Integration vs. Decoupling:

The Leadership Dynamics in the Computing Industry

Lum Wai Seng, Dave Junia

Economics Department, Faculty of Arts and Social Sciences

National University of Singapore

Contents

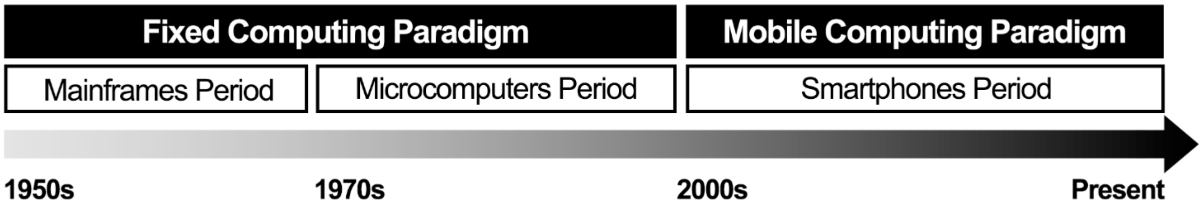
	Abstract	………………...	3
1.	**Introduction**	………………...	3
2.	**The Fixed Computing Paradigm: Phase 1 - Mainframes**		
	2.1 Key Events & Developments	………………...	6
	2.2 Integration's Dominance: Factors & Reasons	………………...	8
	A. Monopolistic Position	………………...	8
	B. Narrow Needs	………………...	8
	C. Lack of Hardware & Software Standards	………………...	9
	D. Lack of Guideposts & Trajectories	………………...	10
3.	**The Fixed Computing Paradigm: Phase 2 - Microcomputers**		
	3.1 Key Events & Developments	………………...	11
	3.2 Decoupling's Dominance: Factors & Reasons	………………...	14
	A. Lessons from the Past Period	………………...	14
	B. Open Competition	………………...	14
	C. Highly Varied User Base	………………...	15
	D. Software Standards	………………...	16
4.	**The Mobile Computing Paradigm**		
	4.1 Key Events & Developments	………………...	18
	4.2 The Struggle for Dominance	………………...	23
	A. Factors Favoring Integration	………………...	23
	B. Factors Favoring Decoupling	………………...	24
5.	**A Dynamic Two Stage Mechanism**		
	5.1 The Two Stage Mechanism	………………...	26
	5.2 Explaining the Transition: Learning	………………...	27
	5.3 Explaining the Transition: Production Dynamics	………………...	29
	5.4 A Single Direction Transition	………………...	30
6.	**Conclusions**	………………...	32
7.	**References**	………………...	33

Abstract

Integration and decoupling are two modes of leadership in the computing industry. This paper studies their relationship over a 60 year history and proposes a two stage dynamic mechanism in understanding competitive dynamics in this industry. It spans two technological paradigms, the fixed computing paradigm (mainframes and microcomputers) and the mobile computing paradigm. The paper explains why and how integration is dominant in the earlier stage of each paradigm before decoupling becomes dominant in the later stage.

1. Introduction

Computing has been one of the most pivotal engines of innovation that has disrupted and changed many other industries in the past 60 years (Yates and Maanen, 2001). The computing industry has undergone rapid waves of disruption and change and this can be divided into two technological paradigms. Mainframes and microcomputers form the first paradigm while smartphones largely account for the mobile computing paradigm.



Technological Paradigms in the Computing Industry

There are two main modes of leadership in the computing industry – integration and decoupling. In each paradigm, both modes of leadership compete with each other for dominance. Integration refers to an approach where a single company exerts complete control on hardware and software choices (Aspray, 1990). In decoupling, software and hardware producers are independent and have control only of their own platforms. The resulting end user device or final product is a joint collaboration between multiple firms. This means that the user identifies the final product as a package from different companies.

This paper suggests a dynamic two stage mechanism and explains how the mode of integration is followed by that of decoupling from observations of over 60 years of computing. While preceding research has focused on the advantages and disadvantages of either approach (see Krickx 1995, Economides 1998, Malerba 2006), this paper proposes a dynamic perspective in understanding the relationship between integration and decoupling.

Sections 2, 3 and 4 will examine important events and developments in each paradigm in chronological order. This would help identify key factors that led to a certain mode of leadership to turn dominant within each paradigm. In section 5, I will then propose a two stage mechanism explaining the movement of dominance from integration to decoupling and discuss implications in understanding the current paradigm of mobile computing. Section 6 concludes the paper.

It would be imperative to define differences between integration and decoupling. Each computing system is delineated into 3 parts (Campbell-Kelly and Aspray, 2004):

1. Hardware refers to the complete device that a user interacts with as an entity. This refers to the final product. Individual components such as processors and memories are deemed to be intermediary goods.
2. Operating system (OS) refers to the lowest level of software interaction with hardware components. It is the foundational software layer by which other types of software are dependent on to run. Examples include Windows, CP/M, OSX and Android.
3. Third party application refers to any piece of software that allow the end user to utilize computers for work and entertainment. This can include business, educational and gaming software. Examples include Visicalc, Office, Stata and Solitaire.

Integration sees a complete control of points 1 and 2 by a single producer while decoupling has different firms handling them separately. Both approaches will have varying time sensitive successes with point 3.

2. The Fixed Computing Paradigm: Phase 1 - Mainframes

2.1 Key Events & Developments

The mainframe computer was preceded by a series of single purpose machines targeted solely at businesses. A popular single use device at that time was the punch card machine that was important for many businesses and industries (Truesdale, 1965). A merger of the largest punch card machine manufacturers in the 1880s led to the creation of International Business Machines (IBM). This subsequently formed IBM's monopoly status as a provider of complete business solutions (Usselman, 1993). As such, horizontal integration occurred in the formation of IBM.

IBM's decision to move its customers towards a computer system led to the launch of the IBM 650 in 1953. The IBM 650 is the first mass produced computing device that signalled the start of the mainframe period. IBM's vision was dictated by marketing managers that believed in providing complete solutions that satisfied all computing needs of its customers (Bashe et. al, 1986). This forced IBM into taking an integrated approach, delivering solutions as a complete integrated package so as to cover as many needs as possible.

IBM 650 was deemed as a success that outdid most of its competitors. However, as a first generation device, the IBM 650 was a new and different system and its potential was not realized by corporations that bought it (Fisher et. al, 1983). Consequently, the IBM 1401 was built to allow business to fully utilize mainframes. In order to do so, IBM continued its integrated approach and expanded hardware capabilities. An example of this was its new high speed printer. It also included software that would replace legacy punch card systems (Truesdall, 1965). IBM 1401 encouraged corporations to adopt mainframes and systemize their workflows as they switched over from old single purpose devices to complete systems (Augarten, 1984).

IBM's competitors included Honeywell, RCA, General Electric UNIVAC and Burroughs & NCR. Due to IBM's already significant lead in enterprise solutions before the onset of mainframes, its competitors were forced into taking continuous catch-up strategies. Even firms that could rival IBM in scale and size (RCA, Honeywell and General Electric) decided to avoid the markets that IBM was well established in. Instead they focused on niche markets that IBM had little interest or penetration (DeLamarter, 1986). As such, IBM's integrated approach did not face major competition in this period.

