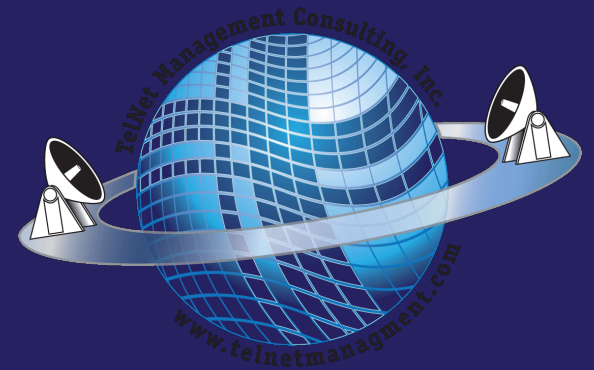**IEEE Central Texas
Consulting Network**

Technical Trends in Telecom/Datacom Drive New Wave of Architectural Design and New Market Opportunities

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Technical Trends in Telecom/Datacom Drive New Wave of Architectural Design and New Market Opportunities

Objective:

Gain a deeper understanding of Telecom/Datacom trends and the identification of emerging market opportunities

Presentation theme

» provides a macro view of technological trends

» discuss impact on semiconductor SoC architectural design

» provide examples covering value chain from semiconductor to service providers for some vertical markets.

Key Topics

» Market Trends in mobility/internet, video/multimedia, computing/storage

» Semiconductor process technology, SoC Architecture

  • multicore, virtualization, power management

» Application example - LTE

Technology Trend – Systems/Devices

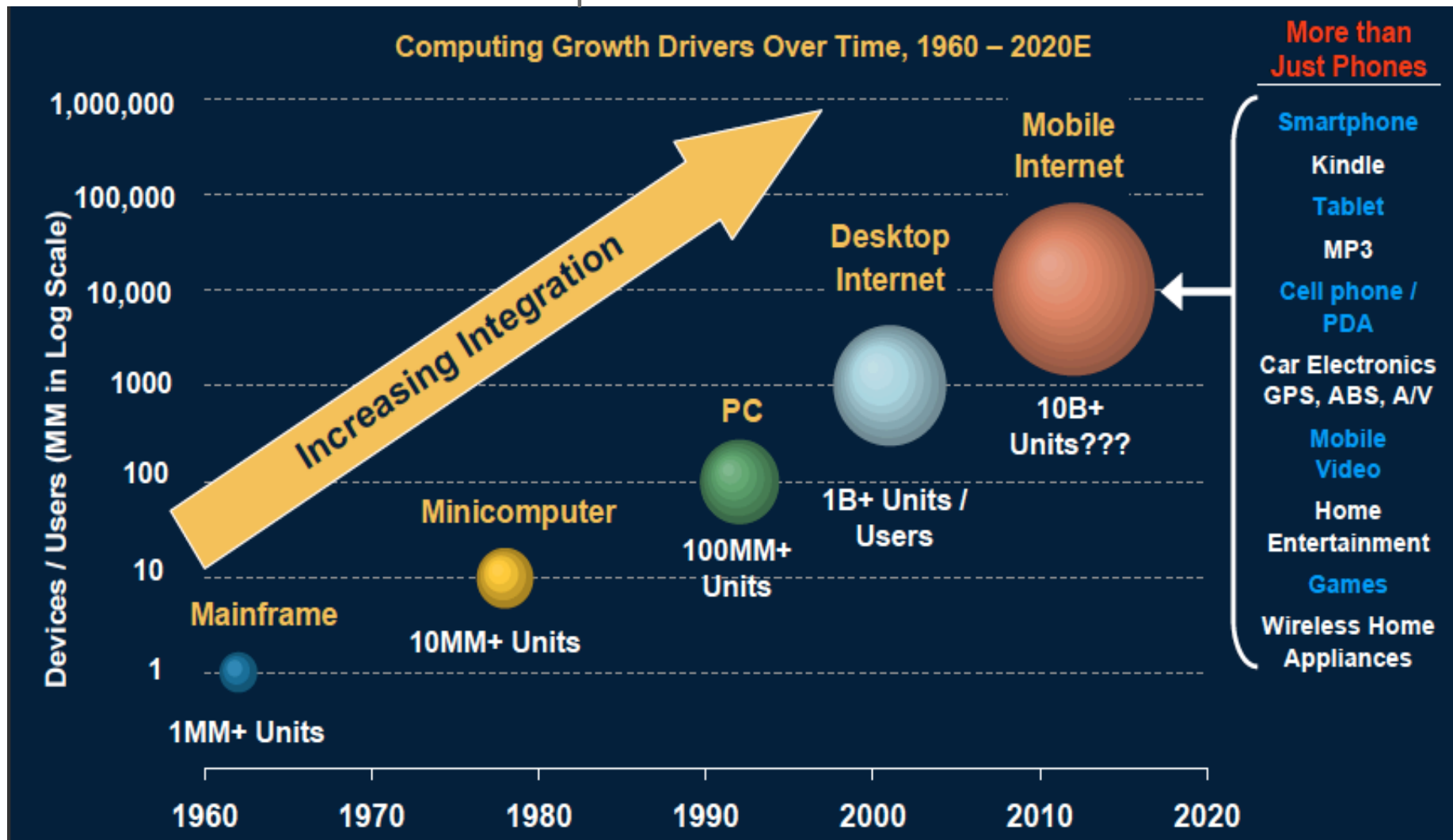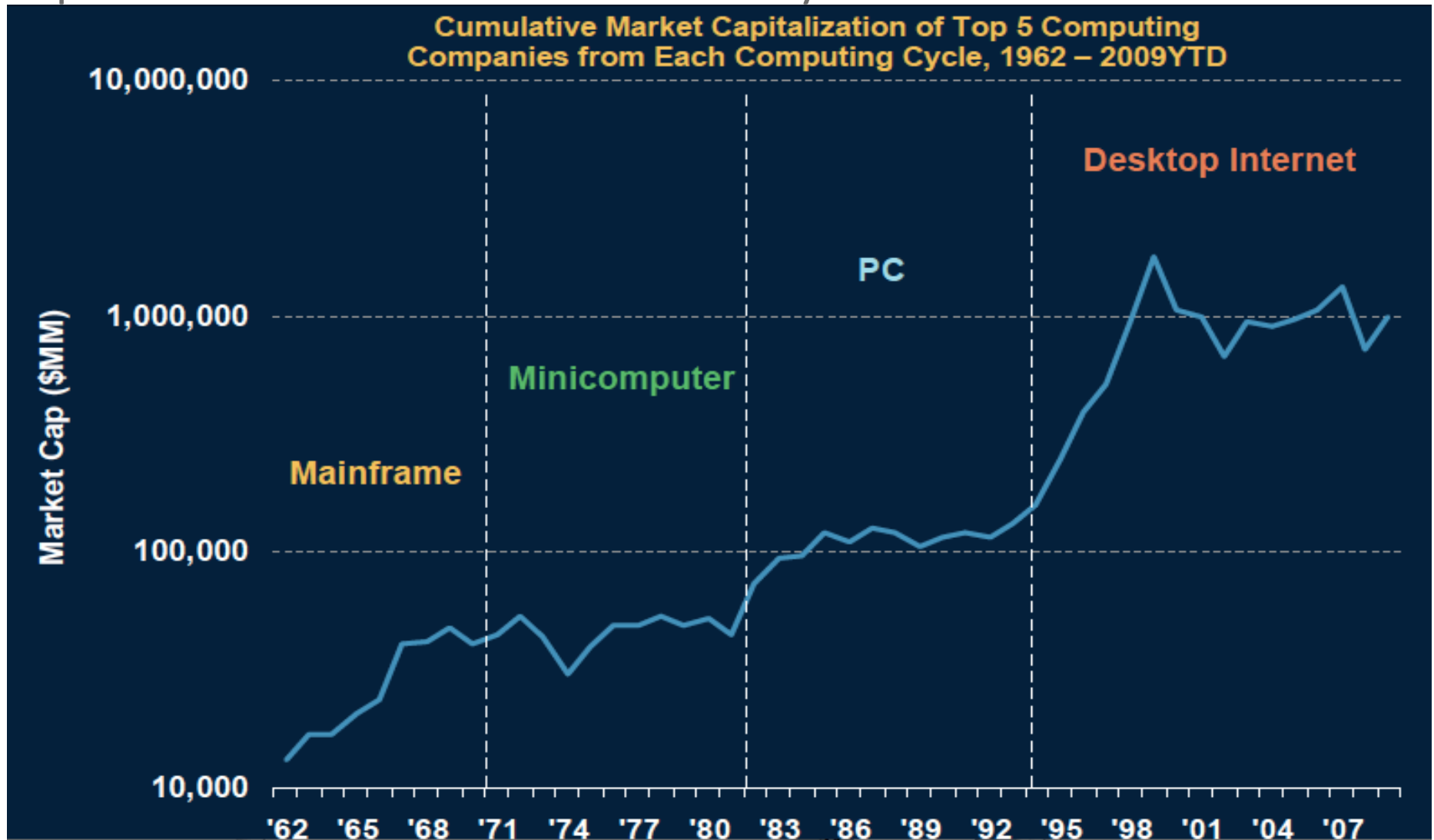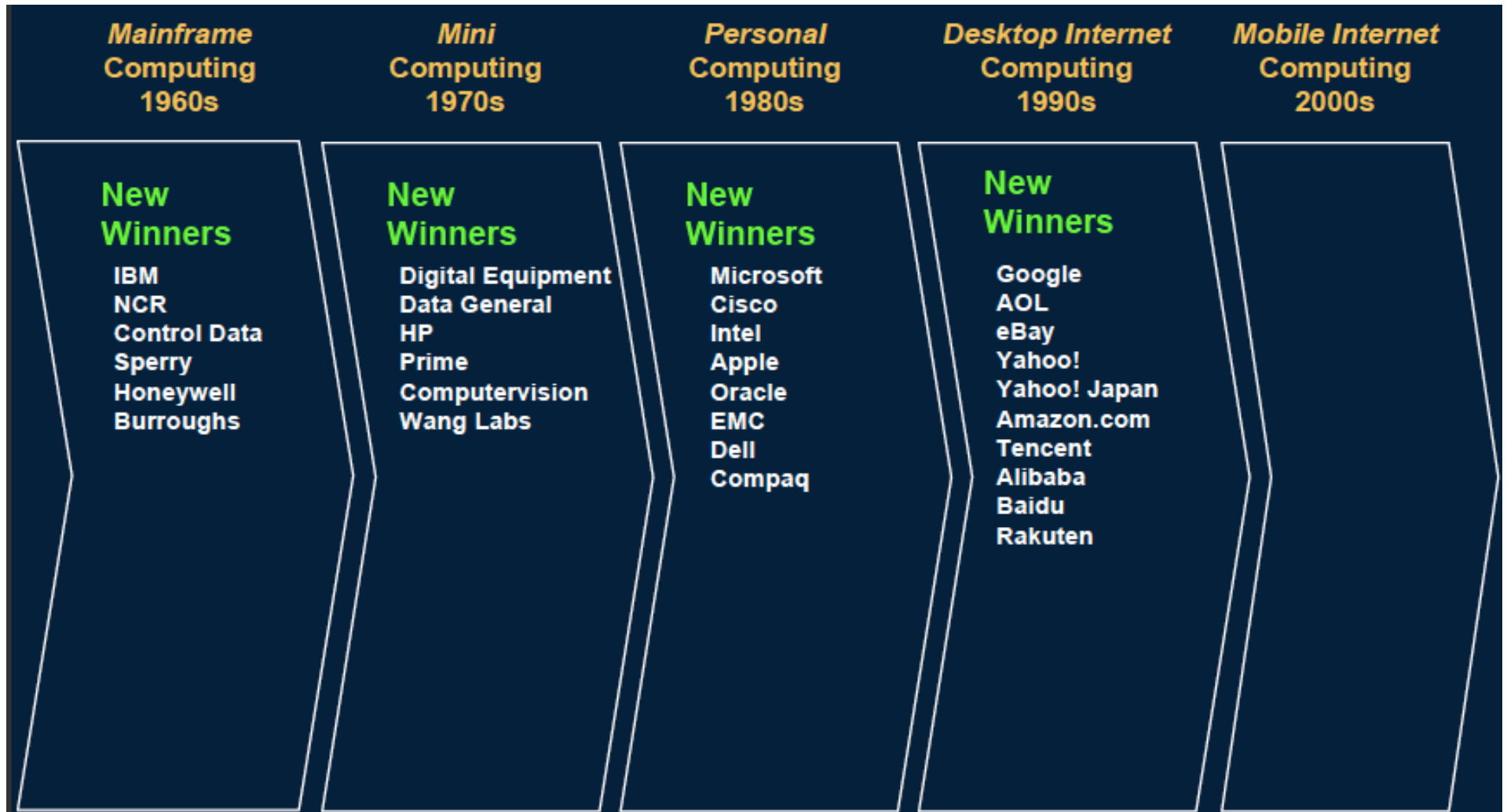| Mainframe Computing 1960s	Mini Computing 1970s	Personal Computing 1980s	Desktop Internet Computing 1990s	Mobile Internet Computing 2000s

New Computing Cycle Characteristics
Larger capacity + Better Processing Power + Improved User Interface + Smaller Form Factor + Lower Prices + Expanded Services = **10x More Devices**

Winners of Each New Cycle Often Create More Market Capitalization than Winners of Prior Cycles

Cumulative Market Capitalization of Top 5 Computing Companies from Each Computing Cycle, 1962 – 2009YTD

Technology Wealth Creation / Destruction Cycles

Mainframe Computing 1960s	Mini Computing 1970s	Personal Computing 1980s	Desktop Internet Computing 1990s	Mobile Internet Computing 2000s
New Winners	**New Winners**	**New Winners**	**New Winners**	
IBM	Digital Equipment	Microsoft	Google	
NCR	Data General	Cisco	AOL	
Control Data	HP	Intel	eBay	
Sperry	Prime	Apple	Yahoo!	
Honeywell	Computervision	Oracle	Yahoo! Japan	
Burroughs	Wang Labs	EMC	Amazon.com	
		Dell	Tencent	
		Compaq	Alibaba	
			Baidu	
			Rakuten	

New Companies Often Win Big in New Cycles While Incumbents Often Falter

Market Trends
     Drivers
          Mobility/Internet
               Smart Devices
                    Wireless Infrastructure

Key Drivers

Bandwidth Explosion

Video
Social Networking
Device Explosion

Converged Networks

Users & Data on the Move
Access any data, any device

Energy Management

PoE
Energy Efficient Ethernet

Incredible network growth!
By 2014…

- Annual global IP traffic will increase by 4x
  - Growing from 176 exabytes to three-quarters of a zettabyte (767 exabytes) in four years

