

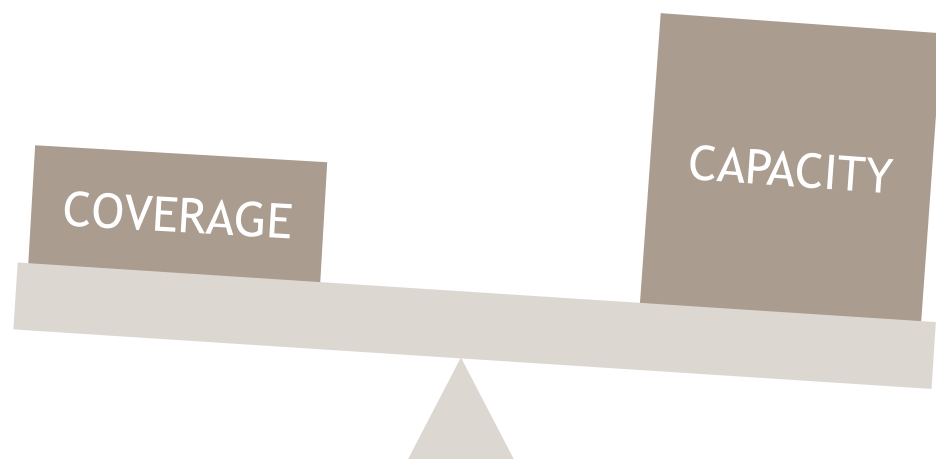


IN-BUILDING SOLUTIONS - LICENSED SPECTRUM (NEUTRAL & OTHER)

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May 2014

THE MARKET SHIFT FROM COVERAGE TO CAPACITY



1-5 YRS

AS USER DEMAND FOR DATA GROWS,
DECISION CRITERIA WILL SHIFT
FROM COVERAGE TO CAPACITY.

