iconectiv™

experience
performance
results

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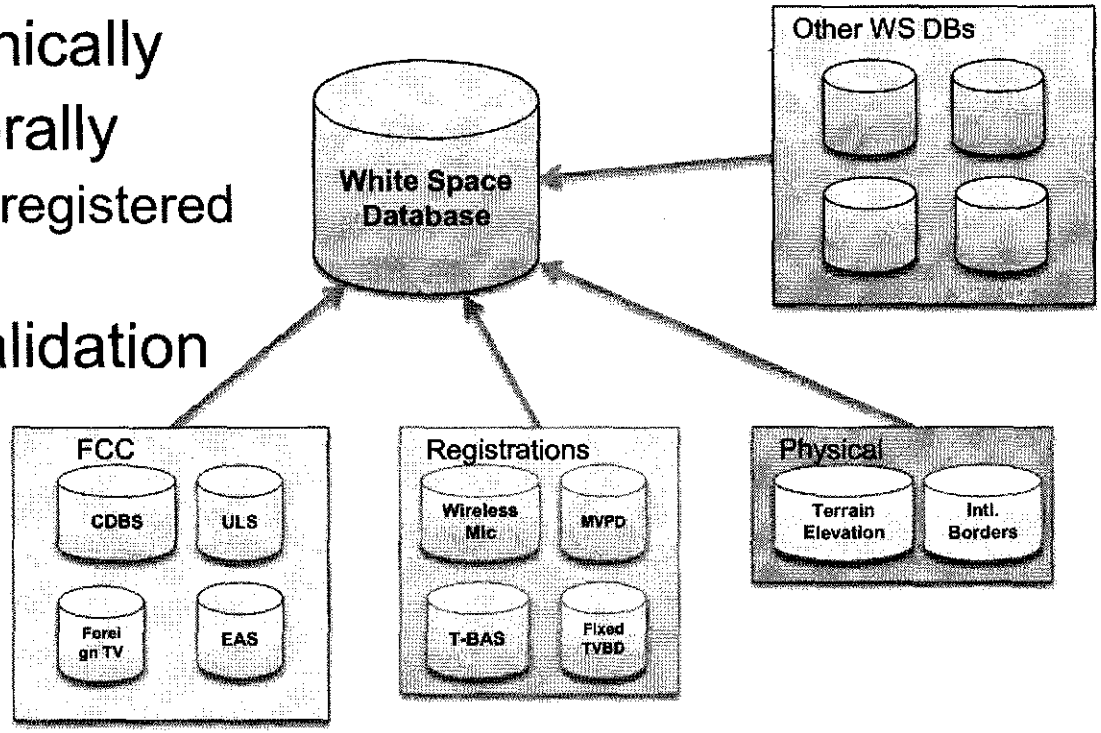
03/13/2013

TVWS geo-location database system

- The TVWS geo-location database is the first evolutionary step toward the Spectrum Access System described in the PCAST report.
- The TVWS geo-location database is a fully functioning commercial system in operation nationwide, not a proof-of-concept
  - The TVWS database provides protection for incumbent license holders in the VHF and UHF TV spectrum
  - It provides protection for other users of the spectrum, such as wireless microphone users, radio astronomy sites, offshore radio telephone service, etc.
  - It provides protection for entities that are fixed and unchanging over time and entities that are event-based and change frequently
  - It provides available channels for a certified device based on location, antenna height, and radio power

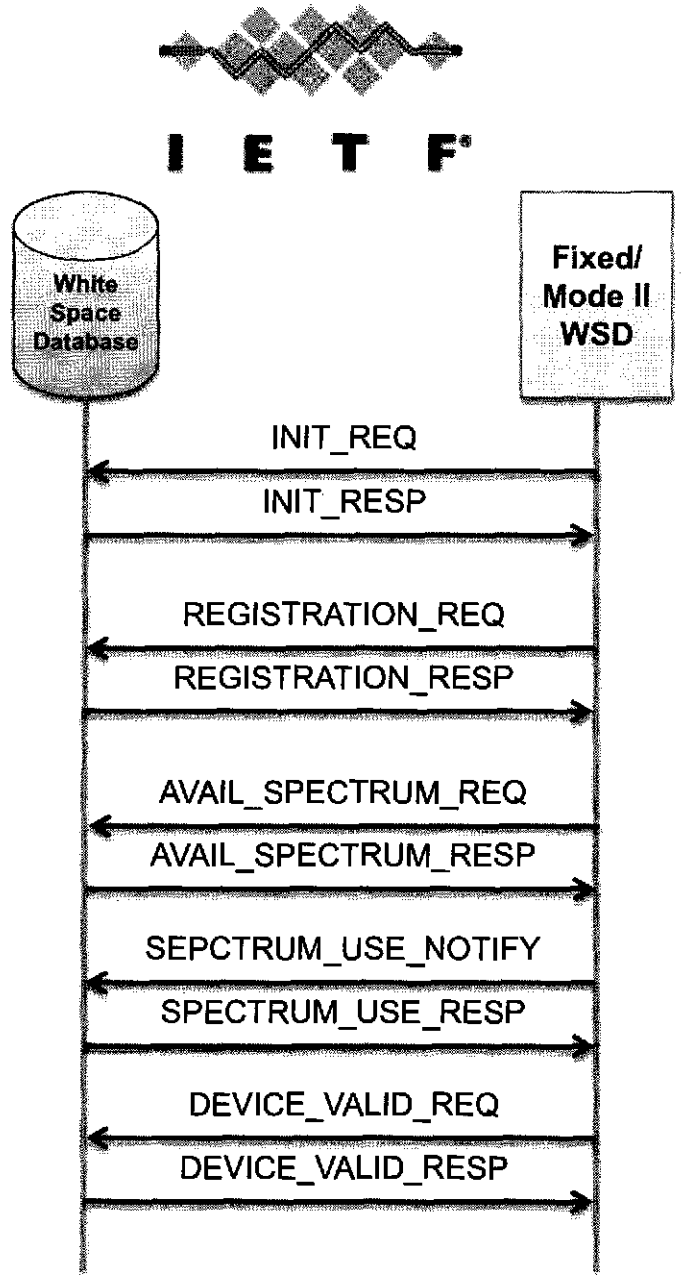
Parallels between TVWS and 3.5 GHz NPRM

- Tiered access
  - Incumbent access is equivalent to broadcast television
  - Priority access similar to wireless microphone registration
  - General authorized access is same as TV band white space devices
- Federal database of incumbent users
  - TVWS databases currently incorporate information about incumbent users from FCC databases
- Protection varies geographically
- Protection changes temporally
  - Event based protection for registered entities
- Security authentication, validation



