Dynamically Adapting Design and Usability in Consumer Technology Products to Technology and Market Life-Cycles: A Case Study of Smartphones

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

Master of Science in Engineering and Management

at the

Massachusetts Institute of Technology

June 2009

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Abstract

Design-driven business strategy has received a lot of attention in recent times, with Apple frequently standing out as an exemplar of the success of such a strategy. Most of the existing literature, while emphasizing the importance of design for market success, takes a fairly static view of design. In this thesis we provide a prescriptive guideline on adapting design strategy over time in response to the dynamics of technology evolution and market adoption mechanisms for technology products.

Our Design Strategy Framework builds on existing literature in three main areas: design, technology adoption life-cycle and market adoption mechanisms. For the purposes of this thesis, we have adopted Sanders perspective of defining a product in terms of three key design attributes - usefulness (functionality), usability (ease of use) and desirability (aesthetics). We have used Anderson and Tushman's paper on the Cyclical Model of Technological Change as our basis for defining the stages in the technology adoption life-cycle. Finally, we have used Rogers' theory on Diffusion of Innovation to define the characteristics of the user base (adopter category) in each stage of market adoption.

Based on this foundation, our framework prescribes emphasis on one of the three design attributes of a product during each stage of market adoption. This recommendation is grounded on the technological maturity during that stage as well as the characteristics of the user segment that leads them to value certain product attributes over others.

This thesis includes a case study of convergent handheld devices (PDAs and smartphones) which illustrates the application of the Design Strategy Framework in providing an explanation for a product's success or failure in the market based on its emphasis (or lack of) on the right design attribute at the right time. The thesis also includes a survey of current and potential smartphone users which is used to further validate the framework.

While this thesis focuses on mobile handheld devices, the findings can be applied across consumer technology products. The Design Strategy framework can be used to determine what aspects of a design to focus a firm's development efforts on, given an understanding of the product's placement in the adoption cycle. Judiciously emphasizing the right aspects of design at the right time can improve a product's chances of market success.

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Acknowledgements

First and foremost, I would like to thank my husband, Visshy, for supporting my life-long dream of going to MIT. I could not have gone through this program as successfully as I did without his encouragement and support every step of the way.

My advisor, Prof. Maria Yang's excitement and support for the idea behind this paper was the primary driver to the successful completion of this effort. She was a great sounding board, and an invaluable guide in helping me channel my thoughts into a coherent thesis. I wish to thank her for all her support and guidance.

I also wish to acknowledge MIT for creating the Engineering Systems Division and allowing programs such the System Design and Management program to thrive. In particular, I will always value the lessons learnt from Prof. Debbie Nightingale's 'Integrating the Lean Enterprise' and 'Enterprise Architecture' courses, which taught me to apply systems thinking to solve complex problems in a practical, real-world sense. SDM has truly given me the confidence in my ability to bound multi-faceted problems and develop creative solutions.

I want to thank Pat Hale, Director of SDM, for creating an environment where people can tailor the program to meet their individual needs while maintaining a strong sense of SDM identity. I also wish to thank Jon Griffith, Bill Foley, Helen Trimble, Chris Bates and rest of SDM staff for their support throughout the course of my stay at SDM.

My experience at SDM would not have been what it was without my classmates. Special thanks to them for enriching my life with their friendship!

My gratitude would not be complete without a shout-out to my parents for inculcating in me the love of learning, and the ability to appreciate and make use of the opportunities available to me.

Last but not the least, I want to thank my friends for being so forgiving of my absence in their lives as I juggled the challenges in mine over the past two years. I hope to be more connected going forward!

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1. : Introduction

This thesis offers prescriptive recommendations on implementing a design driven strategy for consumer technology products. The goal is to explicitly articulate the relationship between design strategy on one hand and technology and market strategies on the other as we strive to answer the following questions:

- As characteristics of user base change, how to design a product that engages new users and invites them to learn how to use the device, while retaining the rich, complex features that power users expect?
- Is ease of use necessary to drive market adoption? Is it sufficient? At which point in a product's adoption cycle does ease of use become a critical attribute of adoption, if at all?

In this thesis we provide a framework to analyze a product in terms of its design attributes. Our Design Strategy Framework grounds this analysis in the context of existing technology and market conditions at the time of product launch. The framework further provides guidance on changing the design attributes in response to the dynamics of technology evolution and market adoption mechanisms. This is followed by a case study of convergent mobile devices which illustrates the application of the Design Strategy Framework in providing an explanation for a product's success or failure in the market based on its emphasis (or lack of) on the right design attribute at the right time. Rather than offering "a mismatch between actual and recommended product design strategy" as an irrefutable explanation for a product's failure in the market, this thesis offers it as one of the possible explanations. While this thesis focuses on a case study of

mobile handheld devices (PDAs, smartphones) as well as a survey of current and potential users of such devices, the findings can be generalized to most consumer technology products.

The remainder of this document is organized as follows:

Chapter 2 offers a survey and analysis of the relevant existing literature on technology evolution and market adoption of technology products. We also present some of the current research on design, its relationship to market and technology development, and some of the successful design driven businesses. In this chapter, we will also introduce our Design Strategy Framework that marries design strategy to technology evolution and market adoption life-cycle.

Chapter 3 provides a short overview of PDAs and smartphones, the key technologies that drive these products as well as an insight into the unique characteristics of this market.

Chapter 4 is a case study involving five handheld products in the PDA/smartphone category. Through the use of these examples, this chapter illustrates the evolution of smartphone technology and market over time. The examples used in this chapter also provide initial evidence of how emphasis (or lack thereof) on the right design attribute can contribute to product success (or failure) in the market.

In chapter 5, we present the analysis of results of a survey conducted on current and potential smartphone users. The results of this survey are used to corroborate our conclusions regarding smartphone adoption and recommendations regarding product design from chapter 4.

Finally chapter 6 presents the conclusion of this thesis and some suggestions for future work.

2. : Background and Literature Review

Design-driven business strategy has received a lot of attention in recent times (1). There are a number of case studies on Apple and iPod as exemplars of the success of a design-driven business strategy (2), (3). In this thesis we propose a framework to guide the implementation of an organization's design strategy and provide a path to drive the evolution of design strategy in response to the dynamics of technology evolution and market adoption of technology products.

This chapter provides an overview of the relevant literature surrounding the key topics that are the foundation of this thesis, namely design, technology evolution and market adoption of technology products. Following this overview, we will present a framework that ties these pieces together to provide a roadmap for co-evolution of design, technology and market strategies.

2.1 What is Design?

Design is classically considered to be the integration of function and form, with Merriam-Webster offering the following technical definitions:

Design (n): An underlying scheme that governs functioning (of a product or system)

Design (v): To create, fashion or execute according to plan

2.2 Role of Design

While design is considered a nebulous and intangible concept, there has been a concentrated effort in recent times to clarify the role of design within organizations and offer methods to

quantify and measure the business value of design (3). As a foundation for this, Sara Beckman[1] defines a design awareness spectrum and details five points along this range that organizations can be classified to fall under:

1. No design awareness

   These organizations do not recognize the value of design at all. They "design by default", where form follows technical necessity and production efficiency.

2. Style

   Design is applied style, often perceived and practiced as a cosmetic afterthought. In this case, design is used to establish the "coolness factor" of a product.

3. Form and Function

   This is the classic practice of design where design is used to make things work better. This approach is generally limited to incremental improvements with design iterations used to improve existing solutions.

4. Problem Solving

   In this case, design is used to find creative solutions to existing problems and expand the alternatives in the solution space.

5. Framing

   Here design redefines the challenge and moves from executing strategy to shaping strategy.

Beckman asserts that good design thinking makes allows shifting between different points along the spectrum when appropriate.

[1] "Designing Innovative Customer Experiences", Sara Beckman, Lecture Notes from SDM Speaker Series, October 31st 2008

2.3 Attributes of Design

Elizabeth Sanders expands on attributes of design and presents three perspectives to judge a product's design (4):

2.3.1 Usefulness

According to Sanders, a useful product is one that consumers need and will use. Usefulness is the ability of the design to deliver the function the product is required to perform. There is a subtle but significant difference between a design engineer's approach to delivering function and an industrial designer's. While a design engineer may be more concerned with the objective characteristics of the technology and product performance, the industrial designer's role is to make the functional architecture invisible and enable the user to use the product without the user needing to know how the product does what it does.

2.3.2 Usability

A useable product is one that consumers can use immediately or learn to use readily. Usability refers to the ease of use of the product, and usually comes under interaction design or human-computer interaction (HCI) branches of study.

2.3.3 Desirability

A desirable product is one that consumers want. The aesthetic appearance, style and brand of a product play a big role in defining its desirability. This drives emotional decision-making on the part of the consumer.

Figure 1 shows the three perspectives of design. The core of this thesis provides a framework to analyze product design using these three perspectives, and a rationale to change the emphasis placed on each perspective in response to changing technology and market conditions. In other words, this thesis will show that to successfully apply a design driven strategy, it is essential to understand how design strategy is married to technology, market and product strategy.

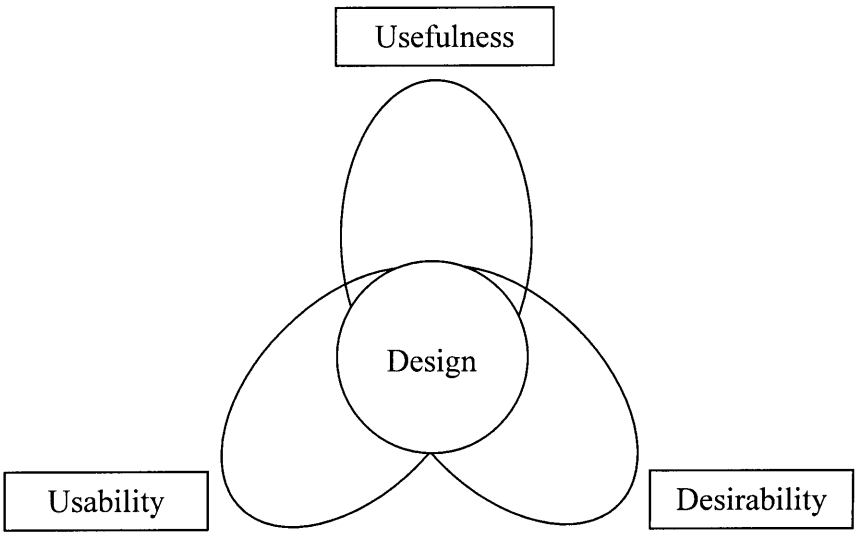


Figure 1: Attributes of Design

In the next couple of sections we will summarize technology evolution and market adoption literature.

2.4 Technology Evolution Cycle

An evolutionary model of technological change was proposed by Anderson and Tushman (5). It states that a technological break-though initiates an era of ferment in which competition among technical variations of the original innovation culminates in the selection of a single dominant design or configuration of the new technology. This era of ferment is then followed by a period of incremental technical progress, which preserves the successful variations until a subsequent new technological discontinuity initiates a new cycle. The key elements of this model are summarized below.

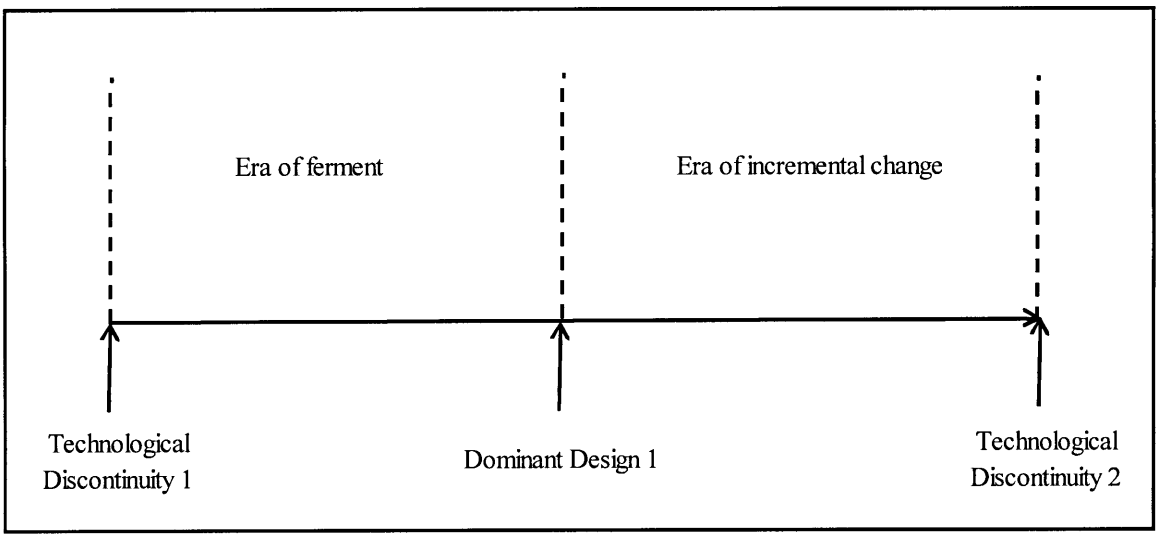


Figure 2: The Technology Cycle[2]

[2] Source: Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change, Philip Anderson and Michael L. Tushman, 1990, Administrative Science Quaterly, Vol. 35, pp 604-633

2.4.1 Technological Breakthroughs or Discontinuities

Technological breakthroughs are innovations that confer a decisive cost or quality advantage, and that possess performance trajectories that are dramatically different from the norm of continuous incremental innovation. These discontinuities can either affect the products themselves or the underlying development processes. Product discontinuities are fundamentally different product forms or architectures, while process discontinuities are fundamentally different ways of making the product.

2.4.2 Era of Ferment

The period following the introduction of a radical innovation is characterized by experimentation as organizations try to understand the implications of this advance. There are two modes of competition in play: one between the old and the new technological regime and the other between firms within the new technological regime. Newer technologies are disparaged by existing technological orders since they do not work as well and are based on paradigms different from the established norm. Concurrent with battles between the old and the new technologies, there is significant competition within the new technological order. Several versions of the new technology appear, both because the technology is not well understood and because each pioneering firm is trying to differentiate its offering from rivals. Anderson and Tushman also offer that the mean number of new designs introduced during the era of ferment is greater than during the subsequent era of incremental change.

2.4.3 Dominant Design

A dominant design marks the end of the era of ferment and is a single architecture that establishes dominance in a product class. Dominant designs emerge as a result of the need for the different players in the industry ecosystem to reduce uncertainty, risk and cost associated with high variation during the era of ferment. Dominant designs allow standardization and drive down costs by permitting volume production and learning efficiencies. A technological discontinuity itself or the first versions of the new technology do not as a rule become dominant designs. The dominant design shaped by the technical variation during the era of ferment and is the cumulative result of the selection process among technological variations.

2.4.4 Relation Between Technology Evolution Cycle and Technology Adoption

Tushman and Anderson also tie the emergence of a dominant design to the diffusion of the new technology. Adoption of the technology during the era of ferment is limited due to the inherent risks confronting potential adopters dealing with multiple versions of the technology. Due to switching costs associated with picking the wrong design (one that fails to become the standard or the dominant design), majority of potential adopters will await the emergence of the industry standard before committing to a new technology. As such, emergence of the dominant design is a prerequisite for mass adoption. (more on innovation adoption dynamics will be covered in the next section). This is shown in Figure 3, where time T1 indicates the emergence of dominant design.

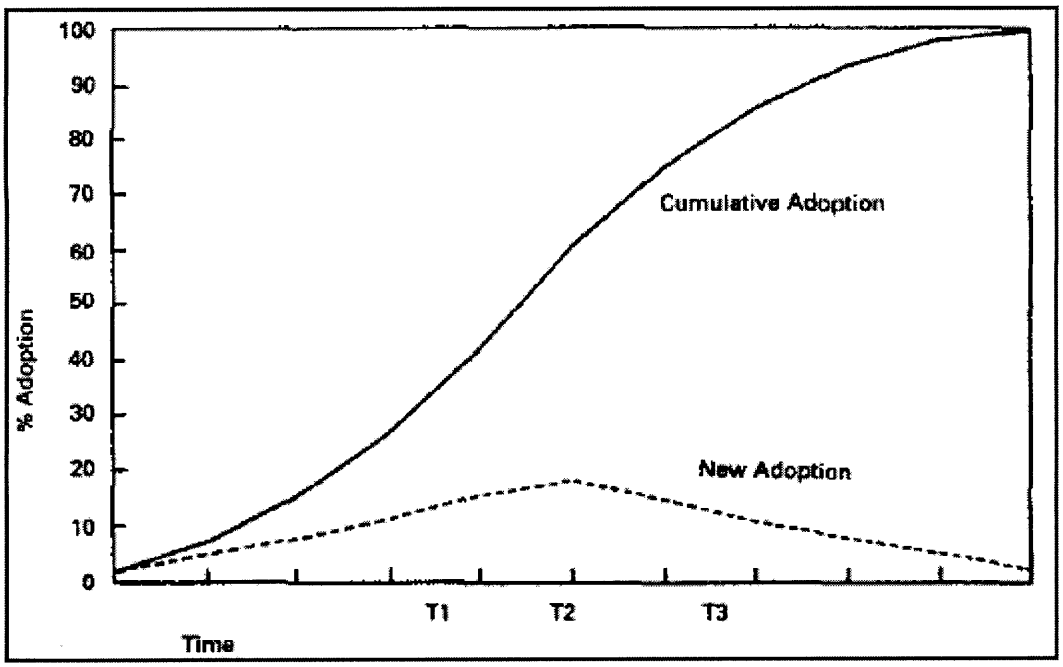


Figure 3: Model of Dominant Design and Technology Diffusion[3]

2.4.5 Era of Incremental Change

Once a dominant design emerges, it gets instituted as the new paradigm. Future technological progress involves incremental improvements and elaborations to the standard. Competition is now based on cost and design variations rather than performance.