  1 ZB = (1,000,000,000,000,000,000,000 bytes = 10^{21})

- Drivers? Video and mobile data
  - Video (TV, VoD, Internet Video, and P2P) will exceed 91 percent of global consumer traffic
  - Internet video will grow from 33% to over 57% of Internet traffic (12 billion DVDs)
  - Mobile data traffic will double every year, increasing 39 times
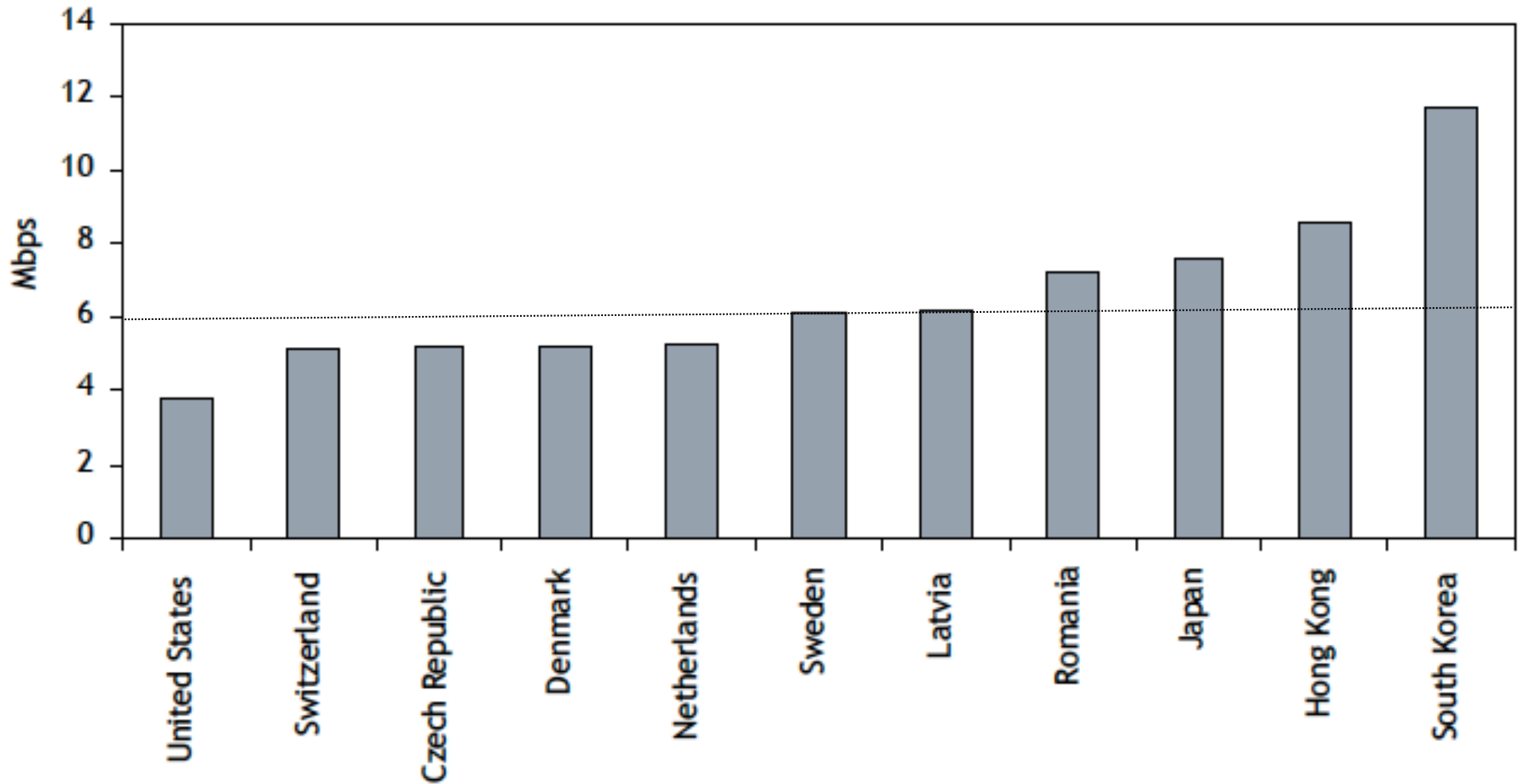 - Peer-to-peer no longer the most voluminous, but still substantial

44.5% CAGR

Implications?
N x 10 Gbps 40 and 100 Gbps interfaces will not only be introduced, but will be commonplace in the coming years

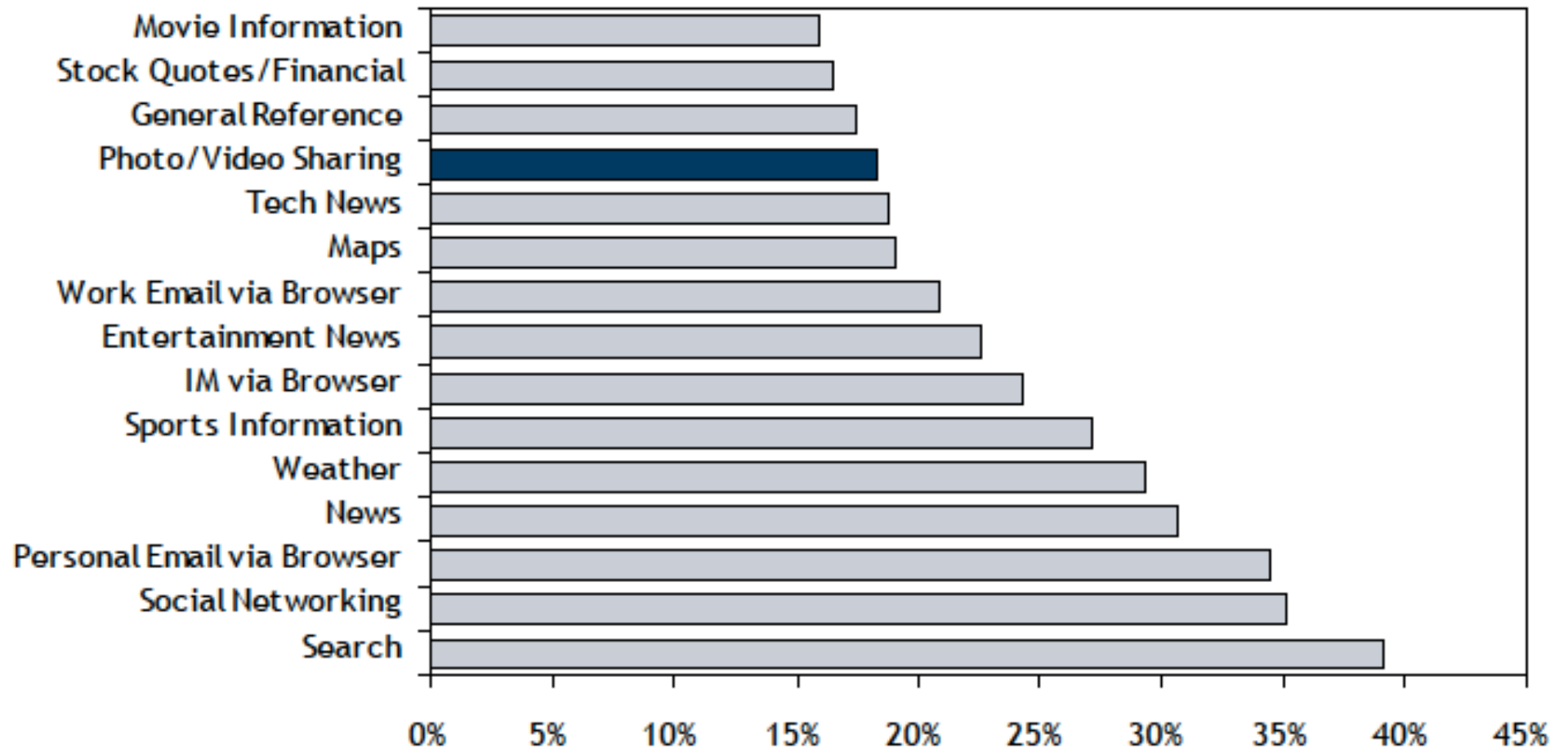Source: *Cisco Visual Networking Index: Forecast and Methodology, 2009-2014*

Average Measured Connection Speed by Country/Region
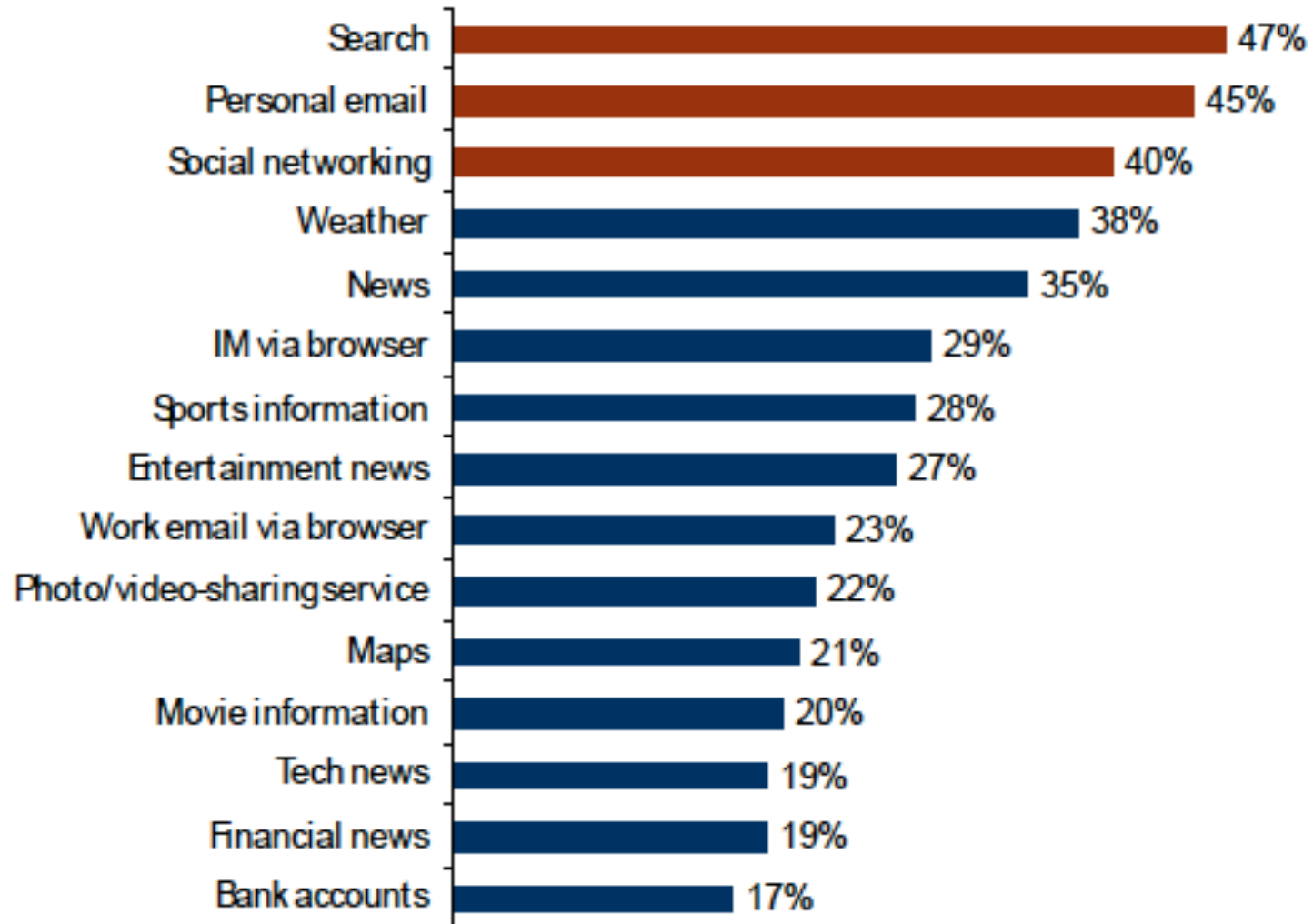

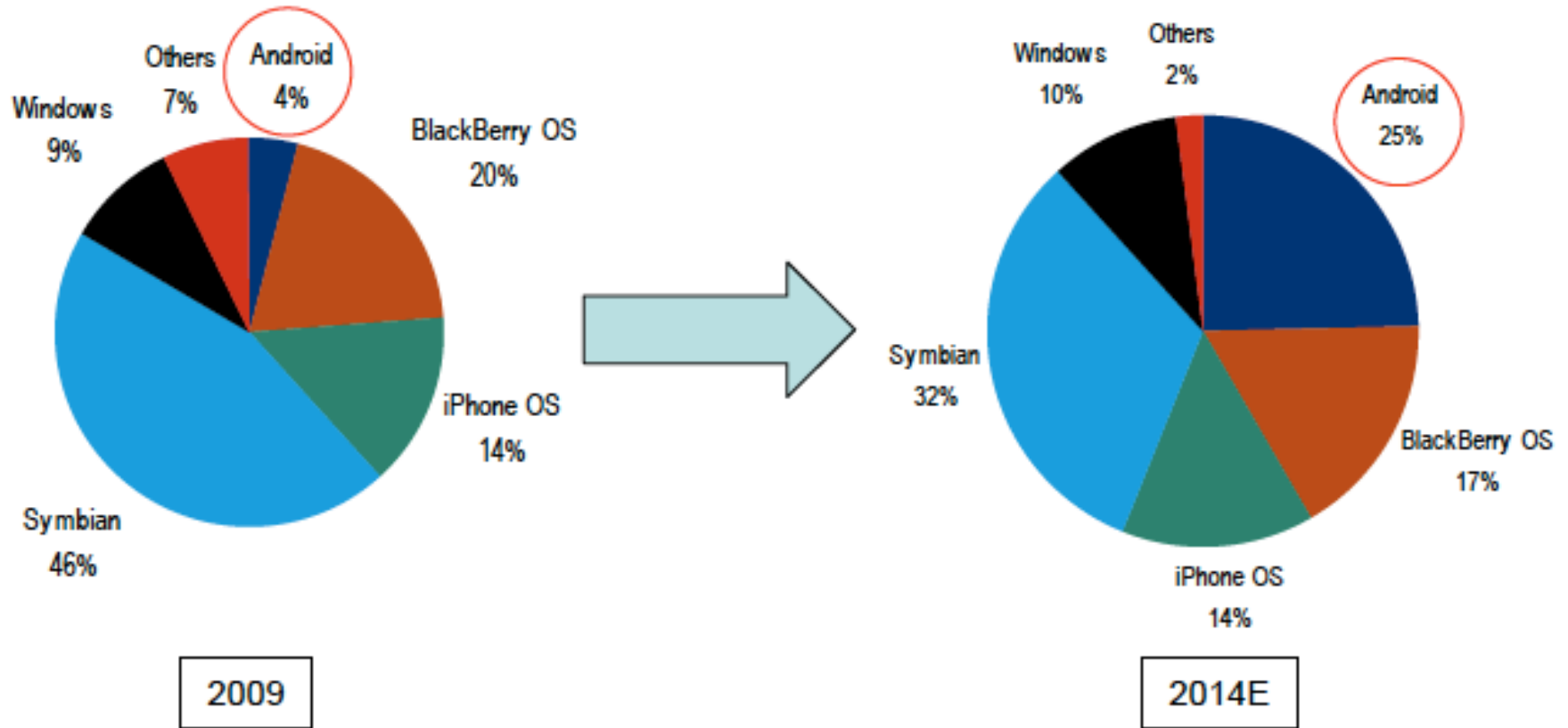Source: Akamai

Primary Users of Mobile Internet

Source: comScore

Leading categories for mobile browsing among US mobile subscribers

Category	Percentage
Search	47%
Personal email	45%
Social networking	40%
Weather	38%
News	35%
IM via browser	29%
Sports information	28%
Entertainment news	27%
Work email via browser	23%
Photo/video-sharing service	22%
Maps	21%
Movie information	20%
Tech news	19%
Financial news	19%
Bank accounts	17%

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Estimated WW Smartphone Shipments by Operating System, 2009-2014