IBM 1401's success encouraged more companies to use mainframes. There was now a demand for more specific variants of the 1401 to fit an increased set of corporate needs. Therefore, many variants of IBM 1401 were built. However, the issue of incompatibility between variants arose as each of them was a standalone integrated machine with its own proprietary hardware and software. IBM was stuck with an exponentially growing number of hardware and software architectures to support (Chposky and Leonsis, 1988). This was a key concern as third party software developers were hindered in the ways they could develop for IBM mainframes. This problem was exacerbated by IBM's preference to keep a firm control on its mainframes in its integration approach (Campbell-Kelly and Aspray, 2004).

As the situation threatened to spiral out of control, IBM made a key decision to integrate all seven variants of the 1401 into a single system. This allowed it to better focus on delivering a strong software platform for this single integrated system. IBM spent up to US$5 billion in research and development to narrow product variation and produced System/360 (Thomas A. Wise, 1966). Its near monopoly position coupled with unrivalled marketing prowess, swept aside older 1401 compatible machines from its competitors (Chposky and Leonsis, 1988).

IBM spent much of the mainframe period expanding and consolidating its product lines as it became increasingly difficult to balance user requirements and system compatibility. Its competitors did not offer much direct competition and took integrated approaches as well. Therefore, the dominant mode of leadership was that of integration.

2.2 Integration's Dominance: Factors & Reasons

A. Monopolistic Position

The first factor comes from the preceding monopolistic market structure in which the mainframe period emerged from. The integrated approach was already dominant in the enterprise solutions market that provided firms with mechanical forms of tabulation such as punch card devices. Thus, firms were already used to such an approach.

Due to its incentives to maintain a stranglehold on its preceding monopolistic status, IBM was motivated to continue such research and development projects in envisioning the next form of computing (Bernstein, 1981). The determination to push into areas where demand was not yet apparent showed both vision and an insatiable desire to maintain its market leader position. There was no apparent intention from IBM to outsource either hardware or software. IBM believed that its integrated approach was a better fit for its business model and would yield better profits.

Lastly, the size of the consumer base that IBM already had placed them in prime position to confidently push its customers forward into the next period of computing. IBM was willing to continually take such risks due to the breadth of its outreach (DeLamarter, 1986). These factors were crucial to IBM's decision to continue with a fully integrated approach as a dominant monopoly.

B. Narrow Needs

The second factor is low variations in the needs of its customers. While IBM's customer base was large, user requirements were generally identical and narrow. Early computers were devoted only to computationally intensive tasks. Data processing and database manipulation were the only functions that firms utilized mainframes for (Campbell-Kelly and Aspray, 2004).

The main weakness of an integrated approach is its inability to meet a wide range of needs. However, this was not exposed during the mainframe period as corporations only used mainframes for intensive singular tasks such as order processing and staff payroll. These needs were similar across different firms. As a result, IBM was able to cover over 90% of the market (Computer & Communications Industry Association, 2008).

C. Lack of Hardware & Software Standards

The third factor that led to integration’s dominance was the lack of hardware and software standards, allowing each mainframe provider to dictate the exact forms of complementing hardware which would work with their mainframes. For example, the IBM 1403 ‘chain printer’ was built such that it worked only on IBM 1401 devices. As the hardware standard of the 1401 was unique, the 1403 could not be used with any other system. Thus, the demand for mainframes from other producers was severely affected (Usselman, 1993). There was essentially no standard until System/360 was introduced (Pugh, 1984). Even then, complementing IBM hardware could not be used with past and future devices.

While System/360 did narrow hardware standards, there were still significant variations in software. There were five different operating systems running on IBM machines, namely OS/360, DOS/360, TOS, BPS and ACP. As each operating system was a closed integrated system, cross compatibility remained a difficult issue (Usselman, 1984). As such, the lack of standards in the mainframe period allowed IBM to monopolistically hold consumers captive. This made integration the only viable form of leadership.

D. Lack of Guideposts & Trajectories

The fourth factor is attributed to the mainframe period being an exploratory stage of the computer paradigm. There was a lack of technological trajectories at that point in time. Technological trajectories are blueprints that map the expected path of innovation for a piece of new technology that is powerful enough to open up a wide range of possibilities through new combinations (Nelson and Winter, 1982). Trajectories allow the best use of known attributes and trends to reduce the level of uncertainty so as to allow decision making to occur under bounded rationality. The mainframe period was at a stage too early for any credible trajectory to be established and firms did not have a common base to work on. Therefore, the computing industry remained at a trial and error phase which meant that cooperation between firms would be almost non-existent. This reinforced the preference for an integrated approach over decoupling.

3. The Fixed Computing Paradigm: Phase 2 - Microcomputers

3.1 Key Events & Developments

The most important event that started the microcomputer period was the birth of its enabling technology – a general purpose logic chip called the microprocessor. In contrast, mainframes had unique CPUs that were costly and had differing proprietary standards (Campbell-Kelly and Aspray, 2004). Intel was the forerunner devoting the largest amount of resources and placing core focus on this new general purpose logic chip. The birth of the microprocessor occurred when Intel's lead designer, Ted Hoff had to design a logic chip for Japanese firm Busicom's new calculator. It was decided that specific custom built logic chips were not the optimal route for Intel. Instead, a general purpose chip that could be programmed later for calculator functions was built (Malone, 1995). Intel was soon joined by competing firms and the Motorola 6800, Zilog Z80 and MOS Tech 6502 soon entered the market. The resulting price competition caused microprocessors to fall to a low price of US$100 per unit (Goldstein and Aspray, 1997).

With microprocessors cheaply made and distributed, a cultural switch occurred as hobbyists became early adopters instead of enterprises. An extremely wide range of microcomputers were built by computing enthusiasts. Multiple firms including Applied Computer Technology, IMSAI, North Star, Cromemco, Vector, Apple and many other small firms emerged quickly to take advantage of the cheap microprocessor (Baum, 1981). The open nature of the microcomputer market meant that it was volatile with quick entrances and exits for many firms, and product variety was at its highest (Cohen, 1984).

Emphasis on software took an even larger centre stage during this period. The ability of microcomputers to enter different markets depended purely on third party software support. It was at this point that Microsoft envisioned the importance of a unified software platform that could support multiple third party applications (Ichbiah and Knepper, 1991). This was later known as the operating system (OS) and it was the underlying software layer that enabled cross compatibility for third party software to run on. The advent of operating systems expanded the market for microcomputers to include non-technical users. In the past, users required technical knowledge to reprogram their devices every time they switched it on. The OS was thus a secondary force that enabled this new period of computing. It brought software standards that helped narrow the wide spectrum that third party software applications were developed in (Ichbiah and Knepper, 1991).

The market for third party software continued to expand and so did its user base. While microprocessors and operating systems merely provided the stage, third party applications were the ones that provided features and productive uses for these devices. A key example of this is Visicalc. The pioneering spreadsheet programme moved micro computing from a hobby to an important business device (Grier, 1988). The software market took off with hundreds of small firms focusing on applications for businesses, education and games.

The booming micro computing market that had business applications threatened IBM and it had to readjust its strategy to adapt to new market conditions. IBM's usual integrated approach was deemed too slow to adapt to the pace of a fast changing micro computing market (Paul Carroll, 1994). IBM needed three years for a newly created product to reach the market which was a far cry from the mere months that new, leaner and smaller competitors took. IBM decided to abandon integration to utilize the decoupled approach that was already common in the microcomputer market. Its decision to go with the Intel 8080 microprocessor coupled with Microsoft's operating system was key to creating the Wintel alliance (Casadesus-Masanell and Yoffie, 2007). IBM's flexibility in switching to a decoupled approach enabled Intel and Microsoft to become dominant hardware and software standards. The presence of such standards triggered a period of consolidation. Integrated competitors such as Apple, did not share the same CPU and OS as its IBM counterparts. Therefore, they received little support from third party developers, leading to lack of market demand.

