The Implication of Open Innovation and Open Source to Mobile Device Manufacturers

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Submitted to the System Design and Management Program in Partial Fulfillment of the Requirements for the Degrees of

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Abstract

Innovations largely contribute to a technology company’s continuous survival and its competitiveness in the market place. Traditionally most companies employed closed innovation model. They kept their discoveries or inventions highly secret and made no attempt to assimilate information from outside. This model worked well until 1990s when advances in technology and society had facilitated information diffusion dramatically. Mobile industry, as one of the most rapidly changing industries, is also forced to adopt the open innovation model in various forms. Recently announced Android platform caused a big stir in the industry. The gradual shift from closeness to openness is inevitable in this industry.

A good example of Open Innovation is the open source software development that has been studied extensively. This study further examines the open innovation model beyond software development, i.e. open innovation in hardware and embedded system development. Lessons are learned through case studies of software, hardware and embedded system related business practice. Recommendations are given to Mobile industry, specifically the cell phone handset industry accordingly. This study will not focus on a specific platform or the user side.

Thesis Supervisor: Michael A M Davies
Senior Lecturer, Sloan School of Management
Acknowledgments

I would like to thank my thesis advisor Michael Davies for being extremely knowledgeable and resourceful. His rich experience in Mobile industry ignites my interest in this topic. Every short conversation with him would sparkle new ideas in my mind. His inputs on this thesis have been greatly appreciated.

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1. Introduction to Open Source and Open Innovation

As an early adopter of open source software in the middle 90s’, I witness the evolution of open source software from hobby projects to viable business models. The attitude towards open source software in some large corporations also changed from suspicious to acceptable then to favorable. In the past five years I worked for one of the largest telecom companies in the US. The company used to have clear rules from top IT executives that banned all open source components from production release due to the concern of support and legal liability. However in the IT development teams, open source development tools and software components are widely used on a daily basis. The popularity of open source software within that company reached the point that some open source components eventually sneaked into the production codes and the top IT executives no longer made public objections. The company’s executives may not realize that one of the major players in the open source community, the Linux Operating System (OS), were already in the production system.

Being an IT professional in the telecom industry and a consumer myself, I also witnessed the dramatic change in the past couple of years in the mobile industry, more specifically the evolution of mobile devices, from exclusively closed system only a couple of years ago to largely open source operating system in the high-end Smartphone at this moment. In fact, four out of the top six smartphone operating systems (Symbian OS, iPhone OS, RIM Blackberry OS, Windows Mobile, Linux/Android, Palm WebOS) are more or less open source platforms. The two exceptions are Research In Motion (RIM) Blackberry OS and Microsoft Windows Mobile OS which are strictly proprietary.
Android is a mobile operating system based on Linux. Android was first announced by Google in November 2007. And then the release of the first Android phone HTC Dream (T-Mobile G1 or Era G1) on October 22, 2008 made big news in the industry. The instant popularity of Android platform and G1 phone were made by the claim of openness and the support from Google and now the Open Handset Alliance. The Android platform is well accepted by both end consumers and developers alike. There are many guesswork of Google’s real motive behind the Android. Regardless of Google’s motive, the Android platform creates a wonderful ecosystem and a battle ground for the whole mobile industry and attracted more players that are not traditionally in the mobile handset business.

The term Open Innovation was originated and developed in a 2003 Harvard Business School Press book by Henry Chesbrough (Chesbrough, 2003). This book provides specific managerial advice how firms can develop business models that reflect this paradigm. Despite its much longer history, interesting enough, Open Source is just one special case of the open innovation paradigm. Open design and open standard are other forms of open innovation.

The focus of this study is how the open source or the open innovation can help mobile device manufactures to survive in this competitive business environment. Strictly speaking, “cell phone/mobile phone” and “mobile device” are not exactly the same term in the past. “Cell phone” is one type of “mobile devices”. While “cell phone” emphasizes the voice function of a device, “mobile device” emphasizes the computing power of the portable device. However there’s a clear trend right now that the two terms are converging. In fact, Microsoft no long makes different Windows Mobile OS for smartphones and PDAs. Starting from Windows Mobile 5 (WM5), there’s only one OS for mobile devices, whether they are PDAs or
smartphones. Mobile device manufacturers can customize Windows Mobile operating system to suit a specific device by enabling/disabling certain features of that OS, or add extra features. In this study, we will also not differentiate these two terms. The two terms may be used interchangeably.

We will focus on the technology strategy and business model instead of the technical differences of different platforms in mobile industry. We are more interested in the lessons learned from the business practices inside or outside mobile industry using open innovation model, whether those practice intentionally or unintentionally followed the open innovation paradigm.

1.1. Introduction of Henry Chesbrough's Research

Innovations largely contribute to a technology company's continuous survival and its competitiveness in the market place. Traditionally most companies employed closed innovation model. They kept their discoveries or inventions highly secret and made no attempt to assimilate information from outside. This model worked well until 1990's when advances in technology and society have facilitated information diffusion dramatically. In his brilliant book, *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Henry Chesbrough described a new paradigm of open innovation that is in contrast to the traditional closed model(Chesbrough 2003). To better understand the open innovation, it's worthwhile to review the older closed innovation model.
1.1.1. The Closed Innovation Paradigm

Henry Chesbrough thoroughly examined the history of Xerox’s Palo Alto Research Center (PARC) over the past thirty years trying to understand how a company that possessed the resources and visions to launch a brilliant research center could let so many good ideas get away. Why did so many of PARC’s innovation in computer industry yield so little for Xerox and its shareholders? The answer to these questions points to both the accomplishments and the problems associated with the way Xerox managed its innovation process which Chesbrough called the *closed innovation* paradigm: the corporation sought to attain competitive advantage by funding research labs to discover new breakthroughs; develop these breakthroughs into products; build the products in its factories; sell the products at higher profit margin and then fund the new R&D by the profits. This paradigm was hardly unique to Xerox and worked well for most of the 20th century. The firms with such vertically integrated research, development and manufacturing capability can command much higher profit margin.

Figure 1 depicts this closed innovation paradigm. The circles represent the ideas and the solid lines show the boundary of the firm. Ideas are screened and filtered during the research process. The Surviving ideas are transferred into development and then taken to market. Some ideas may have resulted in patents but never made to development if the innovation does not fit into the company’s core business. Such completed research projects become the intellectual property of this company and may or may not be used in the future.
Chesbrough’s observation of the battle between Lucent and Cisco revealed that the closed innovation model started to change in the 1990’s. Another example is the Nokia. Building on its industrial experience in the low-tech wood and rubber boots from the earlier decades, Nokia moved itself ahead of Motorola, Siemens and other industrial titans to the forefront of wireless telephony in only twenty years by adopting different innovation process.

Chesbrough summarized four erosion factors that undermined the logic of closed innovation:

- The increasing availability and mobility of highly experienced and skilled people
- The booming of venture capital industry
- The external options for ideas sitting on the shelf
- The increasing capability of external suppliers

Figure 1 the Closed Paradigm for Managing Industrial R&D
On top of the four factors mentioned by Chesbrough, I would add a fifth one, which is the diffusion of information. The world is becoming flat (Friedman 2006) and the information is hard to be contained in one place. Information can be transferred so easily that it seems impossible to prevent diffusion. Today’s information-empowered flat world makes for an idea ecosystem for open innovation.

1.1.2. The Open Innovation Paradigm

The closed innovation paradigm has eroded in various industries. As a result, companies have started to look for other ways to increase the efficiency and effectiveness of their innovation processes. A new approach called Open Innovation by Chesbrough is emerging in place of closed innovation. Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market. For instance through active search for new technologies and ideas outside of the firm, but also through cooperation with suppliers and competitors, in order to create values for customers.

Table 1 shows some of the contrasting principles between Closed Innovation and Open Innovation (Chesbrough 2003).
Table 1 Contrasting Principles of Closed and Open Innovation

<table>
<thead>
<tr>
<th>Closed Innovation Principles</th>
<th>Open Innovation Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>The smart people in our field work for us</td>
<td>Not all the smart people work for us. We need to work with smart people inside and outside our company</td>
</tr>
<tr>
<td>To profit from R&amp;D, we must discover it, develop it, and ship it ourselves</td>
<td>External R&amp;D can create significant value; internal R&amp;D is needed to claim some portion of that value</td>
</tr>
<tr>
<td>If we discover it ourselves, we will get it to market first</td>
<td>We don’t have to originate the research to profit from it</td>
</tr>
<tr>
<td>The company that gets an innovation to market first will win</td>
<td>Building a better business model is better than getting to market first</td>
</tr>
<tr>
<td>If we create the most and best ideas in the industry, we will win</td>
<td>If we make the best use of internal and external ideas, we will win</td>
</tr>
<tr>
<td>We should control our IP, so that our competitors don’t profit from our ideas</td>
<td>We should profit from others’ use of our IP, and we should buy others’ IP whenever it advances our own business model</td>
</tr>
</tbody>
</table>

Figure 2 explains the Open Innovation paradigm. Under the concept of open innovation, research results are able to traverse the firm’s boundaries. The dashed line means the boundaries of the firm is porous. Some ideas may seep out of the firm either in the research stage or later in the development stage. Outside ideas can also get inside the firm by public information or through licensing because they are useful in the firm’s core business. Another important aspect is the further development or out-licensing of ideas and technologies that do not fit the strategy of the company.
The open innovation model states that since firms cannot stop this phenomenon, they must learn to cope with it. It is the business model of the firm that determines what external information to bring inside and what internal information to take outside.

### 1.1.3. Intellectual Property in the Open Innovation

Open Innovation model poses a big challenge to the traditional intellectual property model. In the vertically integrated closed innovation model, sufficient intellectual property protection has been necessary for the firms to justify investments in high-risk researches. In the Open Innovation model, protection of intellectual property is still critical to gain new knowledge and
economic benefits. But the question is, how and to what degree? Who will own the IPs? Who can benefit from the research results? Ideally the problem can be solved by sharing the costs and benefits of innovation and the resulting intellectual property according to the relative contribution of various parties. Intellectual rights can be ensured through appropriate protection strategies that are agreed upon by all parties. But that is easier said than done.