Android OS share of the overall smarphone market is expected to grow

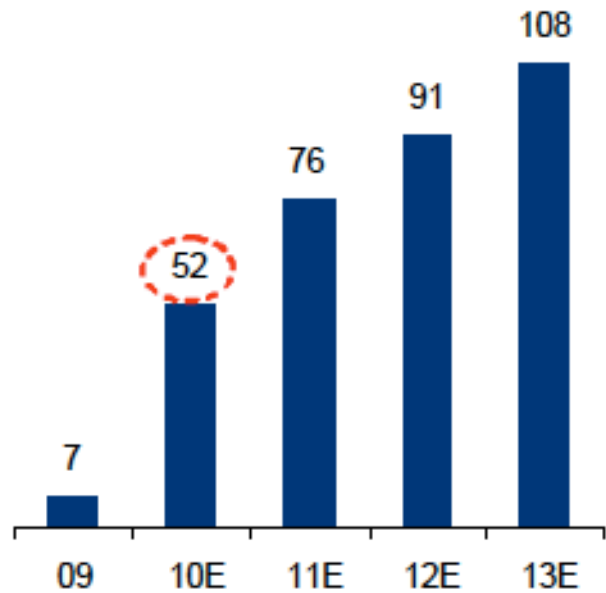# Estimated WW Smartphone Shipments by Operating System, 2009-2014

Operating System	2009	2010E	2011E	2012E	2013E	2014E
Android	7,062	51,821	76,177	91,412	107,866	124,585
Y/Y growth	NA	634%	47%	20%	18%	16%
BlackBerry	34,500	48,705	58,659	67,125	76,520	86,994
	NA	41%	20%	14%	14%	14%
iPhone	25,077	41,046	49,042	55,344	63,646	71,920
	NA	64%	19%	16%	15%	13%
Symbian	77,919	104,690	114,909	126,917	144,848	163,558
	NA	34%	10%	10%	14%	13%
Windows	16,205	17,995	27,933	35,986	42,519	49,474
	NA	11%	55%	29%	18%	16%
Others	12,697	11,046	10,494	10,074	9,772	9,674
	NA	-13%	-5%	-4%	-3%	-1%
Total	173,459	275,302	337,213	386,857	445,171	506,205
	NA	58.7%	22.5%	14.7%	15.1%	13.7%

Source: BofA Merrill Lynch Global Research estimates, IDC, Gartner

Store	Apps
Apple App Store	300,000
Google Android Market	100,000
Blackberry App World	10,000
Nokia Ovi	10,000e
Palm App Catalog	4,000
Windows Phone 7 Marketplace	1,000

Sources: Company data and PJC

Android smartphone shipments (M)

108

91

76

52

7

09   10E   11E   12E   13E

Source: BofA Merrill Lynch Global Research estimates, IDC

Android Platform

Application
Developers

Internet
Companies

Device Manufacturers

Mobile Search

Apps

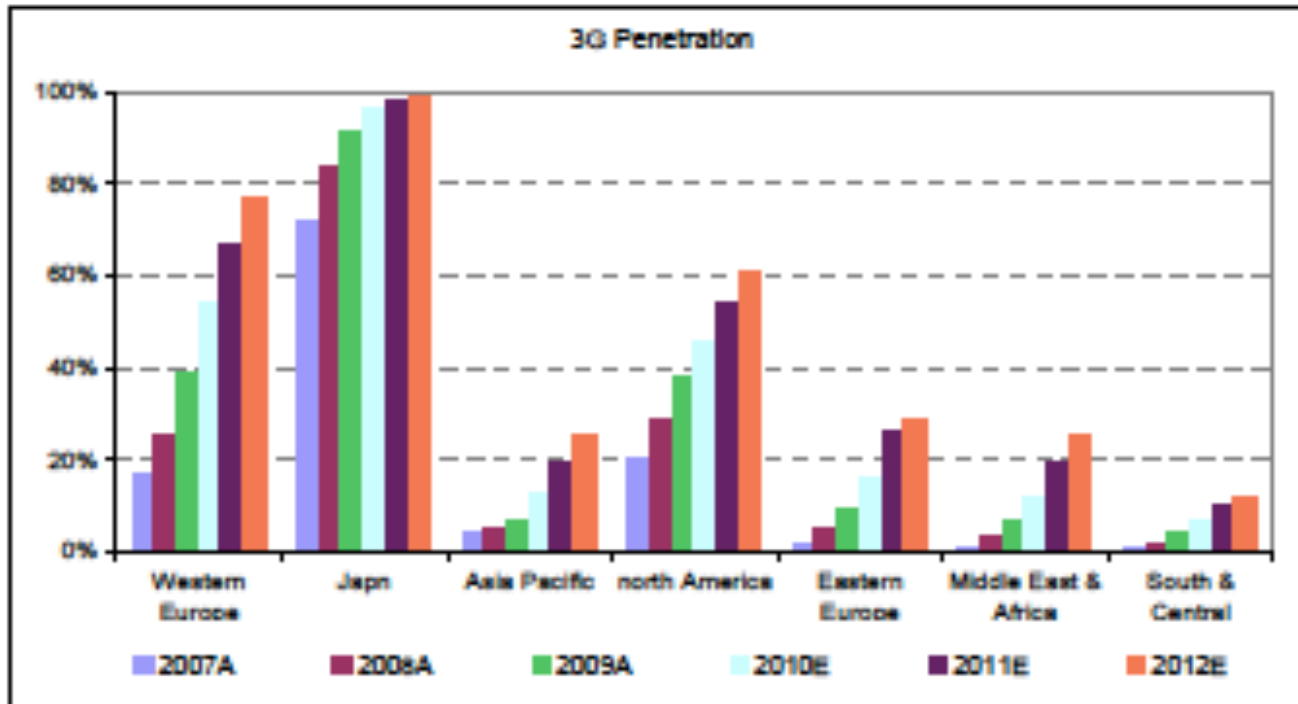Paid Media

Network Carriers

Mobile

Google checkout
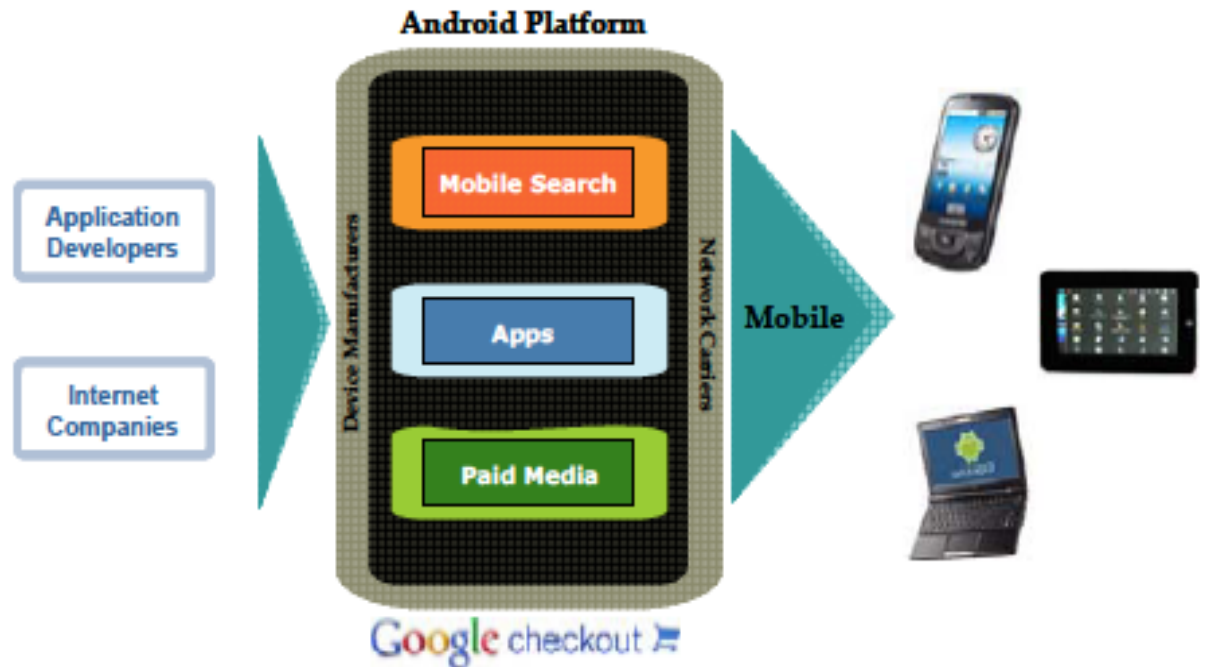
Source: BofA Merrill Lynch Global Research, IDC, Google

Android Ecosystem

3G Penetration rate by Regions

Source: Morgan Stanley Research

Infrastructure market share trends

Overall share (%)	2002	2003	2004	2005	2006	2007	2008	2009	2010E	2011E
Ericsson	24%	25%	27%	28%	30%	32%	34%	32%	33%	33%
Nokia Siemens	23%	24%	23%	24%	24%	19%	19%	16%	15%	15%
Alcatel-Lucent	20%	17%	16%	16%	14%	13%	11%	9%	10%	10%
Huawei	1%	1%	2%	3%	4%	8%	9%	11%	14%	15%
ZTE	1%	2%	2%	2%	2%	4%	4%	8%	9%	9%
Motorola	11%	11%	12%	11%	10%	9%	8%	7%	6%	5%
Nortel	9%	10%	9%	7%	6%	7%	6%	4%	-	-
Samsung	2%	2%	1%	1%	1%	1%	1%	3%	3%	3%
LG	1%	0%	0%	1%	0%	0%	1%	1%	1%	0%
Others	7%	8%	7%	7%	7%	6%	7%	9%	9%	8%
Global	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Company data, Infonetics, Credit Suisse estimates
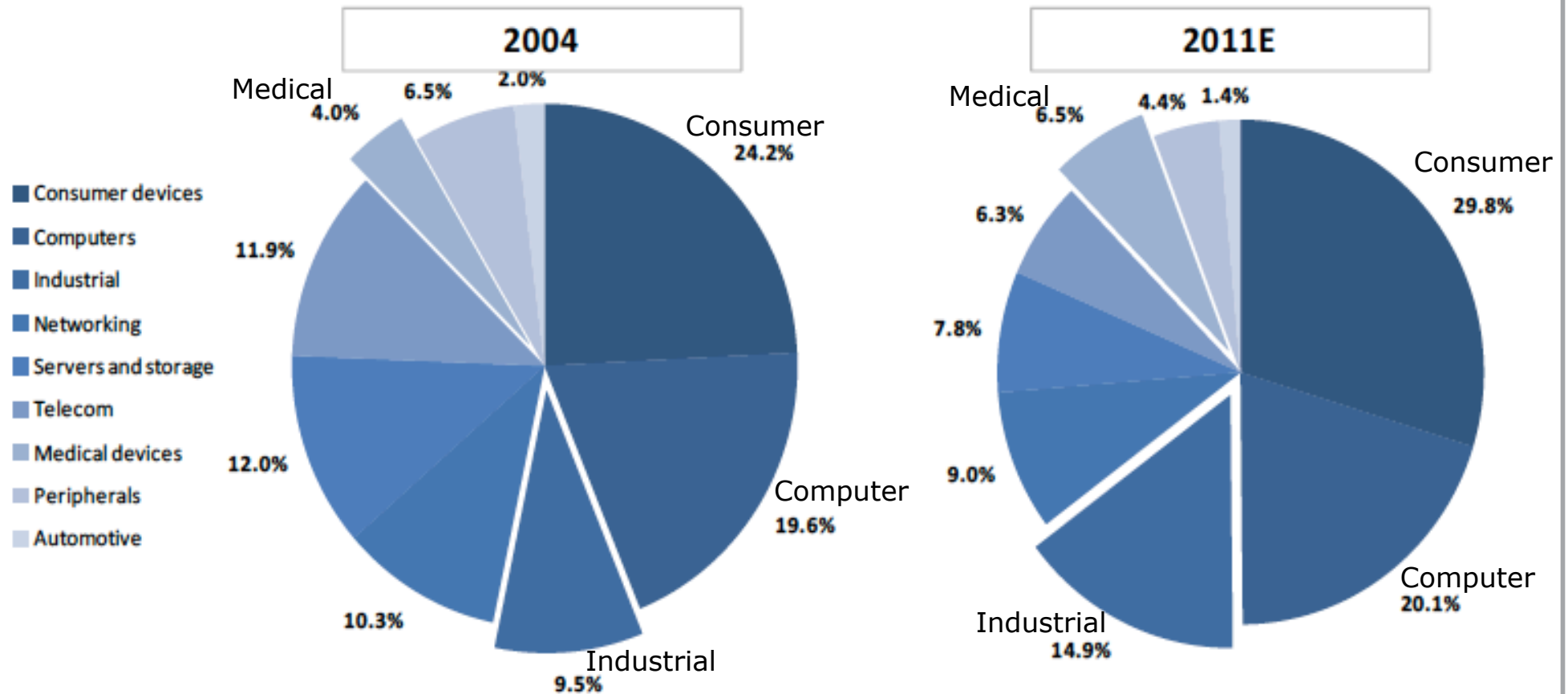
Other Markets

Industrial/Medical

LAN Switching

PBX

Video/ Large Screen

Market segment growth
Industrial & Medical end markets are becoming important, growing sharply

2004

Medical 4.0%   6.5%   2.0%

Consumer 24.2%

11.9%

12.0%

Computer 19.6%

10.3%

Industrial 9.5%

Legend:
- Consumer devices
- Computers
- Industrial
- Networking
- Servers and storage
- Telecom
- Medical devices
- Peripherals
- Automotive

2011E

Medical 6.5%   4.4%   1.4%

Consumer 29.8%

6.3%

7.8%

9.0%

Computer 20.1%

Industrial 14.9%

Source: IDC and Goldman Sachs Research.