2.5 Innovator's Dilemma

Clayton M. Christensen (6) looked at the technology evolution cycle from the perspective of the level of performance required by users. He argues that once a technology product meets customers' basic needs they regard it as 'good enough' and no longer care about the underlying

[3] Source: Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change, Philip Anderson and Michael L. Tushman, 1990, Administrative Science Quaterly, Vol. 35, pp 604-633

technology (Figure 4). At that point, further investment in improving the technological performance yields marginal incremental benefits in terms of market adoption.

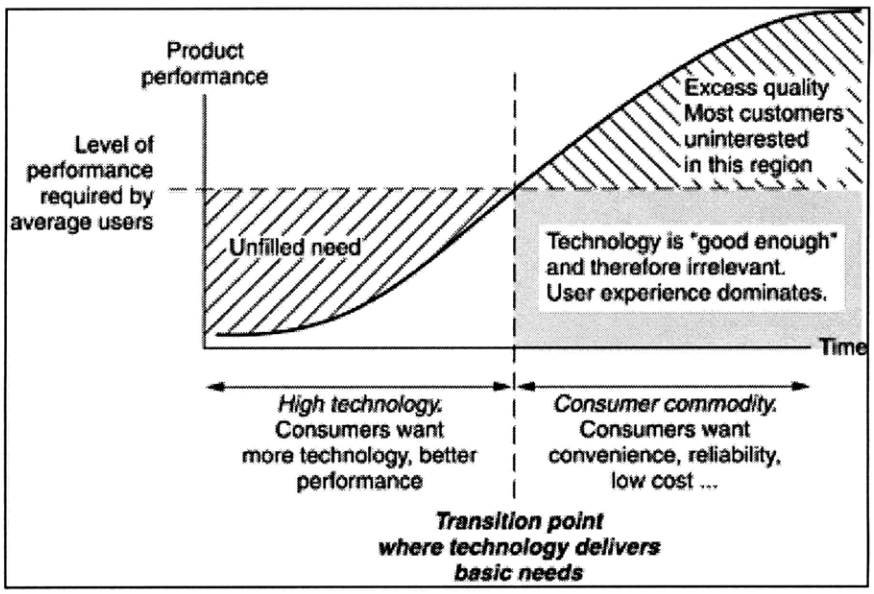


Figure 4: Moving from high technology to consumer commodity[4]

In the next section we will present the diffusion and adoption mechanism for technology products and Geoffrey Moore's high-tech marketing model.

2.6 High-Tech Marketing Model

Geoffrey A. Moore (7) argued that the high-rate of introduction of discontinuous innovations in the high-tech industry compared to other industries implied a greater need for a high-tech marketing model based on the Technology Adoption Life Cycle.

[4] The Innovator's Dilemma, Clayton M. Christensen, 2006

The Technology Adoption Life Cycle, briefly introduced in the section on Dominant Design, is based on research on diffusion of innovations by Everett Rogers (8).

2.6.1 Diffusion of Innovation

Rogers defines diffusion as the process by which an innovation is communicated through certain channels over time and among the members of a social system. The key elements in this definition are:

Innovation

An idea, practice or subject perceived as new by the adopter. The idea could be objectively new in terms of a brand new discovery or it could be new in terms of its use context.

Time

The time dimension is involved in diffusion process in an innovation's rate of adoption in a system, measured as the number of members of the system who adopt the innovation in a given time period.

Social System

Is a set of interrelated units (people, groups, organizations) engaged in joint problem solving to accomplish a common goal. The social system constitutes a boundary within which an innovation diffuses.

Rogers' model describes the penetration of any innovation in stages corresponding to the psychological and social profiles of the various segments who adopt it over time. The adoption curve is bell-shaped with divisions roughly one standard deviation apart. The early and late majority are roughly one standard deviation from the mean, while the early adopters and laggards are within two. The innovators are present at the very onset of a new technology about three standard deviations from the mean.

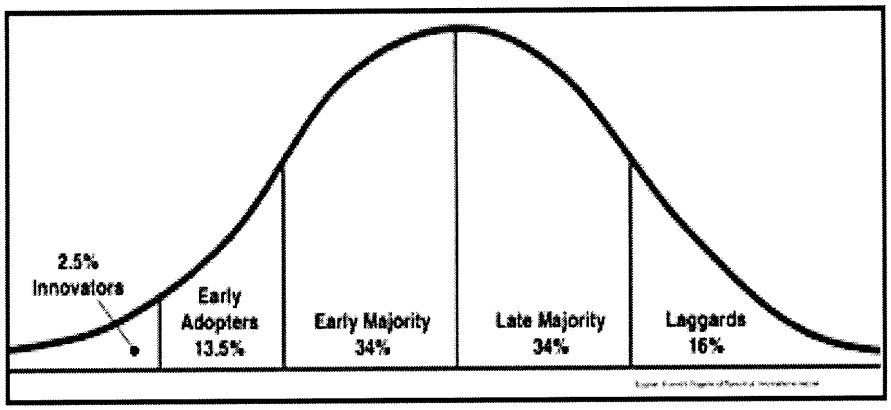


Figure 5: Technology Adoption Life Cycle[5]

Figure 5 shows the technology adoption life cycle and the different adopter categories. The characteristics of the adopter categories are summarized below:

Innovators

Innovators adopt technology for its own sake. They are fascinated by its properties and curious about its use and applications. Winning innovators over at the start of a marketing campaign assures the market that the product is viable.

[5] Source: http://en.wikipedia.org/wiki/File:DiffusionOfInnovation.png

Early Adopters

Early adopters, like innovators, buy into a technology early. However, unlike innovators they are not fascinated by the technology itself, but rather its potential benefits in areas that specifically concern them.

Early Majority

The early majority is driven by a strong sense of practicality. They want to know that a technology is relatively stable and reliable before they invest in it. As argued by Tushman and Anderson (1), this group waits until the early ferment settles and a dominant design appears before buying into it.

Late Majority

In addition to sharing most of the characteristics of the early majority, the late majority is also uncomfortable with technology. They are more cost sensitive and tend to buy from large, well-established companies.

Laggards

Laggards, in general, don't want anything to do with new technology, and are usually regarded as not worth pursuing in any marketing strategy.

In general, moving from left to right of the curve, the groups get increasingly risk-averse and cost sensitive. Moore argued that understanding these differences was critical to effectively market products based on the new technology to each group and described a marketing approach

that is based on working this curve left to right. Moore further depicts the transition between the early adopters and early majority pragmatists as a chasm that many high-technology companies never successfully cross. (Figure 6)

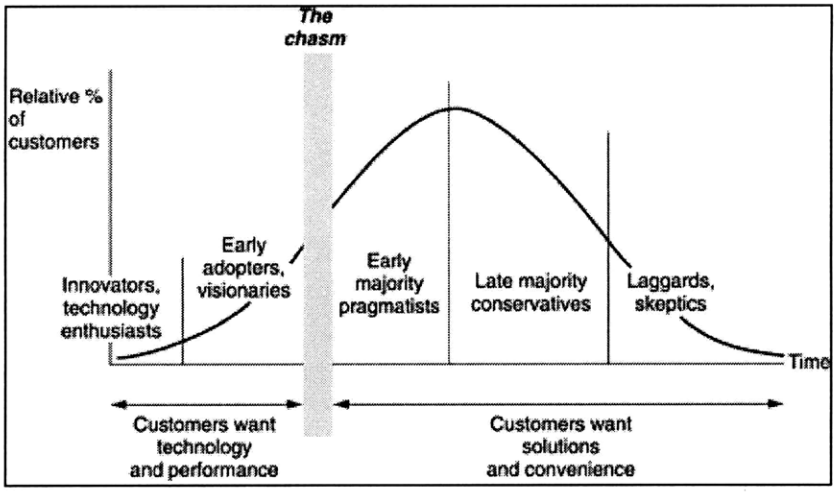


Figure 6: Moore's Market Adoption Curve[6]

2.7 Co-evolution of Technology and Market Demand

Don Norman (9) offers a useful summary tying Christensen's model to Moore's high-tech marketing model. He argues that it is when the technology becomes good enough that the chasm between early adopters and late adopters is crossed (Figure 7). Norman further makes the case that it is not sufficient to change one's marketing strategy as a product/technology moves through its life cycle. He argues for fundamentally changing a product's design to address the differing importance placed by different adopter categories on various dimensions of a product.

[6] Source: Crossing the Chasm, Moore, Geoffery A., 1999

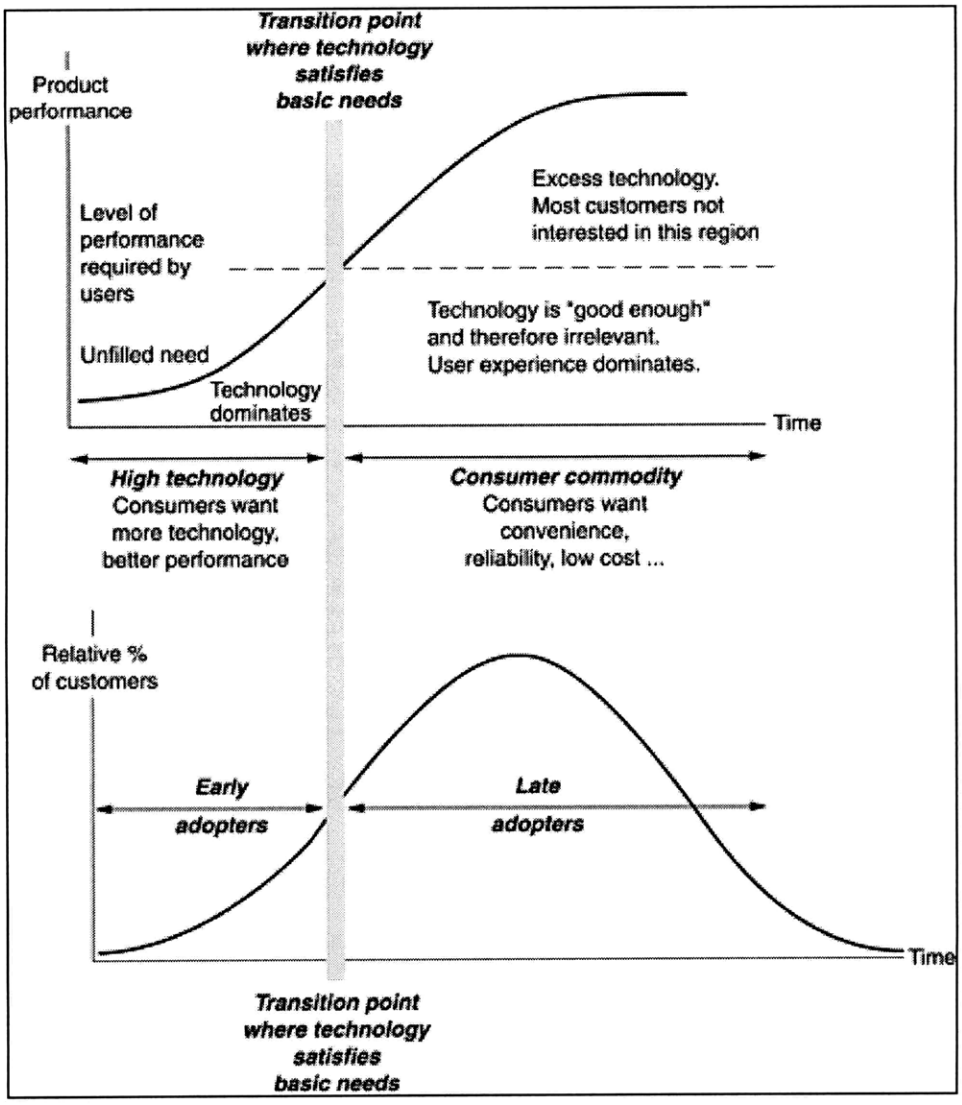


Figure 7: The transition from technology-driven to customer-driven products[7]

Table 1 shows how the product attributes emphasized by each technology era are the ones valued by successive adopter categories leading to the co-evolution of technology and market demand. Technology plays a strong role and hence functionality or usefulness is the strongest attribute of product design in the early stages. Later, once technology meets the basic performance

[7] Source: The Invisible Computer, Norman, Don, 1998

requirements, ease of use, convenience, cost and over-all over experience take on greater importance.

Technology Era	Ferment	Dominant Design	Incremental Innovation	Maturity
Adopter Segment	Innovators/Early Adopters	Early majority	Late majority	Laggards
Valued Attribute	Better than old	Stable performance, ease of use	Reliability, Cost	

Table 1: Co-evolution of Technology and Market Demand[8,9]

2.8 Technology Evolution, Market Adoption and Design

Combining existing literature on technology, market and design strategies provides a useful understanding of the value placed by customers on various design attributes at different stages of market adoption. We have applied this understanding to develop a prescriptive framework that will help product manufacturers achieve the biggest bang for their design buck. The key input to this framework is a solid understanding of where the product is in its adoption life-cycle. Based on a product's position in its adoption life-cycle, this framework will serve as a decision tool to assist resource constrained companies in determining where to concentrate their design resources to maximize market success. As a product progresses through its life-cycle, this framework also assists organizations in dynamically altering their design strategies to meet the needs of newer customer segments and grow their market.

[8] Adapted from Prof. Michael Davies' Technology Strategy for SDM Class Notes
[9] The Invisible Computer, Donald A. Norman, 1998

In the early era, customers' focus on the promise offered by the new technology in terms of improved product functionality i.e. the technology offers a way to meet a need better than any existing solutions. The early adopters or technology enthusiasts, who are highly tech-savvy, are willing to spend the time to learn to use a new product and are willing to pay the price to be the first to own a new product/technology. Industrial design and ease-of-use is irrelevant to this group of users.

In the era of mainstream adoption, resources should be focused on improving the product's ease-of-use and providing stable performance. The emergence of a dominant design signals standardization of functionality and sets the basic level of performance expected. At this point, the product becomes attractive to the early majority of adopters who tend to be pragmatic users and value stable performance and ease-of-use. While this group of users is comfortable with technology, unlike the early adopters they do not have the patience to invest time in keeping up with rapidly changing technology. They prefer to wait till the technology and feature set have stabilized and a clear winner has emergent from the ferment.

At this point, products can fail for two reasons, either they do not meet the basic performance levels established by the dominant design and required by the market or they are still technology focused and very difficult to use. While companies need to keep up with incremental improvements in technology, heavy investment in improving functionality results in non-optimal use of resources. Once a product has reached this phase of the adoption cycle, companies should shift focus of their product development efforts to improving a product's usability while providing the basic level of performance expected.

Once the market has matured, companies should focus on the stylistic and aesthetics elements of the product design. Over time, as adoption increases, production volumes increase and costs drop. With drop in prices and further improvement in product reliability, the late adopters are attracted to the market. At this point, most products available have similar features and functionality and performance is fairly standard and reliable across the board. Companies now need to differentiate by appealing to consumer's emotional reasons for buying such as status and image factors.

In addition to having the right technology and marketing strategies, the right amount of focus on the right design attribute is critical to a product's success in the market.

2.9 Proposed Design Strategy Framework

Building on past research on product design, technology evolution and market adoption of technology products, this thesis proposes a framework to dynamically alter product design in response to the technology evolution and market response cycle. Based on the phase of the adoption life cycle, we propose changing focus on different attributes of the product design. Figure 8 illustrates the above concept and is this thesis' contribution to advancing the current thinking regarding the role of design in driving product adoption over time.

Attribute	Product Adoption Life-Cycle			
		Early	Mainstream	Late
	Usefulness			
	Usability			
	Desirability			

Legend	
	Critical attribute requiring design emphasis in a given life-cycle phase
	Performance on the attribute should maintain levels achieved in previous life-cycle phase. No additional effort beyond sustaining incremental improvements required
	These attributes can be ignored in a given life-cycle phase

Figure 8: Design Strategy Framework

The diagonal of the matrix represents the critical attribute requiring design emphasis in a given life-cycle phase. In other words, in the early market, the usefulness or functionality of the device should be the key focus of design efforts, in the mainstream market efforts should shift to improving the usability and user-experience of the product while aesthetics and style become important differentiators requiring special design attention in the late/mature market.

The upper-triangular section of the matrix represents attributes whose performance needs to be sustained to levels reached in the previous life-cycle phase. Additional efforts may be required to obtain incremental improvements in keeping pace with technology evolution. No breakthrough innovation is required on these attributes. For example, in the mainstream phase, performance on the usefulness attribute should maintain the levels defined by reaching of the dominant design milestone in the early market. Incremental improvements will be required, for example,

improving a product's battery life, but no efforts are required to introduce radically new functionality.

The lower-triangular section of the matrix represents attributes which can be ignored in a given life-cycle phase since they have a perceived lower value for users compared to other attributes. These attributes take on additional importance in subsequent phases. For example, in the early market, usability or desirability (style) has a markedly lower value for users as compared to usefulness or functionality. Hence less design effort should be placed on these attributes in the early market.

3 Mobile Wireless Handset Market

3.1 Overview

In the mobile wireless handset category there are three distinct segments[10] - smartphones, feature phones and basic cell-phones.

