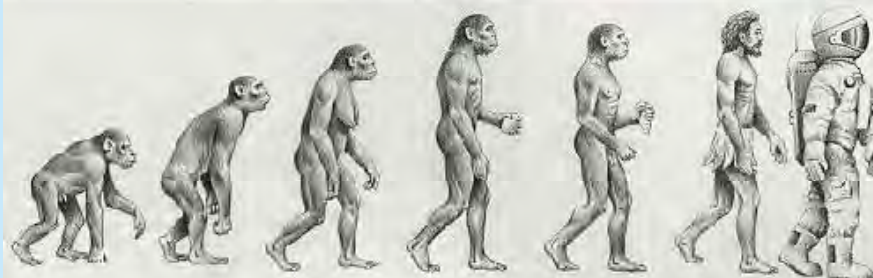


# The Wireless Evolution

Telegraph to Smartphone  
to Future Wireless Species

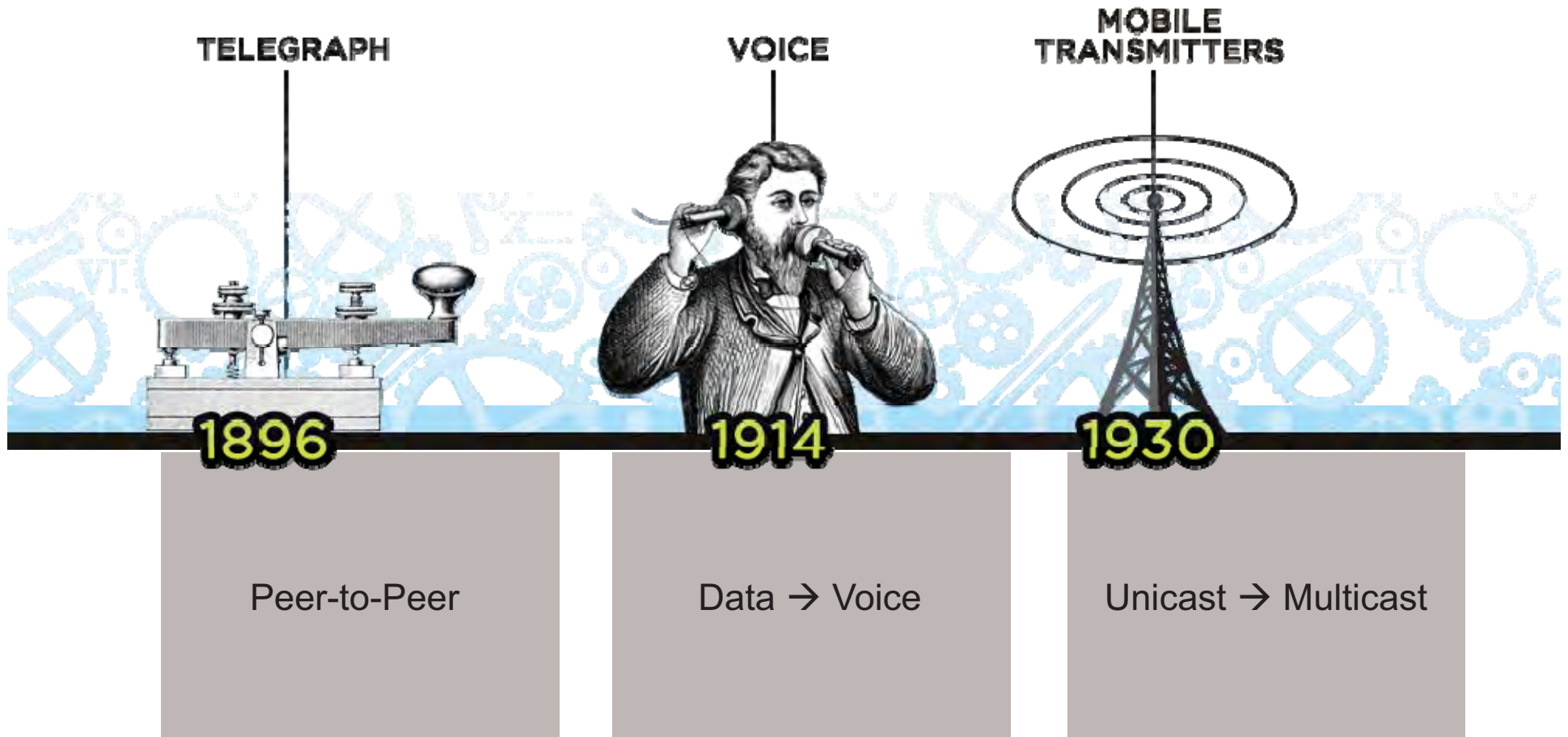
VTC Fall 2011

**Matt Grob**  
EVP & Chief Technology Officer





# BIRTH OF WIRELESS



# VOICE ERA

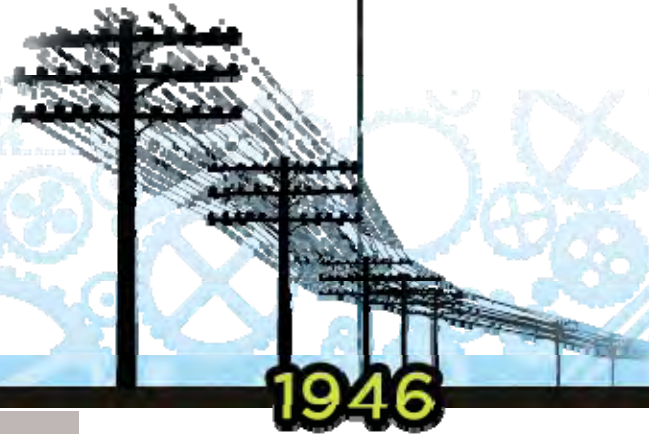
MOTOROLA  
RADIO



Infrastructure gave:

- Longer range
- Lower power devices

MOBILE CONNECT  
TO PSTN



IMTS



Not yet considered

- “Data Mining”
- “Services Platform”
- “Backward and Forward Compatibility”

# BIRTH OF CELLULAR

CB RADIO  
POPULARITY



**1976**

Peer-to-Peer

AMPS



**1983**

Unicast/Infra



**TODAY**

Increasing Versatility



THEN...SUDDENLY...





# Data Traffic Growth



MOBILE DATA  
TRAFFIC GREW

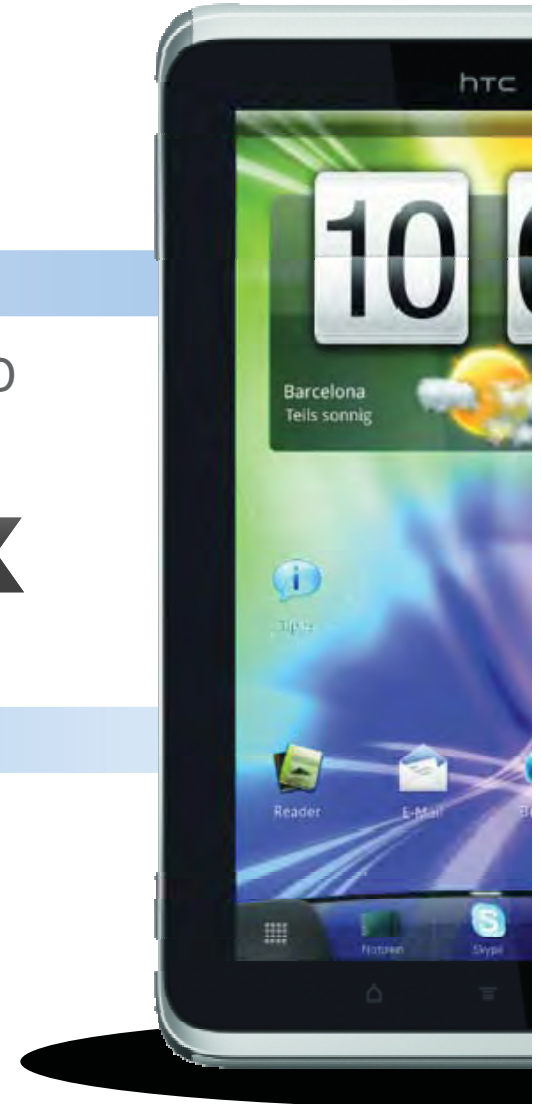
**>2x**

IN 2010

AND IS PROJECTED  
TO GROW

**10–12x**

FROM 2010–2015



Source: Strategy Analytics, March 2011.

