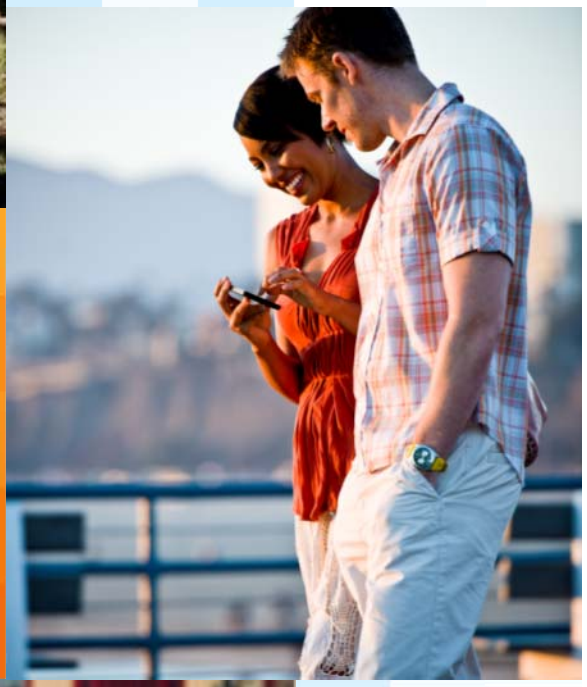


The 3G/4G, Voice and Chipset Evolution

CTIA May 8 2012

Introduction

- Presentations will be available after the sessions
  - See http://www.qualcomm.com/events
- An email will be sent to all participants with a link to presentations (make sure to have your badge scanned)
- All videos are available on Qualcomm's webpages (www.qualcomm.com/technology), youtube and slideshare
- We will make room for questions after each session

The 3G & 4G and Chipset Evolution

- **The wireless evolution and Spectrum** . . . . . **1:00 pm – 1:30 pm**
  Speaker: Rasmus Hellberg, Sr Dir Technical Marketing

- **Small cells and Hetnets**. . . . . **1:30 am – 1:55 pm**
  Speaker: Rasmus Hellberg, Sr Dir Technical Marketing

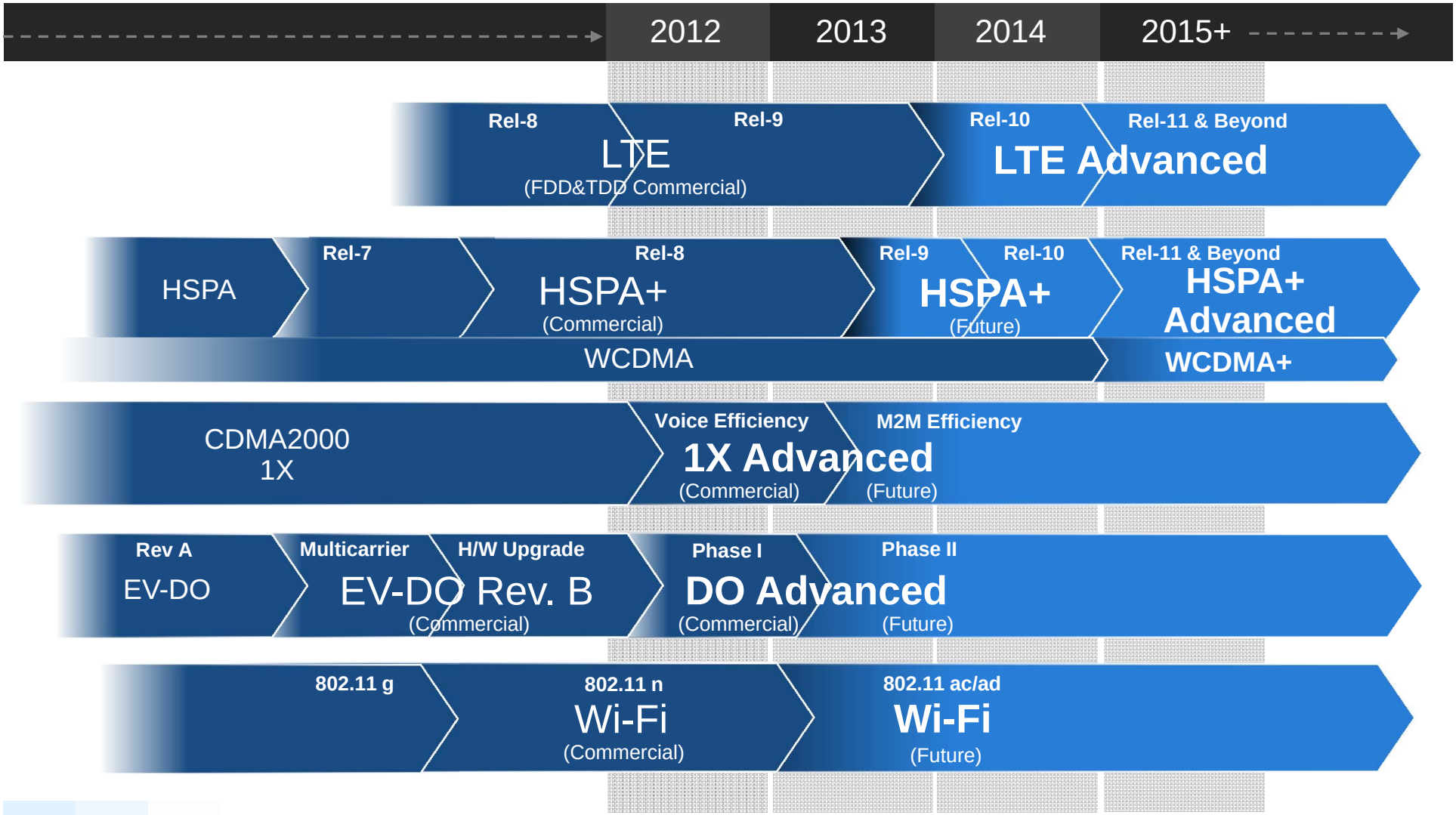
- **The mobile Voice evolution and latest on VoLTE**. . . .**2:00 pm – 2:30 pm**
  Speaker: Peter Carson, Sr Dir Product Management

- **WCDMA+**. . . . . **2:30 pm – 2:55 pm**
  Speaker: Prakash Sangam, Sr Mgr Technical Marketing

- **The Modem evolution** . . . . . **3:00 pm – 3:30 pm**
  —How do we support all bands and technologies?
  Speaker: Peter Carson, Sr Dir Product Management

- **Questions And Answers**. . . . . **3:30 pm – 3:45 pm**

Qualcomm is a Leader in Wireless



Commercial

Note: Estimated commercial dates.

Created 04/18/2012

Circuit Voice Has A Long Life During The Transition to Richer, Carrier Grade VoIP

IMS VoIP: Rich Voice – Ubiquity vs. OTT VoIP

VoLTE Timing is Operator Specific
VoIP over HSPA+ Driven by VoLTE

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Fallback to 2G/3G voice (CSFB) used by most LTE operators while the VoLTE ecosystem is being developed and expanded

Proven Circuit Voice: High Quality, Reliable, Ubiquitous[1]

WCDMA+: Long life of HSPA+ means long life of WCDMA
1X Advanced Commercial (1H 2012)

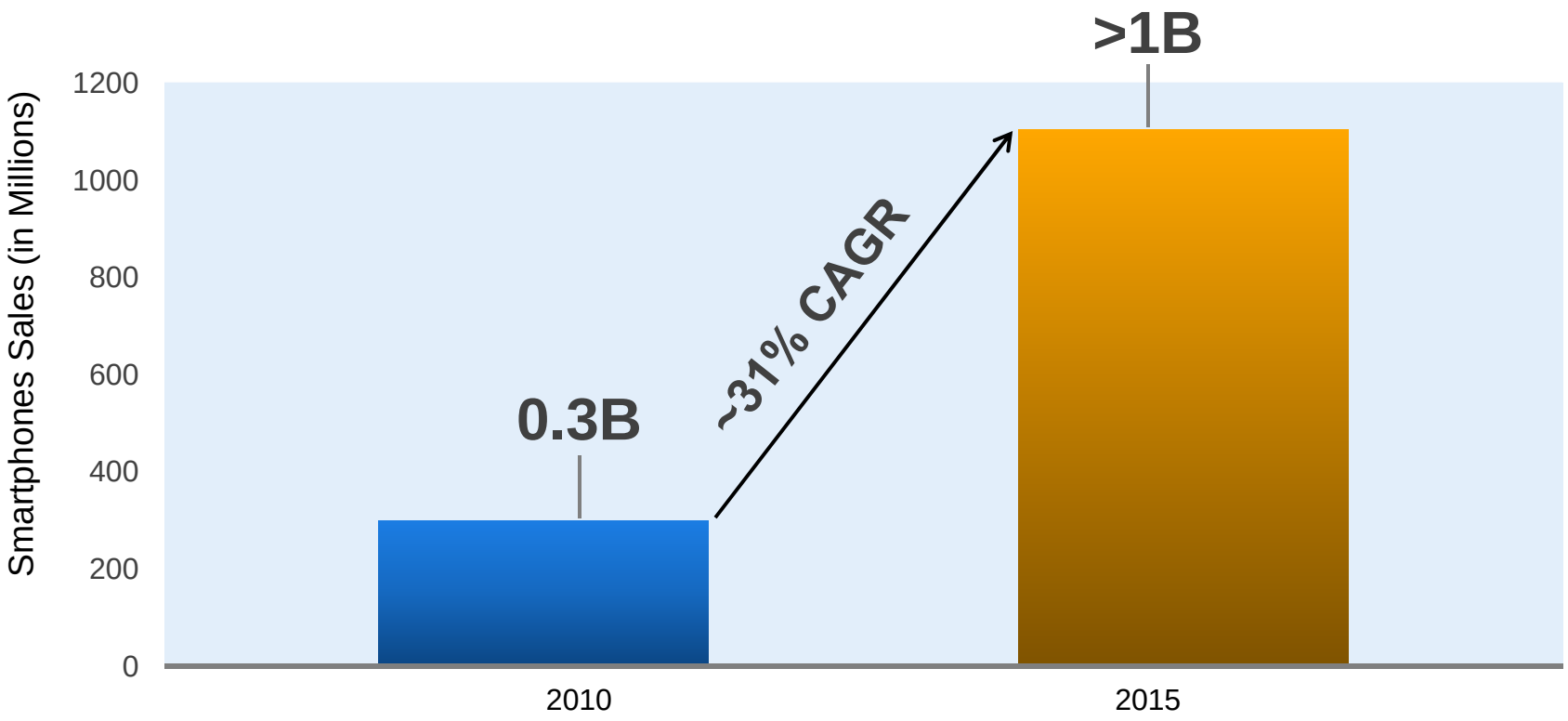
2020+

[1]Thanks to soft handover, proven interoperability and 10+ years of 1X/WCDMA optimizations. OTT=Over-The-Top, voice just like any data service without Quality of Service

