The Mobile Handset Industry in Transition: The PC Industry Revisited?

**Understanding the drivers of dynamic change**

*and implications for firm strategy*

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**Abstract**

This article supports and extends upon other scholars’ examinations of the evolution of technological modularity, vertical specialization and the concepts of the drivers of change in the basis of competition through an analysis of the evolution of the mobile handset industry. It is the thesis of this article that the mobile handset industry value chain is in the process of deconstructing towards more horizontally stratified structures for some device segments. But unlike the PC industry, an industry which some researchers suggest provides a precedent for likely evolution of the mobile handset value chain, this trend will not be uniform or consistent across different product types. This will require mobile phone manufacturers to adapt their organisational structures and value chain approaches accordingly, and to rethink the basis for future competitive advantage.

**Keywords**: Deconstruction, vertical integration, modularity, technological change, mobile phone, cellular phone

**JEL Classifications**: L22, M21, O33
I. Introduction
The evolution of industry structure, especially in technology-intensive industries, has been the focus of an extensive literature for more than half a century. The hypothesis that mature industries evolve towards vertically specialized structures dates back to Stigler (1951) who in turn credited Adam Smith with the original idea. But despite this long heritage, the factors underpinning this trend as well as the degree to which vertical specialization is an inevitable outcome of industry evolution has received little attention.

Through an analysis and comparison of the evolution of the PC and mobile phone industries, this paper both supports and extends upon other scholars’ examinations of the evolution of technological modularity and vertical specialization (Ulrich, 1995; Sanchez and Mahoney, 1996; Henderson and Clark, 1997; Christensen, Verlinden and Westerman, 2002) and the concepts of the drivers of change in the basis of competition (Christensen, 1996; Fine, 1998; Adner and Levinthal, 2001). The paper aims to address the question of why vertical specialization emerged in the two industries (and in the case of the mobile handset industry continues to evolve), and how the emergence of vertical specialization has impacted firm structures and the sources of competitive advantage. It concludes by discussing implications for future business strategy in the mobile handset industry.

II. Evolution of Vertical Specialization in the Personal Computer Industry
In the first decades of the computer industry companies such as IBM, DEC and Hewlett Packard built products that pushed the frontiers of performance and functionality. These products, mainframes and later minicomputers, were complex and expensive to develop and remained the province of the vertically integrated Chandlerian firms (Chandler, 1990) who built their products around proprietary designs and components. In this phase of the industry products exhibited integral architectures – that is hardware and software were designed as closely integrated systems, with individual components lacking the standard interfaces to be compatible with competitors’ products or, as was typically the case, other product models from the same manufacturer.

Williamson (1985, 1989) found that if assets are highly specific, only vertical integration ensures optimal investment into assets and therefore an efficient organization of the value chain. This specificity of assets (proprietary and integral technology) along the computer industry value chain helped maintain conditions conducive to the vertically integrated firm. IBM, as the dominant competitor in the industry, controlled a 70% share in the mainframe business and approximately 95% of the profits in this segment of the market.

This situation changed dramatically in the late 1970s with the entry of a new competitor – Apple Computer. Apple had developed a so-called personal computer, tiny by IBM or DEC’s standards, but which had captured the loyalty of a growing number of personal users. In response, IBM decided to create a new business division and a personal computer of its own. For its personal computer, IBM’s new business division adopted a new business model. Rather than relying on virtual integration and integral product architectures, the company opted for a different approach, outsourcing the microprocessor to Intel and the operating system to Microsoft. This new architecture provided conditions that allowed the emergence of product modularity and what has been termed ‘structured technical
dialogue’ (Billington and Fleming, 1998), permitting efficient coordination between firms for the assembly of a standards-based product. In particular, the new approach provided three key ingredients for the conditions of modularity – specifiability, measurability and predictability of component attributes and interfaces (Christensen, Verlinden and Westerman, 2002).

IBM's decision initiated a dramatic shift in the PC industry, which rapidly ‘deconstructed’ from a vertical to a horizontal or ‘vertically specialized’ structure, with firms assembling modular components and modules based upon industry standards. This emergence of vertical specialization in the PC industry supports recent research on the emergence of intermediate markets, and what motivates this process (Jacobides, 2005). Cost pressures, a pressing need for interoperability, a quest for shortened time to market, and a need to manage increased multidimensional technology complexity all contributed to the decision (Christensen, 1994; Baldwin and Clark, 1997; Fine, 1998). But two key motivating factors seemed to be at the heart of this process: gains from specialization driven by differences in the evolving knowledge bases along the value chain and latent gains from trade emerging from capability differences between specific firms in an industry. The latter factor was also influenced by IBM's decision to focus on only certain parts of the value chain, making reliance on the market desirable (Jacobides, 2005). IBM increasingly recognised that the time when integrated manufacturers could both design and build most of their own hardware and software components and bring products to market quickly and cost effectively, was limited in the face of rapid technological change along multiple dimensions.

The challenge of being able to maintain high performance across a range of activities has been identified as one of the key dilemmas for the vertically integrated firm – vertical integration can lead to the subsidizing of internal activities with weak performance, reducing the overall effectiveness of the company (Porter, 1996; Evans, 1998). This averaging-out is not a problem so long as it does not threaten competitive advantage along the entire value chain, and therefore the firm's ability to support weak performance. But if this is not the case, then the outsourcing of weak performance activities can boost profitability and increase opportunities for growth by allowing the firm to focus on activities in which the firm maintains a competitive edge (Evans, 1998). This problem has been identified by Porter who argues that strategy requires firms "to choose what not to do" (Porter 1998) and deliberately forego potentially attractive opportunities in other parts of the value chain. Faced with the possibility of ‘averaging-out’ threatening the overall performance of its PC business, IBM redesigned its value chain accordingly. This strategy witnessed success in the short-term, with the company improving profitability and regaining dominant market share in the PC segment within two years.

The process of disintegration along the value chain witnessed the emergence of ‘layer players’ (Edelman, 1999), firms specialized on one or more horizontal layers of the vertical value chain, using their specific knowledge bases or capabilities to produce specific components or sub-systems, or undertaking specific value chain activities such as product assembly. Companies large and small entered the market to supply modular subsystems and components: microprocessors, semiconductors, circuit boards, applications, software, peripherals, and PC design and assembly (Fine, 1998; Christensen, Verlinden and Westerman, 2002). By specializing on a few selected technological
opportunities in only one part of the value chain, these layer players were able to develop superior components and modules, and over time attained a higher degree of knowledge about these products vis-a-vis the vertically integrated firms.

The availability of the Intel and Microsoft subsystems – the core ‘building blocks’ of a PC – not only led to an influx of new entrants, but also created significant competition within each horizontal sub-sector. Within each of the subsystem and component categories, new businesses emerged and rather than seeing competition just between PC manufacturers, competition also emerged between firms producing everything from applications to peripherals. Different components of a PC - the monitor, keyboard, memory, disk drive, software, and so on - became standard modules, permitting mass customization in PC system configuration.

Modularity also had a profound impact on industry structure because it enabled independent, non-integrated organizations to buy and assemble components easily. As a result, new entrants emerged who were focused on systems integration rather than developing and maintaining deep technological resources. While not requiring core R&D capability, these new players did require overlapping technological knowledge with suppliers to understand technological developments, to select the right partners and to be able to integrate suppliers’ inputs effectively (Rosenberg, 1990; Brusoni, Prencipe, Pavitt, 2001).

**Defining modularity** Modularity is a strategy for organizing complex products efficiently. A modular system is composed of independent units (or modules) that will still function as an integrated whole when put together as a product for a specified design or variant. The user of a module may utilize the incorporated knowledge of the module, but does not have to acquire the underlying technological resources to do so. (Baldwin and Clark, 1997)

Today, the value of a PC is largely determined by performance of key modular components such as CPU, memory, hard drive, monitor, operating system, software applications and even accessories and warranty services. For example, the Dimension 4700 is one model of Dell PC which is modularized by different components and service offerings, leading to different performance and prices.

<table>
<thead>
<tr>
<th>Model</th>
<th>Dimension 4700</th>
<th>Dimension 4700</th>
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<tbody>
<tr>
<td>Memory</td>
<td>256MB</td>
<td>512MB</td>
<td>512MB</td>
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<tr>
<td>Hard Drive</td>
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<td>40GB</td>
<td>80GB</td>
<td>80GB</td>
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<tr>
<td>Speakers/Video Card</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>After Sales Onsite Service</td>
<td>N</td>
<td>2 Years</td>
<td>2 Years</td>
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<tr>
<td>Virus Protection Security</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>McAfee Security</td>
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<tr>
<td>Price</td>
<td>$649</td>
<td>$799</td>
<td>$899</td>
<td>$999</td>
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Source: www.dell.com

So in the early PC horizontalisation stage, the process of vertical specialization and platform standardisation became inextricably linked. As PC manufacturers opted to dump their own platforms in favour of licensing them from third parties, vertical specialization helped to cut product development period and costs; and standardization helped solve interoperability problems. Some resources efficiency and robustness was sacrificed but as memory became cheaper and microprocessors faster and less expensive, this became increasingly attractive. This in turn provided a window for new non-integrated competitors to enter the market.
Unfortunately for IBM and the other PC manufacturers, the long-term outcome of the shift towards vertical specialization was that third party suppliers – particularly Microsoft and Intel – ended up owning the most profitable parts of the PC value chain. This shift witnessed a massive outflow of profitability and market valuation from PC manufacturers to other players in the PC value chain; ‘In 1986, companies that built and sold computer systems captured about 80% of the total profits being generated in the computer industry. By 1991, however, systems makers were getting just 20%’. The market reallocated profits to the component makers’ (‘Deconstructing the Computer Industry’, Business Week, 23 November 1992: 90-96).