Firms openly embracing the open innovation understand that rarely can a company exclusively control an important technology for an extended period. The forces that diffuse knowledge are so strong that the wiser course is to plan the technology strategy under the assumption that it will be rapidly diffused and imitated. They also understand that it is simply not possible for one company to realize the benefits of all its ideas because ideas need to come together with luck, judgment, skills, timing, motivation, and other ideas to form an innovation complete with a matching business model and delivery system.

Firms which are afraid of open collaboration and believe that outflow of ideas can cannibalize their own business are making a false assumption: if you don’t make your products obsolete, no one else will either. In reality, competitors will always find ways of inventing around a firm’s IPs which allow them to enter the same market quickly.

That said, the internal R&D is still critical for a company’s competitive advantage in order to claim a portion of the value and to transfer external discoveries into its business model. The health of an open innovation ecosystem also depends on the investment of all the participants. You can convert something from another thing, but you can’t create value from nothing.
1.1.4. Business Models in Open Innovation

Technology by itself has no single objective value. The economic value of a technology remains latent until it is commercialized in some way by means of a business model. As commonly said in venture capital industry, a mediocre technology combined with an excellent business model is certainly the winner over an excellent technology combined with a mediocre business model. The same technology commercialized in different ways may yield totally different returns. The business model serves to connect the ideas to the economic outputs.

By Chesbrough’s definition, a business model should serve the following function:

- To articulate the value proposition to the end users
- To identify a market segment for the technology
- To define the structure of the firm’s value chain
- To specify the revenue generation mechanism and estimate the cost structure and target margins of producing the offering
- To describe the position of the firm within the value network lining suppliers and customers, including identification of potential complementary firms and competitors
- To formulate the competitive strategy by which the innovating firm will gain and hold advantage over rivals.

Chesbrough suggests a framework for open innovation companies to combine internal research with external ideas and then deploy those ideas both within their own business and also through other companies’ businesses. The key for these firms is to figure out what necessary missing
pieces should be supplied internally and how to integrate internal and external pieces together into products.

According to Chesbrough, a firm can create and capture values from their technologies in three basic ways:

- Incorporate the technology in its existing business
- Licensing the technology to other firms
- Launching a new venture in new business arenas that can exploit that technology

Xerox was used as a bad example of crating the right business model for promising technologies. With all the wonderful achievements from PARC, Xerox sought to extend its current business model rather than created a different one that can best utilize the discovery from PARC. The end result is, the market value of the spin-off companies from Xerox exceeds the market value of Xerox today by multiple times.

1.1.5. Further reading and useful resources for Open Innovation

There are many excellent online resources for understanding and employing Open Innovation in the business. The list below is certainly not exhaustive, and only serves as the starting point.

- http://www.openinnovators.net/
- http://blog.openinnovation.net/
- http://www.openinnovation.net/Research/Bibliography.html
1.2. **Open Innovation vs Cumulative, Distributed and User innovation**

Often times the term Open Innovation is used to describe a group of new innovation paradigms that contrast to the traditional closed innovation paradigm. Before Chesbrough coined the term Open Innovation, other researchers already discovered some innovation paradigms that did not follow the traditional vertically integrated close innovation model. *User Innovation, Distributed Innovation, Cumulative Innovation, crowdsourcing and Collaborative Innovation*, just to name a few (West 2007).

The term User Innovation was first coined by Eric von Hippel of MIT (von Hippel 1988). Hel observed that many products and services are actually developed or at least refined, by users, at the site of implementation and use. He referred those users as lead user and the innovation process driven by consumers and end users as User Innovation. von Hippel focused on the idea that firms could tap into both the knowledge and desire of users to solve their own needs. Often time, user innovators will share their ideas with manufacturers in hopes of having them produce the product, a process called free revealing. When individual users face problems that the
majority of consumers do not, they have no choice but to develop their own modifications to existing products designed for mass consumers or to design entirely new products to solve their issues (Baldwin, Hienerth et al. 2005). Threadless is a good example of using user innovation to create value.

Cumulative Innovation was promoted by Suzanne Scotchmer (Scotchmer 2004). She observed that initial innovation is rarely complete and new innovation is built on top of previous innovations. Completely new idea is a rare case in the real world. Thus competitors usually build IPs on each other. The Cumulative Innovation creates a “hold-up” problem, i.e. the previous innovation will hold up the later innovation. The solution to this problem is the regulation and policy.

Distributed Innovation is based on the idea that knowledge is not only distributed in the society but also “sticky,” that is, relatively difficult and extremely costly to move between locations. Open source software communities are the most fully developed example of the appearance of distributed innovation systems characterized by decentralized problem solving, self-selected participation, self-organizing coordination and collaboration, free revealing of knowledge, and hybrid organizational models that blend community with commercial success (Lakhani and Panetta 2007).

The Crowdsourcing is basically a combination of Distributed Innovation and User Innovation. The word was first coined by Jeff Howe in a 2006 article (Howe 2006). Crowdsourcing is a distributed problem-solving and production model. Problems are broadcast to an unknown group
of solvers in the form of an open call for solutions. Users--also known as the crowd--typically form into online communities, and the crowd submits solutions. Crowdsourcing is relatively less known to researchers.

Though different terms emphasized different aspects of the innovation process, they do share one commonality: the openness and collaboration. Among them all, the Open Innovation is the most well-known and most generic term to describe the new innovation paradigm that contrasts to the traditional closed innovation. They all belong to the broader phenomenon of open innovation. We will treat other terms as special cases of Open Innovation in practice regardless of individual researcher’s personal emphasis.

1.3. Open Source as an Example of Open Innovation

Unlike the Open Innovation, Open Source is not a new concept. The practice can be traced back to 1960s’ even before the birth of internet. Open Source came out of the free software movement and became popular after the 1998 Open Source Summit. It is the most popular example of Open Innovation over the past twenty years, exemplified by the Linux operating system. The term Open Source usually refers to the Open Source Software development though it could also be used to describe non-software activities. Open Source has been widely studied by many researchers and industry experts alike over the past ten years and is not the focus of this study. We are more interested in how open source model can fit into the technology strategy for mobile phone manufacturers.
Technically speaking, Open Source is a manifestation of Open Innovation because it embraces openness and collaboration. There are some subtle differences between these two concepts. For example some people may argue that these two terms conflict on Intellectual Property (IP) issue, but that argument is a little bit weak. For a company sponsored open source project, the company has to donate its IPs grant unlimited license use to anybody in order to start the project. For example, IBM advocates its open source Eclipse project as a case of open innovation (IBM 2007).

Chesbrough himself also noted, “Open Innovation is sometimes conflated with open source methodologies for software development… while open source shares the focus of value creation throughout an industry value chain, its proponents usually deny or downplay the importance of value capture.” (Chesbrough, Vanhaverbeke et al. 2006).

My own take is that, the major difference is about philosophy, not about the IP or value capture. The difference is exactly the same as that of Free Software and Open Source Software. Richard Stallman, founder of the Free Software Foundation, explained the different terminology of open source and free software: "Free software" and "open source" are the names of two different political viewpoints within the free software community - the community built by the free software movement.

In this study, we will not differentiate the two terms in the context of open source project because they are technically identical (though philosophically they are not the same).
Also note that, not all open source projects are considered open innovation by all researchers based on the criteria of value capture. As noted before, Chesbrough’s definition of Open Innovation focuses more on the innovation process, not the end result. The two key elements of open source as an open innovation strategy are the shared rights to use the technology and collaborative developments of that technology. Joel West added the third criteria: capturing economic return to justify the initial investment (West 2006). Using his third criteria, West believe Open Source and Open Innovation part ways in many open source project. Table 2 shows the differences between open source and open innovation in real world projects.

### Table 2 Overlap of Open Source and Open Innovation (West 2007)

<table>
<thead>
<tr>
<th>Open Source</th>
<th>Open Innovation</th>
<th>Not Open Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM: Apache, Eclipse, Jikes</td>
<td>Apple: Darwin</td>
<td>Many GNU Projects</td>
</tr>
<tr>
<td>BEA: Beehive</td>
<td>IBM: Apache, Eclipse, Jikes</td>
<td>OSDL</td>
</tr>
<tr>
<td>OSDL</td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Not Open Source</th>
<th>PC hardware</th>
<th>Microsoft Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Game Mods</td>
<td>Intuit Quicken</td>
</tr>
</tbody>
</table>

Joel West’s belief that Open Source is Open Innovation only if it has a business model is an extension to Chesbrough’s original definition. However we may argue that we can’t judge an open innovation project because it hasn’t found a good business model at this moment, or the business model is proven to be the wrong one many years later. In other word, we can’t judge whether an innovation process is open innovation based on the end result. Chesbrough didn’t
emphasize the end result either. He addresses this issue in another area of his research, the Open Business Model. Nonetheless value capture is very relevant to our research here because we are interested in the long term survival strategy of cell phone manufactures.

Value Creation

How to create value from open source software? Companies have discovered some business models that are worth pursuing (Dornan 2008)

1. Support services. This is the traditional Linux model, prototyped by Red Hat. The software can be free, but the tech support is not free.
2. Integrator and customization service provider. The difference from the first business model is that the product is not something that can be obtained from the open source website. The service provider builds new product from open source components to meet clients’ business needs. Support is part of the package.
3. Producing equipment that can run the free software. For example, some companies are making routers and video players that run on open source software.
4. non GPL license. For some customers that are not happy with GPL license, many open-source vendors will happily sell them proprietary licenses. For example, Trolltech and MySQL.
5. Pro version. Some companies sell two versions of a software package. The basic version is open source and free; while the other version with more added features is called Pro version. The Pro version usually is not free.
6. Advertisement which can be used to generate revenue from free software.
7. Sell subscriptions for online accounts and server access. Software is free, but the service is not free. Customers pay for the convenience and computation power.