Video: Meeting Data Demand is Child's Play

The Accelerated Smartphone Growth Drives Traffic Even Higher

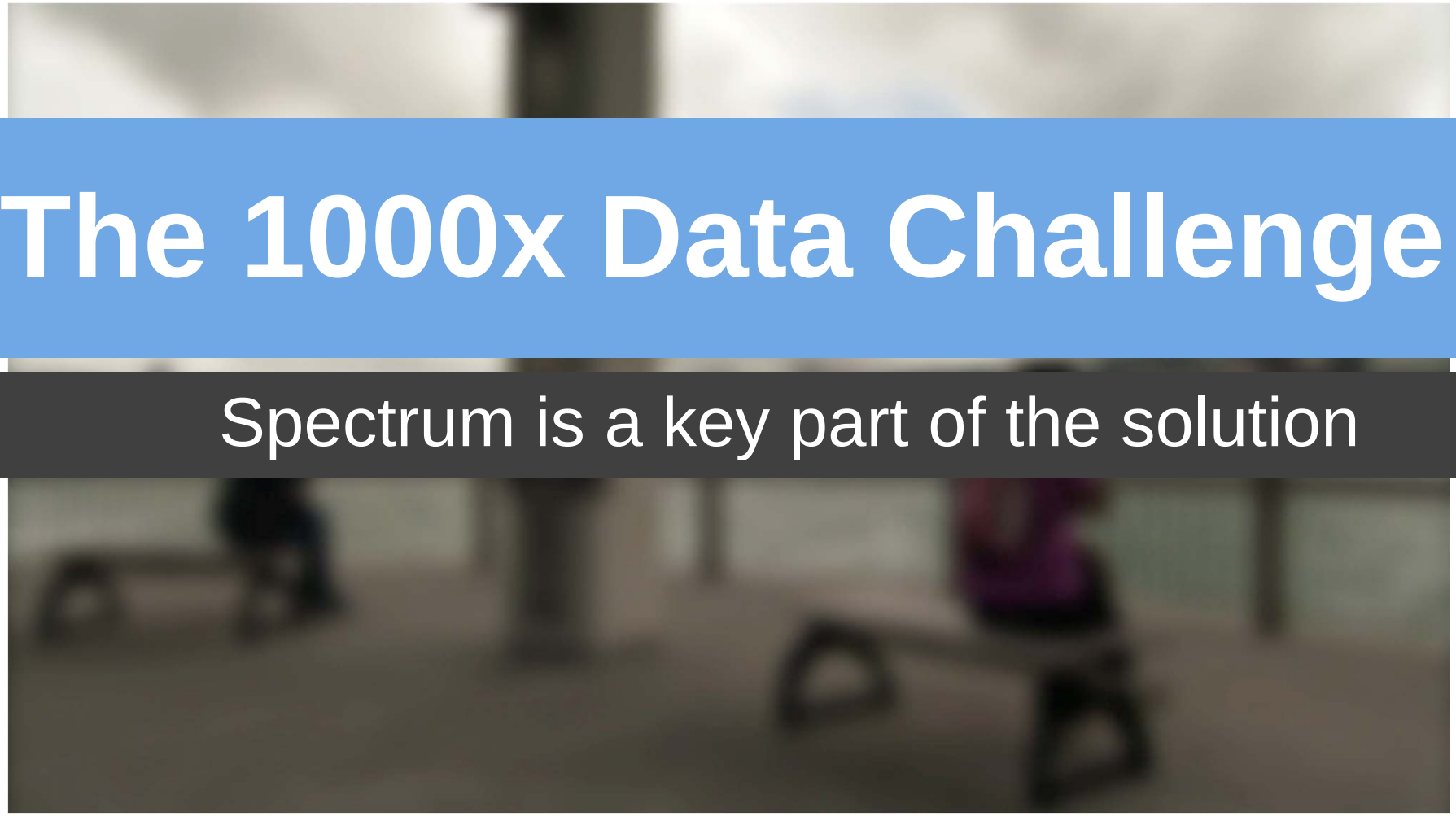
~ 4B CUMULATIVE SMARTPHONE SALES ESTIMATED BETWEEN 2011-2015



Source: Gartner, Sep 2011

The 1000x Data Challenge

Spectrum is a key part of the solution



Data Traffic Growth

MOBILE DATA
TRAFFIC PROJECTED
TO GROW

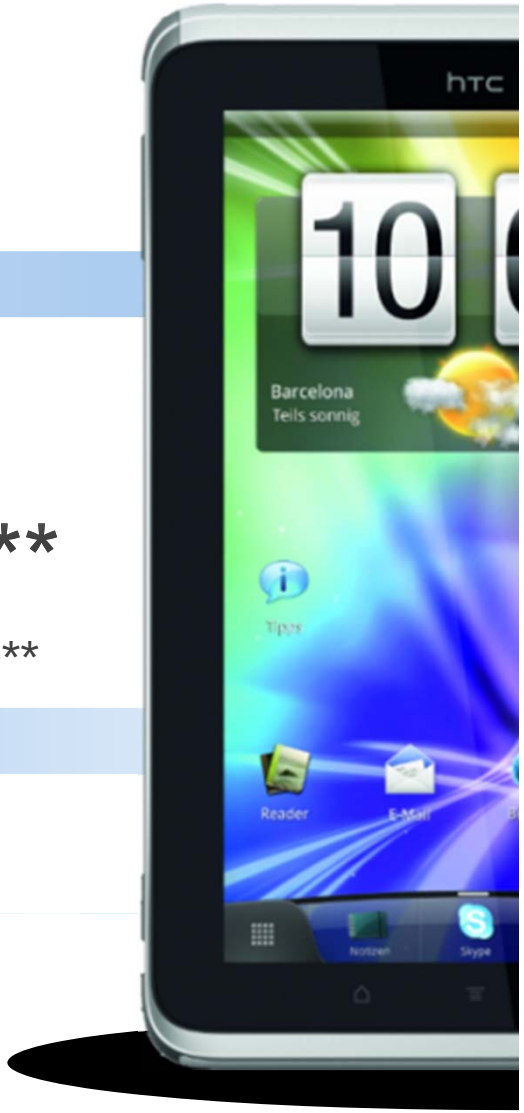
10-12x

FROM 2010-2015*

UP TO

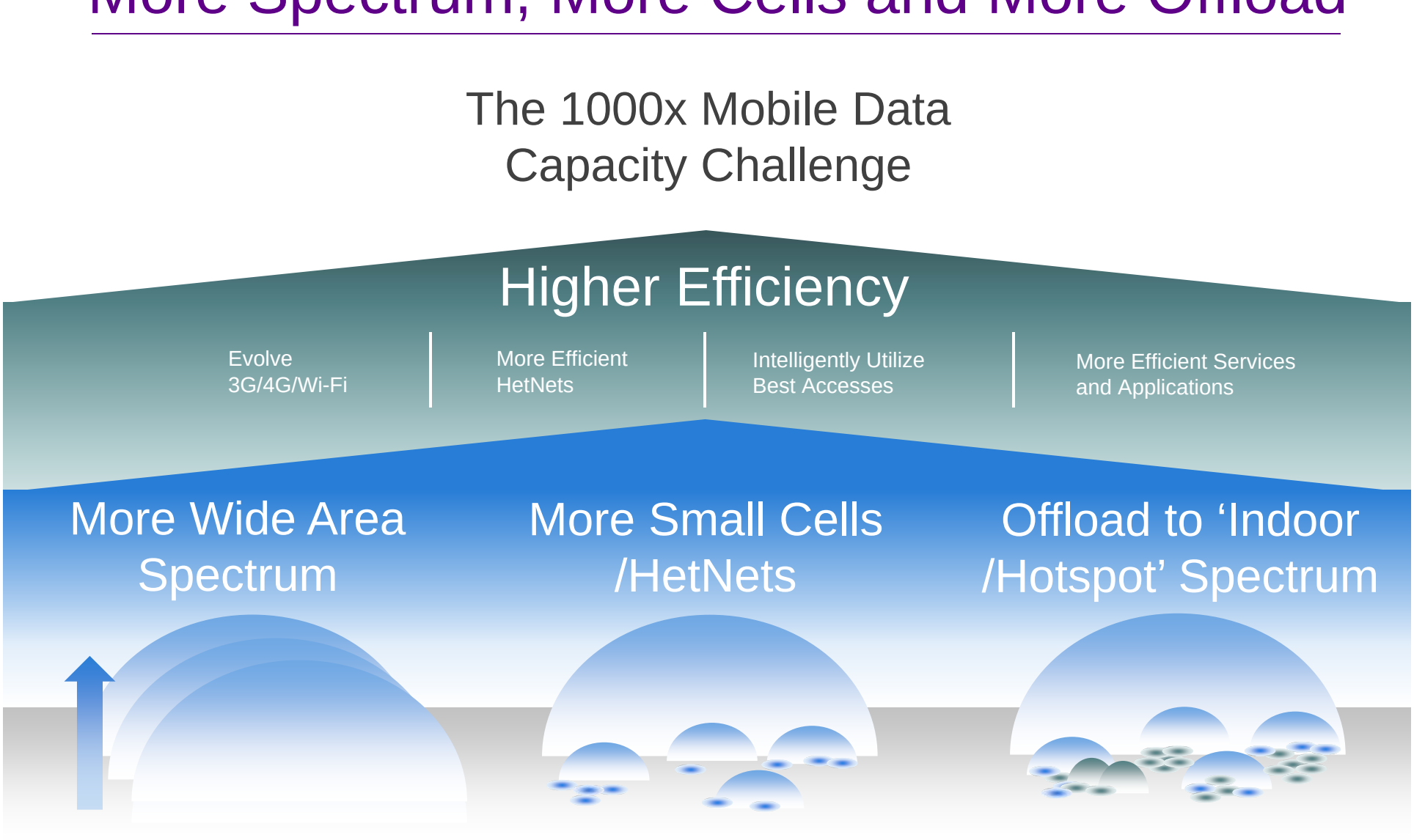
1000x**

FROM 2010–2020**



*Strategy Analytics 2011 ** DoCoMo, 11/2010

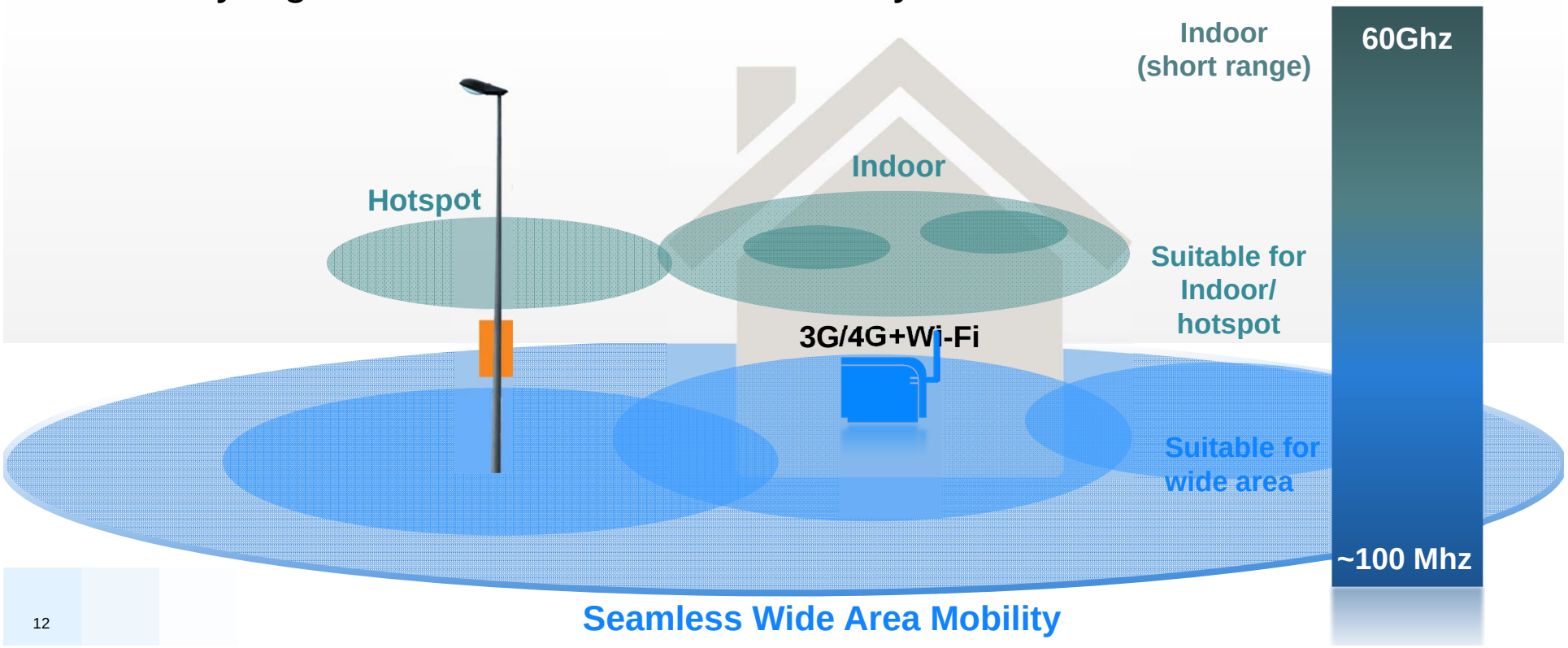
More Spectrum, More Cells and More Offload



More Small Cells—Bring Network Closer to User

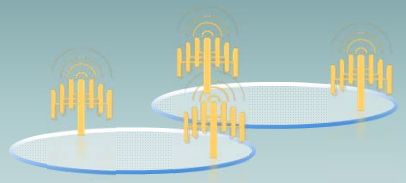
More Offload To ‘Indoor/Hotspot’ Spectrum

- Wi-Fi and its evolution in unlicensed spectrum
- 3G/4G and its evolution in licensed spectrum
  - Enables open pico/femtocells on dedicated spectrum
- Very high bands enable access in every room



Higher Efficiency—Get More Out Of Spectrum

Evolve 3G/4G/Wi-Fi



More antennas (MIMO) and better techniques

Higher voice efficiency to free up resources for data

Improved advanced receivers

Integrated multicast — eMBMS

More Efficient HetNets

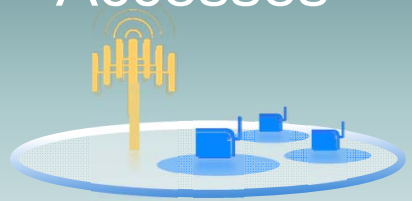
Small Cell Range expansion

Interference mitigation for dense femto deployments

Wireless relays and wireless backhaul

Open neighborhood femtocells

Utilize Best Accesses



Intelligently use 3G/4G and/or Wi-Fi based on e.g.
—Access quality
—Best offload
—Traffic characteristics
—Quality requirements

Select/combine multiple accesses

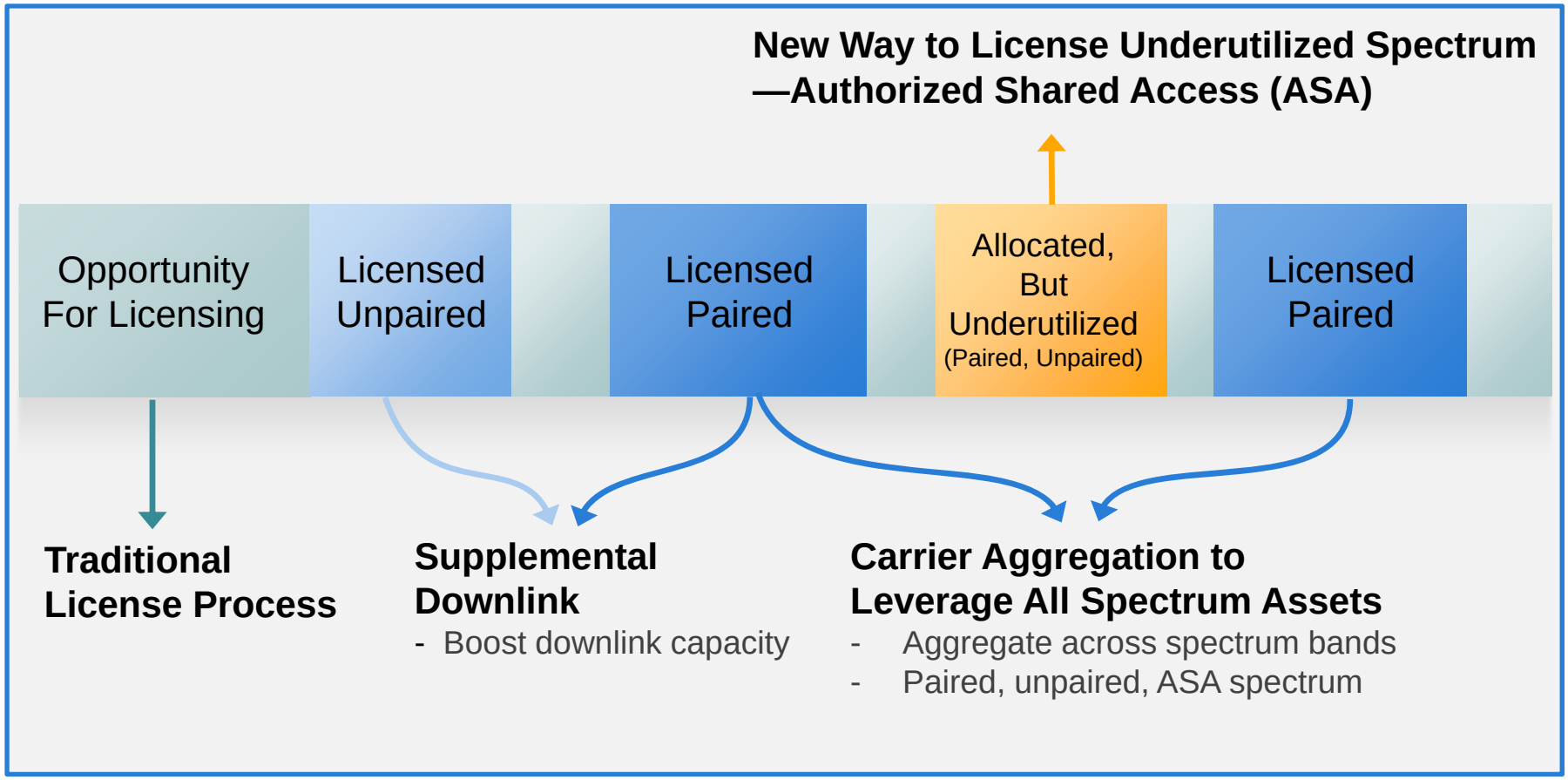
More Efficient Services and Applications

Optimizations, caching, traffic management, etc

More Spectrum

Authorized Shared Access—ASA

More Wide Area Spectrum



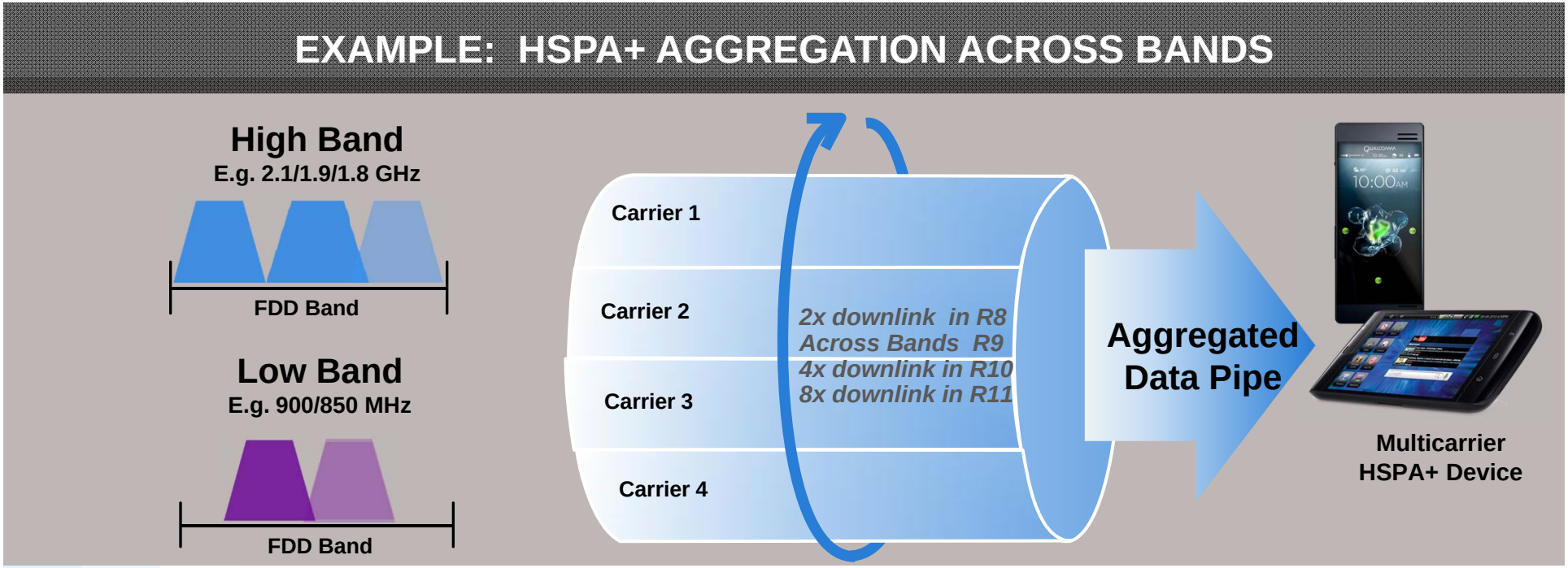
Harmonization and Global Standards Drive Economies of Scale

Carrier Aggregation to Leverage All Spectrum Assets

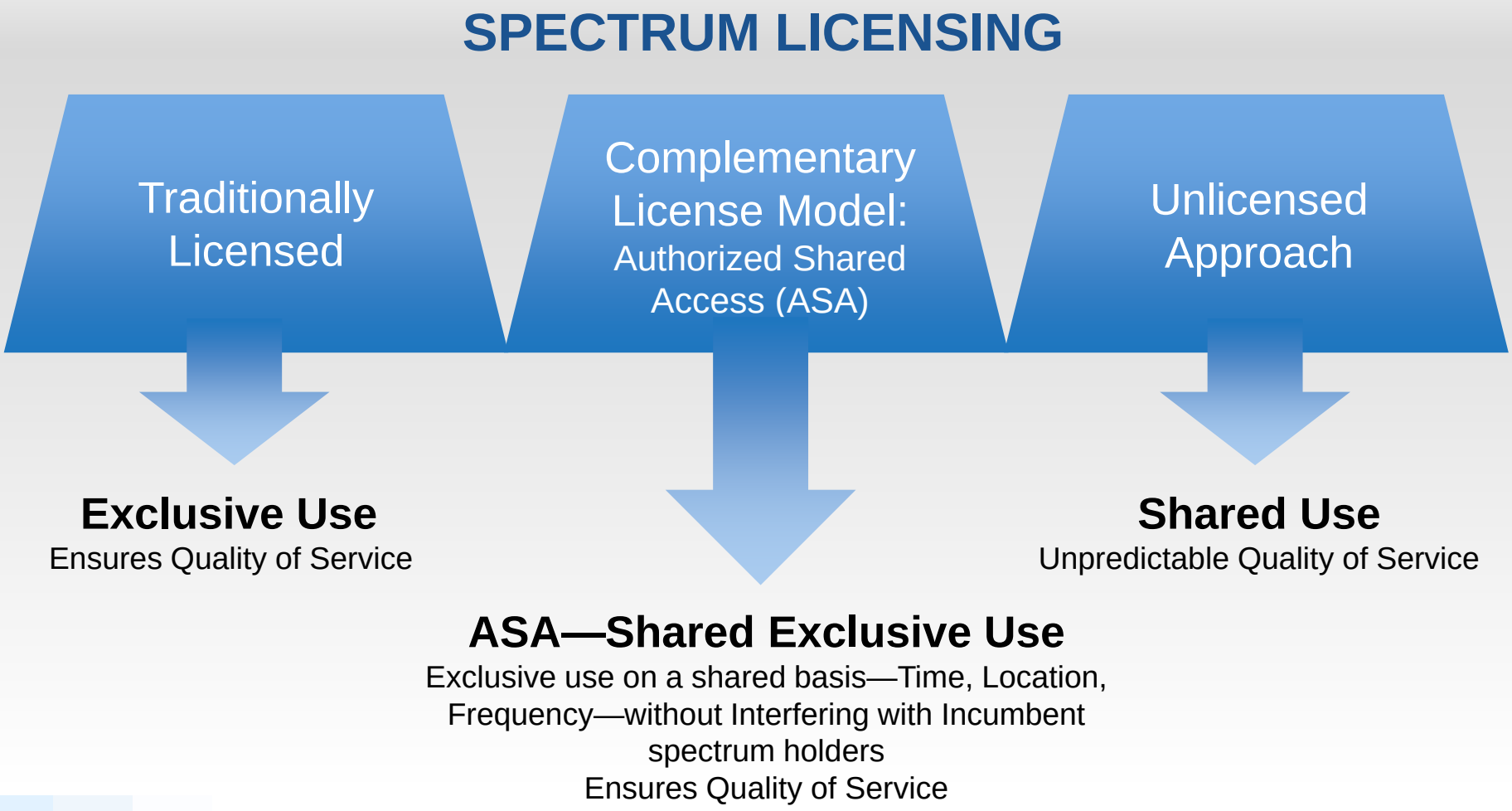
Enhances User Experience
Higher Data Rates to All Users

EV-DO REV B AGGREGATES UP TO 5 MHZ
HSPA+ ADVANCED AGGREGATES UP TO 40 MHZ
LTE ADVANCED AGGREGATES UP TO 100 MHZ

EXAMPLE: HSPA+ AGGREGATION ACROSS BANDS



ASA—A New, Faster Way Of Licensing Underutilized Spectrum



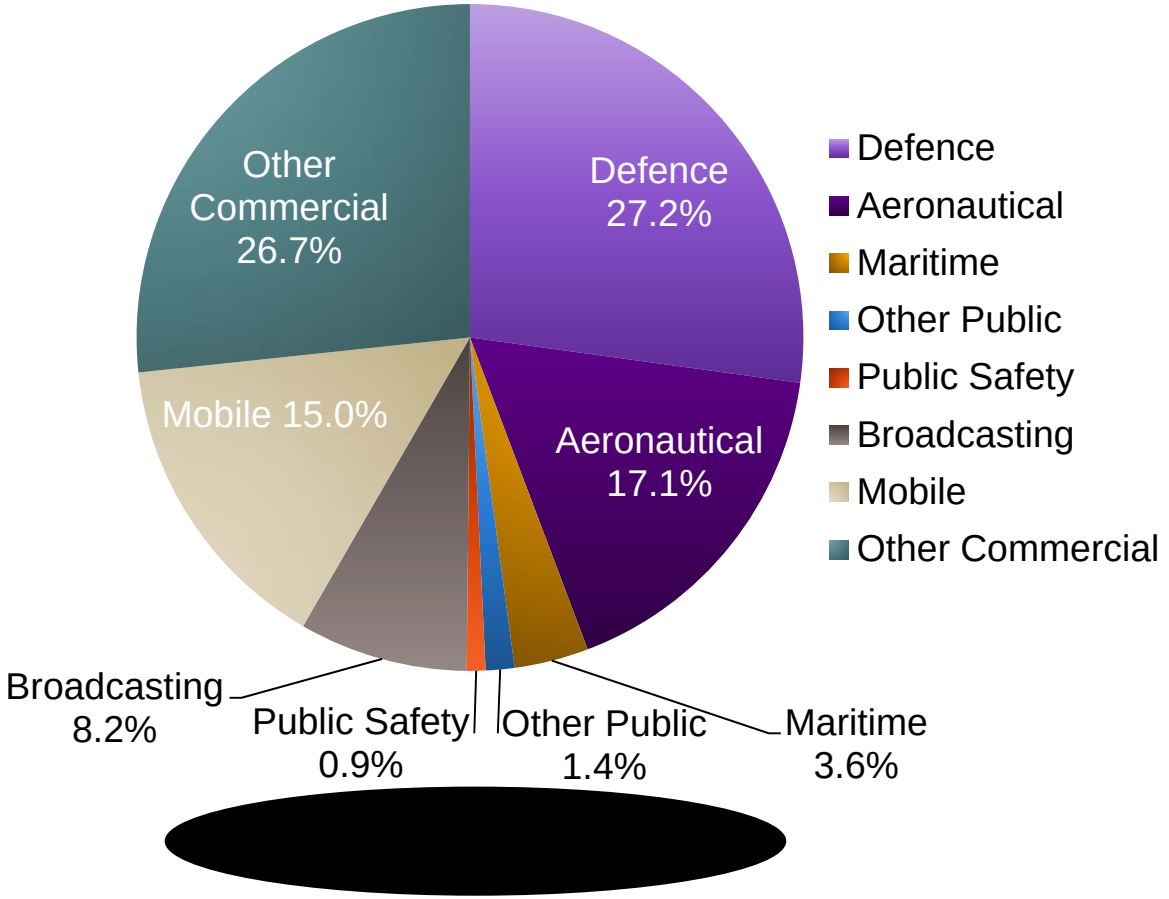
Allocated Spectrum May Be Underutilized

Challenge today:

Repurposing and vacating spectrum takes longer and longer time.