Smartphones

Smartphones can be considered handheld computers that provide advanced capabilities in addition to the basic voice-calling feature offered by standard cellular phones. Although there is no industry standard definition of a smartphone, their commonly accepted distinguishing features are:

1. A distinct operating system
2. Standard interface and platform for application developers
3. Ability to multi-task i.e. run more than one application at the same time

Smartphones have traditionally been used by enterprises to allow workers to stay in touch with their work while travelling. Productivity applications such as Email, Personal Information Management (PIM) and other corporate applications have been the primary drivers of use. To ensure protection of corporate information, information technology (IT) managers have based their smartphone purchase decisions on evaluation of the devices' information security, its corporate IT management features and ability to integrate with existing IT systems.

[10] Important Mobile and Wireless Market Directions, 2008 to 2012, Gartner Research # G00157170, 6 June 2008

Smartphone vendors have in recent years started to target consumers directly with devices and applications designed to appeal to this demographic.

Enhanced or Feature Phones

Feature phones provide strong media, imaging and web functionality beyond basic cell-phones. In contrast to smartphones, they do not have distinct operating systems. Instead they have less sophisticated programmability via platforms such as Java, Ajax, BREW (Binary Runtime Environment).

Basic Phones

Basic phones are primarily used for voice communication and short messaging services (SMS), and may support restricted browsing.

3.2 Value Networks

Before analyzing how the different attributes of a design are valued it is useful to consider the concept of value networks (6). Clay Christensen defines a firm's value network as the context within which it identifies and responds to customer's needs, solves problems, procures input, reacts to competitors and strives for profit. He also goes on to say that the way value is measured differs across networks, and it is the different value placed on different attributes of a product that define the boundaries of a value network. Within a given value network, companies invest

their resources on technologies and on improving the performance of those attributes that are most valued by their customers.

3.2.1 Smartphone Value Network

At a high level, the smartphone value network is shown in Figure 9 below. The purchasers are often corporate IT managers while the end users are corporate executives. A smartphone solution consists of three main components – the hardware i.e. the device, the operating system (OS) and the applications that run on the device. Companies such as Research In Motion (RIM) and Palm both build devices as well as develop operating systems that are run only on their devices. Some devices from companies such as Nokia run operating system from Symbian, while Motorola has devices the run the Windows Mobile operating system from Microsoft. In addition to distinct operating systems, the other distinguishing factor of smartphones is the applications that can be freely run on these devices. Some of the applications, known as "core" applications are provided by device maker themselves, while others – third party applications are provided by Independent Software Vendors (ISVs) or Network Service Providers and are added by users as required.

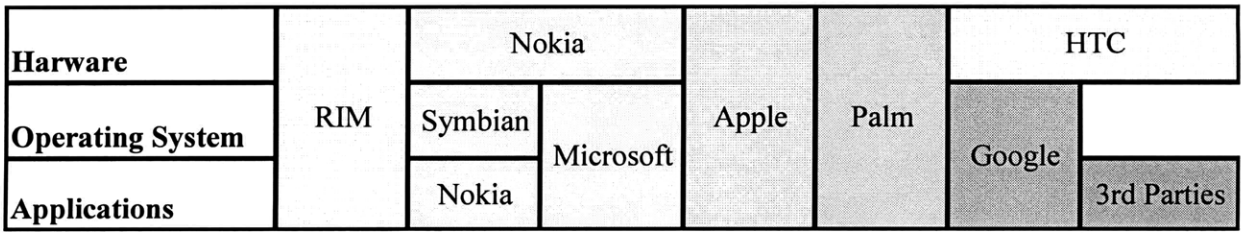


Figure 9: Smartphone Value Network

Given the end customer demographic and use case, the driving applications have traditionally been productivity tools such as Email and Personal information Management (contacts, calendar, tasks). Support for corporate applications and corporate IT tools is also vital as is maintaining the security and integrity of corporate data. For the operating systems, the key attributes are stability, security and support for third party applications. For the device, given the primary application is accessing and responding to email on-the-go, the key attributes are device size and weight (for easy portability), keyboard ease-of-use and device memory.

As mentioned earlier, smartphone makers are now targeting consumers, who were the traditional customers of feature phone makers. Analysis of feature phone value network will be useful in understanding the dynamics of this phenomenon.

3.2.2 Enhanced or Feature Phone Value Network

In case of enhanced phones the end users and the purchasers are one and the same – consumers as opposed to corporations. While the primary driver for cellphone purchase is communication (phone, messaging), there's been increasing demand for media and entertainment applications, which are now part of most mainstream cellphones. The quality and usability of these applications are now gaining importance. Consumers are also more style and image conscious as well as price sensitive, which makes design and price other key attributes of value for feature-rich devices.

3.2.3 Blurring the lines

Over time, feature phones have also started supporting a number of the same applications that smartphones provide. However they still do not have the standard interfaces or the ability to support corporate applications. Feature phones are also smaller and less expensive than smartphones. As a result, price sensitive consumers have preferred high-end feature phones that support most of the functionality they are interested in instead of paying a premium for smartphones.

Thanks to Moore's law, the semiconductor chips (processors) powering phones are getting more powerful, while their prices are dropping[11]. This has allowed smartphone manufacturers to target users outside the core enterprise/corporate world by including multimedia and entertainment applications. Lower prices of semiconductor components have also resulted in lower prices for these devices. These two factors have made smartphones more attractive to consumers. Apple's iPhone, which we will cover in detail in the next chapter, is iconic in creating a well-defined consumer segment in the smartphone market.

Figure 10 below shows the segmentation of the mobile handheld devices market in general, with representative devices in each category. Smartphones, traditionally in the communication and information segments have squarely entered the entertainment segment with the iPhone.

[11] http://www.windowsfordevices.com/news/NS8526831036.html

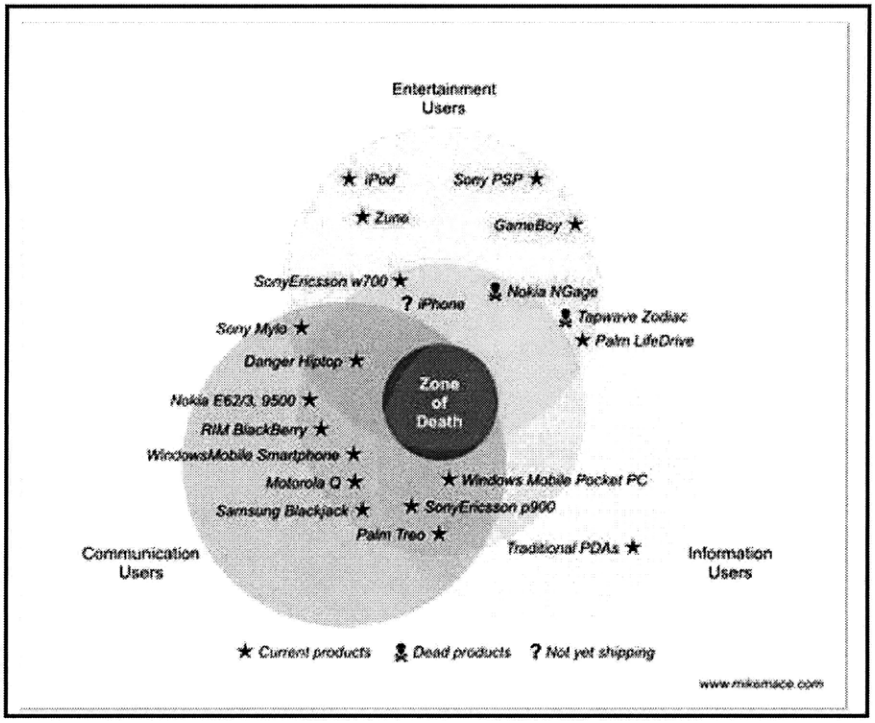


Figure 10: Mobile Handheld Device Categories[12]

3.3 History of Handheld Devices

Over time changes in functionality, usability, and desirability has driven the evolution of handheld devices. Evolution of smartphones to their current state can be best understood by studying the history of relevant handheld devices, starting with Personal Digital Assistants or PDAs.

The term Personal Digital Assistant was first used in 1992 by Apple's then CEO John Sculley with reference to Apple Newton (10). He put forth a grand vision of a device targeted at the mass consumer in a variety of configurations such as electronic books, organizers and personal

[12] Source: http://mobileopportunity.blogspot.com/2007/01/shape-of-smartphone-and-mobile-data.html

communicators. PDAs had evolved to replace the Rolodex and electronic organizers. Early PDA manufacturers adopted a variety of different form-factors and input mechanisms. Some of the features that defined the early PDAs were[13]:

- Standard organizer features such as address book, calendar, notes, to-do lists, calculator
- Ability to synchronize to a PC to import/export Personal Information Manager files and documents

In line with the characteristics of an emerging market, there was considerable ferment in the market. On one hand, customer expectations for the product were wide-ranging. Since users didn't know exactly what the handheld device could do well, they expected it to do everything. A survey[14] conducted by Electronic Design magazine in late 1994 showed that the "wish-list" of features for PDAs included: pocket-size, lightweight and inexpensive; send/receive fax; RF (radio frequency) and/or IR (infra-red) interface to exchange data with other PDAs, printers etc.; RS-232 *(serial data transfer)* interface; built-in modem; cellular data transceiver *(transmitter/receiver)*; voice to text processing; usable QWERTY keyboard for typing[i]. On the other hand, manufacturers approach to meeting these needs were also varied and included various combinations of features per device. Depending on the historical focus of the company, there were three primary approaches to creating handheld devices: traditional computer companies like Hewlett Packard were focused on providing smaller versions of the PC that could be carried anywhere in a pocket or a purse; traditional electronic organizer makers like Sharp and Casio sold devices that focused on the organizer functions such as scheduling, to-do lists and note-taking, while telecommunications companies such as ATT and Motorola designed

[13] http://support.apple.com/kb/TA39904?viewlocale=en_US
[14] "PDAs: what will it take to satisfy users?", Electronic Design, 16 December 1994, Vol. 42, No. 26, pg-49

"personal communicators" that provided wireless connectivity and used data networks to send emails and faxes.

The key trade-offs facing PDA makers at the time were size of the device versus the number of features supported and battery-life versus speed of the processor (the semiconductor chip powering the device). As the number of features increased the size of the device increased. Also more complex features could also be effectively used with a faster processor. However the faster the processor, the more power it consumed, reducing the battery life of the device. Most of the early devices failed because they were either too big and bulky or too slow or required recharging of the batteries every couple of hours. In addition, the devices that offered wireless communication capabilities also faced two other challenges:

- Lack of standardization of wireless communication protocols: As a result wireless modems were often not included as a part of the device and had to be purchased separately by users, adding to the total cost of the device. Modems were also tied to specific networks and could not be used interchangeably.
- Slow network speeds: This limited the applications that could be effectively used and restricted the user base to corporate road warriors who needed critical access to emails and corporate networks when on the road.

PalmPilot, released in 1996, was the first successful PDA. Makers of the Pilot made the right set of trade-offs and focused on building a device that was small enough to fit into a shirt pocket and had a great battery-life. To meet these goals, they chose to use a slower processor and limited the applications supported by the device. The essence of the device was simplicity.

While devices, now known as smartphones, that combined the organizer and wireless data communication features of PDAs along with the voice capabilities of cellular phones have existed since 1994 – the earliest of these being Simon, built by IBM and sold by BellSouth Cellular (11) – these devices did not take off until the standardization of cellular wireless networks in the U.S. around GSM and CDMA standards, and the subsequent expansion of these voice networks to support packet data around 2001-2002[15].

The market for PDAs reached its peak in 2002 and started shrinking thereafter as the market for smartphones took off.

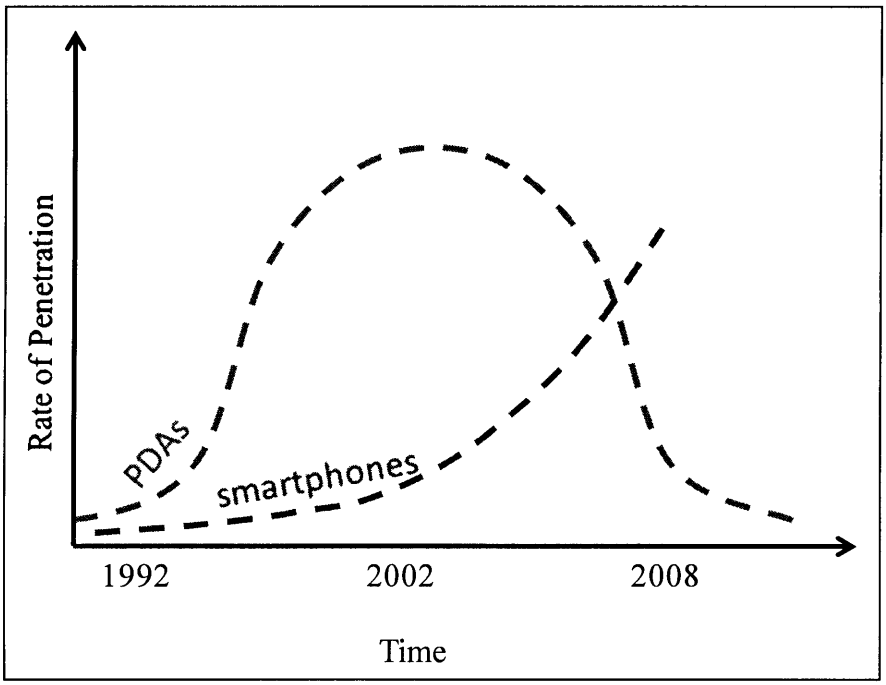


Figure 11: Conceptual Representation of Adoption Curves for PDAs and Smartphones[16]

[15] http://news.zdnet.co.uk/hardware/0,1000000091,2080038,00.htm
[16] Based on review of market reports; not to scale, not based on actual numbers

3.4 Innovation in Mobile Telephony

Applying the technology evolution cycle theory to mobile telephony, Koski and Kretschmer (12) demonstrate the pattern of innovation in the mobile phone market. They show how innovations on the system level (e.g. infrastructure, technological standards) were followed by innovation in technological components enabling improved product characteristics such as lower weight and longer talk time. Once these technological improvements stagnated, a flurry of new features such as games and ringtones were introduced.

Following the nomenclature used in standard EU publications, Koski and Kretschmer classify these innovations into horizontal innovations and vertical innovations, where:

- Vertical innovations allow firms to differentiate products on the basis of technological superiority. This establishes a clear quality ranking in the eyes of all consumers; a better product is one with better individual characteristics. Assuming equal prices, buyers would choose a product with higher "quality" attribute, e.g. faster processor, longer battery life.
- Horizontal innovations allow firms to differentiate products on the basis of additional product features. Ranking of horizontal innovations is less straightforward. Two products with different added features, e.g. different styles and colors, would appeal to different user groups. However, here the principle of "more is better" also applies: given equal prices, a product with a particular feature is better than the same product without.

Horizontal and vertical innovations that are widely imitated form part of the dominant design, e.g. touchscreen, which was a revolutionary feature when Apple released the iPhone are now points of parity across a variety of mobile phones.

Koski and Kretschmer found that vertical innovations come mainly before settling on a dominant design and horizontal ones set in after a dominant design has been found. They explain this on by relating the incentive to innovate to the nature of demand. In the early market, technological advancements lead to relatively large increase in consumers' marginal utility and thus demand. This gives firms incentive to invest in quality improvements i.e. vertical innovations. Market shifts towards manufacturers with highest quality, giving others the incentive to imitate. As a result variation in quality tends to diminish over time leading to standardization of performance or quality levels. In mature markets, when quality is already relatively high, consumers' marginal utility from further quality improvements decreases. Mass market consumers are also more heterogeneous as compared to the early adopters, which drives the need to differentiate products. Since manufacturers cannot differentiate on the basis of quality, the focus of innovation shifts to adding additional/unique features targeted to different user groups i.e. horizontal innovation. In case of handsets, the first technological era revolved around improving technological performance and reducing the size and weight of handsets. Once new handset models became increasingly homogenized around these attributes, to attract new users as well as stimulate replacement demand from existing users, manufacturers focused on designing in additional features such as color displays, games, multimedia messaging and cameras.

Koski and Kretschmer's findings on the horizontal and vertical innovation patterns in global handset markets during 1992-2003 are summarized in Figure 12.

Type of Innovation		Dominant Design	Differentiation
	Vertical		Weight Talk-time Standby-time
	Horizontal	Speed dialing Vibration alert SMS Clock Games	PC Synchronization www capability Number of ringtones Colors Alarm clock Calculator size/dimensions

Figure 12: Horizontal and Vertical Innovation Patterns in Global Handset Markets[17]

Koski and Kretschmer observed that while handsets have become more homogenized in their technical performance and weight, there is considerable variation in handset design (form-factor) and dimensions. Certain horizontal innovations such as clock, games etc. have become common enough to constitute a dominant design at the level of additional features, while others such as colors and alarm clock remain differentiating features.

Appendix B shows a comparative feature list available in some of the current phones.

[17] Innovation and Dominant Design in Mobile Telephony, Koski, Heli; Kretschmer, Tobias; Industry and Innovation, July 2007, Vol 14, Iss 3, pp 305-324

The first BlackBerry smart phone offered "push" Email, Phone, SMS, Organizer, Corporate Data Access and Wireless Internet. It was a standard form-factor with full QWERTY keyboard, monochrome screen and 8 MB of flash memory. It operated on second-generation of (cellular) voice and data networks. Overtime, the BlackBerry has evolved to include camera, media player, Bluetooth, Wifi and GPS, a color screen, not to mention steady expansion of device memory size to support the applications based on these additional hardware capabilities such as maps, video recording and social networking. RIM has also significantly improved its media player to support a wide variety of audio and video formats. Third generation (3G) cellular networks offer the speeds required to support these mobile internet applications.