1.4. **Android: an Open Source Mobile Operating System**

Android was officially introduced to the public on October 21, 2008 by Android Open Source Project and the Open Handset Alliance. Android is the first free, open source, and fully customizable mobile platform. As the Android Open Source Project claimed “Android is not a single piece of hardware; it's a complete, end-to-end software platform that can be adapted to work on any number of hardware configurations. Everything is there, from the bootloader all the way up to the applications. And with an Android device already on the market, it has proven that it has what it takes to truly compete in the mobile arena”

Android had been criticized for not being completely open-source software despite what was announced by Google. Strategy Analytics’ director Neil Mawston also called Android “semi-open-source structure” because parts of the SDK are proprietary and closed source at the time of its first announcement. However, Google has since changed the license agreement so that all parts of Android will be released under the Apache License where applicable and under the GPL elsewhere.
None of the previous mobile OS has ever received such media coverage like Android did. Technologist, end users and developers are all excited about the release of this platform to the public. However Android is not the first open source mobile OS. Android is based on Linux operating system. Linux and Symbian are both open source platforms and they are the dominant platforms in the smartphones sold in China. Somehow Linux and Symbian based phones are not popular in the US market.

At this writing Android OS has very little market share but is expected to gain significant market share in 2009 and the coming years. According to the latest research from Strategy Analytics, global Android smartphone shipments will grow 900 percent in 2009. Healthy support from operators, vendors and developers is driving adoption. Tom Kang, Senior Analyst at Strategy Analytics, said, “We forecast global Android smartphone shipments to grow an impressive 900 percent annually during 2009. The Android mobile operating system from Google gained early traction in the United States in the second half of 2008 and it is gradually spreading its presence into Europe and Asia during 2009. Android is expanding from a low base and it is consequently outgrowing the iPhone OS from Apple, which we estimate will grow at a relatively lower 79 percent annually in 2009.” (Davies 2009)

The unmatched popularity of Android at its introduction can be traced back to its low-cost licensing model, open source structure, and the strong support from the technology giant Google. The other motivator is the strong demand for a truly independent open source platform that is not heavily controlled by a few companies from consumers, developers and some device manufacturers. In the current economic environment, reducing licensing payments and software
development time are even more attractive to device manufacturers and carriers alike (Davies 2009).

2. Overview of Current Mobile Handset Market

There has been a clear shift from fixed landline to mobile cellular technology. The cell phone penetration rate is estimated to be 60% by the end of 2008 (ITU 2009) (Figure 3). In developed country, the penetration rate already reaches 100% (Figure 4). Due to the global economic difficulties, mobile phone market declined by almost 4.6% in Q4 2008 compared to the same period of 2007. Despite this, the whole 2008 brought a 6% increase, with a total of 1,222 million phones delivered by handset manufacturers. (Table 3, Table 4).

(Note: the data have some discrepancies between difference sources. For example, IDC reported a 13% decrease of Q4 2008 sale compared to one year ago, and lower increase of 3.5% for the whole 2008. Nonetheless, those discrepancies do not change the big picture.)
Figure 3 Global ICT Developments, 1998-2008 (ITU 2009)
2.1. *Dominant players in current mobile phone market*

There is no reliable data to show the number of mobile handset manufactures in the world at this writing. Counting the large, brand name manufactures listed on phonedog.com, the number reaches about fifty. However the top 5 manufactures accounted for over 80% of all mobile phones sold worldwide (Table 3, Table 4).

Due to the short life cycle of cell phone products (1-2 years), the annual sales data of units sold can be a good indicator of the total market share. At this writing (Q1 2009), Nokia is still the world’s largest manufacturer of mobile phones with a global market share of about 38.6%,
followed by Samsung (16.3%), Motorola (8.7%), LG (8.4%), Sony Ericsson (7.6%) (Gartner 2009). This estimate is based on the 2008 worldwide handset sale data from Gartner, and the number will certainly change quickly in 2009. The preliminary sales data already indicate that Motorola’s market share is quickly dropping behind that of LG. The Q1 2009 market share is only 6% and is expected to drop further.

Table 3 Worldwide Mobile Terminal Sales to End Users in 4Q08 (Thousands of Units) (Data Source: Gartner March 2009)

<table>
<thead>
<tr>
<th>Company</th>
<th>4Q08 Sales</th>
<th>4Q08 Market Share</th>
<th>4Q07 Sales</th>
<th>4Q07 Market Share</th>
<th>Growth 07 - 08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nokia</td>
<td>118,791.00</td>
<td>37.7%</td>
<td>133,194.40</td>
<td>40.4%</td>
<td>-10.8%</td>
</tr>
<tr>
<td>Samsung</td>
<td>57,517.90</td>
<td>18.3%</td>
<td>44,353.10</td>
<td>13.4%</td>
<td>29.7%</td>
</tr>
<tr>
<td>LG</td>
<td>28,140.90</td>
<td>8.9%</td>
<td>23,545.00</td>
<td>7.1%</td>
<td>19.5%</td>
</tr>
<tr>
<td>Sony Ericsson</td>
<td>23,554.10</td>
<td>7.5%</td>
<td>29,848.80</td>
<td>9.0%</td>
<td>-21.1%</td>
</tr>
<tr>
<td>Motorola</td>
<td>21,700.10</td>
<td>6.9%</td>
<td>39,291.00</td>
<td>11.9%</td>
<td>-44.8%</td>
</tr>
<tr>
<td>Others</td>
<td>65,003.80</td>
<td>20.7%</td>
<td>59,822.40</td>
<td>18.1%</td>
<td>8.7%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>314,707.80</td>
<td>100.0%</td>
<td>330,054.70</td>
<td>100.0%</td>
<td>-4.6%</td>
</tr>
</tbody>
</table>

Table 4 Worldwide Mobile Terminal Sales to End-Users in 2008 (Thousands of Units) (Data Source: Gartner March 2009)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nokia</td>
<td>472,315.00</td>
<td>38.6%</td>
<td>435,453.10</td>
<td>37.8%</td>
<td>8.5%</td>
</tr>
<tr>
<td>Samsung</td>
<td>199,182.00</td>
<td>16.3%</td>
<td>154,540.70</td>
<td>13.4%</td>
<td>28.9%</td>
</tr>
<tr>
<td>Motorola</td>
<td>106,590.00</td>
<td>8.7%</td>
<td>164,307.00</td>
<td>14.3%</td>
<td>-35.1%</td>
</tr>
<tr>
<td>LG</td>
<td>102,555.40</td>
<td>8.4%</td>
<td>78,576.30</td>
<td>6.8%</td>
<td>30.5%</td>
</tr>
<tr>
<td>Sony Ericsson</td>
<td>93,414.50</td>
<td>7.6%</td>
<td>101,358.40</td>
<td>8.8%</td>
<td>-7.8%</td>
</tr>
<tr>
<td>Others</td>
<td>248,189.00</td>
<td>20.3%</td>
<td>218,604.30</td>
<td>19.0%</td>
<td>13.5%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,222,245.20</td>
<td>100.0%</td>
<td>1,152,839.80</td>
<td>100.0%</td>
<td>6.0%</td>
</tr>
</tbody>
</table>
The latest sales data (Q1 2009) from IDC and Strategy Analytics indicate the same market trend (Deffree 2009) (Table 5, Table 6). IDC reports that the overall market dropped 15.8% in Q1 over a year ago. Motorola’s market share keeps dropping, as well as Sony Ericsson’s. Lack of compelling products throughout the portfolio has made it impossible for Motorola to slow down its sales decline. It has been losing share in all key regions because it does not offer 3G and touch screen devices that can compete with other vendors. Sony Ericsson is also facing tough time due to the competitive advantage of its music player and camera features started to decline.

Table 5 Q1 2009 World Wide Mobile Phone Shipment by IDG, April 2009

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Q1 2009 Units Shipped (M)</th>
<th>Q1 2008 units shipped (M)</th>
<th>Q1 2009 market share</th>
<th>Q1 2008 market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nokia</td>
<td>93.2</td>
<td>115.5</td>
<td>38.10%</td>
<td>39.70%</td>
</tr>
<tr>
<td>Samsung</td>
<td>45.9</td>
<td>46.3</td>
<td>18.80%</td>
<td>15.90%</td>
</tr>
<tr>
<td>LG Electronics</td>
<td>22.6</td>
<td>24.4</td>
<td>9.20%</td>
<td>8.40%</td>
</tr>
<tr>
<td>Motorola</td>
<td>14.7</td>
<td>27.4</td>
<td>6%</td>
<td>9.40%</td>
</tr>
<tr>
<td>Sony Ericsson</td>
<td>14.5</td>
<td>22.3</td>
<td>5.90%</td>
<td>7.70%</td>
</tr>
<tr>
<td>Others</td>
<td>53.9</td>
<td>44.9</td>
<td>22%</td>
<td>18.90%</td>
</tr>
<tr>
<td>Total</td>
<td>244.8</td>
<td>290.8</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 6 Q1 2009 World Wide Mobile Phone Shipment by Strategy Analytics, April 2009

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Q1 2009 Units Shipped (M)</th>
<th>Q1 2008 units shipped (M)</th>
<th>Q1 2009 market share</th>
<th>Q1 2008 market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samsung</td>
<td>45.8</td>
<td>46.3</td>
<td>18.70%</td>
<td>16.40%</td>
</tr>
<tr>
<td>LG Electronics</td>
<td>22.6</td>
<td>24.4</td>
<td>9.20%</td>
<td>8.60%</td>
</tr>
<tr>
<td>Motorola</td>
<td>14.7</td>
<td>27.4</td>
<td>6%</td>
<td>9.70%</td>
</tr>
<tr>
<td>Sony Ericsson</td>
<td>14.5</td>
<td>22.3</td>
<td>5.90%</td>
<td>7.90%</td>
</tr>
<tr>
<td>Others</td>
<td>53.7</td>
<td>46.5</td>
<td>22%</td>
<td>16.50%</td>
</tr>
<tr>
<td>Total</td>
<td>244.5</td>
<td>282.4</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Besides the top five, other reputable manufacturers include Apple Inc., AMOI, Asus, Audiovox (now UTStarcom), BenQ-Siemens, CECT, High Tech Computer Corporation (HTC), Fujitsu, Kyocera, Hitachi, HP, Mitsubishi Electric, NEC, i-mate, Neonode, Panasonic, Palm, Matsushita, Pantech Wireless Inc., Philips, Qualcomm Inc., Research in Motion Ltd. (RIM), Sagem, Sanyo, Sharp, Siemens, Sendo, Sierra Wireless, SK Teletech, T&A Alcatel, Huawei, Trium, Toshiba, Telson, ZTE etc. None of them hold a significant share of global market in terms of units sold. However some of them are strong player in regional market.

