18-640 Foundations of Computer Architecture

Lecture 22:
"Mobile Computing: Platforms and Ecosystems"

John Paul Shen
November 25, 2014

A. "The War of Mobile Platforms and Ecosystems"
(A Personal Retrospective)

B. "Mobile and Cloud Computing Future Directions"

Electrical & Computer ENGINEERING

18-640 Foundations of Computer Architecture

A. "Anatomy of The Six-Year War of Mobile Platforms and Ecosystems (2006-2012)"

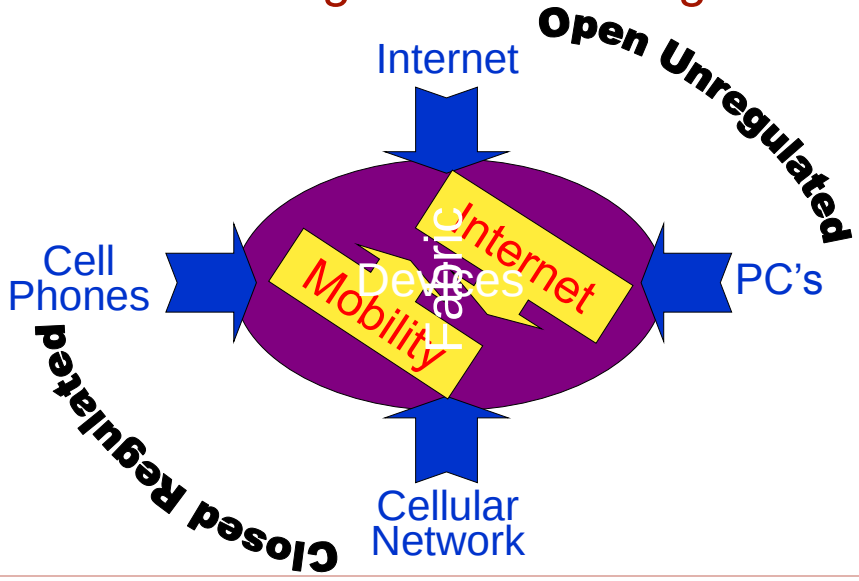
(A Personal Retrospective)

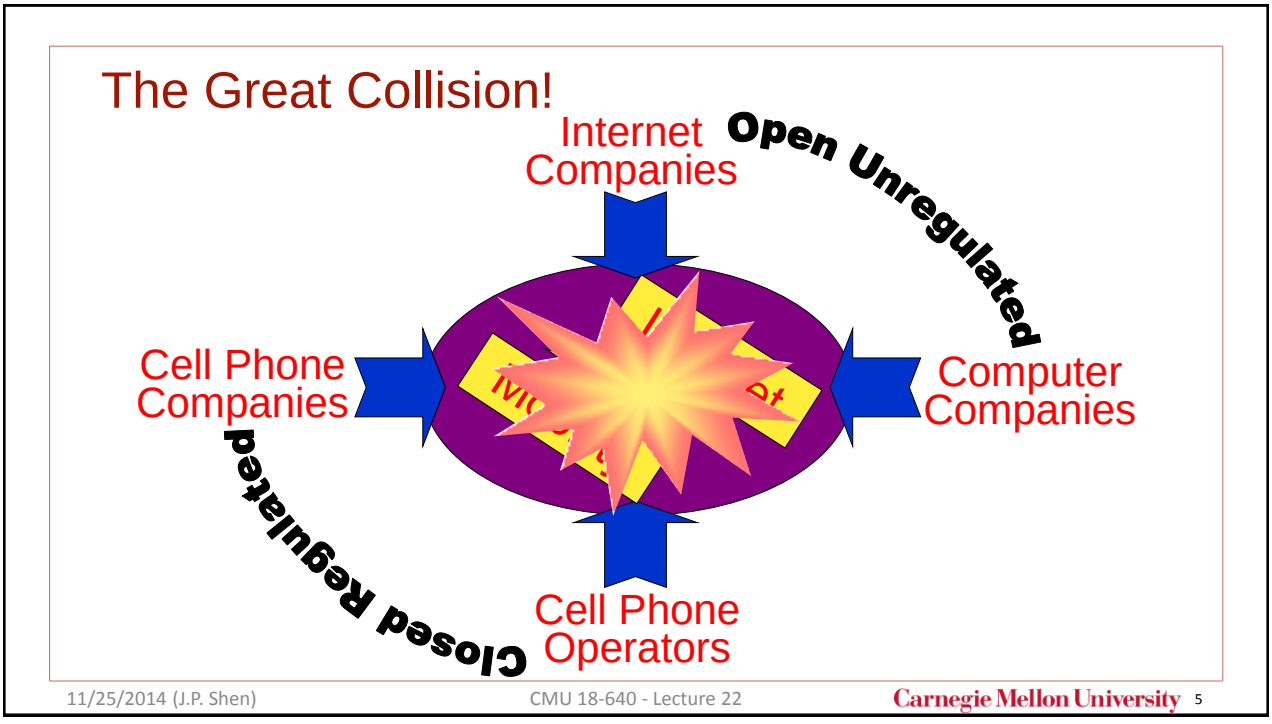
John Paul Shen
Nokia Fellow

November 25, 2014
(First presented on October 18, 2012 at Nokia)