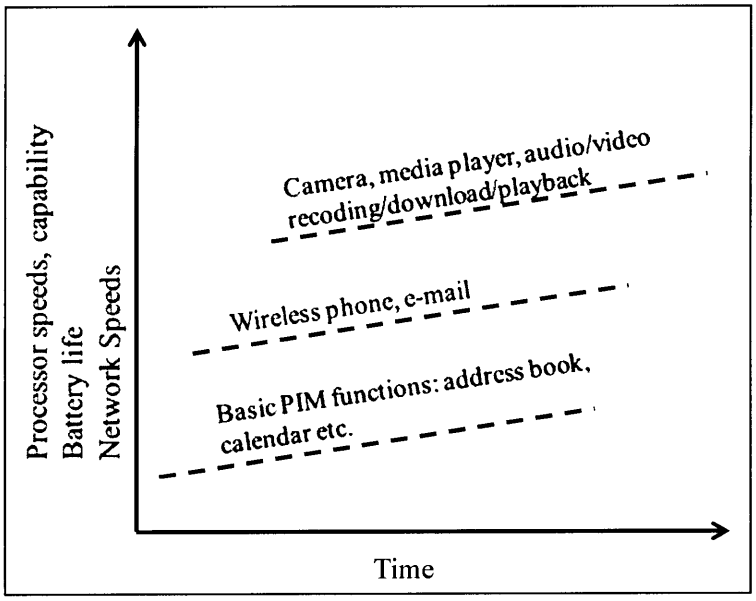


Figure 13: Conceptual Illustration of Evolution of PDA/Smartphone Features with improvemnt in Technology[18]

Until about 2006, the BlackBerry was staunchly an enterprise device, well integrated into corporations along with the BlackBerry Enterprise Server, which supported Microsoft Exchange

[18] Not to scale, not based on actual numbers

Server and Lotus Notes and Domino for corporate email and Personal Information Management (PIM). RIM targeted prosumers and consumers in a big way through the launch of BlackBerry Pearl, a candybar size phone with a compressed keyboard based on RIM's Suretype technology. The Pearl was the first BB device to include a camera and a media player.

2008 saw the launch of four new BlackBerry devices, an unprecedented occurrence for the company that typically launches one new product a year. RIM launched its first flip phone as well as its first touch screen device. The steady introduction of devices with new and compelling features and applications targeted to consumers along with drop in the prices of smartphones, has contributed to explosive growth in RIM's subscriber base from 2 million in 2004 to roughly 21 million at the end of 2008[19].

[19] http://www.rim.com/company/pdf/RIM_History.pdf
http://www.rim.com/investors/pdf/Q3F09_MDA_FS_PR.pdf

4 Case Study of handheld devices

We looked at the adoption cycle of PDAs and smartphones and picked five products that were representative of specific eras along the adoption curve. We studied the design of these products applying the framework developed in Chapter 2. We attempt to explain the success or failure of these products in the market based on the Design Strategy Framework i.e. was the product design strategy appropriate given the performance and maturity of component technologies and the market conditions of the time. Rather than offering "a mismatch between actual and recommended product design strategy" as an irrefutable explanation for a product's failure in the market, this thesis offers it as one of the possible explanations. Co-evolution of product design strategy with technology and market strategies has not been studied in much depth. This thesis attempts to shed further light on this topic by identifying patterns that demonstrate a plausible link.

The five products selected are Apple Newton Message Pad, Palm Pilot, Research In Motion BlackBerry 857, Motorola Q and Apple iPhone. The data used in these product studies came from articles in business and trade publications between 1993 and 2008 taken from Dow Jones Factiva database.

4.1 Apple Newton MessagePad (1993)

Apple's Newton MessagePad[20] was one of the first such devices to enter the Personal Digital Assistant (PDA) market. In fact, the term Personal Digital Assistant was first introduced in 1992 by Apple's then CEO John Sculley with reference to Apple Newton (10).

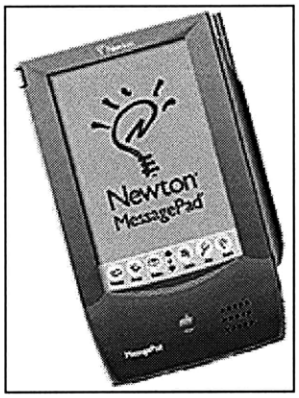


Figure 14: Apple Newton MessagePad

The Newton was positioned as a handheld computer with a pen-based input mechanism and handwriting recognition software that would make the device easy to use and a replacement for the personal computer (13). But upon its release was perceived as a glorified executive organizer, with scheduler, calendar and notepad (14 p. 52). Apple had originally targeted the Newton as a mass-market consumer item (14), but given its launch price-tag of around $700, shifted focus to target business travelers.

[20] In this section, Apple Newton MessagePad, Newton and MessagePad are used interchangeably and refer to the first-generation Newton MessagePad product from Apple Computers Inc.

Features

Newton was a handheld wireless communicator that could link personal files, addresses and lists. It had a pen-based input mechanism and much hyped handwriting recognition software that could convert handwriting to text.

Intelligent Assistance

Apple was betting on differentiating the Newton based on a unique feature known as "intelligent assistance". This feature purportedly understood plain English statements, such as "lunch with John on Thursday" and translated it into an appropriate calendar entry.

Handwriting Recognition

The second key feature of the Newton was its handwriting recognition technology, which purportedly took free-form handwriting and converted into appropriate text entries for various applications.

The Newton did not have an internal modem for wireless data communication, but an add-on modem module could be attached to the device. This along with a PC connectivity kit raised its price to about $1300 (15). Table 2 summarizes the Newton MessagePad's features and key specifications.

Specifications and Features	
Processor Type:	ARM 610
Processor Speed	20 MHz
Battery Type	4 AAA/NiCad Recharge
Battery Life	5-10 hours continuous use
	1-2 weeks average use
Dimensions	7.25 x 4.5 x 0.75 (inches)
Avg. Weight	0.9 lbs
Display	336x240 pixel Black & White
Price	$700
Features	
Built-in Applications	Contacts, Address Book, Calendar, To-do lists, Notes
	Free-form notetaking -- mixing ink handwriting, printed text, and graphics all on the same page
	Converts handwriting to text
Communication Capabilities	Send notes, echange business cards with other Newton users via built-in Infra-red technology
	Send documents to printers
	Send faxes, send/receive email with optional fax model
	Receive paging messages with optional pager modem
	Synchronize files with PC using Connectovity kit
Intelligent Assistance	Actively assists in completing tasks

Table 2: Apple Newton MessagePad Specifications and Features[21]

Market Reaction

Despite being well-designed and intending ease of use, Apple's Newton MessagePad was a commercial failure. It did get the attention of technology enthusiasts and sold 50,000 units in the first month. However sales soon declined dropping to an average of 7,500 units over the following four months (15).

[21] Source: http://www.everymac.com/systems/apple/messagepad/stats/newton_mp_omp.html
https://www.msu.edu/~luckie/gallery/mp100.htm

What Went Wrong?

When the Newton was released, its much-hyped handwriting recognition software got more attention for what it couldn't do than what it could. The handwriting recognition technology was not evolved enough and intelligent assistance capability on the device was relatively primitive and only marginally useful. Thus the very features that were supposed to make the device user friendly and easy to use did not work very well.

But the real issues went deeper than that. Originally Apple had targeted the Newton towards the mass-market consumers with ease-of-use being the primary selling point. Later, recognizing that consumers are very price-sensitive and would not be receptive to the original launch price of $700, Apple shifted focus to target corporate road warriors. But the Newton did not deliver on the key attributes that are valued by business travelers. They found it too big and bulky (weight close to 1 lb.), slow and frustrating to use with poor battery life (16).

This was true not just of Newton, but of all PDAs in the market at the time. As explained in Chapter 2, in the early market, adopters are attracted to products that offer a better solution than current products on the market. The following quotes illustrate the perceptions of PDAs in this regard.

> *"So far, these PDAs are more frustrating to use and more time-consuming than what they purport to replace. They are beta test products being sold as commercial products."*
>
> - Alan Reiter, editor of Mobile Data Report, a newsletter in Alexandria, VA (17)

"I've heard people say that ease of use is one of the key barriers, but I think that's completely wrong. The problem is that they don't do anything useful."

- Nathan Myhrvold, Senior Vice-President of Advanced Technology at Microsoft (15)

Apple and other PDA makers did not factor in the limitations of the component technologies available at the time. They put in device features that stretched the limits of the current technology and as a result compromised the overall performance and quality of the product. In the early market, users are more concerned about performance and device capabilities. Placing Apple's approach on the Design Strategy Framework in Figure 15, we see that they fall in the middle-left box, whereas early market strategy calls for them to be in the top-left box and focus on technology and capability as opposed to ease-of-use.

Attribute	Product Adoption Life-Cycle		
	Early	Mainstream	Late
Usefulness	X		
Usability	O		
Desirability			

Legend	
	Critical attribute requiring design emphasis in a given life-cycle phase
	Performance on the attribute should maintain levels achieved in previous life-cycle phase. No additional effort beyond sustaining incremental improvements required
	These attributes can be ignored in a given life-cycle phase
X	Ideal area of design emphasis recommended by the Design Strategy Framework
O	Actual area of design emphasis for Apple Newton

Figure 15: Apple's Position in the Design Strategy Framework

It is not uncommon for early devices to fail during the era of ferment as companies experiment with different features and designs. As these get ironed out, a dominant design emerges. But, Apple, even in subsequent generations of the MessagePad could not effectively meet all the early market requirements though it improved the handwriting recognition software by including Palm's Graffiti software. The Newton never became a part of the dominant design for PDAs and was ultimately discontinued in 1998.

The next section looks at how Palm approached this problem and made the Pilot one of the most successful PDA products.

4.2 Palm Pilot (1996)

The founders of Palm originally developed the operating system and software for PDAs such as Zoomer. When devices such as Zoomer failed to take hold in the market, Palm founders were convinced that it was because these devices were too bulky and complex and tried to do too much. They were confident that they could create better hardware. The Pilot was the first generation of PDAs developed by Palm Computing in 1996. Later, due to a copyright infringement lawsuit, the name was changed to PalmPilot[22].

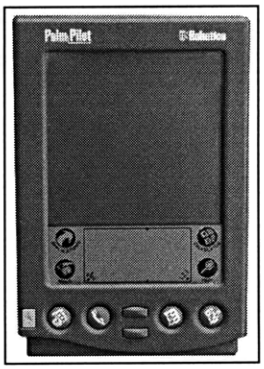


Figure 16: Palm Pilot

The Palm Pilot was targeted towards a travelling business person with a personal computer and carried a price-tag of $299. Its primary function was Personal Information Management (PIM) i.e. providing access to a user's address book and calendar while the user is away from their computer.

[22] In this section, Pilot, PalmPilot and Palm Pilot are used interchangeably and refer to the first generation Pilot PDA from Palm Computing Inc.

Features

The key features and specifications of the Pilot are summarized in Table 3. The two key functional requirements – first, the ability to synchronize information between the device and a computer and second, the ability to enter small amounts of new information into the device - were enabled by two innovative technologies (18):

HotSync

Pilot came with a cradle that attached to a serial port on the computer. Users placed the device in the cradle and had the ability to synchronize data between their computer and PDA by pressing a single button. Pilot also came with its own PIM software, but also had the ability to synchronize with other popular desktop PIM software packages such as Lotus Organizer. This easy synchronicity is what distinguished Pilot from other PDAs as well as other electronic organizers.

Graffiti

Entering data into the Pilot required users to learn Graffiti. Instead of investing in improving handwriting recognition technology to be able to decipher squiggly, cursive writing, Pilot had users meet it halfway by learning to write in a slightly modified alphabet. This standardization of letters and numbers greatly improved the device's handwriting recognition capabilities.

Design

A key design goal was that the device should be able to fit into a shirt pocket (13). The Palm Pilot, when launched, weighed 5.7 ounces and was 4.7" x 3.2" x 0.7" (L x W x D), compared to Apple Newton, which weighed 19 ounces and measured 7.25" x 4.5" x 0.75".

The user interface featured four buttons for one-touch access to standard applications – calendar, address manager, to-do list and memo pad. There was an on screen menu for access to other applications. Since the Pilot was developed specifically as a complement for a PC, the device shipped with a cradle that, again, provided easy one-button push ability to synchronize with the computer.

"...it is not just having a feature, it's all about execution. Backup technology existed when we invented HotSync, but we felt one-touch, no-brained synchronization was critical if you wanted to synchronize frequently..."

- Rob Haitani, Product Manager for first generation Pilot[23]

[23] Information Appliances and Beyond, 2000, edited by Eric Bergman, pp-83

Specifications & Features	
Processor Type:	Motorola dragonball 68328
Processor Speed	16 MHz
Battery Type	2 AAA
Battery Life	Heavy use: 3-4 weeks Normal use: 7-8 weeks
Dimensions	4.7 x 3.2 x .7 inches
Avg. Weight	5.7 oz
Display	160x160 pixel; 4-shade monochrome (no backlight)
Price	$299
Built-in Applications	Date book, Address book, To-do list, Calculator, and Note-taking applications
	Compatibility with existing PIM software.
	Support for applications including Ascend, from Franklin Quest Co.; DataSync, from IntelliLink Corp.; Lotus Organizer; Miscrosoft Office etc
Communication Capabilities	Companion desktop PIM and connectivity software
	One-Touch PC Connectivity through an innovative desktop cradle and HotSync technology
Speed and Simplicity	Easier and faster to use than pen and paper
Extendible Architecture	Small, pluggable memory module that is user- replaceable for adding memory or upgrading software.
	Ability to attach communications add-on products, such as modems and pagers, as they become available

Table 3: Specifications and Features of First-Generation Palm Pilot[24]

[24] Source: http://www.palminfocenter.com/news/8493/pilot-1000-retrospective
http://www.computerhope.com/issues/ch000092.htm

Market Reaction

Palm succeeded in reviving a languishing PDA market. In two years since its launch Palm Pilot sold more than a million units compared to 140,000 Newtons that Apple sold in its first two years.

Why did Palm Succeed?

The essence of the Palm Pilot was simplicity. Previous handheld devices tried to position themselves as standalone machines, potential replacements for portable computers (19). As such, they required strong data-entry and editing capabilities. But the ones with keyboards, had keyboards that were too small and difficult to use, while pen-based devices, such as the Newton, were based on handwriting recognition technology that wasn't yet reliable. Secondly, these devices were too large and bulky to be carried around easily. Finally, they were too complex as a result of trying to do too much, which also resulted in the devices being slow and having poor battery-life. Palm Pilot was positioned portable accessory to a personal computer, not a standalone device.

The makers of the Pilot respected the limitations of the available technology and made judicious trade-offs to optimize the useful features, battery-life and processor capabilities. Recognizing that using a faster processor would compromise the battery-life, given the then state of battery technologies, they opted to use a slower processor. They also realized that running a complex operating system and advanced applications on a slow processor would only result in slow response times and frustrating user experience; and made a conscious choice to simplify the operating system and limit the applications running on the device. They stuck to the design goal

of making the device portable and light-weight enough to comfortably fit in a shirt-pocket. Choosing to keep things simple also allowed them to keep their cost low and sell the device at $299. They focused on offering a solution that worked better than any existing product in the market – a key requirement for success in the early market.

Palm correctly positioned the Pilot for attracting the early adopters (Figure 17). While ease-of-use and small size were key to the success of the Pilot, these would not have helped without the Pilot delivering acceptable quality of functionality within the constraints of the available technology. By focusing on making the device "useful", Palm ensured the runaway success of the Pilot.

Attribute	Product Adoption Life-Cycle		
	Early	**Mainstream**	**Late**
Usefulness	XO		
Usability			
Desirability			

Legend	
	Critical attribute requiring design emphasis in a given life-cycle phase
	Performance on the attribute should maintain levels achieved in previous life-cycle phase. No additional effort beyond sustaining incremental improvements required
	These attributes can be ignored in a given life-cycle phase
X	Ideal area of design emphasis recommended by the Design Strategy Framework
O	Actual area of design emphasis for Palm Pilot

Figure 17: Palm Pilot's Position in the Design Strategy Framework

Another example of a successful product that focused on a niche application to gain foothold into the handheld devices market is Research In Motion's BlackBerry.

4.3 Research In Motion BlackBerry 950 (1999)

"By focusing on the costs and benefits of the entire e-mail habit, rather than just enabling the basic functionality, RIM BlackBerry did for e-mail what Palm did for the datebook." (20)

When the first BlackBerry device, known at the time as Interactive Pager 950, was launched, there were other devices in the market that offered wireless email capability. But they required the use of a separate email address for the wireless device. BlackBerry was the first to offer access to corporate e-mail. It did this by directing user's email from the corporate server to their BlackBerry device without requiring a separate email address. Other devices also had keyboards that were difficult to use. Even on devices from Palm and HandSpring that were extremely well designed and easy to use for PIM functions, the handwriting recognition/pen-based input system did not lend itself to speeds required to respond to emails on-the-go (21). Research in Motion (RIM) had designed a full QWERTY keyboard that while small, was extremely functional.

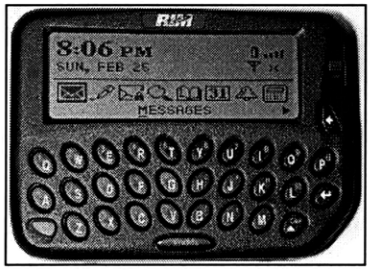


Figure 18: RIM Interactive Pager 950

RIM changed the name of the device to BlackBerry after a lexicon strategist thought that the gadget's keyboard resembled the seeds of a berry. RIM strategically targeted both the mobile professionals who needed to keep up with their e-mail while on the road as well as the information-technology departments of corporations that employed these professionals (22). This was important since the BlackBerry solution required the deployment of a server-side software called BlackBerry Enterprise Server, which "pushed" corporate email directly to employees BlackBerry devices. Purchase of this software, which cost $2999 (23) had to be done by corporations not individuals. So, it was essential to get corporate IT experts "sold" on the solution. The device itself cost $399 and required a $40 per month service which provided unlimited access to wireless email (23).