PAWS device-to-database interface

- International standardization of the interface between the database and white space devices
  - Result of multi-vendor cooperation
  - Not restricted to TV white space operation
  - Provides messaging applicable to white space operation in any band
  - Messaging to inform device of available channels
  - Database can indicate channel priority based on interference modeling from protected entities into "available" channels
  - Messaging from device to database to inform it of chosen channel provides step toward closed-loop feedback



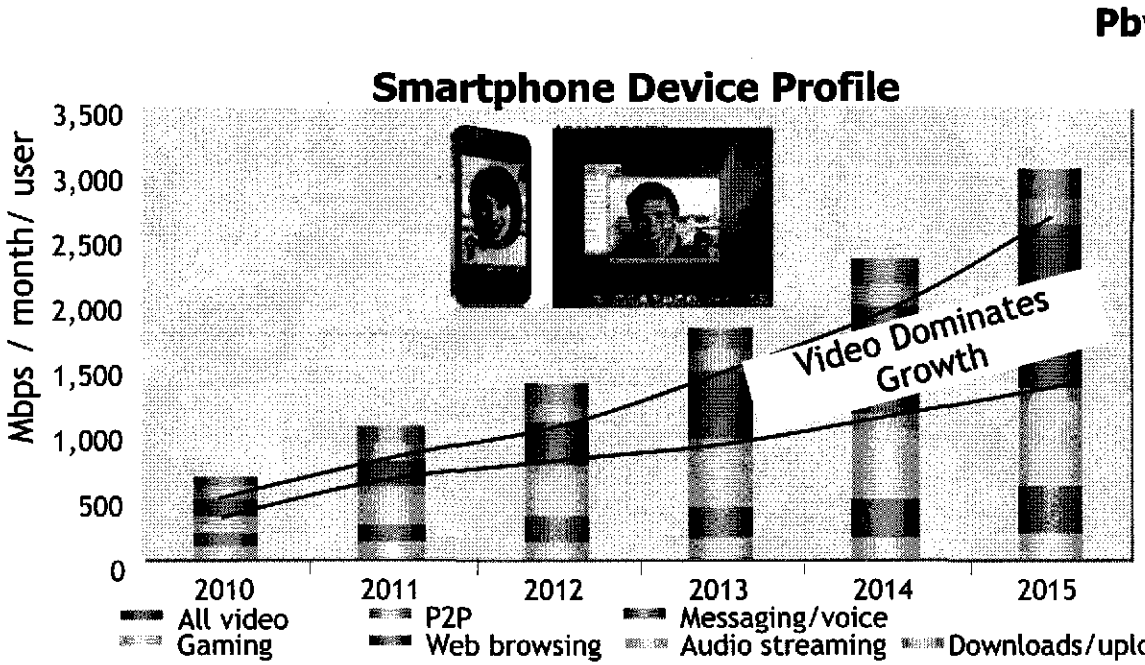
Summary

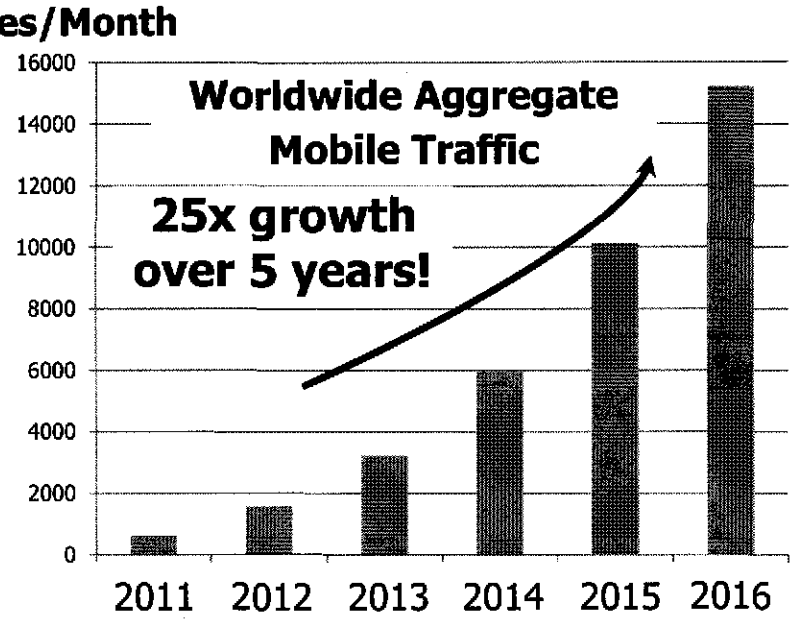
- The TVWS model provides an example of an operational SAS that is
  - Regulatory policy: implemented in the database and not directly exposed to the devices
  - Flexible: rules changed while databases were in operation and changes were quickly accommodated
  - Scalable: database and cloud computing technology has advanced to the point that it can scale to tremendous data volumes
  - Multi-vendor: There are 2 certified and 8 conditionally approved databases
  - Cooperative: The database providers worked together to create standard methods of operation and information exchange mechanisms
- The future of spectrum access… is here today

Small Cell Technology Overview (and 3.5GHz Small Cell CBS Band)

Milind Buddhikot, Rob Soni
March 13, 2013

Bandwidth Hungry Applications will Continue the Wireless Data Explosion





4x growth per user/month & 25x growth in aggregate wireless data traffic over 5 years

Goal: Improving capacity to support high QoE and lowering cost

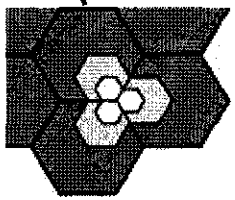
Source: Bell Labs modeling and forecasts

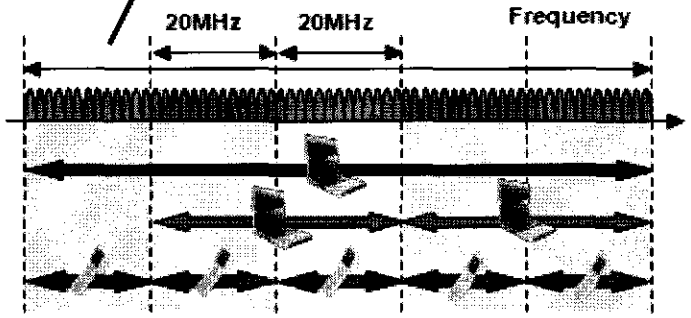
Options for increasing Wireless Capacity & Spectral Efficiency