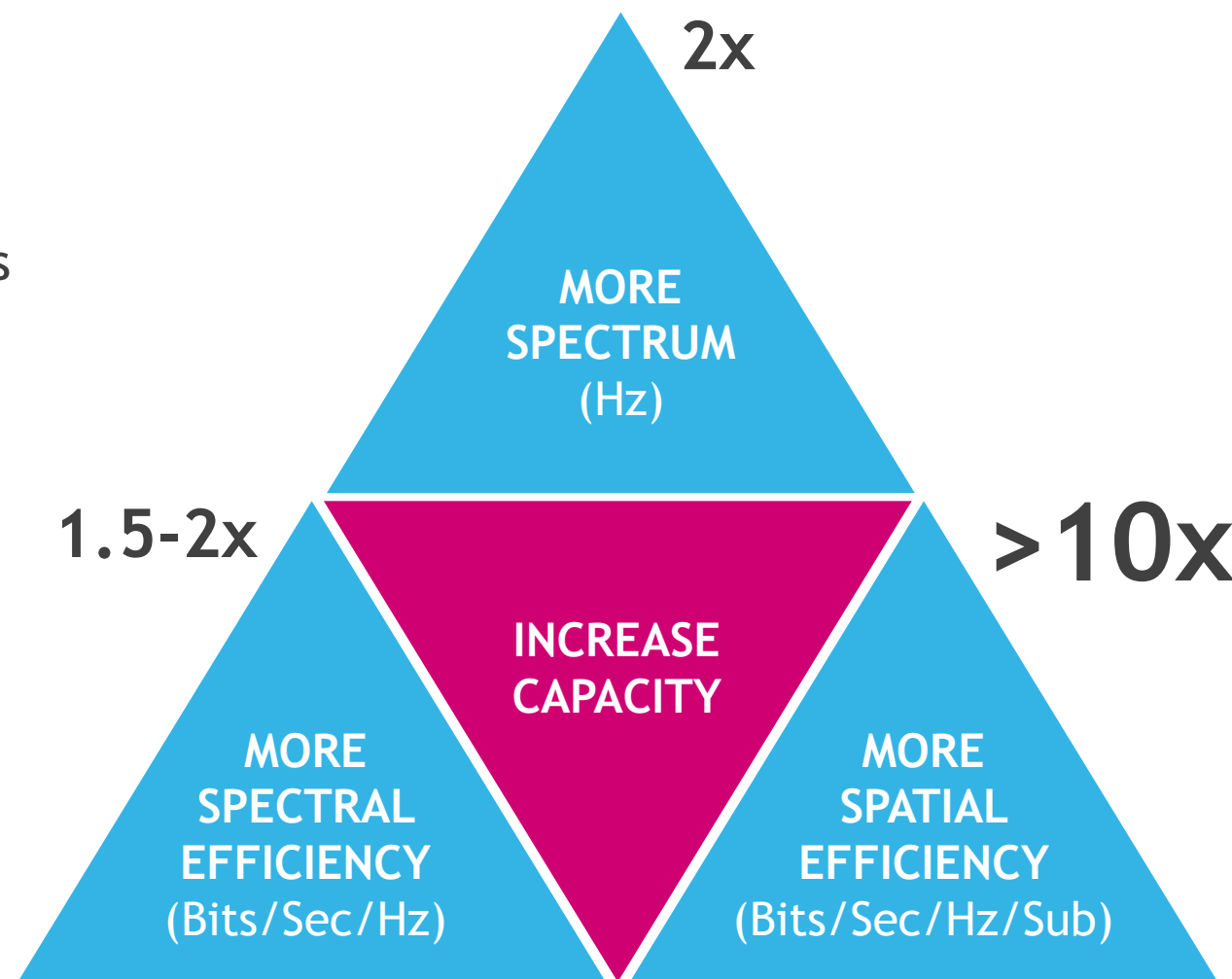
40%

OF TOTAL SPEND WILL BE IN PRIVATE
AND ENTERPRISE SPACES.

**BASIC COVERAGE DOMINATES TODAY'S DECISION CRITERIA,
BUT GROWING USER DEMAND WILL SHIFT OPERATOR FOCUS TO PROVIDING CAPACITY**

INDUSTRY THESIS FOR CAPACITY ADDING SOLUTIONS

- The “mobile computer” and accelerated consumer adoption rates require us to build ultra-broadband wireless IP networks
- Physics necessitates the use of:
 1. Converged use of licensed and unlicensed spectrum (Wi-Fi)
 2. Improved spectral efficiency (LTE)
 3. Spatial efficiency (small cells)
- HetNets are essential, but must be simplified, massively scalable, and multi-vendor ecosystems to be useful



IN-BUILDING SEGMENTATION

- Public space with no operator differentiation:

- Retail/shopping malls
- Airports, train stations
- Parking structures, underground tunnels



Shopping



Train



Airport



Restaurant

- Sponsored public spaces which allow vendor/operator differentiation:

- Sports venues, stadiums
- Retail, shopping malls



Retail store front



Stadium

- Private and enterprise spaces:

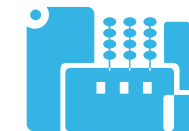
- Offices, corporate campuses
- Healthcare, hospitals
- Manufacturing, industrial
- Hotel, resorts
- Universities, educational institutions
- Government, municipal facilities



Bank



Hospital



Building
(factory)



Regional
headquarters

IN-BUILDING NETWORK ARCHITECTURES

ALL USE THE SAME BASIC BUILDING BLOCKS

	BASE BAND UNIT	RADIO HEAD	ANTENNA	IN-BUILDING CABLING
DAS	Centralized		Distributed	Analog RF or digitized RF (dedicated)
Distributed radio systems	Centralized	Distributed as integrated modules		CPRI (dedicated)
Small cells	Distributed as integrated modules			Ethernet (shared)

COMBINING THE BUILDING BLOCKS IN DIFFERENT WAYS LEADS TO DIFFERENT PROS/CONS

	BENEFIT	CHALLENGE
DAS	<ul style="list-style-type: none">• Neutral host• Coverage• Well understood technology	<ul style="list-style-type: none">• Requires dedicated backhaul• Limited capacity• High TCO (cooling and space)
Distributed radio systems (<i>not common</i>)	<ul style="list-style-type: none">• Very high capacity system (e.g. stadiums)	<ul style="list-style-type: none">• Not neutral host• Needs “unlimited” backhaul
Small cells	<ul style="list-style-type: none">• Easy to scale capacity• Shared backhaul• Cost effective for capacity and some coverage	<ul style="list-style-type: none">• Not neutral host• New technology (proving KPIs and new processes)

STADIUM CHALLENGES

- Host-Neutrality frequently required - DAS has high appeal
- Return on Investment (ROI) unclear for Mobile Operators
 - Infrequent use (very event driven)
 - From zero to HIGH capacity - users may have 5 bars of coverage but at half time they can't surf the internet, check their mail, NOTHING
 - Operators see no additional revenue
 - Wi-Fi alternative for capacity?
- Perception
 - No operator wants to be “the operator” with poor performance