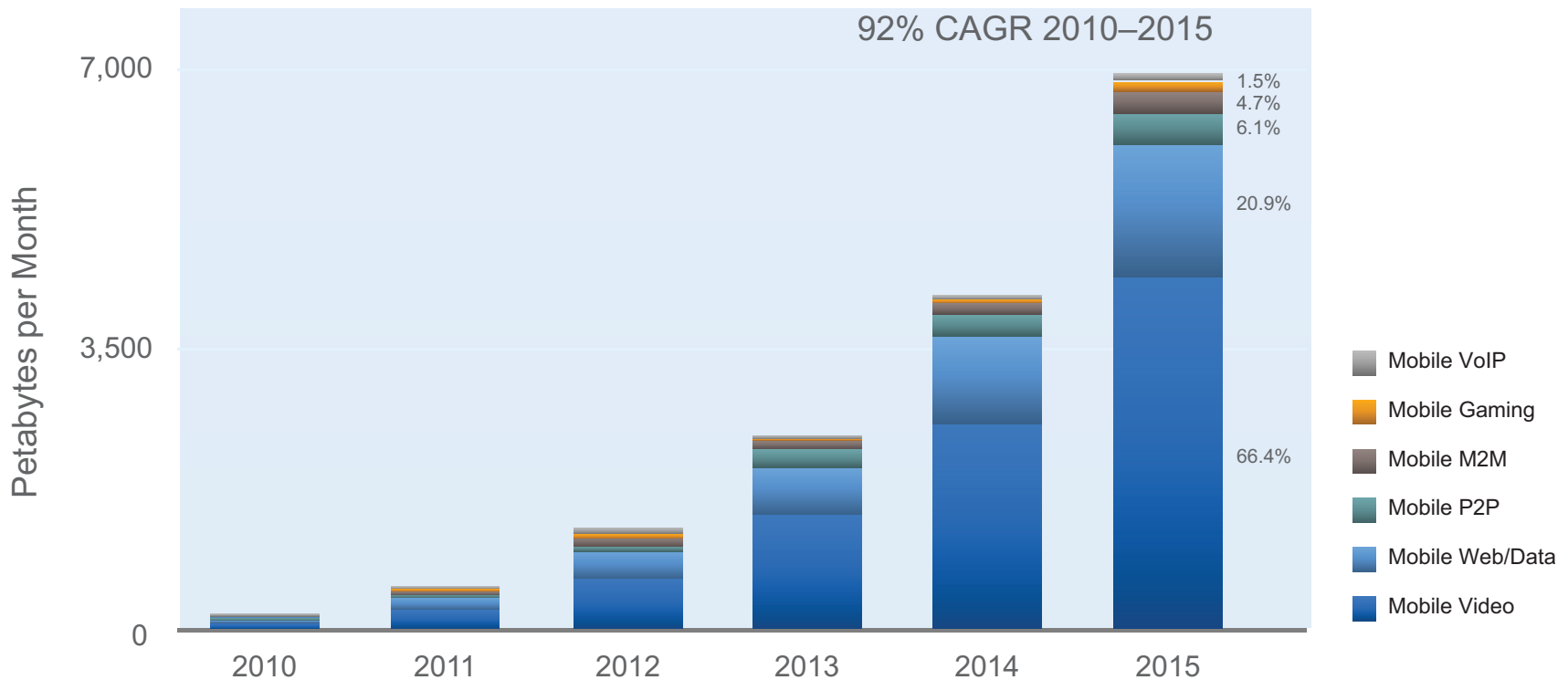


# Data Consumption Driven by Smartphones and Tablet Era



# Mobile Demand Outpacing Supply

## WORLDWIDE MOBILE RICH-MEDIA DEMAND GROWTH



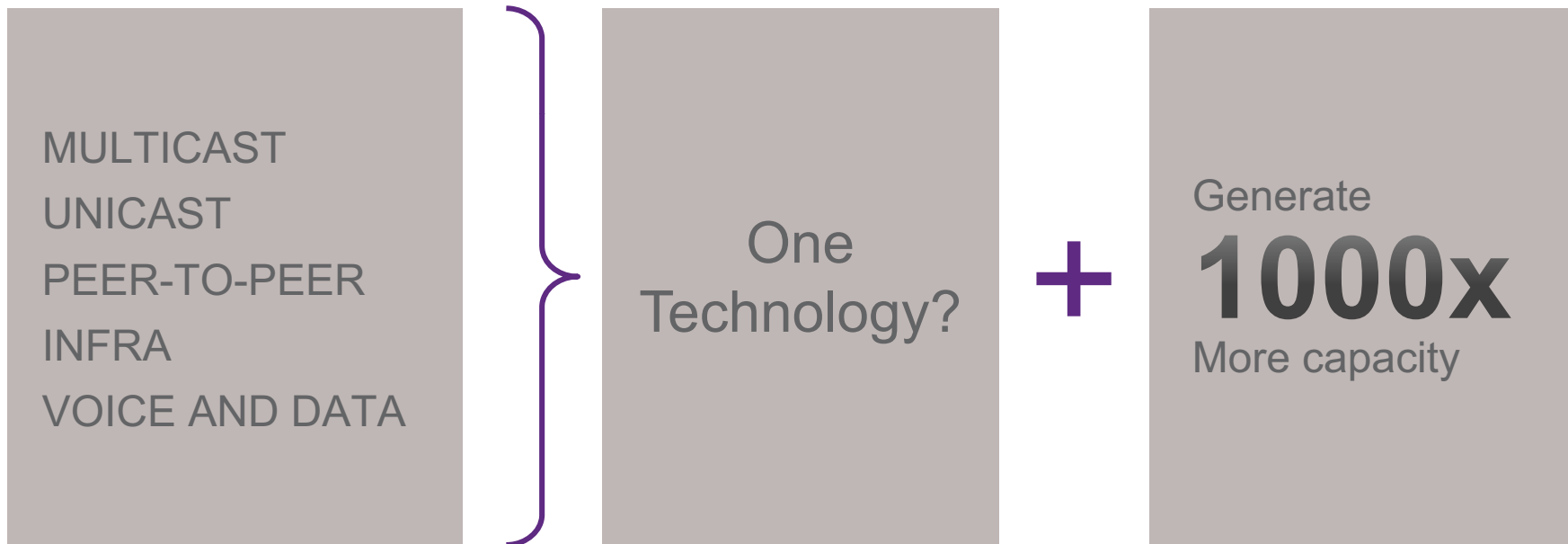
# Now What? (For ~1-5GHz WAN/LAN)