Within the space of just 10 to 12 years, the microcomputer market underwent the full cycle of growth, expansion and consolidation. IBM, in its decoupling approach, had relinquished control of driving advancement in the computer industry to Intel and Microsoft (Paul Carroll, 1994). IBM compatible manufacturers such as Hewlett Packard and Dell were joined by multiple Asian counterparts like Acer, Sony and Toshiba. Even though the market for microcomputers (now simply known as Personal Computers or PC) was wide and expanding, the margins for such system assemblers began to fall. The dependence on Intel and Microsoft meant that there was little they could do to differentiate themselves from each other. IBM decided to leave the PC market in 2005 selling off its entire end user computing devices (both business and personal) to Lenovo in order to concentrate on providing software enterprise solutions (Lohr, 2011). Multiple acquisitions also occurred including Hewlett Packard's acquisition of Compaq and Acer's purchase of Gateway (Gartner, 2007).

Therefore, the dominant form of leadership throughout this period was decoupling as firms adopting this approached took over 90% of the market (Campbell-Kelly and Aspray, 2004). Even firms that utilized the integrated approach did not produce CPUs of their own. Apple's integration approach saw them build their own hardware and software but they still relied on Motorola and later Intel for processors.

3.2 Decoupling's Dominance: Factors & Reasons

A. Lessons from the Past Period

The mainframe period had established a few universal standards that were necessary for the development of microcomputers. Basic instruments such as input and output devices were developed during the mainframe period and were largely copied and expanded on in the microcomputer period. These included keyboards, TV monitors and printers (David, 1986).

Secondly, lessons from preceding eras were largely accountable for Intel's decision to move towards a more general logic chip design. This was spurred by the difficulties faced by mainframe manufacturers towards the end of the mainframe period (Malone, 1995). The microprocessor is the most important enabling technology in microcomputers. There was also consistent effort from multiple manufacturers to focus on cross compatibility when selecting which CPU and OS to adopt. These were definite lessons that were derived from IBM's colossal risk in attempting to consolidate mainframes with System/360.

B. Open Competition

There was a large number of experimental combinations being tried and tested (Baum, 1981). While Intel is the most mentioned processor maker, there were competing options from Motorola, Zilog and MOS that pressured each other to quickly implement lessons learnt in order to survive in an open market (Goldstein and Aspray, 1997).

Open competition forced firms to stay lean and rely on their comparative advantages. This made it important for firms to find complementing partners to cooperate with. Such market conditions propelled and reinforced the prevalence of decoupling as the mode of leadership.

C. Highly Varied User Base

Mainframes were adopted only by corporations and enterprises. However, the microcomputer market had a very different user base. As hobbyists and enthusiasts were the first adopters of microcomputers, it made little economic sense to deliver a costly integrated suite. Microcomputers such as the Altair 8800 were as low as US$439 (MITS, 1975) which made it affordable for smaller businesses and certain individuals to purchase and use. This meant that the computing industry had a very large number of varied customers.

Third party software served a wide variety of users. One of the major categories of software that flourished was gaming. The category of games spurred not only the understanding of human interaction with computers, it also opened up computing to a vast number of users and surpassed multiple barriers such as age and programming expertise (Herman, 1994). Other software categories included educational and general purpose business applications. This is a significant change from the mainframe period where only single purpose business applications were needed.

As the size of the market increased, the ability for a single manufacturer to cover all markets was operationally impossible. This posed difficulties for integrated solutions such as Apple's microcomputers. In response, Apple filled a niche market for content creation and graphics design and is still unable to surpass 10% of the microcomputer market for over 30 years (Carlton, 1997). The change in user base thus made decoupling the mode of leadership in the micro computing period.

D. Software Standards

The fourth reason for the dominance of decoupling was due to the shift in power from hardware to software. This allowed software standards to be formed. The most important standardization was that of the operating system. Microsoft's cementation of power as a software OS provider gave it a strong bargaining power over its hardware partners. IBM, the company that propelled Microsoft as the dominant operating system, was unable to push its own OS/2 operating system due to Microsoft's dominance in the OS market (Hasagen, 2002).

Even the Wintel alliance saw software (Microsoft) hold much of the power. Intel's CPUs are released on an annual basis while new versions of Windows are released every 3-5 years. In the earlier years, Intel was quick to release its first 32 bit chip. However, it had to wait for a decade before Microsoft released a 32 bit operating system that took full advantages of the Intel chip. Intel had little power to push Microsoft to hasten its release and support Intel's new hardware (Casadesus-Masanell and Yoffie, 2007).

Besides processors, system assemblers such as Hewlett Packard, Dell and Acer were also highly dependent on Microsoft's Windows release cycles for the sale of their computers. Consumers usually purchase new PCs when Microsoft releases a new version of Windows. Attempts to diversify into competing operating systems did not fare well for these companies. Dell attempted to launch a Linux based line up of systems but the product line has grown very slowly caused by little third party application support for Linux. (Weiss, 2008).

Power did not fall into Microsoft's hands purely because of Windows. Instead, the captive power that Windows had was driven by the most extensive collection of third party software available on its platform. Apple's approach to producing its own software thus paled in comparison to Windows' massive third party support (Cusumano and Selby, 1995).

As Microsoft's operating system became the dominant software standard, multiple hardware manufacturers and third party developers converged on this standard allowing an effective decoupling approach. All these factors caused decoupling to be the mode leadership in the microcomputer period.

4. The Mobile Computing Paradigm

4.1 Key Events & Developments

The first smartphones include IBM's Simon, Ericsson's GS88, Nokia's 9000. These devices were introduced from 1994 to 1996 (Reed, 2010). The early smartphones were purely integrated devices. The IBM Simon ran a custom processor called Angler with a ROM-DOS operating system. Similarly, Ericsson's and Nokia's variations ran their own custom CPUs with different variants of GeOS. There was no cross compatibility for third party applications due to this. The need for cross compatibility was not imperative at that point due to the small number of users (mostly enterprise) that had a narrow set of needs (Ilyas and Ahson, 2006).

The growing smartphone market was joined by Palm and Microsoft which introduced PalmOS and Windows Mobile. These new operating systems allowed cross compatibility of applications between devices running the same OS. Palm's OS was tightly integrated with hardware while Windows Mobile was distributed among original equipment manufacturers (OEMs) such as Hewlett Packard, Compaq and many others (Ilyas and Ahson, 2006).

The introduction of software standards pushed Nokia to standardize their operating system. Symbian became the most dominant operating system due to Nokia's singular focus on the consumer segment of the smartphone market. While Microsoft's decoupled approach saw more varied handsets, the market was still too narrow and demand was not sufficient. Also, Microsoft's core focus was still firmly locked on the microcomputer market. (Ilyas and Ahson, 2006).

Blackberry joined the ranks of smartphones in 1999 concentrating on the core capability of push email. Blackberry's focus on security and business services made the device the top business smartphone for 8 years (Sweeny, 2009).

