
Innovation
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Innovation
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Corporate R&D:
Excellence in Wireless Innovation

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State of the Art Capabilities Fostering Innovation

Human Resources

- **30% of engineers with PhD, 50% Masters**
- Systems, hardware, software, standards, test engineering
- Ventures, business development, technical marketing, program management

Complete Development Labs

Including prototype development facilities, CPU simulation clusters, antenna ranges, outdoor field systems

Global Research and Development Organization

UNITED STATES	EUROPE	ASIA
• San Diego, CA • Santa Clara, CA • Bridgewater, NJ	• Cambridge, UK • Nuremberg, Germany • Vienna, Austria	• Beijing, China • Bangalore and Hyderabad, India • Seoul, S. Korea

R&D for the Wireless Future

TAKE WWAN TO THE NEXT LEVEL	INNOVATE BEYOND WAN	ENABLE SMART APPLICATIONS	BREAKTHROUGH PERFORMANCE
3G/4G	**Wireless Local Area**	**Application Enablers**	**Processors and Devices**
IMPROVING WWAN TECHNOLOGY	EXCELLING IN ALL FORMS OF WIRELESS	TRANSFORMING THE MOBILE USER EXPERIENCE	RE-ARCHITECTING NEXT-GEN MOBILE DEVICES

3G/4G

HSPA+: Extending UMTS Performance

SIMILAR EFFICIENCY, PEAK DATA RATES AND LATENCY AS LTE

UMTS Performance Enhancements

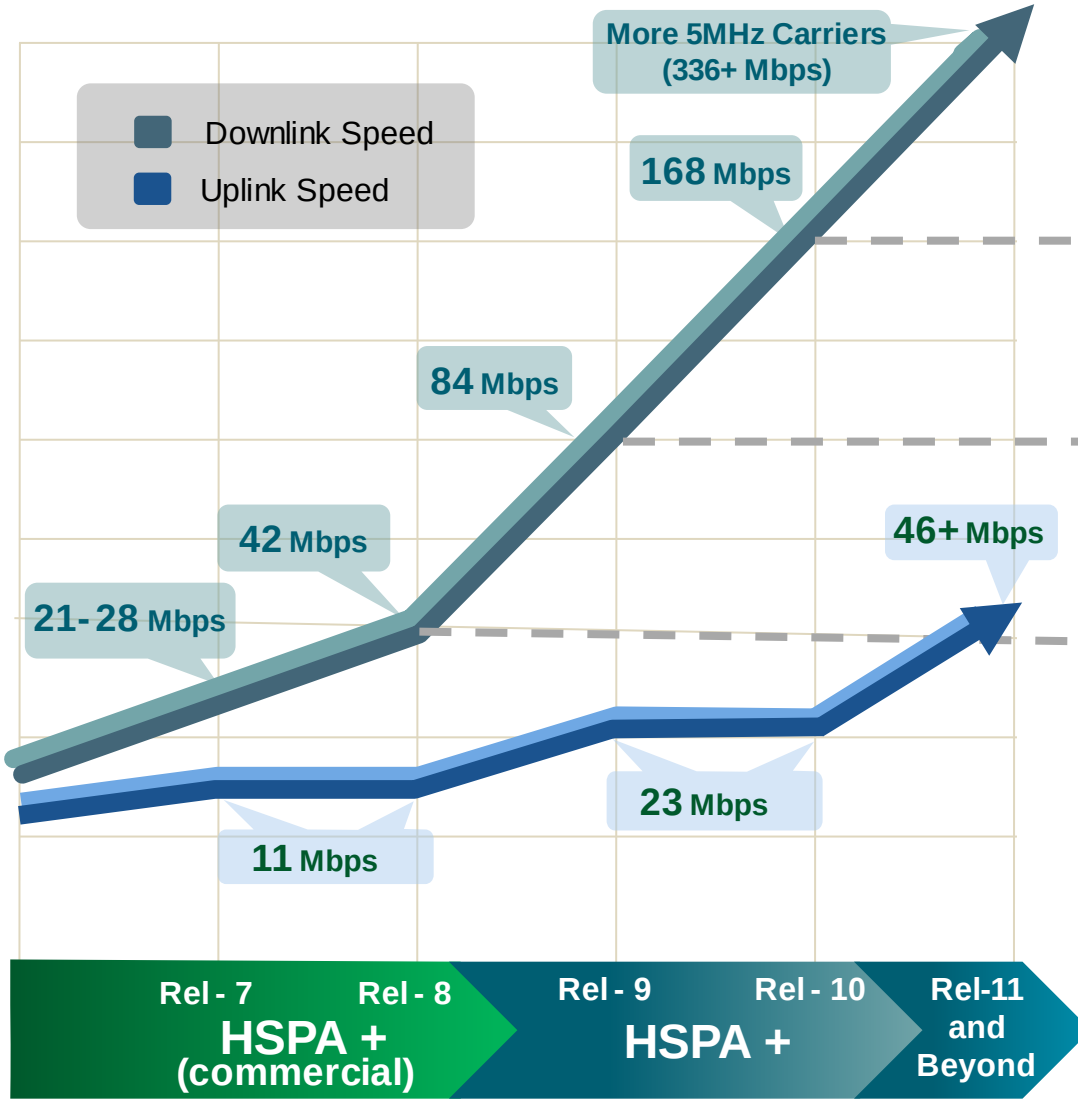
- Increased system efficiency
- Lower latency and higher user throughput