WE ARE APPROACHING A NEW ERA OF VERSATILE SYSTEMS—AKIN TO A 'TWO-PARTY' SYSTEM

3G → 4G

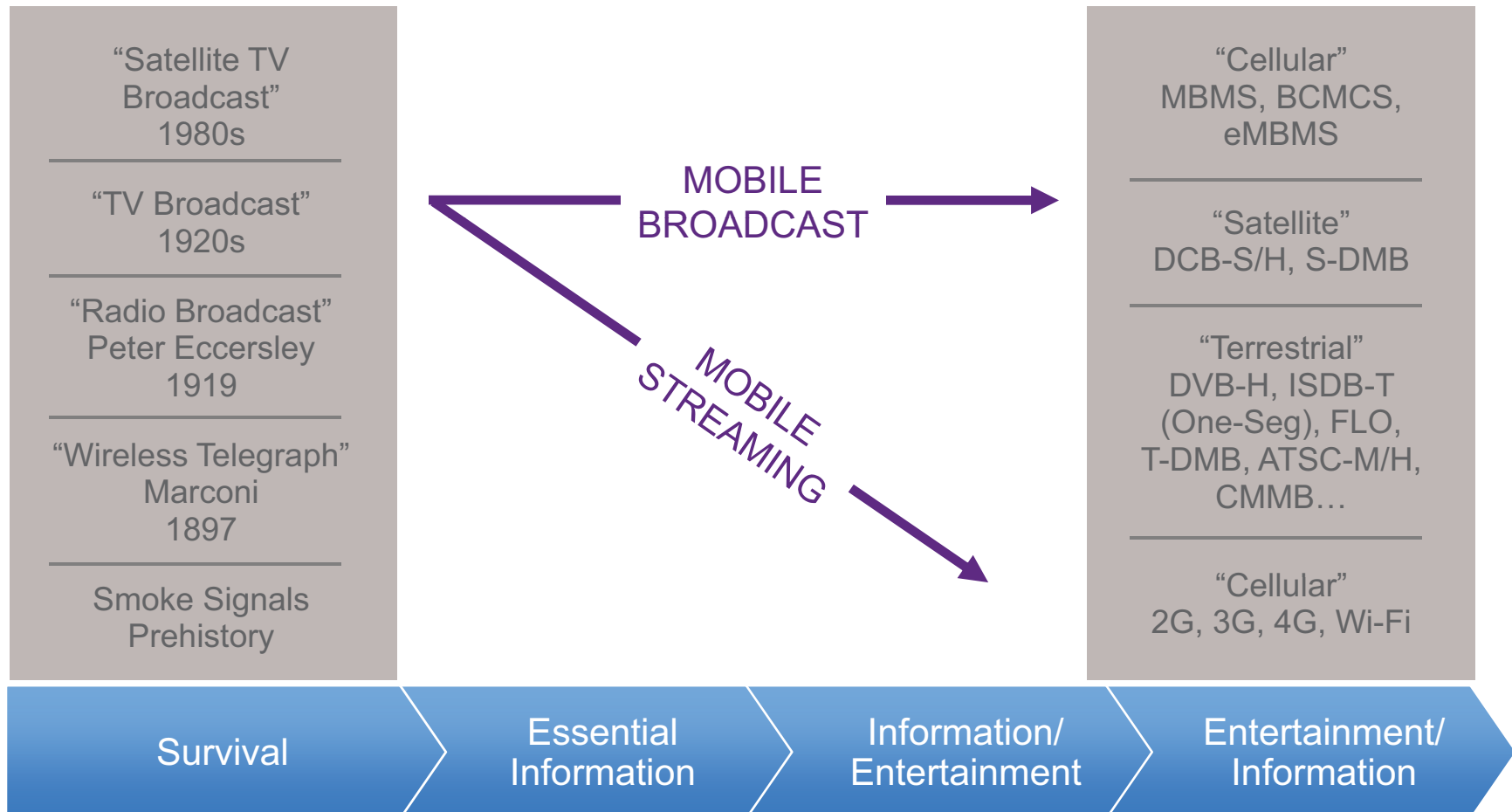
802.11 FAMILY

# Challenges of Versatile Technology



# Historical Perspective

BROADCAST IS FUNDAMENTAL TO COMMUNICATIONS



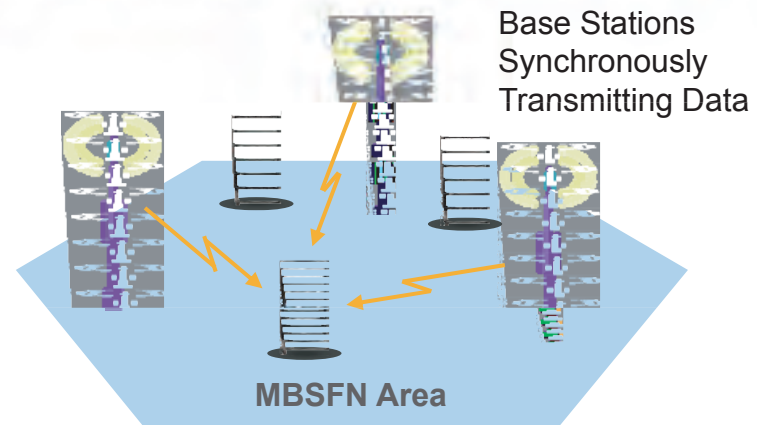
# LTE Multicast (eMBMS)



Offloads popular content from unicast transmission

Flexible capacity sharing between LTE unicast and broadcast

eMBMS benefits from SFN gain

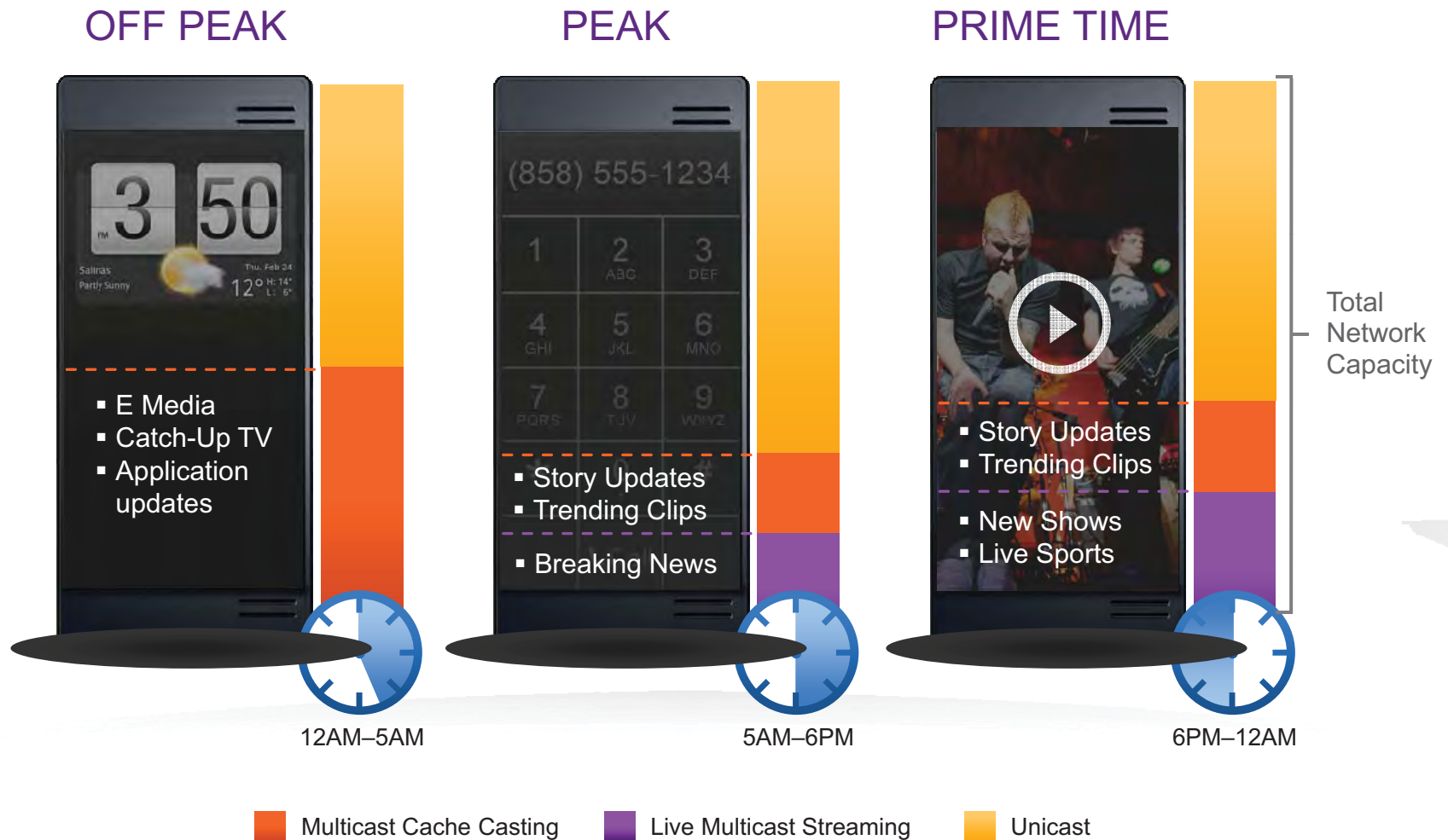


# Delivery Tailored by Content



	Live TV	Personalized Push VoD and Content	On-Demand Long Tail
Content	Sports, news, events	Clips, shows, archived content	Other complimentary content
Delivery	Broadcast	Broadcast	3G/4G/Wi-Fi
User Experience	Live, high-quality, now	User defines what content is desired for on-demand	User searches for specific content

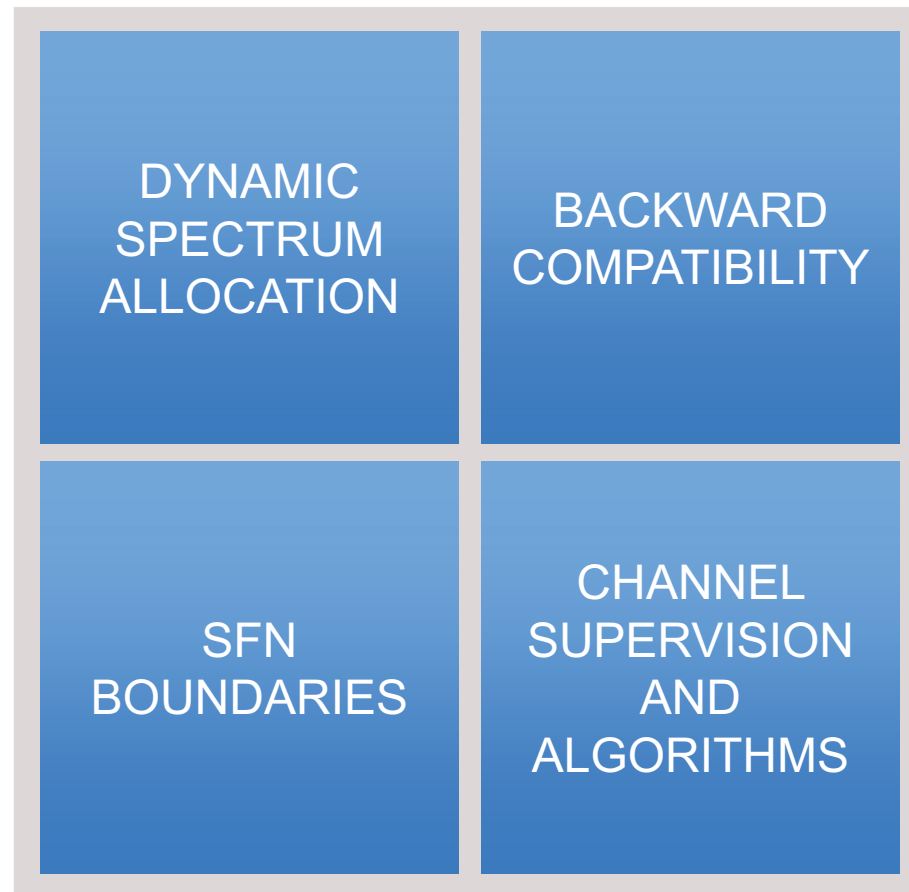
# LTE Flexibly Supports Both Unicast and Multicast—a Trend?