ASA Opportunity:

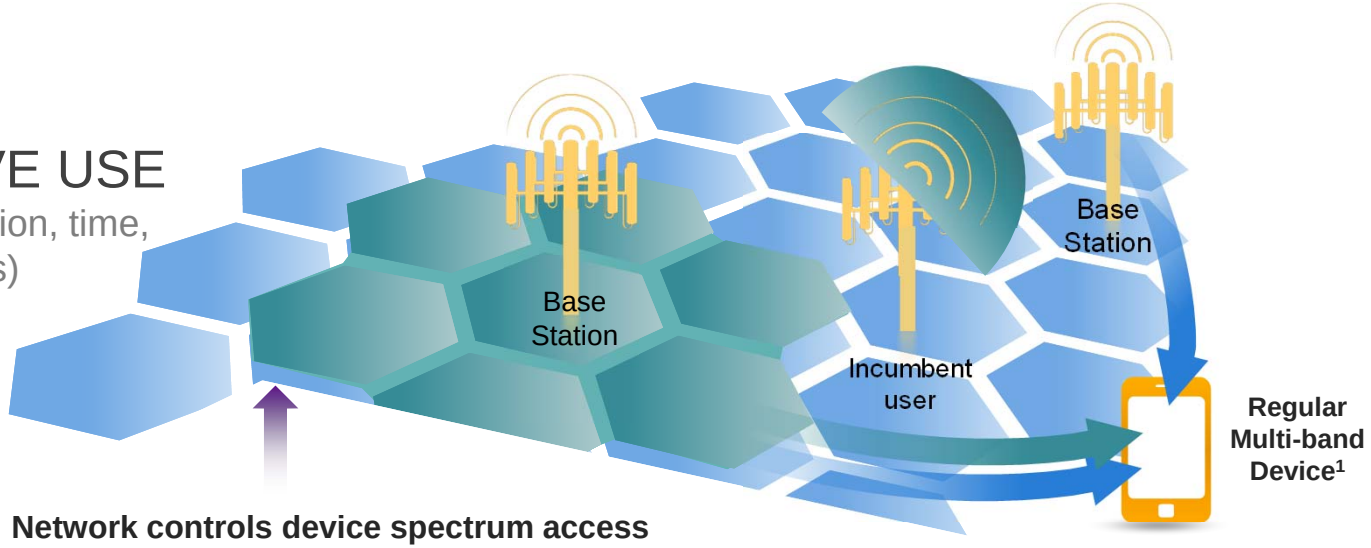
Accelerate harmonization and re-farming.
Access underutilized spectrum, which may always have incumbent spectrum holders.

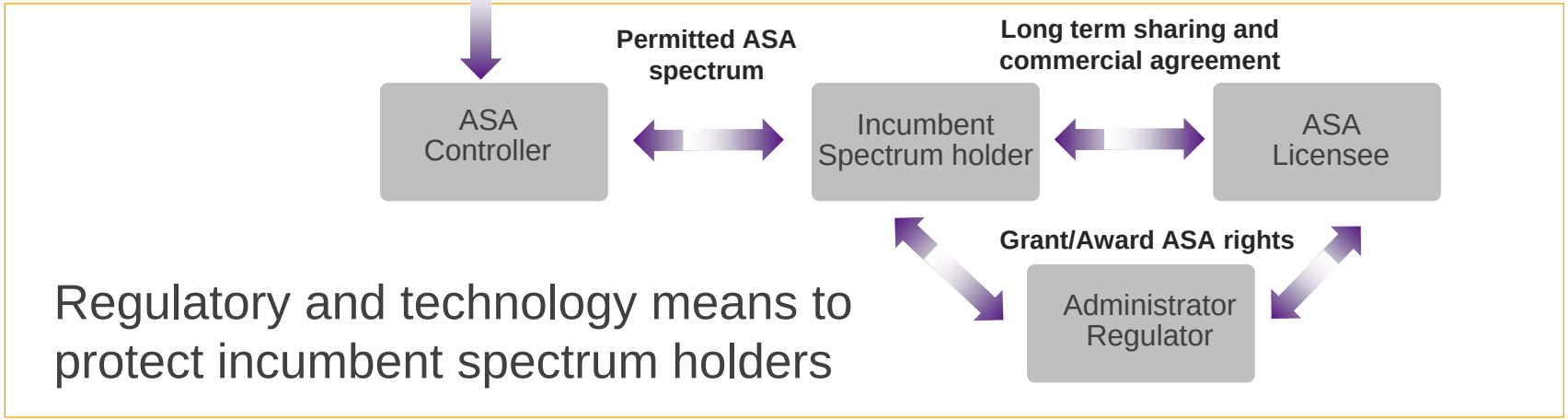


Shows Spectrum Allocation by Sector within in a typical EU country 108 MHz – 6 GHz

ASA: Exclusive Use Ensures Predictability for Long-Term Investments

EXCLUSIVE USE
(For given location, time, and frequencies)



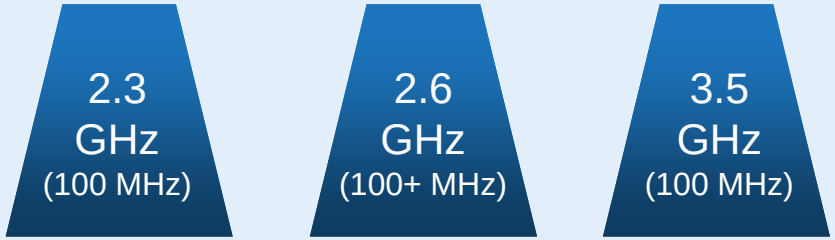


[1]No device impact due to ASA, just a regular 3G/4G device supporting the global harmonized bands targeted for ASA

ASA Targets Harmonized Spectrum Bands

Leveraging global 3G/4G technologies to ensure economies of scale

ASA CANDIDATE EXAMPLES



ASA can make several hundred MHz of spectrum available for mobile broadband

Applicable Regions	EUROPE (Traditionally licensed in e.g. India)	MENA (Traditionally licensed in e.g. Europe)	USA
Incumbent Users	Telemetry, public safety, cameras	Various	Naval Radar
Suitable Technology	TDD	FDD/TDD	TDD
Possible Launch	~2015		

Note: ASA targets IMT spectrum bands, but the concept can be applied generally to all spectrum bands and other technologies

ASA Enables New Business Models and Fosters Competition

Opportunity for lower cost, high quality spectrum[1]

New Business Models

- Differentiated service offering—drives affordable mobile broadband
- Low cost access strategies—e.g. use small cells for targeted capacity

Fosters Competition

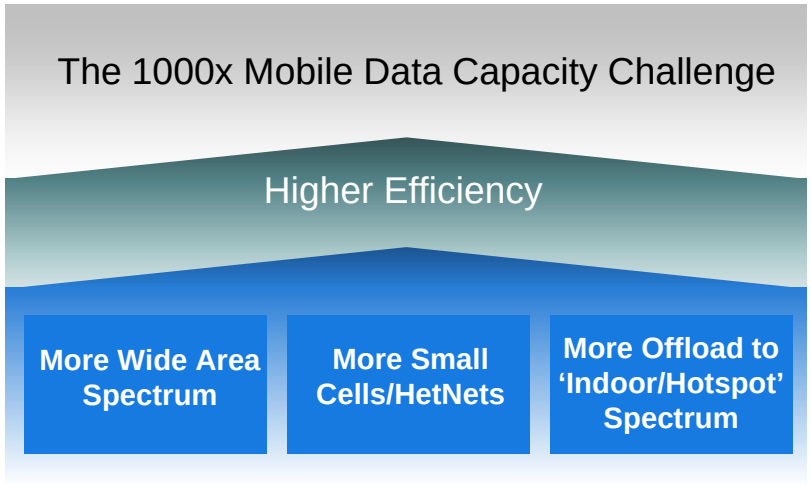
- Enables new entrants, or to complement existing service providers and add capacity
- Enables more end-user choice—based on tariffs quality and services

[1]Lower cost expected due to exclusive use only for certain times, locations, frequencies

ASA Supports Mobile Broadband Growth with New Economic Benefits

SPECTRUM IS KEY TO CONTINUED MOBILE BROADBAND GROWTH

- Initially targets IMT bands and 3G/4G
- Applicable to other bands/technologies



New Economic Benefits

- Unlocks *New* Underutilized Spectrum
  —Not possible, or only partially, with traditional licensing
- Faster access to spectrum means faster economic benefits
- €65 billion economic benefits per year in the EU alone[1]

[1]*Per year 2020 to 2025. Source: Authorized Shared Access (ASA): An Evolutionary Spectrum Authorization Scheme for Sustainable Economic Growth and Consumer Benefit*, Ingenious Consulting Network, Jan. 2011

ASA—A New License Model to Access Underutilized, High Quality Spectrum

- Exclusive use on a shared basis—in time, location or frequency—ensures quality of service
  - Ensures predictability for long-term investments
- Targets harmonized bands and global 3G/4G technologies to drive economies of scale
  - Such as LTE TDD for 2.3GHz in Europe—complementing traditional licensing
- Enables new business models and fosters competition
  - ASA protects incumbent spectrum holders while enabling new entrants/models
- Broad Industry Support—Europe Leading ASA Development
  - Wireless industry, policy makers, regulators
- Supports Mobile Broadband Growth with *New* Economic Benefits
  - Faster access to spectrum, frees-up *new* spectrum not possible with current license models

ASA—Authorized Shared Access

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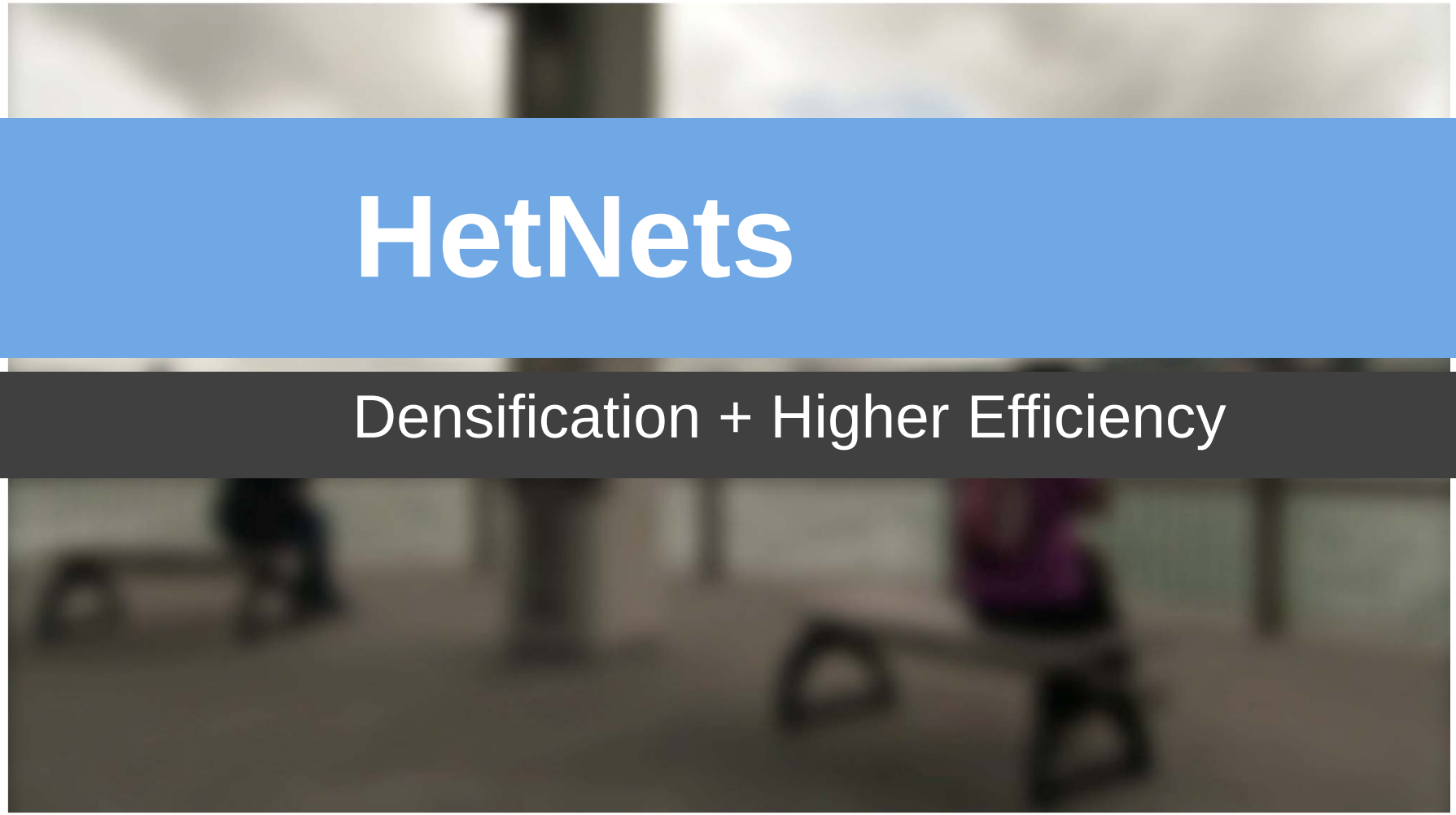
http://www.slideshare.net/qualcommwirelessevolution

http://www.qualcomm.com/blog/contributors/prakash-sangam



HetNets

Densification + Higher Efficiency

More Small Cells —Bring Network Closer to User

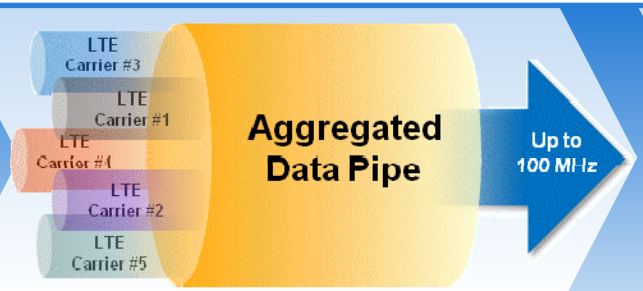
IT IS NOT JUST ABOUT ADDING SMALL CELLS—OPTIMIZATIONS FURTHER IMPROVE PERFORMANCE

HSPA+ HSPA+ Advanced	DO Advanced	LTE Advanced

LTE Advanced Brings Different Dimensions of Improvements—Most Gain From HetNets

Leverage wider bandwidth

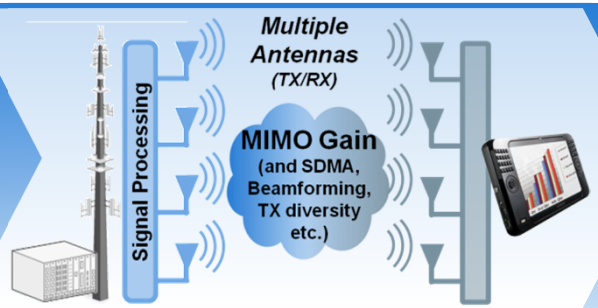
Carrier aggregation across multiple carriers and multiple bands



Primarily higher data rates
(bps)

Leverage more radio links, more antennas

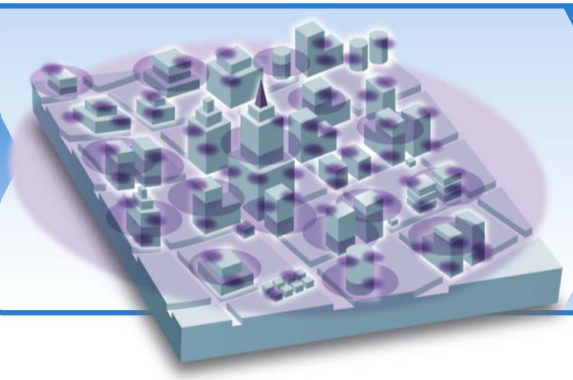
Downlink MIMO up to 8x8, enhanced Multi User MIMO and uplink MIMO up to 4x4



Higher spectral efficiency
(bps/Hz)

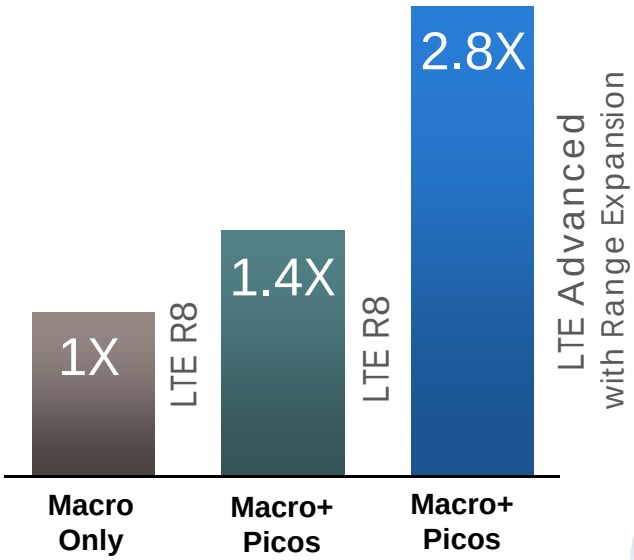
Leverage heterogeneous network topology (HetNet)

With advanced interference management (low power picocells with adaptive resource partitioning and advanced receiver based devices)



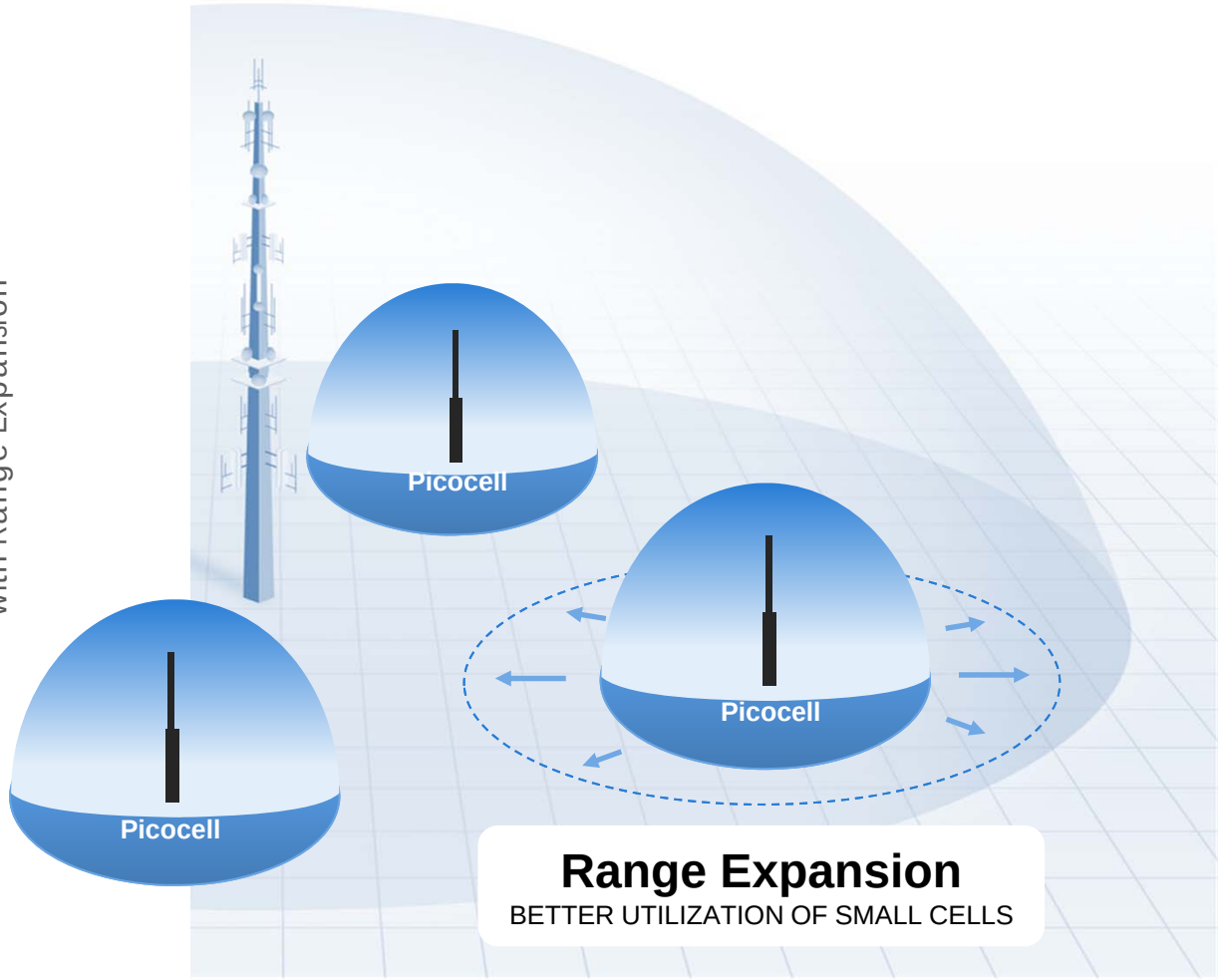
Higher spectral efficiency per coverage area
(bps/Hz/km^2)