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Applications, Infrastructure, and System management Software, Along with Storage Hardware, Expect the Largest Incremental Spending Increases in 2010
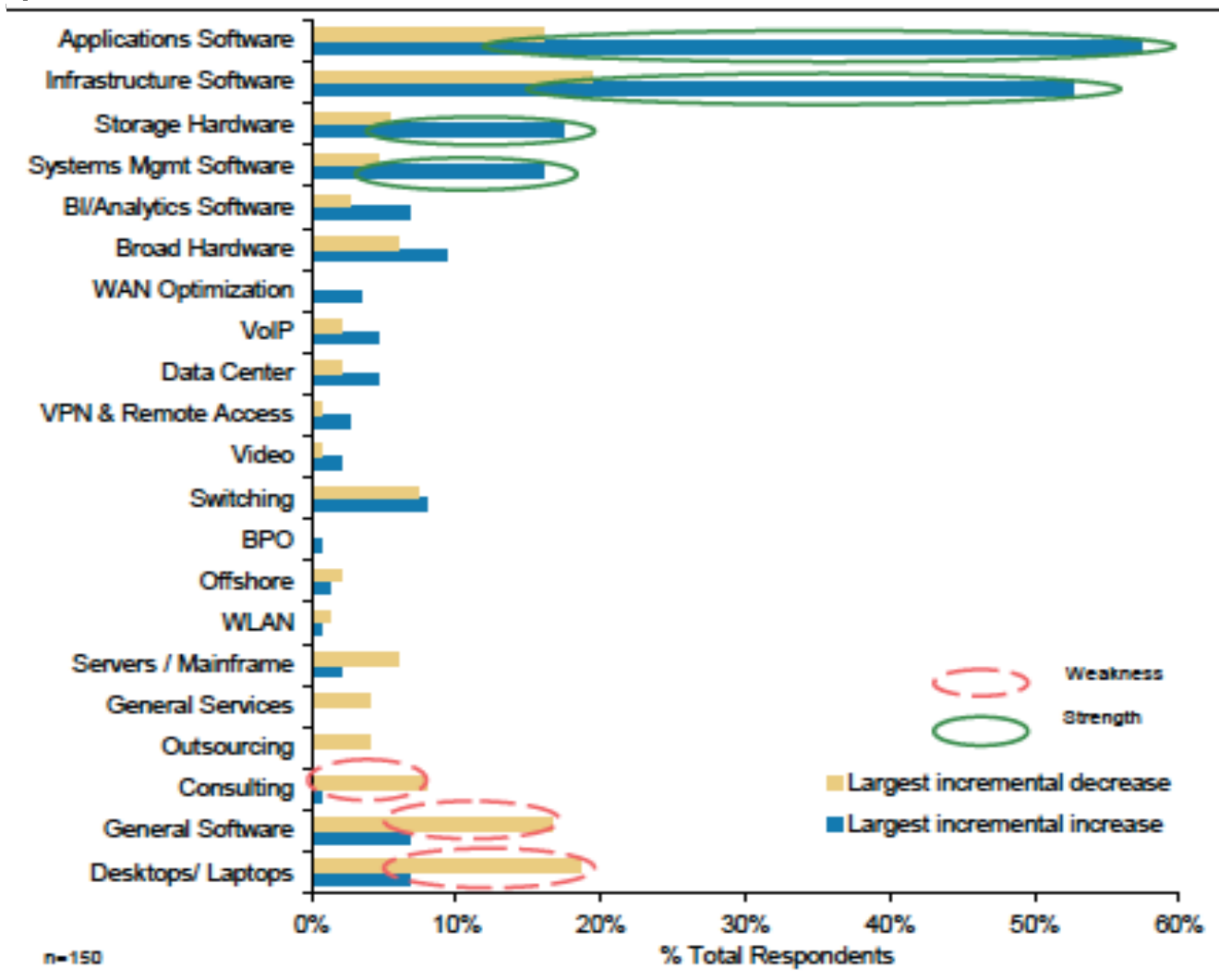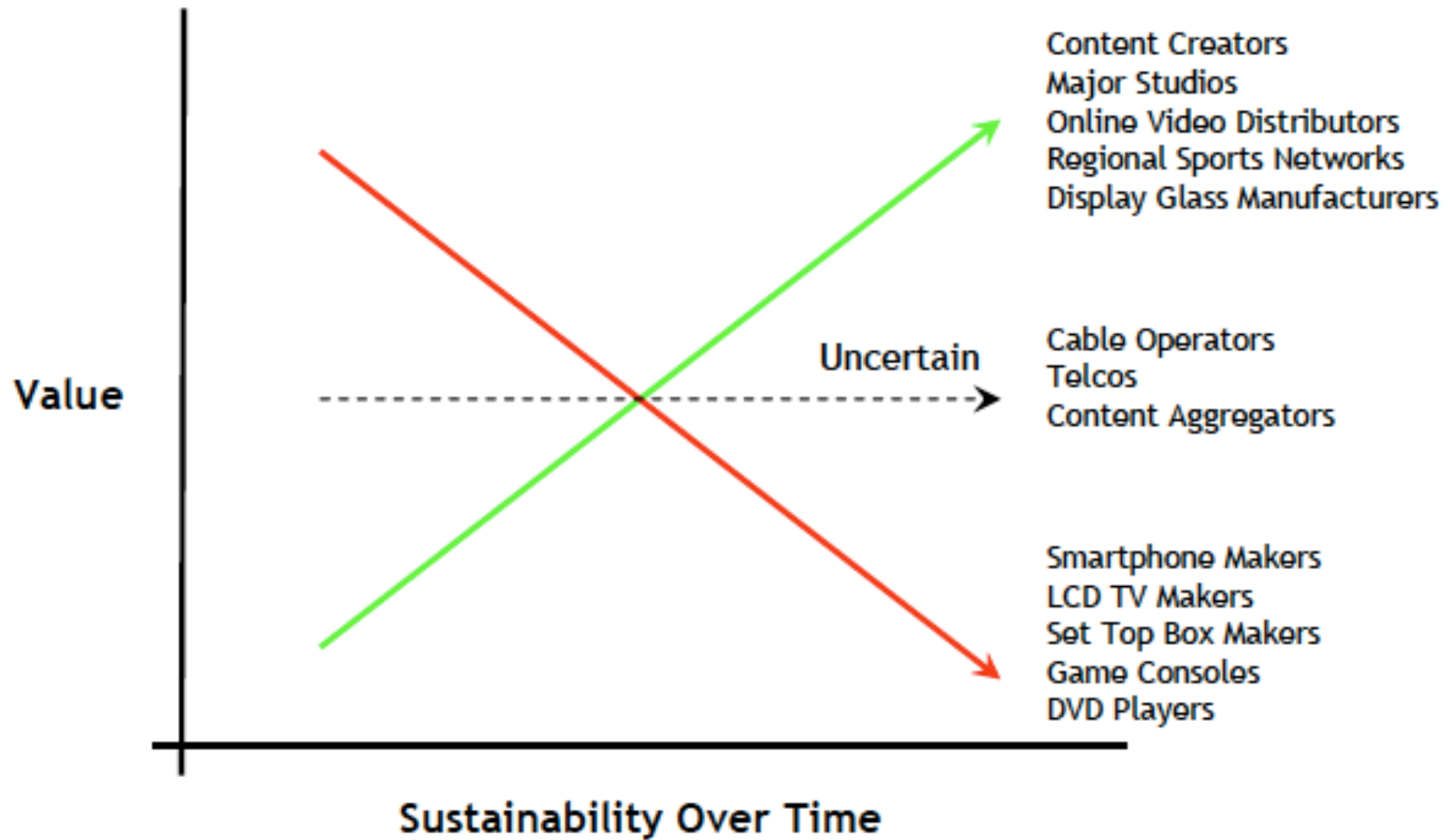

Source: Morgan Stanley CIO Survey

More respondents expect to increase LAN switching expenditures over next 12 months
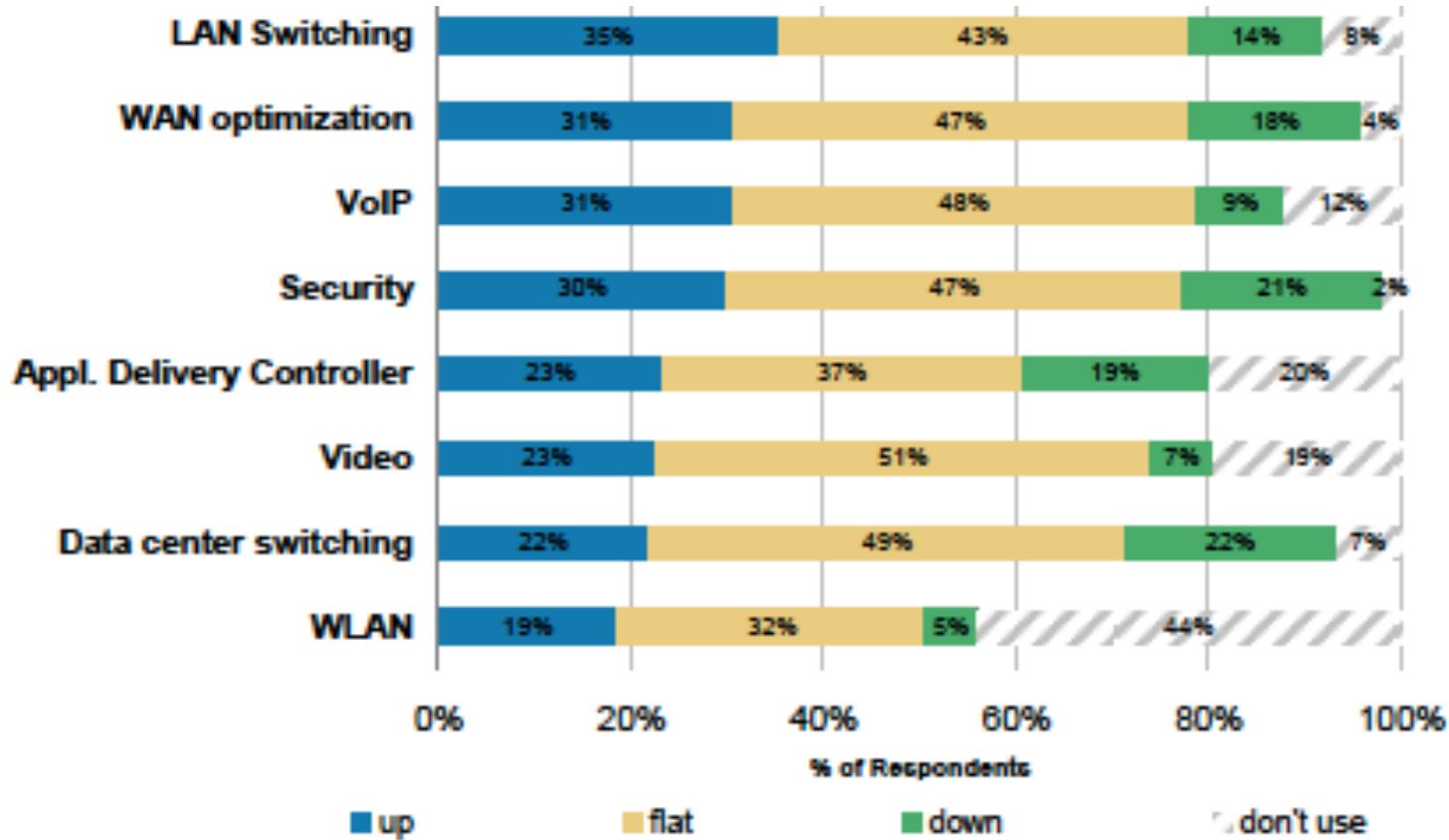
The Potential Video Value Shift

Content Creators
Major Studios
Online Video Distributors
Regional Sports Networks
Display Glass Manufacturers

Uncertain

Cable Operators
Telcos
Content Aggregators

Smartphone Makers
LCD TV Makers
Set Top Box Makers
Game Consoles
DVD Players

Value

Sustainability Over Time

Source: RBC Capital Markets, Diagram is not to Scale

Screens driving towards 165 diagonal inches

Source: Company reports, RBC Capital Markets

Other Markets Cont'd
Cloud Computing
Server/Storage

# Cloud Computing, Server, Storage, Data Center

Server growth is estimated at 7% for 2011
Buying patterns may have begun a transformational shift towards virtualization:

• Towards cloud service providers and web giants (Amazon, Google, Microsoft)

• Away from corporations

• 2013 server growth rate will be negative driving further consolidation in the industry (storage and software)

• Virtualization technology is driving dynamic change in the data center and increasing the adoption rate of cloud computing (both public and private)

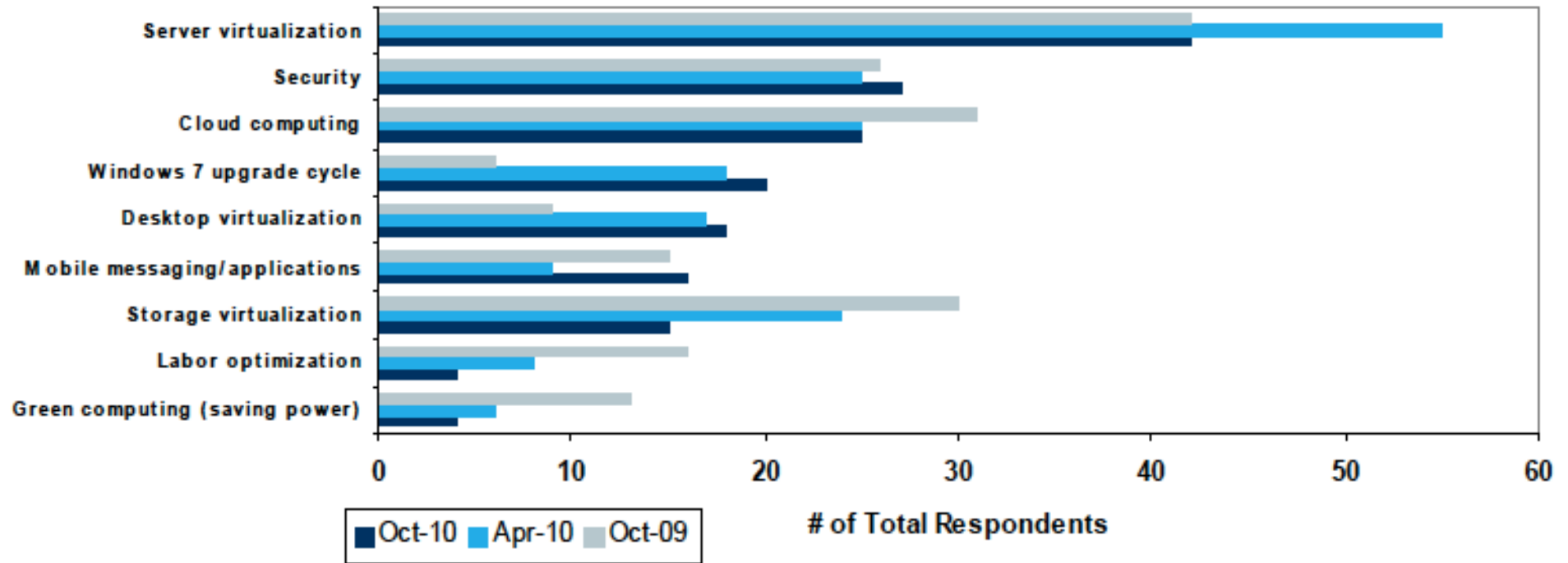• Biggest winners are storage solution providers and big system vendors