Electrical & Computer ENGINEERING

The Great Convergence...It All Began in 2006…




The Great Collision!
Internet Companies
Open Unregulated
Cell Phone Companies
Computer Companies
Closed Regulated
Cell Phone Operators
11/25/2014 (J.P. Shen)
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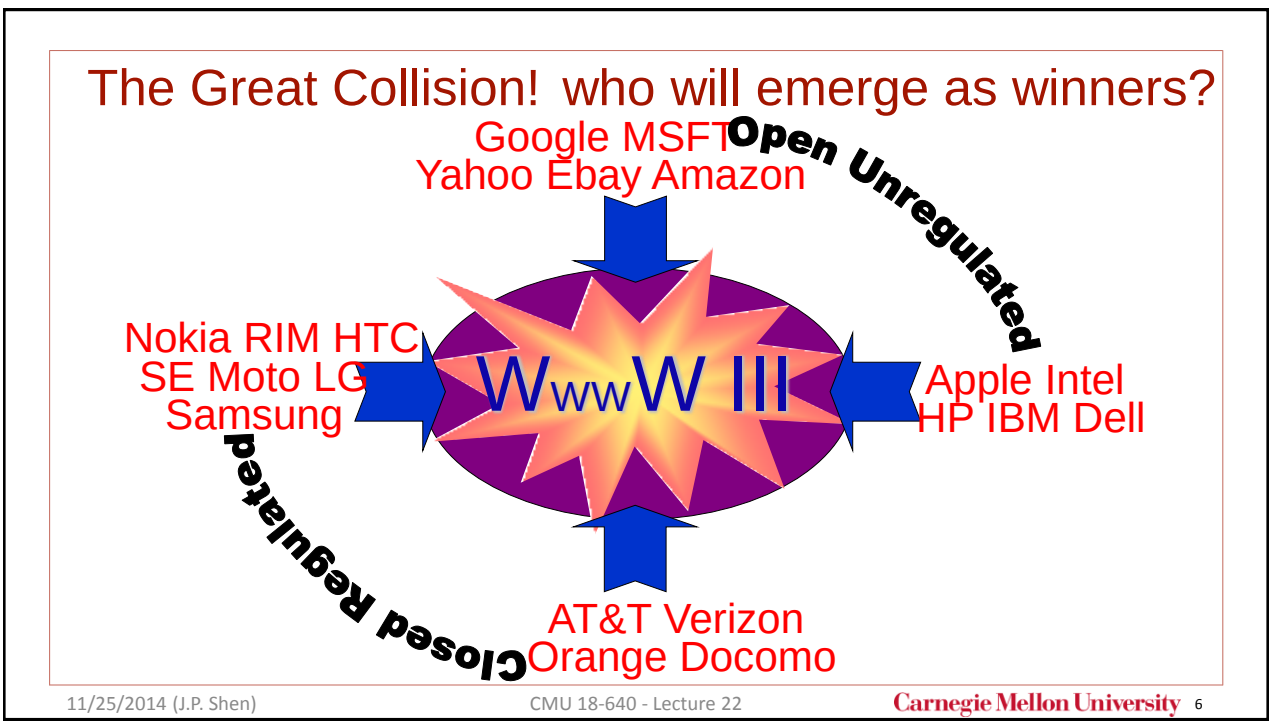
The Great Collision! who will emerge as winners?
Google MSFT
Yahoo Ebay Amazon
Open Unregulated
Nokia RIM HTC
SE Moto LG
Samsung
WwwW III
Apple Intel
HP IBM Dell
Closed Regulated
AT&T Verizon
Orange Docomo
11/25/2014 (J.P. Shen)
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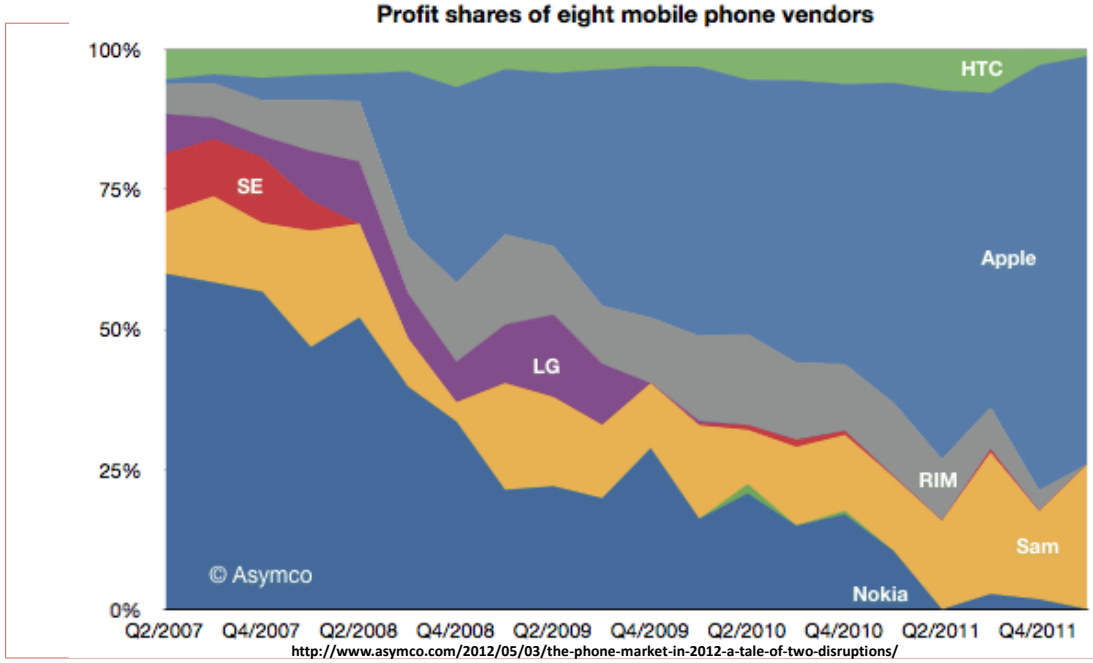
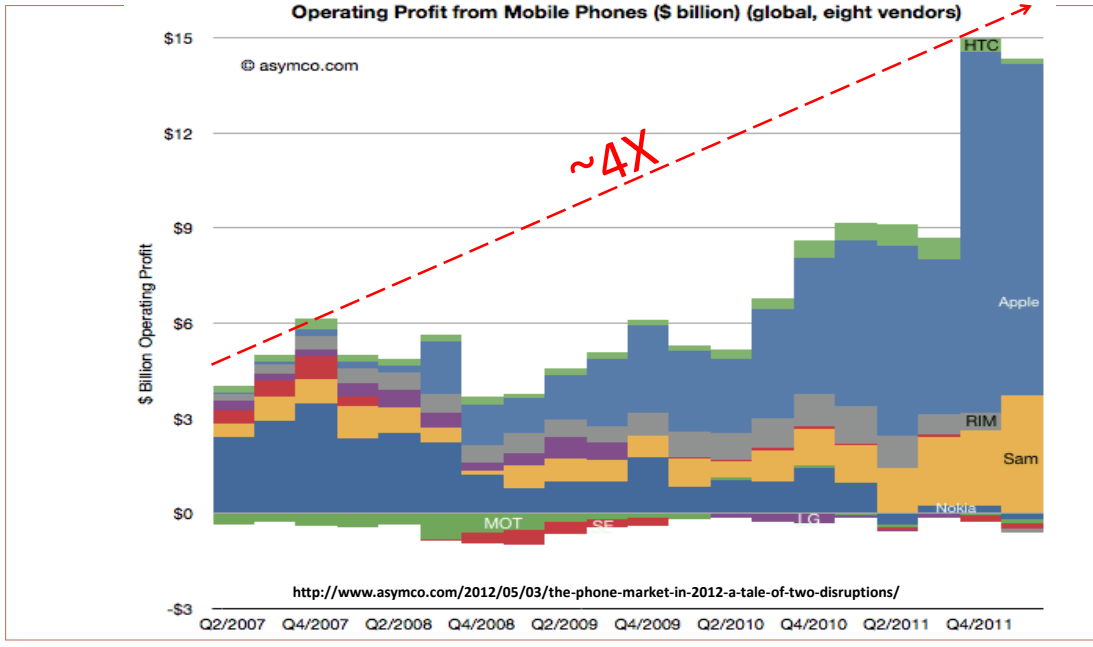


http://www.asymco.com/2012/05/03/the-phone-market-in-2012-a-tale-of-two-disruptions/



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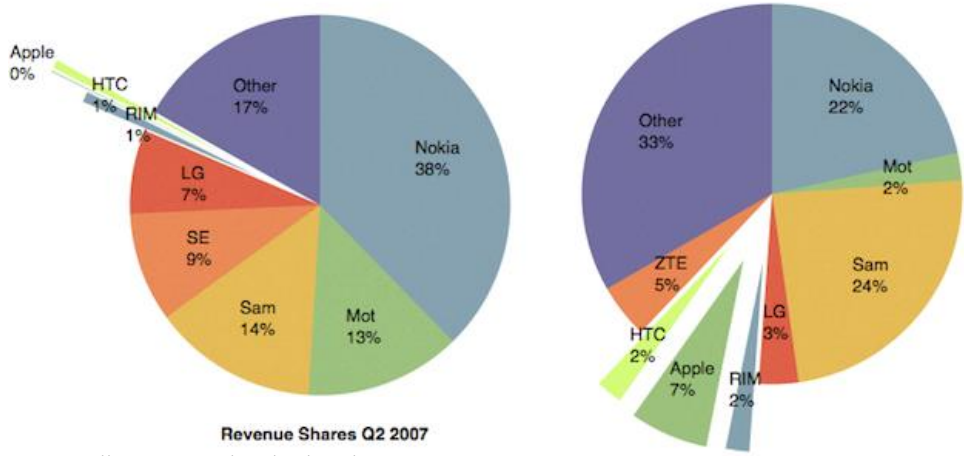
Volume Shares