### 2.2. Dominant players in current smartphone market

**Smartphone market share by manufacturers (Table 7, Table 8)**

Growth in demand for smartphones has outpaced the rest of the mobile phone market for several years. Despite the total mobile phone shipment keep declining in Q1 2009 due to the weak economic condition worldwide, smartphone shipments continue to grow year on year at 4% (Deffree 2009). Smartphones continued to be a driving force for consumers to upgrade their devices. For some operators in mature markets, smartphone account for 50% of the entire handset offering. During 2008, smartphone sales increased by 13.9%, while the market as a whole grew only 6%. The smartphone total market share is about 11-12% of the total handset market.
Table 7 Worldwide: Smartphone Sales to End Users by Vendor, 4Q08
(Thousands of Units) (Gartner 2009)

<table>
<thead>
<tr>
<th>Company</th>
<th>4Q08 Sales</th>
<th>Market Share 4Q08</th>
<th>4Q07 Sales</th>
<th>Market Share 4Q07</th>
<th>Growth 4Q07-4Q08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nokia</td>
<td>15,561.70</td>
<td>40.8%</td>
<td>18,703.30</td>
<td>50.9%</td>
<td>-16.8%</td>
</tr>
<tr>
<td>RIM</td>
<td>7,442.60</td>
<td>19.5%</td>
<td>4,024.70</td>
<td>10.9%</td>
<td>84.9%</td>
</tr>
<tr>
<td>Apple</td>
<td>4,079.40</td>
<td>10.7%</td>
<td>1,928.30</td>
<td>5.2%</td>
<td>111.6%</td>
</tr>
<tr>
<td>HTC</td>
<td>1,631.70</td>
<td>4.3%</td>
<td>1,361.10</td>
<td>3.7%</td>
<td>19.9%</td>
</tr>
<tr>
<td>Samsung</td>
<td>1,598.20</td>
<td>4.2%</td>
<td>671.5</td>
<td>1.8%</td>
<td>138.0%</td>
</tr>
<tr>
<td>Others</td>
<td>7,829.70</td>
<td>20.5%</td>
<td>10,077.30</td>
<td>27.4%</td>
<td>-22.3%</td>
</tr>
<tr>
<td>Total</td>
<td>38,143.30</td>
<td>100.0%</td>
<td>36,766.10</td>
<td>100.0%</td>
<td>3.7%</td>
</tr>
</tbody>
</table>

Table 8 Worldwide: Smartphone Sales to End Users by Vendor, 2008
(Thousands of Units) (Gartner 2009)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nokia</td>
<td>60,920.50</td>
<td>43.7%</td>
<td>60,465.00</td>
<td>49.4%</td>
<td>0.8%</td>
</tr>
<tr>
<td>RIM</td>
<td>23,149.00</td>
<td>16.6%</td>
<td>11,767.70</td>
<td>9.6%</td>
<td>96.7%</td>
</tr>
<tr>
<td>Apple</td>
<td>11,417.50</td>
<td>8.2%</td>
<td>3,302.60</td>
<td>2.7%</td>
<td>245.7%</td>
</tr>
<tr>
<td>HTC</td>
<td>5,895.40</td>
<td>4.2%</td>
<td>3,718.50</td>
<td>3.0%</td>
<td>58.5%</td>
</tr>
<tr>
<td>Sharp</td>
<td>5,234.20</td>
<td>3.8%</td>
<td>6,885.30</td>
<td>5.6%</td>
<td>-24.0%</td>
</tr>
<tr>
<td>Others</td>
<td>32,671.40</td>
<td>23.5%</td>
<td>36,176.60</td>
<td>29.6%</td>
<td>-9.7%</td>
</tr>
<tr>
<td>Total</td>
<td>139,287.90</td>
<td>100.0%</td>
<td>122,315.60</td>
<td>100.0%</td>
<td>13.9%</td>
</tr>
</tbody>
</table>

Smartphone market share by OS (Table 9, Table 10, Figure 5)

The smartphone OS war is very interesting to watch over the past several years. The landscape is changing dynamically. So far there’s no clear winner. The introduction of Android OS and G1
phone make the whole landscape even more interesting to watch. Unlike the handset market that has many players competing, the OS market is pretty much limited to 6 mobile operating systems, namely Symbian, Research In Motion Blackberry OS, Microsoft Windows Mobile, Mac OS X, Linux/Android, Palm OS. Despite the fame, according to Gartner, iPhone market share was 1.3 percent of total phone sales in fourth quarter and only 0.9 percent for the year. In contrast, App Store has 25,000 applications, more than the number available for Symbian OS or Windows Mobile. Besides Windows Mobile and RIM OS, the other four operating systems are open source, or semi-open-source.

Table 9 Worldwide: Smartphone Sales to End Users by Operating System, 4Q08 (Thousands of Units) (Gartner 2009)

<table>
<thead>
<tr>
<th>Company</th>
<th>4Q08 Sales</th>
<th>Market Share 4Q08</th>
<th>4Q07 Sales</th>
<th>Market Share 4Q07</th>
<th>Growth 4Q07-4Q08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbian</td>
<td>17,949.10</td>
<td>47.1%</td>
<td>22,902.50</td>
<td>62.3%</td>
<td>-21.6%</td>
</tr>
<tr>
<td>RIM</td>
<td>7,442.60</td>
<td>19.5%</td>
<td>4,024.70</td>
<td>10.9%</td>
<td>84.9%</td>
</tr>
<tr>
<td>Windows Mobile</td>
<td>4,713.90</td>
<td>12.4%</td>
<td>4,374.40</td>
<td>11.9%</td>
<td>7.8%</td>
</tr>
<tr>
<td>Mac OS X</td>
<td>4,079.40</td>
<td>10.7%</td>
<td>1,928.30</td>
<td>5.2%</td>
<td>111.6%</td>
</tr>
<tr>
<td>Linux</td>
<td>3,194.90</td>
<td>8.4%</td>
<td>2,675.90</td>
<td>7.3%</td>
<td>19.4%</td>
</tr>
<tr>
<td>Palm OS</td>
<td>326.5</td>
<td>0.9%</td>
<td>449.1</td>
<td>1.2%</td>
<td>-27.3%</td>
</tr>
<tr>
<td>Other OSs</td>
<td>436.9</td>
<td>1.1%</td>
<td>411.3</td>
<td>1.1%</td>
<td>6.2%</td>
</tr>
<tr>
<td>Total</td>
<td>38,143.30</td>
<td>100.0%</td>
<td>36,766.10</td>
<td>100.0%</td>
<td>3.7%</td>
</tr>
</tbody>
</table>
Table 10 Worldwide: Smartphone Sales to End Users by Operating System, 2008 (Thousands of Units) (Gartner 2009)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbian</td>
<td>72,933.50</td>
<td>52.4%</td>
<td>77,684.00</td>
<td>63.5%</td>
<td>-6.1%</td>
</tr>
<tr>
<td>RIM</td>
<td>23,149.00</td>
<td>16.6%</td>
<td>11,767.70</td>
<td>9.6%</td>
<td>96.7%</td>
</tr>
<tr>
<td>Windows Mobile</td>
<td>16,498.10</td>
<td>11.8%</td>
<td>14,698.00</td>
<td>12.0%</td>
<td>12.2%</td>
</tr>
<tr>
<td>Mac OS X</td>
<td>11,417.50</td>
<td>8.2%</td>
<td>3,302.60</td>
<td>2.7%</td>
<td>245.7%</td>
</tr>
<tr>
<td>Linux</td>
<td>11,262.90</td>
<td>8.1%</td>
<td>11,756.70</td>
<td>9.6%</td>
<td>-4.2%</td>
</tr>
<tr>
<td>Palm OS</td>
<td>2,507.20</td>
<td>1.8%</td>
<td>1,762.70</td>
<td>1.4%</td>
<td>42.2%</td>
</tr>
<tr>
<td>Other OSs</td>
<td>1,519.70</td>
<td>1.1%</td>
<td>1,344.00</td>
<td>1.1%</td>
<td>13.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>139,287.90</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>122,315.60</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>13.9%</strong></td>
</tr>
</tbody>
</table>

**Smartphone OS Market Share 2008**

- Symbian: 52.4%
- Research In Motion: 16.6%
- Windows Mobile: 11.8%
- Mac OS X: 8.2%
- Linux: 8.1%
- Palm OS: 1.8%
- Other OSs: 1.1%

Data Source: Gartner 2009

Figure 5 Smartphone OS Market Share 2008
3. Case Study of Open Innovations outside Mobile Industry

Mobile handset is a physical electronic device which falls into the category of embedded devices. Embedded device is a special-purpose computer system designed to perform one or a few dedicated functions in contrast to a general purpose computer such as a PC. Usually embedded devices consist of dedicated hardware and software. Both hardware and software are essential for the functions of the device. In a cell phone, the software piece is called firmware.

Though open source software is the norm today, open source hardware design or embedded system is still rare but does exist. Open source in mobile industry is still a pretty recent phenomenon. To understand how the mobile handset manufactures can ride on the wave of open source movement in mobile industry, how they can capture value from the “openness”, we can examine a few business cases outside mobile industry that used the open source or open innovation. Then we will apply the lessons learned to mobile industry

3.1. Open Source in Software Development

3.1.1. Overview of open source software

Since our primary interest in this study is technology strategy and business model, the history and evolution of open source software development is out of scope for this discussion. There are plenty researches that have been conducted or are being conducted, and we will only touch the area of motivations and business impacts because this study is about technology strategy.
Early studies have found three general categories of contributor motivations (Hars and Ou 2002; Kakhani and Von Hippel 2003; West 2003):

- Direct utility: e.g. the end product can be directly used by the contributors
- Intrinsic benefit, such as learning a new skill or developing a network
- Personal satisfaction by signaling one’s capabilities to gain respect from peers; self fulfillment; altruism; pleasure derived from “playing”.

Those early studies failed to point out real motivations behind the involvement of some companies with commercial interest lately. Those firms’ incentive to participate in the open source software development is quite different from those of individuals. Their decision is purely based on their technology strategy and business strategy.

Some companies participate in the open source community to win adoption of their technology and to gain first-mover advantage. Sharing may lead to the establishment of a de facto standard or the generation of network effects; some companies may contribute to create demands for other products in their core business. On the other hand, some companies participate because they have no choice. Other benefits for the firms include symbiotic or parasitic gains from community, shaping industry and pre-empt competitors and benefit spillover to participants and non-participants alike (West 2007).