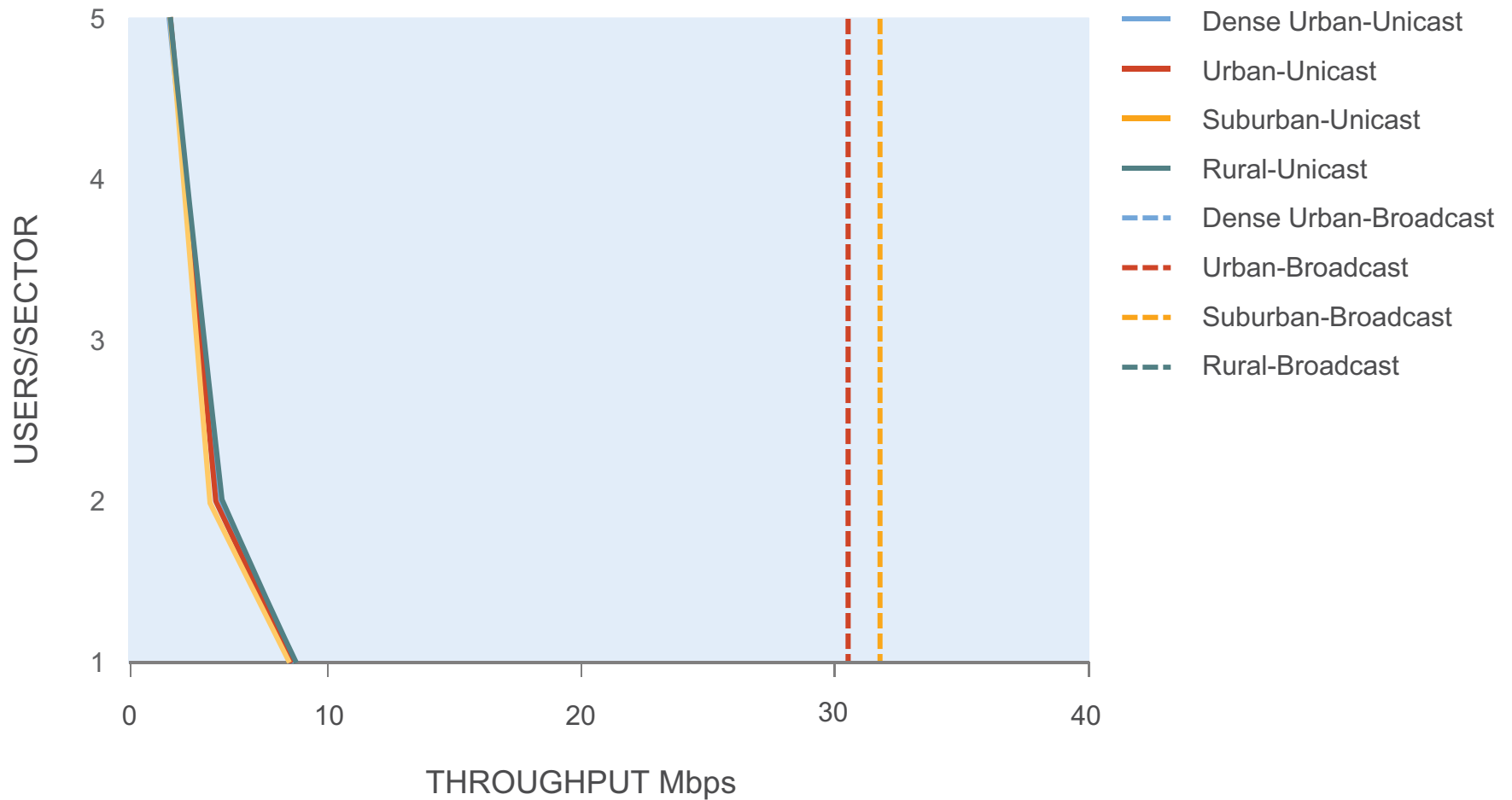


# Multicast Challenges

---



# How Efficient is LTE Multicast Relative to Unicast?



# Number of Users per Cell

“COUNTING” IS A DEFINED MECHANISM IN RELEASE 10

-> How to determine how many listeners there may be

## Challenges

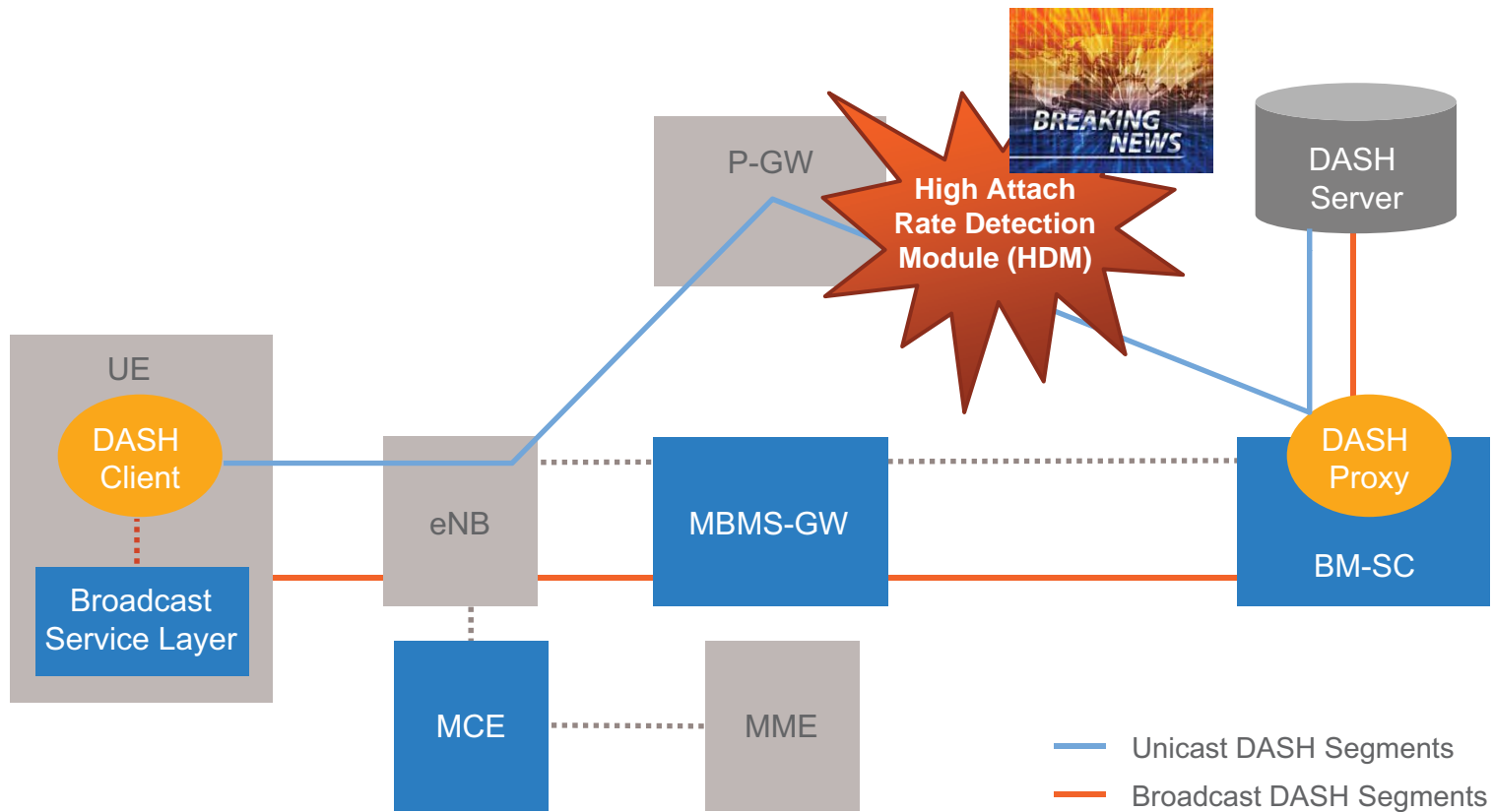
- Accuracy
- Counting UEs in both idle and connected state?
  - Rel10 only counts connected
- How to count all releases of UEs? (Backward compatibility when a new mechanism is introduced in later release)