CR&D key industry firsts:

- First VoIP demonstration over HSPA
- First multi-carrier HSPA demo
- First HSPA+ UL Closed Loop TxD demo
- First multipoint Tx demo
- Industry leading IC designs

MIMO AND
MULTI-CARRIER HSPA

ADVANCED RECEIVERS
(IC, TxD)



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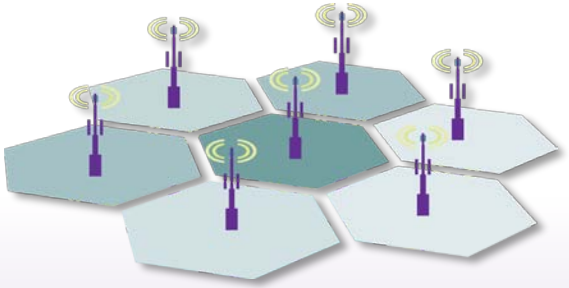
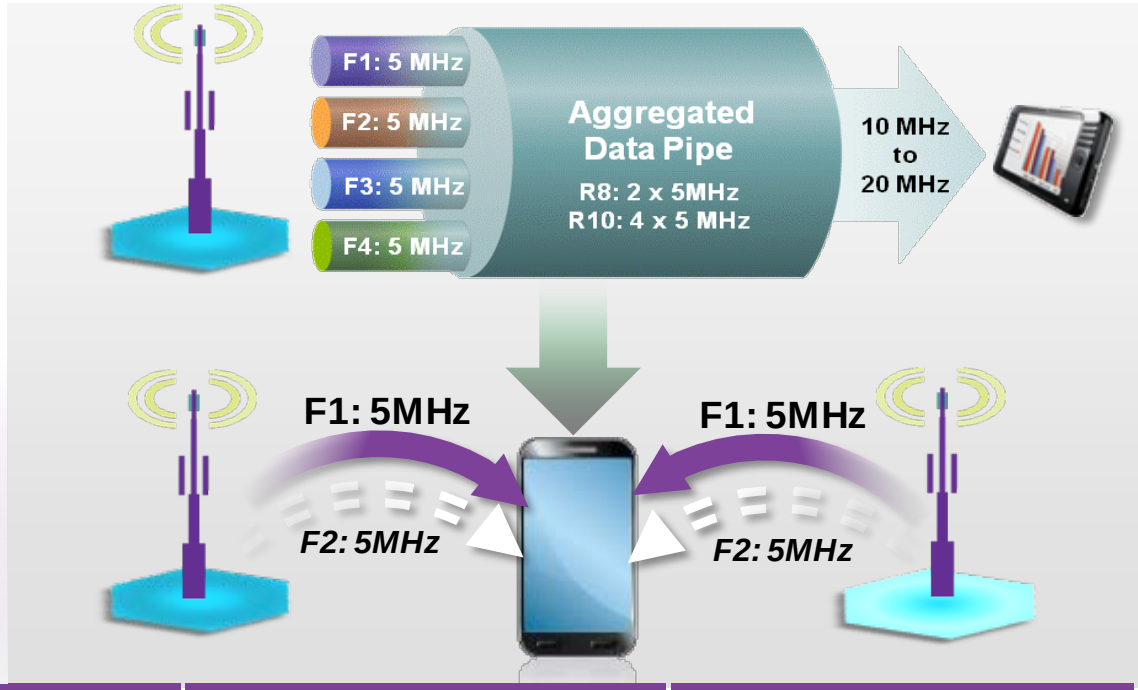
HSPA Multicarrier Evolution to Sector Aggregation