LTE Advanced Range Expansion Further Improves HetNets



Data Rate Improvement

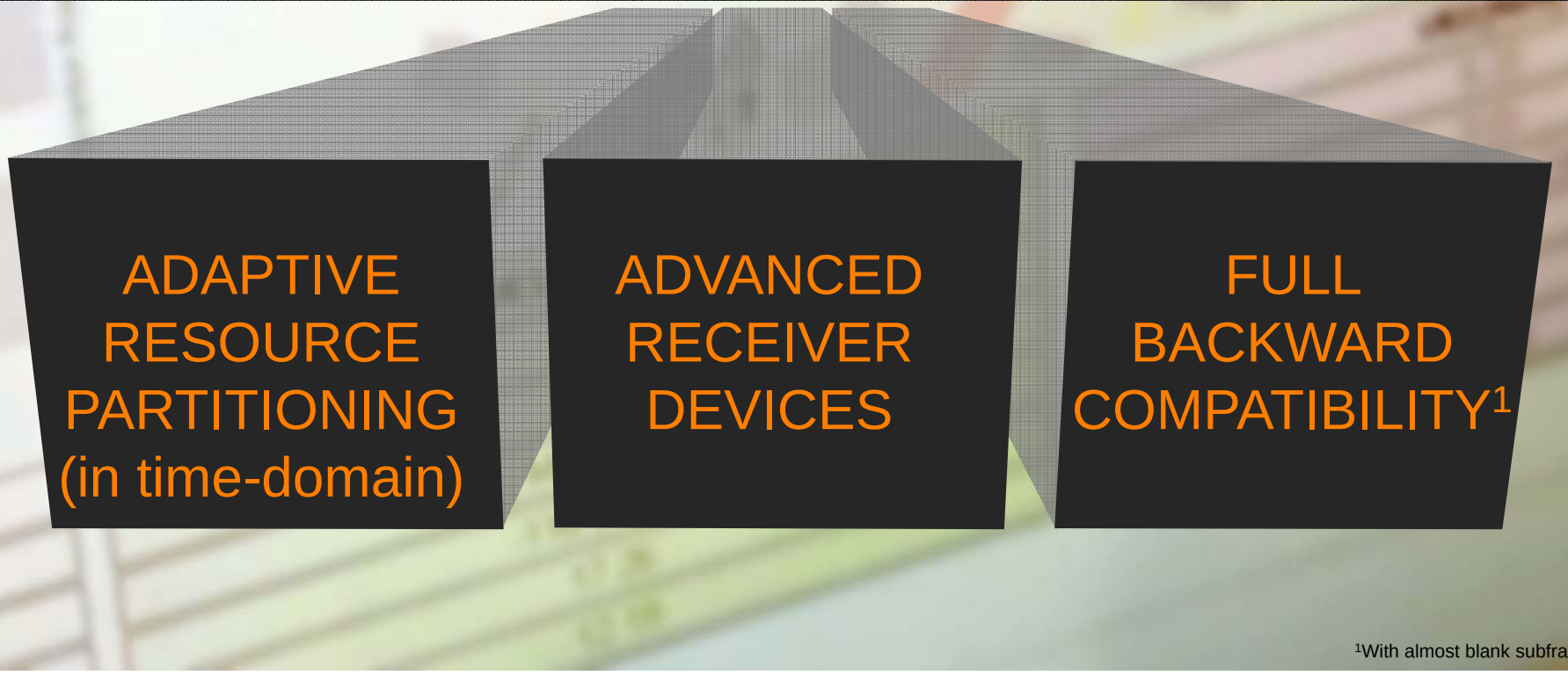
Median downlink data rate[1]



Assumptions: 4 Picos added per macro and 33% of users dropped in clusters closer to picos (hotspots) : 10 MHz FDD, 2x2 MIMO, 25 users and 500m ISD. Advanced interference management: enhanced time-domain adaptive resource partitioning, advanced receiver devices with enhanced RRM and RLM[1]Similar gain for the uplink

THE SECRET SAUCE:

ENABLES RANGE EXPANSION THAT ALLOWS MORE USERS TO BENEFIT FROM SMALL CELLS



[1]With almost blank subframes

ADVANCED RECEIVER DEVICES WITH INTERFERENCE CANCELLATION

(CANCELLING OVERHEAD CHANNELS[1])

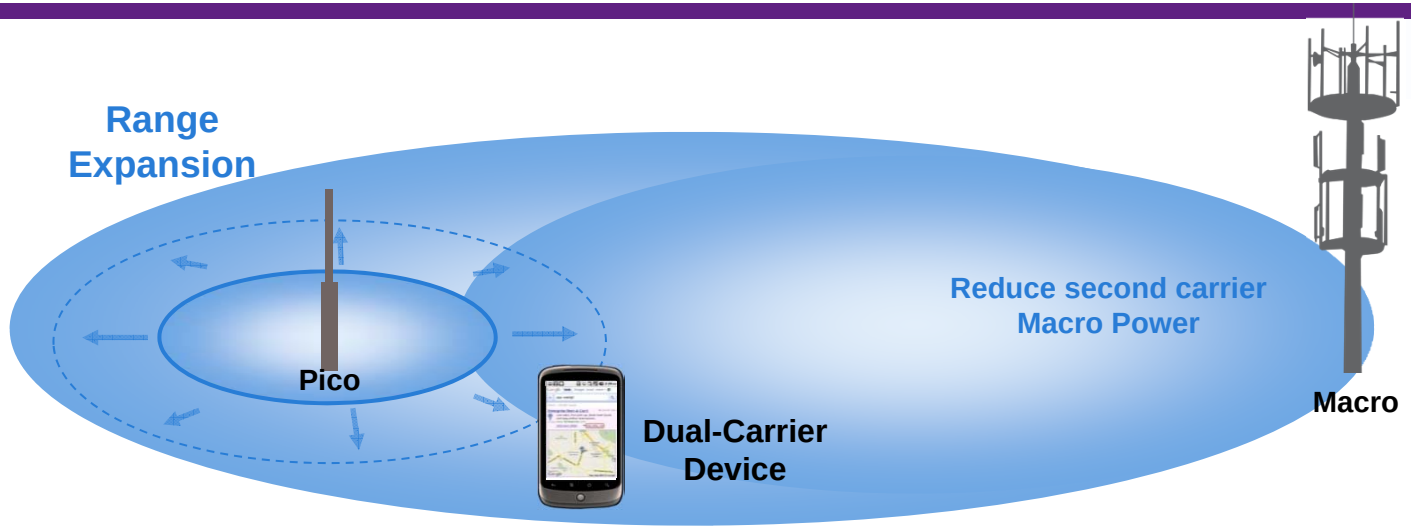
TO DISCOVER SMALL CELLS	TO ENABLE HIGHER DATA RATES	TO ENABLE FULL RANGE EXPANSION

[1]Device interference cancellation cancels overhead channels such as common reference signal(CRS)

Video: MWC 2012 LTE Advanced HetNet Demo

What About HSPA+?

HetNets Range Expansion



It's not just about adding small cells — Optimizations Further Improve HetNets

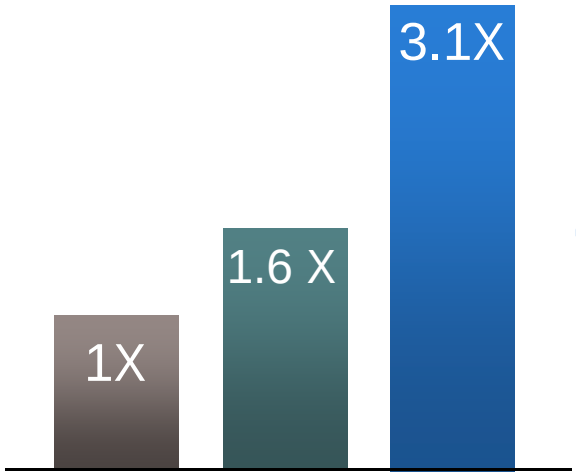
HetNet Range Expansion Can Be Done Today:

- Today: Dual-Carrier and Reduced Macro Power
- Even Better with MultiFlow—Balances Uneven Load
- Advanced Device Receivers Provide Additional Gain

Note: Self-Organizing Networks (SON) techniques can also improve Heterogeneous networks (HetNets) and are standardized already in R10, such as Minimization of Drive Tests (MDT) and Automatic Neighbor Relation (ANR)

HSPA+ HetNet Range Expansion—Today!

LEVERAGING DUAL-CARRIER AND PARAMETER OPTIMIZATIONS



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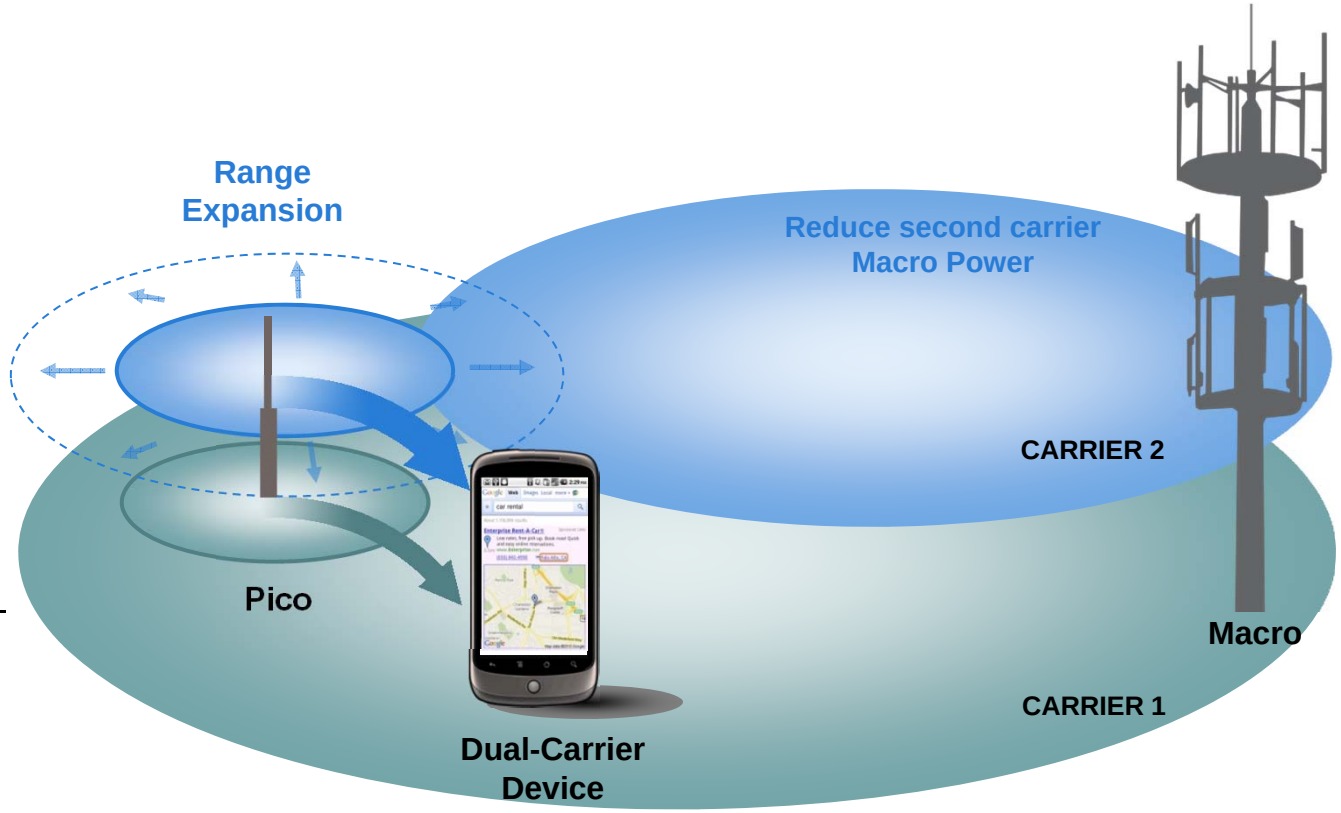
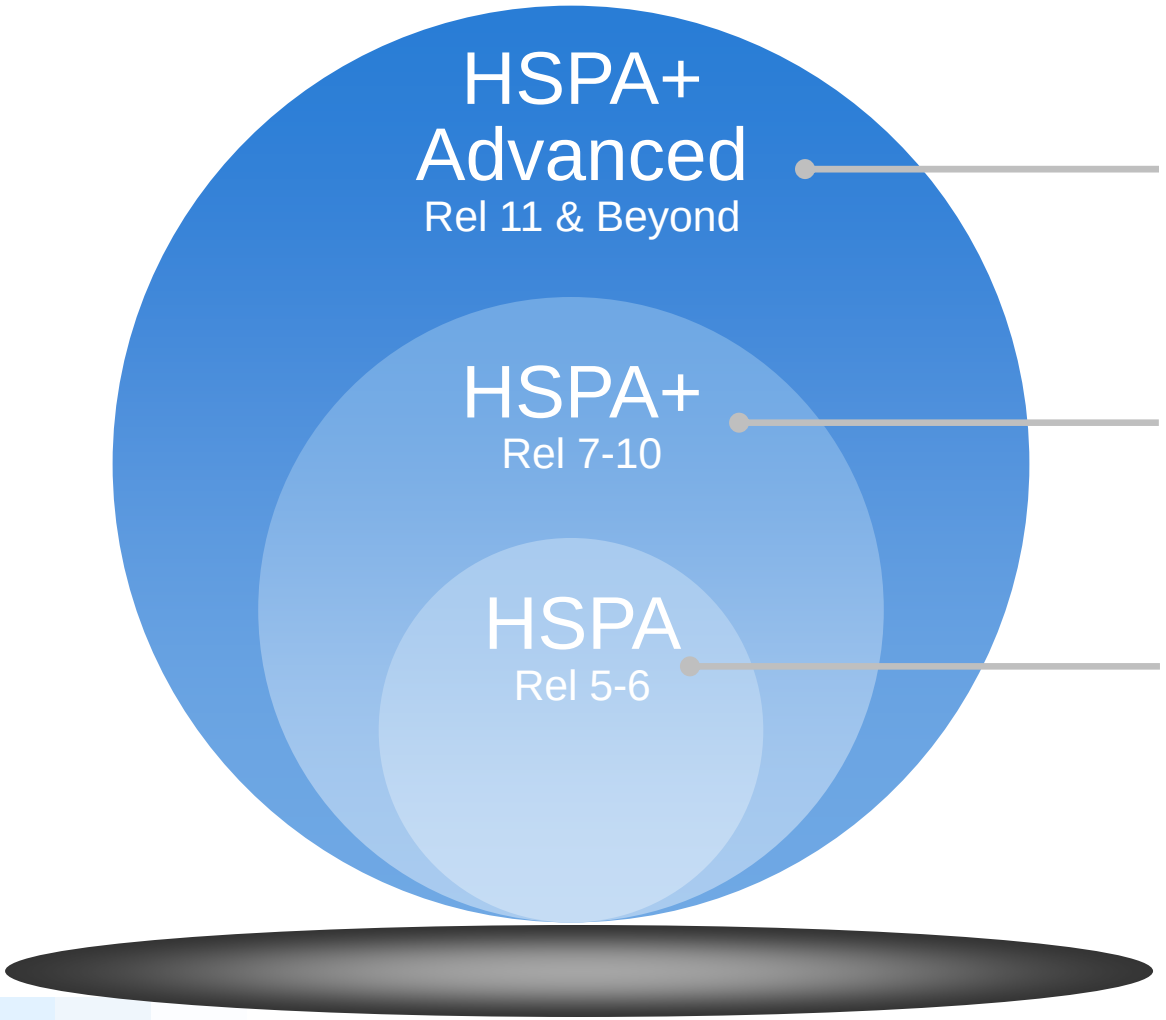


4 Picos added per macro and 50 % of users dropped in clusters closer to picos (within 40m), Model PA3 full buffer ISD 500m. Enabling range expansion features: reduced power on second macro carrier , dual carrier devices and mitigating uplink and downlink imbalance (3dB Cell-individual offset (CIO) and pico noise-figure pad)