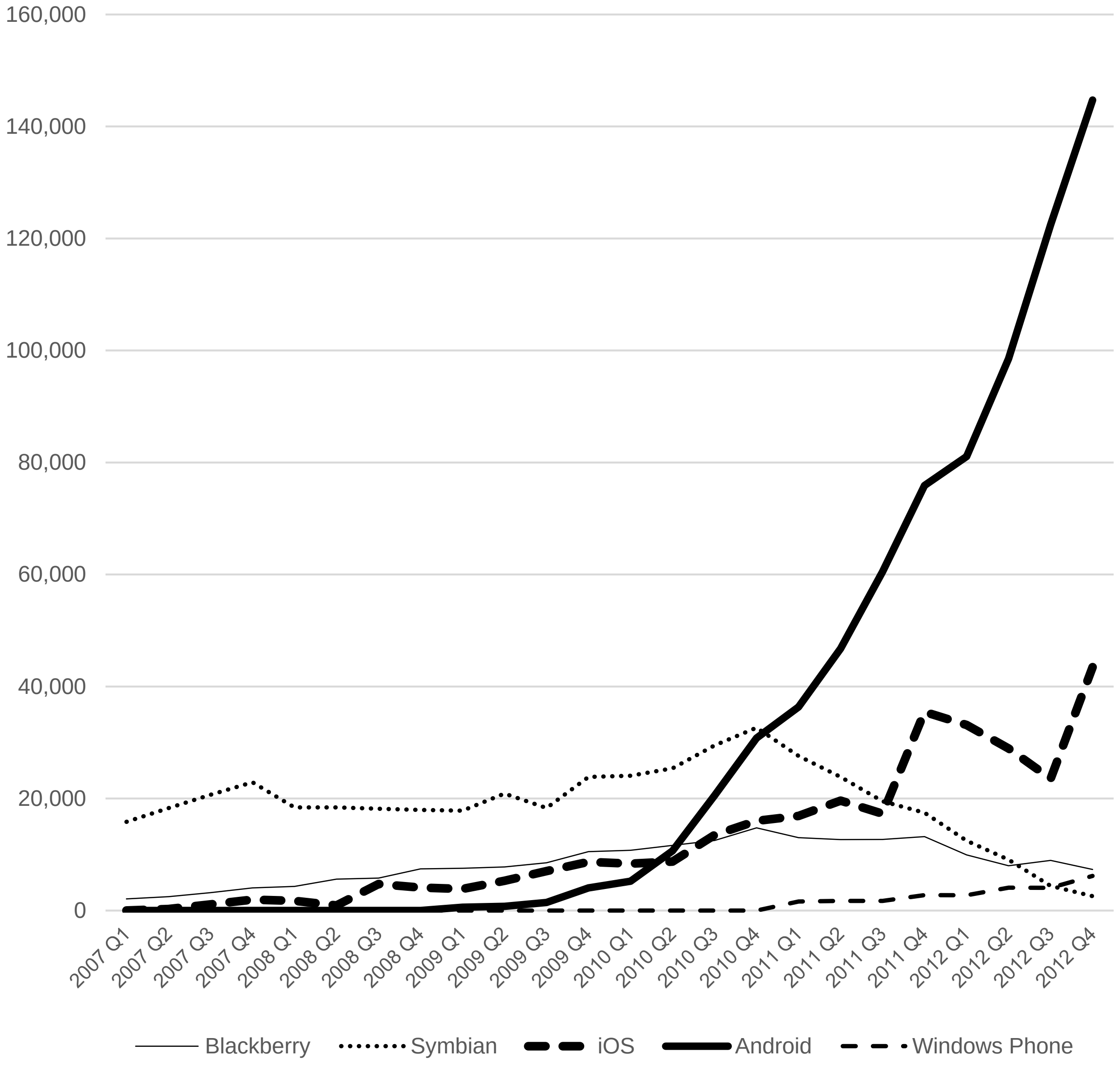
In this first part of the mobile computing paradigm, the mobile phone market remained focused on delivering emails and office styled applications. The key mode of leadership was clearly integration as software ecosystems for all popular operating systems remained small and user needs were less varied.

The second part of the mobile computing paradigm began in 2007 when Apple and Google launched the iPhone and Android operating system respectively. The iPhone ran an integrated operating system called iOS while Android was built as an open operating system that any phone manufacturer could customize under the Open Handset Alliance (Open Handset Alliance, 2007). It is at this point of the mobile computing paradigm that two vastly different modes competed for leadership of the market.

Apple's close integration of hardware and software meant that consumers identified the iPhone as an entity on its own. There was no real emphasis on the type of CPU and operating system it was running. Apple had licensed ARM technology to build its own customized processor and the operating system that the iPhone and iPod Touch ran was later named iOS. The integrated approach saw Apple pushing devices as a whole with little focus on the intricate hardware and software specifications of the device.

Within the same year (2007), Google announced its own version of a mobile operating system known as Android. Google's approach was drastically different from Apple's. Google had no interest in being involved in the production and development of CPUs and final hardware. Taking a very clear decoupling strategy, Android was first partnered with HTC and Samsung together with CPU manufacturers Qualcomm and Texas Instruments (Qualcomm, 2008). In 2008, the HTC Dream became the first Android phone to be launched.

From 2007 to 2010, iOS and Android dominated the smartphone markets as Nokia and RIM (later renamed Blackberry) lost significant market share. The most important change to the market was the strong push for the consumer (non-business) sector in adopting smartphones. With a different audience, the third party application market grew quickly as user needs were widely varied. Thus, Android and iOS took the lead in the market. This can be seen in the figure below (Gartner, 2012).



World Wide Smartphone Sales by Operating System (Thousands of Units)

(Source: Gartner, 2012)

Even though iOS and Android were both announced in 2007, Apple entered the market a year before Android phones were sold. Apple's unique mastery of its supply chain meant that it was able to meet high demand without notable shortage issues (The Economist, 2012). Also, its integrated approach allowed Apple to create a rather limited but well-built smartphone where hardware and software worked seamlessly together (Cunningham, 2012). Thus, a first mover advantage, good supply chain management and the use of an integrated approach allowed Apple to capture higher margin segments of the consumer market.

However, the dominance of the integrated approach ended as soon as the first mover advantage evaporated. Even though Apple had lost significant market share, it was argued that Apple was only targeting the high margin segment of the smartphone market. That changed within three years as Android devices were built that targeted the same high margin segment. Samsung's mobile division launched its Galaxy series that targeted the same market segment as Apple did. HTC later did the same with its One series in 2012 while Sony, LG and Motorola also began to target the high profit margin segment (Ruddock, 2013). These phones were priced similarly or higher than the iPhone. With greater experience working with its partners, these manufacturers were able to launch devices that were on par with the integrated iPhone experience. In the space of two years, Samsung phones took leadership of the market with its growth outpacing Apple, having successfully encroached on Apple's preferred market segment. By end 2012, Android took a 70% share of the international market as Apple's early lead came to an end (Gartner, 2012).

Apple's integrated approach could not match the faster turnarounds and advancements on an OS level. Due to integration, iOS and the iPhone had to undergo concurrent annual cycles of updates. This rigid release timeframe paled in comparison to Android that was updated frequently in a short span of a few months. Android hardware makers also released new phones every four to six months (Donnelly, 2013). While faster turnaround times made the Android platform relatively unpredictable in the early years, market consolidation after 2010 allowed the decoupling approach to leapfrog a predictable and rigidly integrated iOS in market share.