Typically Uneven Loading



Heavy Load
Medium Load
Light Load

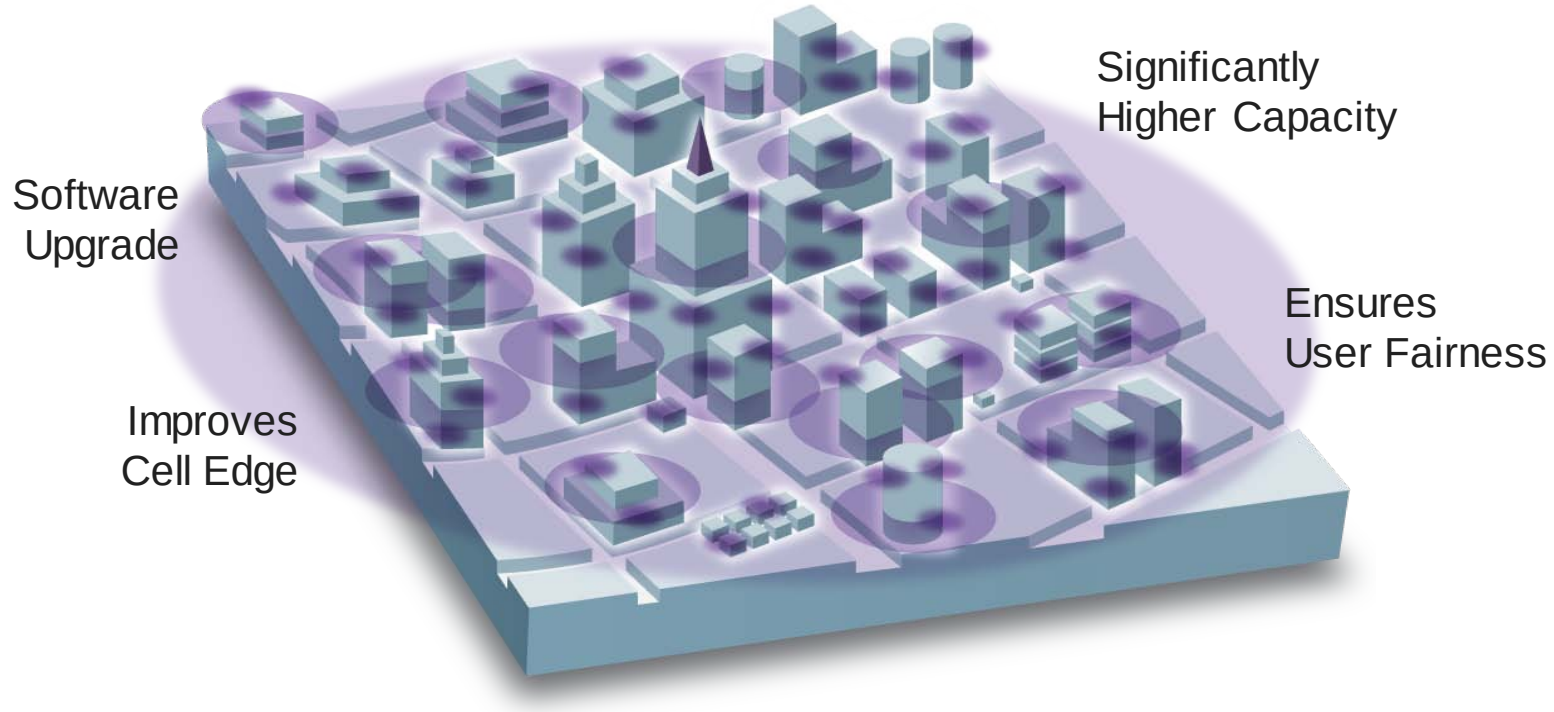


Improved Cell Edge	Network Load Balancing	Benefits HetNets1	Software Upgrade
By serving user from multiple sectors	Utilizes unused capacity in neighbor sectors Improves user experience in loaded sector	Effectively increase small cell boundaries—better utilization	RAN software upgrade Same device hardware

Note: Sector aggregation is a candidate for 3GPP beyond release 10 [1]Heterogeneous networks: Macro networks with added small nodes like pico cells