HSPA+ Advanced—Taking HSPA+ to The Next Level



Maximizing HSPA+ Performance

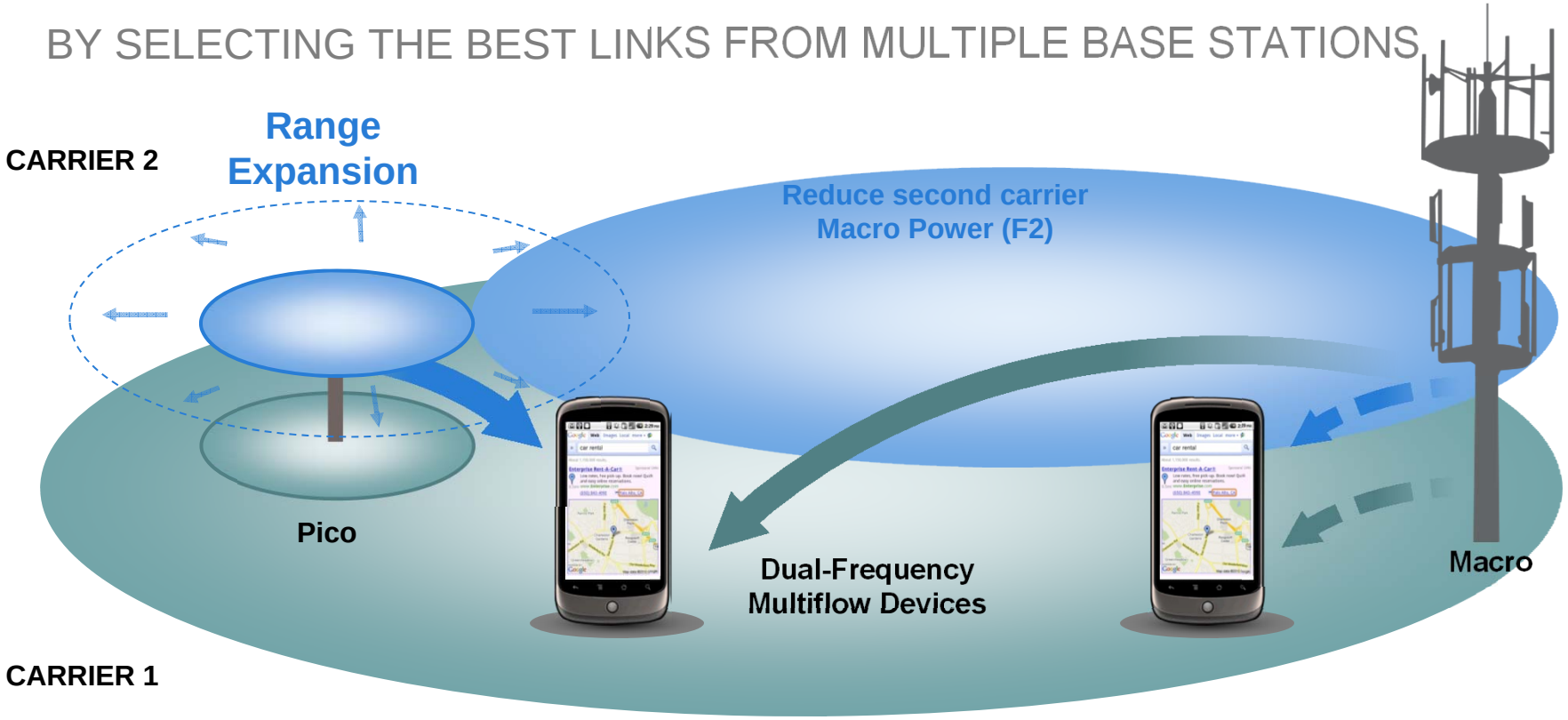
HSPA+ is The New Baseline

100% of WCDMA operators have upgraded to HSPA

Video: HSPA+ Advanced

Even Better With MultiFlow—HSPA+ Advanced

BY SELECTING THE BEST LINKS FROM MULTIPLE BASE STATIONS



PICO BETTER UTILIZED	MACRO OFFLOADED	ALL USERS IMPROVED

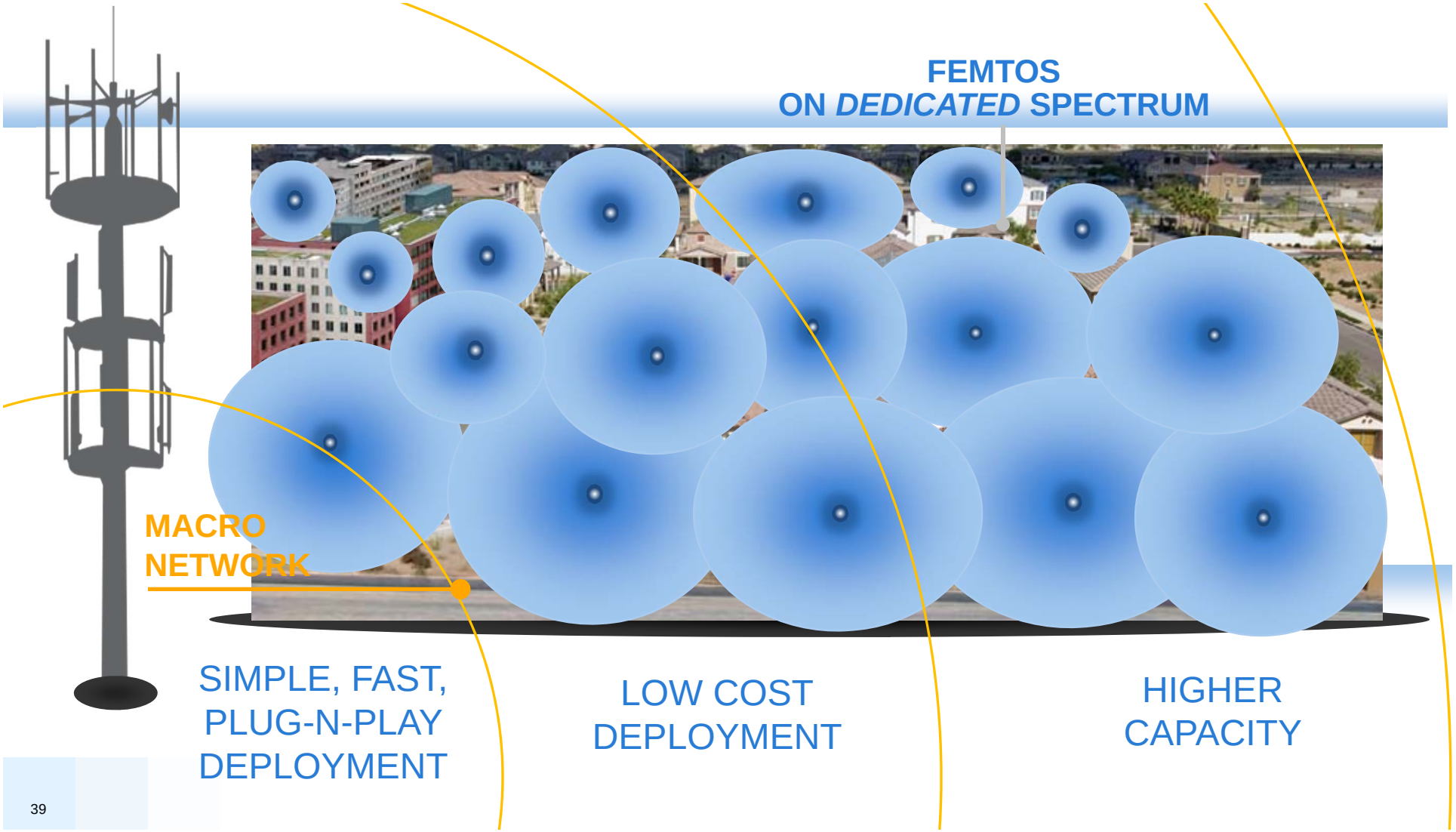
Enabling features: reduced power on second macro carrier , dual carrier devices (or dual frequency Multiflow), and mitigating uplink and downlink imbalance (3dB Cell-individual offset (CIO) and pico noise-figure pad)

Extreme Densification—Small Cells Everywhere

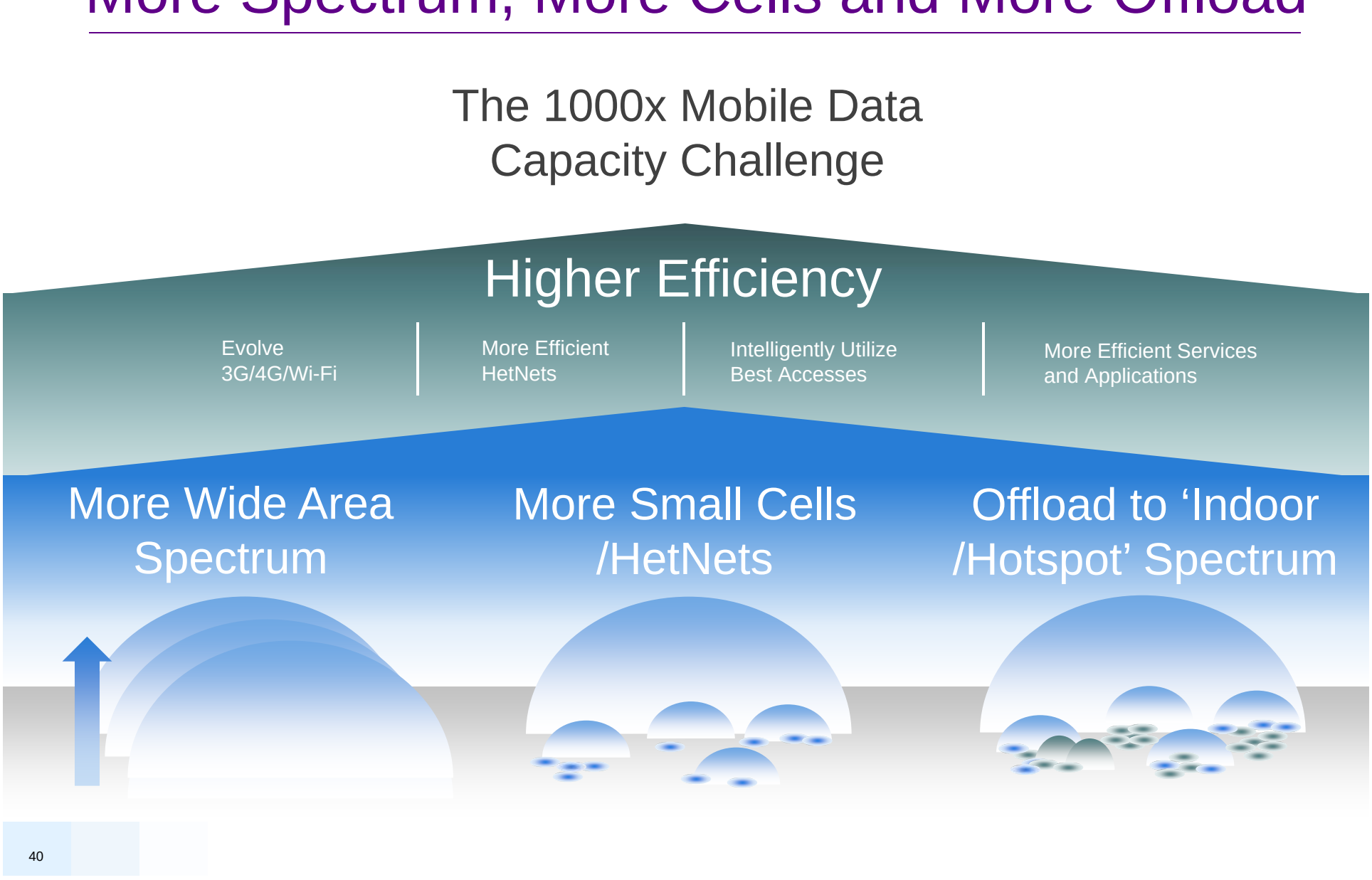
LOWER COST AND SMALLER SIZE—EXAMPLE OF COMPLETE 3G FEMTO

Neighborhood Femtos - New Deployment Model

OPEN-ACCESS INDOOR FEMTOS PROVIDING OUTDOOR COVERAGE



More Spectrum, More Cells and More Offload



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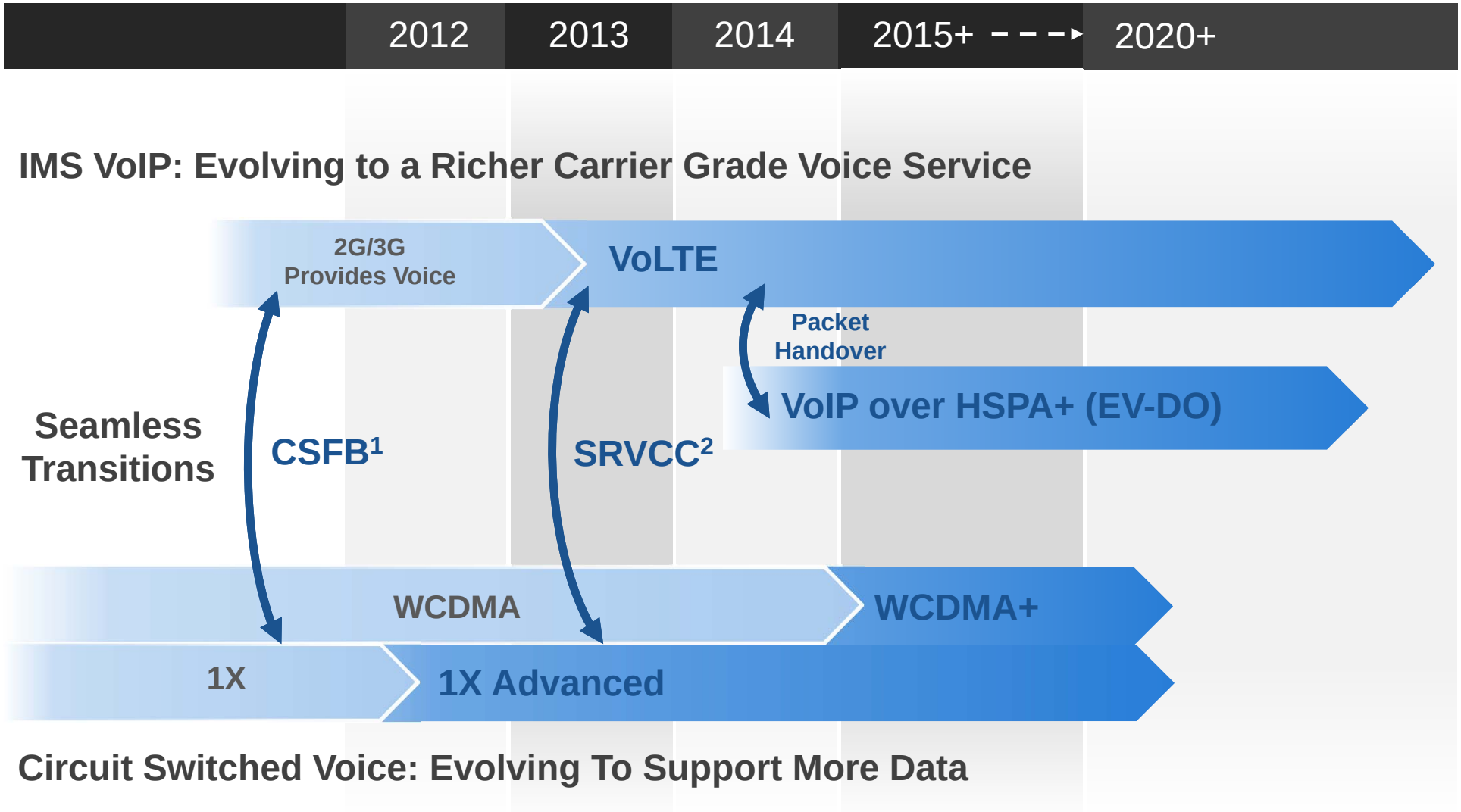
1X Advanced Commercial (1H 2012)

2020+

[1]Thanks to soft handover, proven interoperability and 10+ years of 1X/WCDMA optimizations. OTT=Over-The-Top, voice just like any data service without Quality of Service

Qualcomm: Comprehensive Voice Evolution Leadership



Blue: Qualcomm Technology Leadership

[1]CSFB: Circuit Switched Fallback. [2]SRVCC: Single Radio Voice Call Continuity to enable handover to WCDMA/1X/GSM CS voice outside VoLTE coverage.

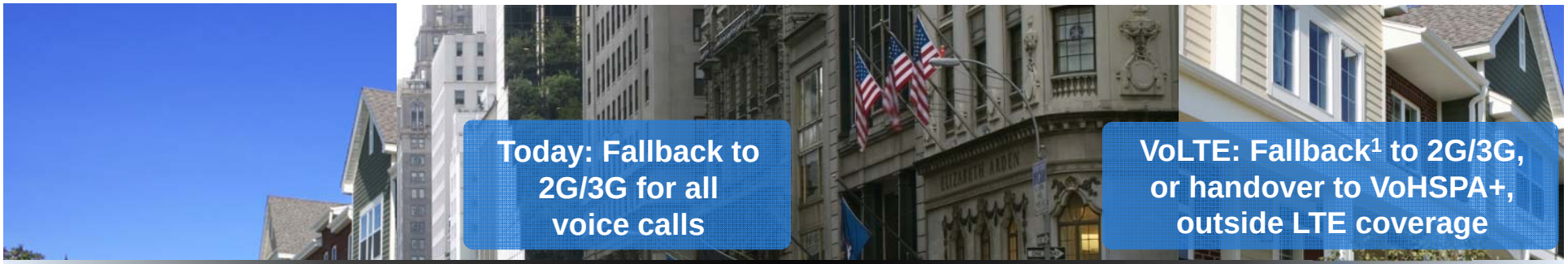
2G/3G Provides LTE Voice Today —And Future VoLTE Fallback

2G/3G Provides Voice

CSFB[1] to WCDMA, 1X or GSM voice is commercial since 2011.

VoLTE—IMS VoIP over LTE

Ccommercialization with SRVCC[1] starting in 2013, maturing in 2015



Today: Fallback to 2G/3G for all voice calls

VoLTE: Fallback[1] to 2G/3G, or handover to VoHSPA+, outside LTE coverage

LTE ***(FDD or TDD)***

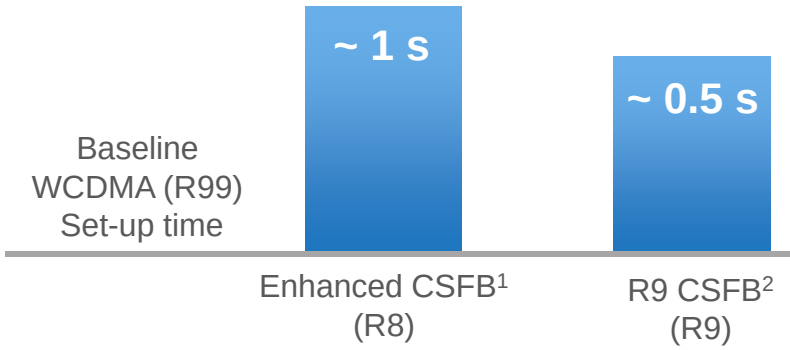
2G/3G Voice & EV-DO/HSPA+ Data

Voice Continuity and Global Roaming

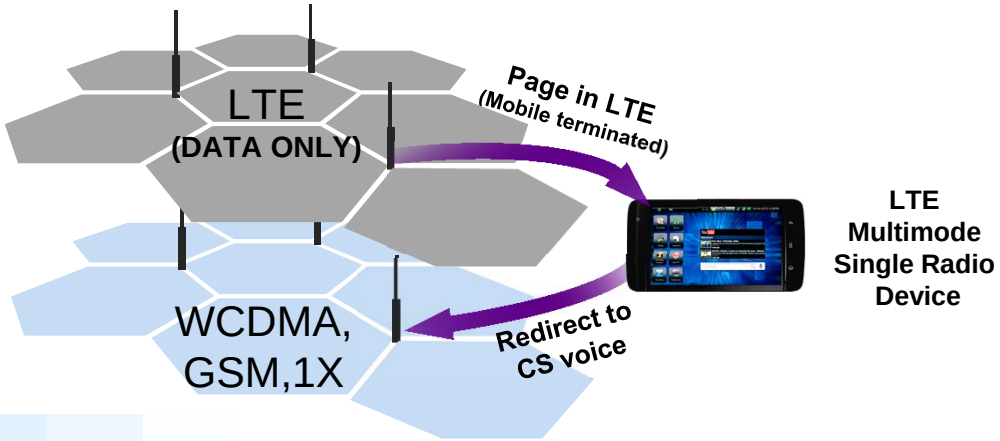
[1]SRVCC: Single Radio Voice Call Continuity. CSFB: Circuit Switched Fallback.