We will examine only a few cases to see why some commercial software firms adopted the open source model and how the open source model helped their business. There’s no question about the social effect of the open source community, however we are more interested in the business models, specifically the lessons that can be applied to mobile industry.
3.1.2. Red Hat: build new business from nothing

Red Hat, Inc. is the market leader in open source software systems for mainframes, servers, workstation and embedded device. Red Hat's Open Source strategy offers customers a long term plan for building infrastructures that are based on and leverage open source technologies with focus on security and ease of management. Red Hat also offers support, training and consulting services to its customers worldwide and through top-tier partnerships. Red Hat was incorporated in 1995 by Bob Young and Marc Ewing. Red Hat went public on August 11, 1999, the eighth-biggest first-day gain in the history of Wall Street. In August 2002 Red Hat announces the Red Hat Alliance. Committed partners include Alias|Wavefront, BMC, Borland, Checkpoint, Computer Associates, Dell, HP, IBM, Legato Systems, Novell, Oracle, Rogue Wave, Softimage, Synopsys, TIBCO, and VERITAS. Red Hat officially announces its entry into the enterprise software market with the "Enterprise-Ready Linux" event with partners Oracle and Dell. Red Hat achieved first profitable quarter in 2001. Red Hat stock became part of the NASDAQ-100 on December 19, 2005.

In their very early days, Red Hat distributed and sold the shrink-wrapped CDs of their Red Hat Linux distribution. Even though the same software could be downloaded free from their servers and many mirror sites, people opted to buy the CDs for the convenience. As the internet bandwidth and storage capacity increased dramatically, it’s more convenient for users to download the new CD images from internet. As a result, that stream of revenue to sell packaged Linux diminished with the bust of dot com bubble. Today Red Hat partly operates on a professional open-source business model (free software with paid professional services) based on professional quality.
assurance services, and subscription-based customer support. Customers pay one fixed price for unlimited access to services such as Red Hat Network and up to 24x7 supports.

Now the interesting question is, Red Hat does not have any proprietary technology and it doesn’t provide services that the OEM (IBM, HP, Dell) can’t provide, then how could it build a business from nothing to the size that almost matches Sun Microsystems?

The story written by the founder Robert Young “How Red Hat Software Stumbled Across a New Economic Model” in 1999 may shed some lights (Young 1999). At the time of founding, Young didn’t understand that “bizarre economic model” either but decided to give it a try anyway. In the next couple of years, Red Hat developed a business plan that was compatible with the “bizarre business model” by trials and errors. To answer the question how to make money in free software, Young explained “While making money with free software is a challenge, the challenge is not necessarily greater than with proprietary software. In fact you make money in free software exactly the same way you do it in proprietary software: by building a great product, marketing it with skill and imagination, looking after your customers, and thereby building a brand that stands for quality and customer service.”

Another advice from Young in term of finding a new business model is, “You can't compete with a monopoly by playing the game by the monopolist's rules. The monopoly has the resources, the distribution channels, the R & D resources; in short, it just has too much strength. You compete with a monopoly by changing the rules of the game into a set that favors your strengths”
At this writing, Red Hat has a market capitalization of $3.7 Billion. For comparison, Sun Microsystems’ market capitalization is $6.68 Billion (they have about the same market capitalization of $2.7 Billion at the lowest market level of January of 2009). To investors, Red Hat’s business model is transparent and understood, whereas Sun’s is not. As Red Hat’s direct competitor, Sun Microsystems also has an open source support operation but only account for a small portion of Sun’s total revenue. It’s also interesting to note that Red Hat’s another direct competitor in the open source arena, IBM adopted a different strategy. Unlike Red Hat which has no proprietary system, IBM still maintain a large portfolio of proprietary products despite its significant participation in open source software community. IBM has not given away the value farm by creating open source software stacks that cannibalize or replace its proprietary value stack sales. How long they can maintain that advantage is a good question to ask.

3.1.3. Novell

Just like IBM which had its near-death experience in 1990s’, Novell also had similar experience when it failed to anticipate the market change in 1990s. Today’s Novell is a complete new company operating on a completely new business model.

Novell was found in 1983 primarily as a hardware company but soon abandoned hardware business and focused on software for networking. At that time PC industry was booming. Firms became increasing interested in ways to connect their PCs. Netware was released in 1983 and soon became the leader of networking market. By 1988 Novell had a 50% share of PC networking market. Novell did extremely well throughout the 1980s, acting aggressively to
increase its market share initially by selling the expensive Ethernet cards at cost; by the early
1990s, Novell NetWare held nearly 70 percent of the network operating system market. During
that period, Novell took advantage of its position in the computer networking industry and
created a massive distribution network involving 13,000 independent distributors. Value-added
resellers range from mass-market discounter to high-level system integrators. Novell
intentionally left some gaps in the NetWare product line so their partners could fill the gap and
capture the value. As a result their channel partners had vested interest in Novell’s success.
These massive channels turned out to be the best asset of Novell in 2000s when Novell
reinvented itself with a totally new business model.

Despite its success and monopoly status in the networking industry, Novell failed to recognize
the change in its market in early 1990s. Their market share plummeted because NetWare missed
out on the huge server application wave. The release of Microsoft’s Windows NT with built-in
networking capability posed perhaps the largest threat Novell had ever faced. Novell tried to
diversify by purchasing WordPerfect and Quattro Pro but that strategy did not work out well.

Seeing its market diminishing, Novell decided to reincarnate itself at the end of 1990s and soon
moved to Linux domain. In 2003, Novell acquired SuSE, a developer of a leading Linux
distribution and Ximian, a developer of open source Linux applications. However Novell
adopted a completely different open source strategy and business model compared to those of
Red Hat or IBM. Today Novell is a mixed-source company mixing open source with
proprietary software to architect their product line. The company no long relies on the traditional
open-source business model that depends on support and service revenue streams. The company
also made it clear its plans to shift from direct sales and service to a channel-based business model. The company is no longer the same company at its peak time, but it survived. So we can say the mixed-source and channel-based business model are the strategies Novell is betting on today and so far they are working.

3.1.4. Lessons Learned from the software industry

1. Change the mentality. Company should not assume it is easier to make money selling proprietary software. The IP model of software development and marketing is proven to hard to make living. So companies should get used to the free software, and participate in the open source development. During the process, they may be able to figure out a business model to make living. Novell didn’t realize the value of its channels established in the past when it entered the open source software domain. But they figured it out eventually. In the past, the vertically integrated R&D worked well, but companies shouldn’t feel comfortable staying in the same environment. Try not to be the frog in the “boiling frog” story. As an example, Motorola felt so comfortable from its past achievement, it didn’t move fast enough in react to the market change. As a result, its market share dropped significantly, and that trend is still continuing.

2. Embrace the change. It’s quite common that companies get trapped by their own success. Once they establish a money making business model, they will only seek additional opportunities that fit that model. Companies not only need to get used to changes, but also need to welcome and seek changes. Some mobile handset companies are bound to face the same challenges Novell faced before. If they learn to embrace changes like Novell did, they may be able to survive.
3. Be proactive. Even though IBM survived after its transition of 1990s, it came to what it is today not at a cheap price. If they could react to the change in the industry earlier, their price would be much lower. The same principle applies to the cell phone industry. If manufacturers are proactive, they will anticipate the industry change, and then design a strategy according to the change. For example, if the consumers’ buying choice is not based on technology or feature/price ratio, but the fashion or culture, then companies should shift their focus quickly from the technology centered R&D process to the user centered process.

3.2. Open Standard and Open Source in Hardware Development

While there are several hundred open source software projects in the world, there are very few open hardware projects. In the past, the lack of standard digital form to transfer information significantly hindered the collaboration between designers. With the adoption of standard hardware description language (HDL) such as Verilog, designers from anywhere in the world are able to design chips together. Still, compared to the popularity of open source software projects, open source hardware projects are still isolated cases probably due to the much smaller number of developers that are capable of designing chips compared to the number of software developers.
3.2.1. Sun’s OpenSPARC

The OpenSPARC project (http://www.opensparc.net/), launched by Sun Microsystems to create an open source community centered around its "Niagara" Sparc T1 processors, is probably the most famous open source hardware design project up to now. SPARC stands for Scalable Processor ARCHitecture. The technology is based on RISC. SPARC International is currently managing SPARC related IPs.

Sun Microsystems began shipping the UltraSPARC T1 chip multithreaded (CMT) processor in December 2005. Sun surprised the industry by announcing that it would not only ship the processor but also open source that processor. By March 2006, UltraSPARC T1 had been open-sourced in a distribution called OpenSPARC T1. In 2007, Sun began shipping its newer, more advanced UltraSPARC T2 processor, and open-sourced the bulk of that design as OpenSPARC T2. Figure 6 depict the design principle of Sun’s T1 and T2 processors.
Chip Multi- Threading (CMT) Design

The official goals of OpenSPARC Initiative state (www.opensparc.net):

- To significantly increase participation in processor architecture development and application design by making cutting-edge hardware intellectual property freely available.
- To eliminate barriers to the next big build-out of the Internet.
- To improve collaboration and cooperation among hardware designers.
- To enable community members to build on proven technology at a markedly lower cost.
- To encourage innovation.
- To foster bringing bold new products to market

However the real goal of Sun in disclosing microprocessor design data, which took its engineers significant efforts to develop, is to increase the amount of equipment using SPARC and the
already disclosed OpenSolaris operating system (OS) by tapping the open course community. By leveraging the open source community, developers will be able to rapidly create new and more tightly integrated thread-rich applications at a markedly lower cost. Sun senior vice president and Fellow, Scalable Servers Group chief technologist Mike Splain, commented, "We wanted to lower the barriers to introducing the SPARC architecture to boost the number of system-on-chip (SoC) and other integrated circuits (IC) developed. If these chips are used in various products, it will increase our business opportunities." (Keys 2006)

**Lesson Learned**

By giving away the technology that is not in the core business of the company does not necessarily cause the loss of the asset. On the other hand, with careful planning, by giving away a technology to build a community that has the potential to be the customer of the complement products. Manufacturing microprocessor is not the core business of Sun but the processor is a key component of its server that can distinguish Sun from its competitors. Sun derives its revenue from the sale of servers, operation systems and service contract. With a fraction of its original development cost, Sun can get better processors at cheaper price to boost its servers’ performance. The mobile can adopt the same strategy. If the company bets on the mobile web as the next generation source of revenue, then it can design a mobile OS specific for mobile web. Since the hardware part will become commodity anyway, the company can open up the design of device, either the key components that are specialized for the mobile web OS, or the whole device.
3.2.2. Personal computer’s open standard

The whole personal computer (PC) industry is about thirty years old. No other industry can match the innovations happened in PC industry in such short a period. Most early players in PC market no long exist today. Some such as Texas Instruments, Commodore, Amiga and Wang never adapted their software and hardware to the IBM standard. The proprietary system just didn’t win the heart and soul of average PC users, so the market. A few survived reinvented themselves and now they are not the same companies as they used to be.