Features

The key features of BlackBerry 950 are summarized in Table 4. In addition to the device itself, RIM provided everything needed to make the solution work: the software (operating system), the servers that routed e-mail from the wired network and the airtime that RIM leased from mobile-phone carriers (24). The innovative components of this solution were:

"Push" E-mail (25)

Push e-mail refers to e-mail systems that provide an "always-on" capability, in which new e-mail is instantly and actively transferred (pushed) as it arrives by the mail server to the e-mail client including smartphones. This is in contrast to the polling email delivery protocol where the email client) polls the server to see if there is new mail, and if so downloads it to a mailbox on the user's computer. Although

push e-mail had existed in wired-based systems for many years, BlackBerry service from RIM was one of the first uses of the system with a portable, "always on" wireless device.

BlackBerry Enterprise Server

RIM's BlackBerry uses wireless devices and a BlackBerry Enterprise Server (BES) attached to a traditional e-mail system. The BES monitors the e-mail server, and when it sees new e-mail for a BlackBerry user, it retrieves (pulls) a copy and then pushes it to the BlackBerry handheld device over the wireless network. These servers were installed in customers' IT departments and allowed users to send and receive email from almost anywhere. The servers also allowed for the coordination of wired and wireless email, so that customers could use their BlackBerries to access the email accounts they used at the office (24).

Keyboard and Navigation

Measuring 2.4 x 3.5 x 0.93 inches and at 4.7 ounces, the first BlackBerry pager was conveniently sized. To make small keyboards more usable for typing emails on-the-go, RIM introduced the concept of "thumb" typing, which also allowed single-handed device operation. RIM augmented the keyboard with a well-designed thumbwheel, which allowed easy scrolling through long emails.

Specifications & Features	
Processor Type:	Intel 80386*
Processor Speed	~25 MHz **
Battery Type	1 AA Alkaline
Battery Life	Approximately 3 weeks data/email usage
Dimensions	2.4 x 3.5 x 0.93 inches
Avg. Weight	4.7 oz
Display	User selectable 6 or 8 line display
Price	$399
Built-in Applications	Wireless email, organizer, wireless calendar, wireless internet, paging
Communication Capabilities	Embedded RIM wireless modem
	Works on 900 MHz Mobitex network
Email Account Compatibility	Integrates with existing enterprise email account, integrates with a new handheld email account
Keyboard	QWERTY keyboard
Navigation	Thumb-operated trackwheel and ESC key
Notification	Tone, vibrate, on-screen or LED indicator
Other	Includes BlackBerry Desktop software and docking cradle
	Works with BlackBerry Enterprise Server

Table 4: Specifications and Features of BlackBerry 950[25]

Market Reaction

While its calendar and contact management functions were primitive compared to Palm based PDAs, the BlackBerry Pager quickly gained popularity for doing one thing really well – e-mail (26). This was in part because it offered remote users "instant" e-mail; new e-mails appear on the

[25] Source: http://www.blackberrycool.com/2005/07/rim-circa-1999-blackberry-history-revisited/2/
http://www.intel.com/pressroom/kits/quickreffam.htm

device as soon as they arrive, without the need for any user intervention. The handheld became a mobile, dynamically updating, copy of the user's mailbox.

The popularity of the BlackBerry led to terms such as "CrackBerry" becoming part of popular lexicon. (the ability to read e-mail that is received in real-time, anywhere, has made the BlackBerry devices infamously addictive, earning them the nickname "CrackBerry") (27).

As a result of the success of BlackBerry, other manufacturers have developed push e-mail systems for other handheld devices, such as Symbian- and Windows Mobile-based mobile phones (25).

BlackBerry's Success

Like Palm, RIM focused on solving one critical problem facing mobile professionals – convenient wireless access to corporate emails. It developed the required component technologies to deliver a complete solution, in other words a "whole product", and provided a solution that worked better than anything that existed in the market. Figure 19 shows how RIM correctly placed the BlackBerry for success in the still emerging market.

"It has allowed me to transcend inbox anxiety. I never need to go to my computer and say, 'look at all this email,'"

- Seth Goldsein, New York Venture Capitalist (28)

Attribute	Product Adoption Life-Cycle			
		Early	Mainstream	Late
	Usefulness	XO		
	Usability			
	Desirability			

Legend	
	Critical attribute requiring design emphasis in a given life-cycle phase
	Performance on the attribute should maintain levels achieved in previous life-cycle phase. No additional effort beyond sustaining incremental improvements required
	These attributes can be ignored in a given life-cycle phase
X	Ideal area of design emphasis recommended by the Design Strategy Framework
O	Actual area of design emphasis for BlackBerry

Figure 19: BlackBerry 950's Position in the Design Strategy Framework

BlackBerry Evolution

BlackBerry devices used to operate on dedicated point-to-point data networks that used the DataTac and Motibex standards. These first-generation data networks offered data rates of the order of 8 – 19.2 kbps on these networks meant that email attachments and images could not be effectively transmitted. By 2002, a new non-voice international wireless standard, the General Packet Radio Service (GPRS), had emerged. GPRS uses existing Global System for Mobile Communication (GSM) cellular networks and converts wireless data into standard internet packets, enabling interoperability between the internet and the GSM network at up to ten times

the speed of prior systems. The convergence of voice and data networks enabled email to be sent and received on cell phones and led to the birth of smartphones. The market for smartphones started growing while the PDA market was shrinking. The first BlackBerry device to support both voice and data was BB 5810, launched in 2002.

As mentioned in Chapter 3, with improvement in network speeds, processor capabilities and battery technology, more sophisticated applications started appearing on advanced cellphones and smartphones. The evolution of the BlackBerry is covered in Appendix C. Although a number of competitors had since launched similar offerings, BlackBerry strength in mobile wireless corporate email also made it a dominant player in the smartphone market.

Everybody in the business is trying to be the BlackBerry killer.
- Clint Wheelock, vice president of wireless research, NPD Group, 2005 (29)

4.4 Motorola Q (2005)

Prior to 2005, Motorola, which was one of the leaders in the cellular phone market in the U.S. did not have any offering in the smartphone segment. This changed after the arrival of Ed Zanders as the new CEO in 2004. Anticipating growth in mobile email usage, Zanders wanted a "BlackBerry-like" device to be a part of Motorola's future roadmap (30). Pursuing a radically revamped product development strategy where design led and engineering followed, Motorola had just launched the blockbuster success ultrathin Razr phone. Motorola's smartphone development team decided to draw inspiration from the Razr for the design of their "BlackBerry-killer" and even internally referred to the device as "Razrberry"!

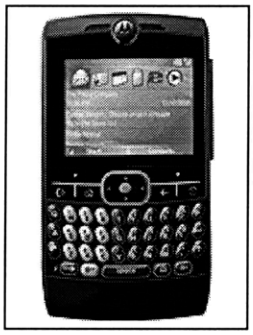


Figure 20: Motorola Q

When it was launched, Motorola's smartphone, Q[26], was the thinnest QWERTY device (29) in the market at 0.45 inches thick and weighing 4 ounces. Moto Q, at $199, was targeted towards corporate users but projected as suitable for enterprise and casual users alike (31).

[26] In this section, Motorola Q, Moto Q and Q are used interchangeably and refer to Motorola's Q smartphone released in 2005

Features

Table 5 summarizes the features and specifications of Q. As we can see, with network speeds, processor capability and battery technology improving, manufacturers were continuously adding new features to the devices. Motorola Q had a feature list in par with the leading smartphones in the market at the time (compare to BlackBerry device features in 2005 listed in Appendix C).

Specifications & Features	
Processor Type:	Intel XScale PXA272
Processor Speed	312 MHz
Battery Type	Li-Ion, 1170 mAh
Battery Life	Stand-by - up to 240 hours; Talk time (continuous) - up to 5 hours
Dimensions	4.57 x 2.48 x 0.45 inches
Avg. Weight	4.06 oz
Display	Stand-by - up to 240 hours; Talk time (continuous) - up to 5 hours
Price	$199 (with service contract)
Built-in Applications	Multi-media messaging (MMS)
	Audio formats supported: iMelody, MIDI, MP3, AAC, WAV, WMA, WAX, QCELP
	Image formats supported: GIF87a, GIF89a, JPEG, WBMP, BMP, PNG
	Video formats supported: H.263, MPEG-4, GSM-AMR, AAC, WMV
	PIM functionality with Picture Caller ID
	Advanced speech recognition and speakerphone
	Mobile Phone
Communication Capabilities	Connectivity via Bluetooth, IrDA and mini-USB
	CDMA model with 800/1900-MHz bands, CDMA2000 1x and CDMA2000 EV-DO networks.
	GSM 850 / 900 / 1800 / 1900 + GPRS/EDGE Data
Additional Hardware Features	1.3 megapixel camera with photo lighting
	Video capture and playback
	Mini-SD removable memory card slot
Keyboard	QWERTY thumbboard
Navigation	5-way navigation button and thumb wheel
Notification	Thumb-operated trackwheel and ESC key
Other	Ability to synchronize via USB or Bluetooth to a Microsoft Outlook or Microsoft Exchange Server database via Microsoft ActiveSync.

Table 5: Motorola Q Specifications and Features[27]

[27] Source: http://en.wikipedia.org/wiki/Motorola_Q
http://www.gsmarena.com/motorola_q-1232.php

Market Reaction

Unlike the instant wild success of Razr, the Q did not take-off as expected. Its price was attractive, but despite this and its sleek, polished looks, Motorola Q did not dethrone BlackBerry as the market-leading smartphone (32).

Why Did the Design Strategy that Worked So Well for Razr Not Work with the Q?

The answer lies in the position along the adoption curve for each of these devices. The cellular phone market in the U.S. had already reached the maturity stage for voice and basic data services, with penetration of over 80%. The technology was mature, and features and performance were well-established. In the mature stage of the market, different products are on-par as far as the feature-set and performance is concerned; they get differentiated based on brand, design and style. By focusing on stylish design, Motorola was able to differentiate its product - Razr - in a mature and saturated market.

Smartphones, on the other hand, were just entering the early mainstream market. Basic features and requirements had been identified, technological performance had standardized and a dominant design had been established. Once the dominant design emerges is when the market truly starts to take-off. Factors such as stable performance, ease of use and price are the important drivers of purchase at this point.

For the Motorola Q, user reviews and reports indicated low satisfaction with the user interface, menu selection, keyboard use, screen resolution, battery life as well as with performance of basic tasks.

> *"The Q is a mixed bag. Its hardware is elegant. Its software is annoying, often requiring two clicks to do what takes one on the Palm."* (32)

The Q had all the right features and a price point that made it competitive to other products on the market, but did not deliver in terms of stable performance and ease of use, the bar for which had been set by market leaders such as Palm and BlackBerry devices.

Figure 21 and Figure 22 compare Motorola Q's and Razr's respective positions in the Design Strategy Framework.

Attribute	Product Adoption Life-Cycle			
		Early	Mainstream	Late
	Usefulness			
	Usability		X	
	Desirability		O	

Legend	
	Critical attribute requiring design emphasis in a given life-cycle phase
	Performance on the attribute should maintain levels achieved in previous life-cycle phase. No additional effort beyond sustaining incremental improvements required
	These attributes can be ignored in a given life-cycle phase
X	Ideal area of design emphasis recommended by the Design Strategy Framework
O	Actual area of design emphasis for Motorola Q

Figure 21: Motorola Q's Position in the Design Strategy Framework

Attribute	Product Adoption Life-Cycle			
		Early	Mainstream	Late
	Usefulness			
	Usability			
	Desirability			XO

Legend	
	Critical attribute requiring design emphasis in a given life-cycle phase
	Performance on the attribute should maintain levels achieved in previous life-cycle phase. No additional effort beyond sustaining incremental improvements required
	These attributes can be ignored in a given life-cycle phase
X	Ideal area of design emphasis recommended by the Design Strategy Framework
O	Actual area of design emphasis for Motorola Razr

Figure 22: Motorola Razr's Position in the Design Strategy Framework

The "usefulness" criteria is established by the emergence of a dominant design in the space. This reduces a lot of the uncertainty regarding market requirements for new entrants, who do not face the "trial and error" experimentation that the early market players did. To grow their share of the market, new entrants have to provide stable performance on the required features, but distinguish themselves with superior usability characteristics. This is even more important in the smartphone market. As we have seen, with technological progress, the number of features that smartphones can effectively support has grown – the devices are now truly handheld computers. But each additional feature adds to the complexity of the device and reduces its usability. Emphasizing

ease of use in product design is key to gaining market share in a rapidly expanding mainstream market. The next product in this study has successfully managed to do this.

4.5 Apple iPhone (2007)

Apple's iPhone launched amidst huge-fanfare in summer 2007 (33) with reportedly more than 270,000 units being sold in the first two days. The design of this device boldly challenged the established dominant design for smartphones.

Traditionally mobile phones had been designed to be operated by one hand.

"Handhelds are about doing something else (while using the handheld), they fit within the context of people's active lives."

- Mark Rolston, senior vice president of creative for Frog Design (34)

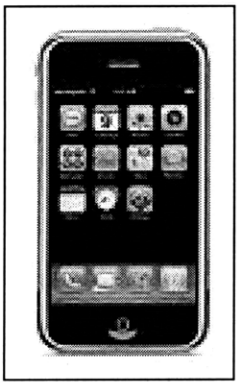


Figure 23: Apple iPhone

Human ergonomics necessitated the use of thumb-operated user interfaces to achieve this goal. This along with the presence of real buttons allowed people to use mobile phones while moving by feeling their way around a keypad, without having to glance at the screen. RIM had even pioneered the design of smartphones with full Qwerty keyboards to be used with one hand. The

term "BlackBerry Thumb[28]" has joined the ranks of "carpal tunnel syndrome", and become a part of popular vocabulary referring to repetitive stress injury resulting from overuse of small gadget keyboards.

Apple changed this design paradigm with the iPhone by introducing a touchscreen user interface. The touchscreen interface with virtual keyboard (and buttons) forced users to adopt a two-handed mode of operation. People would need to look at the screen to make sure they are selecting the right buttons. The virtual keyboard also did not facilitate the speedy typing that mobile business executives demanded and had come to expect for their e-mail and messaging needs.

Features

The key feature list and specifications of the first generation iPhone are list in Table 6. This device, when first launched it did not offer full support for third-party applications development and download and also did not have the ability to multi-task i.e. run more than one application at the same time, for e.g. take notes or access calendar or address book functions while talking on the phone. This led some experts to questions whether the iPhone even fell into the category of smartphones[29].

[28] http://arthritis.webmd.com/news/20050126/blackberry-thumb-real-illness-just-dumb
[29] http://www.engadget.com/2007/01/09/the-iphone-is-not-a-smartphone/

NOTE:

Apple later opened the phone to third-party application developers and launched the Apple AppStore where users can download applications from. The AppStore currently has 25,000 unique applications, and had 300 million downloads as of December 5th 2008[30].

30

http://www.informationweek.com/news/personal_tech/iphone/showArticle.jhtml?articleID=212202251&cid=iwhome_art_iPhon_mostpop

Specifications & Features	
Processor Type:	ARM1176JZF
Processor Speed	412 MHz
Battery Type	Li-Ion
Battery Life	Stand-by up to 300 hours; talk time (continuous) up to 8 hours
Dimensions	4.5" x 2.4" x 0.46"
Avg. Weight	4.8 oz
Display	Capacitive touchscreen, 16M colors, 320 x 480 pixels, 3.5 inches
Price	$299 (with contract)
Built-in Applications	Phone, photocall
	HTML browser
	Messaging SMS, Email, viewable attachment support for .jpg, .tiff, .gif (images); .doc and .docx (Microsoft Word); .htm and .html (web pages); .key (Keynote); .numbers (Numbers); .pages (Pages); .pdf (Preview and Adobe Acrobat); .ppt and .pptx (Microsoft PowerPoint); .txt (text); .vcf (contact information); .xls and .xlsx (Microsoft Excel)
	Google Maps
	PIM including calendar, to-do list
	Photo browser/editor
	Voice memo
	Integrated handsfree
	Audio formats supported: AAC, Protected AAC, MP3, MP3 VBR,
	Video formats supported: H.264 video, up to 1.5 Mbps, 640 by 480
Communication Capabilities	GSM/EDGE (850, 900, 1800, 1900 MHz) + GPRS/EDGE Data
	Bluetooth (headset only)
	USB
Additional Hardware Features	Accelerometer sensor for auto-rotate
	Proximity sensor for auto turn-off
	2 MP Camera
	TV output (firmware 1.1.1)
	iPod audio/video player
Keyboard & Navigation	Multi-touch input method, virtual keyboard
Notification	Downloadable polyphonic, MP3 ringtones, vibration alert

Table 6: iPhone 2G Features and Specifications[31]

[31] Source:
http://www.gadgetadvisor.com/gadgets/apple-iphone-2g-1st-generation-and-3g-2nd-generation-compared
http://www.apple.com/iphone/specs.html
http://www.engadget.com/2007/07/01/iphone-processor-found-620mhz-arm/
http://smokingapples.com/iphone/ipod-touch-2g-processor-faster-than-iphone/

Market Reaction

The iPhone has continued to be a big hit with over 11 million units being sold worldwide in 2008, bringing Apple's market share in the smartphone space to 8.2% behind Nokia (44%) and Reseach in Motion (17%)[32].