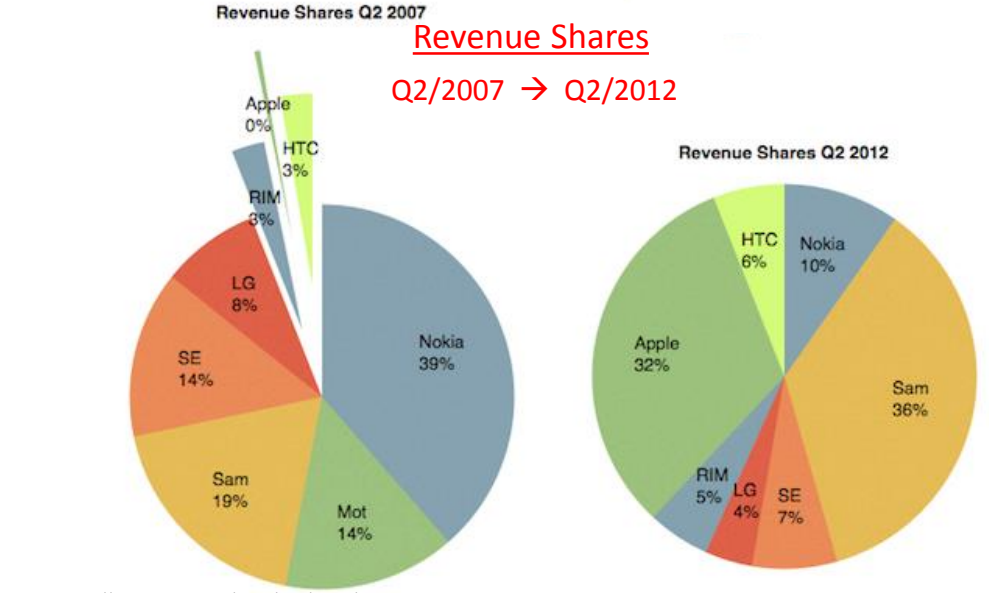
Q2/2007 → Q2/2012



http://www.linkedin.com/today/post/article/20121017140439-19021-five-years-of-the-mobile-phone-industry-at-a-glance

Revenue Shares

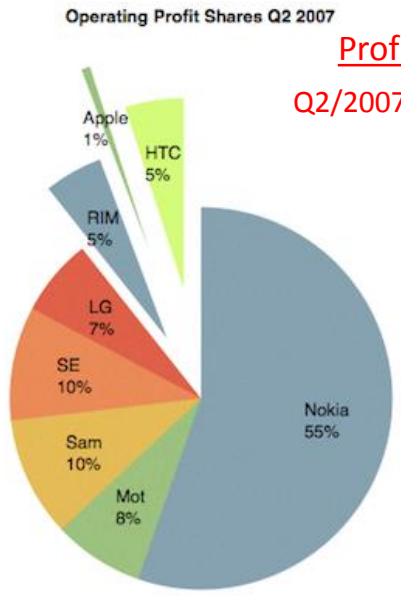
Q2/2007 → Q2/2012

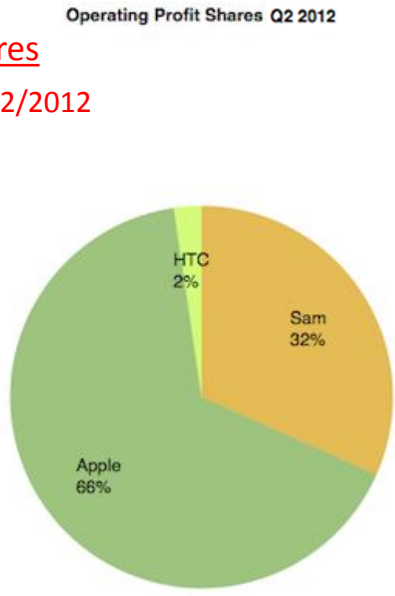


http://www.linkedin.com/today/post/article/20121017140439-19021-five-years-of-the-mobile-phone-industry-at-a-glance

Profit Shares

Q2/2007 → Q2/2012





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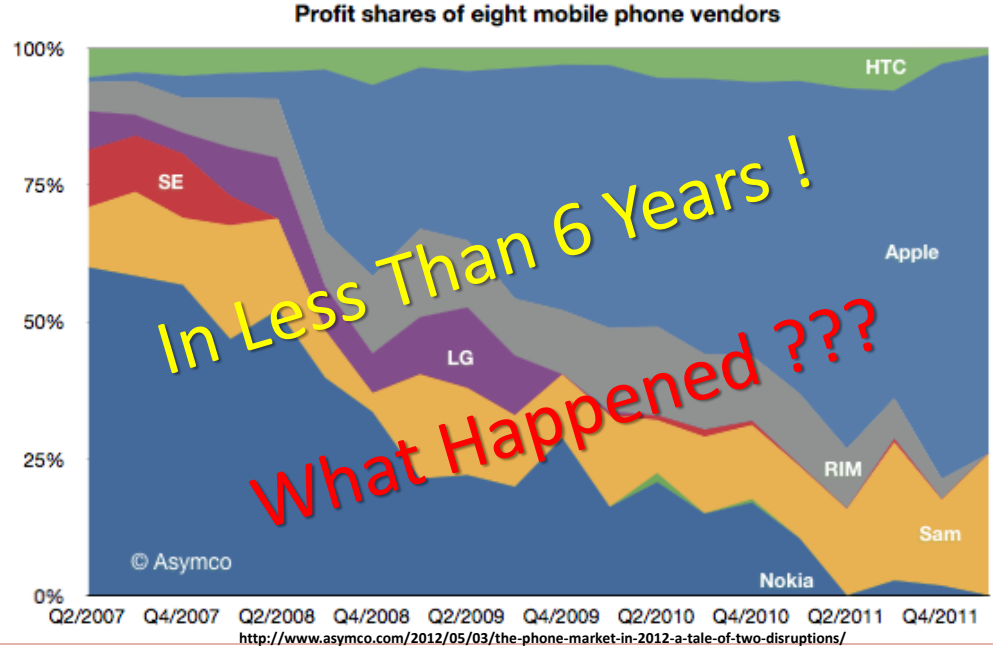

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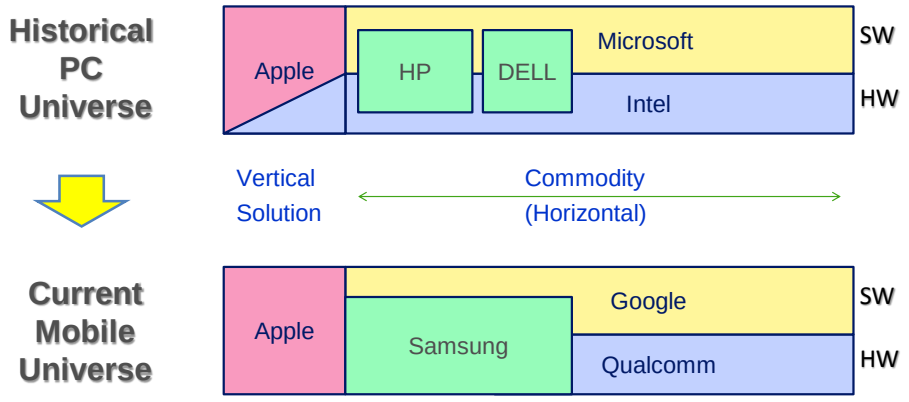
Mega Trends in Market Ecosystems



High Tech Market Dynamics

- Why go VERTICAL? … mainly for <u>better total margin</u>, there are margins at all layers of the abstraction to be gotten; more layers more margins (vertical also facilitates cross layer optimization for UX). But must be willing to invest big.
- Why go HORIZONTAL? … mainly for better <u>overall efficiency</u> for the whole industry by sharing costs for the platform development and maintenance. But must compete with others in the horizontal space.
- Why LAYERS OF ABSTRACTION? … deal with complexity efficiently and facilitate independent innovation and development in each layer; drive industry efficiency in each layer through competition at each layer.