In the very early days, all the big players are vertically integrated companies. They designed and manufactured every component of a PC, from hardware to software and applications. IBM is a typical example. During 1990s, the competition forced the industry to shift from vertically integrated business model to horizontally integrated business model. The Firms won the competition are the firms which are specialized in PC components. Intel and Advanced Micro Devices (AMD) are specialized in CPU and flash chip design and manufacturing. They are the two CPU manufactures survived today. Nvidia and ATI (was acquired by AMD in 2006) are the only two graphic chip manufactures left today. IBM lost its edge during that period and was forced to exit PC industry. What brought IBM’s success is exactly what almost killed IBM, the standardization of PC.

During 1980s, the IBM design was accepted as the industry standard which all manufactures essentially copied. IBM opened the interfaces and standards of all PC components. After 1987, IBM overplayed its role in defining the industry, and lost it position in marketplace.
The open standards defined by IBM encouraged competition and innovation. The innovation encouraged by the open standard is also open innovation. Even though formal collaboration was not that common between competitors, they could easily learn others’ design by reverse-engineering because all components conform to the same standard. Those competitions and innovation drove up features and drove down prices of PC components and PC itself dramatically in a short period. Soon PC became commodity. Nowadays, almost every family in United States owns at least one PC.

The mobile handset industry is experiencing exactly the same revolution at even faster speed. The standardization is inevitable. The open standard will encourage open innovation which in turn will turn cell phone components and cell phones into commodity. Most cell phone manufactures are still vertically integrated company. Sooner they realized that they have to abandon their vertically integrated business model, the better chance they can survive the competition. The current movement of open source mobile OS is just the beginning of the revolution that will disintegrate the industry giant like Nokia, Motorola etc.

3.3. Open Source in Embedded System Development

The open source or semi open source projects in the embedded system are more common than open source hardware design but less common than open source software. The reason is obvious. Embedded device has two pieces, the firmware which is the software that enables all the functions of the device, and the hardware piece which support the software. Most open source projects are done on the firmware part with some modifications on the hardware side.
In the past researchers haven’t paid enough attention to the open source projects of embedded devices. Most projects in this domain generally fall into the category of von Hippel’s user centered innovation paradigm and are done by hacking communities. The lead users in the hacking communities are able to design much better products than the original manufactures using exactly the same piece of hardware. Unlike open source software communities, the motivation of those “hacker” is usually their personal needs. They are not satisfied with whatever the manufactures can provide so they start to invent themselves. Surprisingly, in most cases, manufactures haven’t been able to capture the value from users’ innovation.

3.3.1. DD-WRT and Buffalo Technology.

Home network equipment business today is commodity business. The US market is dominated by a few players, such as LinkSys (a Cisco subsidiary), DLink, Netgear etc. Buffalo Inc or Buffalo Technology (wholly owned subsidiary of Melco Holdings Inc, headquartered in Japan) is a multinational provider of innovative network solutions for the home and business - from wireless networking and storage to memory and multimedia devices. Buffalo branded routers are very popular among advanced users in the US due to certain models’ compatibility with DD-WRT firmware.

DD-WRT (www.dd-wrt.com) is a free third party developed firmware released under the terms of the GPL for many ieee802.11a/b/g/h/n wireless routers based on a Broadcom or Atheros chip reference design. DD-WRT is a Linux-based firmware designed to replace the firmware that
ships pre-installed on many commercial routers. This is done for a variety of reasons; including but not limited to the addition of many features which are not typically included in a manufacturer's router firmware but required by advanced users. Used and tested by hundreds of thousands users, DD-WRT firmware has much fewer bugs in many cases, DD-WRT firmware also adds stability over the stock firmware. In every aspect, DD-WRT is a much better firmware regarded by majority of users over the stock firmware. It is estimated that one million DD-WRT® based routers are already in use worldwide,

DD-WRT versions up to v22 were based on the Alchemy firmware from Sveasoft, which in turn is based on the original GPL’d Linksys firmware and a number of other open source projects. DD-WRT versions from v23 onwards, are almost completely rewritten. The Linux kernel part is based on the OpenWrt kernel which is a similar open source project. The project was created directly from Sveasoft's decision to start charging for their firmware, closing the door to open source. The firmware is currently maintained by BrainSlayer and he’s drafting a different business model in order to support himself through this project. (source www.www-wrt.com). The partnership with Buffalo Technology probably is in that plan.

Despite the superior feature of DD-WRT firmware and it’s compatibility with wide range of router hardware, the major market players haven’t been able to capture the potential value except Buffalo Technology.

In October 2007, Buffalo Technology announced a strategic partnership with DD-WRT community to develop 802.11g routers to provide small businesses and ISPs with a high-
performance solution that is covered by Buffalo’s two-year manufacturer’s warranty and full tech support (Buffalo 2007). The partnership addresses the shortcomings of each side so they complement each other perfectly. On the Buffalo Technology side, they get the best firmware for their routers without development effort, and they also get the free technical support from the community. The technical support is usually a major headache for consumer network equipment manufacturers. On the DD-WRT side, the agreement addressed the hardware warranty issue which is the major concern for end users using third party firmware.

The question is, why only Buffalo Technology is willing to tap into the DD-WRT community to create win-win business model? The answer probably lies in the market position of each company. The larger companies, like LinkSys, DLink, have much larger product portfolio, and much larger distribution channels. When one product line is at the end of its life cycle, companies will abandon the support of that product and try to move users to a new product in order to generate new revenue. For those companies, value captured from DD-WRT may cannibalize the revenue from other product line. Buffalo Technology does not have that concern because they have much smaller market share.

For mobile industry, the same story may happen in the future. Smaller market players will jump on open source projects to increase their competiveness. If the dominant players do not participate early to pre-empt competition, then they are bound to lose market share in the long run.
DD-WRT is a rare case that manufacturer and hacking community made a good business case. There are many hacking projects similar to DD-WRT that create great value for consumers, but they are ignored by the original equipment manufacturers, or sometimes their interest are not aligned with manufacturers interest. The following section will list a few projects if someone is interested in further reading.

3.3.2. XDA-Developers

XDA-Developers.com is a community dedicated to improving HTC branded smartphone. The website was started as a result of the lack of support from both service providers and manufactures. “Since we develop software for it, we need information, and nobody seemed eager or ready to give us what we needed. So we 'reverse-engineered' the devices, found a lot of information, and shared it with the world. But as our site grew we realized that lots of ordinary users were also suffering from a lack of support. They started using the xda-developers forum to communicate and before long the forum was as much a user forum as it was a developer forum”. The ROM (the firmware of a cell phone) developers are often called “chef” because they “cook” the customized ROMs for various phones.

This community is not exactly an open source community because some applications or ROMs are not open-source but nonetheless they are all free and open to public. Because the existence of this community, HTC branded phones become highly sought-after smartphones among advanced users. It’s not clear how many innovations HTC has assimilated; HTC has been unquestionably benefited by the existence of this community, albeit there are concerns about IP issue there because Windows Mobile OS is not open source.
3.3.3. NSLU2-Linux

NSLU2-Linux (www.nslu2-linux.org) is a development group and user community dedicated to the improvement, development and modification of the firmware and hardware of the Linksys NSLU2, the Synology DS101, the Iomega NAS100d, the D-Link DSMG600, and other ixp4xx-based devices with large attached storage. The firmware developed by this community dramatically extended the functionality of original NSLU2 devices. LinkSys is aware of the activities of this community and DD-WRT community, but they didn’t do anything to discourage them. It would be interesting to quote a comment from Mike Wagner, director of marketing for Linksys regarding all the activities going on with their NSLU2. "While Linksys does not support any of the alternate firmware available for the NSLU2, we are always delighted to see a product gain such widespread acceptance. Like the similar community that emerged to enhance the WRT54G before it, the creativity and ingenuity of Linksys customers inspires us to continually improve our products" (Buzbee 2006). Nonetheless, LinkSys is benefited from those users innovation.

3.3.4. CHDK

CHDK (stands for Canon Hack Development Kit) is free software released under the GPL. CHDK is a firmware enhancement that operates on a number of Canon Cameras (Canon Point and Shoot digital camera only at this moment). CHDK gets loaded into your camera's memory upon boot up (either manually or automatically). It provides additional functionality beyond that currently provided by the native camera firmware (source http://chdk.wikia.com). The enhanced capabilities that CHDK provides are most likely to be of interest to experienced photographers,
but they are not to the interest of Canon. Canon deliberately disabled certain features in some product lines in order to differentiate the market. The development of CHDK is likely to cannibalize Canon’s sale in higher end camera model. So far Canon hasn’t taken any action against the CHDK community.

### 3.3.5. Rockbox

Rockbox ([www.rockbox.org](http://www.rockbox.org)) is an open source firmware for mp3 players, written from scratch. It runs on a wide range of players including Apple’s iPod, Sandisk’s Sansa series. The developers feel the original firmware is lacking some features and contains a number of annoying bugs that they don’t want to live with. The Rockbox firmware was written from scratch so there’s no IP issue. Not every manufacturer is lenient with Rockbox community. Some companies like Iriver and Archos specifically state that using Rockbox firmware will void warranty. Apple hasn’t done anything against the project, but Apple is certainly not in favor of Rockbox. Apple is a company that doesn’t want users to tell them what to do. They believe they can tell users what they really need.