While product modularity and vertical deconstruction had offered real benefits to vertically integrated firms like IBM, it also came at a price. The emergence of modularity changed the entire PC industry structure by lowering barriers to entry and leading to tougher rivalry, and resulted in value flowing to those vertical specialists that controlled key performance enhancing technologies. Although still a powerful and influential company, IBM had been outdistanced by its suppliers, who had taken the lion’s share of the profits and industry power that flowed from IBM’s standard-setting products. IBM's suppliers also won the allegiance of millions of customer who came to care far more about the supplier’s logo – “Intel inside” or “Windows XP” – than about the brand name of the company that assembled the components and shipped the final products. The power in the value chain shifted, as did the financial rewards. Manufacturers found it increasingly hard to differentiate and add value because consumers perceived value to lie primarily in the features provided by key performance enhancing components.

One of the few PC manufacturers to generate consistent profits under the new industry structure during the decade to 2005 was Dell Computer. Rather than trying to internally develop technologies via vertical integration, Dell has acted as a value chain orchestrator or what has been defined in the literature as a ‘system integrator’ (Rosenberg, 199; Brusoni, Prencipe, Pavitt, 2001), a firm that concentrates on efficiently integrating the components and modules of different vertical specialists, and on marketing and customer service. Dell was estimated to have accounted for almost 100% of profits in the PC industry since 2000, with the industry excluding Dell generating near to USD 2 billion in losses over the same period.

Dell has not built its success on product performance or functionality – two of the key differentiators during the early phases of the PC industry. Indeed, the company uses many of the same components from the same suppliers as its competitors and typically spent little more than 1% of annual turnover on research and development (Vedpuriswar, 2004). Rather, Dell has built its dominance in a modular world upon dimensions such as supply chain efficiency (Dell connected directly to customers and suppliers, and at end fiscal 2000 the company held six days of inventory compared to 20 to 70 days for major competitors), product customization (Dell supplied all of its products to order) and customer service (average industry downtime for a faulty PC in 2000 was 16 hours but only 8 hours for Dell).

Dell has not put strong focus on product R&D, preferring its suppliers to be the main sources of product innovation, Dell had won 550 patents for business process innovation by 2004, ‘ranging from wireless networks in factories to a
configuration for manufacturing PCs that was four times as productive as a standard assembly line’ (‘What you don't know about Dell', *Business Week*, 3\(^{rd}\) November 2003: 57-64). Instead of developing deep technological capabilities, Dell has built overlapping technological knowledge with its suppliers which has helped it to understand technological developments in different parts of the industry, to select the best component and module suppliers, to integrate these suppliers’ inputs into a coherent whole faster and more efficiently than its competitors, and to provide complements to its products that customers value.

The success of Dell supports Teece’s (1986) assertion that complementary assets such as supply chain efficiency and customer service can increase the value of technological innovation as knowledge becomes more widely dispersed. The company's competitive advantage has not originated so much in its technological resources, but from the complementary assets that has enabled it to add value to the integrated PC product system. Dell's success also supports research suggesting that fragmentation in the upstream value-chain can create profit opportunities through vertically integrating into downstream activities (Teece, 1988; Afuah, 2001), and that by controlling critical complementary assets, firms may strengthen bargaining power towards suppliers and buyers (Arora, Fosfuri and Gambardella, 2001).

While a horizontally stratified structure came to dominate the PC industry since the late 1980s, it should be noted that products in the most performance-demanding tiers of the mainframe computer and enterprise server markets remained architecturally interdependent and proprietary, supplied by the integrated divisions of companies such as IBM, HP and Silicon Graphics (Christensen, Verlinden and Westerman, 2002). The delivery of cutting-edge functionality at the very top-end of the computing market still required engineers to develop interdependent designs. This outcome fits with the reasons for ongoing dominance of integrated architectures articulated by Ulrich (1995), who showed that moving to a modular architecture can force designers to compromise or back away from the frontiers of what is technically possible.

III. Evolution of the mobile handset industry value chain

During the late 1980s and into the 1990s large firms such as Motorola, Ericsson, Nokia and Siemens pushed the frontiers of mobile phone performance, and the industry was considered to be a classic case for a vertically integrated industry. ‘These vertical integrators not only controlled the design, production and marketing of mobile phones, but also the mobile communications infrastructure business’ (Bruhl, Stieglitz, 2005).

Evolving from a suitcase-sized device with limited appeal beyond a very narrow niche of business and professional users, these vertically integrated firms invested huge sums in research and development to improve the performance and reduce the size of mobile phones. As was the case with the earliest PCs, software components, hardware components and operating systems were produced in-house, and assembled together in interdependent product architectures. And just as was the case in the early days of the PC industry, this was a period dominated by large integrated players, as the resources required to entry the fledgling mobile phone industry were beyond the means of most small and medium sized players.
This was also a time of big bets, as different vendors backed competing mobile phone technologies - Motorola spent ten-plus years and $2.6 billion on the Iridium satellite phone project, which failed to take off after showing initial promise. Other competitive battles took place between European vendors such as Ericsson, Nokia and Siemens with their GSM standard, and Qualcomm’s CDMA, Motorola’s AMPS system and Ericsson’s TDMA in the Americas. Similar battles had taken place in the PC industry – between IBM and Apple in the 1980s, and later between Microsoft’s Windows, IBM’s OS2 and Apple’s own proprietary operating system.

The mobile device industry during the late 1990s was spurred by an explosion of demand for wireless telecommunications across much of the Western world. First in Europe and then North America, penetration rates exploded as consumers were attracted to the convenience and productivity benefits of access to mobile networks. Device manufacturers could hardly keep up with demand for their handsets. In the words of one senior executive from a mobile device manufacturer in northern Europe interviewed by the author in 1999: "We are a company that does not sell its products. Rather, we allocate capacity to our preferred network operator customers." Not surprisingly, this was a ‘golden age’ for the mobile phone industry, and managers who experienced these years still talk of the exuberance and excess of annual events such as the GSM conference in Cannes. Corporate sponsored yachts, helicopter flights and the very best champagne were in ample supply.

To deliver to the demands of the market, handset manufacturers continued to push the performance of their products. Customers, both mobile network operators (MNOs) and end users themselves, were more than willing to pay for enhanced functionality, usability and reliability. Vendors endeavoured to make the best devices possible, and in most cases built their products around proprietary, interdependent, optimized designs. These designs involved a very close interface between design and manufacturing, requiring vertically integrated firm structures.

There were very few standardized mobile phone components at this time, and a limited degree of outsourcing. The industry outsourcing that did exist was mainly for capacity purposes, rather than the outsourcing of core technology development. Quite simply, as the engineers at the large mobile device manufacturers attempted to deliver increasingly higher-performance products, they could not simply assemble standardized components as this would have forced them to back-away from what was technologically possible.

There were very few independent component manufacturers in existence at this time that could meet the stretching technical requirements of companies such as Nokia, Ericsson or Motorola, a situation that mirrored the experiences of firms such as IBM as they strove to bring the earliest PC models to market. The three key ingredients for the conditions of modularity – specifiability, measurability and predictability of component attributes and interfaces (Christensen, Verlinden and Westerman, 2002) were simply not present. A typical mobile phone manufacturer’s value chain for this period is shown at Exhibit A.

By the late 1990s the winds that had been driving the mobile phone industry – rapid penetration of mobile telecommunications in Europe and North America – started to wane. Furthermore, the basic functionality of mobile
phones had reached what the vast majority of consumers required, and they were becoming less willing to pay a premium for product attributes such as usability and reliability. A further trend that started to impact the market was the growth in pre-paid subscriptions, with less affluent consumers coming into the market who were unwilling to pay premium prices for mobile phones. This posed significant challenges for some mobile handset vendors and a great opportunity for others.

Europe's Ericsson was hard hit by changes in the industry, as it had been slow to invest in low-cost manufacturing, industrial design and building a consumer brand. Its phones were viewed by many consumers as being of high quality, but expensive and of poor aesthetic design, and the company recorded a USD 1.6 billion loss in 2000. Motorola's mobile phones were also priced high (more than USD 200 till 2000), so the company had trouble penetrating the mass market. Its slim V-series phones were priced at around USD 500, when the average selling price of digital phones in the US was only USD 150 to USD 200.

Firms, such as consumer electronics giant Sony, which tried to enter the market without deep expertise in core mobile technologies such as Radio Frequency (RF) modules or cellular protocol stacks also found the going tough. There were few suppliers of modular components at this time, resulting in difficulties in sourcing quality mobile phone parts, high bill of materials (BOM) costs and strong supplier power. After being beset by quality problems, Sony eventually merged its mobile phone operations with Ericsson.