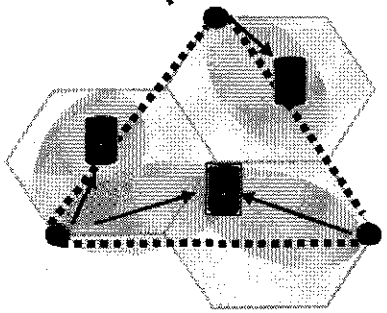
Focus of this talk

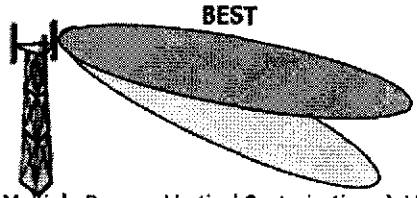
Downlink Comparison

Cell Split	Add Carriers	Carrier Aggregation	MIMO (4Tx)	eICIC	CoMP	AAA or 6 Sector	Metrocells/ HetNet	Centralized Baseband
Expensive	Requires *Spectrum*	<1.2x gain under load	<1.2x gain under load	~1.25x gain on top of HetNet	<1.1x gain through Rel-11	1.4x to 2x for certain deployment scenarios	Gain = N (number of metros per eNB)	Large gains for stadiums, venues





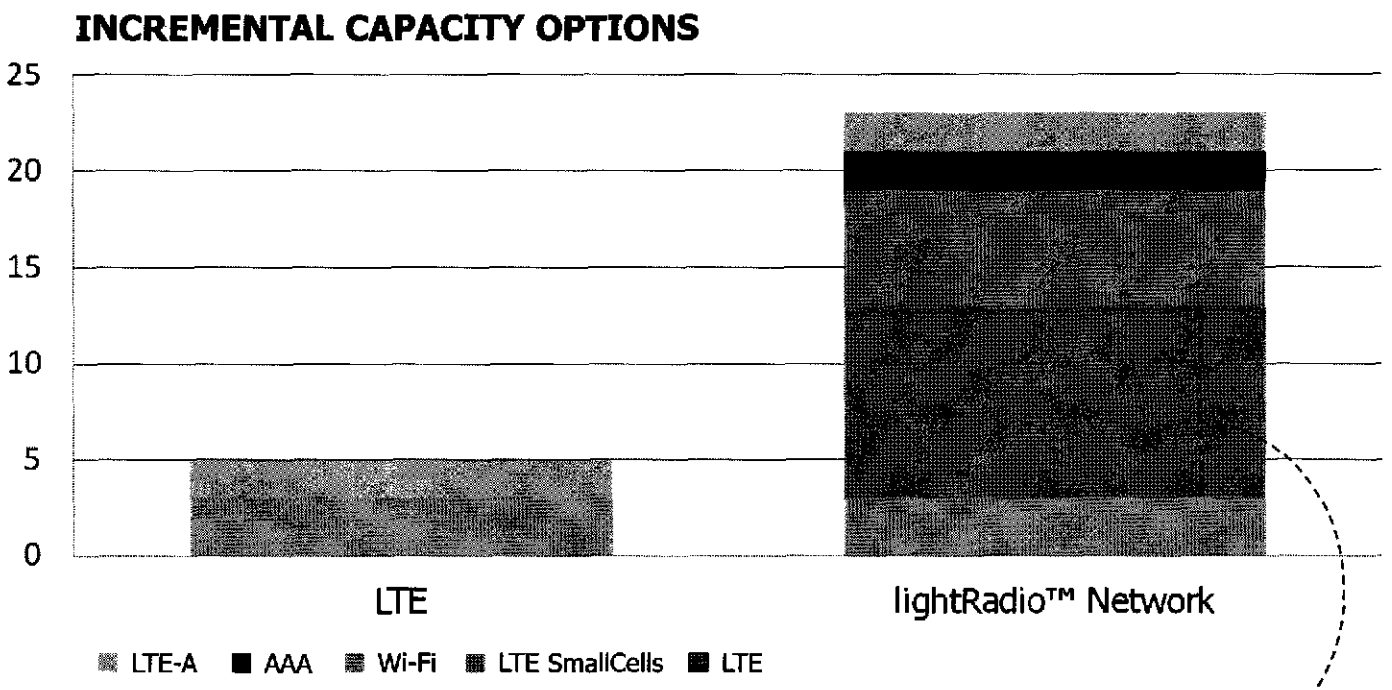




Multiple Beams: Vertical Sectorization → Virtual sectorization → 3D Beamforming

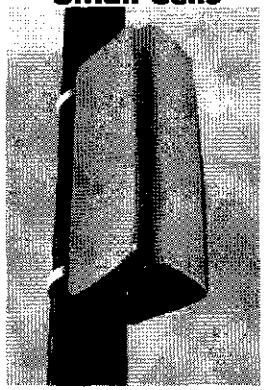
Solving the equation requires AAA, Metro Cells/HetNets and Centralized Baseband
The Essence of Alcatel-Lucent lightRadio