2G/3G Voice Fallback (CSFB)

Commercial Since 2011 and Widely Deployed



SIMILAR CALL
SET-UP TIME AS TODAY
(MOBILE ORIGINATED
OR TERMINATED CALL)

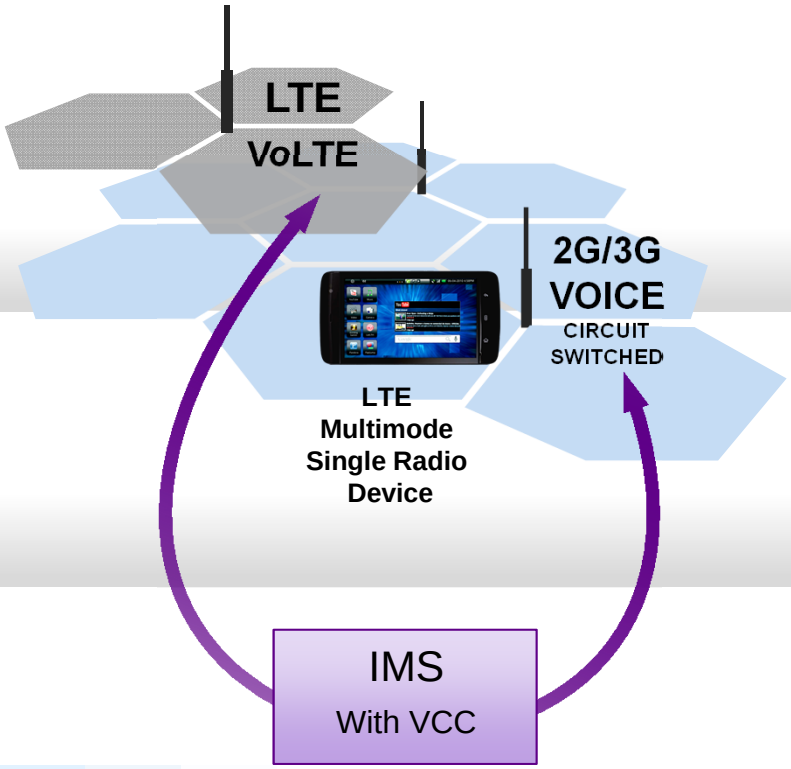


RELIABILITY ON PAR
WITH TODAY'S
NETWORKS

[1]Redirection without reading the non-mandatory system information blocks 'SIBs', 1xCSFB for 1X is also redirection based in R8.
[2]System information provided directly in a LTE redirection message to speed up the transition, aka 'SIB tunneling". Enhanced R9 1xCSFB is Handover based

SRVCC Ensures Seamless Voice Continuity

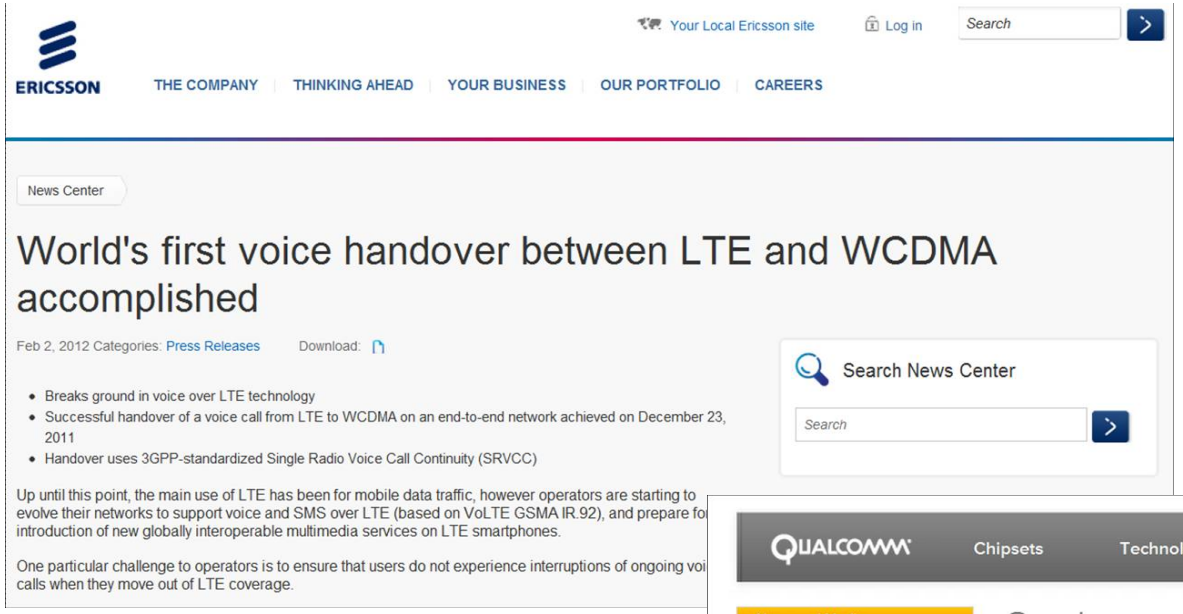
2012	2013	2014	2015+
VoLTE w/ SRVCC	VoLTE on par with CS Voice Quality	Mature Interoperable VoLTE	



- Single Radio Voice Call Continuity (SRVCC) enables handover to 2G/3G Voice Outside VoLTE coverage
- Multimode devices ensure global roaming from day one
- VoLTE IMS can expand to support other VoIP accesses (HSPA+, EV-DO etc.)

[1]SRVCC for VoLTE to 2G/3G circuit switched voice is defined in 3GPP Rel-9, with enhancements in Rel-10

World's First SRVCC Handover by Qualcomm and Ericsson (Feb 2012)



Different VoIP Models Will Co-Exist

OPERATOR PROVIDED SERVICE

3RD PARTY PROVIDED SERVICE

OVER-THE-TOP VOIP (BEST EFFORT)

IMS/RCS VoIP

Operator Client

3rd party Client

Opportunity To Offer Quality Of Service to OTT VoIP Provider

Interoperable, ubiquitous rich voice solution[1]

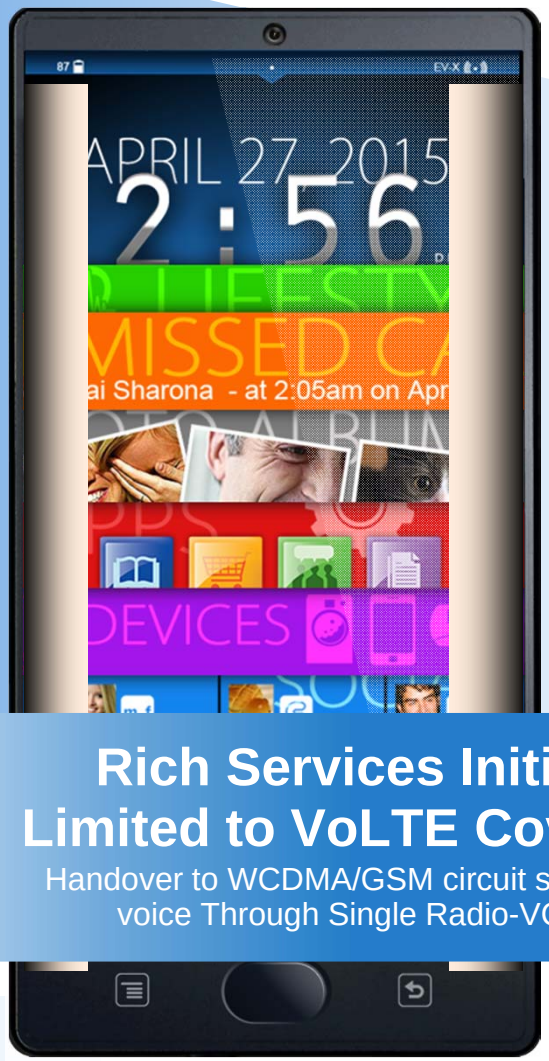
May not interoperate with other VoIP solutions

Carrier Grade Voice

Variable Quality, Dependent on Network Load

[1]IMS/RCS based VoIP is the industry solution for carrier grade voice, to enable a ubiquitous VoIP solutions .

VoLTE with VoHSPA+ Ensures Rich Voice Everywhere



Integrated Presence

Enhanced contacts with presence
Integrated messaging, chat, synch. etc

Enriched Voice/Push to Share

Share multimedia content during call,
such as video, pictures, files etc.

Video Telephony

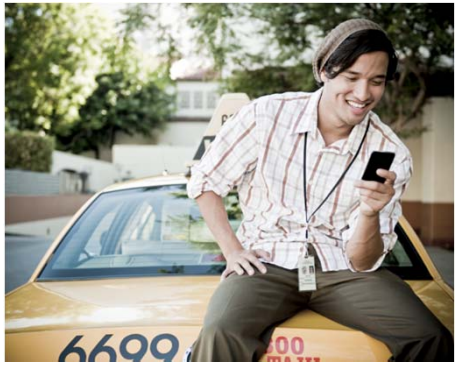
With full interoperability

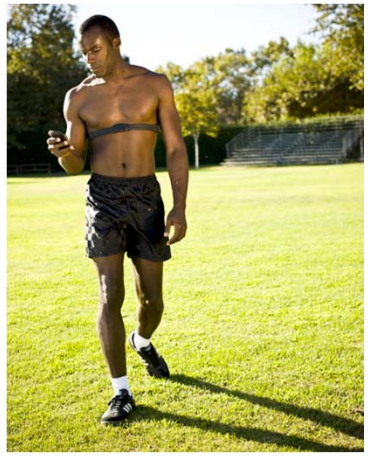
Rich Services Initially Limited to VoLTE Coverage

Handover to WCDMA/GSM circuit switched voice Through Single Radio-VCC

VoLTE with VoHSPA+ Ensures Consistent and Seamless Rich Voice Experience

Based on Rich Communication Suite (RCS), an industry effort leveraging IMS to providing mobile phone services.



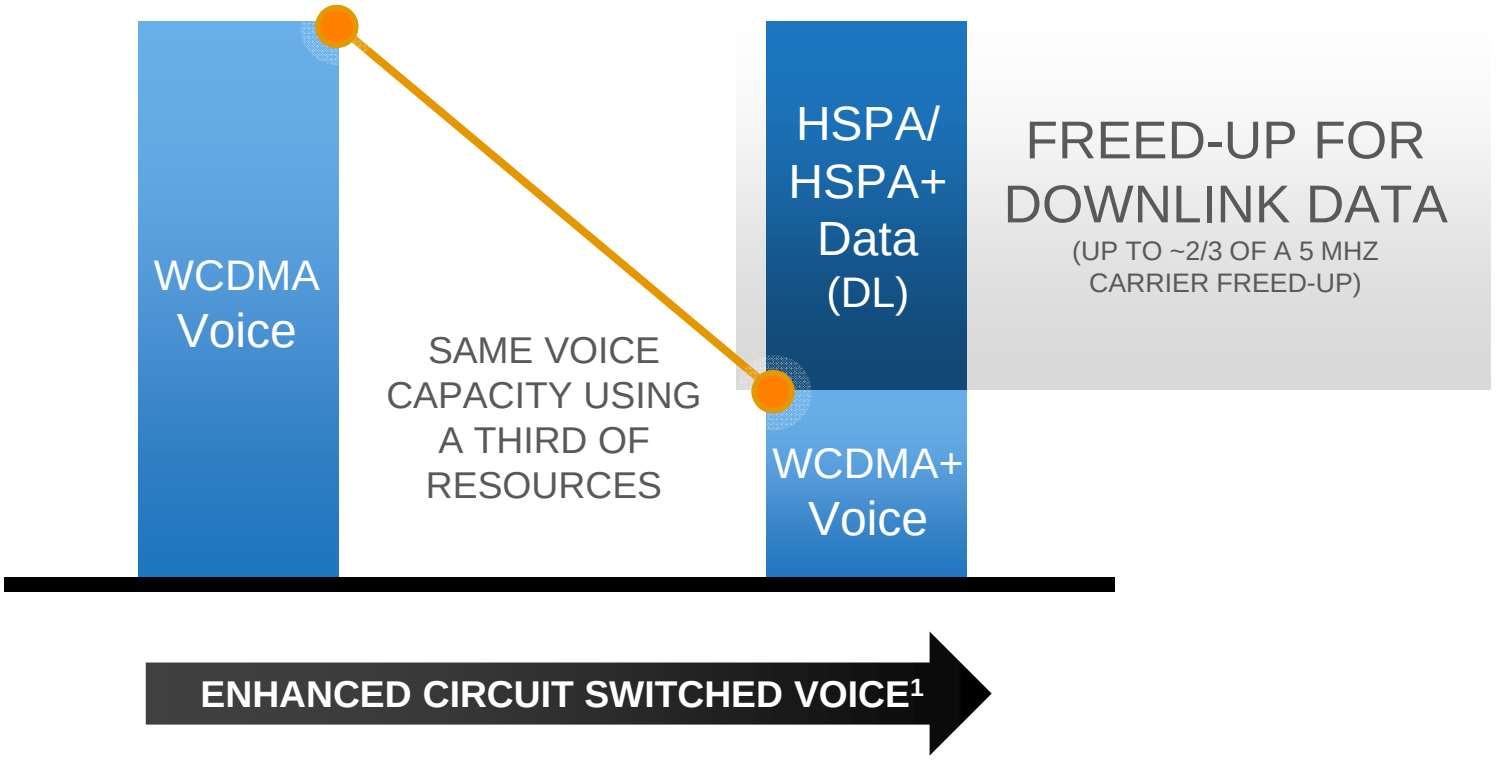


Circuit Switched Voice Evolution

Make Voice More Efficient to Support More Data

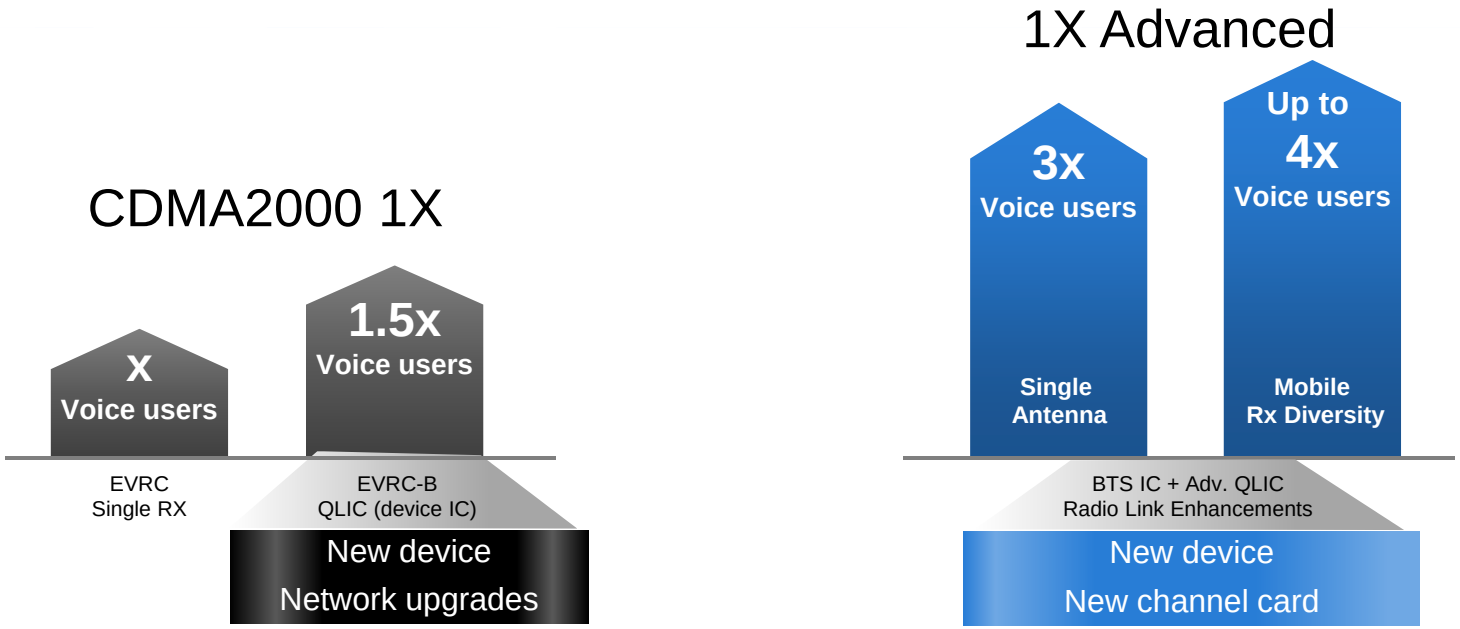
WCDMA+: More Efficient Voice to Support More Data

Triples Voice Spectral Efficiency to Free Up ~2/3 of a Carrier for Data

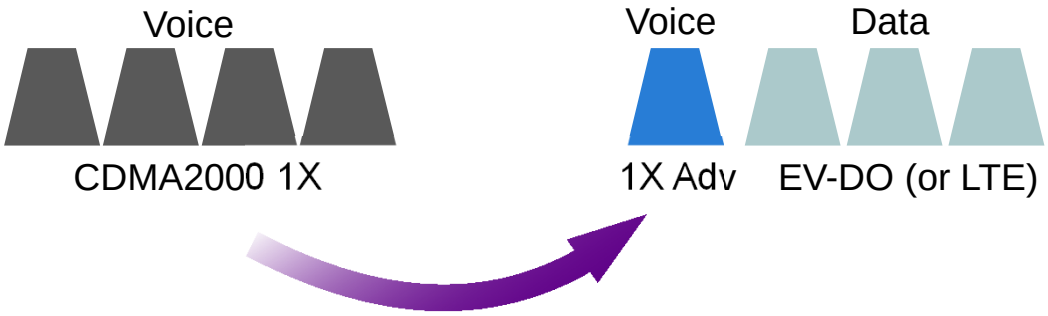


[1]Improvements such as overhead optimizations, early termination and new codec (EVS) 5.9kbps. Single receive antenna assumed. WCDMA+ enhancements targeted for 3GPP R12.

1X Advanced Frees Up Spectrum for Data



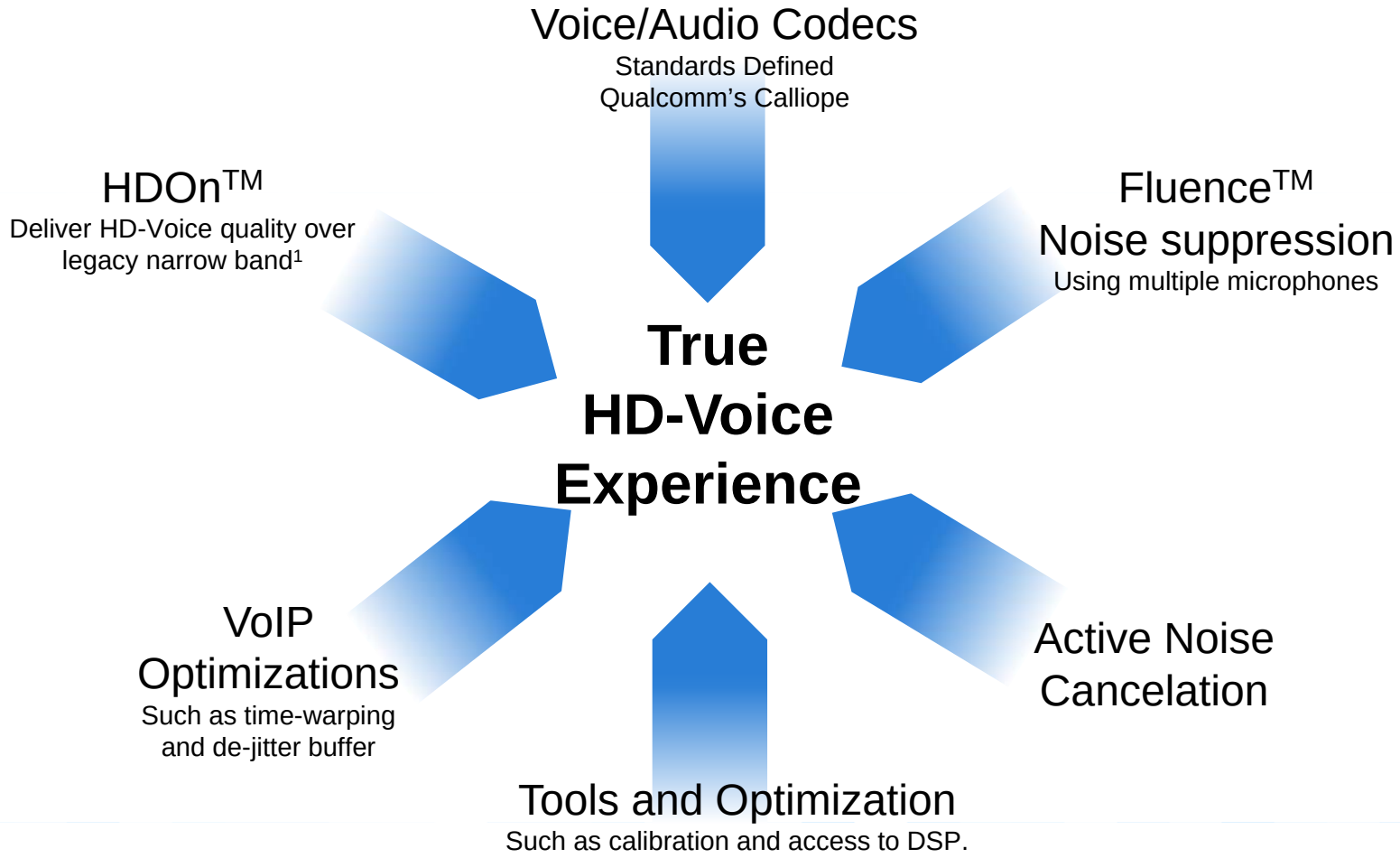
Same Voice Capacity in ~¼ of the Spectrum



Voice Quality Evolution

Qualcomm Provides Leading Voice Quality Technologies for 3G Circuit Switched Voice , IMS VoIP and OTT VoIP