Meanwhile, as consumer requirements began to change Nokia launched new products, emphasizing ergonomics and aesthetics. The company introduced interchangeable fascias that allowed consumers to alter the style of their phone, and invested heavily in building a consumer brand. Importantly, the Finnish company also invested heavily in lean manufacturing, and was ahead of its competitors in automating assembly and establishing production in low-cost countries. As early as 1996 Nokia initiated a major supply chain management project aimed at speeding up turnover and slashing inventory. Component prices were renegotiated and chip suppliers were told to cut delivery times from twelve to eight weeks. At the same time, the division overhauled its management information systems. New software allowed purchasing managers to track excess parts and reroute them, and forecasting methods were revamped. These actions provided a huge windfall for the company when the pre-paid phenomenon took hold in Western Europe, as Nokia was one of the few mobile phone companies to be able to deliver a relatively low-cost product to this more price-sensitive segment.

Nokia was also one of the first firms in the mobile phone industry to develop a platform approach to its mobile device portfolio, developing different versions of phones from a relatively small number of shared product architectures. This helped Nokia to reduce costs and increase economies of scale; in comparison, in 2000 Motorola had 128 phone variants, which used hundreds of different silicon pieces on the circuit boards alone. Although not quite as extreme as the case of IBM, which collectively sold 5,000 hardware products and 20,000 software products in
Motorola’s diversified approach caused similar inefficiencies in terms of widely spread and sometimes poorly coordinated product development efforts and high costs.

IV. Recent trends in vertical specialization in the mobile phone industry.

Since the turn of the millennium, the product architecture approaches and commercial models of the established mobile phone manufacturers have diverged significantly. Coming from a more or less common integrated and proprietary approach, there has been a trend towards outsourcing of software, operating systems, components and sub-systems, and deconstruction of the value chain. This trend has been driven by several factors which also impacted the move towards modularity and vertical specialization in the PC industry:

1. Latent gains from trade for companies who are able to sell technology across firm boundaries,
2. Emerging capability differences amongst firms in the industry driven by increased multidimensional technology complexity as phones have become more sophisticated.

Some firms within the mobile phone industry, such as Ericsson and Qualcomm, have sold or hived off upstream or downstream businesses to focus on activities within the value chain that they consider to be their core competence. Others vendors such as Nokia continue to own but are de-coupling upstream from downstream operations, taking the former to sell to competitors and new entrants, and the latter to purchase components from third party suppliers when necessary to maintain competitiveness.

There has been the emergence of reference design houses, created mostly from the internal radio frequency platform development groups, internal software houses and/or semiconductor businesses of the established players, that integrate software components, hardware components and an operating system into a tested and verified system solution that can be used to build a mobile phone. These firms now license their designs to both original device manufacturers (ODMs) and original equipment manufacturers (OEMs), and work closely with their customers to minimize perceived design and manufacturing risks. As of mid 2005, Nokia was virtually the only remaining manufacturer that did not rely on third-party platforms to some extent, with reference designs and platform solutions still developed in-house across all product segments.

Qualcomm was one of the first companies to split up its vertical structure, selling off its handset division in 1999 to focus on CDMA baseband chipsets and other technology components which now form the basis of third-generation wireless networks. Today the company receives royalties from the shipment of any CDMA handset, and in 2004 alone, Qualcomm spent almost USD 1 billion, or 19 percent of its revenue, on research and development. Around one-third of the company’s 2004 revenues (and 60 percent of its profits) came from royalties on all equipment that uses the technology; the remainder came from selling the chips that rely on that intellectual property, where it has a market share of 80 percent².

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Siemens also acted early to break-up its integrated structure through the creation of Infineon (hardware solutions) and acquisition of software developer Conneon as reference design houses to provide platform solutions. Motorola Inc. has remained an end-to-end supplier from silicon to software. But in February 2004 the original handset division was split into Motorola PCS (Personal Communications Sector) and Freescale (a mobile platform provider), which was subsequently divested from Motorola Inc and listed as an independent company. Freescale remains the main platform provider to Motorola, and Freescale’s platforms are also used by Motorola's ODMs partners. Since 2002, Motorola has licensed its handset designs to at least 12 other manufacturers.

What is inside a mobile phone?

The core technology inside a mobile phone is typically based on a chipset existing of three or more main components (Integrated Circuits) designed to collectively provide a complete functionality for communication and running applications. The Radio Frequency Circuit (RF) sends and receives voice or data signals to the mobile phone, while the Mixed Signal Circuit converts the signals from digital to analog and vice versa so that the information can be managed by the Baseband Circuit (BB). The BB can be seen as the phone processor where both the application software and the communication software is managed. The difference between Application Software and Communication Software is that the latter is real time critical, which means that it is live and functioning constantly. The software can be managed by a common Real Time Critical Operating System (RTOS), which is the industry standard in entry-level phones. The key difference between an entry-level phone and a smartphone is that a smartphone uses two operating systems, one for the real time critical communication part and one for the applications. Examples of these application operating systems are Microsoft and Symbian. Smartphones also typically incorporate a dedicated application processor that provides enhanced performance of the applications.

Ericsson created Ericsson Mobile Platforms (EMP) at the time of the creation of the Sony Ericsson joint-venture in 2001 as a platform provider to license complete, end-to-end interoperability tested mobile platform designs to other vendors, both established and new entrants. Today, EMP offers total system solutions for both 2.5G and 3G that includes hardware (RF & BB) and software (RTOS, OS, Applications), reference design, development tools, support and documentation. Key customers include Sony Ericsson as well as a number of Korean, Japanese and other East Asian manufacturers. Other platform suppliers include Qualcomm, Agere, Texas Instruments (TI), and Broadcom. At the time of writing, Nokia did not yet offer its hardware platforms to third parties, but was actively developing its Series 60 application framework (see below). The general set-up for platform providers a lot and the offering can range from hardware design only with standard ASICs to a total system solution that includes hardware, software, customer support and customer training to help manufacturers quickly start developing their products.

Established OEMs also now work with ODMs such as Flextronics who are contracted for ‘Ready To Launch’ (RTL) product development. These devices are typically based on a product specification developed by the brand owner and reference design house, and the ODM is contracted for manufacturing. But some specialized ODMs such as Arima, HTC, Compal, and Bellwave are also moving to offer product design and integration, meaning that a complete functionality related design and implementation of operating system, applications and hardware components is created, either done by the specialized ODM or in collaboration with the OEM. So today, a brand
owner can be a traditional handset manufacturer, mobile network operator (for example T-Mobile’s MDA smartphone produced by HTC) or any other company having the ambition to market and sell mobile handsets – a significant shift from the situation even a few years ago.

The approach of mobile phone manufacturers to working with ODMs has varied, but the overall trend has been for manufacturers to outsource an increasing share of their production. ‘Growth in the volume of ODM handset manufacturing exceeded 40% in 2004, and this trend is likely to continue’ (Goldman Sachs Global Equity Research, ‘The ODMs are coming’, 23 June 2005). Siemens has chosen to focus internal development on the entry segment, and retained internal capacity for product design and integration, production, distribution, marketing and sales of low-end products, while using ODMs for the design and production of high tier handsets. Sony Ericsson has relied on ODMs such as Flextronics for outsourced manufacturing across some of its mid-tier products and smartphones, and has outsourced both development and production in the lower segments. Motorola PCS has used ODMs for some development and production of handsets, especially in the lower segments, with about 20% of the company’s handsets made by third-party contractors during 2003. The company planned to increase that total to 30% by end of 2004 (Johnsson, 2004.). Nokia has tended to use 3rd party contract manufacturers only for volume production at the end of a product lifecycle. Both Samsung and LG undertake manufacturing in-house.

Defining the Segments

A. **Entry Level**: A mobile phone with voice and text messaging capability, and some basic applications. Does not necessarily include a color screen or camera module, and is often targeted at new users and lower spend pre-paid users. Retail price range approximately USD60 to USD 200. At the time of writing Motorola had announced the forthcoming release of a sub-USD 40 entry level handset.

B. **Mid-tier**: A color screen mobile phone with a digital camera, higher quality sound, downloadable applications (with e.g. Java) and MMS in addition to SMS messaging. Might include open OS and some advanced functionality at the upper end of the segment. Retail price range approximately USD200 to USD 300.

C. **Smartphone**: More advanced mobile phone typically with higher quality color LCD screen, open OS and higher pixel digital camera. Functionality typically includes some or all of the following: bluetooth, multi-band, calendar function, multimedia player, advanced gaming applications, video playback and capture, radio, push email, Internet browser, touch screen, external memory, Wi-Fi. Price range typically over USD 300.