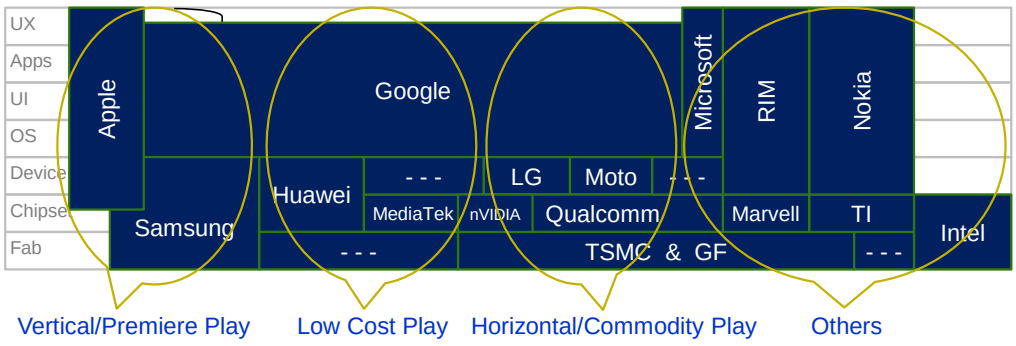
High Tech Market Dynamics

- LAYERS OF ABSTRACTION:

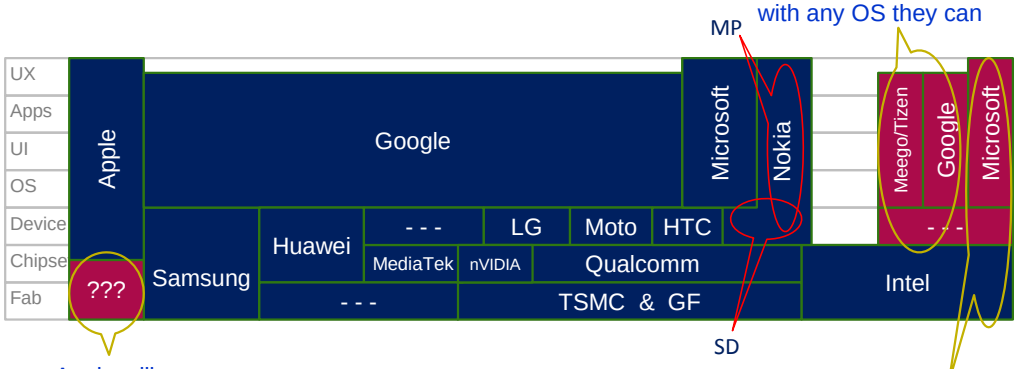
	Layers of Abstraction		
	User Experience (UX)	APP STORE	ECOSYSTEM
SOFTWARE	Applications (from 3rd party)	DEVELOPERS	
	User Interfaces (UI)	PLATFORM	
	Operating Systems (OS)		
HARDWARE	Mobile Devices (product)		
	Chipsets & Components		
	Fabrication & Manufacturing		

Mobile Landscape – circa 2007

Layers of the SW and HW Stack



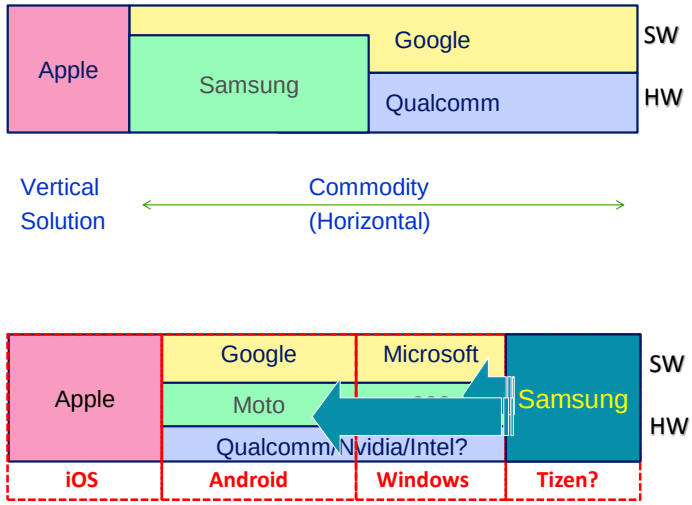
Mobile Landscape – circa 2012



Possible New Trends in Ecosystems? … Go Vertical!

Current Mobile Universe

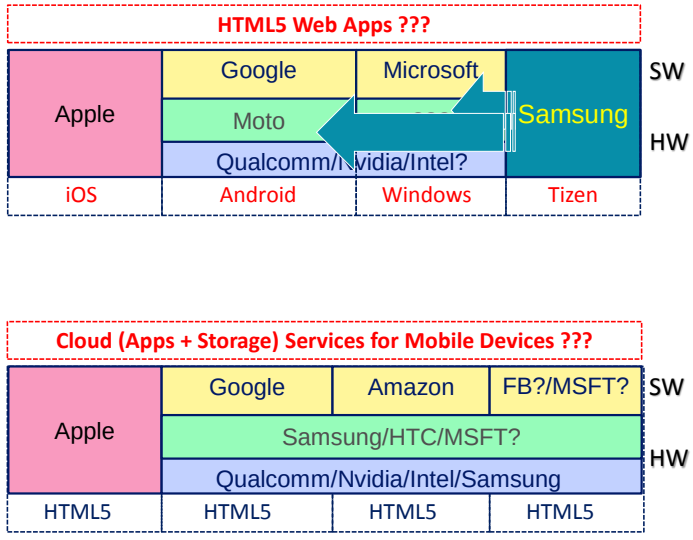
Emerging Convergence Universe ?



Possible New Trends in Ecosystems? … Go Horizontal!

Emerging Convergence Universe

Alternate Convergence Universe ???



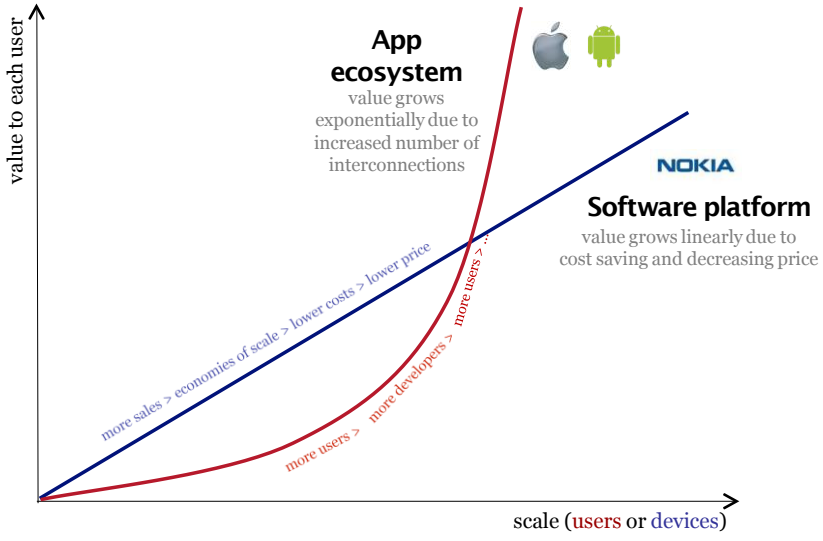
High Tech Market Dynamics (Lessons Learned…)

- EXPOSED ARCHITECTURE vs. EMBEDDED ARCHITECTURE:

	Layers of Abstraction		
	User Experience (UX)	APP STORE	ECOSYSTEM
SOFTWARE	Applications (from 3rd party)	DEVELOPERS	
	User Interfaces (UI)	PLATFORM	
	Operating Systems (OS)		
HARDWARE	Mobile Devices (product)		
	Chipsets & Components		
	Fabrication & Manufacturing		