Microsoft re-entered the second period of the mobile computing paradigm late in 2010 as it replaced its aged Windows Mobile with Windows Phone. It followed a decoupling approach similar to Google’s Android. Due to its late entrance into the market, Microsoft’s Windows Phone remains a minor player (Fieber, 2012). Nonetheless, it must be noted that a clear decoupling approach was used in this case.

The decoupling approach has taken the current lead in the mobile computing paradigm. However, the decoupled approach has yielded uneasy alliances and partnerships. With Android and Windows Phone, hardware manufacturers still faced a familiar situation of being completely dependent on the OS provider for success. In response to this, Samsung, Intel and other hardware partners have grouped together to support a secondary OS known as Tizen. Tizen is a Linux based OS that is still currently under development. However, Tizen is a backup platform in the event that Google and Microsoft decide to steer the directions of their OSes in ways disagreeable to their hardware partners (Tizen, 2013).

It is not only hardware manufacturers that have begun to plan for a possible failure in partnerships with Google and Microsoft, Google on its own has purchased Motorola. Industry observers interpret this move as an option for Google to take an integration approach in the event of breakdowns in partnerships with its hardware vendors (McCarthy and Golvin, 2011). In Mobile World Congress 2013, Google mentioned that it was uneasy having Samsung as its most major partner by a large margin (Wall Street Journal, 25 Feb 2013). Therefore, the problems associated with decoupling are often tied to worries of the imbalance of power between hardware manufacturers and software providers.

Nonetheless, decoupling has become the dominant mode of leadership after initial approaches to the mobile computing paradigm were integrated in nature.

4.2 The Struggle for Dominance: Integration vs. Decoupling

A. Factors Favouring Integration

There are three factors that favour integration. Firstly, integration again proved to be beneficial when entering a new paradigm. iOS created and captured a new market segment. While smartphones were already in use by a small base of business users, Apple's strategy of a media consumption device opened the market to consumers (Honan, 2007). A new market segment with more varied needs gave Apple space in which it could define standards. Apple's move took the industry by surprise and competitors took a year to respond to the new product. This allowed Apple's integrated approach to flourish in a new paradigm.

Secondly, Apple's integrated move was complemented with excellent supply chain management. Its ability to source for components and manage quick turnarounds meant that it was able to hit the market faster that most of its counterparts. With the exception of Samsung, Apple is still able to outperform hardware-only manufacturers like HTC, Sony and LG (The Economist, 2012).

Thirdly, Apple's first mover advantage allowed it to bypass problems that were observed in the previous paradigm. Developers prefer to write software for more open operating systems due to wider support. However, due to its first mover advantage, Apple was able to build a robust third party app ecosystem more quickly than its competitors. As Android faced early fragmentation problems before consolidation, Apple's software ecosystem reaped full advantages as the most attractive platform to develop for (Distimo, 2012). Therefore, Apple's first mover advantage allowed it to avoid third party developer issues usually associated with an integrated approach.

B. Factors Favouring Decoupling

The first factor that favours decoupling is that of software advancement. Apple's software advancement has been relatively slow as compared to Android. iOS has undergone 6 iterations in 6 years with no significant advancement in feature sets. Apple's decision to keep iOS light to augment hardware capabilities meant that it was unable to launch more significant software updates that would keep iOS fresh (Yarrow, 2012).

In contrast, Google's approach was to keep working on its operating system at a much quicker pace. Being specialized in software, Google's Android has undergone 18 revisions with 10 of them being significant ones (Ziegler, 2011). In each revision, Android allowed developers to access more and more operating system services (also known as application programming interfaces, APIs). This meant that software could better communicate with both the operating system and other applications, increasing the feature set of the platform. On the other hand, iOS preferred to lock down most of its APIs releasing only a small handful in each annual iteration.

With faster and more significant updates, Android quickly became a mature OS with a consistent release cycle and a wider feature set. It was also at this time that Android overtook iOS in market share and the gap has continually widened worldwide (Mukherjee, 2012).

Secondly, decoupling is able to better adapt to market growth. Google's decoupled approach took over leadership from Apple's integration as Android phones were able to reach a wider spectrum of users. While Apple had only a single device that catered largely to the higher margin portions of the market, Android was able to fill niches by having many hardware partners who made multiple Android variants themselves. Android phones from hardware manufacturers effectively filled every price range available (Donnelly, 2013). More importantly, major hardware partners like Samsung was also able to cater to different needs. It has produced Android devices for every screen size from 3 to 10 inches (Reisinger, 2012). This move was beneficial as it matched the extremely wide and varied user base that characterized mobile computing.

Thirdly, decoupling was able to mount a quick catch up after market consolidation. This largely erased the benefits of integration that Apple enjoyed due to its first mover advantage. With Android beginning to invade Apple's high margin market segments, third party application developers could no longer ignore Android due to its greater outreach. Former iOS only applications like Instagram and Path made their moves to create Android versions (Ngak, 2012). The application support of Android has grown steadily to match iOS in late 2012. With over 600,000 third party applications in its Google Play store, Android has caught up and drawn even with iOS (Robertson, 2012).

At this time of writing, decoupling has taken the lead with the future of integration resting purely on the shoulders of Apple and Blackberry. Decoupling's current success is expected to continue into the future as the mobile computing sees an even larger and more varied base that continues to widen and grow.

5. A Dynamic Two Stage Mechanism

Observations of the relationship between integration and decoupling in the preceding sections of this paper suggest a two stage mechanism. This section explains the mechanism, direction and the transition from integration to decoupling.

5.1 The Two Stage Mechanism

It is observed that both the computer and mobile computing paradigm have undergone similar patterns in advancement. Each paradigm begins with integration before decoupling takes over as the dominant mode of leadership. Integration is well suited for new computing products that have not existed previously. There are larger risks in producing such devices as the market potential is unknown. Therefore, it is significantly harder for various firms to cooperate and work towards building a singular device with decoupled approach. The mainframe period and the early portions of mobile computing thus had very specific devices that were built in house and released only in small quantities. These were exploratory devices whose main functions were to identify case use scenarios and test adoption rates (Ilyas and Ahson, 2006). The IBM Simon, Nokia 9000 and iPhone bear evidence in the mobile computing paradigm as did the IBM 650 and 1401 in the computer paradigm. Integrated products that turned successful in gaining market traction led to more advanced devices that were still built under integration.

However, the integrated approach does not seem to last for long. IBM's dominance in the non-portable product category dissolved the moment hardware and software standards were accepted across the industry. (Lohr, 2011). The reasons for decoupling's eventual dominance is due to a widening market and growing variety in user needs. Even Apple's tremendous initial dominance has been very quickly eroded as it is unable to cover different markets (Etherington, 2013). This is why the decoupling approach has consistently emerged as the dominant mode over time.

Decoupling has still proven to be problematic when used as an initial approach of entering a market. This is true even though experience in the computer paradigm has shortened periods of consolidation in mobile computing. Google has faced issues with going fully decoupled at the start. These early issues caused Google to combine both integrated and decoupled approaches as the market for tablets and hybrids continued to consolidate. Google had to move quickly to work very closely with Asus to produce the Nexus 7 as a Google controlled design and experience (Pegoraro, 2012). It has also done the same for its numerous other Nexus smartphones. While such problems have eased with market consolidations, there remain significant problems with using a decoupled approach at the start of a new paradigm.

