Qualcomm Atheros Small Cell Products

4G World, October 2012

QUALCOMM®

Qualcomm Driving Small Cell Technology

Investment in enabling technologies

- Extensive small cell system on chip (SoC) development
- Initiatives in HetNet, SON, HotSpot 2.0
- Wi-Fi leadership

3G 4G Wi-Fi

DesignArt provides immediate access to field tested LTE & backhaul SoC

- Single SoC supports LTE access and LOS/NLOS wireless backhaul

DesignArt Networks

Qualcomm SoC roadmap levers UE leadership & scale

- Qualcomm is leader in 28nm process node
- Low power processors including Snapdragon™

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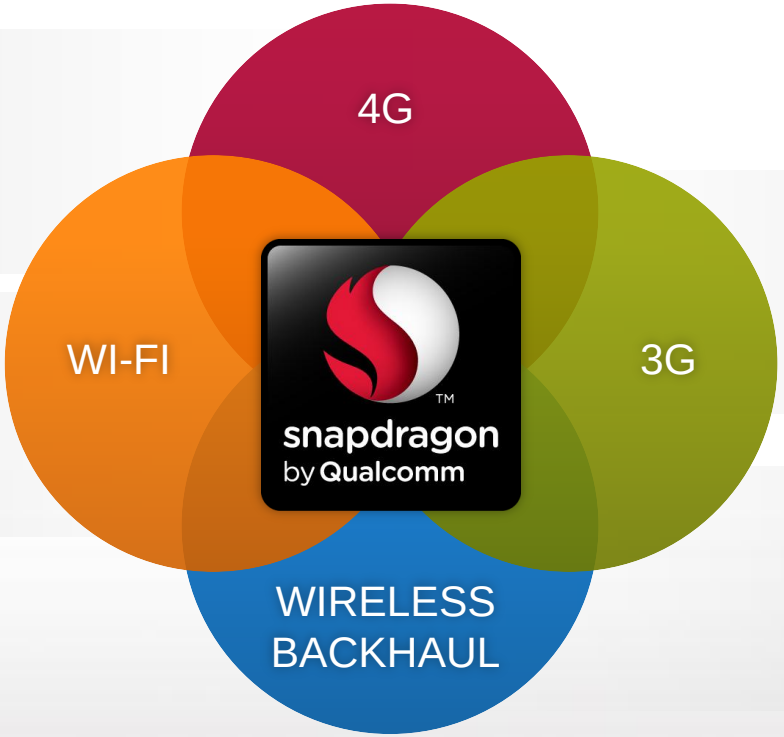
Qualcomm Small Cell Value Proposition

Industry's highest level of small cell technology integration

LTE
- FDD/TDD
- Carrier aggregation

802.11n/ac
- Dual-band, dual concurrent
- 3x3 MU-MIMO



UMTS/HSPA+
- Rel. 10

Unified Mobile Backhaul
- LOS/NLOS
- 10/20 MHz TDD/FDD
- 2x2 MIMO

- Concurrent 3G/4G access
- Complete RF solution: RFICs, DPD/CFR, Network Listen, digital I/Q
- Comprehensive supporting portfolio: Wi-Fi 802.11n/ac, Gbit Ethernet, Bluetooth, GNSS, power management

Qualcomm's Small Cell Differentiation

Systems expertise: Silicon and firmware/software; market leadership in UE silicon enables synergies (interoperability, features)

Best-in-class performance: Modem, RF, GPS, Snapdragon processor, security, low power, and dedicated network listen

Multiple technologies: Small cell SoC supports both 3G and 4G

Complete RF solution: Global 3GPP bands; Rx/Tx Diversity, High Performance Rx Sensitivity; optimized for enterprise use

Wi-Fi integration: Optimized reference designs, connectivity manager, systems design, and algorithm for cellular and Wi-Fi interworking

Fully validated and field tested UltraSON™ and HetNet solutions

- Interference management for shared & dedicated carrier deployments (3G and 4G)
- Mobility management in active and idle states (active and idle hand in)
- HetNet algorithms to enable multi-vendor deployments and Wi-Fi integration