In addition to the growth of outsourced manufacturers, there has been a proliferation of firms specializing in the design and development of specific hardware components. Some of these companies manufacture dedicated and proprietary hardware components such as radiofrequency chips (Skyworks, RF Microdevices, Philips and Agilent), power management and audio components (Analog Devices, Dialog, Renesas, and National), and application processors (TI, Intel, Freescale and Samsung). Other companies specialize in the manufacture of key peripheral components such as displays, camera modules, memory and batteries. Example of key peripheral suppliers include Intel, Samsung, and TI in memory; Seiko, Philips, Samsung, Sony, and Toshiba-Matsushita Display in LCD displays; Sony, Agilent, Panasonic, Micron, and Samsung in Cameras; Panasonic, Hitachi, Sony, and Sanyo in batteries and; RFMD and Skyworks in radio. Many of these components need to be customized to be able to be used since there
are few standardised interfaces, but there is now a strong push within the industry towards developing the conditions for modularity – specifiability, measurability and predictability of component attributes and interfaces. Standard hardware components such as resistors, capacitors, filters, duplexer have already evolved in this direction.

Very recently some component suppliers have sought to develop and market subsystem rather than individual components. A good example of this is RFMD, a company that previously developed power transistors before starting to integrate them in power amplifier modules and subsequently complete radio frequency (RF) subsystems. To succeed, RFMD has attempted to work with handset manufacturers to create standard interfaces between its modules and other product components. Some chipset suppliers are moving in the same direction.

Another group driving the development of specifiability, measurability and predictability for component attributes and interfaces have been the suppliers of cloned or “copycat” components. These firms have grown by basically cloning existing components, but to achieve volume advantages have recognised the need to develop products that can easily replace any ODM component. That means that the cloned component needs to be modular and produced to fit many different interfaces. This can be done for subsystems, such as an LCD or camera system.

But perhaps the most significant move towards the creation of the conditions for modular product architectures has been the creation of the Mobile Industry Processor Interface (MIPI) Forum, founded by ARM, Nokia, ST Electronics and Texas Instruments. This Forum has the explicit objective of aiming to create open specifications for interfaces between mobile application processors, displays, cameras and other components.

There has also been a trend towards the outsourcing of operating systems and applications software, and there are several separate mobile phone software components, controlled by international standardization bodies or proprietary groups which need to be integrated into a system to make a mobile phone. An operating system is also needed to run both the system and applications.

To run a mobile phone a manufacturer needs a real time operating system (RTOS) to run the communication related parts. The RTOS can also be used to run applications, however it is not necessary, as a non-RTOS (Open application OS) can also be used for this purpose. RTOS vendors in the mobile phone industry are ENEA, Wind River, Green Hills – Integrity, Esfia RedBlue.

The main open operating system suppliers are Symbian, Microsoft and Nucleus. Smaller competitors include Linux and Palm. The OS is typically composed of three layers: the OS kernel, the system layer and the application engines. The lowest layer is the kernel which provides the interface to the device hardware. All major vendors are competing with somewhat different OS strategies. Nokia is the main owner of Symbian, with companies such as SEMC, Motorola, BenQ, Siemens, Samsung, Lucky Goldtsar Electronics (LG), Sendo, Lenovo, and Panasonic being major licensees. HTC, Samsung, Motorola, Panasonic and a number of other suppliers, have licensed the Microsoft OS. Nucleus is used in many handsets manufactured for Japanese MNO DoCoMo.
Applications are important differentiators for handset manufacturers and operators, and differentiation is created either by tangible features, services or introduction of new functionality. To run applications the handset requires an application engine, which can handle the distribution, downloading and payment of applications. This kind of software is also evolving towards standardised interfaces, due partially to the fact that the development speed is very fast even in the entry segment and most (new) suppliers of integrated platforms or products do not have the strength to do all of their application engine software development in-house.

Another significant driver for standardization in the area of OS and application engines is the evolution of the mobile network operator industry, with some MNOs pushing towards working with fewer vendors and a narrower range of OS and application engines in an effort to reduce costs and complexity. Vodafone and Japan’s NTT DoCoMo had been particularly influential, and at the time of writing several other multinational operators had also begun to implement plans to limit the number of vendors and platforms with which they worked. A standardized platform can provide numerous cost savings opportunities for operators through areas such as device verification, service creation, device provisioning, customer care and training. It has been reported that porting applications or services across a platform-based phone can take 95% less cost than porting applications across feature phones using proprietary platforms. Overall operator cost savings on the 2nd platform-based phone can amount to up to 40 percent, and the platform based-handset projects can shorten rollout times by up to a third, thereby lengthening the overall lifecycle of the phone resulting in higher revenues per phone.

Qualcomm is the major supplier of application engines for the CDMA standard, with its binary runtime environment for wireless, or BREW. At the time of writing, no GSM handset vendor had announced plans to incorporate BREW into their handset designs although Qualcomm was working to promote its application engine directly to MNOs in Europe. Main suppliers of application engines to the GSM market included Nokia Series 60, Microsoft Windows Mobile, Openwave and Sun Microsystems. Motorola is also expected to launch its own content platform by end 2006. The main difference between the BREW platform and other application engines is that Qualcomm software is proprietary while most other application engines are open. The Qualcomm technology that only supports applications developed for the BREW environment, while application engines such as Series 60 will support third party applications developed on alternative technologies platforms. But at the time of writing Qualcomm had announced the development of a modular BREW application engine that would untether its content delivery and management platform from its content and service library, and support other content formats aside from its own proprietary runtime environment.

In the past few years the industry has seen the evolution of application providers who offer their applications directly to original device manufacturers (ODMs) and original equipment manufacturers (OEMs), and the commercial

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5 ibid. pg. 24
models used in this case are generally license or certification. Applications are handled by the handset’s application engine, and can be either proprietary developed or 3rd party developed using a modular environment. Example of application developers include Teleca, Openwave, Sasken, Convergelabs and Access. A more recent development in response to the rollout of higher bandwidth 3rd Generation (3G) networks has been the move by vendors such as Nokia to integrate Internet search engine software such as Yahoo! into their devices.

Additionally, basic software components might be added to a mobile phone. Examples of basic software components include codecs (MP3, AAC, Microsoft WMA, RealAudio, and Sony Atrac3), Radio interface protocol stacks (TTPCom, UbiNetics, Condat, Convergelabs) and Java engines (Esmertec, Savaje, Aplix, Kada).

Finally, beyond manufacturing, component and software outsourcing many mobile phone manufacturers have also started to outsource logistics, warehousing, stock replenishment and operator branding services. United Kingdom-based 20:20 Logistics is a value added distributor for mobile phone brands such as Nokia and Sony Ericsson, supplying dealers, retailers and network operators. The company has grown from USD 70 million in revenues in 1996 to more than USD 2 billion in 2004. A related company, Dextra, Solutions, specializes in customized packaging, point of sales solutions and product communications for both OEM and ODM accessory products. With sales of more than USD 800 million in 2004, the company was the largest distributor of mobile phone accessories in Europe.

A typical value chain for a mobile phone manufacturer in 2005 – excluding Nokia with its more integrated approach - is shown at Exhibit B.

V. Mobile phone industry evolution by product tier – Diverging from the PC industry

The ongoing emergence of vertical specialization in the mobile phone industry has had different trajectories depending on product segment. Complete integrated solutions continue to dominate for new to market technologies (a good example of this is the early generation Blackberry products from Research in Motion (RIM) and the N-Gage from Nokia) or when optimizing for cost. In other segments, particularly in mid-tier and smartphones, modular architecture building blocks are emerging to enable flexibility and differentiation as product lifecycles become progressively shorter.

Entry-level

Nokia is globally the dominant player (>50 % market share) in the entry-level segment. Other large entry-level vendors include Siemens, Motorola, and local brands, primarily in China, while brands like Alcatel, Sagem and Philips are also active in this tier of the market.

To create a cost optimized solution leading manufacturers continue to integrate software and hardware components very closely in proprietary, integrated product architectures, and there currently exist few interfaces that could be made industry standard in entry-level mobile phones. Evidence suggests that this approach still provides a scale
advantage for players such as Nokia, who have deep research and development capabilities and tight integration between development and manufacturing. Another consideration is the fact that cost efficiency in design and component procurement (bill of materials) is perhaps less important than efficient supply chain management and volume production for this low-margin segment, providing further scale advantages for the bigger players.

Nokia’s strategy has been to launch a new platform in a phone in the high/mid end segment, and then continue to develop the platform by decreasing cost, improving quality and, to some extent, adding product and key operator features. To migrate existing products down to the entry segment, the company has worked to reduce the costs of the chipset, main components and software platform, providing a minimum of quality cost (as the phone is basically the 3rd or more generation) and very limited development costs in this segment. More recently the company has also developed some new low-cost products designed specifically for launch into the lower tiers of the market.

Siemens had been the challenger in the entry-level segment, and performed well while Nokia did not decrease its margins. Siemens used their own chipset (now separated into Infineon) and software, and used a chassis concept to quickly launch several variants in the entry to mid segment using the same platform. The lower volumes and the less advanced re-use strategy saw Siemens at a disadvantage versus Nokia, and the company was unable to keep a healthy margin in this segment. Indeed, after accruing significant losses Siemens decided to divest its mobile phone division to Taiwanese ODM BenQ in mid 2005.