Therefore, it can be established from observations over sixty years of computing history that the integrated approach has proven to be a better mode of leadership at the onset of a new paradigm. However, after periods of consolidation, decoupling emerges as the dominant mode because it is better able to adapt to changing market conditions and cater to a broader and more varied customer base. This is the two stage mechanism where integration has an early advantage before being overtaken by a decoupled approach.

5.2 Explaining the Transition: Learning

It seems that the transition from integration to decoupling is driven by learning and consolidation. Learning allows a firm to progress from point to point within a trajectory (Freeman, 1992). Its general direction moves from learning at the source of production (doing) to multi-way information flows between all involved in the product (interaction).

At the starting point of each technological paradigm, the lack of trajectories and guideposts forces firms to experiment. In these early exploratory stages, firms begin to learn and understand more about the technology through repeated rounds of learning by doing. An example of this is IBM's decision to create a more compatible Model 1401 after facing compatibility issues with a rigidly standalone Model 650. Learning also occurs between firms and users (Lundvall, 1988). Intel's decision to push for a general purpose logic chip was driven by lessons learnt from IBM's previous experiences. This entire process of learning by doing and interacting enabled the computer industry to enter a phase of consolidation. Through consolidation more is known about the technological trajectory. This allows more common points of understanding, which enables firms to seek partnerships rather than produce everything on their own. As such, learning is an important transition device that allows consolidation which in turn sees decoupling take over as the dominant approach.

Learning also occurs between different paradigms. Lessons from the mainframe and micro computing paradigm are carried over to that of the mobile computing paradigm. Apple is one of the key examples. Lessons it learnt from the first paradigm caused the firm to take a very keen focus on its supply chain capabilities and also on the importance of third party application support. Apple took these lessons from the previous paradigm and quickly implemented them in mobile computing. This was how Apple avoided common integration pitfalls from the previous paradigm.

Learning also affects the speed of consolidation in each technological paradigm. The period of consolidation is also seen to be shortened dramatically as mobile phones took only ten years to move from a device specific processor chip to a more general purpose logic chip in the mobile computing paradigm. The same consolidation process took over 30 years in the computer paradigm.

Learning is thus an important transition device that enables decoupling to take over as the dominant form of leadership through consolidation. Learning also causes these important periods of consolidation to be dramatically shortened from paradigm to paradigm.

5.3 Explaining the Transition: Production Dynamics

What enables either integration or decoupling to become dominant is its ability to balance the production of hardware and software at a specific point in time within the paradigm. Each component has its own production time whether be it in integration (multiple departments within a single firm) or decoupling (across multiple firms). These individual production times must coincide in order for the device to be successfully delivered. It is more probable for production times to coincide when there larger numbers of producers. This is true when a device is produced using a decoupled approach. Multiple hardware partners assures a software vendor that at least a few of them will be able to line up their hardware for a joint launch. However, in the case of integration, there exists only one line for hardware and one line for software. Minicomputers like Apple's LISA (Bergin et. al., 1996) and Blackberry's mobile z10 device are examples where hardware and software played a continual waiting game for each other to catch up. The resulting mismatch in development cycles meant that the platforms came to market far behind its competitors. With fewer options at hand, it is more likely for integration to face production times that are out of sync. This upsets the balance due to production inefficiency which delays the launch of the product.

As observed, integration is dominant when markets are small with a narrow user base. This means that market conditions are unconducive for multiple producers. Under such conditions, the hardware and software balance is easily kept within a single firm as external competition is low. However, integration is unable to keep this balance as the market widens and multiple competitors enter the market.

The same need for the right balance at the right time can be seen in decoupling. Decoupling is able to find its balance at the later stages of each paradigm. However, this balance cannot be found at early stages as there are no common standards for large numbers of producers to jointly produce (Hashagen et. al., 2002). This can be seen in the early days of Android. Hardware manufacturers had to forge new partnerships with CPU makers and work with a new operating system that they barely had experience with. It took a few years before market conditions suited the decoupling approach. This later allowed the important hardware - software balance to be found.

Therefore, the dominance of integration or decoupling is underscored by the ability of each approach to ensure a dynamically efficient joint production of hardware and software. Over time, decoupling becomes better suited to this process causing it to become dominant in the second stage of this mechanism.

5.4 A Single Direction Transition

It is observed that decoupling assumes leadership over time largely due to the importance of software and the power that it wields. Therefore, the two stage mechanism does not occur in reverse and only a movement from integration to decoupling appears to be possible. The single direction nature of this mechanism is explained in two parts.

Firstly, it is observed that software dictates the adoption and popularity of the computing platform. Features and the way devices are used are fully dependent on third party software and operating systems (Lohr, 2001). Thus, the constraint of each platform is the number of software developers it is able to attract. This will determine the number of features available in each operating system. Developers will pick an operating system it deems able to reach the widest audience and focus on that platform. This results in the sub market for operating systems to be rather narrow with no more than two to three recognized and widely adopted

OSes per paradigm (Lohr, 2001). The widespread adoption of an operating system causes the OS to become a monopoly over time. This movement is difficult to reverse. This can be seen where efforts to dethrone Windows in the past paradigm and Android in the mobile computing paradigm have been largely ineffective.

With the knowledge that popular operating systems turn monopolistic over time, software developers prefer to develop for a platform that has the widest hardware support as this increases the chance that they can reach out to as many markets and user types as possible. Tying an operating system to a single manufacturer in an integrated approach is thus unattractive to developers in the long run. Therefore, popular operating systems are monopolistic and also tend to be those that are open, allowing multiple hardware vendors to build devices for it.

As such, these two factors make it difficult for any technological paradigm to see a reverse movement from decoupling to integration. Thus, the two stage mechanism is observed to be linear and moves only in a single direction.

6. Conclusion

This paper discussed different forms of leadership throughout the past two computing paradigms and identified dominant modes at different time periods. Reasons and factors of each dominant form have also been analysed. There is a clear trend that leadership shifts from integration to decoupling within each paradigm.

To understand this transition, this paper proposed a two stage mechanism. Integration is the preferred form of leadership at the start of a paradigm that later gives way to decoupling. This movement occurs only in a single direction and its transition is driven by learning, consolidation and production dynamics. This paper expects that decoupling will become even more dominant as the mobile computing paradigm matures.

The computing industry is both a fascinating and powerful driving force in innovation. With many facets of the economy defined by developments in computing, it is imperative to view competing forces vying for market leadership in a dynamic manner. Better understanding of leadership dynamics in this industry will enable the computing industry to advance and efficiently bring positive change, innovation and development to the economy as a whole.

7. References

A. Pedegs, "System/360 And Beyond," IBM Journal Of Research And Development, Vol. 25, No. 5, September 1981, Table 2, p. 387; various data on file in IBM Corporate Archives.

Android Open Source Project. 2008. Philosophy and Goals. Available at: http://source.android.com/about/philosophy.html Last accessed: 26 Jan 2013

Aspray, William. 1990. John von Neumann and the Origin of Modern Computing. Cambridge, Mass.: MIT Press

Augarten, Stan. 1984. Bit by bit: An illustrated History of Computers. New York: Ticknor & Fields

Barron, David W. 1971. Computer Operating Systems. London: Chapman and Hall

Bashe, Charles J., Johnson, Lyle R., Palmer, John H., and Pugh, Emerson W. 1986. IBM's Early Computers. Cambridge, Mass.: MIT Press

Baum, Claude. 1981. The System Builders: The Story of SDC. Santa Monica. Calif.: System Development Corporation

Bergin, Thomas J., Gibson, Richard G., and Gibson, Richard G. Jr, eds. 1996. History of Programming Languages. vol. 2. Reading, Mass.: Addison-Wesley

Bernstein, Jeremy. 1981. The Analytical Engine. New York: Random House.