### 3.3.6. Lesson Learned

From the open innovation cases we have examined in the embedded device industry, we can say that values created by user innovation haven’t been captured in most cases. Smaller companies should actively participate in and guide the user innovation and seek the right opportunity. Dominant players should give the freedom to the user innovation. They may not see immediate
commercial return from those innovations, but they never know if someday user innovation turns to disruptive technology.

4. Current Open Source Development in Mobile Industry

The industry trend is quite clear right now that the cell phone devices are going to two extreme: the low cost “dumb” phone and the feature-rich smartphone. The smartphone market share sets to surge in the next couple of years. By 2013, almost one out of four phones will be smartphone (See chapter 5.2). If counting the revenue instead of units sold, then smartphones will account for much larger market share due to the higher price. This growth, coupled with a fast pace of innovation, presents an excellent opportunity for handset manufactures to increase revenues and profits with higher prices higher margin devices.

4.1. Open Source Mobile Platforms

For the smartphone market, the ongoing battle is about the mobile operating system. Just like the early days of PC industry, there are many players in the mobile OS field. In fact the market is more fragmented today than early days of PC industry. We count at least eight OS platforms in today’s smartphone, not including different flavors of Linux based mobile platform. Each platform offer different openness, from completely proprietary to completely open source.

1. Symbian: Symbian is an open source platform today. Nokia acquired all the shares of Symbian Ltd. in June 2008 and decided to open the platform. The Symbian Foundation was established as a non-profit foundation to "provide royalty-free open platform and accelerate innovation" with the intent to unite Symbian OS, S60, UIQ and MOAP(S) to
create one open mobile software platform. Membership of this non-profit foundation will be open to all organizations.

2. RIM Blackberry: this is the most closed platform in all the smartphone OS. There’s no sign that RIM will open the platform. The drawback of this OS is the lack of applications from third party. That landscape may change as RIM plans to launch a BlackBerry Storefront this year.

3. Microsoft’s Windows Mobile: Originally designed for PPC/PDA, now one platform for both PDA and smartphone (the line is blurred anyway). Windows Mobile is proprietary system, but not as closed as RIM Blackberry because Microsoft opened some modules. The best thing about this OS is the sheer variety of available applications.

4. Apple’s iPhone OS (Mac OS X): The new entrant in the market, but already took a large chunk of the smartphone market. iPhone OS is Unix based but not open.

5. Google’s Android: the newest player in this field. Linux based, completely open source platform. Currently have a large developer community.

6. Palm OS (Palm’s new webOS): the new Palm OS (named WebOS) for its Palm Pre smartphone is open source platform. Whether Palm is too late in the game is still not clear at this moment.

7. LiMo (Linux Mobile): LiMo platform is based on Linux and developed by LiMo Foundation. LiMo Foundation was founded in January 2007 by Motorola, NEC, NTT DoCoMo, Panasonic Mobile Communications, Samsung Electronics, and Vodafone with the goal of establishing a globally competitive, consistent Linux-based operating system for mobile devices for the whole mobile industry.
8. Various Linux base OS from Trolltech, Access, Purple Labs, Open Plug, Ala Mobile, OpenMoko and Mizi Research. None of them have significant market share. Completely open source or semi-open source platform.

Figure 7 depicts the openness of mobile OS market

![Figure 7: Openness and Smartness of mobile OS](image)

**Figure 7 Openness and Smartness of mobile OS**
Figure 8 depicts the top five mobile phone vendors’ support for different OS

- **Nokia (40%)**
  - Symbian
  - Linux
- **RIM (20%)**
  - Blackberry
- **Apple (11%)**
  - Mac OS
- **HTC (4%)**
  - Windows Mobile
  - Android
- **Samsung (4%)**
  - Windows Mobile
  - Android
  - Linux

Figure 8 Mobile OS Support by Top 5 Vendors

4.2. **ShanZhai (Bandit) Phone Phenomena in China: Open Innovation?**

*ShanZhai* Phone, literally translated to “bandit cell phone”, refers to cell phones manufactured by unauthorized or small-scale factories on the South East Coast of China. Many factories are family workshops with 5-10 workers. They usually copy the design and the function of branded cell phones with much lower price. In fact, ShanZhai phones have been around for a quite a few years, but it started to gain huge attention and market shares from 2008. The Shanzhai phone also refers to the phones that are partial knock-off or any phone with ingenious design but not from brand-name companies. The word “Shanzhai” now even extended to other fields of people’s life and become part of the grass-root culture. It’s also been reported that Shanzhai phones have been spotted in some developing countries and we expect to see more reports of Shanzhai phones outside Chinese market. Recently Indian government and service providers
banned the Shanzhai phones from the network because some Shanzhai phones may not have unique IMEI number. But shortly the ban was lifted due to the strong demand from consumers. Researchers in China are also trying to understand this phenomenon to help the government to cope with possible consequences.

In the largest electronic market in Shenzhen, China, I personally tested at least five iPhone clones priced from $80 to $120. Some iPhone knock-offs (see Figure 9) I tested are almost identical to real iPhone outside but with more features inside. It’s said that those shops could crank out 1:1 knock-off of any new release from any brand name manufacture in two weeks if they can get hold of a sample phone. Knock-offs are not the only product those manufactures are producing. They also make some ingeniously designed phones that no brand name cell phone manufactures have ever made. The IP issues and ethic issues are beyond this study. We are trying to understand why those Shanzhai manufacturers can move so fast on technology innovation while the multinational manufactures’ cannot.
There are some explanations for the extremely low cost of ShanZhai (Bandit) phones (GCB_China 2008; Yang and Li 2008):

1. The integrated all-in-one cell phone chip from Mediatech; Little investment on R&D. To be fair, there are certain R&Ds on the design and manufacturing process, but not on technology. The cost of components is the major cost of the phone, then the cost of
assembly. An experienced Shanzhai phone workshop can come up with a new design
fair quickly with little effort, so the design cost is also fairly low compared to brand name
manufactures.

2. The capability to source low cost components. For example Shenzhen is one of the
manufacturing and distribution centers of Shanzhai phones. All the components, such as
screens, keyboards, IC chips are widely available with 100 miles of the city, and very
cheap.

3. Capability to tap into the existing supply chain. They are able to utilize the same supply
chain established by big companies without previous investment.

4. Extremely low manufacturing cost. The labor cost is extremely low. Not much upfront
investment.

5. Evasion of tax. Those small workshops usually don’t pay the tax. Compared to the
legitimate companies, they have cost advantage.

6. No testing, no regulatory compliance. It’s been known that most Shanzhai phones do not
comply with radiation safety standard. So customer is at the Shanzhai phone
manufactures mercy in term of radiation safety.

Despite the popularity and ongoing research on this phenomenon in China, little is known how
those small manufacturers could design and manufacture a new phone in such short time frame,
regardless whether their phones are knock-offs or original designs. Talking with shop owners
revealed that those manufacturers may employ a process similar to open innovation model (but
not open source) in their design and manufacturing. Most manufacturers are in the vicinity of
Shenzhen. There exists a community very similar to the open source software communities for
the Shanzhai phone manufacturers even though there’s no official organization. They do share information, not voluntarily but by the “force of nature”. Unlike the open source software communities, their knowledge is not documented anywhere but spread from one shop to another shop by the word of mouth. There’s really nothing the individual owner can hide. There’s no concept of IP or IP protection. If someone figure out how to source a cheap component, that knowledge can easily be replicated into other factories even the originator doesn’t like to share. That’s just the nature of that community. It’s said that most Shanzhai phones use Linux operating system (not confirmed). The source codes or libraries are not really shared but copied from one owner to another owner thanks to the lack of IP protection. They don’t need to write the application or the operating system from the scratch. They only need to customize the UI of existing applications to look identical to the original devices. If we think the whole community as one company, and the Shanzhai phones are the product portfolio of the whole company, then it’s like thousands of engineers are working together to produce cell phones at the lowest cost and fastest turnaround time without anyone to coordinate them. Actually you have to think those thousands engineering are competitors among themselves. Isn’t that amazing?

So for the multinational cell phone manufactures, they do have some lesson to learn from the Shanzhai cell phone manufacturers’ community. If anyone of them masters a fraction of the innovation speed of the Shanzhai phone manufacturers, then landscape of mobile industry will be changed dramatically.
5. Prediction of Future Mobile Handset Market

5.1. Dumping the landline for mobile only

The most recent data show that 20 percent of US households had only mobiles during the last half of 2008 while only 17% had landline only. Six in 10 U.S. households have both landline and cell phones, while one in 50 has no phones at all (FRAM 2009). The trend will continue at faster speed in the near future. What does that information tell the mobile industry? While the mobile penetration rate is almost 100 percent in United States, mobile service providers should still see this as a positive sign to increase their revenue. When people dump the landline, they have more budgets to spend on mobile service, presumably non voice service. Though mobile service providers will find it hard to increase the account numbers, they should be able to find room to increase ARPU (Average revenue per user).

5.2. Smartphones Set to Surge

Mobile handset manufactures should also see previous news as a positive sign. With the increased spending on non-voice related service, the demand for smartphone will also increase. Industry observers Juniper Research already claimed that worldwide sales of high-end mobile phones should double to 300 million annually by 2013 thanks to rising demand for Web 2.0 apps on the go (Lomas 2009). The analyst believes 23% of all new mobile phones will be smartphones by 2013. For US market, Gartner estimate that More than 35 million smart phones are expected to sell in the U.S alone this year, up 77% from a year ago, in a market worth $11.8 billion. By 2012, the market will be worth $29.2 billion, with nearly 100 million units sold.
Some fear the popularity of smart phones will push down the price of higher-end feature phones offered by the large handset makers. The consequence is a challenge to maintaining or boosting margins (Cheng 2008). For this reason, smartphone market should be an interesting battle ground to watch in the next couple of years. This is also the battle field for open source mobile operating system as most smartphones are on open source OS now.

5.3. The Decline of the Mid-Market Cell Phone

According to ABI Research, even as the overall mobile phone market surges, sales of mid-market cell phones are expected to crash in the next five years. ABI anticipates that just 441 million such phones will be shipped in 2013, down from 854 million in 2007 (Yarow 2008). Today mid-level phones represented 74% of the market, while low-end phones represented 16% and smartphones 10%. In 2013, ABI expects to see a 46%, 23%, 31% market share for low-end, mid-level and smartphones. The dumb (phone) become dumber, the smart (phone) become smarter, and leaves the middle one nowhere. The smartphones using open source operating systems will have cost advantage over the phones with proprietary system. The decrease of smartphone price also pushes hard on the mid-market phones.