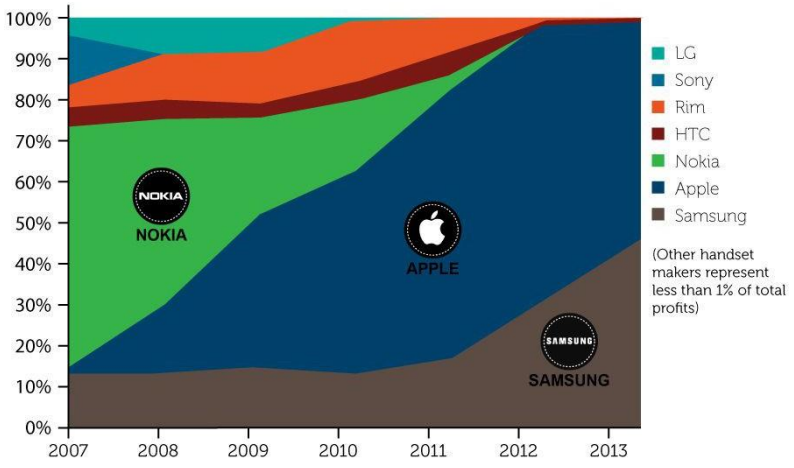
- Leverage 3rd party developers
- Embrace legacy software
- Ensure backward compatibility
- Grow the entire market/industry

App ecosystems won by superior growth potential



handset profits Are owned by Apple & Samsung. Why?

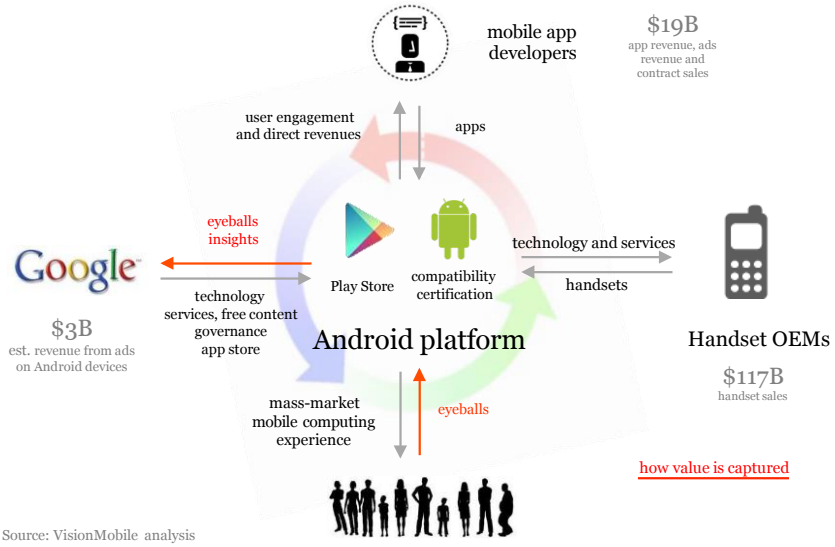
The duopoly of profit share in the handset industry



Data: McKinsey, Asymco, Canaccord, VisionMobile estimates

The Android GDP: An ecosystem valued at $149B

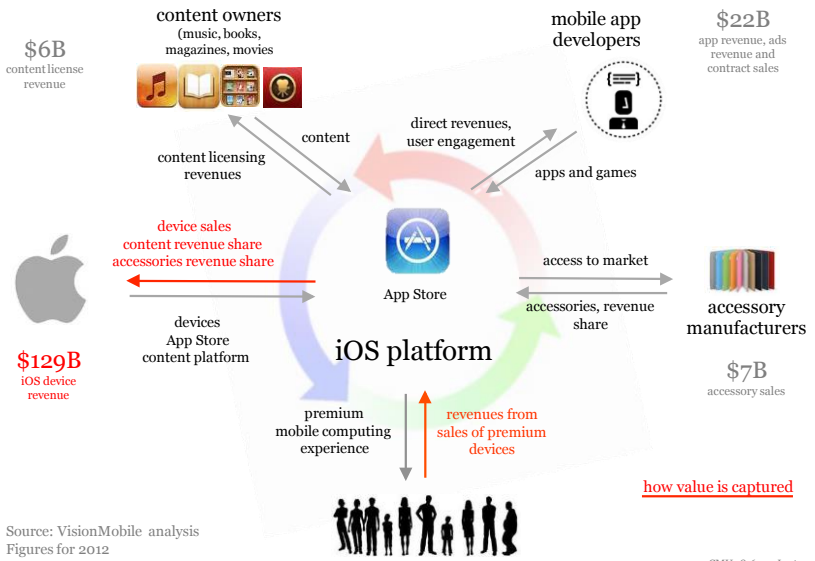
Enormous defensive value for Google's core business, but little direct value capture



Source: VisionMobile analysis
Figures for 2012

The Apple GDP: The iOS ecosystem has grown to $163B

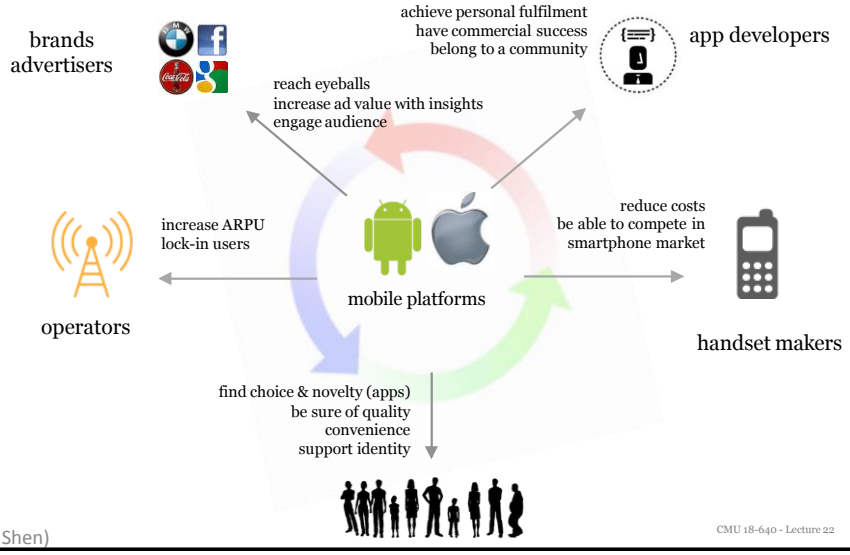
Apple captures most of this revenue



Source: VisionMobile analysis
Figures for 2012

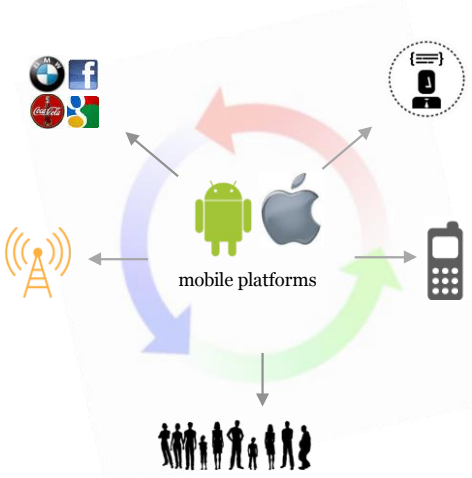
Apple, Android deliver benefits to all sides

exponential growth comes from cross-side network effects across all five sides



To compete, Challengers have to achieve the impossible

three conditions necessary to compete with Apple / Android



Three conditions to compete:

1. achieve the same outcomes cheaper/faster/better
2. activate all sides of the network simultaneously for same-rate growth
3. Incur additional opportunity cost for participants due to limited resources
   (e.g. to adopt WP you have to abandon Android)

HTML5 is pitched as the future of mobile apps

...but what is HTML5, really?