Success of the iPhone

iPhone's success can be attributed to the following factors:

1. User experience

   Apple used the touchscreen user interface to drastically improve the smartphone experience for users and make accessing its complex features simple and intuitive.

   The high-end cell phones (feature rich phones) were equipped with camera, music players and internet browsers. However due to small screens and carriers' restricting access to content, the overall multimedia experience was far from satisfactory on these phones. While smartphones had started including consumer-oriented features such as camera and music players, screen size was still limited and they were primarily optimized for corporate email and messaging functions. With iPhone, Apple sought to fill this gap and provide a great multimedia user experience on a high end phone.

   On other smartphones a significant portion of the device is occupied by buttons that are used only when typing. iPhone's user interface allows the virtual buttons to be discarded when the user switches applications leaving more screen real estate to provide a richer experience with

[32] http://apple20.blogs.fortune.cnn.com/2009/03/12/iphone-sales-grew-245-in-2008-gartner/

browsing and video playback applications. Given that some of the mail selling points of the iPhone are the multimedia applications, the lack of one-handed usage model and slower typing seems to be an acceptable trade-off for its users.

2. Familiarity: Leveraging strength of iPod and iTunes

Consumers are trending towards convergence i.e. a single device that meets all their mobile needs. At $499 the iPhone may have seemed expensive to some, but it made sense to those used to carrying an iPod plus a phone. With iPods selling in the $250 range and video iPods costing as much as $350, iPhone allowed users to consolidate their multiple devices without sacrificing their iPod experience. The iPhone, in other words, was already compatible with other aspects of the users' life-style.

> *"Compatibility: The degree to which an innovation is perceived as consistent with the existing values, experiences and needs of potential adopters. Compatibility helps give meaning to the new idea so that it gets regarded as more familiar. In general, compatibility is positively related to the rate of adoption."* (8)

Touch interface was not an entirely new concept for users of iPod and iTouch. While touch was a revolutionary concept for traditional phone, for iPod/iTouch users this interface on the iPhone just represented an evolution of Apple's existing product line. This familiarity aided in the adoption of iPhones. The same innovation may not have been as widely accepted or successful had it been introduced by someone without the same history and credibility with consumers.

Also, given that people were already familiar with the iTunes interface, downloading and playing music on the iPhone was a well-integrated experience. On smartphones and other high-end phones, while possessing media playing capabilities, did not make it as convenient or seamless for users to download content.

While outside the scope of this study, a third critical factor that helped Apple successfully create an alternate dominant design in the smartphone space was the strength of its brand. Apple products had always had a reputation for being well-designed. With iPod, whose operations are extremely intuitive, Apple took this reputation into the mainstream beyond the "techie" macintosh users. The iPhone with its stylish design had the same "wow" factor as the iPod. But style alone would not have made the iPhone successful without Apple also delivering a compelling user experience.

iPhone's positioning along the design strategy-market adoption matrix is shown in Figure 24. By focusing on improving the device usability and user-experience, Apple drove smartphone adoption into the mainstream markets. They were successful in expanding the smartphone market by creating a sub-category of media/entertainment focused devices with a compelling user-experience.

Attribute	Product Adoption Life-Cycle			
		Early	Mainstream	Late
	Usefulness			
	Usability		XO	
	Desirability			

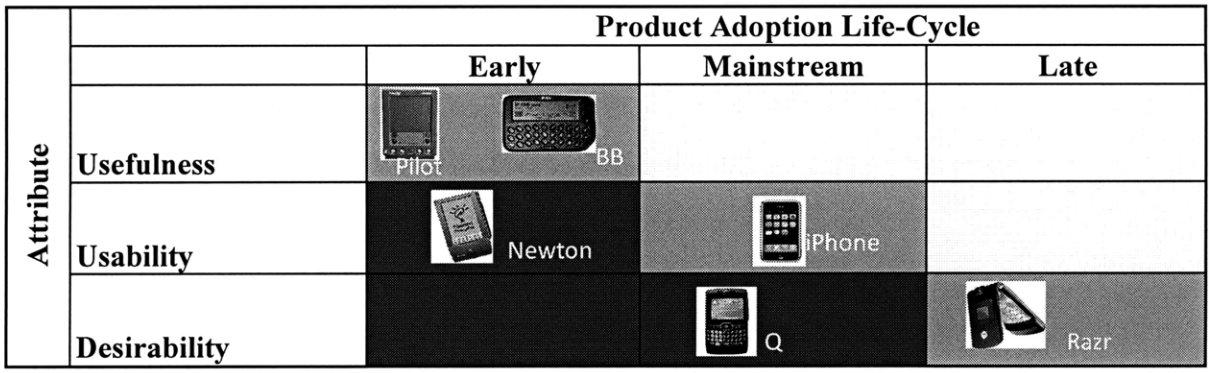
Legend	
	Critical attribute requiring design emphasis in a given life-cycle phase
	Performance on the attribute should maintain levels achieved in previous life-cycle phase. No additional effort beyond sustaining incremental improvements required
	These attributes can be ignored in a given life-cycle phase
X	Ideal area of design emphasis recommended by the Design Strategy Framework
O	Actual area of design emphasis for Apple iPhone

Figure 24: Apple iPhone's Position in the Design Strategy Framework

Summary

Figure 25 summarizes the results of our study. Devices placed along the diagonal of the matrix have experienced market success. One of the reasons contributing to the failure of devices such as Apple Newton and Motorola Q is the emphasis on the wrong attribute at the wrong phase in the product adoption life-cycle. In the early market, it is important to focus on differentiating products by offering a better solution and meeting a real need better than any existing product. Compelling user experience and ease of use are the key design attribute that drive adoption into the mainstream markets. Once the market matures and the field is crowded with products that are

comparable in terms of functionality and usability, the focus must shift to style and aesthetics to differentiate.



Legend	
	Critical attribute requiring design emphasis in a given life-cycle phase
	Performance on the attribute should maintain levels achieved in previous life-cycle phase. No additional effort beyond sustaining incremental improvements required
	These attributes can be ignored in a given life-cycle phase

Figure 25: Summary of Case Study Based on the Design Strategy Framwork[33]

While focus on the right design attribute at the right time is not the only criterion nor by any means a sufficient criterion that ensures a product's success in the market-place, these results demonstrate that it is necessary.

33

Since smartphone market is currently in the early mainstream stages, we have included Razr, which is not a smartphone, in the matrix to illustrate a successful design strategy for a late-stage market.

5 Smartphone Survey

5.1 Introduction

We administered a survey to look for consistency between the proposed framework and user opinion. The goal was to validate the proposed framework by analyzing user responses to questions regarding:

1. The adoption process of smartphones
2. The decision making process with respect to purchase of smartphones
3. Their perceptions regarding smartphones, in particular comparing the two leading brands in the U.S. – BlackBerrry and iPhone

5.2 Analysis of Survey Responses

The survey was administered to the students of MIT SDM program as well as opened to members of my personal and professional network on Facebook. Overall the survey garnered 79 responses.

It is important to note a couple of disclaimers:

1. The audience for this survey tends to be more technologically savvy than the general population. Hence one needs to be careful while generalizing the results of this survey to apply to a broader audience.

2. Respondents self-reported information, meaning that if someone says they are a "late adopter", they may be an "early adopter" in the context of the entire US population, but they perceive themselves to be late adopters among their peers.
3. Given the limited number of responses, the results may not be statistically significant, especially in drawing conclusions regarding early adopters (only 8 respondents in this category). However, the results do provide directional indicators of trends.

The questions in the survey are listed in the Appendix A. The results have been analyzed and summarized below.

5.3 Smartphone Adoption Trends

5.3.1 Adopter Category

We asked the users to self-identify themselves based on their purchase habits for technology products. The question was based on the psychographic characteristics of different adopter groups identified by Everett Rogers (8). To keep the question simple, we grouped Rogers' Innovators and Early Adopters into Early Adopters, Early Majority and Late Majority into Mainstream and Laggards into Late Adopters. The actual question asked in the survey is reproduced below. The category names in parenthesis were not a part of the survey question, and have been added here for clarity.

Question

Select one of the following options to indicate your purchase behavior with respect to technology products:

- I am the first in line to get a new device as soon as it hits the market (Early Adopter)
- I prefer to wait for friends/family/coworkers to use the product and get their recommendation before purchasing new technology products (Mainstream)
- I prefer my current method of doing things and will not switch to a new technology product until I absolutely have to (Late Adopter)
- Don't know

Of the 79 respondents, 10% [8] self-identified as early adopters, 61% [48] as mainstream and 28% [22] as late adopters.

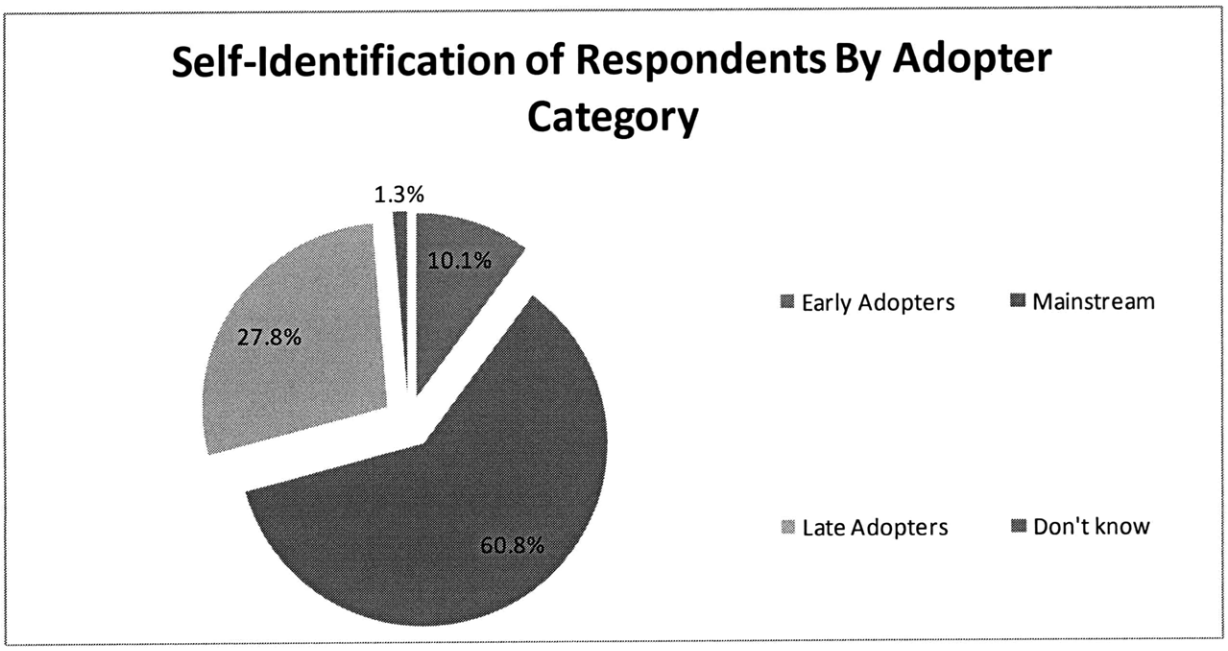


Figure 26: Self-Identification of Respondents By Adopter Category

5.4 Distribution of Types of Handheld Devices Used by Respondents

Next we asked users to select their current mobile wireless device.

Question

What mobile phone do you currently own? (If you own more than one phone, select the option that best represents your primary phone)

- Basic phone (voice, SMS)
- Feature rich phone (includes camera, music player, web access)
- Smartphone (e.g. BlackBerry, iPhone)
- Other

Of all the respondents, 25% [20] said they used basic phones, 29% [23] used a feature-rich phone and 46% [36] used a smartphone.

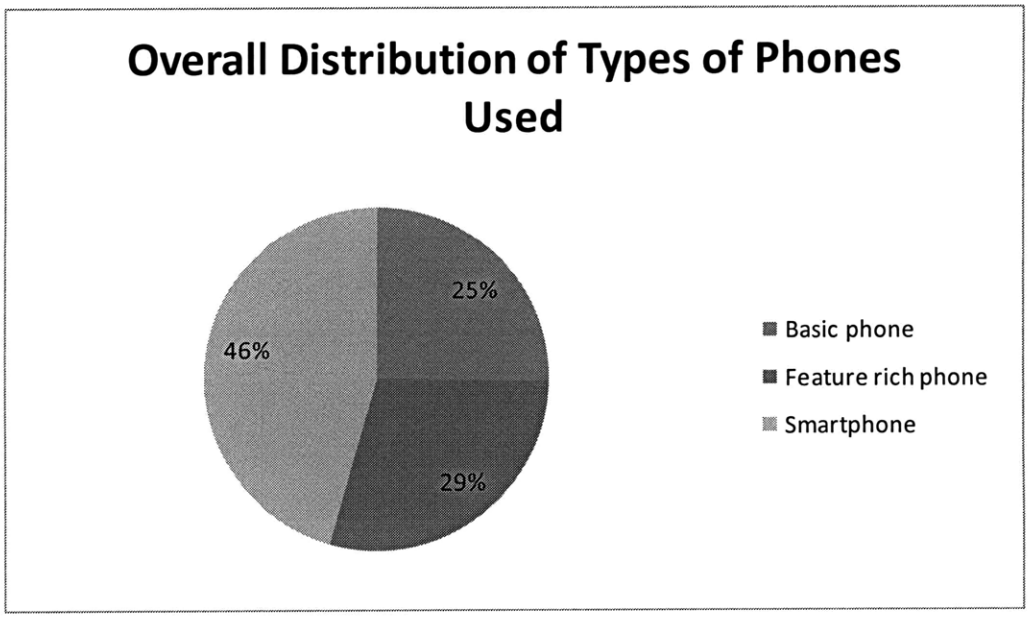


Figure 27: Distribution of Types of Phones Used By Survey Respondents

5.5 Phone Usage by Adopter Category

We further cross-tabulated the type of phone used by the self-identified adopter category - of the eight respondents the early adopter category, 88% [7] used smartphones and 12% [1] used feature-rich phones. Of the 48 respondents in the mainstream category, 52% [25] used smartphones, 27% [13] used feature-rich phones and 21% [10] used basic phones. Of the 22 respondents in the late adopter category, 18% used smartphones [4] while 41% [9] used basic phones and 41% [9] used feature rich phones.

To put it another way, we cross-tabulated just the smartphone users by adopter category and see that of the 36 smartphone users, 19% [7] are early adopters, 69% [25] are mainstream adopters and 11% [4] are late adopters.

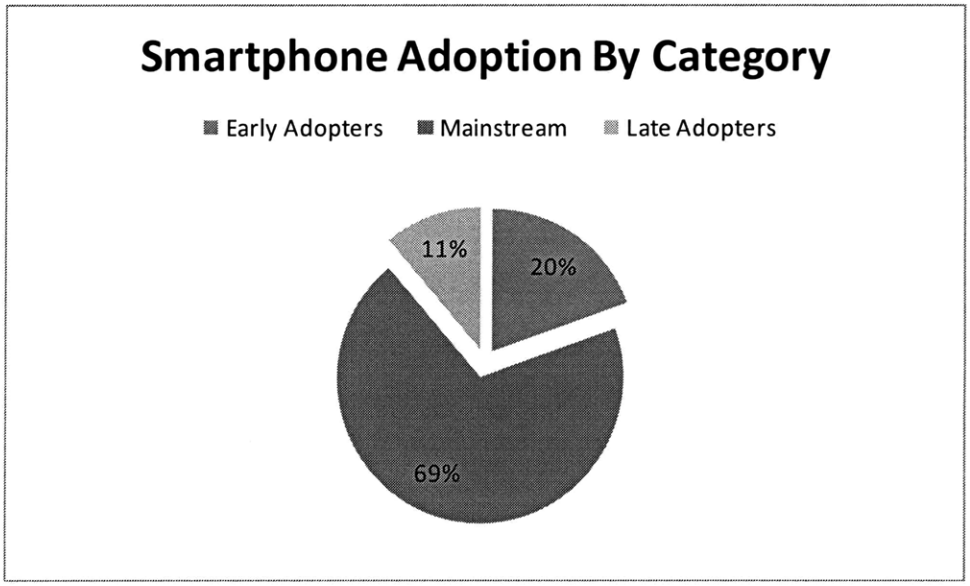


Figure 28: Smartphone Adoption By Category

Conclusion

This data supports our earlier conclusion in Chapter 4, based on market reports, that smartphone adoption has reached the early mainstream.

5.6 Purchase Behavior and Decision Making Process

We asked the respondents to rank several attributes in terms of their importance to making a purchase decision on a phone.

Imagine you were in the market for a new phone. How would you rank the following phone attributes in terms of importance to your purchase decision?

(1 - least important; 5 - most important)

- Overall Quality
- Price
- Ease of use
- Recommendation from friends
- Popularity
- Style/design
- Battery life
- Productivity features - email, to-do list etc.
- Entertainment features - music/video player
- Messaging features - email, IM, MMS
- Mobile web access
- Browser quality

- Camera resolution/quality
- Screen resolution
- Size/weight
- User interface
- Availability of 3rd party applications/games
- Familiar user interface
- Availability of familiar applications

We added the number of respondents who scored 4 or 5 for each attribute. Based on this, the top five attributes marked as important or very important by most respondents (>85% of respondents) are as shown in Figure 29 - overall quality of the device, user interface, battery life, ease of use and size/weight of the device.