Qualcomm Engineering Services provides field and RF optimization

Small Cell Vision

NEIGHBORHOOD SMALL CELL

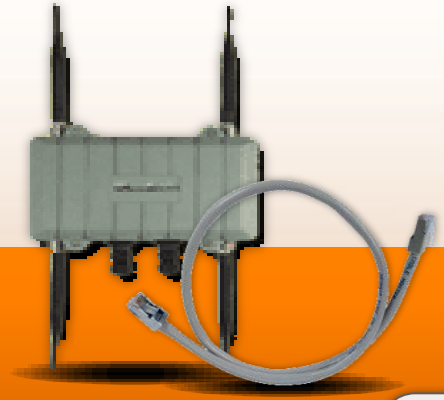
Provide Low Cost Access

- LCA with 3G/4G/Wi-Fi
- UltraSON
- Coexistence & AP Connection Mgmt

ENTERPRISE

Provide in Building Coverage

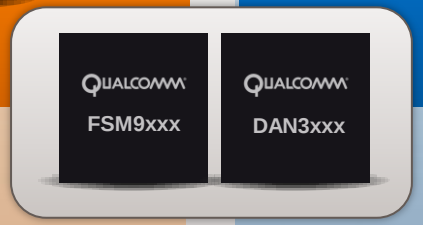
- 3G/4G/Wi-Fi
- UltraSON
- Coexistence & AP Connection Mgmt



METRO/PICO/MICRO

Outdoor Hotspots

- 3G/4G/Wi-Fi
- UltraSON and HetNet
- HotSpot 2.0
- Coexistence & AP Connection Mgmt
- Wireless Backhaul



Convergence of Cellular and Wi-Fi Infrastructure

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CHALLENGES

- Efficient cellular offload
- Seamless mobility and user experience
- QoS management
- Security
- Radio coexistence

QUALCOMM DIFFERENTIATION

- Wi-Fi and 3G/4G cellular SoCs & RF
- Complete reference designs
- End-to-end connection management
- Mobile IP
- Self configuration

Foundations: Hotspot 2.0, UltraSON, HetNet

Converged Access Points

- Complete reference designs
  - Flexible, modular
  - 3G/4G/Wi-Fi RF band flexibility
- RF considerations:
  - Radio coexistence
  - Power consumption (e.g., Power over Ethernet)

Qualcomm is Developing Reference Designs for Converged Access Points

- Radio and connection management
  - Best radio link selection (Wi-Fi vs. cellular)
  - QoS management
  - Scheduling
- Hotspot 2.0
  - Seamless Wi-Fi connectivity for mobile devices
  - User access to information without having to associate with the Wi-Fi AP
  - Improved information security between STA and AP
  - Traffic offload from cellular to Wi-Fi

Multi-Technology Connection and Radio Resource Management

- Smartphones will associate themselves with known Wi-Fi access point whenever discovered.
- This is not always the best choice.
  - May result in Wi-Fi congestion
  - May cause excessive interference or high activity on other Wi-Fi APs in the vicinity
  - There may be areas where Wi-Fi signals are much weaker than cellular.

AP Connection Management

- Decision maker
  - AP or mobile
- Input info per system (Wi-Fi/small cell/macro)
  - Backhaul rate, Internet connectivity, available OTA and hardware resources
  - Available resources monitored both for cellular and Wi-Fi
  - Macro info can be collected via network listen
  - Mobile info: applications, path loss, rate category
- Estimate performance metrics per system
  - Metrics: throughput, delay/jitter, load
  - Throughput prediction prior to connection
  - End-to-end throughput estimate during connection
- Select system
  - Pick best system for each mobile at admission or during connection

AP Connection Management

- Seamless traffic and mobility management across licensed and unlicensed systems
- Joint system selection software can utilize network and mobile based information.
- The combination of enhanced AP and Qualcomm's Connectivity Engine (CnE) at UEs

	Enhanced AP	Non Enhanced AP
UE with CnE	Best optimization with complete information	Intelligent selection based on UE info and network estimation
UE without CnE	Intelligent selection based on AP info and standardized UE reports	No optimization

Qualcomm is developing enhanced AP methods for system selection that can operate with mobiles with CnE and without CnE

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