Motorola has used ODMs (BenQ, Compal and Chime) for entry-level products, but based on platforms from Freescale, while Sony Ericsson has used ODMs (Arima, Flextronics) and a mix of platforms from EMP and Broadcom. Both Motorola and Sony Ericsson have found it difficult to match the scale and cost advantages of Nokia’s highly integrated approach in this segment, although Motorola has recently announced its intention to bring to market a sub-USD 40 handset. It remains to be seen which design approach (integral or modular) Motorola will take for this new product. Samsung and LG only compete in the higher entry segments, where they typically try to achieve a higher user value through stylish industrial designs and use of more advanced LCDs.

Chinese vendors such as TCL and Ningbo Bird have, in general, bought complete platforms from platform suppliers (chipsets, reference designs and all software). A typical example of such a platform supplier is Wavecom that offers a complete GSM module with all software, and the manufacturer only needs to add mechanics, LCD, acoustics and battery. Most Chinese manufacturers have limited development skills, and have not been capable of integrating a phone on their own, but industry observers believe that they will eventually acquire the needed competence. As the Chinese vendors get experience, it is likely that they will take a larger ownership of the integration to add more value and decrease the bill of materials costs.

But despite these trends, there is no guarantee that the Chinese manufacturers will be able to compete on cost against some of the established players, especially Nokia. Following a decision by the Chinese government to loosen controls over the licensing of mobile phone manufacturing, Chinese companies lost market share in the domestic market to foreign competitors. Nokia increased its share of the Chinese market from 15% in 2003 to almost 20% in 2004, and in the process overtook Motorola, which saw its own share slip from 17% to 12.1%.
Number three vendor Samsung rose to 11.9%, from 10.5%. The largest local manufacturer, Ningbo Bird, saw its share fall from 10% to 8.6%, while Chinese rival TCL Communications Technology dropped from 9.7% to 7.2% (‘Nokia Leads Chinese Phone Market’, TeleGeography Communications Update, 16 April 2005). In mid 2005 TCL reported that net profits fell by 30% over the same period in 2004 as a direct consequence of the effects of foreign brand competition (TeleGeography Communications Update, July 2005).

Mid-tier and smartphones

The situation for mid-tier and high-end ‘smartphones’ has been quite different, and modular product architectures have been steadily evolving. High levels of multidimensional complexity and the rapid evolution of software and key components such as cameras and LCDs has meant that in-house development has become prohibitively complex and expensive for all but the largest manufacturers.

As mentioned above, the emergence of a small number of dominant operating systems (Microsoft, Symbian, Linux) have encouraged manufacturers to converge around similar design approaches. The trend for PDA manufacturers such as Palm to integrate complete mobile phone modules into their products has also spurred this trend. Furthermore, the functionality of smartphone devices built upon modular architectures is becoming more than good enough for all but the most demanding tiers of the mass market.

Nokia initially acted in a very similar way in the smartphone segment as in the entry segment, trying to achieve as much volume advantage as possible through the re-use of the platform and technology used. But the company has recognised the need to license an increasing number of software components in this segment as certain proprietary applications have become required by their customers (key operators). The company is also starting to outsource an increasing number of components such as camera modules to keep pace with rapid technological change. In the past, Nokia could afford to wait to introduce new technologies until they were available in high volumes from suppliers. But in a fast changing business, Nokia’s delays in introducing new technologies such as cameras, color series and speedier data rates had become a handicap.

Motorola’s approach in the mid-tier and smartphone segments has been similar to Sony Ericsson. As has been mentioned above, Sony Ericsson separated its platform business, Ericsson Mobile Platforms (EMP) at the time of the merger in 2001. Product research and development for smartphones is done in-house, but the company has outsourced part of its software application development to be able to keep up the development speed with limited resources. One of the companies used by Sony Ericsson is Teleca (formerly AU-Systems), which has rapidly established itself as a leading independent mobile phone application supplier. NEC, Panasonic and Sharp all have continued to develop components for mobile phones internally, however they do not have complete application or OS software capabilities, and use both external platforms and 3rd party applications.

In PDA smartphones, Taiwan-based HTC has been successful in working with operators such as T-Mobile to bring to market devices targeted at the corporate market. With a background in the PC and handheld computing industries,
the company has partnered closely with Microsoft and other component and subsystem suppliers to develop devices based on some of the most modular architectures in the industry. The company has also been aggressive in incorporating modules from the PC industry, such as Wi-Fi chipsets, into its PDA smartphones. PDA smartphones have appeared to emerge as a likely 'dominant design' (Abernathy and Utterback, 1978; Christensen, et al., 1998) for the enterprise segment, and this is likely to further accelerate the development of standardised modules and components in this tier of the market.

Some of the new entrants such as Samsung have proven to be very competent product integrators, with internal development of some key components but a much higher degree of outsourcing than has been the norm. Samsung has a different background than the established players in the mobile phone industry, being a consumer electronics company with large internal development of key peripherals such as LCD, camera modules and memory. With 2004 worldwide electronic product sales of USD 27 billion, over 64,000 employees in 89 facilities, and a global network in 47 countries, Samsung is one of the strongest players in the world in the global semiconductor and consumer appliances market. But unlike Sony, another consumer electronics giant that tried to enter the mobile phone industry but was beset with difficulties before its joint-venture with Ericsson, Samsung pushed into the industry at a time when components and sub-systems were becoming more readily available. In hindsight, Sony's timing of entry to the mobile phone industry was perhaps premature, coming during a phase when vertical specialization had not yet gained a foothold.

Samsung has utilized its internal strengths fully and has achieved competitive advantage through deep consumer electronics design expertise and access to high quality LCDs, memory and cameras. The company has not had the complete application suites, component portfolios or radio platforms of the established players, opening larger possibilities for third party vendors. Platforms and applications have been sourced from different suppliers; such as Qualcomm, TI, Agere, Philips and Teleca and Openwave. Samsung has used the platform suppliers’ reference platform designs without large modifications, using its product design prowess and own key components as the key differentiators.

Using a greater degree of outsourcing than has traditionally been the case in the mobile phone industry, new entrants such as Samsung and LG have been very aggressive in launching new models – between 2001 and end 2004 Samsung introduced more than 130 new models, based on 78 platforms designs. In 2003 alone, Samsung introduced more than 25 new models, compared to 12 for Motorola. Whereas other companies have changed their product line every 12 to 18 months, Samsung has done so every nine months. Samsung’s rapid product development capabilities have enabled it to introduce the first voice-activated phones, the first handsets with MP3 players, and digital camera phones that were able to send photos over GSM communications networks.

High-end and new-to-market products

Similar to the case with computing industry segments such as mainframes and top-end enterprise servers, more integrated architectures and firms have tended to dominate in ‘leading edge’ or new to market mobile phone...
products that have stretched the boundaries of device functionality. An example of this kind of product is the Blackberry by Research in Motion (RIM) that has dominated the push-email segment in recent years. Requiring a unique combination of software, hardware and network components to deliver a new to market application to users, RIM developed the Blackberry product around a proprietary design with very close integration between R&D and manufacturing. Quite simply, RIM was unable to outsource software and hardware design and development to third party suppliers as the product was based on a new to market concept. The three key ingredients for the conditions of modularity – specifiability, measurability and predictability of component attributes and interfaces, are likely to remain elusive for early generation mobile devices which push the frontiers of performance and functionality. Other products in this category include the Nokia N-Gage and some of the new-to-market converged multimedia players.

VI. Implications for firm strategy
There is a prevailing piece of wisdom about industry structure and value chain evolution that says that in most industries dominant, integrated firms give way over time to a horizontally stratified ecosystem of specialised firms (Chesbrough and Teece, 1996; Grove, 1996, Christensen, Verlinden and Westerman, 2002), and some scholars have speculated that the horizontal stratified value chain structure found in the PC industry might be the new (and permanent) industrial structure for the mobile phone industry.

Based on our analysis of the mobile phone handset industry, we believe that the industry is moving towards horizontally stratified structure in the mid-tier and smartphone segments. Products based around an open operating system such as Microsoft or Symbian are likely the first that will develop towards modular architectures. Nokia has announced that it targets to have its Series 60 operating system in 25% of all Nokia phones by 2007, which means that the company intends to force Open OS down in the mid-tier segment. Mobile phones in this segment will most likely be built upon 2 to 3 core integrated sub-systems, with peripheral components added to this platform.

As was the case with the PC industry, there seem to be several motivating factors at the heart of this process: gains from specialization driven by differences in the evolving knowledge bases along the value chain and latent gains from trade emerging from capability differences between specific firms in the industry (Jacobides, 2005). As was the case in the PC industry, costly technology shifts have required open solutions to minimize R&D investment and a higher degree of vertical specialization, due to cost pressure both in terms of matured technologies and investment cost of new technologies.

Multidimensional complexity is making it increasingly difficult for mobile phone vendors to retain all activities in-house and s resulting in the evolution of capability differences between different firms. This, in turn, is increasing the gains from trade across firm boundaries. This is particularly true in the face of shortened product lifecycle times and the aggressive entry of new competitors that are leveraging their own core competences in areas such as industrial design, marketing and component development in combination with access to mobile phone platforms and subsystems. As handsets have become more sophisticated, firms from adjacent industries such as consumer

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6 It should be noted, however, that RIM is moving to a more horizontal approach, and the company has moved to license its BlackBerry messaging software to a host of competitors, including PalmSource, Nokia, and Motorola.
electronics (for example digital cameras and LCDs) have seen the opportunity to move horizontally to supply components to handset manufacturers.