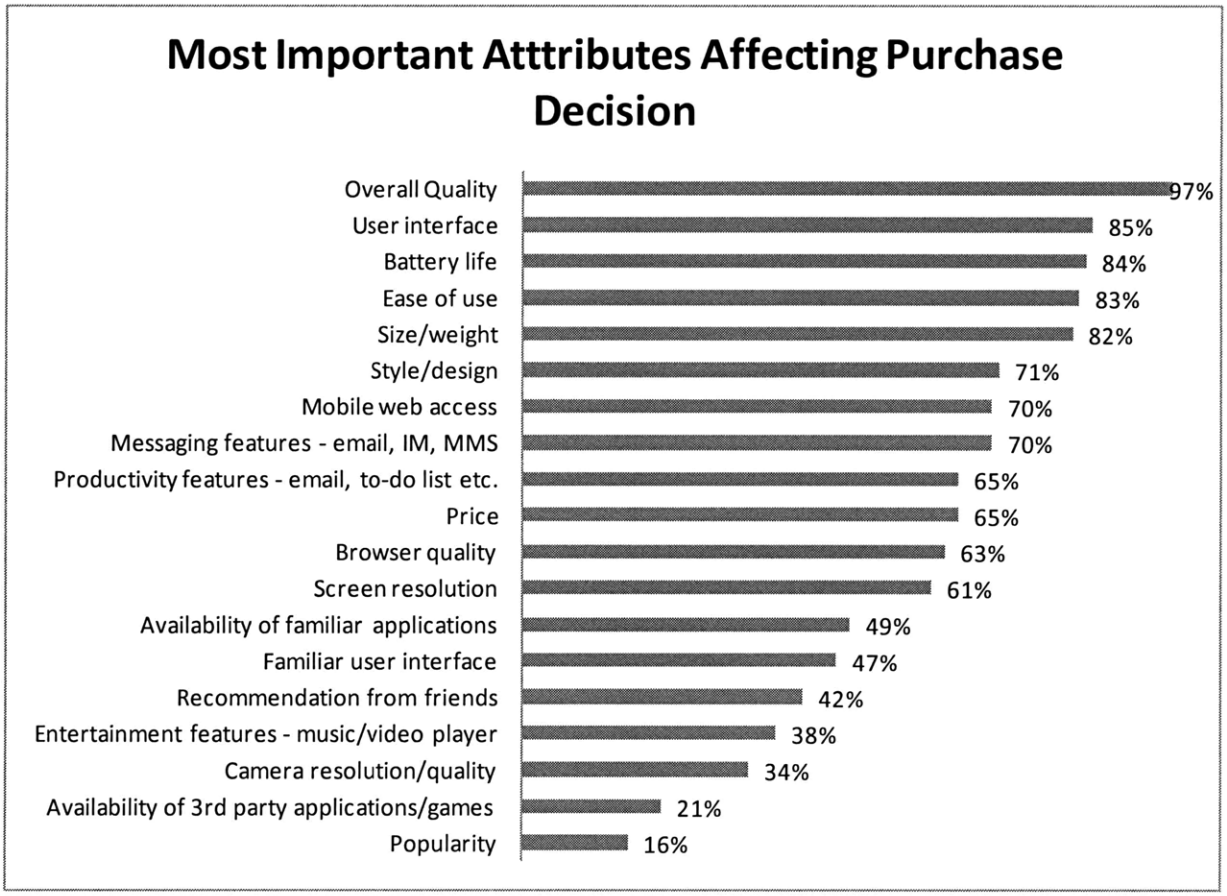


Figure 29: Attributes Affecting Purchase Decision

In addition, 60-70% of the respondents ranked specific device features such as email and web access as important, style/design of the device was important to 71% of respondents, price was an important attribute for 65% of respondents, while availability of applications was important only to 21% of respondents.

5.7 Importance of attributes by adopter category

Early Adopters

Cross-tabulating the importance of the attributes with users identified as early adopters, we find features such as email and web access are important to majority of the early adopters (>85%), 75-85% of early adopters value battery life, user interface and ease of use, 75% consider size/weight and style important while 50% consider price important (Figure 30).

This is consistent with Geoffery Moore's explanation (7), where he characterizes early adopters as people who adopt new technologies and products based on the features. According to Moore, early adopters are typically less sensitive to price, placing a greater value on the product's ability to offer a better solution.

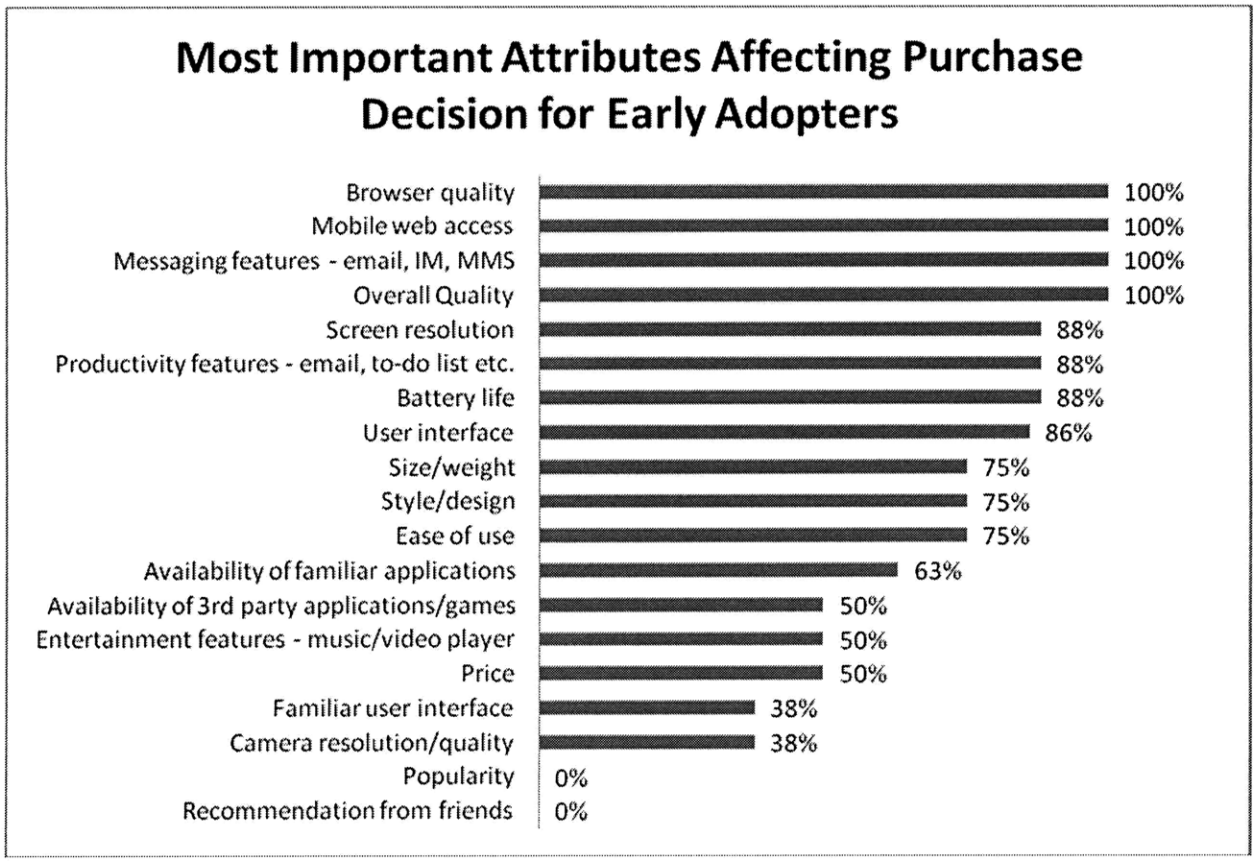


Figure 30: Attributes Affecting Purchase Decision for Early Adopters

Mainstream

For majority of the mainstream adopters, quality, the user interface, battery life, size/weight of the device and ease of use are most important attributes that affect the purchase decision. 65-75% of mainstream adopters regarded features such as email and web browsing important, while 66% consider the price of the device important factor in making their decision. (Figure 31)

This is again consistent with Rogers' and Moore's description of the characteristics of this adopter category. Mainstream adopters tend to be practical and pragmatic. While they value the

features of the product, they do not purchase devices purely because of innovative features. They prefer to wait until the features have been stabilized and performance is reliable, placing a greater value on the user interface and ease of use. While price is important to mainstream users they do not base their purchase decision solely on price.

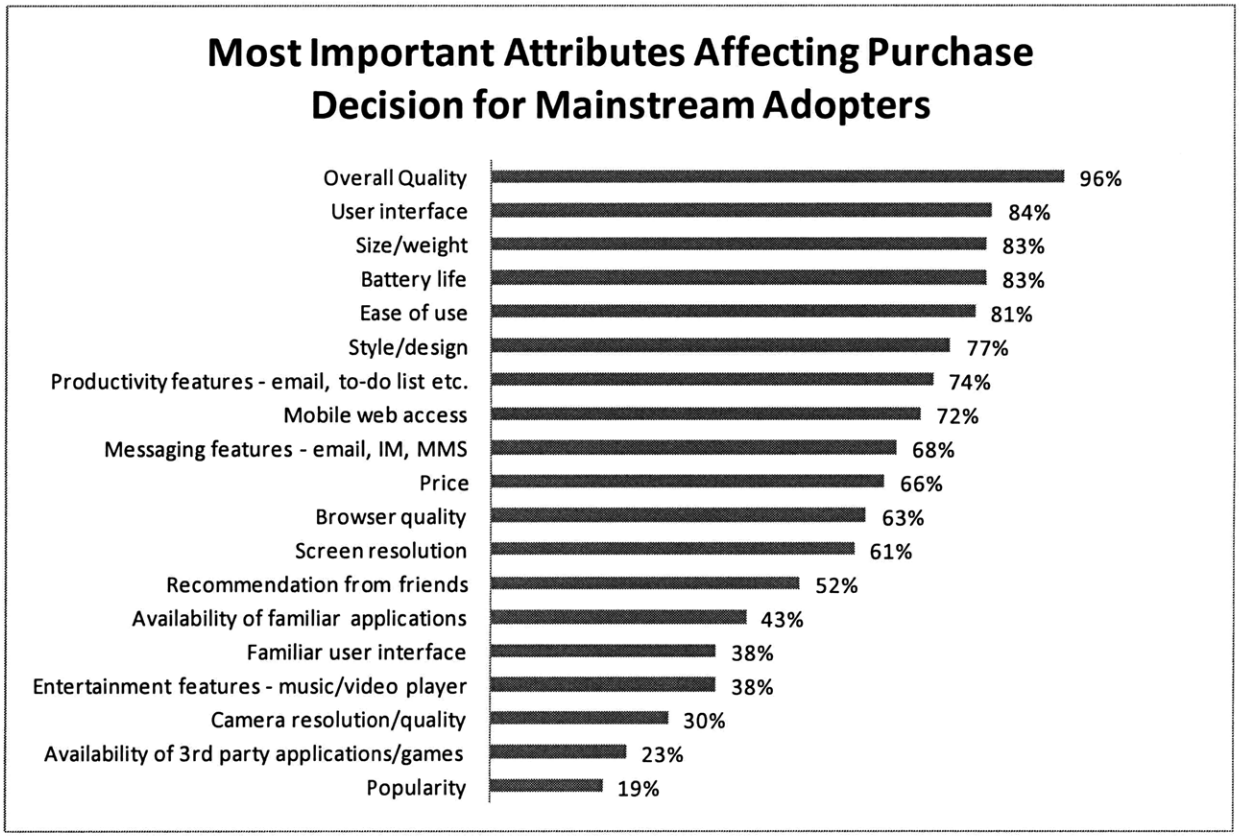


Figure 31: Important Attributes Affecting Purchase for Mainstream Adopters

Late Adopters

Late adopters placed a higher emphasis on price and lower value on features compared to mainstream users. They do highly value a good user interface and ease of use as well as a

familiar user interface (Figure 32). This segment does not like change, consistent with Rogers' and Moore's desciption.

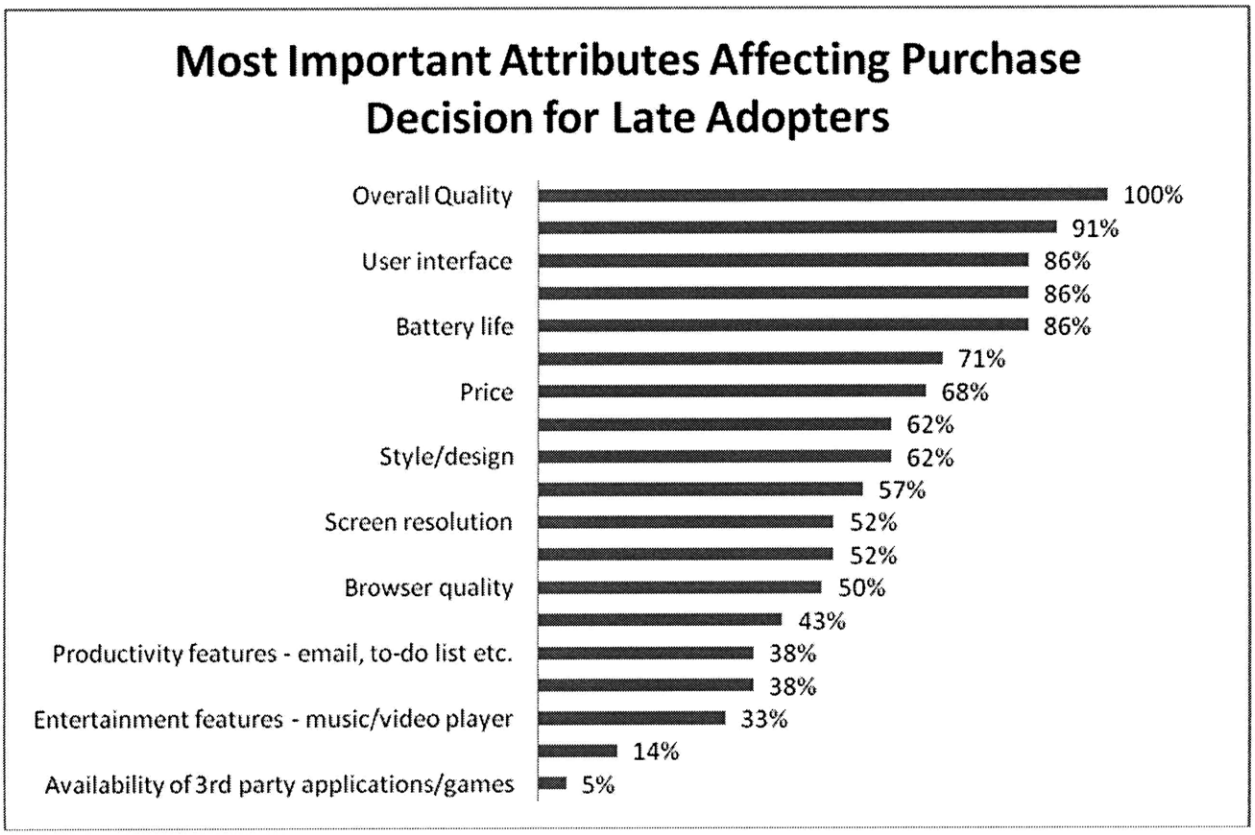


Figure 32: Important Attributes Affecting Purchase Decision for Late Adopters

Conclusion

Smartphone adoption is in the early mainstream stage. Mainstream users primarily value quality, (usable) user interface, battery life, size/weight of the device and ease of use. Price is important to mainstream users, but they do not base their purchase decision on price alone. Hence it is important for manufacturers to differentiate their products based on the attributes that this segment values. Overall quality, battery-life and size/weight across devices of different

manufacturers have converged around certain standards. Going forward, to differentiate their products and to drive further adoption in this segment, manufacturers need to design better user interfaces and emphasize ease of use.

5.8 Smartphone Comparison

Users were asked to select individual devices based on their **perceptions** of its relative performance on a given attribute compared to other devices. The device options were BlackBerry, iPhone or the user's current phone (if not a BlackBerry or iPhone). BlackBerry and iPhone were selected since they are the top contenders in the smarphone category in the U.S[34]. A section of the question is reproduced here. Full set of questions are available in the Appendix A.

Select one device for each statement to indicate your PERCEPTION of the following devices, whether based on first-hand experience or not.

Answer Options	iPhone	BlackBerry	My current phone (if not a BlackBerry or iPhone)	Can't say
Is a better phone				
Is better at playing music and video				
Is better at accessing email/messaging				
Has a better camera/takes better pictures				
Has a better web browser				

[34] http://www.thestandard.com/news/2009/02/19/iphone-sales-slump-q4-blackberry-surges

The results for some of the attributes that were identified as important in earlier question regarding purchase behavior are reproduced here. For full set of responses refer to the Appendix A.

The iPhone scored higher in terms of perceptions of overall quality, ease of use, accessibility of features and ability to master new features.