Solving the 25x Capacity Problem



Advanced Antennas

Small Cells



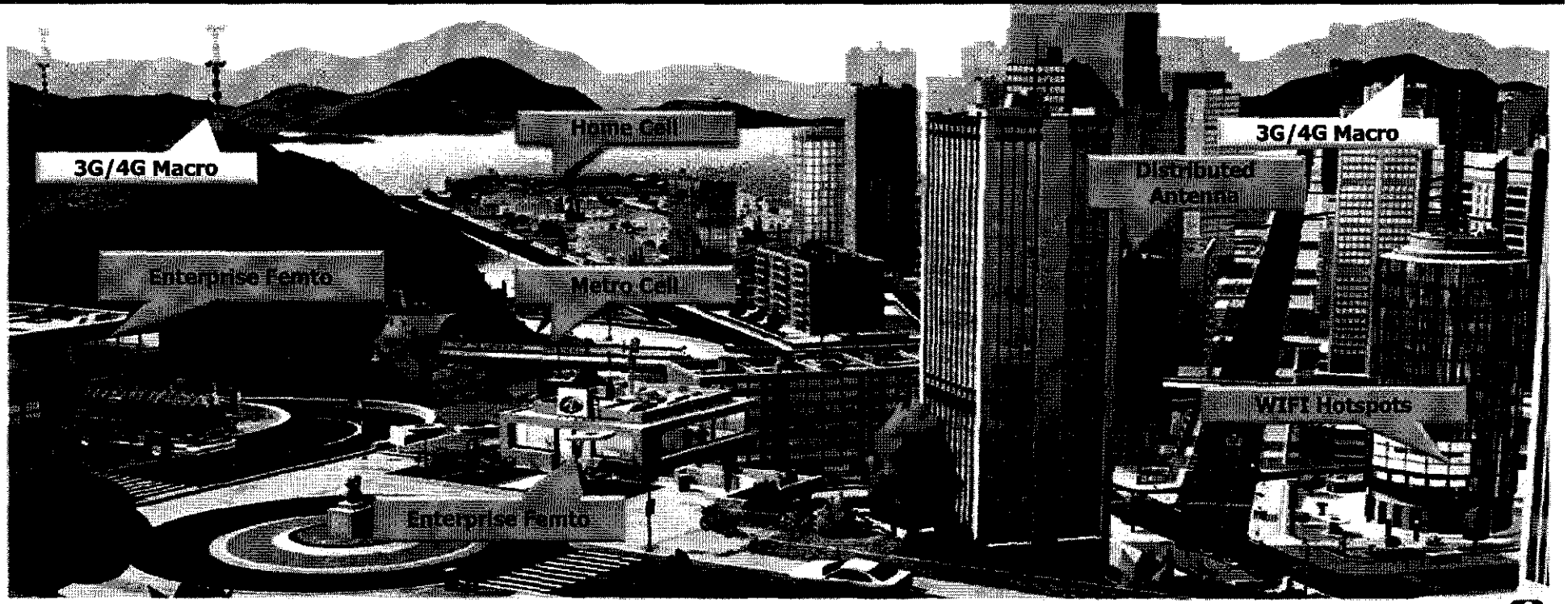
SMALL CELLS ARE NOW CRITICAL FOR ADDRESSING WIRELESS DATA

Small Cells: Indoor, Outdoor - Anywhere?

Better coverage, capacity and customer experience

Support new devices and services

Private vs. Public small cells



ALCATEL-LUCENT METRO CELL PORTFOLIO

METRO CELL INDOOR V2

1

W-CDMA

250mW
All-in-one

Available in
850 MHz
1900 MHz

METRO CELL OUTDOOR V2

2

W-CDMA

250mW
All-in-one

Available in
850 MHz
1900 MHz
2100 MHz

METRO CELL INDOOR (MCI)

3

LTE

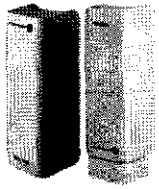
2 x 250 mW
All-in-one
Cube-based

Avail Date:
Jun 2013 (B25)

METRO CELL OUTDOOR (MCO)

4

W-CDMA

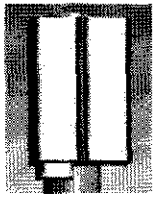


1W
All-in-one
Cube-based
Wi-FI AP option

Avail Date:
Mar 2013 (B1)
Mar 2013 (B2)

5

Multi-standard

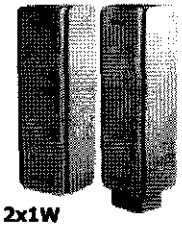


3x1W
All-in-One
Cube-based
Wi-Fi AP option

Avail Date:
Sept 2013 (B2)

6

LTE



2x1W
All-in-one
Cube-based
Wi-Fi AP option

Avail Date:
Mar 2013 (B25)
Sept 2013 (B2/B7)

7

LTE

2x5W
All-in-one

Avail Date:
Mar 2013 (B13)
Sept 2013 (B17)

Common Metro Dock
GE= Now
GPON = Q3 2013

Common Wi-FI AP
Sept 2013

METRO RADIO OUTDOOR (MRO)

8

LTE

2 x 1W (B13)
2 x 5W (B38)
Distributed BBU
Cube-based

Avail Date:
Now (B13)
Sept 2013 (B38)

femtoforum Awards 2011 winner

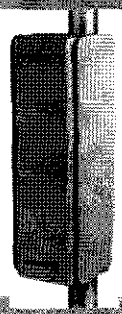
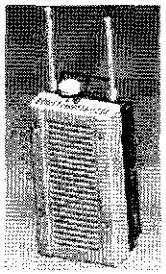
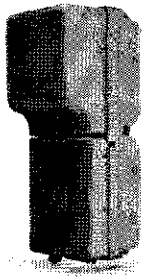
Alcatel-Lucent

telecoms LTE AWARDS 2012

telecoms LTE NORTH AMERICA AWARDS 2012

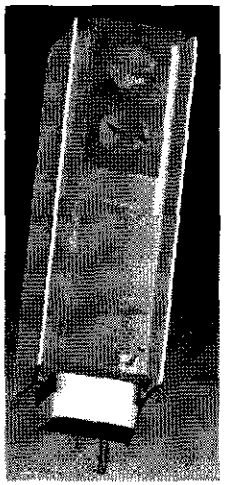
COVERING MULTIPLE TECHNOLOGIES AND DEPLOYMENT SCENARIOS

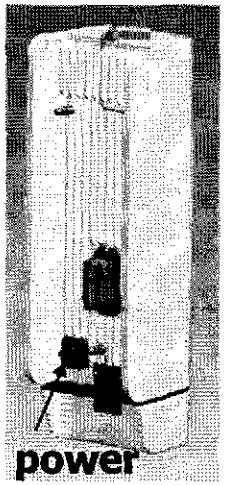
LTE METRO CELLS - WHERE TO USE THEM

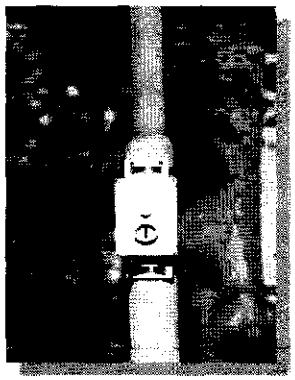
PRODUCT	METRO CELL INDOOR LTE	METRO CELL OUTDOOR LTE	METRO CELL OUTDOOR LTE	METRO RADIO OUTDOOR LTE
				
POWER	2 X 250 mW	2 X 1 W	2 X 5 W	2 X 1 W
MAX ACTIVE USERS	64	64	200	~ 200
				
USE CASES	INDOOR HOTSPOTS	OUTDOOR HOTSPOTS INDOOR HOTSPOTS FROM OUTDOORS COVERAGE HOLE-FILL	MACRO EXTENSION LARGE PUBLIC VENUES RURAL AREAS	LARGE PUBLIC VENUES