LTE Advanced Leadership

LTE ADVANCED REALIZES FULL BENEFITS OF HETEROGENEOUS NETWORKS

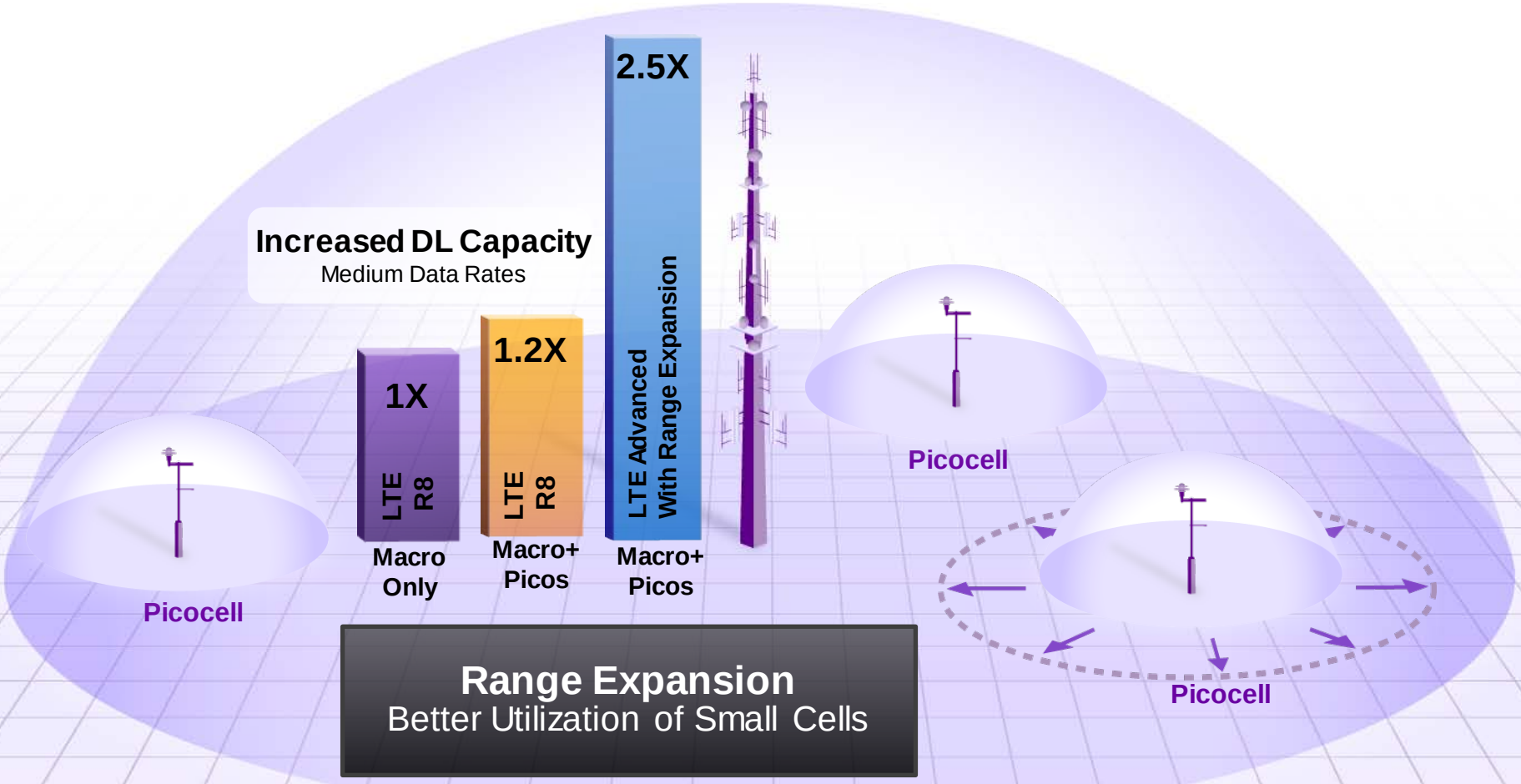


A LEADING CONTRIBUTOR TO LTE ADVANCED STANDARDS

SPEARHEADING TECHNOLOGY DESIGN EFFORTS

STATE-OF-THE-ART LTE ADVANCED TEST BED

LTE Advanced: Increased Network Capacity and User Experience



Assumptions: 4 Picos per Macro randomly dropped within macro coverage, see 3GPP R1-101509. Based on range expansion (intelligent node association –s assign user to eNB with weaker SNR, based on path loss, under certain conditions) and adaptive resource allocation. Based methodology in R1-084026: 10 MHz FDD, 2x2 MIMO and 25 users