## Proposals

- Query UEs from RAN
- Backend counting through registration and tracking area update information
- Combinations



# eMBMS for High Attach Rate Events





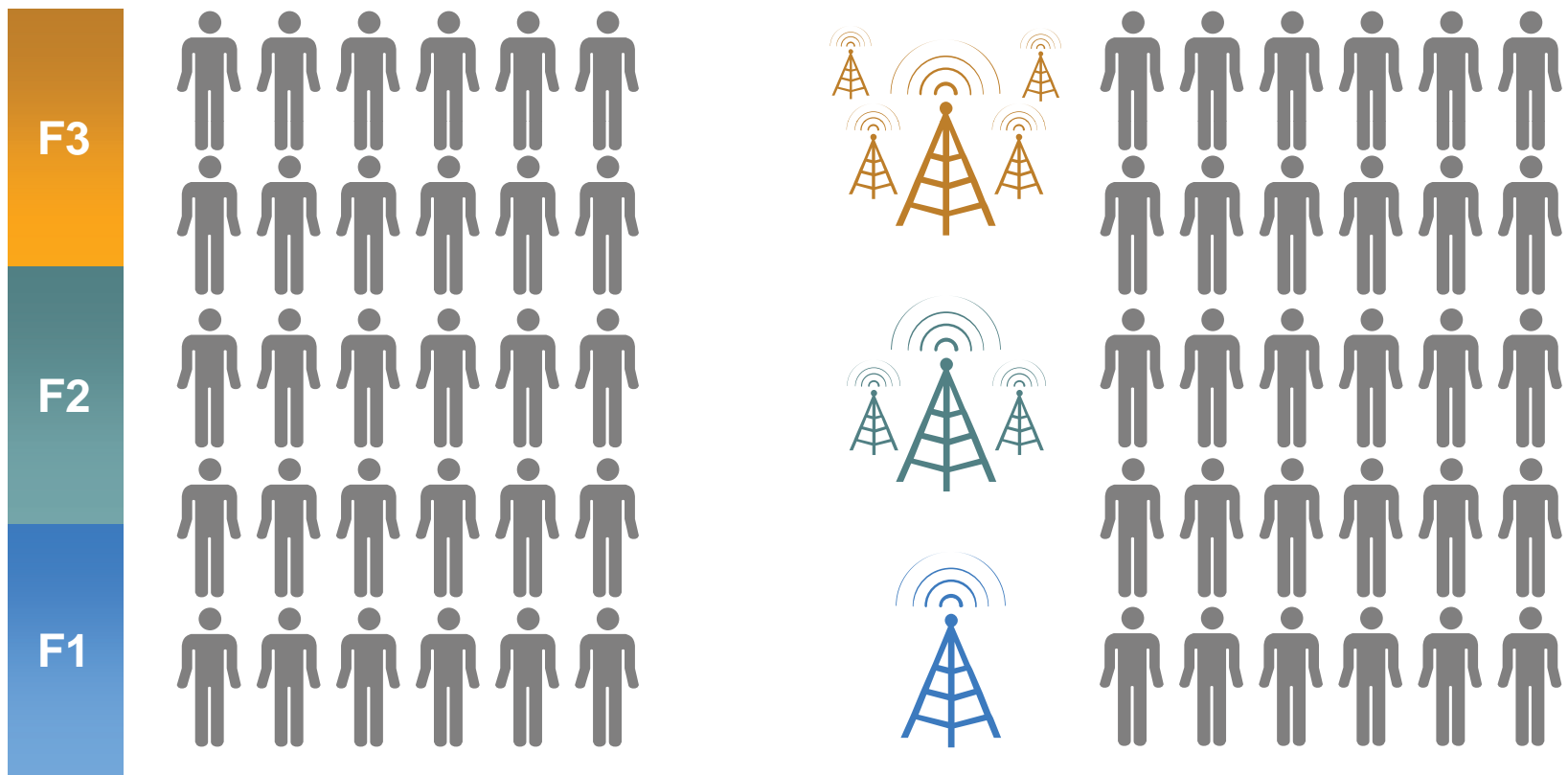
Small Cells

# 1000x More Network Demand

SMALL CELLS PROVIDE REAL GAINS IN BEARER CAPACITY

MORE SPECTRUM

MORE BASE STATIONS



# Self Organizing Networks for Small Cells: UltraSON

## Tx Power Calibration Suite

- Network Listen-Based Tx Power Calibration (NLPC)
- Mobile Assisted Range Tuning (MART)
- Guest Mobile Protection (GUMP)

## UL Interference Management Suite

- Controlled Limit on UE Power (CLIP)
- Macro Aware Rise Setting (MARS)
- Rx Diversity

## Mobility Management Suite

- Idle Model Femtocell Discovery
- Active Hand-In
- Mobile Assisted Self Configuration (MASC)
- Tx Diversity

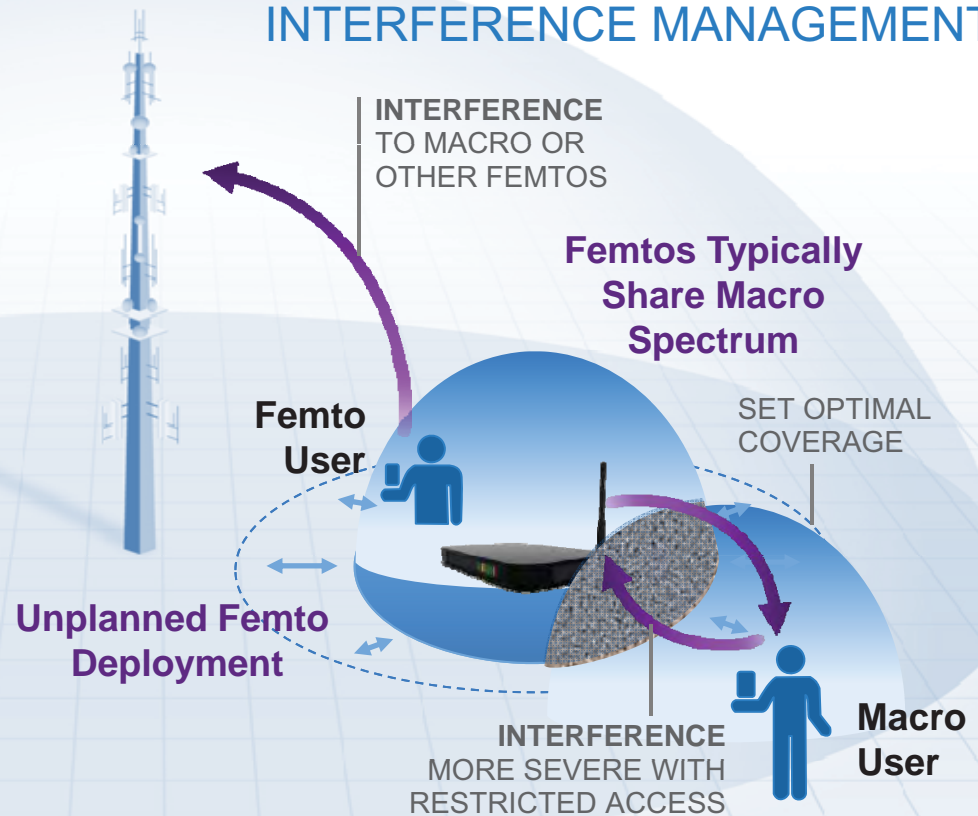
# Femtocells Require Innovative Interference and Mobility Management