Braun, Ernest, and MacDonald, Stuart. 1978. Revolution in Miniature: The History and Impact of Semiconductor Electronics. Cambridge: Cambridge University Press.

Brennan, Jean F. 1971. The IBM Watson Laboratory at Columbia University: A History. New York: IBM Corp.

Brock, Gerald W. 1975. The U.S. Computer Industry: A Study of Market Power. Cambridge, Mass: Ballinger.

Campbell-Kelly, Martin, and Aspray, William. 2004. Computer: A History of the Information Machine 2nd Ed. Boulder, Colo.: Westview Press

Carlton, Jim. 1997. Apple: The Inside Story of Intrigue, Egomania, and Business Blunders. New York: Random House.

Carroll, Paul. 1994. Big Blues: The Unmaking of IBM. London: Weidenfeld & Nicolson.

Casadesus-Masanell, Ramon and Yoffie, David B. 2007. Wintel: Cooperation and Conflict in Management Science. Vol. 53 No. 4 pp.584-598

Chas, G. C. 1980. "History of Mechanical Computer Machinery." Annals of the History of Computing 2. no. 3: 198-226.

Chposky, James and Leonsis, Ted. 1988. Blue Magic: The People, Power and Politics Behind the IBM Personal Computer. New York: Facts on File.

Clarke, Gavin. 2013. Microsoft Blasts PC Makers. The Register. Available from: http://www.theregister.co.uk/2013/01/24/windows_8_blame_game/ Last accessed: 17 Feb 2013

Cohen, Scott. 1984. Zap! The Rise and Fall of Atari. New York: McGraw-Hill

Computer & Communications Industry Association. 2008. IBM Tightens Stranglehold Over Mainframe Market; Gets Hit with Antitrust Complaint in Europe. Available at: http://www.ccianet.org/index.asp?sid=5&artid=62&evtflg=False Last Accessed: 16 Feb 2013

Cunningham, Andrew. 2012. What happened to the Android Update Alliance? ArsTechnica. Available from: http://arstechnica.com/gadgets/2012/06/what-happened-to-the-android-update-alliance/ Last accessed: 16 Jan 2013

Cusumano, Michael A., and Richard W. Selby. 1995. Microsoft Secrets: How the World's Most Powerful Software Company Creates Technology, Shapes Markets, and Manages People. New York: Free Press.

David, Paul A. 1986. "Understanding the Economics of QWERTY: The Necessity of History." In Parker 1986, pp. 30-49

DeLamarter, Richard Thomas. 1986. Big Blue: IBM's Use and Abuse of Power. New York Dodd, Mead.

Diaz, Sam. 2010. Google's New Core Business: All Internet, all the time. ZDNet. Available from: http://www.zdnet.com/blog/btl/googles-new-core-business-all-internet-all-the-time/42635 Last accessed: 20 Jan 2013

Distimo. 2012. Apple App Store Performance: The 2012 Top 100 Global Brands. Available from: http://www.distimo.com/publications Last accessed: 15 Feb 2013

Donnelly, Caroline. 2013. Samsung overtakes Apple to lead smart device market. IT Pro. Available from: http://www.itpro.co.uk/mobile/19282/samsung-overtakes-apple-lead-connected-device-market Last accessed: 20 Feb 2013

Economides, Nicholas. 1998. "Competition and Vertical Integration in the Computing Industry." Journal of Economic Behavior & Organization 26. no. 1: 75-91.

Eklund, Jon. 1994. "The Reservisor Automated Airline Reservation System: Combining Communications and Computing." Annals of the History of Computing 16. no. 1:6-69

Elliot, Jim. 2010. IBM Mainframes - 45 Years of Evolution. IBM Corporation.

Etherington, Darrell. 2013. Why Every Analyst Is In Love With The Siren Song Of The Low Cost iPhone. TechCrunch. Available from: http://techcrunch.com/2013/02/22/why-every-analyst-is-in-love-with-the-siren-song-of-the-low-cost-iphone/ Last accessed: 26 Feb 2013

Fieber, Joseph. 2011. Why Windows Phone 7 Is Too Late. PC World. Available from: http://www.pcworld.com/article/243715/why_windows_phone_7_is_too_late.html Last accessed: 24 Jan 2013

Fisher, Franklin M., McKie, James N. V., and Mancke, Richard B. 1983. IBM and the U.S. Data Processing Industry: An Economic History. New York: Praeger.

Freeman, Chris. (1992), "The Nature of Innovation and the Evolution of the Productive System", in The Economics of Hope: Essays on Technical Change, Economic Growth and the Environment, London: Pinter Publisher.

Frieberger, Paul, and Swaine, Micael. 1999. Fire in the Valley: The Making of the Personal Computer, 2nd e.d New York: McGraw-Hill.

Gartner. 2007. Acer to Acquire Gateway, Strengthening Its Global Position. Available from: http://www.gartner.com/id=516810 Last Accessed: 5 Feb 2013

Gartner. 2012. World Wide Smartphone Sales by Operating System. Available from: http://www.gartner.com/technology/mobile/. Last accessed: 16 Jan 2013

Goldberg, Adele, ed. 1988. A History of Personal Workstations. New York: ???

Goldstein, Andrew, and Aspray, William. eds. 1997. Facets: New Perspectives on the History of Semiconductors. New York: IEEE Press.

Graziano, David. 2013. Samsung Leads A Smartphone Sales Boom. BGR. Available from: http://bgr.com/2012/11/14/smartphone-sales-q3-2012/ Last accessed: 15 Jan 2013

Graziano, Don. 2013. Google Exec Calls Motorola Acquisition an Insurance Policy against Samsung. BGR. Available from: http://bgr.com/2013/02/26/google-samsung-relationship-android-344669/ Last Accessed: 26 Feb 2013

Grier, David A. 1998. "The Math Tables Project: The Reluctant Start of the Computing Era." IEEE Annals of the History of Computing 20, no. 3: 33-50

Hashagen, Ulf, Keil-Slawik, Reinhard and Norberg, Arthur eds. 2002. History of Computing-Software Issues. Berlin, Germany: Springer-Verlag

Herman, Leonard. 1994. Phoenix: The Fall and Rise of Home Videogames. Union, N.J.: Rolenta Press

Honan, Mattew. 2007. Apple unveils iPhone. Macworld. Available from: http://www.macworld.com/article/1054769/iphone.html Last accessed: 26 Jan 2013

IBM, 2006. Mainframe Hardware Course: z/OS. IBM Corp.

Ichbiah, Daniel, and Knepper, Susan L. 1991. The Making of Microsoft. Rocklin, Calif: Prima Publishing

Illyas, Mohammed and Ahson, Syed. 2006. Smartphones Research Report. Chicago: IEC Publications.

Ingram, Matthew. 2013. Blackberry 10 Smartphone Gets a Few Cheers. GigaOm. Available from: http://gigaom.com/2013/01/30/blackberry-10-smartphone-launch-gets-a-few-cheers-a-bunch-of-jeers-and-a-lot-of-meh/ Last accessed: 26 Feb 2013

Kemeny, John G. and Kurtz, Thomas E. 1968. "Dartmouth Time-Sharing." Science 162, no. 3850 (11 Oct): 223-228

Krickx, Guido A. 1995. Vertical integration in the computer mainframe industry: A transaction cost interpretation. New York: Stern School of Business.