A set of browser specs by 2 standard groups: W3C and WHAT

WHAT WG - Web Hypertext Application Technologies

The WHAT working group specs merge into W3C specs

Brings capabilities of web apps closer to those of native apps

UI tools, off-line storage, 2D graphics, plugin-free video/audio

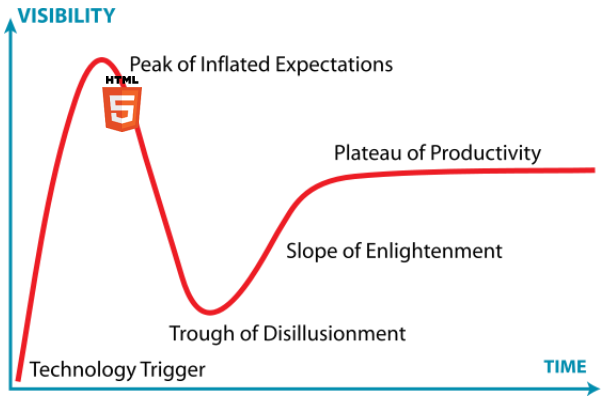
geo location, speed and communication

Many benefactors, but no clear leader

all pushing and hyping HTML5 for their own unrelated reasons

- Apple looking to move the web away from Flash
- Google searching for more ways to commoditize complements
- Facebook aiming to break-down Apple/Google silos and distance Adobe
- Microsoft to onboard web developers onto Windows 8
- Mobile operators hoping to regain control lost to native platforms
- Qualcomm aiming to create a competitive advantage for its chips
- Brands looking use web as a low-cost way to go cross-device and cross-screen
- Adobe aiming to sell tools that facilitate web-to-native hybrid apps

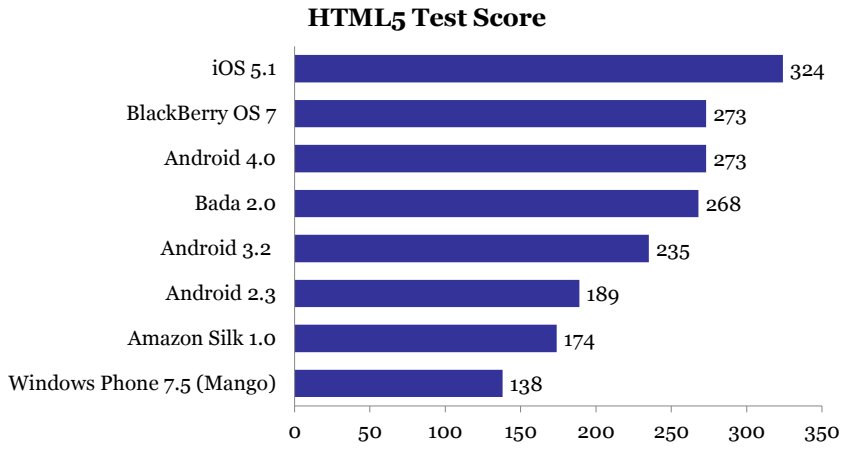
But HTML5 is just past the peak of expectations



Fragmentation across platforms (iOS, Android, BlackBerry, Windows Phone)
Challenged to compete with native user experience
Lack of distribution channels and monetisation for web apps

Source: VisionMobile

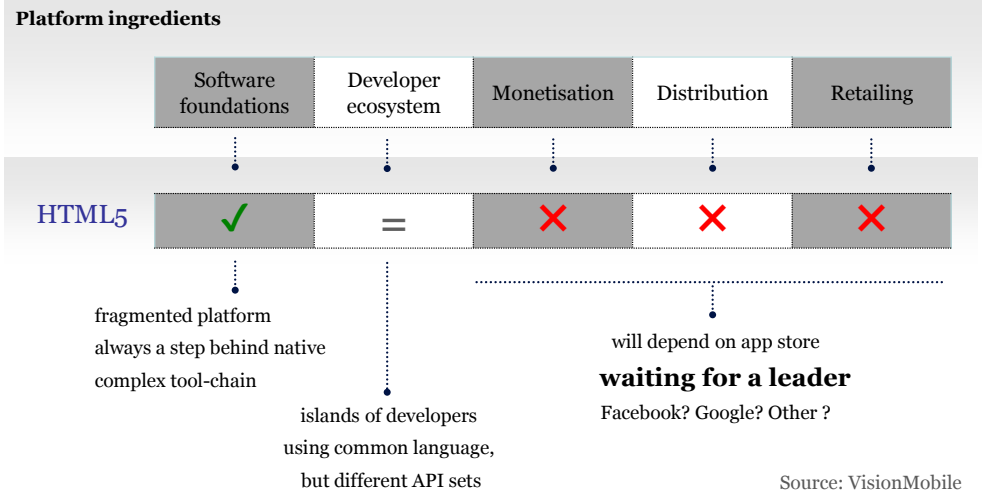
HTML5 is fragmented across platforms



Source: html5test.com, April 2012.

HTML5 is a technology lacking key ingredients

unable to compete with iOS and Android platforms



Source: VisionMobile

Google & FB are building complete platforms

adding missing ingredients on top of HTML5 enabling technology

Key ingredients	Software foundations	Developer ecosystem	Monetisation	Distribution	Retailing
	application runtime, developer tool-chain, & platform APIs	Developers building and publishing apps around the software foundation	micropayments, ad networks and settlement	app distribution to end users through SaaS or devices	app discovery, promotion, placement, search & recommendations
HTML	HTML5 browsers (fragmentation)	Fragmented	---	---	---
	HTML5 with Chrome API	web developers	Google Checkout	PC, Mac, Android, Chrome OS	Chrome Web Store
	HTML5 with Facebook APIs	Web and Flash developers	FB Credits	900M Facebook users	FB app recommendations

HTML5 may end up a yet another walled garden despite the promise of openness

Source: VisionMobile

So many platforms, so little time

Developers face a real challenge making apps for multiple platforms

Source: VisionMobile

Cross-platform tools come to rescue

drastically reduce costs by code reuse and efficient developer resource management

2000

today – explosion of tools

100+ tools!

Source: VisionMobile

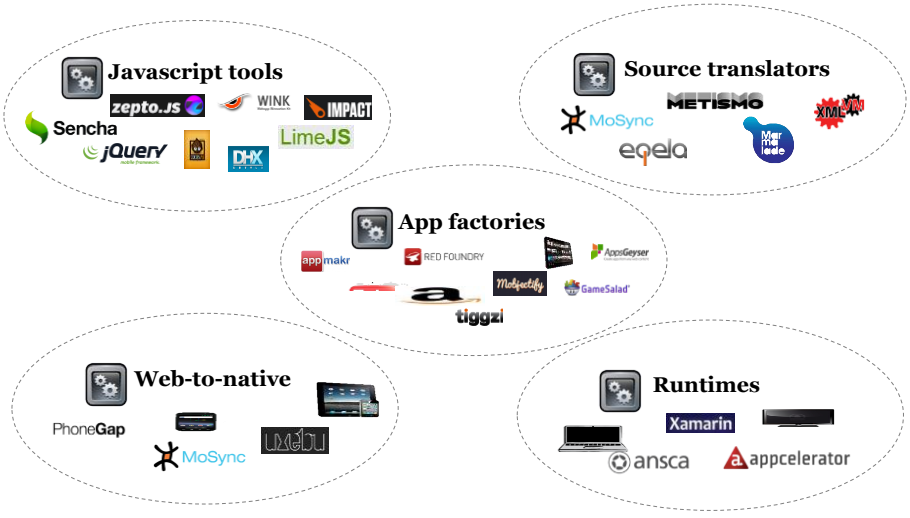
Mergers & Acquisitions in the CPT space

Company	Product & type	Acquirer	Date
Aptana	Development environment	Appcelerator	Jan-11
Metismo	Bedrock Java-to-native source code translator	Software AG	May-11
TapJS	Game hosting platform and API	AppMobi	Jun-11
TapLynx	App factory	Push IO	Jun-11
RhoMobile	Rhodes enterprise apps framework	Motorola Solutions	Jul-11
Particle Code	Source code translator	Appcelerator	Oct-11
Nitobi	PhoneGap tool for creating web hybrid apps	Adobe	Oct-11
Strobe	Web app framework and app management platform	Facebook	Nov-11
Cocoafish	Post-download app services	Appcelerator	Feb-12
Worklight	Enterprise app platform	IBM	Feb-12