LTE Advanced Test Bed in San Diego

EVALUATING DESIGNS TO REALIZE THE FULL BENEFIT OF HETEROGENEOUS NETWORKS

Live since March 2011

Multiple macrocells and picocells in a co-channel deployment

Demonstrating e.g. pico discovery and range expansion with mobility

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LTE Device-to-Device (FlashLinq)

PROXIMAL DISCOVERY AND COMMUNICATION TECHNOLOGY

Benefits Users, Operators and Developers:

- Enables variety of new apps leveraging Direct Discovery/Communications
- Complement WAN/Enhance cloud apps
- Long device stand-by time
- Highly scalable to support large number of devices and apps

Key Characteristics

- Provides IP Applications with a "Sense" of Their Proximate Internet Peers
- Standards development to support LTE device-to-device communications

Fully Distributed Ad-Hoc Synchronous System	Efficient Autonomous Discovery Protocol	High Spectrum Efficiency and Re-Use	Licensed Spectrum	Mobility to WWAN and WLAN	Several 100s Meters Range

Wireless Local Area

WiFi Advanced—Next Generation WLAN

60 GHz Band (802.11ad)

Multi-Gbps Sync-n-Go

900 MHz Band (802.11ah)

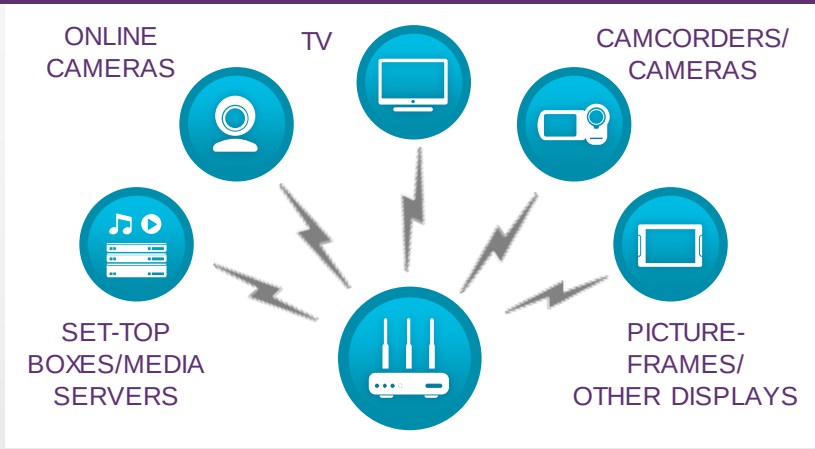
Sensors, M2M, Internet of Things

600 MHz Band (802.11af)

TVWS for Cellular Offloading

Low Cost Access, Hetnets and WiFi-Direct Enhancements

5 GHz Band (802.11ac)



- Evolution of 11n WLAN, > 1 Gbps
- MU-MIMO—up to 8 antenna AP 20/40/80/160 MHz bandwidth
- On path to commercialization in multiple MSMs and QC-Atheros APs

Apps Enablers

Awareness: Your Digital 6th Sense

LEVERAGE MOBILE DEVICE TO INFER DAILY LIFE SITUATIONS, IDENTIFY RELEVANT INFORMATION AND PRESENT IT TO ENHANCE OUR LIVES

Raw Data	Inferred Context	Situations
Sensors	Actions	Family
Application	Environments	Work
	Places	Social

IN THE FUTURE YOUR MOBILE PHONE WILL SENSE, DISCOVER and LEARN RELEVANT THINGS AROUND YOU

CR&D Focus

Context as Service	Personalization	Privacy Sensitivity
Optimization for memory, battery and bandwidth	Incorporate user actions, preferences and feedback	For many applications, data and inferences don't need to leave the phone

Listen: Sound Recognition for Augmented UX

RECOGNIZE SOUNDS AND ENABLE SMART APPLICATIONS

- Derive contextual information from audible events
- Inference of scenes, alerts, speaker and keywords
- Enables 3rd party software developers to enhance products with additional audio information

OPTIMIZING QC CHIPSETS TO DRIVE LISTEN FEATURES

Listen Demo

Thank You