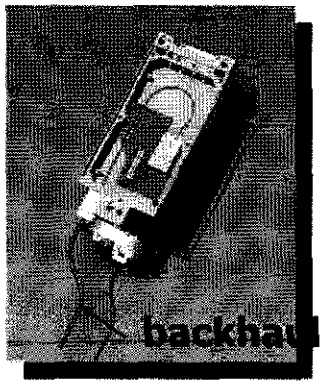
lightRadio™ Family Concept

RF Module	WCDMA (IuH architecture) LTE (eNodeB architecture) Up to 5W EIRP Directional Antennas Multiple band classes (w/ lightRadio cube)
Integrated Carrier-Grade Wi-Fi	Access Points Backhaul Including Daisy Chaining
MetroDock	GE GPON Wi-Fi Daisy chaining (cabled or Wi-Fi) Small Cell Router – for metro aggregation PoE+ injector NLOS LOS microwave

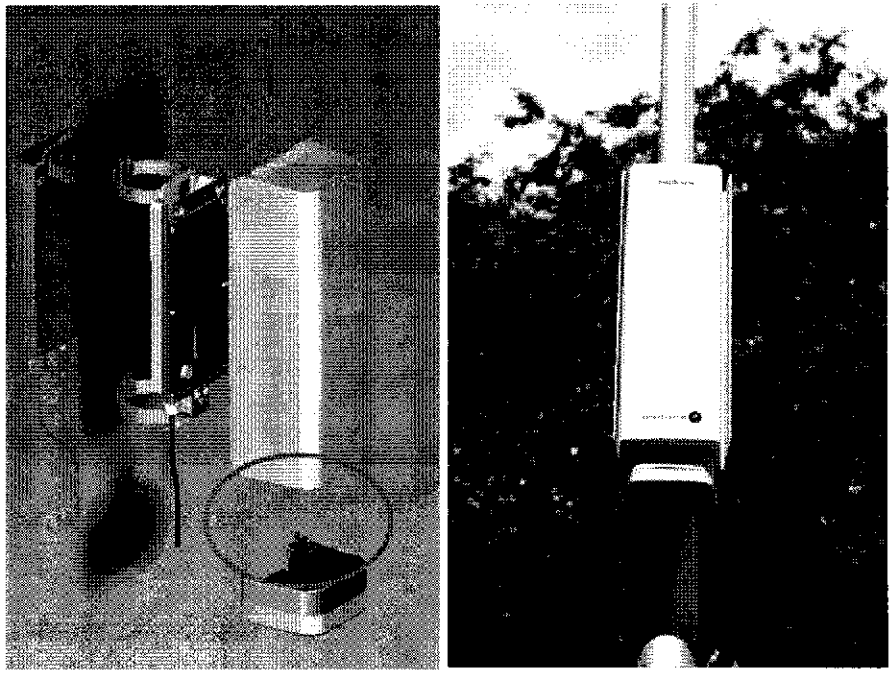




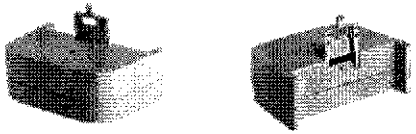




LightRadio™ Wi-Fi AP module



MCO WI-FI AP Module



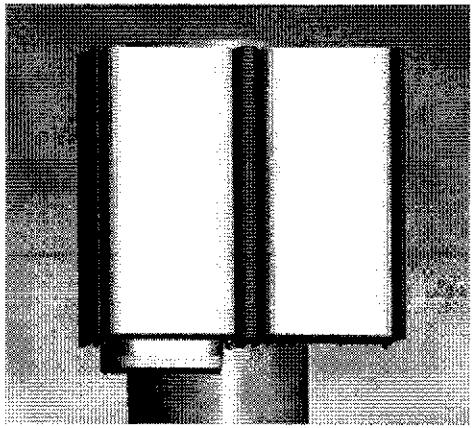
FRONT BACK

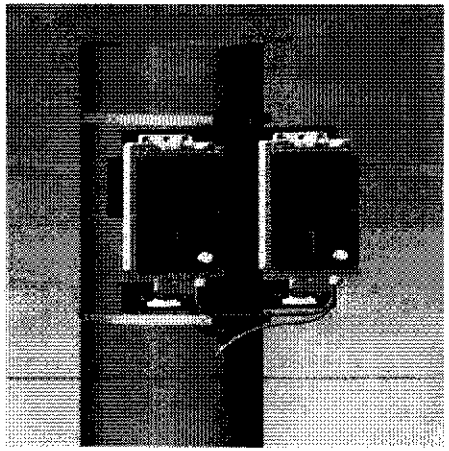
Dual-Band Dual-Concurrent Wi-Fi access point

- Supports **carrier grade Wi-Fi (Hotspot 2.0)**
- Simultaneous support of 2.4 / 5 GHz dual-band (802.11 b/g/n, 802.11a/n)
- output power for 2.4GHz and for 5GHz
  - up to 28dBm with integrated low-gain antennas
  - up to 32dBm with integrated high-gain antennas
- 20/40 MHz bandwidth
- 16 SSIDs (8 per frequency band)
- High capacity, up to 256 connected users
- Integrated directive antennas optimized for 2x2 MIMO
- Backhauled and powered via Metro Cell Outdoor module
- Passive cooling
- Seamless Wi-Fi / Cellular experience)

LTE Carrier Aggregation (CA) Readiness

MCO LTE 2x1W

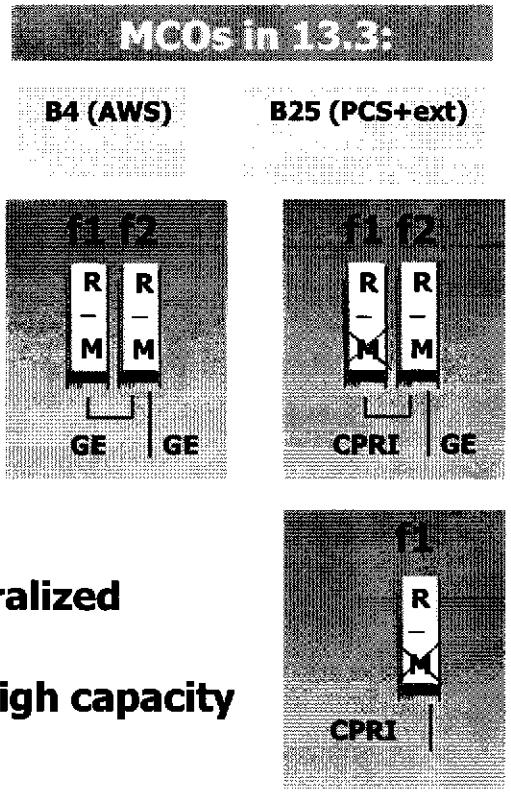




MCO v1.1 LTE module can be operated
- as MCO using local modem
- as RRH connected to an external modem

