Mobile Broadband Technologies and Silicon Solutions

I. Standards and Technologies
II. Services and Trends
III. Silicon Vendors and Solutions

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Mobile Broadband Standards and Technologies
Why Broadband?

- Mobile data growth by 17x between 2008 and 2013, but the revenue growth is less than 2x
- Carriers need new solutions to meet the traffic demand while keeping increased profitability
Why Broadband?

- Shannon’s channel capacity:
  \[ C = BW \cdot \log_2 (1 + S / N) \]
- BW and power trade off for the capacity
  - At a certain point of BW utilization, BW increase is more efficient than power increase
- Bandwidth utilization

Cellular Standards by Generations

1G (Analog) and 2G (Digital): Voice services only
2.5G: Data Services
3G: Simultaneous Voice & Packet Data (ITU Definition: 384 kbps for mobile and 2 Mbps for fixed)
Cellular Standards by Data Rates

Excellent Mobile Broadband Today
Voice and Full Range of IP Services

Enhanced User Experience
Improved voice and data capacity

CDMA2000
Best in class voice capacity
1.5x increase with available features

1x Advanced
4x increase compared to today’s voice capacity

EV-DO
Rev. A
Phase I
Phase II
DO Advanced

Rel. 0
EV-DO
DL: 2.4 Mbps
UL: 153 kbps

Rev. A
EV-DO Rev. B
DL: 3.1 Mbps
UL: 1.8 Mbps

Rel. 8
HSPA+
(HSPA Evolved)

Rel-9 & Beyond

HSPA
Phase I
Phase II

Rel-99 Rel-5 Rel-6

HSPAWCDMA
Rel-99 Rel-5 Rel-6

HSPA
Rel-7
Rel-8
Rel-9 & Beyond

DL: 1.8 Mbps
UL: 1.8 Mbps

Rel-9
LTE
Advanced
Rel-10

DL: 28 Mbps
UL: 11 Mbps

Rel-8
LTE
Advanced
Rel-9

DL: 42 Mbps
UL: 11 Mbps

Rel-10

DL: 84 Mbps and beyond (10 MHz)
UL: 23 Mbps and beyond (10 MHz)

LTE
Leverages new, wider and TDD spectrum

2009 — 2010 — 2011+
HSPA+ Evolution Path

HSPA+ Downlink
Theoretical Peak Rate in Mbps

3GPP Rel 7
21
2x5 MHz
64 QAM

2010

3GPP Rel 8
84
2x10 MHz
64 QAM

Dual-Carrier/Combinations

3GPP Rel 9
42
2x10 MHz
64 QAM

2x2 MIMO

3GPP Rel 10
168
2x20 MHz
2x2 MIMO
64 QAM

Multi-Carrier/Combinations

2011

High Effiency
Faster user experience

2012

4G Mobile Broadband Evolution: 3GPP Release 10 and Beyond, 4G America
LTE Features by Releases

**Rel-8**
- Data rate (20MHz)
  - Up to 300Mbps/75Mbps
- MIMO (up to 4 ant – DL)
- Up to 64QAM
- OFDMA/SC-FDMA
- Reduced latency

**Rel-9**
- Optimization for Mobility
- Enhanced SON
- ICIC
- eMBMS
- Enhanced LCS

**Rel-10**
- Carrier Aggregation (up to 100MHz)
- Advanced MIMO (8 DL, 4 UL)
- Data rate (100MHz, 40MHz)
  - Up to 1.2Gbps/600Mbps
- Het Net
- eICIC
- Relaying
- Enhancement of SON, eMBMS
- X2 for HeNBs

**Rel-11**
- CoMP
  - JP(joint processing)-CoMP
  - CS/CB(coordinated scheduling, coordinated beamforming)-CoMP

Remark: different operators would have interests in different Rel-10 features. CA would be operators who have spectrum to aggregation; mimo would be important for some TDD operators who already have 8 Tx/cell; hetnet eICIC would be important for operators interested in hotspots and small cells.
WLAN Standards

- **802.11b**: 1999, 2.4 GHz, 11 Mbps
  - 2.4GHz ISM band
  - DSSS/CCK Modulation
  - 11 Mbps data rates
  - 500 ft range