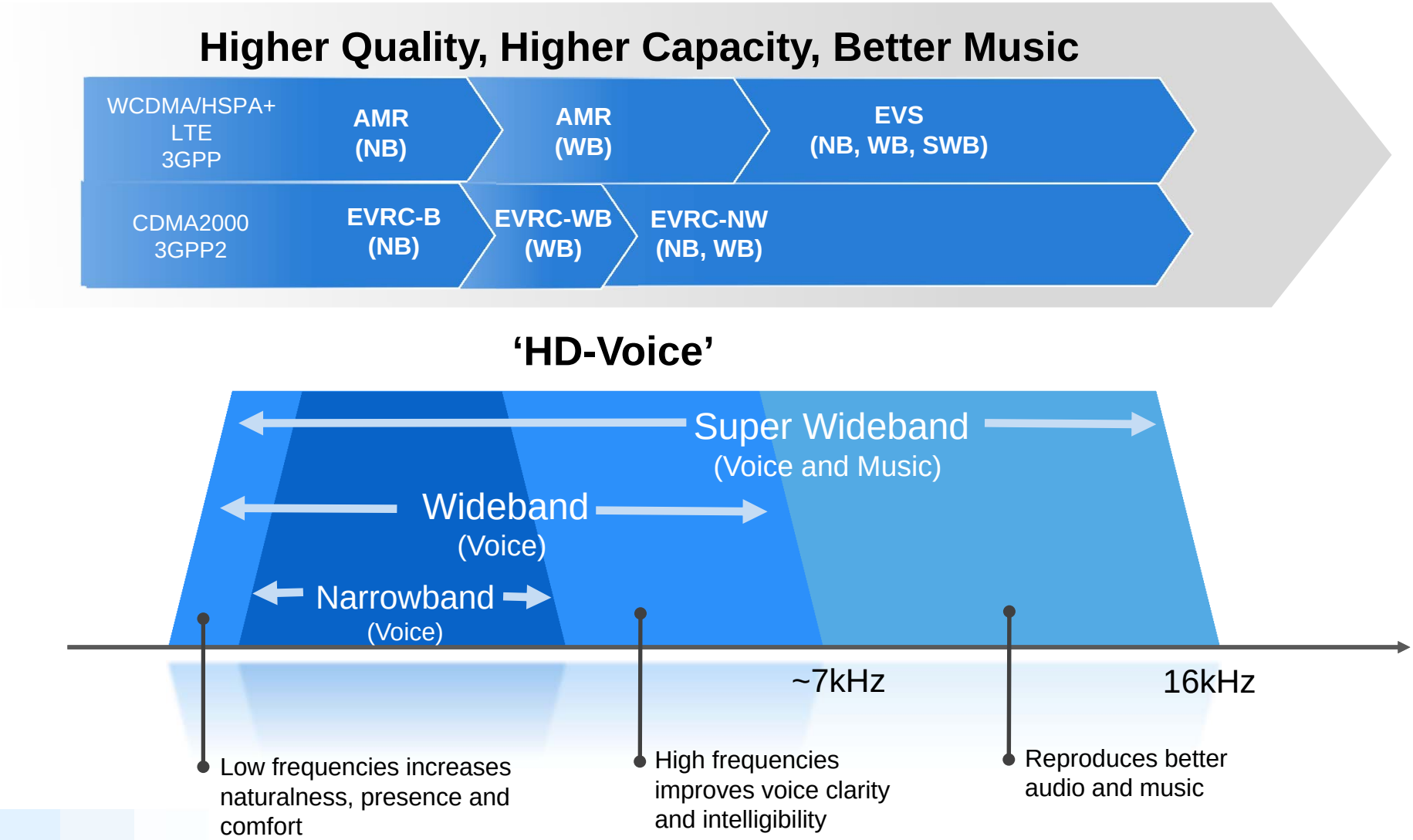
Qualcomm Enables The Best Voice Experience



HD-Voice Across 3G Voice, IMS VoIP or Over-The-Top VoIP

[1]Such as "HDOn-eAMR" which transmits true WB compressed voice quality over a NB channel. Qualcomm's 'Widevoice' can also artificially create WB voice quality at the handset

Continuously Enhanced Codecs to Improve Voice and Audio



Note: EVS has additional modes not shown that are optimized for music, stereo and even wider bandwidths.

Summary: Evolving Voice for More Data, Better Quality, Richer Experience

- Qualcomm: Comprehensive Voice Evolution Leadership
  - 1X Advanced, WCDMA+, IMS VoIP over LTE, HSPA+, EV-DO, and seamless transitions
- 2G/3G Provides LTE Voice Today & Future VoLTE Fallback
  - CSFB widely deployed, future VoLTE needs SRVCC to ensure seamless voice
- VoLTE with VoHSPA+ Ensure Rich Voice Everywhere
  - Ensures a seamless and consistent *rich voice* user experience
- WCDMA+: More Efficient Voice to Support More Data
  - Triples WCDMA circuit switched voice spectral efficiency
- Qualcomm Enables The Best Voice Experience
  - Leading Voice Quality Technologies for 3G circuit switched voice, IMS VoIP and OTT VoIP (HDOn, Calliope Fluence..)

The 3G & 4G and Chipset Evolution

- **The wireless evolution and Spectrum** . . . . . **1:00 pm – 1:30 pm**
  Speaker: Rasmus Hellberg, Sr Dir Technical Marketing

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  —How do we support all bands and technologies?
  Speaker: Peter Carson, Sr Dir Product Management

- **Questions And Answers**. . . . . **3:30 pm – 3:45 pm**

Migration to WCDMA Voice from GSM Voice

UMTS900 Well Established for HSPA+ Data and WCDMA Voice

"…UMTS900 is standard in most new devices destined for Europe, the Middle East, Africa, and Asia Pacific markets, with the 900/2100 MHz combination for WCDMA-HSPA increasingly commonplace…"

- GSA

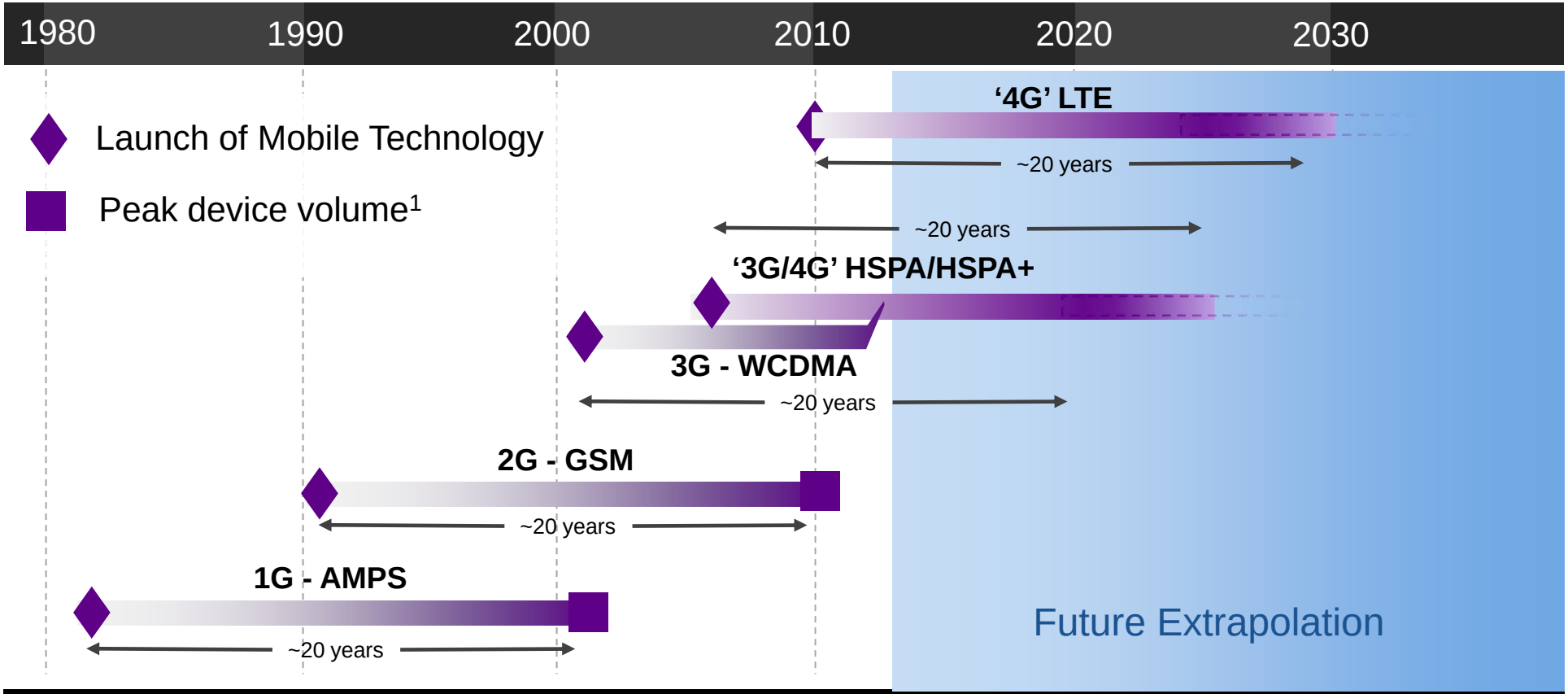
40 Commercial Networks

719 Devices Announced

>54 Countries Allow Refarming[1]

[1]Some countries may not need regulatory approval; Source: www.gsacom.com as of Feb 9, 2012

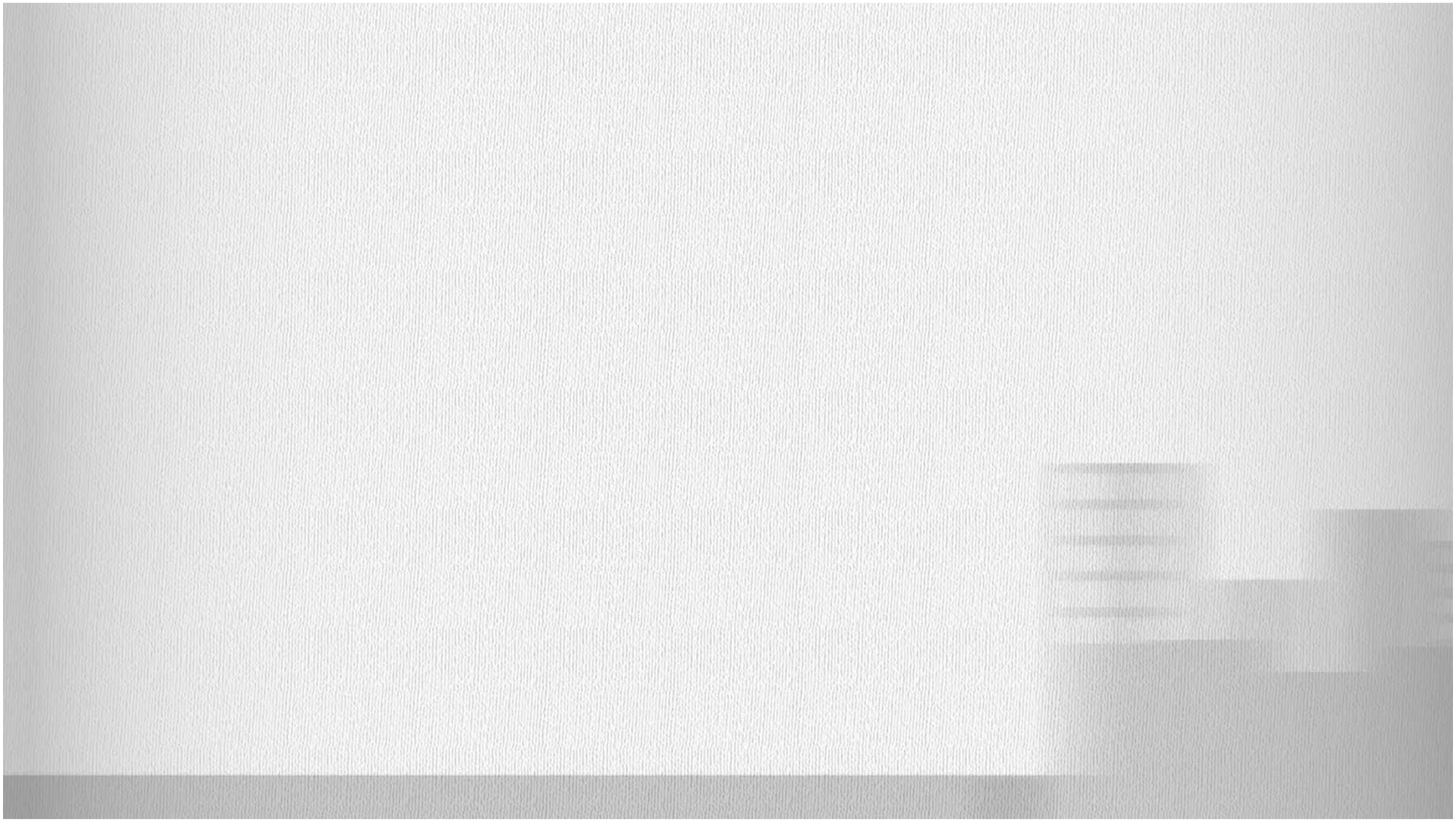
WCDMA Circuit Voice Has a Very Long Life Thanks to the Success of HSPA+



~20 years from launch of a new mobile technology generation to peak device volume

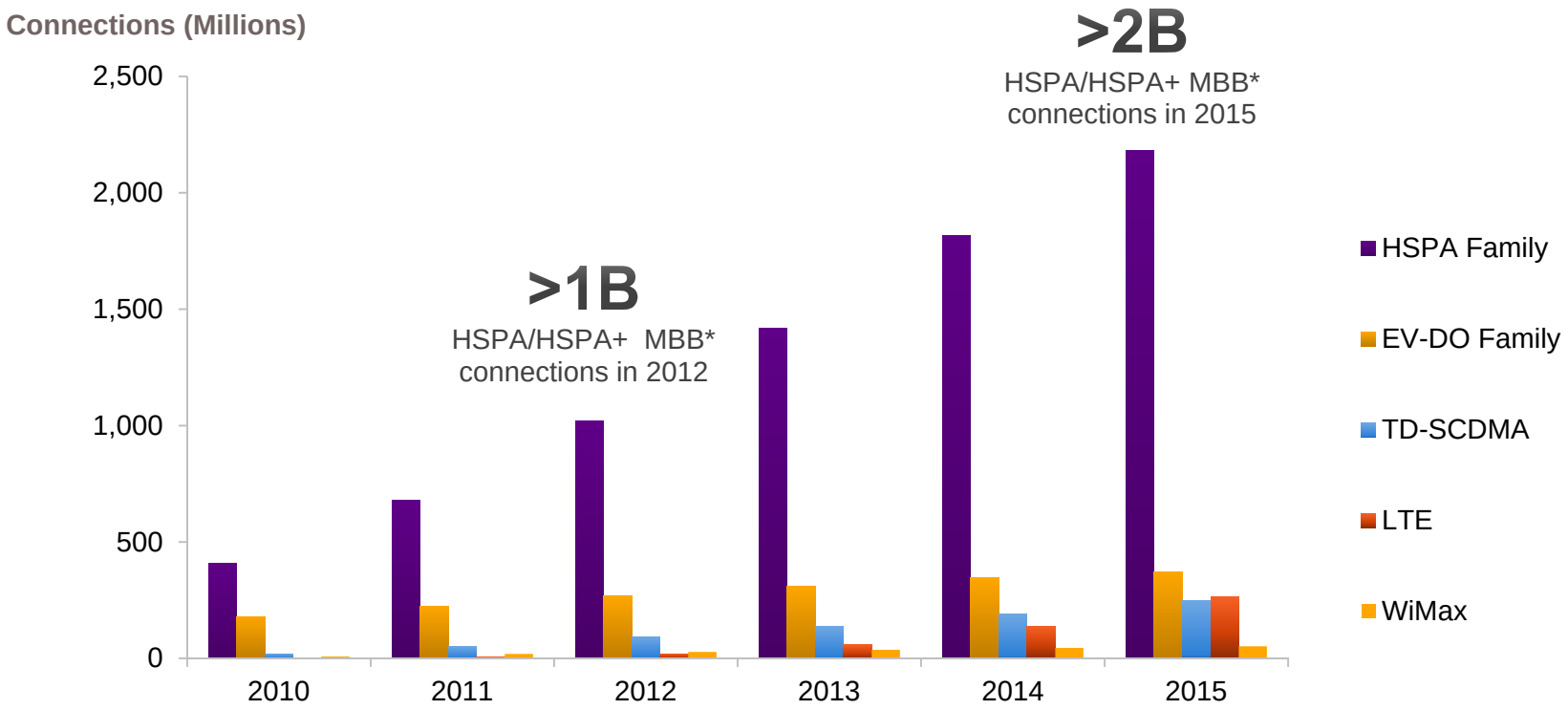
[1]Sources: ABI June 2011 and Strategy Analytics Sept 2011, devices is only handset. A multimode device is counted only as the latest technology, e.g. a GSM/HSPA+/LTE device is counted as LTE.

Video: HSPA+



2 Billion HSPA/HSPA+ Subscribers in 2015 Will Be Using WCDMA voice

HSPA/HSPA+ relies on WCDMA for voice

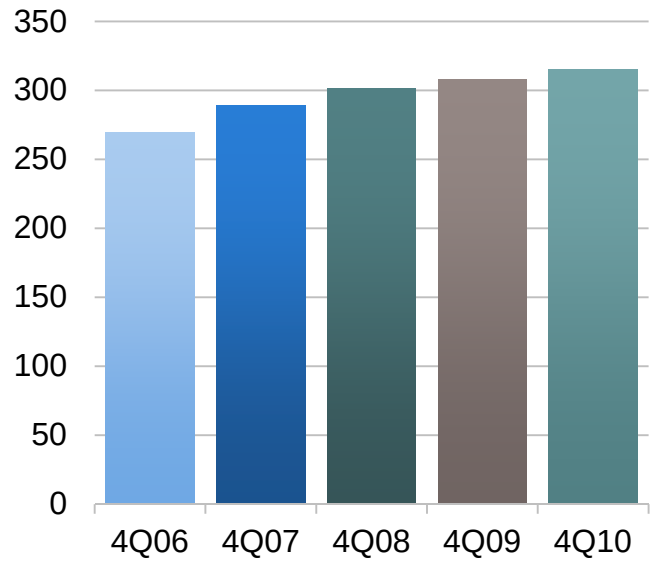


Source: HSPA, EV-DO ,TD-SCDMA and LTE subs – Wireless Intelligence (Oct '11) and WiMax - ABI (Aug '11)

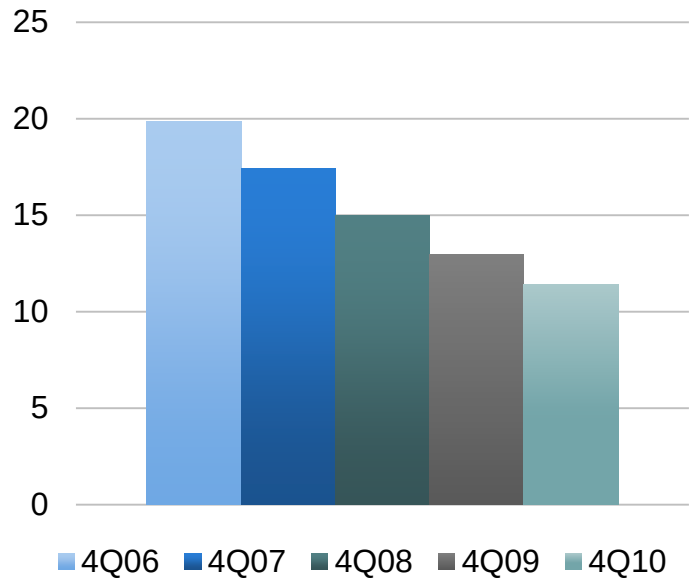
Voice Usage Stable But Revenue Declining

Growth in CALA, MEA & E. EUROPE, but flat or decline elsewhere

Stable Minutes of Use per Subscriber (Global)[1]



Declining ARPU ($ Global)[1]