But we have identified an additional driver of vertical specialization in the mobile handset industry that was not present in the PC industry – the influence of the mobile network operators. Large operators such as Vodafone, T-Mobile and NTT DoCoMo represent the distribution channel for tens of millions of handsets and therefore have significant bargaining power in negotiations with handset vendors. These firms are looking for commonality between different phones in order to reduce their costs for testing, porting applications, training and support. This commonality can be had by specifying common device functionality and application environments such as BREW, Series 60 or Microsoft Mobile, which is in turn having a significant impact on handset vendors’ approaches to OS and application engine selection.


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Source: Collected From Various Sources

We have observed that there are indeed similarities between the evolution of the PC and mobile phone industries. Like PCs, mobile phones are becoming increasingly sophisticated and more advanced devices now incorporate microprocessors, memory, operating systems, applications and core components such as LCD screens and keypads. But there are also significant differences between the architectures of the two products – mobile phones are much smaller and are not yet based on a small number of ‘dominant designs’ as is the case with PCs (primarily desktop and laptop configurations), and there is no single dominant technological standard as ‘Wintel’ in the mobile phone industry. Mobile phones have evolved from voice-centricity to data applications, while the PC has evolved from data centric applications to communication with the evolution of the Internet and alternative connectivity technologies (wireline, Wi-Fi, GPRS, Wi-Max).

The future evolution of the mobile device value chain is likely to differ depending on the type of device and segment. Horizontalisation is ongoing, but at a different pace in different segments. It is likely that largely integrated solutions will continue to be needed when introducing new technologies (normally high-end) or when optimizing cost (low-end), while modular architecture building blocks will continue to evolve to meet flexibility and differentiation (both smartphones and mid-tier). This will require mobile phone manufacturers to take a different product and organizational responses by segment – a ‘one size fits all’ approach will not be sustainable. Based on this analysis,
it is interesting to note the 2004 decision of Nokia to divide its mobile phones division into three different groups – mobile phones (i.e. entry level and lower mid-tier), multimedia (i.e. mid-tier and smartphones) and enterprise (i.e. high-end enterprise devices and solutions). This seems to have been an altogether appropriate response to the evolution of product architectures, although it remains to be seen if the company will be able to develop the requisite organisational processes and cultures within the different divisions to deal with the challenges and opportunities presented by each segment. We also question whether a separate division should have been created by Nokia for developing ‘bleeding edge’ new to market products that require more integral architectural approaches, as the processes and organisational culture typically required to bring this type of to market do not seem to fit easily within the three existing divisions.

End-users and operators are demanding applications and functions from the PC industry (USB, Outlook, RealPlayer, MP3 etc), further pushing mobile device manufacturers towards standardised component and software interfaces. This demand for the integration of computer and media software and components in mobile phones has enabled players from the computer and media industry to capture horizontal positions, beginning in the Open OS smartphones segment where demands for functionality are largest. Network effects cannot be underestimated, and a key element of Microsoft’s Mobile OS value proposition to both mobile network operators and end consumers is interoperability with its PC operating systems and applications. This has been a particularly effective strategy for capturing market share in the PDA smartphone segment that is targeted mostly at corporate users.

Software and applications will become increasingly important value creators for mobile device brands – in 2004 almost 80% of Nokia’s Euro 3.76 billion R&D budget was directed towards software, primarily for use in products and solutions (Karhonen, 2005). But as IBM discovered in the PC industry, growing complexity will make it difficult for even the largest competitors to keep up the pace and due to this, modular software application solutions will dominate. Many consumers segments will demand applications from the PC and entertainment space, and the impact of network effects should not be underestimated. As this trend towards software modularity continues to evolve in the mid-tier and smartphone segments, established companies such as Motorola, Siemens-BenQ, Samsung and Sony Ericsson have to take a strategic decision. Should these companies invest heavily in their own operating systems? Or should they license Symbian, Microsoft or other operating systems for their mid-tier and smartphone products? Based on the experience of the PC industry, there is an obvious danger for manufacturers if the industry tips towards a single dominant standard.

Any firm wishing to compete as a mobile handset manufacturer in the future will need to develop strong systems integration capabilities. High levels of multidimensional complexity in components (digital camera, LCD, memory etc) for mid-tier and high-end devices will continue to push manufacturers towards more standardised interfaces and modular product designs. As the industry moves towards a higher degree of vertical specialization, the barriers to entry for mobile phone manufacturers will fall. Variable rather than fixed costs will become more significant, and core R&D capability will not be a requisite for competitive advantage, but successful firms will still need overlapping technological knowledge with suppliers to understand technological developments, to select the right partners and to be able to integrate suppliers’ inputs effectively. The cost structure of non-integrated design/assemble firms tends to
be dominated by variable rather than fixed costs. Because it is high fixed costs that give rise to steep scale
economies, assemblers of modular products are able to compete on relatively flat scale curves, small competitors
will be able to enjoy similar costs to larger ones (Christensen, Verlinden and Westerman, 2002). This trend is
already apparent in the entry of competitors such as Israeli-Korean handset design and manufacturing house
Emblaze Mobile, which are able to bring high-quality mid-tier and smartphone products to market at relatively low
volumes, but at comparable cost to much larger manufacturers.

As entry barriers fall, profitability is likely to flow away from handset manufacturers to manufacturers of key
performance enhancing components and modules (both hardware and software), a trend that was witnessed in the
PC industry (Christensen, Raynor and Verlinden 2001), but which has not been fully explored within the scope of
this paper. But as in the PC world, the OS, software applications and microprocessor subsystems are likely to be
critical in determining the performance of future mobile devices, so the battle to control these elements will be
intense. We predict that other component manufacturers, like the manufacturers of peripherals and components that
have eventually overshot the performance requirements of the mass market in the PC world, are unlikely to reap
substantial profits in the longer term as industry standards are established and technologies mature. The exception
here might be external memory and display technologies (LCDs), which continue to fall short of evolving customer
requirements.

We believe that, as has been the evolutionary path of many other industries, it will become increasingly difficult to
compete primarily on product functionality in the mobile phone industry as different vendors gain access to the same
or similar components and modules. First mover advantage is likely to be short lived for competitors coming to
market with higher performing digital camera modules, higher memory capacity or LCD screens, as competitors are
also likely to be able to source these components within a relatively short period of time. As was the case in the PC
industry, ‘complementary assets’ (Teece, 1986) or resources that can raise the value of a firm’s technological
innovations will therefore become increasingly important as a means of strengthening the appropriability of profits.

As Teece (1986) points out, innovations often only reduce the value of technological resources and knowledge,
while leaving the value of complementary assets such as operational efficiency, brand and customer relationships
untouched. Indeed, according to Teece’s (1986) definition these complementary assets can increase the value of a
firm’s technological innovations. Other researchers have shown that by controlling critical complementary assets,
 firms may strengthen bargaining power towards suppliers and buyers (Arora, Fosfuri and Gambardella, 2001
 Chapter 5). Mobile phone manufacturers should take note that Dell, the highest performing PC manufacturer in the
world today, has built its dominance upon complementary assets such as supply chain efficiency, customization and
customer service rather than technological innovation.

Similarly, Apple Computer has had phenomenal success in selling what is essentially a commodity product (an MP3
Player is little more than a hard drive combined with a simple operating system) based upon its iPod brand, user
friendliness and consumer experience (iTunes). The rapid growth and success of ‘service intermediaries’ in the
mobile phone industry such as 20:20 Logistics and Dextra also point to opportunities to create value beyond the
core product, and supports research that suggests fragmentation in the upstream value-chain can create opportunities to vertically integrate downstream assets (Teece, 1988; Afuah, 2001). Examples of complementary assets in the mobile handset industry include:

1. Design and development synergies with MNO customers: Innovation and configuration
2. Time to market competitiveness and launch rollout: Launch accuracy, achieving testing project milestones
3. Commercial development and value creation: Value bundles, vendor/MNO brand alliance& synergies, margins and terms, value life cycle enhancement (analysis &development), cost to acquire and retain
4. Handset vendor's trading differentiation and value add: Merchandising, sell through rate, accessories, life cycle optimization, product education and understanding
5. Handset vendor's logistics optimization and cost reduction: Inbound, warehousing, forecasting, demand planning, reverse logistics, after sales service, customer experience

These dimensions of performance are likely to become increasingly important, especially in the mid- and high-end segments, a trend that has already been recognized by many of the established competitors:

“Beyond product innovation, we are also focused on enhanced partnerships with our customers by aligning with their business strategies and objectives. A core component of our customer partnership strategy is the expansion of opportunities for carrier customers to increase average revenue per user (ARPU). By utilizing customizable platforms, we enable our carrier customers to go to market with handsets that feature differentiated user interfaces, such as consumer personalization, to help them build consumer loyalty. These platforms also generate revenue opportunities for our carrier customers by supporting data productivity applications, gaming, music and other entertainment offerings and customized content.” Ed Zander, Chairman and CEO, Motorola Inc., December 2004.