FOR RESTRICTED ACCESS/LARGE SCALE OPEN ACCESS DEPLOYMENTS

## MOBILITY MANAGEMENT

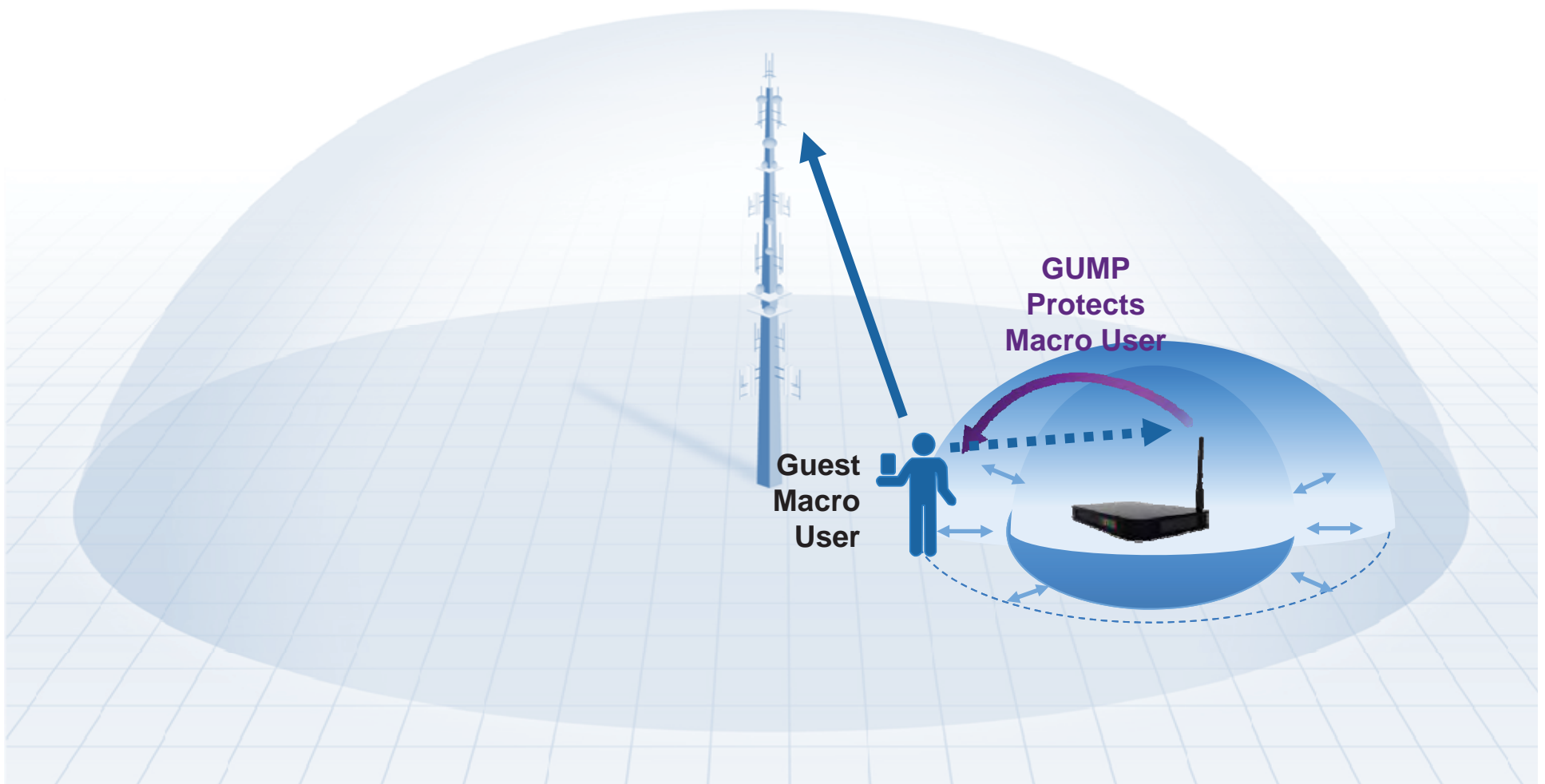
- Femto Discovery → Beacon
- Reliable Handoff → Beacon Assist