5.4. PC Maker entering mobile phone space

As the cell phone is shifting to commodity, the traditional mobile device companies are not the only players in this market. The new trend in the industry is that PC makers are entering the mobile device market either by supplying smartphone or via their 3G-enabled netbook devices. Apple shipped its first smartphone iPhone in the middle of 2007. iPhone is highly regarded by
many consumers. Dell and Acer are both entering the smartphone market this year (year 2009). Technically speaking, smartphone is not that different from the PDAs that Dell used to make (Dell exited its PDA business in 2007). Hewlett-Packard is already in the smartphone business by expanding its iPaq business line. Other PC makers are expected to follow the suite. The popularity of netbook and its 3G-capable feature also make the line between a portable computer and cell phone blurred.

5.5. Industry Calls for Collaboration

Several industry experts already stood out calling for collaboration and open standards. Calls for co-operation from the biggest player in this market probably carry more weight. Speaking at the Mobile World Congress (MWC) conference in Barcelona this February, Nokia CEO Olli-Pekka Kallasvuo told delegates: "The next phase of our industry will require some courage because a change always requires a shift away from what we are comfortable with, what we are used to."
He also added "We will have to work together with competitors, new players and partners in different ways far more than in the past. By sharing resources and ideas, by tapping into each other's expertise we can accelerate our efforts and transform our products and services by leaps and bounds. Mutually beneficial relationships among industries and companies will be more important than ever." (Lomas 2009)

6. Discussion and Recommendation

The mobile industry is undergoing fast-paced changes, probably faster than any industry existed before in the history. Motorola already gave away its leadership in only a couple of years though it is still the strongest player in US market. Motorola’s loss in cell phone sector widens as its
market shares keep dropping. Nokia remains the worldwide leader in mobile handset industry and is confident of maintaining its competitive advantage in technology, innovation, productivity for the foreseeable future. However, history has shown that the status quo does not prevail forever. How to survive in this extremely competitive business environment is the question every mobile handset company wants to understand. Open innovation is certainly one of the answer, but not the only answer, or absolutely the right answer for every company.

6.1. **Criteria for What to Open, What to Close**

From closeness to openness, the trend is clear and inevitable in the mobile industry. For the mobile device manufacturers, if they can’t change the trend, then they have to learn to adapt to it. Their challenge is how to decide what area to open, what area to remain proprietary. There are a few criteria that firms can use to make their decision. Some of them have already been discussed in various places in this study.

1. Difficulty of information diffusion:
   For the technologies that are expected to diffuse rapidly, companies should open them as early as possible to benefit everyone in the field. Holding them in the darkness does no good to anyone. For the technologies that are not expected to diffuse easily, keep them in private domain.

2. Global impact: open the technologies that are not the core business to stimulate demand for other products. Like the shaver and razor business model. i.e. sell the complement product.

3. Initial investment and long term gain/investment ratio: If the initial invest is too high, better to open the technology and make joint development effort. IBM calculated that it costs approximately $500 million annually to maintain an industrial-strength operating system. If IBM invests $100 million of its man power to support Linux development, it will get same quality product with $400 million savings. Other big firms did similar
calculation. That’s exactly the reason why the big firms are the major contributors to the Linux community today.

4. Breakdown the system or business to components and categorize them. For the commodity category, open the system and license the technology. For the rapidly evolving components such as operating system and applications, better join the open source development. For the components that are hard to imitate, keep them in the house. Change the business model to sell those components instead of the whole system.

6.2. A Model Based on Stage of Current Technology

Chesbrough recommended an anti-piracy strategy to software industry based on the stage of the technology life cycle (chesbrough 2007). Similarly mobile industry can adopt similar strategy to decide what to open, what to close.

The life cycle of a technology has four stages (Figure 7), namely the introductory stage, growth stage, maturity stage and decline stage. At the introductory stage, the technology diffusion is very slow. Customers are not willing to try something new unless there are significant benefits. Many wonderful technologies died during this stage before they could even reach the growth stage. In the growth stage the adoption of the new technology grow exponentially until the market is saturated. Then new technology will emerge to replace the old technology.

If the technology in a mobile handset company’s portfolio is in the introductory stage and growth stage, company should open the technology. It pays to be open in the very early phase of a new technology to get the information out to help the diffusion. Besides no one really know the best business model for the new technology anyway. During growth stage, company should also
adopt the open strategy to drive the growth so the technology can become dominant design of the industry. If a technology is in the maturity stage, company may consider keeping it closed to reap the existing value. Company should also consider licensing the technology to other firms to maximize the value before the technology become obsolete. If the technology is in the last phase, the decline stage, company should keep it close, and aggressively license and enforce the IP. Company can also consider exiting that technology and only collect the loyalty. For example Lucent is still collecting tons of money from the technologies it created many years ago but no longer pursued.

![Technology Life Cycle](image)

**Figure 10 Four Stages of Technology Life Cycle**
6.3. From Ubiquity to Invisibility: Next Phase of Mobile Industry

The stages of technology diffusion are critical mass (ownership by 20–30% of the population), ubiquity (30–70%), and finally invisibility (more than 70%). In the last stage, so many people have the technology that it's taken for granted (Brown 2009). "The step after ubiquity is invisibility" was first said by Al Mandel who held high-level positions at Apple and AOL. He pointed out that once a technology had reached the point where everyone had it, people simply forgot about it and from then on assumed it would be there. Clearly PC already reached the "invisibility" stage while mobile devices is still in the "ubiquity" stage. The two industries share so many similarities that what happened before in PC industry will most likely happen again in mobile industry. What we can expect is the "invisibility" stage in the mobile industry.

![Time Line](image)

**Figure 11** the size change of computer and cell phone over time
The cell phone industry is experiencing the same device size change as what happened before in PC Industry (Figure 8). Similarly the transition from proprietary to standard system will also happen in mobile industry (Figure 9).

**Figure 12 Standardization Road Map for PC and Mobile Industry**

6.4. *Four strategies learned from Open Source Software*

Joel West identified four strategies of open innovation in software that addressed the unique combination and exploitation of innovation from multiple sources. Surprisingly these strategies are also applicable to the mobile industry (West 2006) in the area of mobile OS development and mobile device design. Table is the summary of these four strategies.
Table 11 Four Strategies to Use Open Innovation

<table>
<thead>
<tr>
<th>Open Source Strategy</th>
<th>Maximizing Returns of Internal Innovation</th>
<th>Role of External Innovation</th>
<th>Motivating External Innovation</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pooled R&amp;D</td>
<td>Participants jointly contribute to shared effort</td>
<td>Pooled contributions available to all</td>
<td>Ongoing institutions establish legitimacy and continuity</td>
<td>Coordinating and aligning shared interests</td>
</tr>
<tr>
<td>Spinouts</td>
<td>Seed non-commercial technology to support other goal</td>
<td>Supplants internal innovation as basis of ongoing innovation</td>
<td>Free access to valuable technology</td>
<td>Sustaining third party interest</td>
</tr>
<tr>
<td>Selling Complements</td>
<td>Target highest value part of whole product solution</td>
<td>External components provide basis for internal development</td>
<td>Firms coordinate ongoing supply of components</td>
<td>Maintaining differentiation as shared components add capabilities</td>
</tr>
<tr>
<td>Donated Complements</td>
<td>Provide and extensible platform for external contributors</td>
<td>Adding variety and novelty to established products</td>
<td>Recognition and other non-monetary rewards</td>
<td>Third parties can control the user experience</td>
</tr>
</tbody>
</table>

6.5. Change Business Model

Brand Management in the Open Source Model

In the very early days when Red Hat tried to figure out a business model, Robert Young looked at the commodity industry, from bottled water, soap to ketchup and learned some ideas (Young 1999). The brand name behind those commodities stands for quality, consistence and reliability. So they realized the value in brand management of those commodities that they could emulate.
Everyone can make ketchup in their kitchen but no consumer does that because it’s cheaper and more convenient to buy ketchup from Heinz or Hunts. Heinz has 80% of the market because they have been able to define the taste of the ketchup in the mind of ketchup consumers. Coca Cola and Evian are able to sell billions of dollars of tap water in the US market because they address the irrational fear that water coming from our tap is not to be trusted. Now the cell phone business is increasingly becoming commodity business, any company can use the free open source OS in its product. What will really differentiate in the market is the company that can define the product in the mind of consumer and can do the brand management well. Those companies will take the market eventually.

**Lego Business Model**

Every kids grow up in US knows the Lego brand name. They have used Lego kits to demonstrate their creativity. They build houses, machines, animals and anything you can name using many small plastic pieces from that company. Kids even build sophisticated robots for robot competition using Lego kits. Lego does not build any final product, but it supplies the building material. It’s up to the user to exhibit his/her creativity using their products.

Mobile industry just started disintegration. If the industry has to go through the process of disintegration, standardization and specialization, then think about the Lego business model. It’s not too bad to be Lego. The catch is, probably only a few “Lego” can co-exist.
6.6. **Strategy to Cope with the Shanzhai Phones**

1. Give up the low end phone market: instead, provide the key components to the assemblers. Generally speaking, in a mature business, the integrator has very thin margin, and the component manufacturers have much better margin.

2. Crack down the knock-off: this strategy need the cooperation from Chinese government, especially the local government. It may not be their best interest to shutdown Shanzhai business. But it won’t hurt to give it a try.

3. Partner with service provider to lock out the non-compliant phones. As stated before, Indian government and service providers tried before, but they soon gave up due to the pressure from consumers.

6.7. **Watch Out for Disruptive Technology**

No one can really predict the upcoming disruptive technology, but company should be prepared to change when the disruptive technologies emerge on the horizon. As Charles Darwin said, “It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.” This statement is especially true for high-tech industry and has been proven by the recent history of this field. For example, IBM transformed itself from a computer vendor to a service provider as of today and survived the harsh environment. On the other hand, most companies which competed with IBM in the computer hardware business no longer exist. It’s not always easy to spot the disruptive technologies, but companies can always bet on a group of technologies to minimize the risk.
Bibliography