Where is your firm with regard to Server Virtualization?
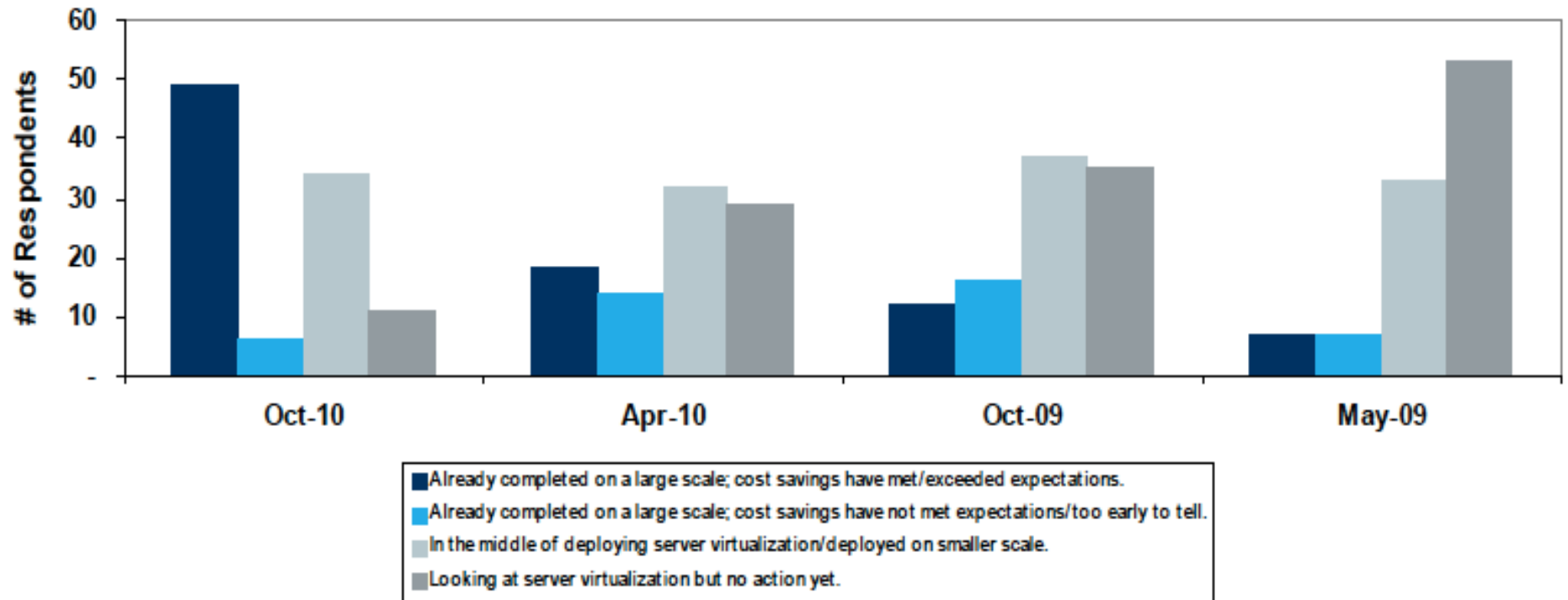
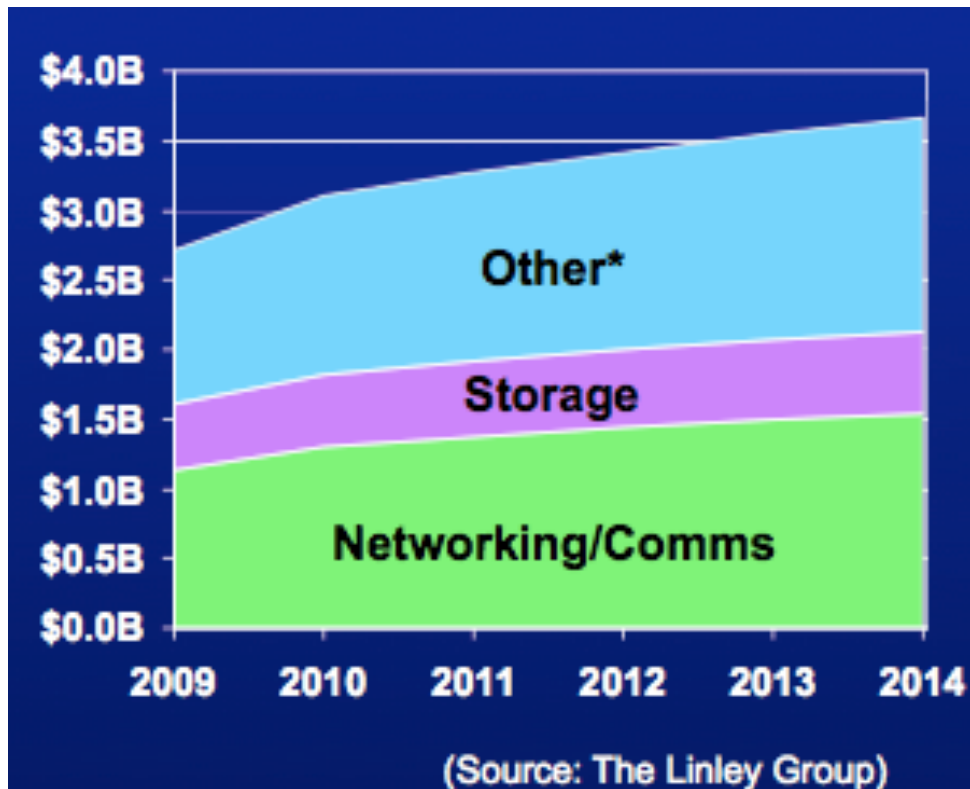Source: Barclays Capital CIO Survey October 2010

Biggest Trends Driving Spend Decisions into 2011

Source: *Barclays Capital CIO Survey October 2010*

High Speed Embedded Processors

Chart: Market size ($B) 2009–2014 stacked area showing Other*, Storage, Networking/Comms
(Source: The Linley Group)

*POS terminals, kiosks, industrial, imaging, mil/aero…

- Total 2010 market is $3.1 billion
  - 42% nw/comms
  - 16% storage
  - 42% "other"
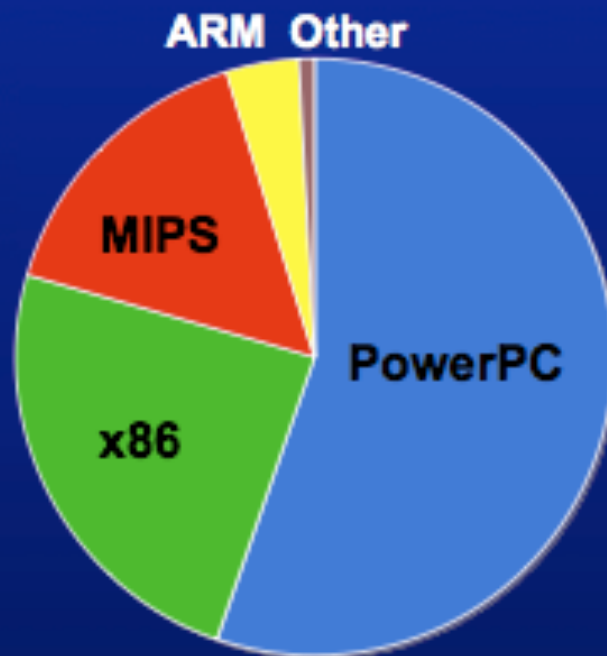- Rebound in 2010 drives 14% surge
- Steady growth of 4%–5% after that

Semiconductor
Process Technology
SoC Architecture Design

Multicore

Virtualization

Power Management

Architecture Usage

Networking and Comms, 2009

Pie chart showing architecture usage in Networking and Comms, 2009: PowerPC, x86, MIPS, ARM, Other

(Source: The Linley Group)

- PowerPC is most popular for both networking and telecom equipment
  - Cisco, Huawei, Alcatel…
- x86 used mainly in high-end NAS and security
- MIPS gaining share
  - Due to Cavium, RMI
- ARM gaining share in NAS
  - Due to Marvell

New Networking System Driver
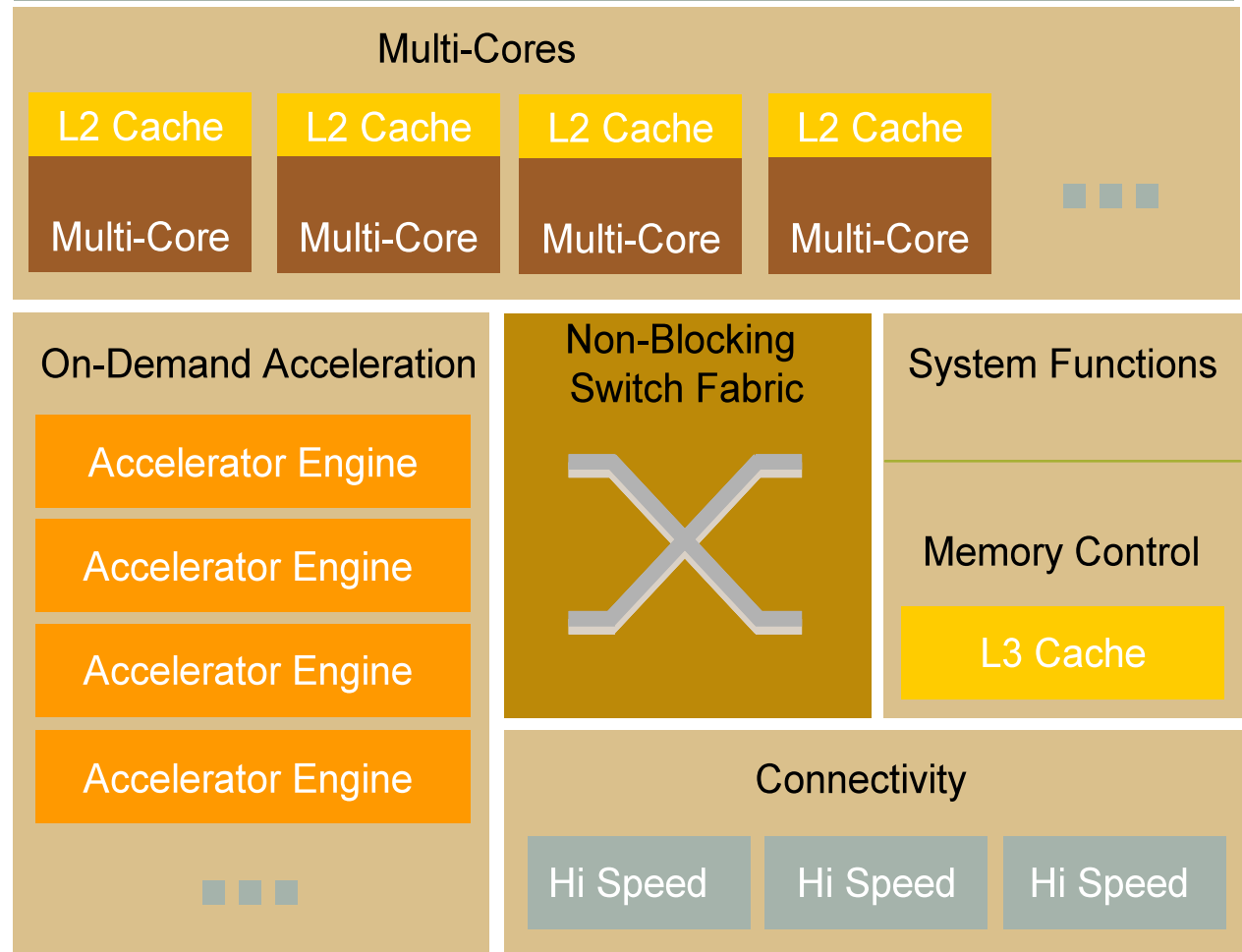## Multi-Core/Accelerator Engine SoC - Architecture template

Goals
- Performance
- Ease of use, programmability

Components
- On-chip fabric/cache
- 32+ cores
- Serdes
- Accelerator engine app-specific

Multi-Core/Accelerator Engine Platform (SOC-MC/AE Architecture)

Multi-Cores

| L2 Cache | L2 Cache | L2 Cache | L2 Cache |
| Multi-Core | Multi-Core | Multi-Core | Multi-Core |

On-Demand Acceleration

Accelerator Engine

Accelerator Engine

Accelerator Engine

Accelerator Engine

Non-Blocking Switch Fabric

System Functions

Memory Control

L3 Cache

Connectivity

| Hi Speed | Hi Speed | Hi Speed |

SoC Networking System Driver

Multi-Core/Accelerator Engine SoC - Architecture template

The MC/AE architecture is designed not only to provide superior performance and energy efficiency, but also to ease the industry's transition to multicore processors via explicit investment in the complementary software enablement ecosystem.

We see that

(a) geometric scaling is inherent in the scalable on-chip switch fabric, scalable multicores, three-level cache hierarchy, and high-speed connectivity;

(b) *equivalent scaling* is inherent in the integration of on-demand accelerator engines; and

(c) *functional diversification* is inherent in a hybrid simulation environment and enablement ecosystem.

A white paper describing details of the SOC Networking MC/AE platform architecture is separately available.
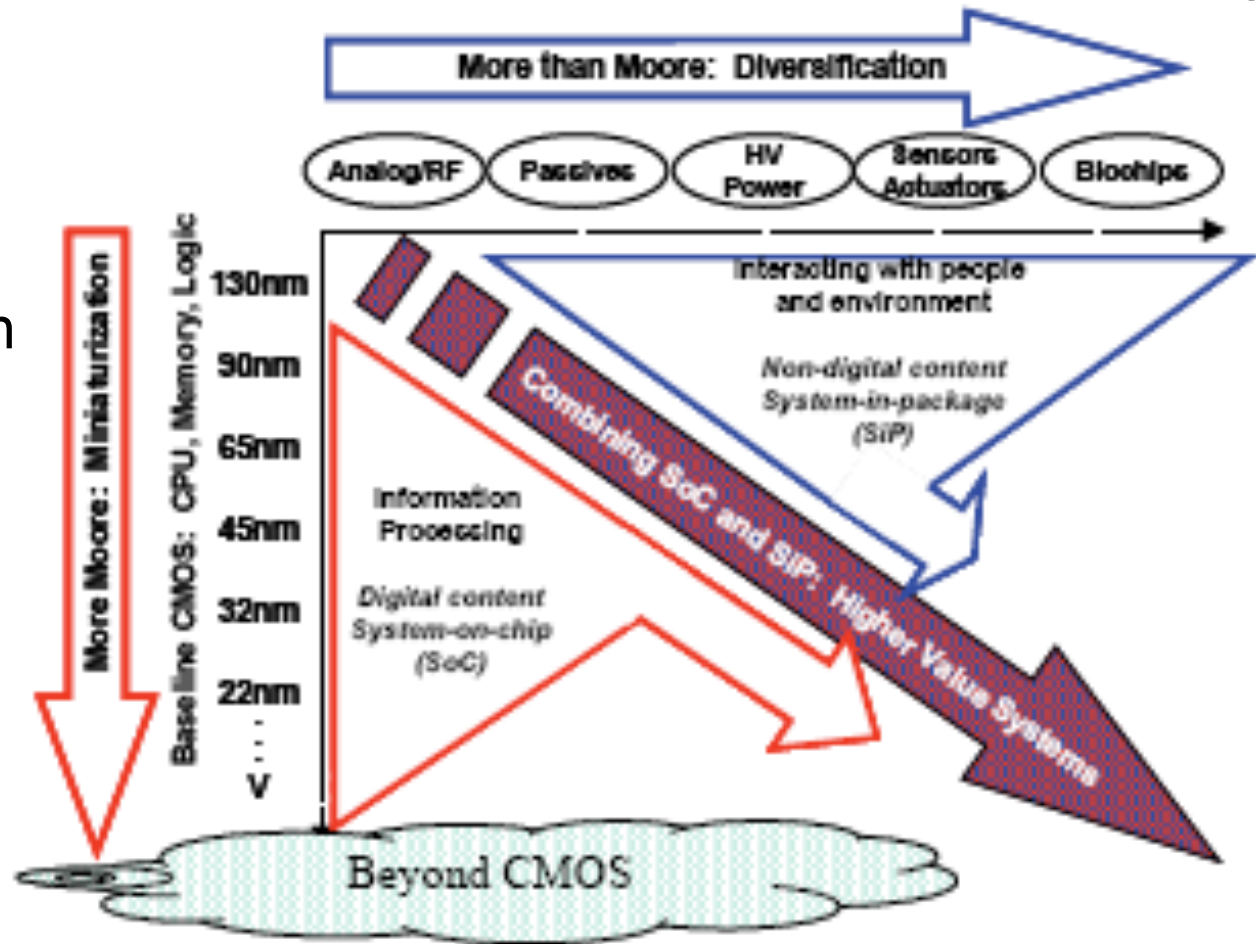
SoC *Networking* System Driver

Multi-Core/Accelerator Engine SoC - Architecture template

CMOS challenge next 15 years

New approach - Post CMOS

-Reduce cost-per-function

-Increase performance

-Scaling: no of devices + new manufacturing + design paradigms

System-in-package – SiP Integration of CMOS and non-CMOS within a single package

Year of Production	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
IS (From 2007 ORTC Table 1 Update):	68	59	52	45	40	36	32	28	25	23	20	18	16	14	13	11

ITRS: 2007

New *Networking* System Driver

Multi-Core/Accelerator Engine SoC - Architecture Modeling

Assumptions

Target Market Segment: Mid-to-high end segment of the embedded space.
Power: Power constraint for embedded networking space 30-40 watt
Workload: Mid-range switching/routing workload

Model assumptions include the following.
- Die area is constant
- Number of cores increases by 1.4× / year
- Core frequency increases by 1.05× / year
- On-demand accelerator engine frequency increases by 1.05× / year
- Underlying fabrics – logic, embedded memory (cache hierarchy), on-chip switching fabric, and system interconnect – will scale consistently with the increase in number of cores.

The figure shows a roughly 1000× increase in the system processing performance metric, which is the product of number of cores, core frequency, and accelerator engine frequency. Per the scenario shown, future 32nm system performance is 54× (with 30 cores) the system performance of a 4-core implementation at 65nm in 2007.