## INTERFERENCE MANAGEMENT

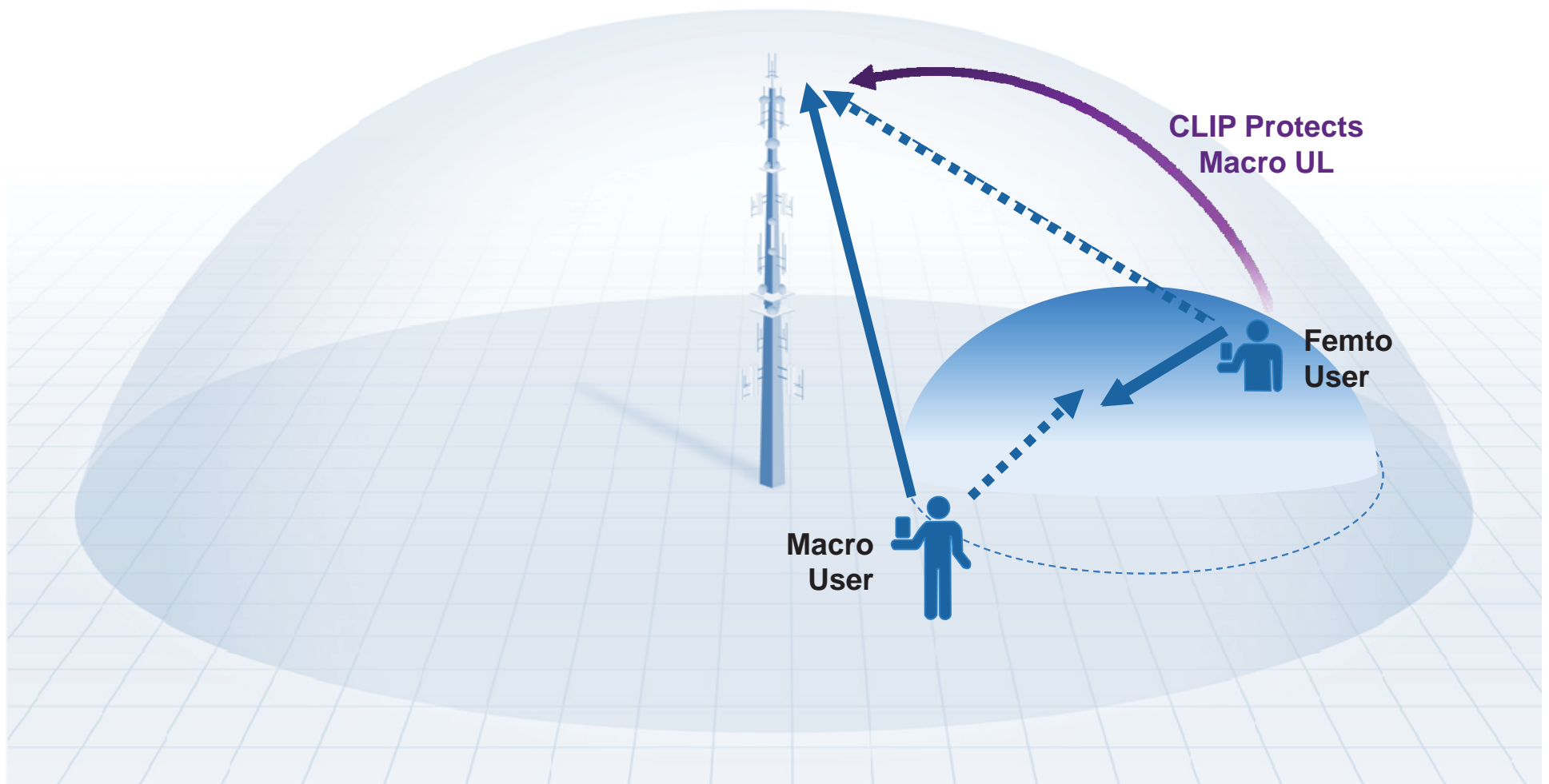




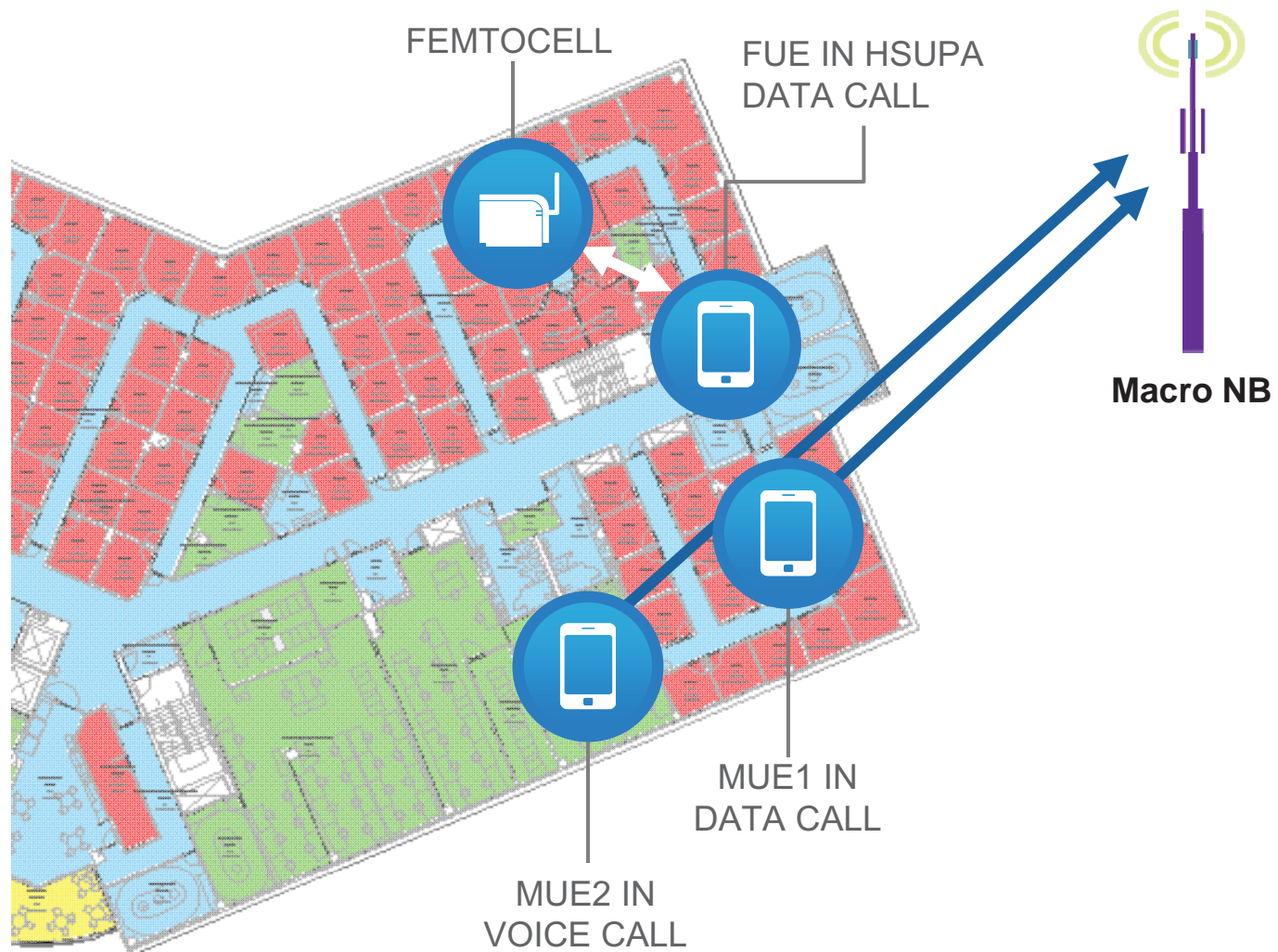
# Guest Mobile Protection (GUMP) Protects “Nearby Active” Mobiles



# Controlled Limit on Power (CLIP) Protects Macro UL from Femto UE Interference



# CLIP: Over-the-Air Test Setup



# Evolution: Femtocells to Femto Networks

RESIDENTIAL

SMALL ENTERPRISE

LARGER SCALE ENTERPRISE/RESIDENTIAL

## Initially: Indoor Hot-Spots

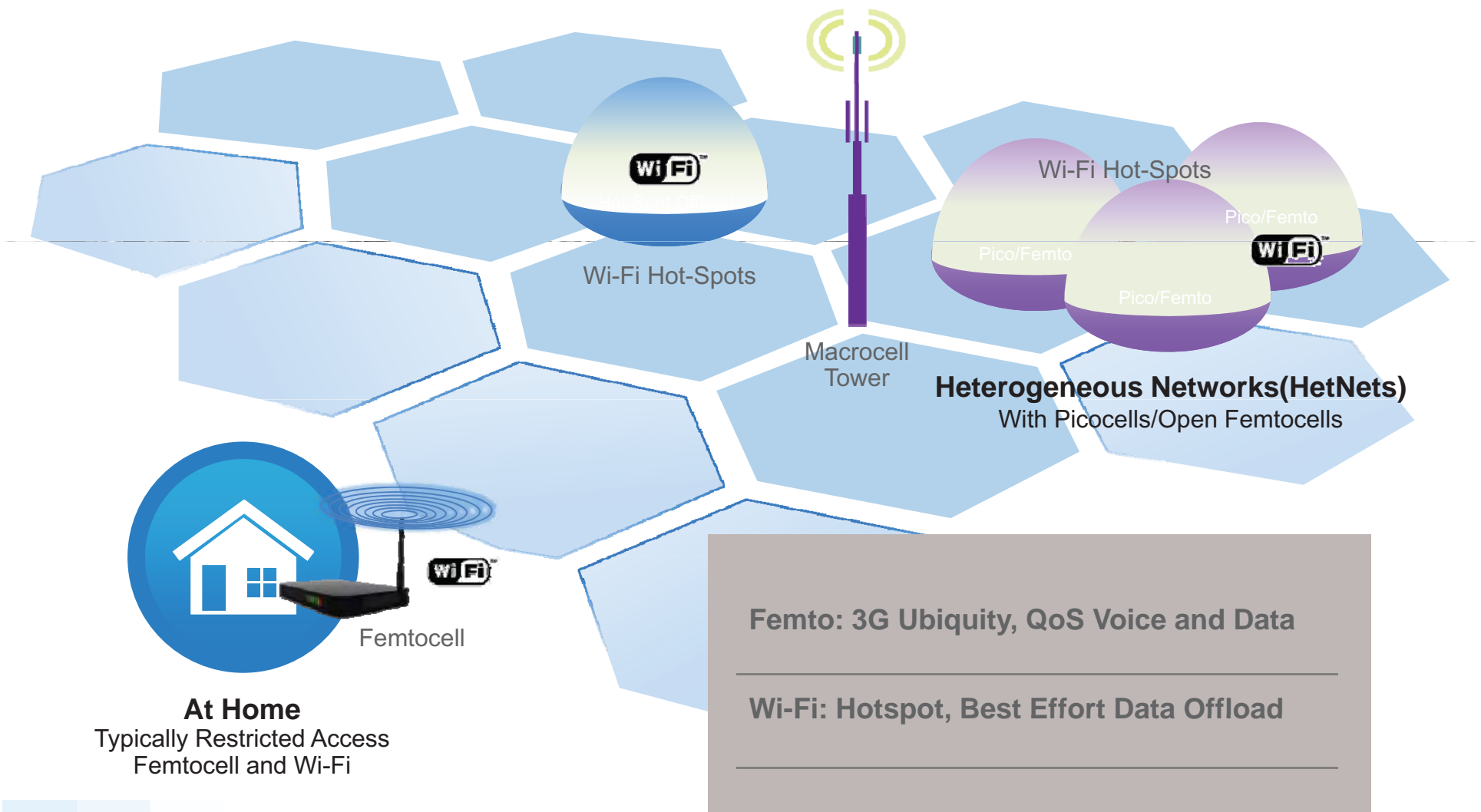
- Deployed by user—"unplanned"
- Supports restricted access
- User's broadband connection
- Scalable Femto network architecture

FEMTOCELLS  
USED AS  
TRADITIONAL  
PICOCELLS

## Next: Denser Indoor and Even Outdoor Deployments

- Also deployed by operator
- More enterprise and open access
- Inter-Femto service continuity (soft HO)
- Interference coordination

# Wi-Fi Complements Femtocells





White Space

# TV White Space Devices

In the USA the FCC has specified two classes of TV white space devices

FIXED

PERSONAL/PORTABLE

## PERMISSABLE TV CHANNELS

TV Channel	Frequency Band	Frequency (MHz)	Allowed Devices
2	VHF	54–60	Fixed
5–6	VHF	76–88	Fixed
7–13	VHF	174–216	Fixed
14–20	UHF	470–512	Fixed
21–35	UHF	512–602	Fixed and Portable
36	UHF	602–608	Portable
38	UHF	614–620	Portable
39–51	UHF	620–698	Fixed and Portable

# TV White Space Devices

## FIXED DEVICES USE OUTDOOR ANTENNAS

## CLASSES OF PORTABLE DEVICES

Mode I: Client  
Mode II: Access Point

## PERMITTED TX POWER

Fixed: 30 dBm with up  
to 6 dBi antenna gain  
Portable: 20 dBm with  
no antenna gain