Voice Provides Majority of Revenue[2]—Data Demand Increasing

Make Voice more Efficient to Support More Data While Ensuring Quality

[1]Source: Strategy Analytics Wireless Operator Benchmarking Report 2011. 2Source: Yankee group 2010, estimates 70% of revenue from voice in 2014

More Efficient Voice to Support More Data

WCDMA+

Triples Voice Spectral Efficiency

- To free up resources for data

Can Free Up ~2/3 of a Carrier for HSPA+ Data

- While supporting the same voice capacity as WCDMA today

Ensures High Quality, Reliable, Ubiquitous Voice

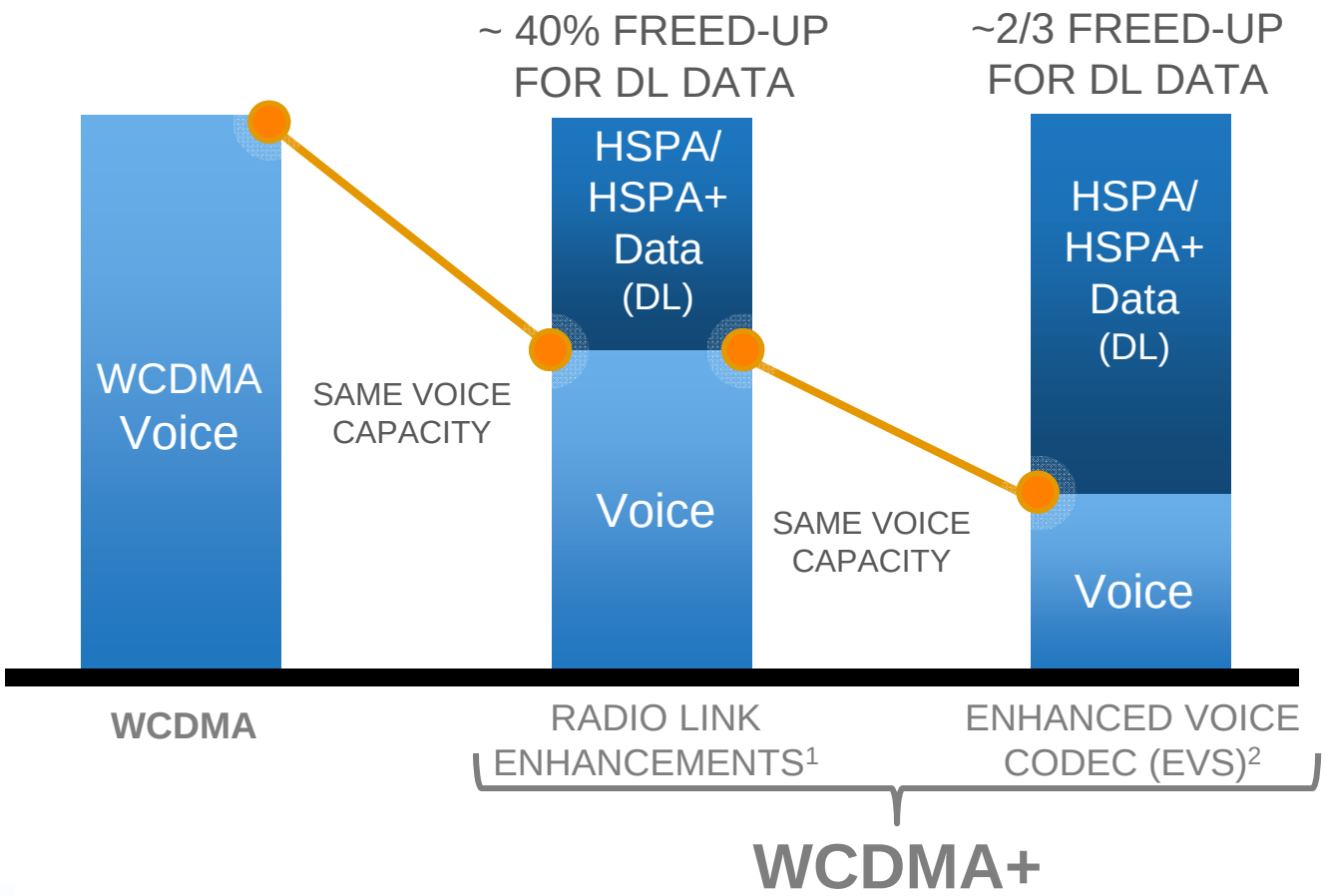
- WCDMA+ builds on proven WCDMA circuit switched voice

Relevant to All HSPA/HSPA+ Operators

- The long life of HSPA+ means a long life of WCDMA—Addresses all device segments

WCDMA+ Triples Voice Spectral Efficiency

~2/3 of a Carrier Freed up for Data by Enhancing Circuit Switched Voice



Assumptions: single receive antenna and rake receiver assumed for voice, dual receive diversity assumed for data. [12]WCDMA+ enhancements targeted for 3GPP R12
[1]AMR 12.2k vocoder. [2]EVS 5.9kbps VBR Wideband mode.

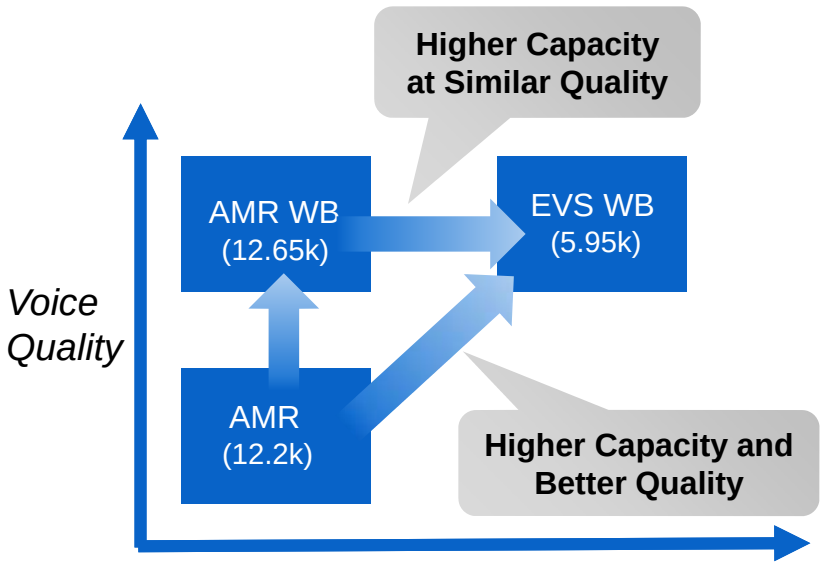
WCDMA+: The Secret Sauce

RADIO LINK ENHANCEMENTS[1]

1) Reduces overhead—more power left to support more users
   Such as slower power control (750 MHz) and removal of dedicated downlink pilot

2) Less energy to transmit a voice frame —less interference and higher capacity
   Such as early voice frame termination[2]

ENHANCED CODEC—EVS WB[2]

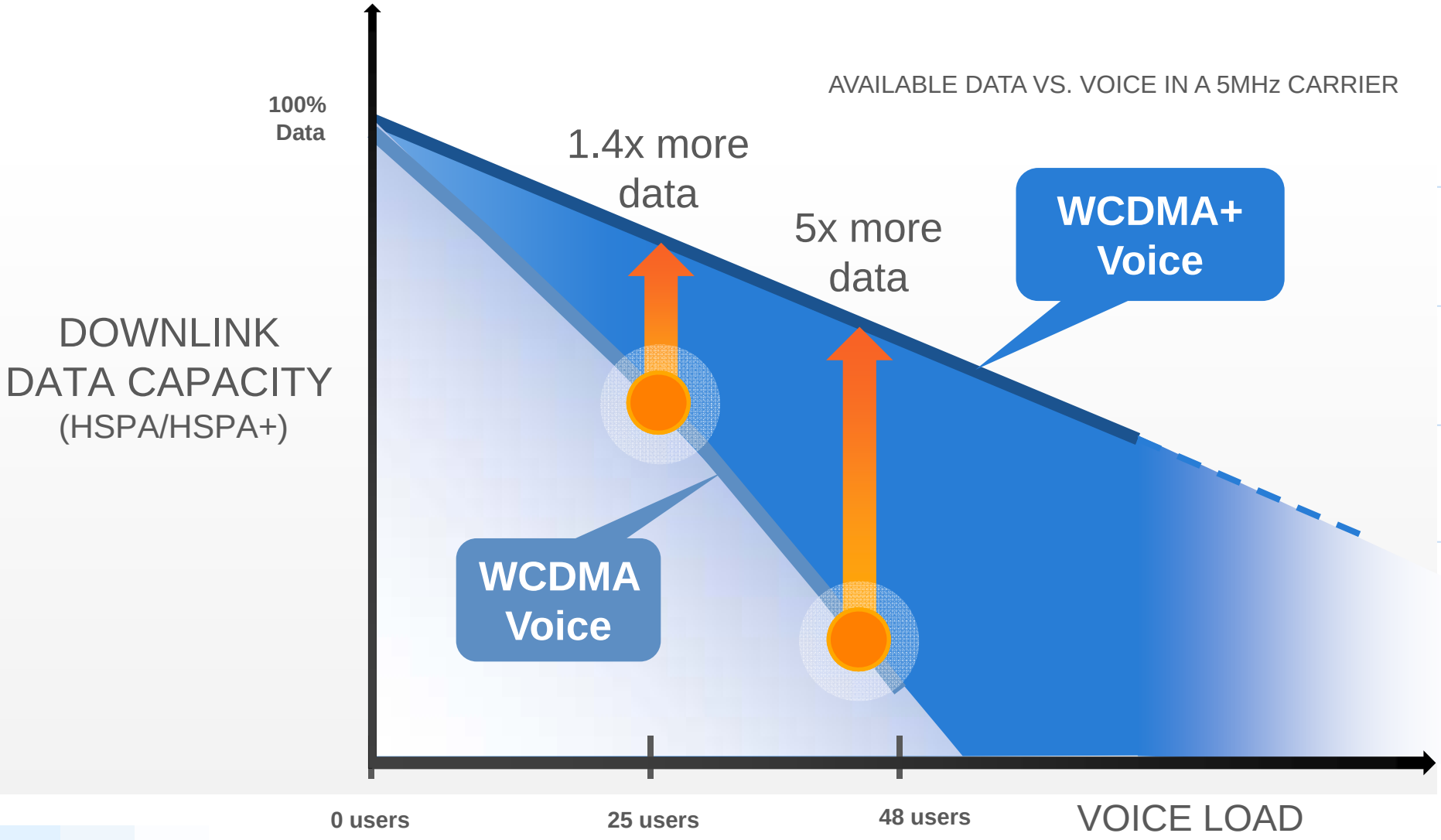


TARGETED FOR 3GPP RELEASE 12

A GLOBAL INITIATIVE

[1]Applies both to downlink and uplink, uplink improvements also needed to enhance uplink data capacity. [2]The 20 ms voice-frame transmission can be terminated as soon as it is successfully decoded, compared continued to repeating all packets the full 20ms frame. [2]EVS = Enhanced Voice Services, with a source controlled variable bit-rate mode.

More Data Capacity at All Voice Loads



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WCDMA+ Ensures High Quality, Reliable and Ubiquitous Voice

Builds on Proven WCDMA Voice[1]

Global Roaming in Global Bands

Simultaneous Voice and HSPA+ Data

Leverages Existing Investments

Extended Talk-Time[2]

[1]High quality tanks to soft handover, proven interoperability and 10+ years of WCDMA circuit switched voice optimizations. [2]Current consumption reduced by ~10% with WCDMA+

WDCMA+ Addresses all Device Segments

Cost-Effective Penetration Across *All* Device Segments

Basic features—such as single receive antenna and no HSPA+ required—ensures cost-effective entry/low-end devices[1]

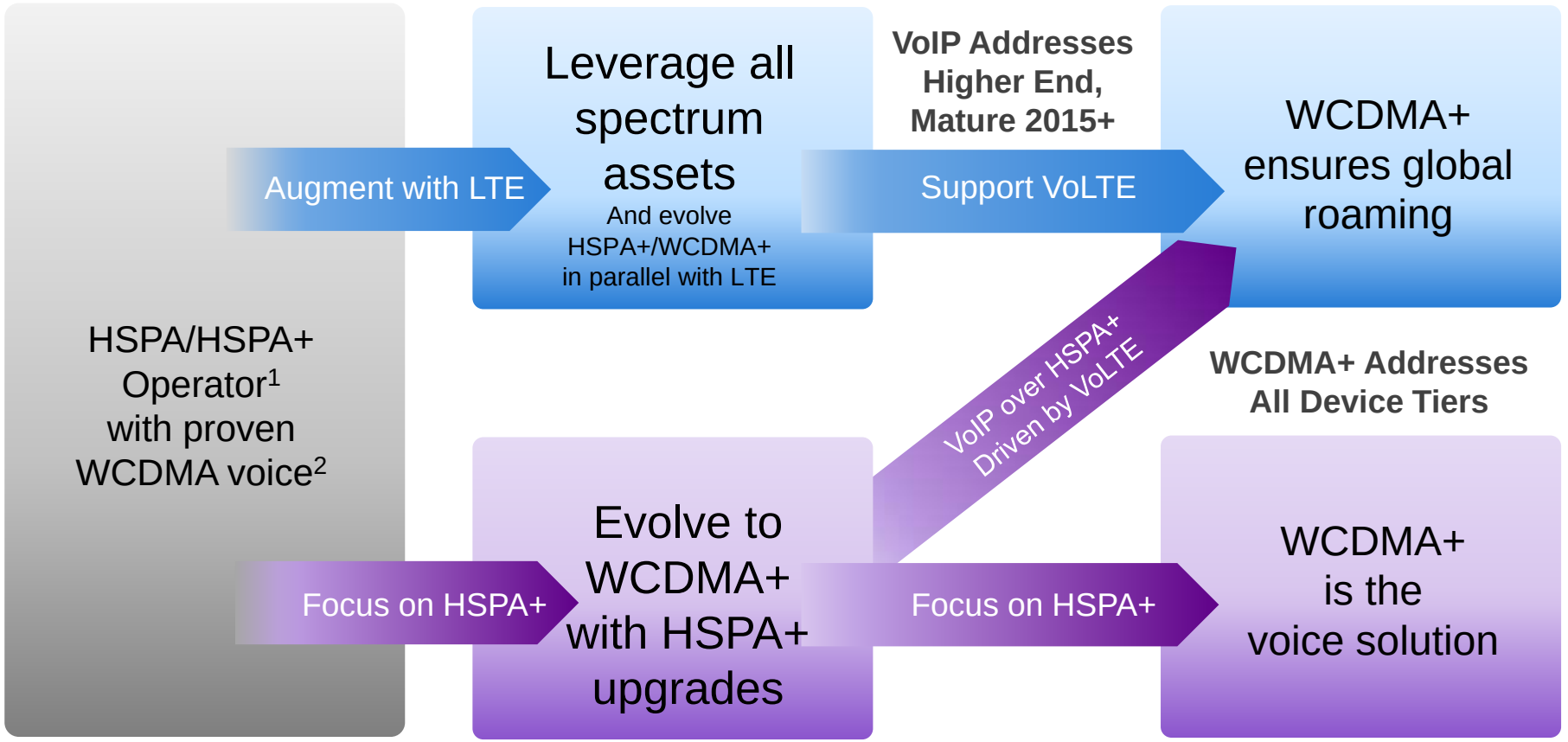
Latest HSPA+, dual receive diversity and latest advanced receivers[2] provide even better performance—especially for data services

Need to address all device segments
—including 50% of shipped handsets in 2015 that are not Smartphones[3]

[1]single receive antenna and rake receiver required for stated gains. [2]Such as device equalizer and interference cancellation using Q-ICE™ [3]Source: Average of Gartner, IDC and Strategy Analytics (September 2011).

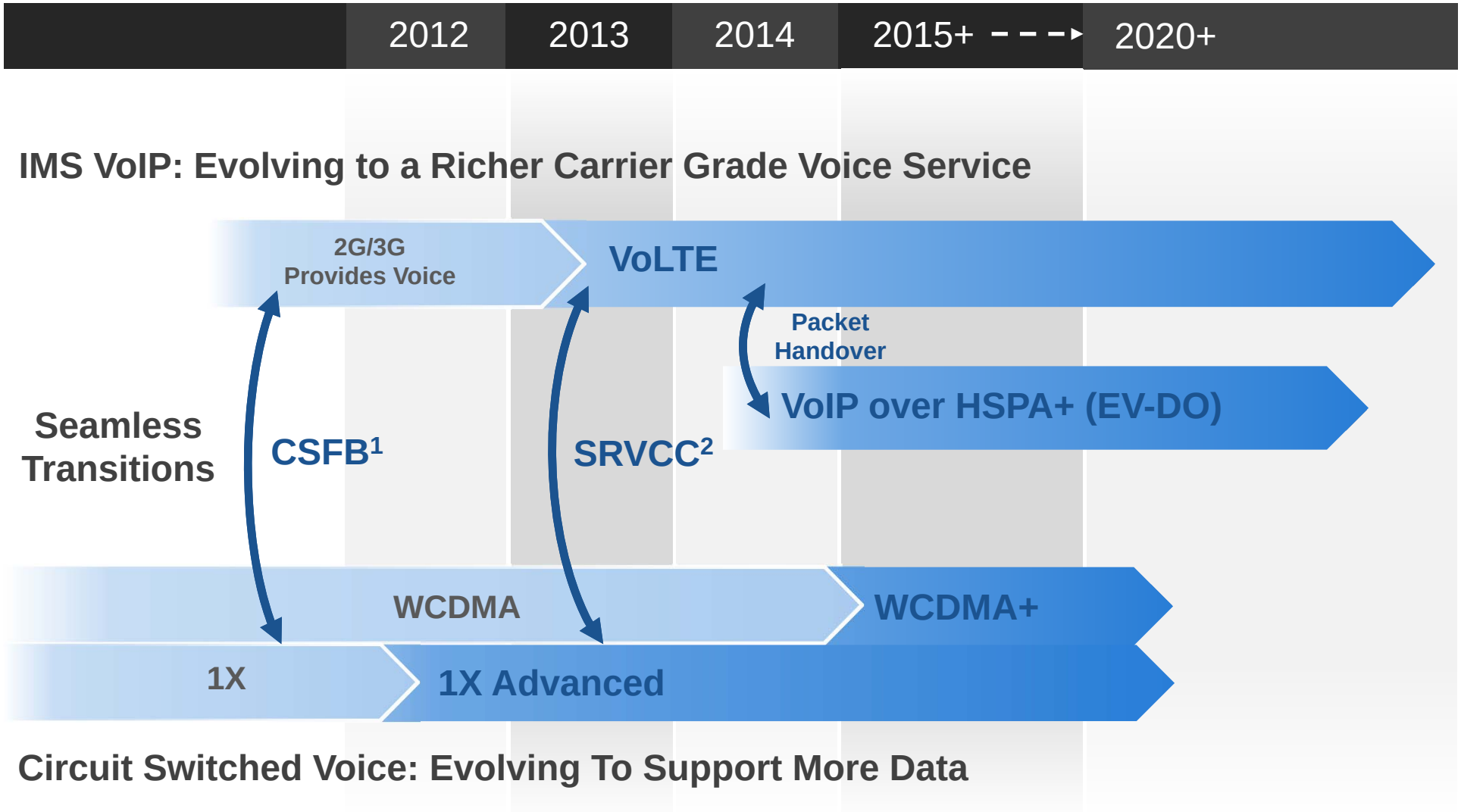
WCDMA+ Relevant to *All* Operators

The long life of HSPA/HSPA+ means a long life of WCDMA



[1]All WCDMA operators upgraded to HSPA, so there is always HSPA/HSPA+ with WCDMA. [2]With proven quality, reliable soft handovers, interoperability and global roaming

Qualcomm: Comprehensive Voice Evolution Leadership



Blue: Qualcomm Technology Leadership

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Modem evolution slides are available in a separate deck

QUALCOMM®

Modem Evolution

CTIA Special Session

Thank You