New *Networking* System Driver
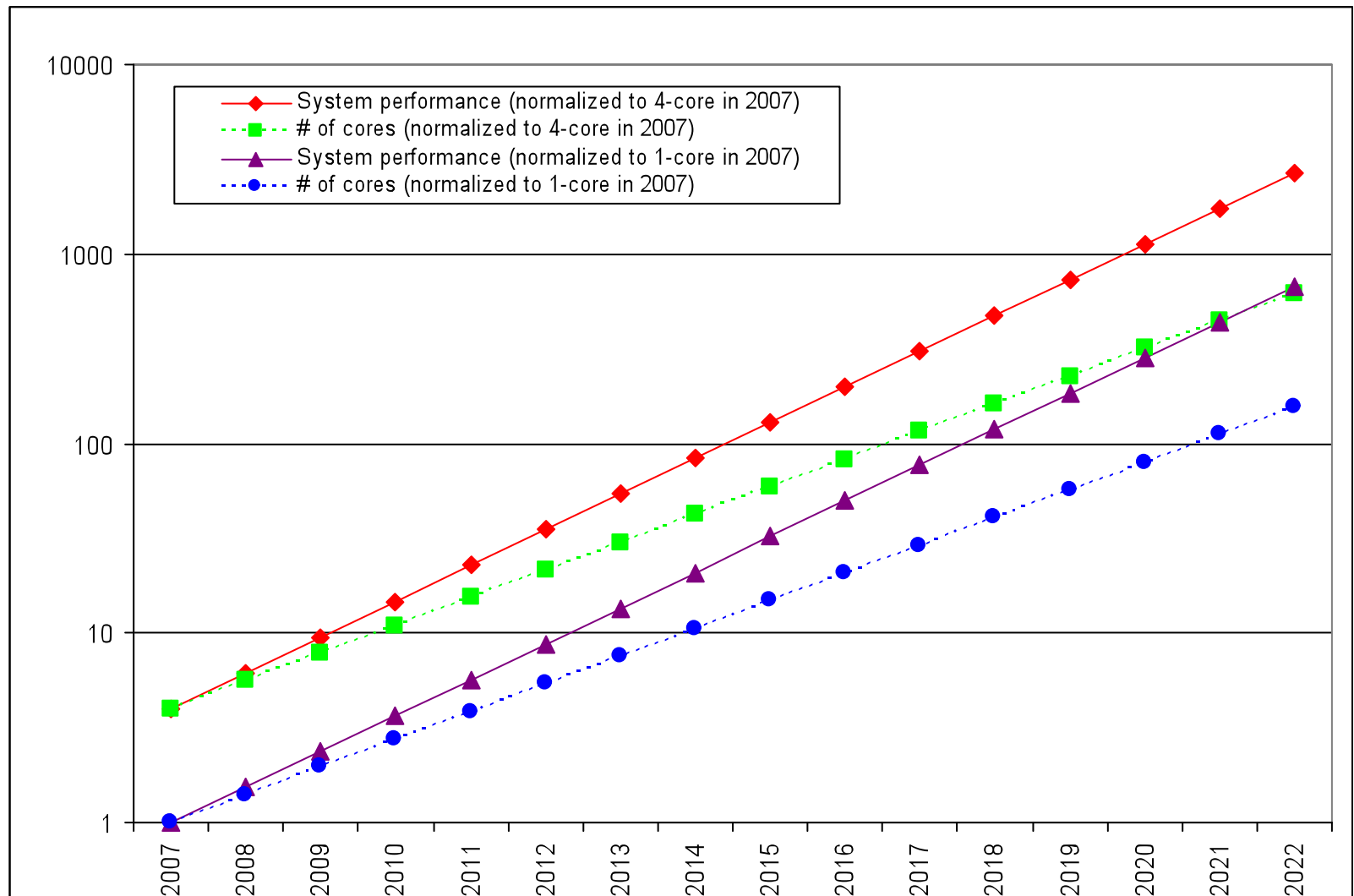## Multi-Core/Accelerator Engine SoC - Architecture Modeling
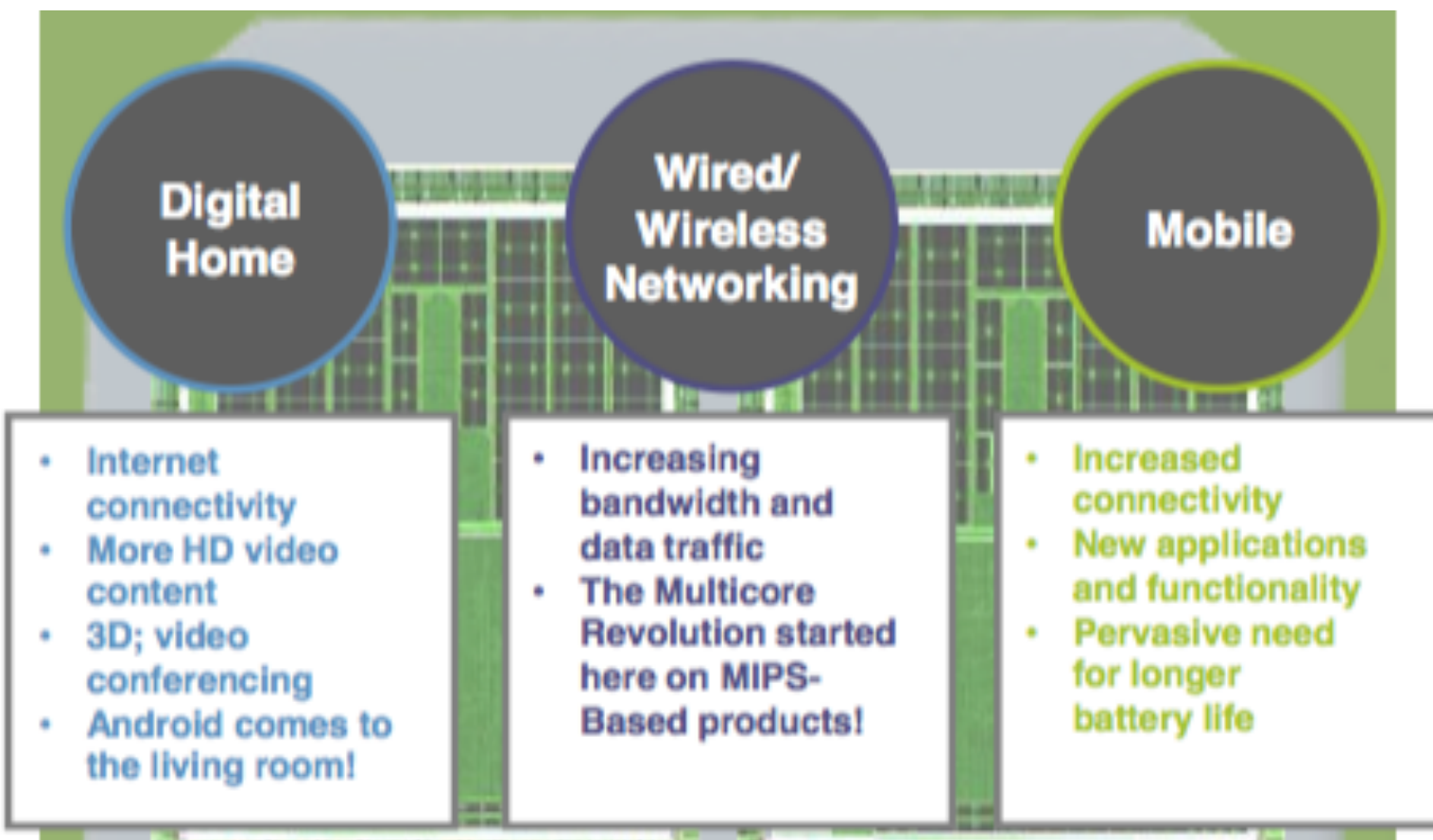
Two scenarios are shown:
Scenario 1:
Number of cores are normalized to 1-core in 2007 and System performance normalized to 1-core in 2007.
Scenario 2:
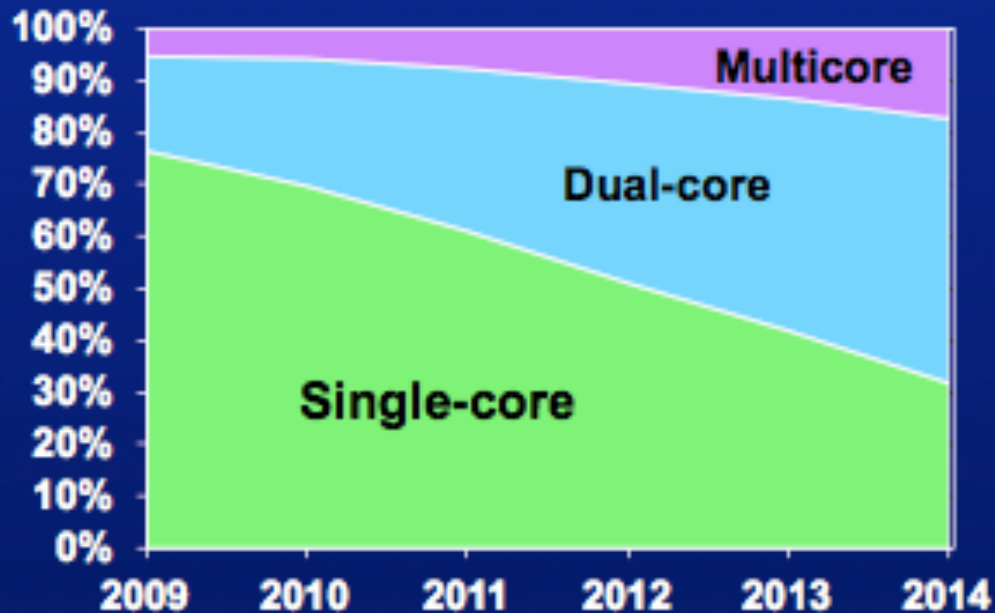Number of cores are normalized to 4-core in 2007 and System performance normalized to 4-core in 2007.

Legend:
- System performance (normalized to 4-core in 2007)
- # of cores (normalized to 4-core in 2007)
- System performance (normalized to 1-core in 2007)
- # of cores (normalized to 1-core in 2007)

ITRS: 2007

Multicore Eveolution

Digital Home

- Internet connectivity
- More HD video content
- 3D; video conferencing
- Android comes to the living room!

Wired/ Wireless Networking

- Increasing bandwidth and data traffic
- The Multicore Revolution started here on MIPS-Based products!

Mobile

- Increased connectivity
- New applications and functionality
- Pervasive need for longer battery life

Multicore Forecast

Networking and Comms segment (by revenue)
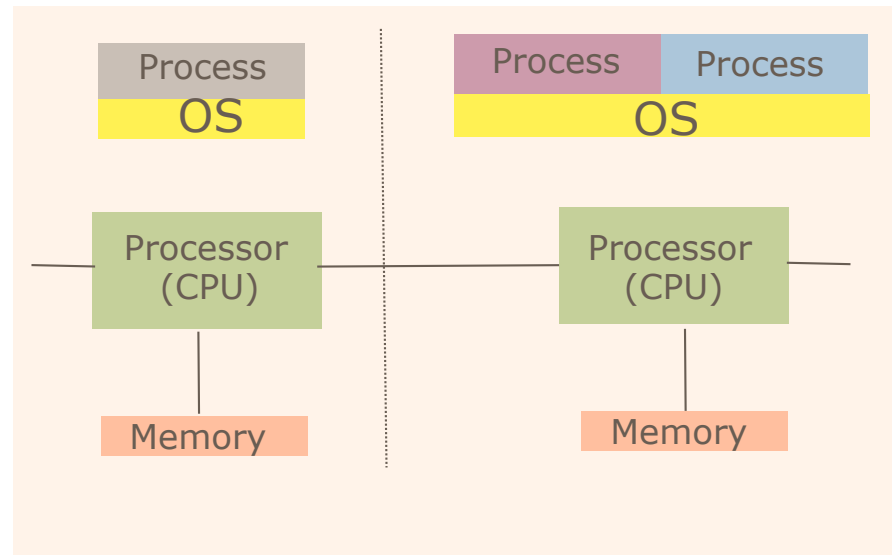
(Source: The Linley Group)

- Single core still the most popular
- Dual core will surpass in 2013
- Multicore is four or more CPUs
- Revenue lags design wins by 3-5 years

SMP vs AMP

Process	Process	Process
OS		

Processor (CPU)	Processor (CPU)
Memory	Memory

Process		Process	Process
OS		OS	

Processor (CPU)		Processor (CPU)
Memory		Memory
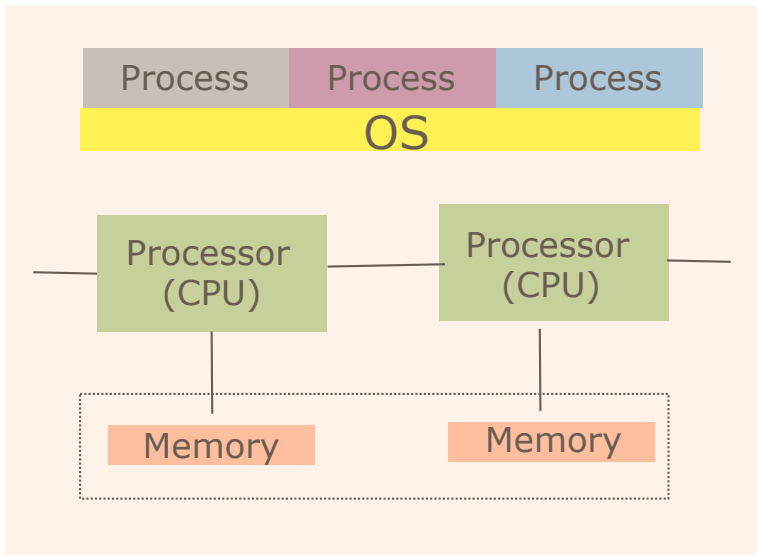
Symmetric multiprocessing (SMP) has all CPUs sharing one OS and one memory space

Asymmetric multiprocessing (AMP) has each CPUs with its own OS and its own memory space