- **802.11a/g**: 2003, 2.4 GHz, 54 Mbps
  - 2.4GHz & 5GHz bands
  - OFDM, 20 MHz BW
  - 54 Mbps data rates
  - 100-200 ft range

- **802.11n**: 2009, 2.4 & 5 GHz, 600 Mbps
  - 2.4 GHz & 5GHz bands
  - OFDM, 20/40 MHz BW
  - MIMO: 2-4 antennas
  - 600 Mbps data rates
  - 200 ft range

- **VHT (Very High Throughput)**
  - **802.11ac**: (2.4 & 5 GHz bands)
  - **802.11ad**: (60 GHz Band)
  - > 1Gbps data rates

- **Original 802.11**: 1997, 2 Mbps
  - 802.11b: 1999, 2.4 GHz, 11 Mbps
  - 802.11a: 1999, 5 GHz, 54 Mbps
  - 802.11g: 2003, 2.4 GHz, 54 Mbps
  - 802.11n: 2009, 2.4 & 5 GHz, 600 Mbps
  - VHT: Being worked on
The Roadmap to 4G

Time


Data rate

<10kbps  <200kbps  300k-10Mbps <100Mbps  100M-1Gbps

Mobility

High

GSM

CDMAOne

1G

2G

High

IMT-Advanced

4G

Middle

WCDMA

CDMA2000

3G

3G+

Low

BWA/16e

802.16/WiMAX

802.11/WiFi

WLAN

802.11n/WiFi

WLAN

AMP

S

STACS

BWA/16m

1G

2G

3G

3G+

HSPA

1xEV-DO

LTE

BWA/16e

802.16/WiMAX

802.11/WiFi

WLAN

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802.11/WiFi

WLAN

802.11n/WiFi

WLAN
4G Wish List

- High Data Rates: 100 Mbps @250 km/h, 1 Gbps
- Nomadic
- Spectral Efficiency > 10bps/Hz
- Latency < 5 ms
- IP/Web based services
- Seamless connectivity and global roaming across multiple networks
- Smooth handoff across heterogeneous networks
- Guaranteed QoS for multimedia services
Key Features in 4G Networks

- New Radio Interface Protocol Features
  - OFDMA (orthogonal frequency division multiple access)
  - High order modulation
  - Interference management
  - MIMO (multi input multi output)

- Distributed Access Network Architecture
  - Flattened architecture – No BS controller
  - Direct communication among eNBs

- Packet Switched Core Network Architecture
  - IP based core network
  - IP multimedia subsystem (IMS)
Mobile Broadband Services and Trends
Mobile Broadband Evolution in Perspective
3G Will Continue to Drive Volume Into the 2010s

- HSPA subs are expected to reach ~1B by 2013
- 3G expected to enable 95% of mobile broadband subscribers by 2014
- Total 3G mobile broadband subscribers are projected to 2B by 2014

Note: 3G includes EV-DO family, HSPA family and TD-SCDMA; * number of unique wireless connections

Source: HSPA Family - Average of Strategy Analytics (May09), Informa (Oct09), Wireless Intelligence (Oct09); EV-DO Family - Average of SA (May09), Informa (Oct09), Wireless Intelligence (Oct09); WiMAX - In-stat (Oct09); LTE - Average of Strategy Analytics (May09) and ABI (Sep09); TD-SCDMA - Average of Strategy Analytics (May09), Informa (Oct09), Wireless Intelligence (Oct09).
Mobile Service Evolution At a Glance

Services Evolution

Text Messaging  Ringtones  MMS  Music & Video on Demand  Blogging Social Networking  RSS Feeds & Tagging  Advertising & Recommend
Creating New Mobile, Computing and CE Device Categories
Smartphones

- Currently smartphones are at the center of ‘converged’ mobile, computing and CE devices.