Newer industry entrants such as Samsung have already demonstrated the power of marketing, brand management and excellence in industrial design; Samsung has experienced explosive growth in recent years, while maintaining the highest average selling price (ASP) in the industry. The company posted record sales of 55.7 million cell phones in 2003, growth of 32 percent over the previous year, keeping the average selling price (APR) of its cell phones at about USD190, compared with about USD150 for Nokia and about USD 145 for Motorola. The company’s compounding annual growth rate for mobile phones was 45% over the period 2001–2004, versus overall market CAGR of 19%. The company secured number three market share in 2004 with 12.7% of the global handset market, while overtaking No.2 Motorola in terms of revenue (Samsung Electronics Presentation to Analysts, June 2005. http://www.samsung.com/ir). But Samsung has been one of the few companies from the consumer electronics world that has been able to effectively build up the complementary assets outlined above. Others such as Japan’s Panasonic, NEC and Sharp have found it very difficult to expand market share outside of their home markets. Given the need to build complementary assets beyond product quality and functionality to succeed with MNO customers, the acquisition of Siemens’ mobile division by Taiwanese consumer electronics company and ODM BenQ seems to have a strategic logic despite the apparently unattractive commercial basis of the takeover.

Given that complementary assets are often not affected by the changing nature of technological innovation (for example the evolution from integral to modular product architectures), they can sometimes insulate established firms against the threat of competition from new entrants (Bruhl, Stieglitz, 2005). Realizing that capabilities in brand management and consumer-centric design are becoming important complementary assets in the face of ongoing...
industry change, Motorola has recruited industrial designers from Apple and Nike and expanded advertising efforts, spending more than USD 200 million on its “Intelligence Everywhere” and “Hello Moto” campaigns since 2002 (Mike Dano, ‘Motorola reorders design, manufacturing strategies,’ RCR Wireless News, 9th May 2005, Vol. 24, Issue 19, pp.1-2).

Nokia has also invested heavily in industrial design and brand building. As early as 1995 the company set up a full-time dedicated design center in Los Angeles, which by end 2005 acted as headquarters for a network of design teams in Japan, China, Germany, Britain, Finland and Denmark. Nokia spent more than EUR 2.5 billion (5% of sales) on advertising and promotion in 2003-2004. The company has invested heavily in print and broadcast advertising, such as its “Connecting People” campaign, and has sponsored a variety of sporting and leisure events. Nokia has promoted its products by sponsoring movies in which Nokia phones feature prominently alongside the lead characters. According to a survey published in August 2004 by Interbrand, Nokia is now the 8th most valuable brand in the world (Simonson, 2005).

Nokia has also invested in improving the efficiency of its supply chain. The company was ranked 2nd only to Dell in a 2004 AMR study of supply chain efficiency, and ahead of companies such as Wal-Mart and Procter and Gamble. In the 3rd quarter of 2004 the company reported that it had captured an additional EURO 215 million in profit by being able to respond quickly to above forecast demand that required the assembly of 4.7 million additional phones and the integration of more than 1 billion additional components (Pietila, 2005). Despite a declining market share and ASP, the Finnish company has leveraged its operational efficiency, an important complementary asset, to maintain amongst the highest profitability in the industry. With 2004 operating margins of 19% the company was ahead of Samsung (17%), Motorola (10%), Sony Ericsson (8%) and LG (5%) (Simonson, 2005).

But a word of caution on the above analysis – the complementary assets view is based very much on the maintenance of the status quo in the significant role played by MNOs in distributing and (in many markets) subsidizing handsets. Some markets, especially in Northern and Western Europe, are witnessing two important trends – the rapid growth of low-cost SIM card only offers and/or the development of so called ‘converged’ or triple-play (fixed-mobile-broadband) strategies. Both of these developments might well see the growth of the retail channel as an important distributor of mobile handsets as telecommunications companies focus more on the sale of connectivity and less on the distribution of devices. Consumer electronics companies have a long history in managing these channels compared to the typical mobile handset vendor, and anecdotal evidence suggests that the sale of handsets via retail channels can negate potential value differentiators such as design and development synergies, commercial development and value life cycle enhancement that have insulated established handset vendors from new entrants. If Wal-Mart and other mass-market retailers become important distributors of mobile handsets, then this could change industry dynamics significantly.

Some researchers predict that in the lower tiers of truly commoditized product markets, integrated architectures might become or remain interdependent. If all customers required exactly the same features and functionality from a
product, and their requirements remained predictable over time, then the flexibility and options value of modularity might have little value (Baldwin and Clark, 2000; Christensen, Verlinden and Westerman, 2002). It might then be possible that a single interdependent product design might indeed be a lowest cost solution (Christensen, Verlinden and Westerman, 2002). The evolution of the mobile phone industry seems to evidence this hypothesis, and it will most likely be a much slower process for the entry-level segment to move towards modular architectures as the dominant product approach. The most cost optimized solutions continue to integrate core components very closely, with RF platform, shared memories and RTOS bundled together in proprietary architectures. Furthermore, there is less pressure to offer advanced functionality beyond voice and SMS messaging in this segment, reducing the levels of multidimensional complexity to be managed by manufacturers. Nokia, the most highly integrated industry player continues to dominate the entry-level with approximately a 50% market share, and the company's recent success in taking market share from low-cost manufacturers in China testifies to the effectiveness of its integral product approach, lean manufacturing and supply chain efficiency.

Despite the likelihood of integral approaches continuing to dominate the lower tiers of the market, some analysts suggest that this segment will begin to shrink as a percentage of total handset sales over the coming years. Therefore, despite the potential advantages of an integrated approach companies such as Nokia may well be defending a declining market (see Exhibit 4).

Exhibit 4: Forecast of Mobile Handset Sales by Segment

![Exhibit 4: Forecast of Mobile Handset Sales by Segment](Image)

Source: ARC, 2004

Similar to the experience from other industries, new-to-market products which push the frontiers of device functionality and performance are also unlikely to move towards modular architectures in the short term. Quite simply, for engineers to wring the best performance out of these devices to serve the most demanding tiers of the market, they will need to continue to develop their products on integral product architectures. We therefore predict that integrated companies with deep R&D capabilities will continue to dominate this segment.

VIII. Conclusion

While we have demonstrated that there are differences between the evolution of the mobile phone and PC industry value chains, handset manufacturers should learn from the PC industry and make sure that their vertical outsourcing decisions are not made simply on which value chain option is cheaper or faster to market. While this logic might appear to make compelling sense in the short-term, previous research suggests that this logic can result in a firm
outsourcing those elements of value-added in which most of the industry’s profits will be made in the future – and to retain activities in which it is difficult to maintain long-term advantages versus competitors (Grove, 1996; Fine, 1998; Christensen, Verlinden and Westerman, 2002).

Value chain design should therefore be recognized as a strategic activity that will determine the fate of a mobile device manufacturer, and of future profits and power distribution in the industry. As has been the case in other industries that have evolved towards vertical specialization (Jacobides, 2005), the gains from specialization driven by differences in the evolving knowledge bases along the value chain, and latent gains from trade emerging from capability differences between specific firms have been key drivers of value chain disintegration in the mobile handset industry. An additional (and increasingly important) driver of vertical specialization has been the mobile network operators, who are likely to continue their move towards specifying common device functionality and application environments.