Typical application: enablement of CA
- **initial deployment all-in-one using on-box modem**
- **re-configuration into RRH for CA operation**

Other application: enablement of BBU centralized operation
- **to benefit from Rel11+ COMP and other high capacity features**



Deployment of Small Cells: Shared Carrier Deployment Planned vs. Uniform

Shared Carrier: Same carrier channel used in macro and small cells leading to interference interactions

- Field studies show traffic in macro cells is often spatially clustered
  - Placing the metro cells within the hotspot results in **high amount of traffic offload** and **large throughput gains**
  - **~50% macro cells are amenable to >50% offload with Metros**
  - **~25% cells allow 25%-50% offload**

- Small cell effectiveness depends upon three key hotspot characteristics:
- **Distance from macro** – greater the distance, more effective small cells are
- **Amount of traffic in <u>each</u> hotspot** – the greater, the better
- **Number of hotspots** – too few will not allow much offloading, too many will result in inter-Metro interference

Shared Carrier approach provides Lower Economic Return, But Still 30 - 35% of Traffic Is Offloaded

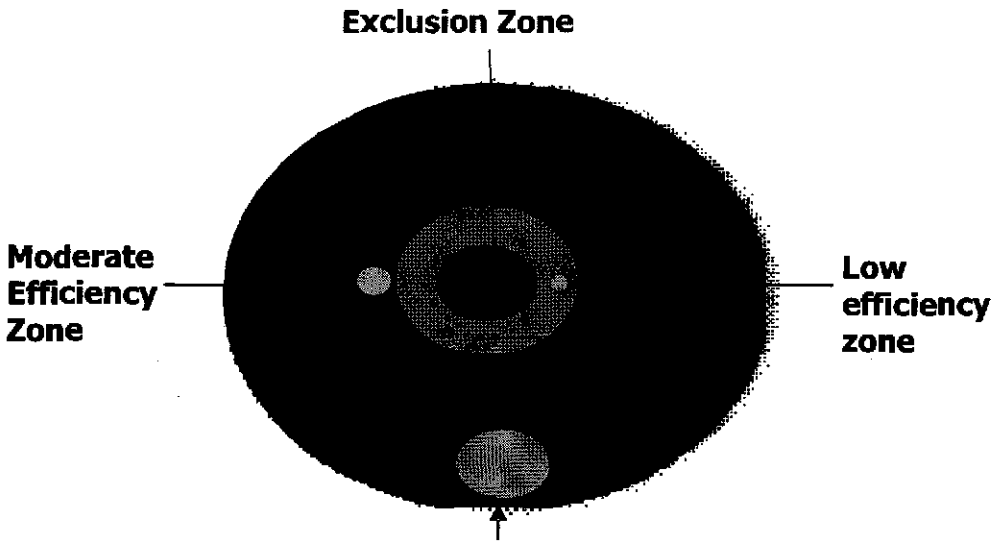
- Offers effective capacity and coverage for some use cases (indoor locations, etc.)
- Only option for operators with low-spectrum holdings

Metro Cell Coverage Area in a Shared Carrier Deployment

Field results and simulation data show all locations are not suitable for metro cells:

When the macro signal is very strong at a particular site, it causes two issues:

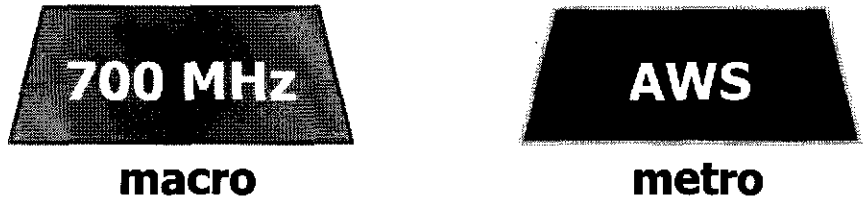
- **Shrinks metro cell coverage footprint → inefficient at macro offloading traffic**
- **High uplink noise rise at the metro cell → saturation due to dynamic range of metro cell receiver**



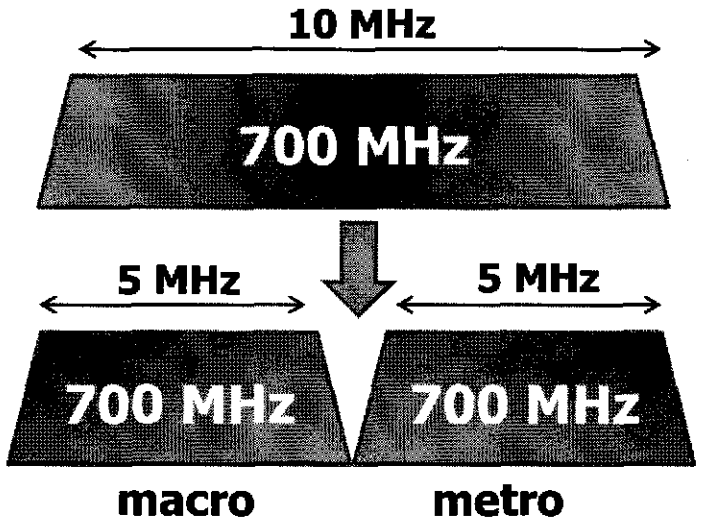
- **The "exclusion zone" is the region where the metro cell coverage is so small that it does not provide useful capacity offload from the macro**

Deployment of Small Cells: Dedicated Carrier for Small Cells

Two carriers from non-contiguous or separate band class



Or Two carriers created by splitting one contiguous carrier

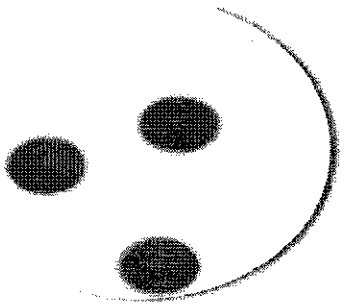


Dedicated Carrier

Independent (orthogonal) channels used in macro and small cells

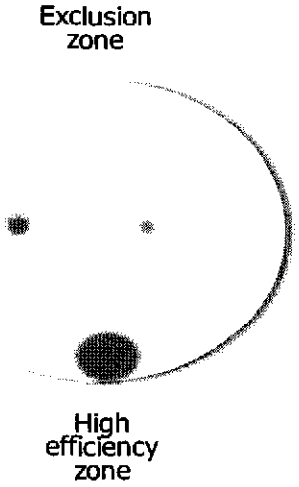
Why Consider a Dedicated Carrier for Metro Cells?