- A smartphone is a mobile phone that offers more advanced computing ability and connectivity than a contemporary basic feature phone - Wikipedia.
Smartphones

- Phones embed OS designed for supporting user App
- Wireless devices become computers
- Computers adding wireless
  - WWAN, WPAN, FM, GPS, NFC
- Phones become ‘Mobile Internet Devices’
- Phones become consumer electronics
  - Include all consumer electronic functions except air-conditioner and refrigerator
- Voice centric -> data centric service
  - Multi-media services
  - Provides service for information, entertainment, communication, education, …
- Smartphones keep evolving
  - UI, Functions, Services, Display, …
Wireless Technologies for Smartphones

- **WWAN (Wireless Wide Area Network) Technology**
  - Basic for mobile communication (2G, 3G, 4G)
- **WLAN (Wireless Local Area Network)**
  - Broad WLAN coverage
  - Provides high speed data service
- **WPAN (Wireless Personal Area Network) Technology**
  - Bluetooth
    - a standard feature in smartphones
    - hands-free mobile phone usage
  - RFID
  - NFC
- **FM Radio**
  - a mobile application option or widget
- **GPS (Global Positioning System)**
  - GPS is nearly standard on all smartphones
  - Critical for location based service
Mobile Broadband
Silicon Vendors and Solutions
Silicon Vendors for Baseband and Applications Processors

- **Baseband Silicon Vendors**
  - Qualcomm, Intel, Renesas, ST-Ericsson, Icera (Nvidia), MediaTek, Broadcom, Spreadtrum, HiSilicon

- **Applications Processor Silicon Vendors**
  - Qualcomm, Texas Instruments, Renesas, Broadcom, Marvel, Samsung, Intel, ST-Ericsson, Nvidia, Telechips, Freescale

- **Baseband-integrated Applications Processors**
  - Qualcomm, Broadcom, ST-Ericsson, Marvell, MediaTek
Modem Evolution and Technology Leadership (QCOM)

- **HSPA+**
  - 103 Launches
  - 148 Network Commitments
  - 13 Multi-Carrier

- **REV A and B**
  - 107 Commercial Networks
  - 33% Growth YoY
  - 7 KDDI REV B Devices

- **LTE**
  - 17 Launches
  - 128 Network Commitments
  - 14 LTE TDD Trials

- **MDM 9x00 LTE Cat3**
- **MDM 8650 DO RevB**
- **MDM 8220 DC-HSPA+**
- **MDM 8200 HSPA+**

- **FEB 2009**
  - HSPA+ 21Mbps

- **AUG 2010**
  - DC-HSPA+ 42Mbps

- **JAN 2010**
  - EV-DO RevB

- **NOV 2010**
  - 4G LTE

Modem Technology Enhancements (QCOM)

- **HSPA+**
  - 84 Mbps Rel-9
  - 42 Mbps Rel-8 integration/optimization

- **CDMA2000**
  - 1xAdvanced
  - EV-DO Advanced

- **LTE**
  - LTE FDD/TDD, TD-SCDMA
  - 100 Mbps Cat3 integration/optimization

- **3G Advanced Receivers**

- **28nm HSPA+**
  - 84 Mbps

- **28nm Integrated LTE / 3G Multimode**

- **MDM 9615**
  - LTE Cat3
  - TD-SCDMA

- **MDM 8225**
  - HSPA+ 84 Mbps

- **MDM 8215**
  - DC-HSPA+ TD-SCDMA

- **MSM 8270**
  - DC-HSPA+

- **MSM 8960**
  - LTE Cat3
  - HSPA+/DO

- **MSM 8270**
  - DC-HSPA+

- **MSM 8960**
  - LTE Cat3
  - HSPA+/DO
LTE / 3G Multimode Device Evolution Strategy (QCOM)

- **3G Coverage**
  - LTE data only
  - LTE coverage

**3G Data Coverage/Roaming**
- LTE data only
- LTE coverage

**3G Voice Coverage/Continuity and Roaming**
- LTE data only
- LTE coverage

**3G Simultaneous Voice/Data**
- VoLTE
- CSFB and SVLTE

**Simultaneous VolP and LTE data**
- LTE data only
- LTE coverage

**VoLTE with 3G VolP or SR-VCC**

**Initial Launches**
- Data Cards

**Initial Voice Solution**
- LTE Data Handsets

**Long Term Voice Solution**
- LTE VoIP Handsets
Thank You!