Tx: **T**ransmit
- Rx: **R**eceive

Future of In-Building Tech: Millimeter Wave

mmW is seen as key component of 5G networks.

Restraints

- High free space loss
- LOS
- Atmospheric absorption (H_2O, O_2)
- Multi-path/reflection fading

Benefits

- Helped with density
- Beamforming advances
- Applications in metro-macro
- *In-building*

Reference Points:

Current Cellular Spectrum

- 700 MHz
- 850 MHz (Cell)
- 8/900 MHz (SMR)
- 1900 MHz (PCS)
- 2.1 GHz (AWS)
- 2.3 GHz (WCS)
- 2.5 GHz (BRS)

Possible Future Cellular Spectrum

- **600 MHz*
- **3.5 GHz (shared access)*
- **5 GHz (unlicensed)*
- 28 GHz (FCC assessing potential geographic licensure)
- 39 GHz (FCC assessing potential geographic licensure)
- **37 GHz (FCC assessing for hybrid, IB and geographic licensure)**

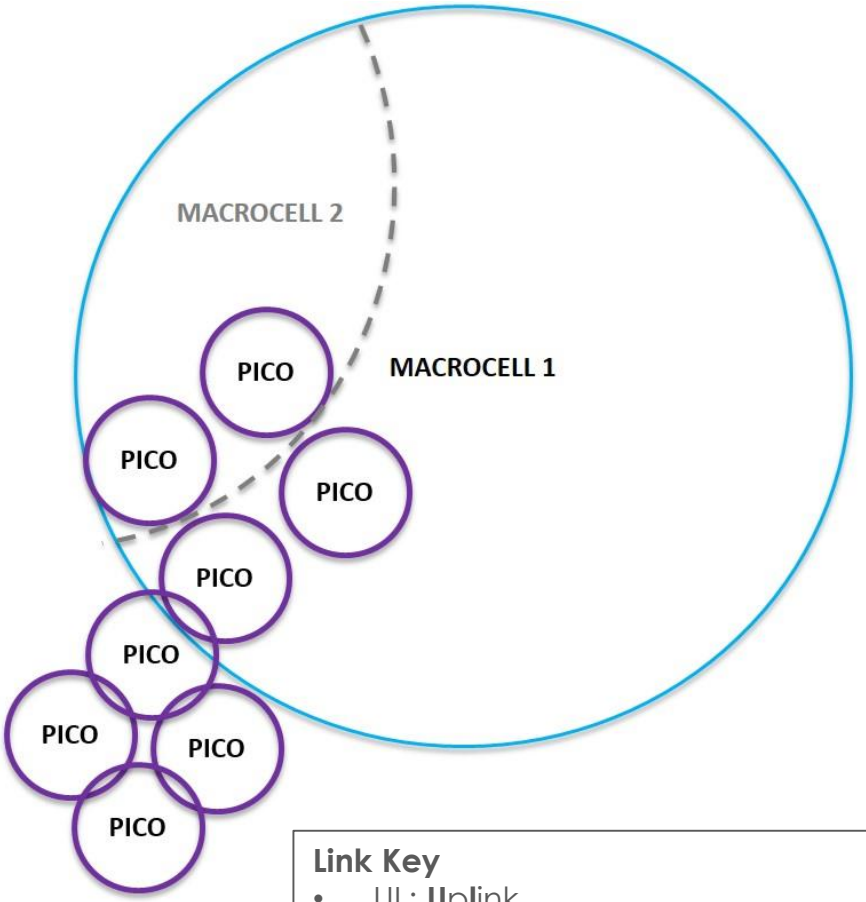
Future of In-Building Tech: Link Decoupling & Tiered Networks

Current UL/DL association is to the same BTS.

DUDe is Natural Progression
- UL/DL separation
- User-based
- Mesh network BH potential
- Control/data plane split
- Tiered, in-band BH
- Use-based link assignment

Similar Tiered-Network Concepts:
- Coordinated Multipoint (CoMP)
- UL/DL Additions
- Resource management
- Mesh backhaul offload

DAS Emulation of Tiers
- DAS/SC parallel networks
- Macro participation in DAS



Link Key
- UL: **Up**link
- DL: **D**own**l**ink
- DUDe: **D**ownlink/**U**plink **De**coupling
- CoMP: **Co**ordinated **M**ulti**p**oint