Coverage area of metro cells deployed with dedicated carrier



Moderate efficiency zone

Coverage area of metro cells deployed with shared carrier

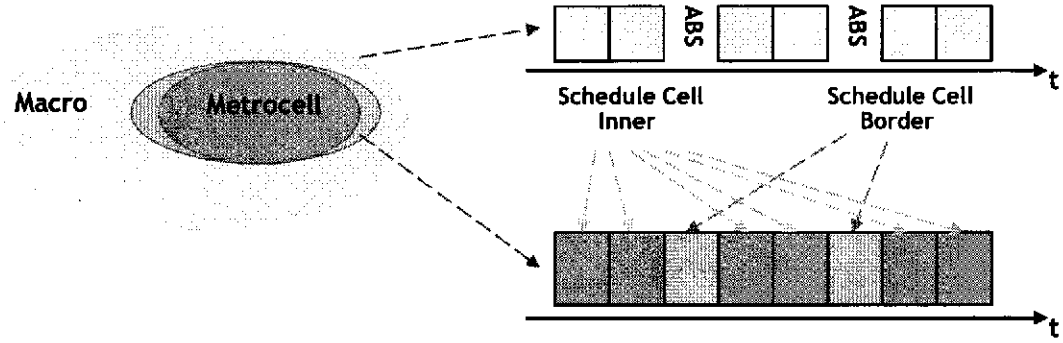


- Optimum amount of traffic offload (bias) increases with increasing number of metro cells per macro (result of load balancing with larger # of metros)
- **Clear gains in Cell Border Throughput (CBTP) from dedicated carrier**

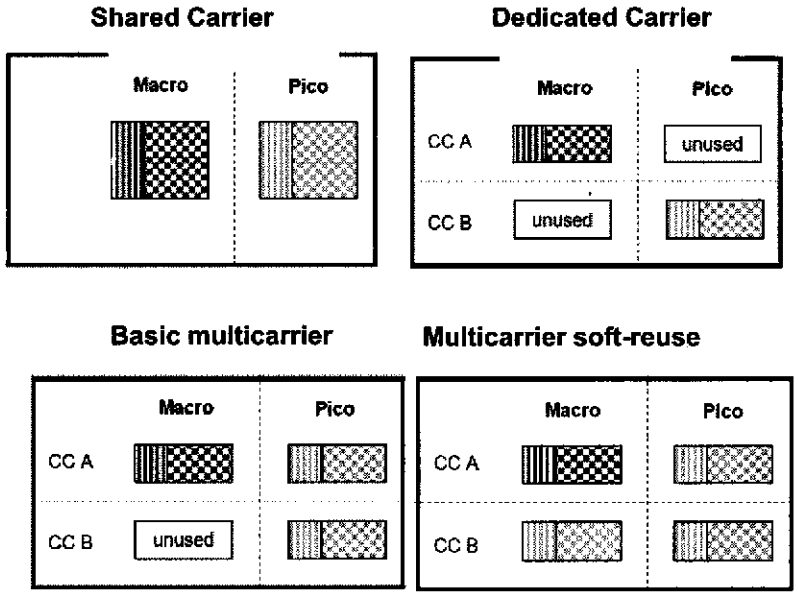
- **Without interference from macro, a dedicated carrier metro cell can cover a much wider area regardless of proximity to the macro**
  - **Coverage area configured through cell selection *priorities and thresholds***
- **High efficiency traffic offloading without need for exclusion zone**
- **But… are we using the spectrum wisely? → Reduces spectral efficiency**

More advanced techniques

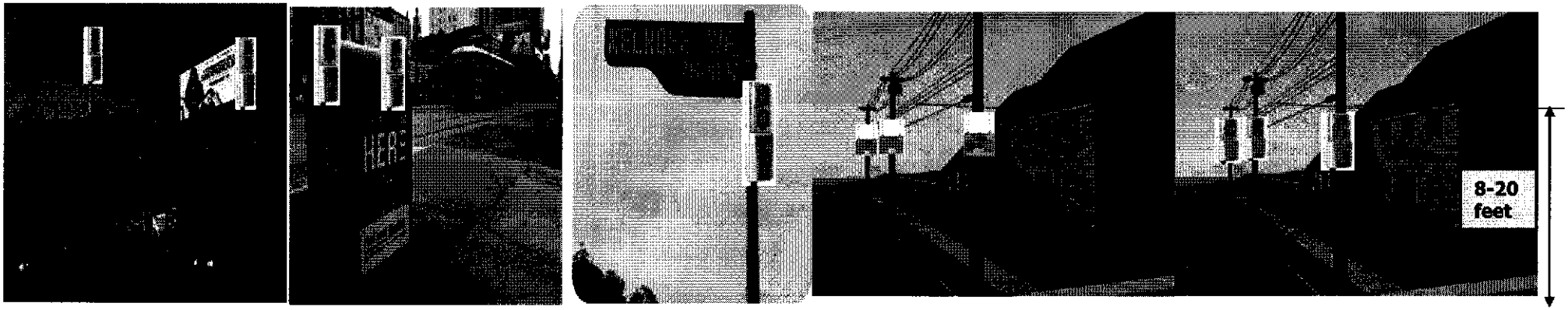
- **eICIC for shared carrier deployment**
  - **Almost Blank Sub-frames (ABS)**
  - Interference Cancellation (both UE and Network based solutions)



- **Multicarrier approach:** Metro cell uses two component carriers (CC A and CC B), macro uses just CC A alone (basic scheme) or CC A full power and CC B with reduced power (soft-reuse scheme)
  - With or Without carrier aggregation