Multicore Evolution
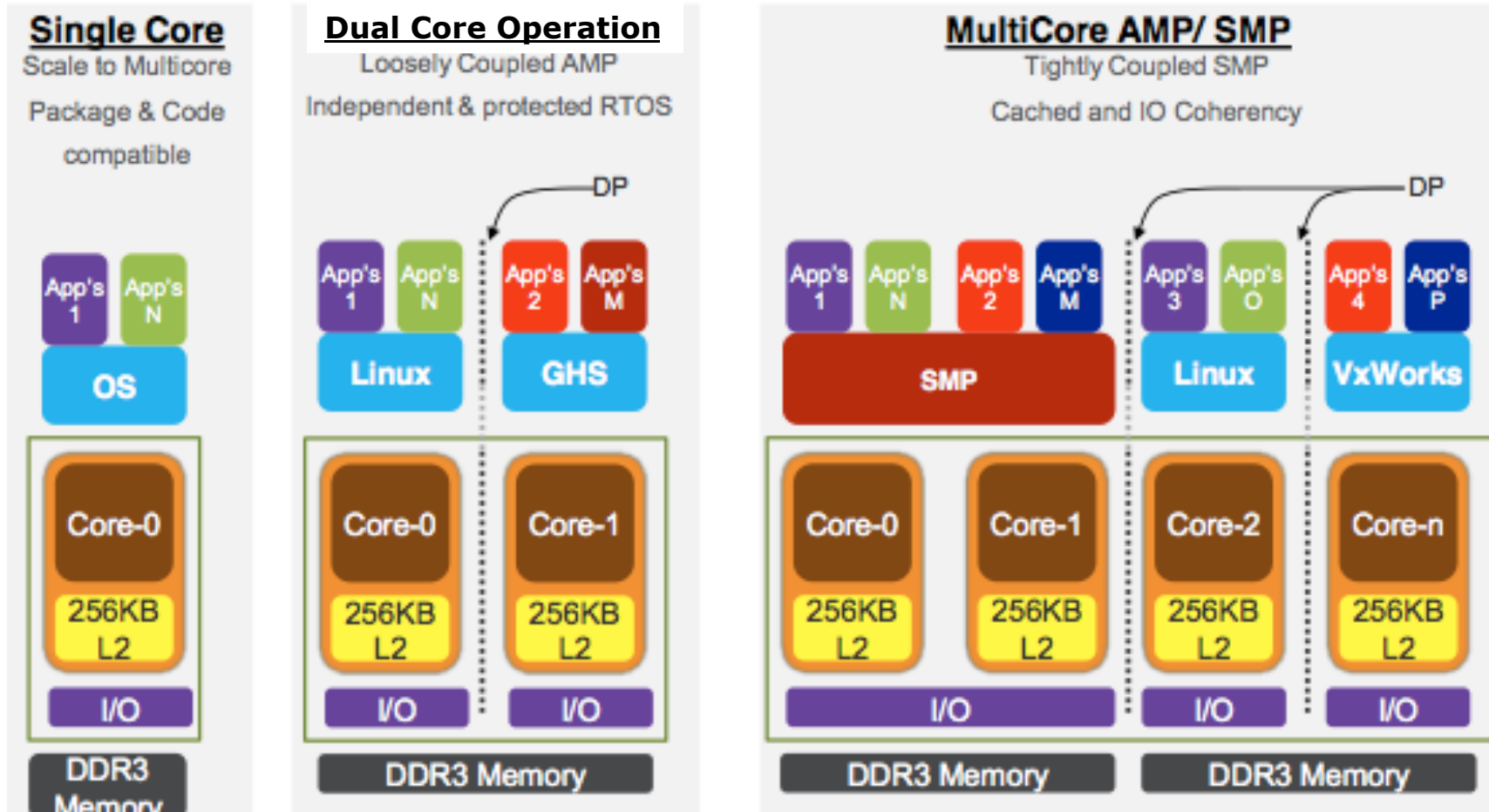
Next Generation Application drives Processor Integration
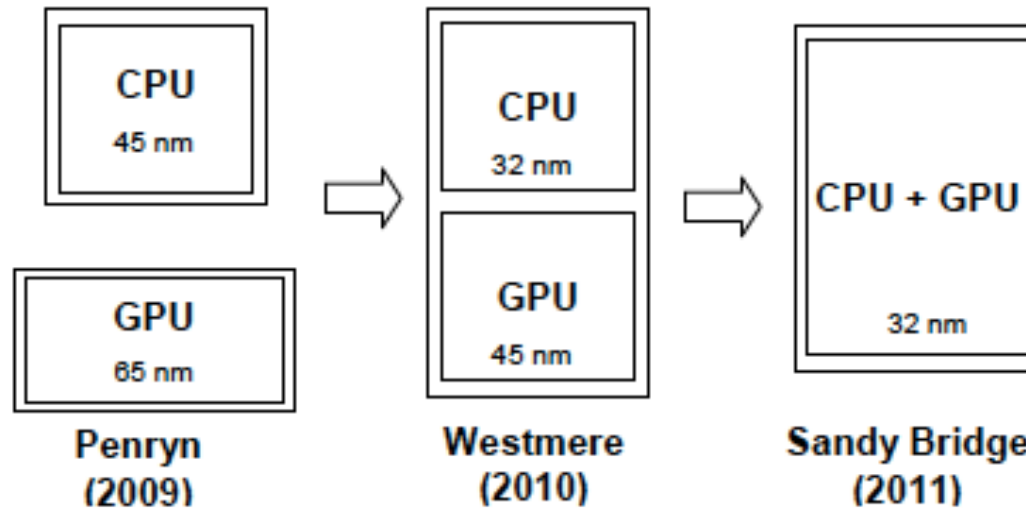
Cost:	● Lower BOM cost for PC OEMs due to savings on discrete graphics, and lower design and validation costs
Performance:	● Graphics improvement 2X
Form Factor:	● Fewer components and smaller footprint ● Enables thinner and lighter computing devices

Virtualization

- Virtualization is making one system appear to be multiple systems

- Virtualization enables consolidation, reducing cost because there is only one physical system

- Virtualization isolates software environments

Hardware Virtualization

- ## With Hardware support
  - No cycles scanning object code
  - Page-table modifications handled in hardware
  - For MMU-intensive code, performance gain is up to 25%
  - Some overhead for device drivers, scheduling, etc.

- ## Without hardware support
  - Hypervisor spends cycles scanning object code
  - Page-table modifications consume CPU cycles

Why Power Management?

Improve Efficiency – e.g. Data Centers
- Never completely off
- Rarely fully loaded
- Dissipate 50% of total power while idle

Remove Performance Constraints
- Limited power availability (Power over Ethernet)
- Dimensional constraints (heat sinks)
- Physical barriers (tamper covers)

Reduce Cost
- Heat dissipation
- Cooling
- Supplying Power

Meet Regulations
- Federal Energy Management Program (US)
- International Energy Agency (Europe)
- Department of Climate Change (Australia)

Maximizing Power Savings

- ## At System Level
  - Provide greater power savings
  - All devices not fully loaded simultaneously
  - Some devices seldom used

- ## At Device Level
  - Active State
    - All subsystems not fully loaded simultaneously
    - Interfaces support power saving states
      - PCIe
      - USB
      - Ethernet
  - Standby State
    - Systems Idle for extended periods
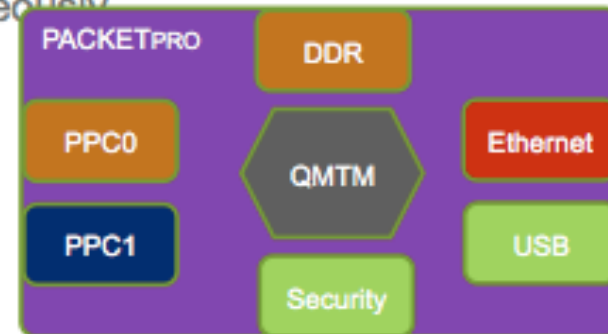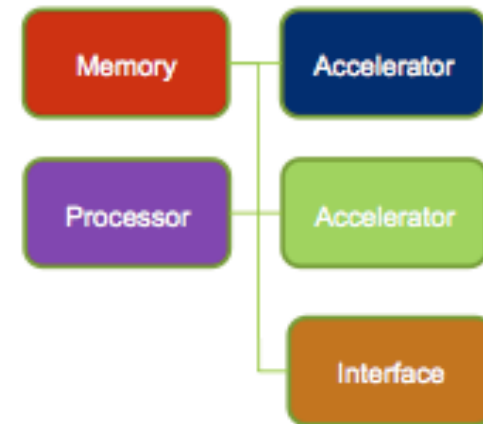
Standby State Power

- Appliances idle for significant time
  - Household appliances
    - DVD players, Set top boxes, power adapters, etc.
  - Office equipment
    - Multi function printers, computers, flat panels, networking equipment

- Dissipate power even when "off"

- Consume 10% of total household energy in US

- > $3 Billion in Energy Costs!

- 1 Watt Initiative
  - International Energy Agency initiative
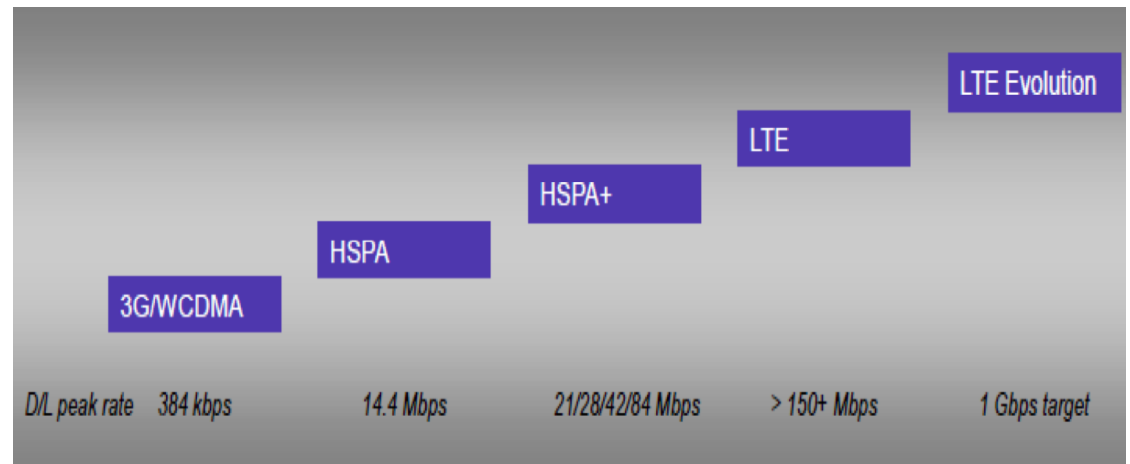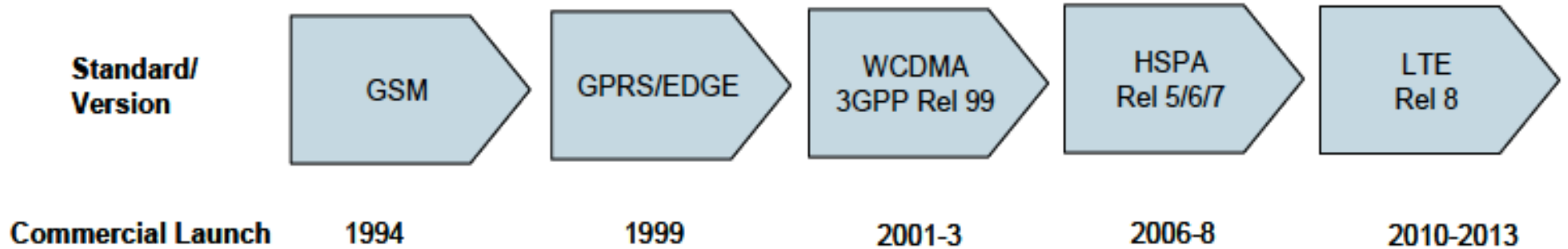 - Reduce standby power dissipation to 1 Watt or less
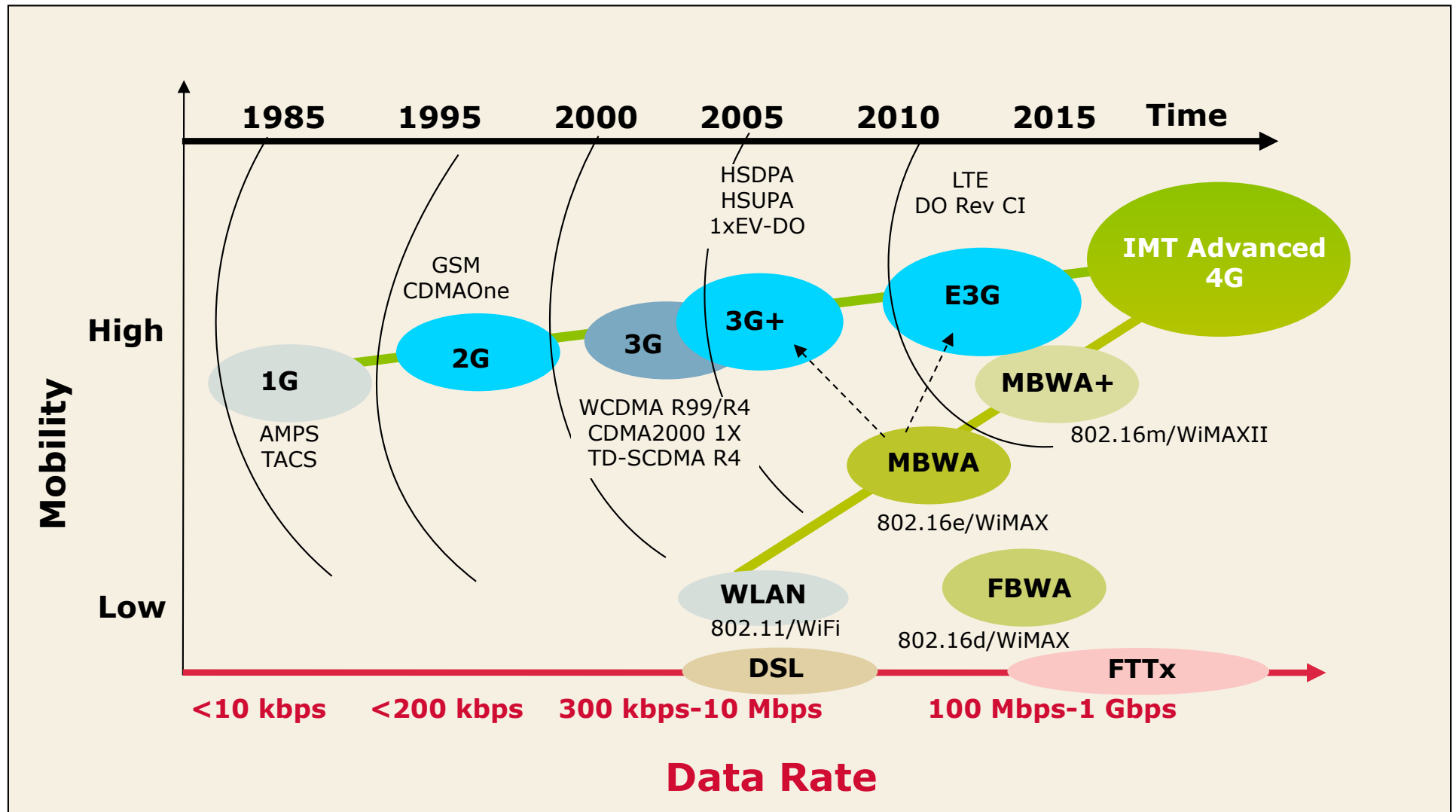
Walkthrough Example – Wireless (LTE)