Lammers, Susan. 1986. Programmers at Work: Interviews with Nineteen Programmers Who Shaped the Computer Industry. Washington, D.C.: Tempus, Redmond

Lee, Matthew. 2013. Samsung’s backup plan: Tizen 2.0 demo proves it can compete with Android. Available from: http://www.geek.com/articles/mobile/samsungs-backup-plan-tizen-2-0-demo-proves-it-can-compete-with-android-2013031/ Last accessed: 02 Mar 2013

Levy, Steven. 1994. Insanely Great: The Life and Times of Macintosh, the Computer That Changed Everything. New York: Viking

Lohr, Steve. 2001. Go To: The Story of Programmers Who Created the Software Revolution. New York: Basic Books

Lohr, Steve. 2012. Even a Giant Can Learn to Run. New York Times. Available from: http://www.nytimes.com/2012/01/01/business/how-samuel-palmisano-of-ibm-stayed-a-step-ahead-unboxed.html?_r=1& Last Accessed: 26 Jan 2013

Lundvall, Bengt-Åke. (1988), “Innovation as an interactive process”, in Dosi, Giovanni. et al (eds.) (1988), Technical Change and Economic Theory, London & New York: Pinter Publishers. Available at http://econpapers.repec.org/bookchap/ssalembks/dosietal-1988.htm. Last accessed: 29 Feb 12.

Malerba, Franco., Nelson, Richard., Orsenigo, Luigi., and Winter, Sidney. 2006. Vertical Integration and Dis-integration of Computer Firms: A History Friendly Model of the Co-evolution of the Computer and Semiconductor Industries. Milano: Sarfatti.

Malone, Michael S. 1995. The Microprocessor: A Biography. New York: Springer-Verlag

McCarthy, John and Golvin, Charles. S. 2011. Analysis: Google's Acquisition of Motorola Mobility. Forbes. Available from: http://www.forbes.com/sites/forrester/2011/08/15/analysis-googles-acquisition-of-motorola-mobility/ Last accessed: 16 Jan 2013

Meeker, Mary. 2012. Internet Trends @ Stanford Bases. Kleiner Perkins Caufield Byers. Available from: http://www.slideshare.net/kleinerperkins/2012-kpcb-internet-trends-yearend-update Last Accessed: 27 Jan 2013

MITS (August 1975). "World’s Most Inexpensive BASIC language system". Popular Electronics (Ziff Davis) 8 (2): p. 1.

Mowery, David C., ed. 1996. The International Computer Software Industry. New York: Oxford University Press

Mukherjee, Sangeeta. 2012. Evolution Of Android OS: From G1 To Jelly Bean. International Business Times. Available from: http://www.ibtimes.com/evolution-android-os-g1-jelly-bean-697079 Last accessed: 16 Jan 2013

Nelson, Richard R. and Winter, Sidney G. 1982. An Evolutionary Theory of Economic Change. Cambridge, Massachusetts: The Belknap Press of Harvard University Press.

Ngak, Chenda. 2012. Instagram Launches for Android Smartphones. CBSNews. Available from: http://www.cbsnews.com/8301-501465_162-57408761-501465/instagram-launches-for-android-smartphones/ Last accessed: 26 Feb 2013

Open Handset Alliance. 2007. OHA Frequently Asked Questions. Available from: http://www.openhandsetalliance.com/oha_faq.html Last Accessed: 27 Feb 2013

Pegoraro, Rob. 2010. Nexus 7 Writes New Chapter in Android Tablets. Discovery News. Available from: http://news.discovery.com/tech/google-nexus-7-android-tablet-review-120710.htm Last Accessed: 8 Jan 2013

Petre, Petere. 1985. "The Man Who Keeps the Bloom on Lotus". Fortune, 10 June, pp. 92-100.

Pugh, Emerson W. 1984. Memories That Shaped an Industry. Decisions leading to IBM System/360. Cambridge, Mass: MIT Press

Qualcomm. 2008. History. Available at: http://www.qualcomm.com/about/history Last accessed: 27 Jan 2013

Reed, Brad. A Brief History of Smartphones. PC World. Available from: http://www.pcworld.com/article/199243/a_brief_history_of_smartphones.html Last accessed: 27 Jan 2013

Reisinger, Don. 2012. Samsung's Secret? Ubiquity. CNN Money. Available from: http://tech.fortune.cnn.com/2012/08/13/samsung/ Last accessed: 17 Feb 2013

Robertson, Adi. 2012. Google Announces 20 Bilion App Installs, 600,000 Apps and Games. Available from: http://www.theverge.com/2012/6/27/3120892/google-play-20-billion-app-installs Last Accessed: 7 Jan 2013

Ruddock, David. 2013. Sony's CEO Says He Wants To Focus On High-End Android Phones, But Is That Enough To Change Anything? Available from: http://www.androidpolice.com/2013/01/17/sonys-ceo-says-he-wants-to-focus-on-high-end-android-phones-but-is-that-enough-to-change-anything/ Last accessed: 20 Feb 2013

Smith, William D. (April 5, 1970). "Maxi Computers Face Mini Conflict: Mini Trend Reaching Computers". New York Times.

Sweeny, Alastair. 2009. Blackberry Planet: The Story of Research In Motion and the Little Device that took the World by Storm. Ontario: Tri-Graphic Printing.

The Economist. 2012. Apple and the American Economy. Available from: http://www.economist.com/blogs/freeexchange/2012/01/supply-chains Last accessed: 24 Feb 2013

Tizen. 2013. About Tizen. Available from: https://www.tizen.org/about Last accessed: 24 Feb 2013

Truesdell, Leon E, 1965. The Development of Punch Card Tabulation in the Bureau of the Cesnus, 1890-1940, Washington, D.C.: U.S. Department of Commerce

Usselman, Steven W. 1993. "IBM and Its Imitators: Organizational Capabilities and the Emergence of the International Computer Industry." Business and Economic History 22, no. 2:1-35.

Wall Street Journal. 2013. Samsung Sparks Anxiety at Google. Available from: http://professional.wsj.com/article/SB10001424127887323699704578324220017879796.html?mg=reno64-wsj Last accessed: 25 Feb 2013

Weiss, Todd R. 2008. A year later, sales of Linux on Dell computers continue to grow. Computer World. Available from: http://www.computerworld.com/s/article/9077678/A_year_later_sales_of_Linux_on_Dell_computers_continue_to_grow Last Accessed: 5 Feb 2013

Wise, Thomas A. 1966a. "I.B.M.'s $5,000,000,000 Gamble." Fortune, September, p. 118.

Yarrow, Jay. 2012. It's Time For Apple To Unleash A Major Software Overhaul. Available at: http://www.businessinsider.com/apple-ios-software-2012-11. Last accessed: 16 Feb 2013

Yates, JoAnne, and Van Maanen, John. 2001. Information Technology and Organizational Transformation: History, Rehtoric, and Preface. Thousand Oaks, Calif.: Sage

Ziegler, Chris. 2011. Android: A Visual History. The Verge. Available from: http://www.theverge.com/2011/12/7/2585779/android-history Last accessed: 16 Jan 2013