## CHANNELS ADJACENT TO TV BROADCASTS CHANNELS

Fixed: Not permitted  
Portable: Reduce TX  
power to 16 dBm

## STRICT OUT-OF- BAND EMISSIONS

## INTERFERENCE AVOIDANCE MECHANISMS (EITHER/OR)

Geo-location with  
database access  
Spectrum sensing



# Case Study: TV White Space Availability

## GOOGLE EARTH COLOR CODING FOR TVWS CELLULAR CAPACITY OFFLOAD

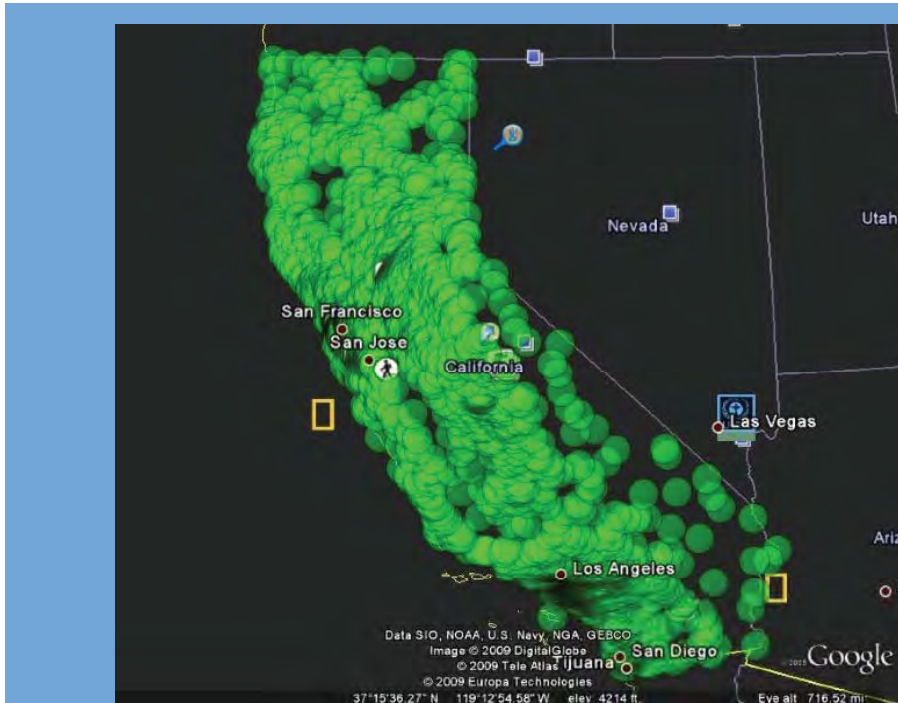
Performance	Capacity Gain	Number of Fixed Channels
Good (Green)	> 50%	$\geq 3$
Fair (Yellow)	20%–50%	2
Bad (Red)	< 20%	1

## GOOGLE EARTH COLOR CODING FOR TVWS FEMTO

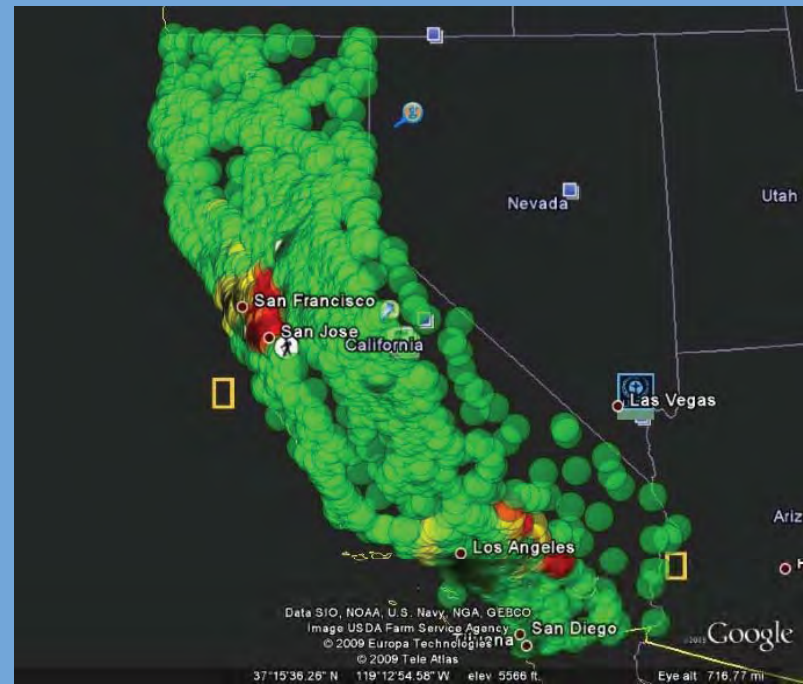
Performance	Outage Probability	Number of Portable Channels
Good (Green)	$\leq 2\%$	$\geq 4$
Fair (Yellow)	2%–5%	3
Bad (Red)	> 5%	$\leq 2$

# White Space Availability (California)

FEMTO

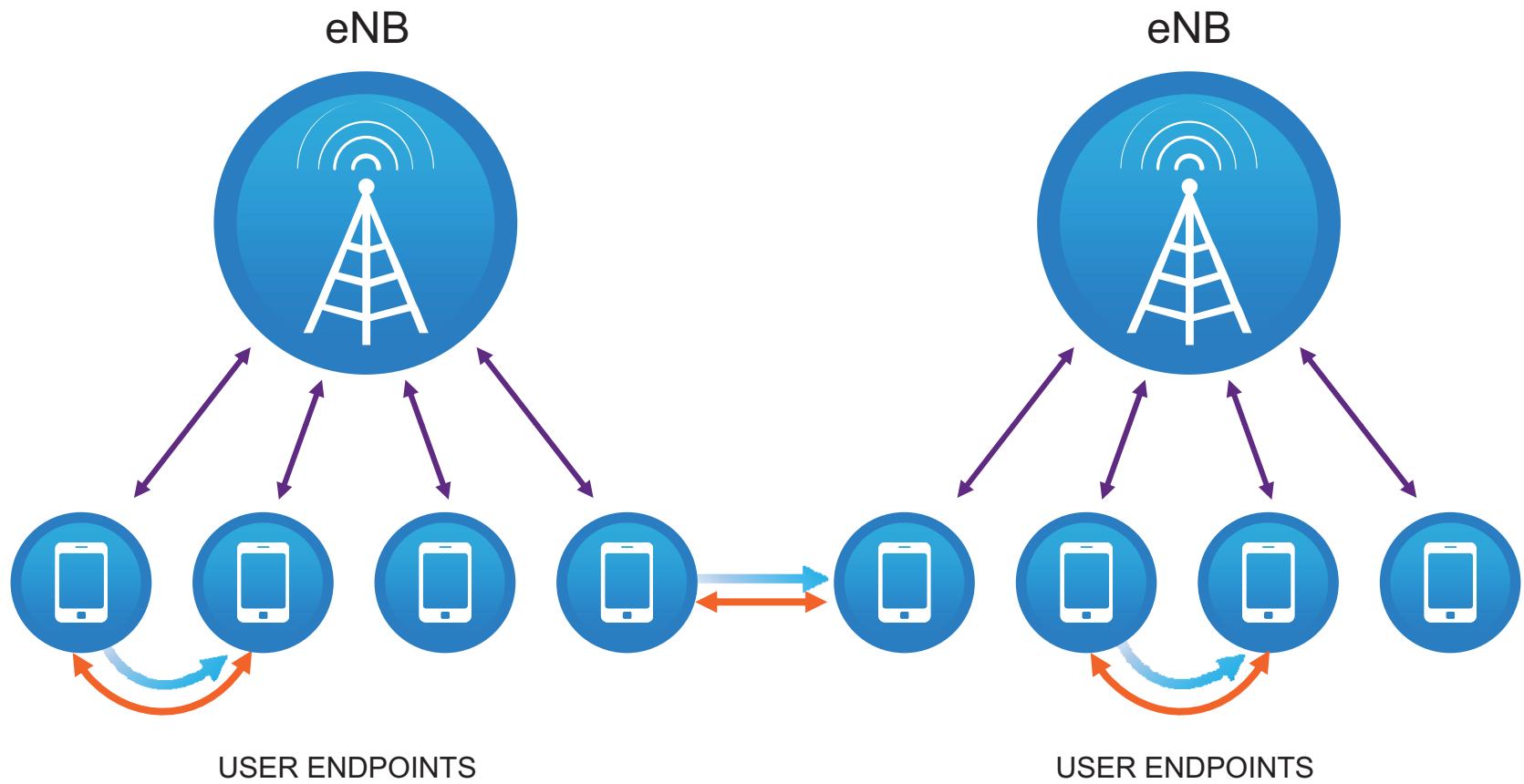


CAPACITY OFFLOAD





➤ Peer to Peer



WAN  
Communications



Peer-to-Peer  
Discovery



Peer-to-Peer  
Communications



# Are We Now Asteroid Proof?

THE NEWEST EVOLUTION OF WIRELESS

UNICAST

BROADCAST

VOICE, DATA,  
AND EVEN  
PEER-TO-PEER

SCALABILITY  
(mix big/large stations)

LICENSED/  
UNLICENSED BAND  
OPERATION AND  
INTER-OPERATION

LIMITS FOR  
MODEM/LINK  
PERFORMANCE

PROTECTED SPECIES. SAFE FROM EXTINCTION.









---

DON'T COUNT ON IT...

~~PROTECTED SPECIES. SAFE FROM EXTINCTION.~~







Follow us on:



» Thank You

For more information on Qualcomm, visit us at:  
[www.qualcomm.com](http://www.qualcomm.com)  
[www.qualcomm.com/blog](http://www.qualcomm.com/blog)