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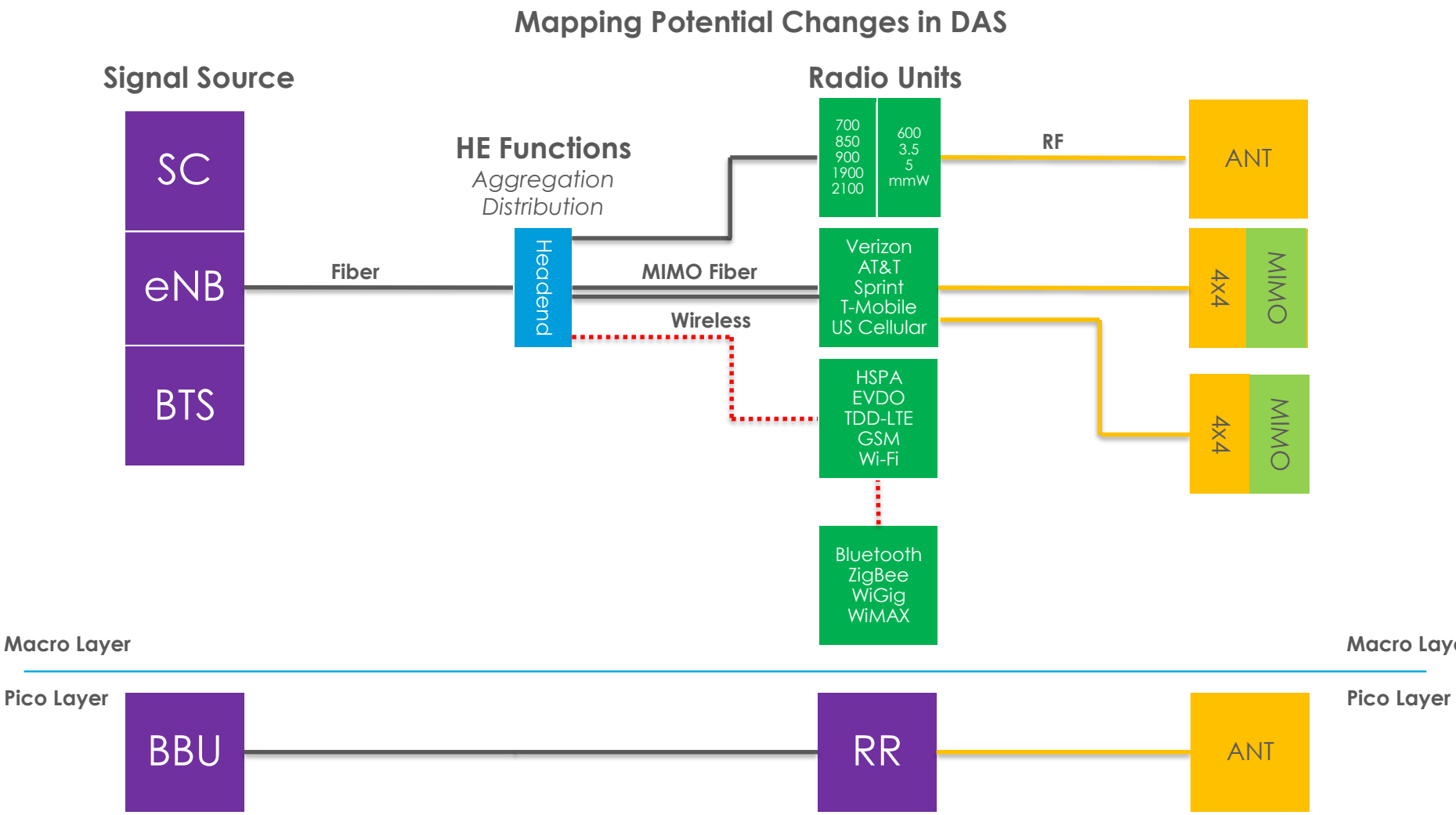
Future of In-Building Tech: DAS Adapts



Future of In-Building Tech: DAS Adapts

Mapping Potential Changes in DAS Functionality

	Signal Source	Headend Function	Frequency Support	Technology Support	Fronthaul Transport	MIMO	Network Topology
Contemporary DAS	Largely RF-based	RF Filtering, RF Conditioning, RF Combining, RF-Optical Conversion	Cellular, Public Safety, Unlicensed	All Cellular, FDD-LTE, Wi-Fi	Analog Fiber	Majority SISO, 2x2 C-MIMO exceptions	Single layer
Next Generation DAS	Digital CPRI	Optical Signal Aggregation, Optical Distribution	Cellular, Public Safety, Unlicensed, Shared Access Bands, mmW	All Cellular, LTE-A, TDD-LTE, Wi-Fi, ZigBee, Bluetooth, WiGig, WiMAX	Digital Fiber and Wireless	2x2-4x4 C-MIMO, D-MIMO variations	Macro-Pico Tiering Emulation

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Wrap-Up & Audience Questions

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Special thanks to the following whose contributions and guidance were of great help:

- Dan Harkness
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- Mobilitie

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