CONVENTIONAL DISTRIBUTED ANTENNA SYSTEM (DAS) ARCHITECTURES VS. METRO RADIOS VS. “ENHANCED - DAS WITH CDIU”

LTE BBU Rack
(digital CPRI out)



Option 1

Remote Radio Head Rack
(CPRI to RF conversion: **high power**)



RF Attenuator Rack
(30W down to 1W)



Option 2

Metro Radio Outdoor - MRO
(CPRI to RF conversion: **low power**)

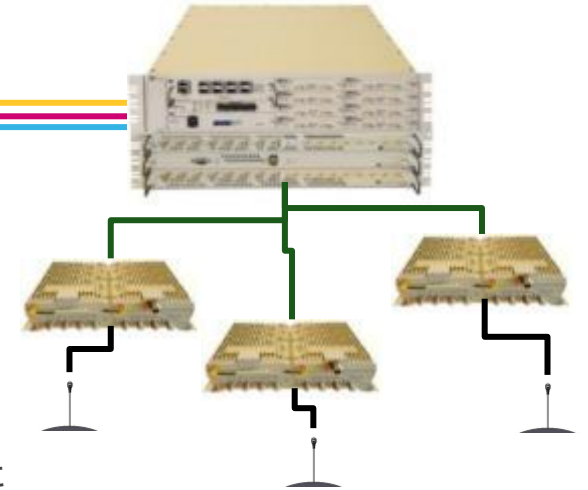


Option 3



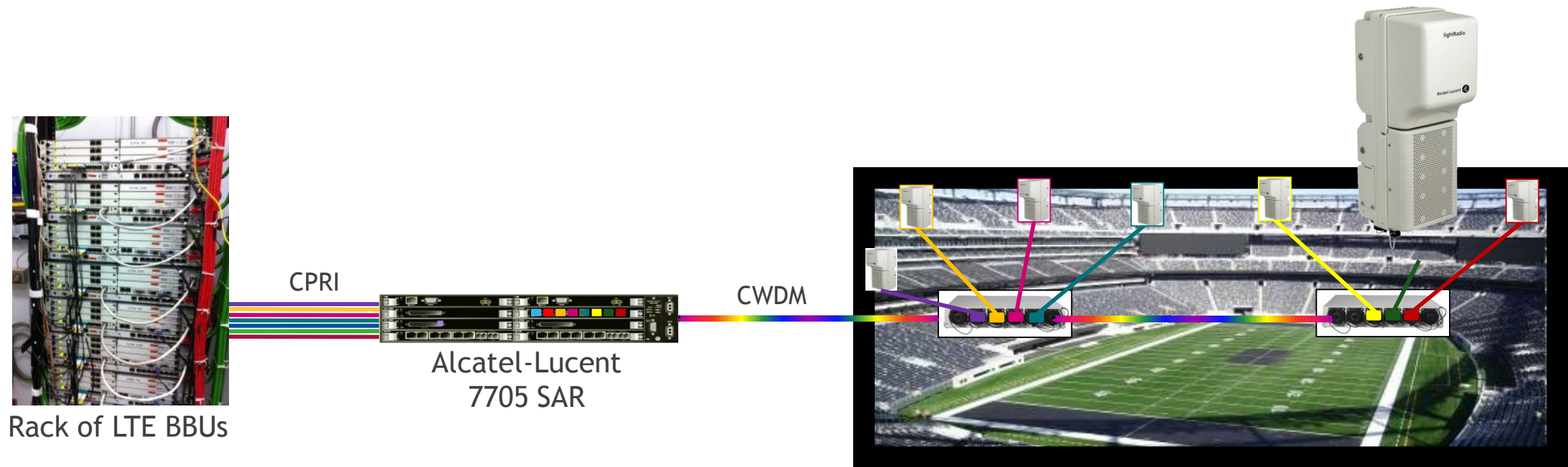
CPRI Digital Interface Unit
(CDIU) eliminates all front
end RF conversion

DAS (samples, quantizes and
converts RF to optical signal
and distributes to Remote
Access Points which amplifiers
and converts to RF)



- Reduced OPEX & Improved Performance
- Improved MIMO → Higher Peak Rates
- Lower Noise Rise → Fewer Dropped Calls

DISTRIBUTED RADIO FOR VERY HIGH CAPACITY





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