3.5 GHz and Small Cells in Cellular Systems



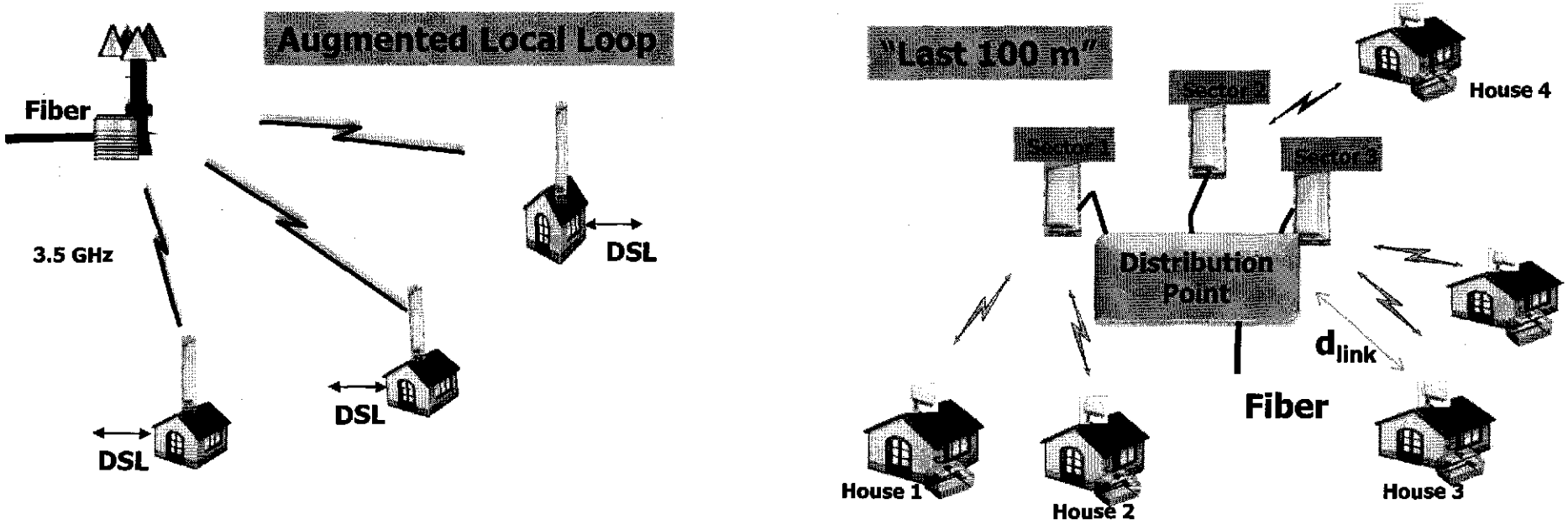
Small Cell Access

- Dedicated carrier small cell systems can leverage *priority access channels* in 3.5 GHz

Small Cell Backhaul

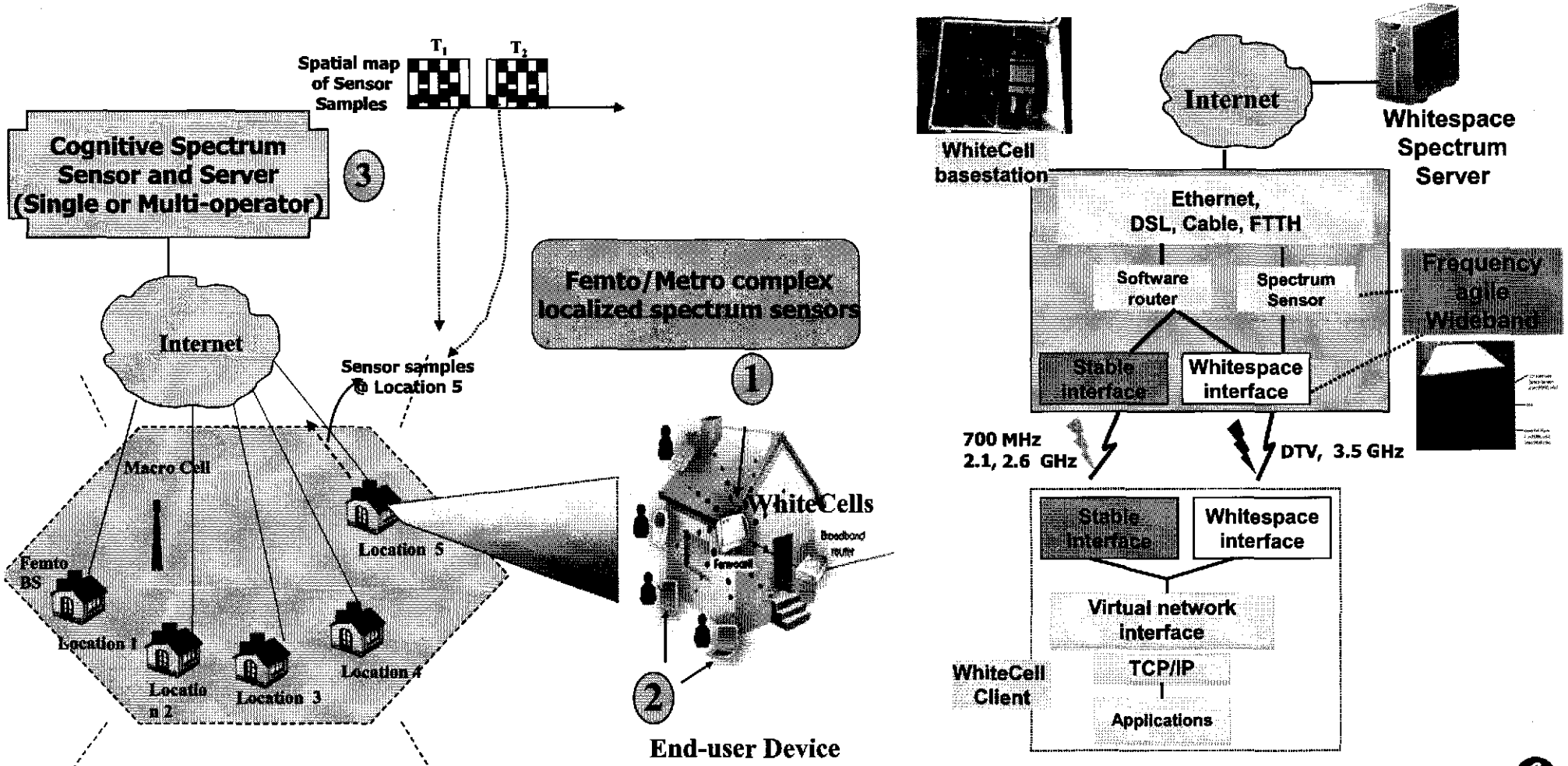
- Deployment in clutter at 8-20 feet
- Obstacles, foliage, rapid change in propagation environment → Line-of-Sight (LOS) at 30/60/80 GHz microwave fails. Microwave backhaul products are not suitable
- Non LOS (NLOS) or near-LOS (nLOS) backhaul required which needs sub-6 GHz spectrum
- 3.5 GHz can be ideal suited

3.5 GHz and Fixed Wireless Access Using Small Cells



- Fixed broadband over copper pairs can be augmented with 3.5 GHz Fixed Wireless Access (FWA)
- Multi-antenna systems at 3.5 GHz can be small and efficient
- Effectively leverage small cell technology

WhiteCells: High Capacity Dual-Technology Small Cells (Research)



AT THE SPEED OF IDEAS™