Systems integration capabilities will become increasingly important, and phone manufacturers will also need to look to those complementary assets which will help them to win in a world in which product differentiation built upon functionality will become increasingly difficult. In particular, mobile phone manufacturers should act quickly to build those complementary assets – brand equity, manufacturing efficiency, supply chain efficiency, service and other dimensions of value - which will provide points for future competitive advantage.
### Appendix A – Terms and Abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3G</td>
<td>Third-generation mobile system</td>
</tr>
<tr>
<td>3GPP</td>
<td>Third-generation Partnership Project</td>
</tr>
<tr>
<td>AAC</td>
<td>Advanced audio coding</td>
</tr>
<tr>
<td>API</td>
<td>Application program interface</td>
</tr>
<tr>
<td>ARM</td>
<td>Advanced RISC Machines</td>
</tr>
<tr>
<td>ARPU</td>
<td>Average revenue per user</td>
</tr>
<tr>
<td>CLDC</td>
<td>Connected limited device configuration</td>
</tr>
<tr>
<td>CPO</td>
<td>Customer project organization</td>
</tr>
<tr>
<td>CPU</td>
<td>Central processor unit</td>
</tr>
<tr>
<td>DSP</td>
<td>Digital signal processor</td>
</tr>
<tr>
<td>EDGE</td>
<td>Enhanced data rates for global enhancement</td>
</tr>
<tr>
<td>EMP</td>
<td>Ericsson Mobile Platforms</td>
</tr>
<tr>
<td>ER</td>
<td>Error report</td>
</tr>
<tr>
<td>GPRS</td>
<td>General packet radio system</td>
</tr>
<tr>
<td>GSM</td>
<td>Global system for mobile communication</td>
</tr>
<tr>
<td>H.263</td>
<td>ITU-T standard for video codec</td>
</tr>
<tr>
<td>HSDPA</td>
<td>High-speed download packet access</td>
</tr>
<tr>
<td>IMEI</td>
<td>International mobile equipment identity</td>
</tr>
<tr>
<td>IMS</td>
<td>IP multimedia subsystem</td>
</tr>
<tr>
<td>IOT</td>
<td>Interoperability testing</td>
</tr>
<tr>
<td>IP</td>
<td>Internet protocol</td>
</tr>
<tr>
<td>IPR</td>
<td>Intellectual property rights</td>
</tr>
<tr>
<td>IPv4, IPv6</td>
<td>IP version 4, IP version 6</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid crystal display</td>
</tr>
<tr>
<td>JCP</td>
<td>Java Community Process</td>
</tr>
<tr>
<td>JSR</td>
<td>Java-specification request</td>
</tr>
<tr>
<td>MMS</td>
<td>Multimedia messaging service</td>
</tr>
<tr>
<td>MP3</td>
<td>MPEG audio layer-3 codec</td>
</tr>
<tr>
<td>MPEG</td>
<td>Motion Pictures Coding Experts Group</td>
</tr>
<tr>
<td>ODM</td>
<td>Original design manufacturer</td>
</tr>
<tr>
<td>OMA</td>
<td>Open Mobile Alliance</td>
</tr>
<tr>
<td>OMTP</td>
<td>Open Mobile Terminal Platform</td>
</tr>
<tr>
<td>OPA</td>
<td>Open-platform API</td>
</tr>
<tr>
<td>OSI</td>
<td>Open system interconnection</td>
</tr>
<tr>
<td>PDA</td>
<td>Personal digital assistant</td>
</tr>
<tr>
<td>Q&amp;A</td>
<td>Questions and answers</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
<tr>
<td>RF</td>
<td>Radio frequency</td>
</tr>
<tr>
<td>RS232</td>
<td>Serial (9-pin) adapter</td>
</tr>
<tr>
<td>SDK</td>
<td>Software development kit</td>
</tr>
<tr>
<td>SIM</td>
<td>Subscriber identity module</td>
</tr>
<tr>
<td>SMS</td>
<td>Short message service</td>
</tr>
<tr>
<td>USB</td>
<td>Universal serial bus</td>
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<tr>
<td>VM</td>
<td>Virtual machine</td>
</tr>
<tr>
<td>WAP</td>
<td>Wireless application protocol</td>
</tr>
<tr>
<td>WB-AMR</td>
<td>Wideband adaptive multirate</td>
</tr>
<tr>
<td>WCDMA</td>
<td>Wideband code-division multiple access</td>
</tr>
</tbody>
</table>
Appendix B - Main Component Suppliers to the Mobile Phone Industry

**Real Time Operating System**
- ENEA, Wind River, Green Hills – Integrity, Esfia RedBlue and Nucleus

**Operating System**
- Symbian, Microsoft, Palm, Linux

**GSM/GPRS/EDGE Full Platform (hardware and software) and Chip Suppliers (hardware only)**
- Agere Systems, Broadcom, Freescale Semiconductor, Infineon Technologies, Philips, Texas Instruments, Ericsson Mobile Platforms

**WCDMA Full Platform (hardware and software) and Chip Suppliers (hardware only)**
- Available as of mid 2005: Freescale, Qualcomm, EMP
- Products expected 2006: Agere Systems, Broadcom, Freescale Semiconductor, Renesas Technology Corp, Texas Instruments

**Global Positioning (GPS) Chip Set Suppliers**
- Fujitsu Microelectronics, Global Locate, Infineon & Xemics, NEC, Nemerix, Qualcomm/SnapTrack, RFMD, SiGe Semiconductor, SIRF Technology, STMicroelectronics, Texas Instruments

**Bluetooth RF & Baseband Chip Suppliers**

**Camera Sensor and Camera Chip Processors**
- Agilent, Micron Matrix, OmniVision Technologies, Samsung Electronics, Seiko-Epson, Sharp Microelectronics, Sony, STMicroelectronics, Toshiba

**Mobile Graphics Coprocessors**
- Fujitsu, Nazomi Communications, NVIDIA, Toshiba, ViMicro, Zoran (Emblaze Semiconductor)

**Application Processors**
- Freescale Semiconductor, Intel, NeoMagic, Qualcomm, Renesas (SH-Mobile), Samsung, STMicroelectronics, Texas Instruments

**Color Display Suppliers**
- Clare-Micronix, Epson Seiko, Leadis, Philips Semiconductor, Renesas (Hitachi), Samsung, Sanyo, Sharp, Solomon Systech, Toshiba

**Other Software Suppliers**
- Advanced Telecommunications Research Institute, Blue Mug, Comsys, Magic4, Opera, Software, PacketVideo, Sasken, Symbian, TTPCom, Wavecom

**R.F. Transceiver & Power Amplifier Suppliers**
- Analog Devices, Freescale, Infineon, Maxim, Philips, Qualcomm, RF Micro Devices, Skyworks Solutions, Texas Instruments, STMicroelectronics

**Power Amplifier Suppliers**
- Philips, RF Micro Devices, SiGe Semiconductor, Silicon Laboratories, Skyworks

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Exhibit A: Typical Value Chain for a Mobile Phone Manufacturer in the 1990s – Highly Vertically Integrated

Product Value Chain – Mobile Phones

Generic Component Provisioning
- HW Components
- SW Components

Specific Component Provisioning
- SW Application & OS
- Platform

Device Provisioning
- Product specification
- Design & Integration
- Manufacturing

End-user brand value definition
- Marketing & Sales
- After Sales Services

Silicon and other HW component manufacturing
Silicon and other HW component development process
HW design (dedicated and/or proprietary or standard)
Standardization body controlled or proprietary protocol stacks, codecs, network signaling stack, app. environment engines
Application suite, Open OS
SW System = Integration of different SW components
Reference Design = SW System + HW components
End-use device specification
Design & Integration = Platform + other HW comp. + SW Apps. (+ open OS)
Physical assembly and production
B2C Marketing & Sales (Brand owned sales channels)
B2B Marketing & Sales (Operators and Wholesale)
Exhibit B: Typical Mobile Phone Manufacturer Value Chain in 2005 – Emergence of Horizontal Specialisation

<table>
<thead>
<tr>
<th>Value System</th>
<th>Generic Component Provisioning</th>
<th>Specific Component Provisioning</th>
<th>Device Provisioning</th>
<th>End-user brand value definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Immaterial/Service domain</td>
<td>Physical (product) domain</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>component development process</td>
<td>6. Standard or generic HW</td>
<td>project</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>components</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>component manufacturing</td>
<td>of SW system solutions</td>
<td>specification</td>
<td></td>
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<td></td>
<td></td>
<td>8.System reference design, test</td>
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<td></td>
<td></td>
<td>and verification</td>
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<td></td>
<td></td>
<td>9.SW applications</td>
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<tr>
<td></td>
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<td>12.Physical Manufacturing and</td>
<td></td>
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<td></td>
<td></td>
<td>assembly</td>
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<td></td>
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<td>13. Marketing &amp; Sales</td>
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<td>14.Distribution</td>
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<tr>
<td><strong>Value System</strong></td>
<td>1. TI, ST Micro, Philips</td>
<td>4. OS SW</td>
<td>16.Product design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. TI, ST Micro, Philips, 3rd</td>
<td></td>
<td>project</td>
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<tr>
<td></td>
<td>party fabs</td>
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<tr>
<td></td>
<td>3. Codecs (mp3), network</td>
<td>5. Design of dedicated or original HW components</td>
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<tr>
<td></td>
<td>signaling stacks (GPRS),</td>
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<tr>
<td></td>
<td>protocols (IP, TCP),</td>
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<tr>
<td></td>
<td>application environment</td>
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<tr>
<td></td>
<td>engines (Java) etc.</td>
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<td></td>
<td>4. RTOS (Enea, Wind River,</td>
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<tr>
<td></td>
<td>Green Hills), Open OS (Win CE,</td>
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<td></td>
<td>Linux, Symbian), Use IF SW</td>
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<tr>
<td></td>
<td>(UQ, Series6G)</td>
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</tr>
<tr>
<td></td>
<td>5. BB ASIcs, RF ASIcs, BT</td>
<td>10.Integration of platform +</td>
<td></td>
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<tr>
<td></td>
<td>chip, app processor</td>
<td>other HW comp. + SW apps.</td>
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<tr>
<td></td>
<td>6. Display, memory, camera,</td>
<td>(uses RTOS if integrated phone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>battery, filters, capacitors,</td>
<td>or open OS if smartphone)</td>
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<tr>
<td></td>
<td>resistors, duplexers etc.</td>
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</tr>
</tbody>
</table>

1. Integration of protocols, network signaling stacks, codecs, and RTOS into a working SW system solution.
2. Integration test and verification of SW system + HW components + SW components.
3. Application development and integration into application suite.
4. Integration of platform + other HW comp. + SW apps. (uses RTOS if integrated phone or open OS if smartphone.)
5. Product planning and specification of functionality, segmentation, positioning etc.
6. Conducted either by OEM, ODM or EMS.
8. Customer services etc.
The Mobile Handset Industry in Transition

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