Source: VisionMobile Cross-platform Developer Tools 2012 report

Diversity of tools catering to all use cases

catering to all sorts of developers, types of apps and mobile platforms



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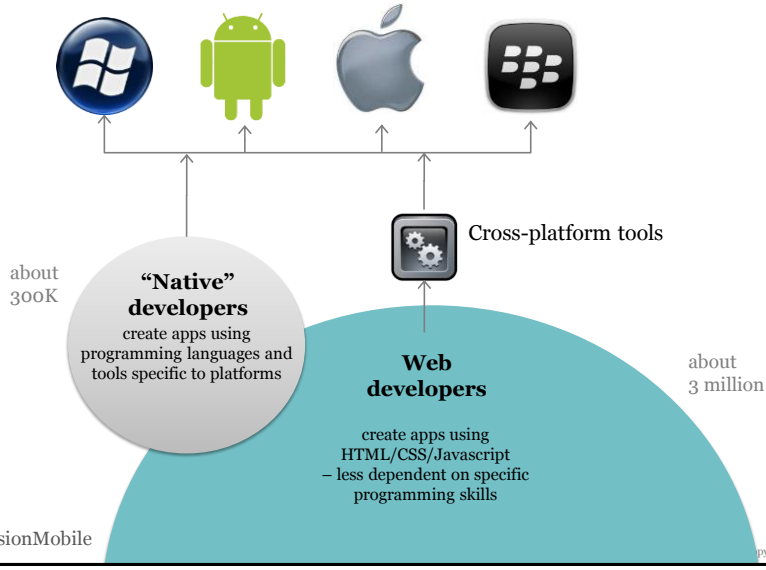
Source: VisionMobile

Cross-platform tools democratize development

Extend the reach of masses of web developers beyond the browser



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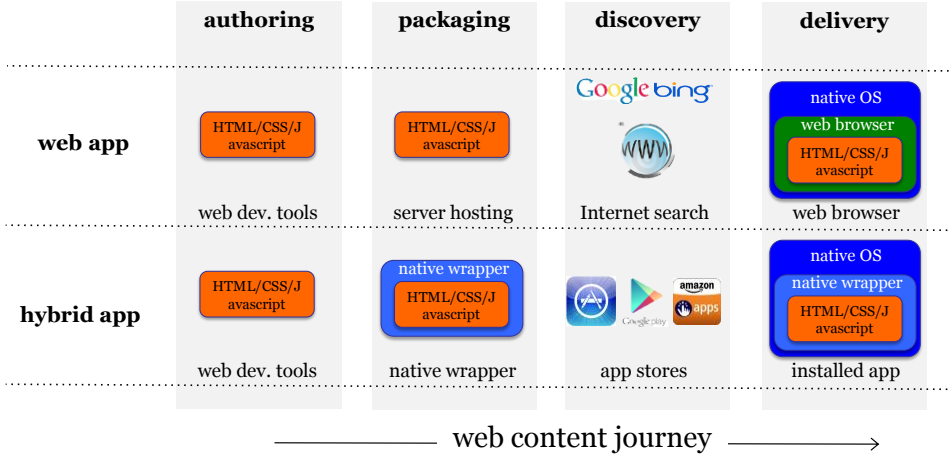
Source: VisionMobile

CPTs take the web beyond browsers

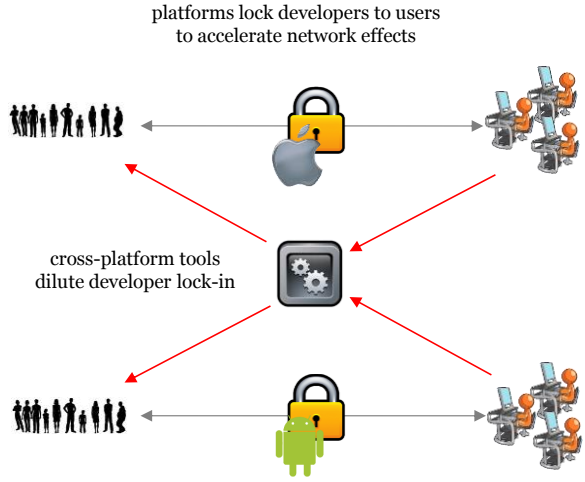
Combine ease of web development with advantages of native apps



Source: VisionMobile

Cross-platform tools reduce power of platforms

CPTs dilute developer lock-in



Source: VisionMobile

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B. "Mobile and Cloud Computing Mega-Trends and Future Directions"

(A Personal Perspective)

John Paul Shen
Nokia Fellow

November 25, 2014

Electrical & Computer ENGINEERING
Carnegie Mellon University

AD 2013: Quite A Momentous Year…

ABSTRACT:

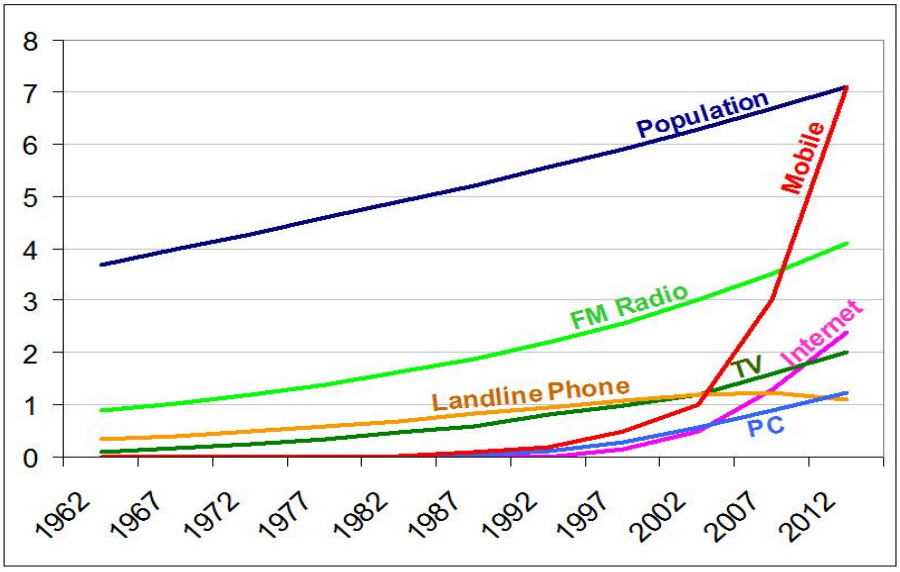
In the summer of 2013 the total number of mobile phone subscriptions world wide surpassed the total population of our planet.

> *"This is totally unprecedented in the human history of technology. No technology ever, has even come close. Not television sets, not PCs, not radios, not cars, not motorcycles, not even bicycles; not credit cards, not even bank accounts; not books in print, not newspaper circulations; not the reach of electricity or landline telephones or even running water; not wristwatches, not toothbrushes, not even pens and pencils… have been as widely used as mobile is today."* [Tomi Ahonen, 2013]

By the end of 2013 the total number of smartphones world wide exceeded the total number of PCs, of any kind, in the world. These smart mobile devices are mobile computers; they also serve as rich sensing platforms on the global scale.