Standards

SoC Architecture

Reference Solution

4G Device Application

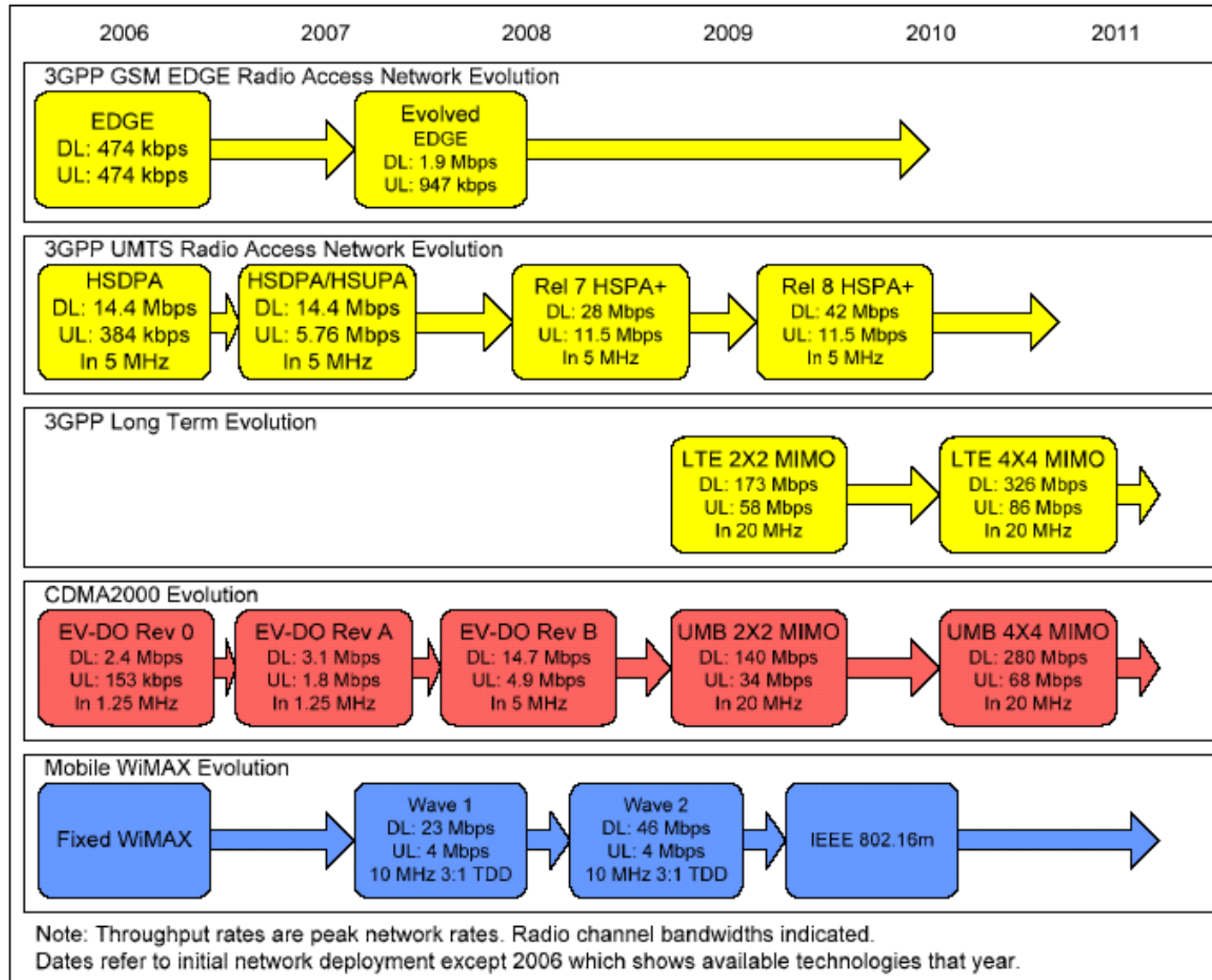4G Network

Wireless radio Standards & Downlink Speed

Standard/ Version	GSM	GPRS/EDGE	WCDMA 3GPP Rel 99	HSPA Rel 5/6/7	LTE Rel 8
Commercial Launch	1994	1999	2001-3	2006-8	2010-2013

LTE Evolution

LTE

HSPA+

HSPA

3G/WCDMA

D/L peak rate	384 kbps	14.4 Mbps	21/28/42/84 Mbps	> 150+ Mbps	1 Gbps target

Wireless Technologies Roadmap

Source: Freescale Semiconductor, September 2007

Broadband Wireless Technology Timelines

Note: Throughput rates are peak network rates. Radio channel bandwidths indicated.
Dates refer to initial network deployment except 2006 which shows available technologies that year.

Source: Rysavy Research
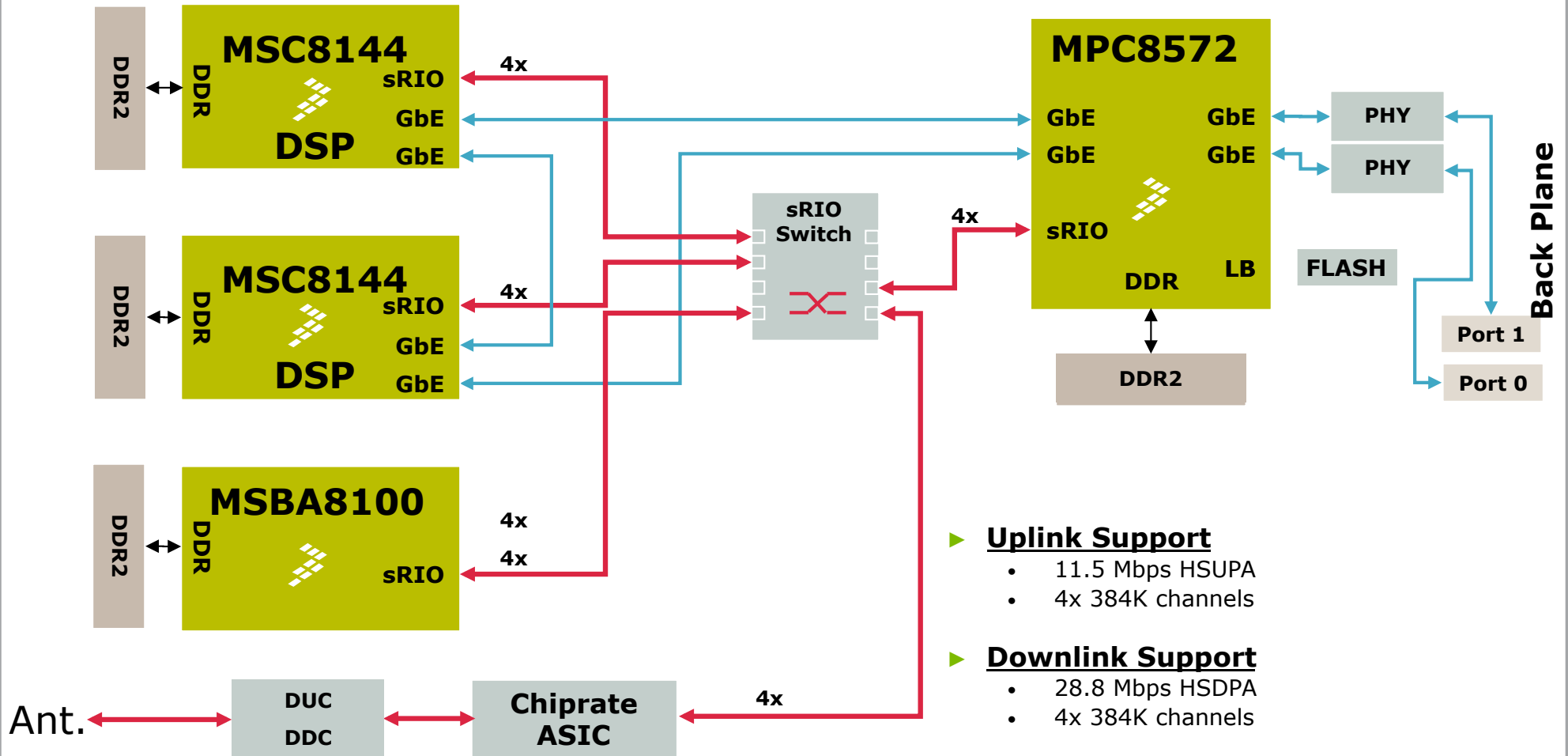
Scalable Programmable Multi-standard Basestation Platform - LTE and WIMAX Capable
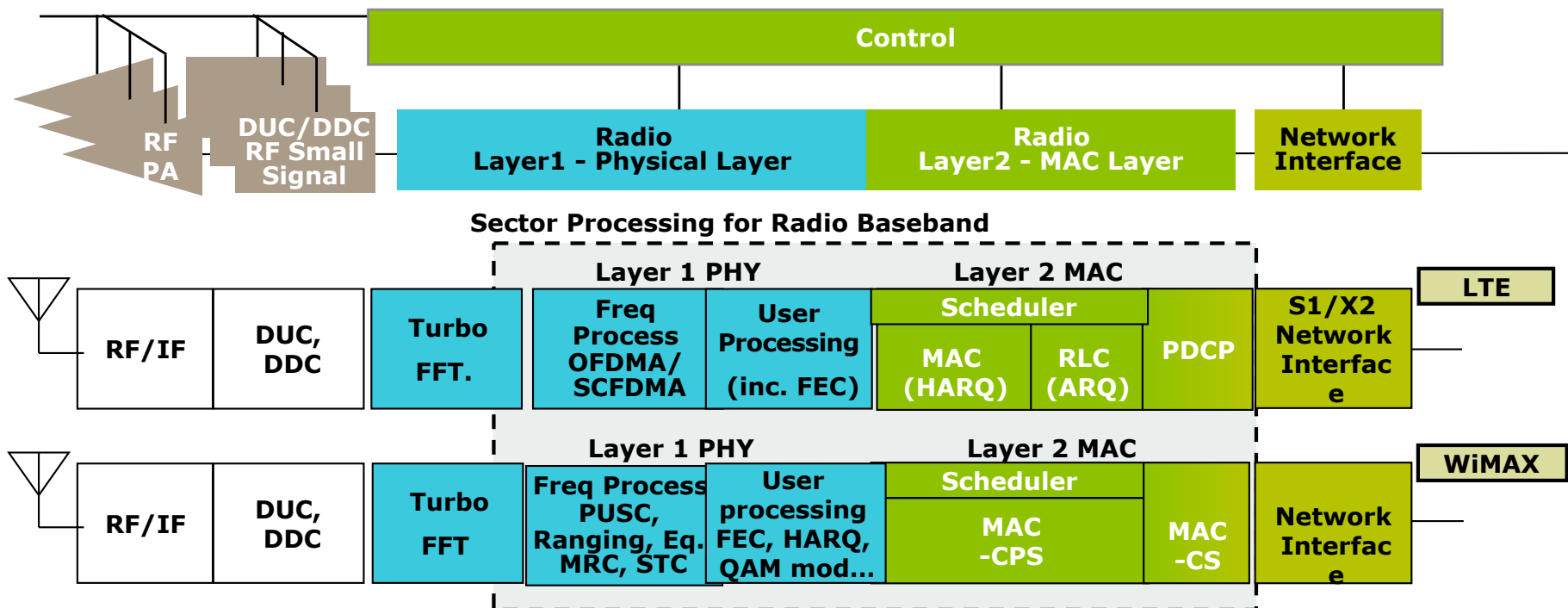
3G-HSPA+, 5 MHz - Use Case

Uplink Support
- 11.5 Mbps HSUPA
- 4x 384K channels

Downlink Support
- 28.8 Mbps HSDPA
- 4x 384K channels

Source: Freescale

WiMAX/LTE AMC Base Band Channel Card Features

WiMAX-3G/LTE multi-standard architecture

► **Connectivity**

- AMC 0.4
    - Gigabit Ethernet
    - 4x/1x Serial RapidIO®
    - 1 x Gigabit Ethernet
    - 2 x Fast Ethernet
    - 2 x RS232
    - RF I/F

► **Support**

- MPC8541/55E/8548
    - Linux®, download tools
- MSC8126/8144
    - SmartDSP OS, CodeWarrior®

► **Form Factor**

- Dual-width full height AMC

► **Availability**

- Board and reference collateral - available now

Source: Freescale

Key 4G Applications

Internet Access

Mobile Media

Voice/ Video Phone

Broadcast

Home Network

Internet Access

Mobile Media

Video Phone

Broadcast

Home Network

Internet Search Engine

Grand Challenges for Next-Generation Handsets

Seamless Mobility

Miniaturization
- Power
- Size
- Cost
- Product Development Cycle

Multimode
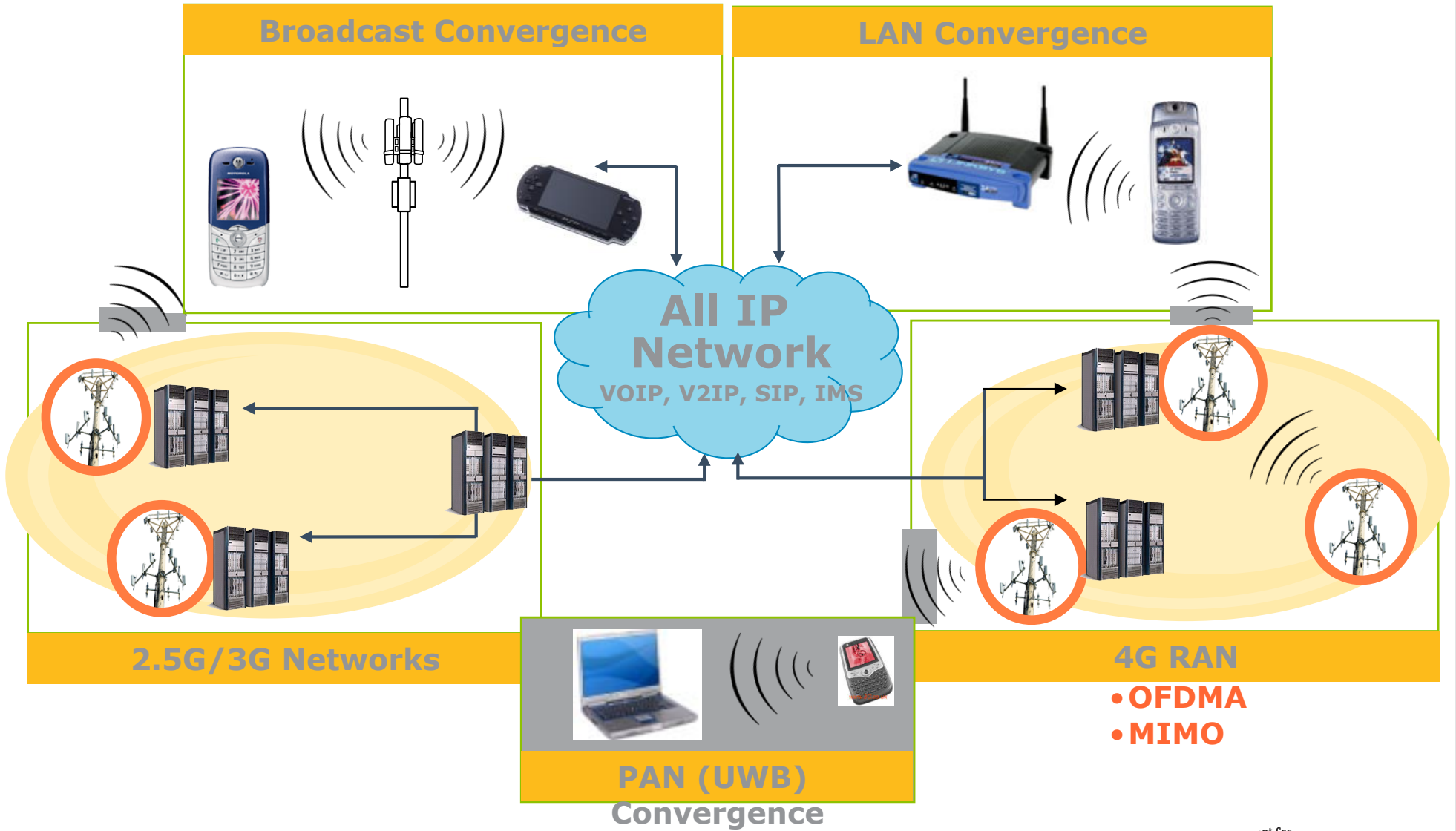- Seamless handoff
- Multimode support
- Reconfigurable Network

Multimedia
- Audio
- Video
- Graphics
- Imaging

$$$ Money
- Revenue Distribution/ Billing
- Security
- Ecosystems

4G Networks

Broadcast Convergence

LAN Convergence

All IP Network
VOIP, V2IP, SIP, IMS

2.5G/3G Networks

PAN (UWB) Convergence

4G RAN
- **OFDMA**
- **MIMO**

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Conclusion

Summary - Opportunities of growth areas in Telecom/ Datacom

Technology Analysis/Market Research/Business Development:

» Handset/Smart Devices

» Infrastructure & Networking

» Video technology and Multimedia

» Example: Mobility and cloud computing

» Value chain from semiconductor to service providers for some vertical markets.

Design/Development/Services

» SoC Architecture Design

 • Multicore, Virtualization, Power Management

» System/Application Software development

» Reference solution

» Services

Thank You

Questions?