This talk will highlight some of the research work done by Nokia Research - North America Lab on *Mobile Sensing and Social Services* and *Visual Computing and Mixed Reality*, and suggest some interesting directions for future research in the areas of *Human Behavior Modelling and Understanding* and *Global-Scale Mobile and Swarm Computing*.

Global Media End of 2012



Source: *TomiAhonen Almanac 2012* and *TomiAhonen Mobile Forecast 2012-2015*

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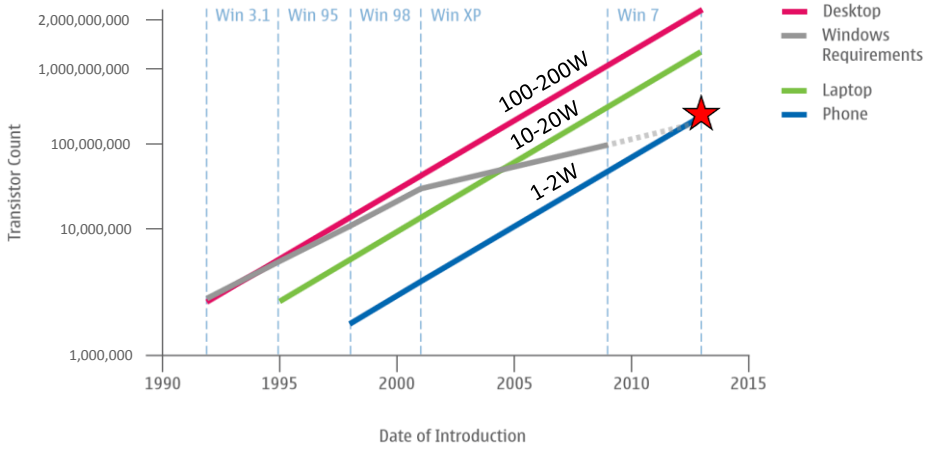
Moore's Law is Alive and Well

Cross Over Point in 2013



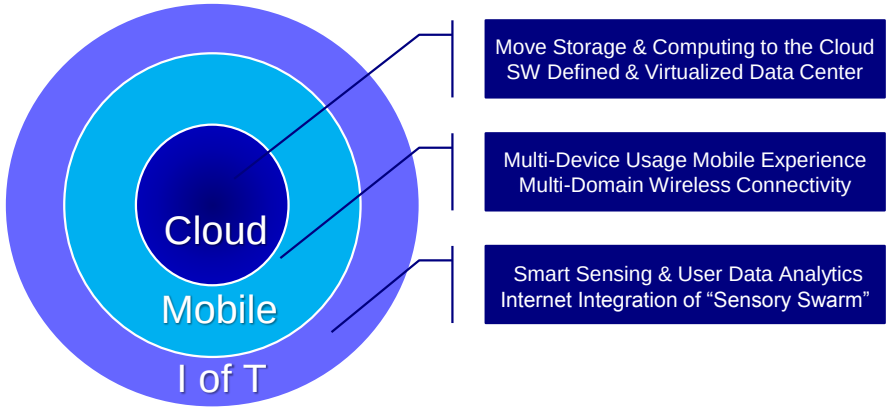
Global Mobile Computing Universe:

"Internet of Things"

"The Edge of the Cloud"
Santa Clara, August 27, 2010
A Workshop Offered by the MuSyC and GSRC FCRP Research Centers

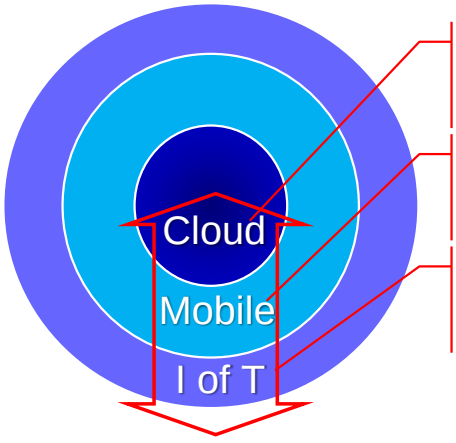
Current Mega-Trends

The computing cloud ecosystem is maturing and several trends are becoming evident and dominant



Potential Disruptions

The current cloud architecture can and will be disrupted as players begin to create new and better consumer experiences



Shift Computing to the Cloud Edge:
Off Load Core Network Bandwidth Demand
Reduce Service Delivery Latency to Users

Truly Seamless Mobile Experience:
Seamless Cross-Device Cross-Domain UX
Unify both Broadband and Broadcast UX

Human Sensing for Common Good:
Deliver Real IOT Value to Mobile Users
Use both Eulerian and Lagrangian Sensing

Seamless Roaming Experience Across 5+ Screens

	PC	smartphone	tablet	living room	dashboard
	Mac computers	iPhone	iPad	Apple TV	CarPlay
Google	Chrome browser	Android	Android tablets	Google TV, Chromecast	Open Automotive Alliance
Microsoft	Windows, Office	Windows Phone	Windows 8	Xbox	Windows in the Car
amazon	Online store	Soon to come?	Kindle Fire	Fire TV	?

Mobile and Cloud Computing Research Ideas (?)

"The Edge of the Cloud"
Santa Clara, August 27, 2010
A Workshop Offered by the MuSyC and GSRC FCRP Research Centers

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Computing Megatrends

- Leading-Edge Supercomputing
  - Current TOP100 supercomputers are Petascale (10^{15} FLOPS) systems
  - Challenges for next 7 years: push towards Exascale (10^{18} FLOPS) systems
  - Must improve performance/power efficiency from 1 GF/W to 100 GF/W
- Web Based Cloud Computing
  - Push towards cloud computing creates huge network bandwidth demands
  - Tension will result in federated and fragmented cloud computing models
  - Wireless edge of the cloud will be core to computing and communication
- Personal Mobile Computing
  - Continuation of Moore's law expected for at least two more process nodes
  - 100 GF/W technology can provide mobile supercomputers for mass market
  - Dealing with legacy SW and device installed base will be a huge challenge

Mobile Supercomputing

- Mobile Supercomputers
  - Improving performance/power efficiency to 100 GFLOPS/W will enable a Terascale (10^{12} FLOPS) mobile supercomputer with a 10W power budget.
  - An airborne supercomputer capable of 100 TFLOPS can then be deployed in an UAV (e.g. the RQ-1 and MQ-1 Predator drone) with a 1KW power budget.
- Architecture Innovations
  - Dataflow driven execution model supported by powerful SW tool chain and programmable and extremely energy-efficient HW fabric will be essential.
  - Exploitation of massive data level parallelism and inherent data redundancy.
- Form Factor Innovations
  - Extreme integration via 3D TSV die stacking of diverse technology dies, e.g. many-core processors, high-BW DRAMs and SSDs, FPGA, and power delivery.

Emerging Killer Applications

- Real-Time Environmental Sensing and Processing
  - Highly mobile and autonomous real-time data collection, data analytics, and data inference, without having to off-load to some remote cloud infrastructure.
  - Example: real-time traffic, special events monitoring, disaster management.
- Rapid Situational Deployment of Cloud Resource
  - On-demand localized wireless service can be provided by an UAV equipped with an airborne base station for special needs, e.g. a major sporting event.
  - Such drone based resource can provide very low latency and high bandwidth local services and function as the edge of the traditional cloud infrastructure.
- Swarm-of-Drones Infrastructure for Demanding Scenarios
  - Swarm of collaborating drones can be rapidly deployed to provide wireless communication and Petascale (10^{15} FLOPS) supercomputing infrastructure.