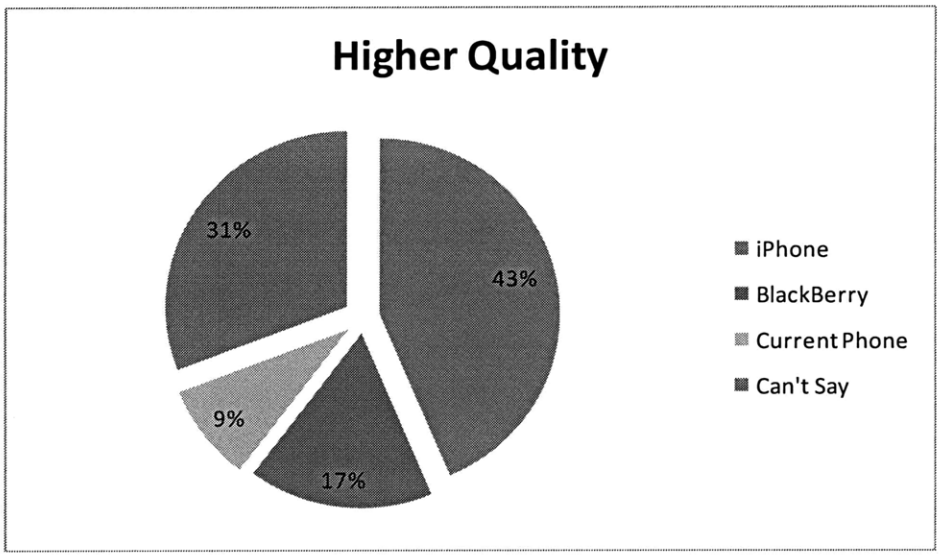


Figure 33: Ranking of Devices Based on Perceptions of Quality

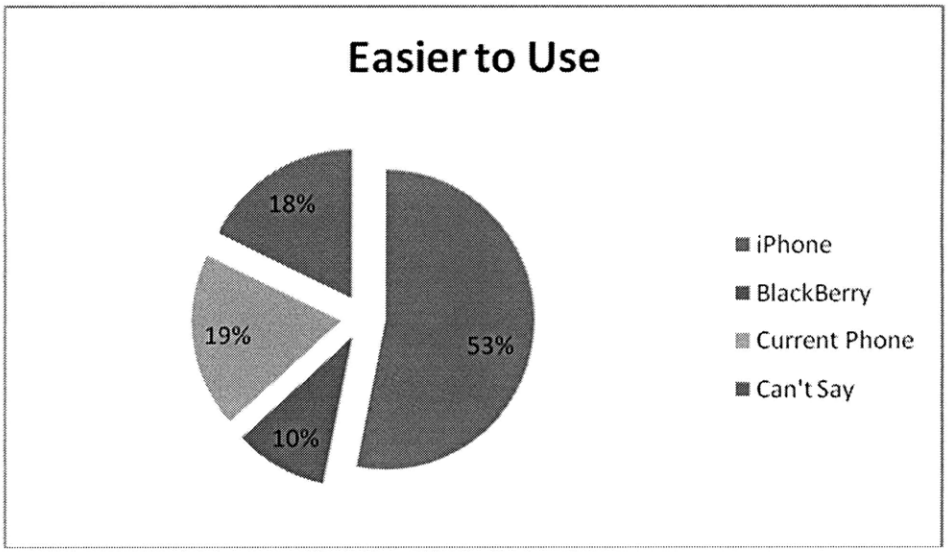


Figure 34: Ranking of Devices Based on Perceptions of Ease-of-Use

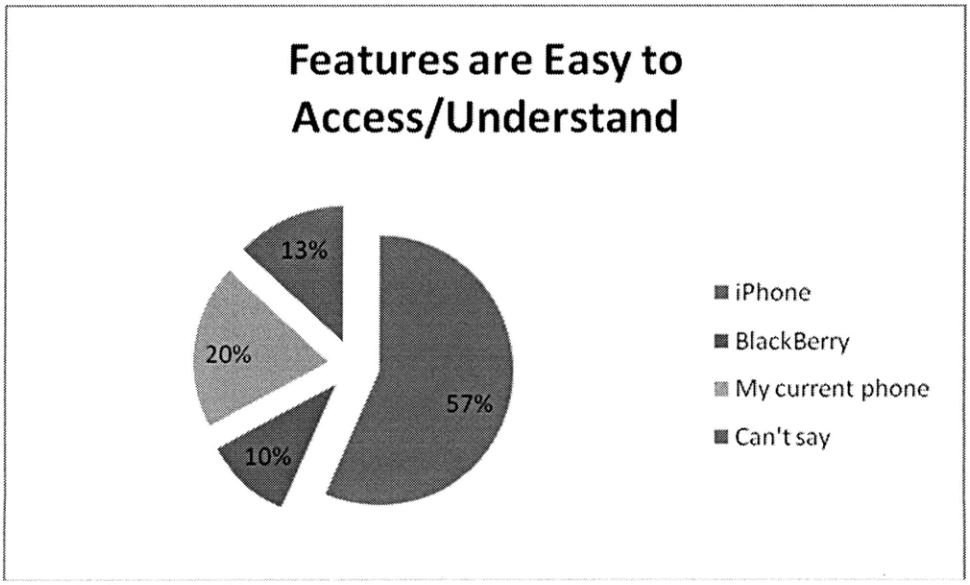


Figure 35: Ranking of Devices Based on Feature Accessibility

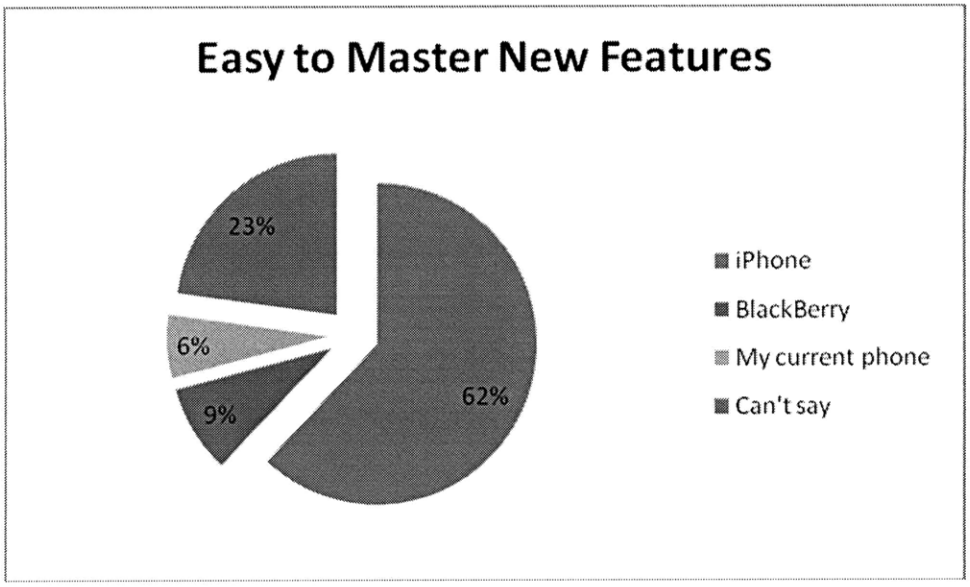


Figure 36: Ranking of Devices Based on Ability to Master New Features

BlackBerry devices were ranked higher in terms of battery life and keyboard usability.

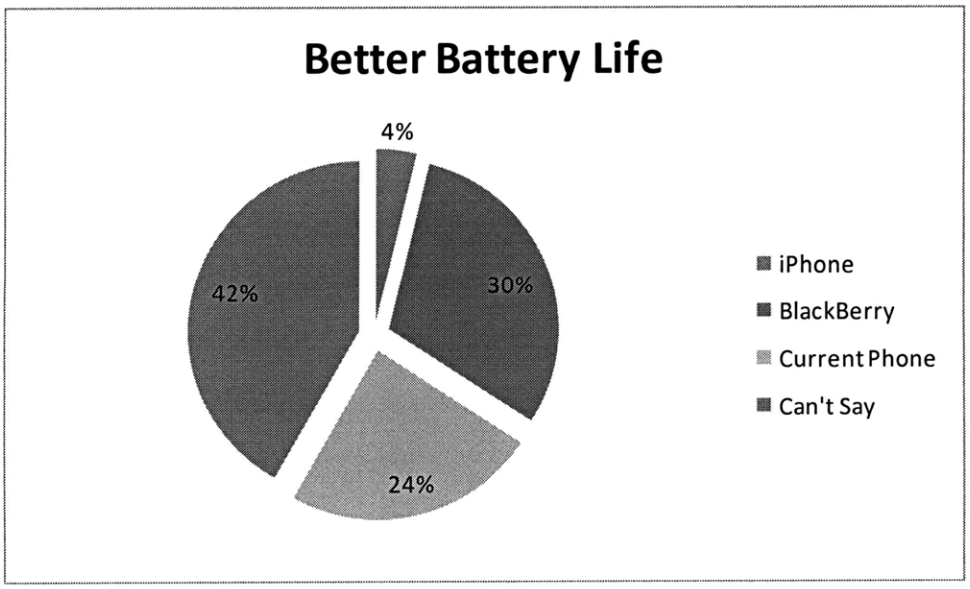


Figure 37: Ranking of Devices Based on Battery Life

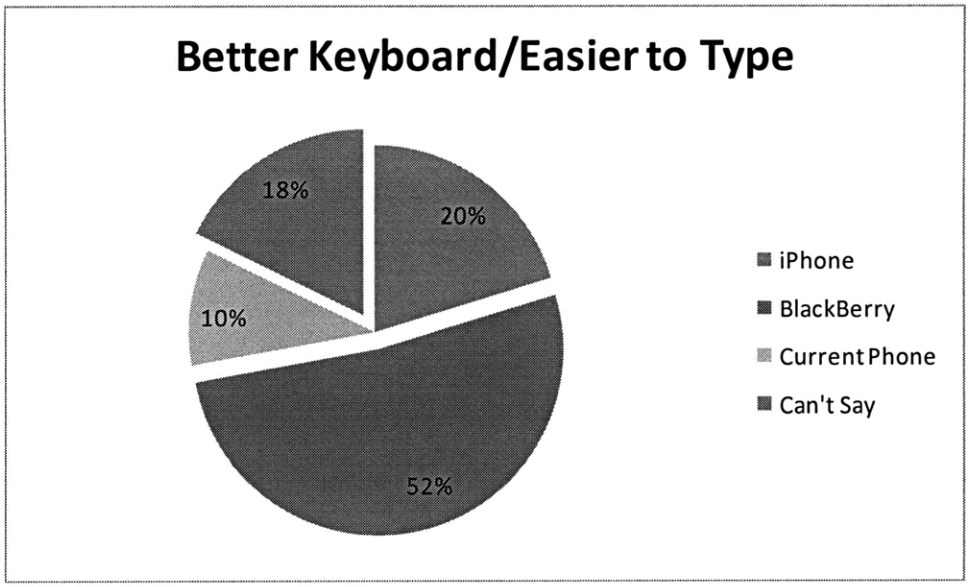


Figure 38: Ranking of Devices Based on Keyboard Usability

Conclusion

The perception of the devices and their rankings are reflective of how the devices are positioned with regard to their core user base.

BlackBerry is more oriented towards business users and is known for its strong email/messaging capabilities. As such, its keyboard is designed to facilitate rapid and comfortable typing despite a small surface area. Users' perceptions and rating of the BlackBerry reflect this.

iPhone, on the other hand, is a more consumer oriented device. Apple has designed its user interface to simplify and provide a compelling user experience. The ratings reflect this.

At a high level, these ratings indicate areas where each of the devices needs to improve in order to expand their market and be attractive to the others' user base.

5.9 Broader Implications for Makers of Convergent Devices

We also asked users a couple of other questions that yielded interesting, if slightly contradictory, results.

Users were asked to identify the reason for not owning a smartphone (if they were not current smartphone users).

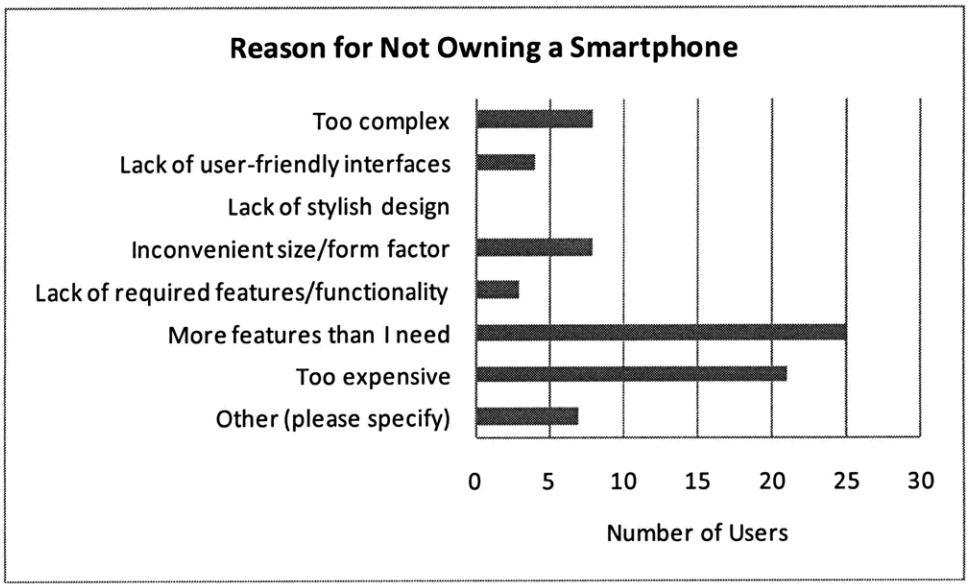


Figure 39: Top Reasons for Not Owning a Smartphone

Of the 41 users who responded to this question, the 61% [25] selected "More features than I need" as one of the reasons.

In a separate question, users were asked their opinion on convergent (multi-purpose) devices versus multiple single function devices.

Answer Options	Response Frequency	Response Count
I prefer to carry devices dedicated to performing single functions e.g. phone, mp3 player, gps	21.8%	17
I prefer to carry a convergent device, such as a smartphone, that does it all	78.2%	61

The majority, 78%, responded that they preferred a convergent device.

Conclusion

There appears to be an opportunity here to reconcile users' preference for convergent devices with their perception that smartphones carry more features than they need. Innovative design methods such as offering users the ability to customize the features and functionality to meet their needs, perhaps even in a dynamic manner, would be one solution. Another would be to follow the "progressive disclosure" method. Google is a classic example of this. Their main page has a simple text search box, but users have access to more sophisticated and advanced features as and when they need to use them. These advanced features do not clutter the main page or overwhelm the user.

6 Conclusions and Future Work

This paper provides insights in two important areas:

1. Alignment of design strategy with technology evolution and market adoption cycles

Our case study of five hand-held devices has demonstrated the need to dynamically align product design strategy with technology evolution and market adoption cycles. While focus on the right design attribute at the right time is not the only criterion nor by any means a sufficient criterion to ensure a product's success in the market-place, our study demonstrates that it is necessary.

In particular, we have shown that in the early stage of a market, when there is considerable technological ferment, products have to demonstrate the ability to apply the technology to uniquely fulfill a critical and unmet need. This is the attribute most important to the early adopters. Thus, both from a technology strategy perspective and to meet the demand of the early market, manufacturers need to focus on the **usefulness** of the product

As the market evolves and technological performance stabilizes and standardizes, competitors copy the dominant design and multiple products offer similar features and performance attributes. Mainstream users value stable performance and ease of use. At this stage, to stay aligned with technology evolution and market demand, manufacturers need to differentiate their products based on ease of use and providing a compelling user experience, while meeting the

established standards for technical performance i.e. product design focus should now shift to the **usability** of the product.

Finally, as the technology matures products converge around standard features and prices drop. Lower prices makes the products even more attractive to late adopters who seek a shallow learning curve and expect products to "just work", which is enabled by mature technology. Late adopters buy for aesthetics and style since by then products are more alike than different in terms of feature-set and performance. Hence at this stage alignment to technology and market demand entails design focus on improving the **desirability** or style of the product.

Figure 40 is reproduced here to illustrate this point. Products should be anchored along the diagonal of the matrix while meeting requirements of the upper-triangular area in order to achieve market success.

Attribute	Product Adoption Life-Cycle		
	Early	**Mainstream**	**Late**
Usefulness			
Usability			
Desirability			

Legend	
	Critical attribute requiring design emphasis in a given life-cycle phase
	Performance on the attribute should maintain levels achieved in previous life-cycle phase. No additional effort beyond sustaining incremental improvements required
	These attributes can be ignored in a given life-cycle phase

Figure 40: Design Strategy Framework

2. Smartphone Adoption

Our case study and results of the survey have indicated that smartphone adoption is in the early mainstream stage. Mainstream users primarily value quality, (usable) user interface, battery life, size/weight of the device and ease of use. Price is also important to mainstream users, but they do not base their purchase decision on price alone. Overall quality, battery-life and size/weight across devices of different manufacturers have converged around certain standards. In addition, as battery as well as processor technologies have improved, smartphones have started incorporates consumer-oriented features found in high end cellphones such as cameras and media players. Each additional feature increases the complexity, both real and perceived, of these devices. Hence going forward, to to drive further adoption in this segment, manufacturers need to design better user interfaces and emphasize ease of use.

Apple has led the way in this area with the iPhone, which features the breakthrough touchscreen interface. Apple, always known for its focus on user-experience, failed with the Newton because of applying this strategy in the early market, which was the wrong point in the technology evolution and market adoption cycle. With the iPhone, they spurred mainstream adoption and expanded the smartphone market by creating a new sub-category of media/entertainment focused smartphones with a compelling user-experience. Apple challenged the established dominant design in the smartphone space and installed the touchscreen user interface as a viable, alternate dominant design. Although competitors have rushed to launch their own versions of products with touchscreens, they have not been able to reproduce the spirit of iPhone's intuitive user interface. Touchscreen user interface is the only the means, and perhaps not the only one, of

delivering a compelling user experience. Apple's competitors seem to be treating it as an end in itself.

Future Work

This paper focused on the study of mobile handheld devices i.e. smartphones and PDAs. Smartphones and PDAs have certain unique characteristics such as the potential to turn into handheld computers, which technology advances are leading them towards. This has reinforced the need to improve the usability and make feature complexity more manageable for such devices. One area of future work would be to study the applicability of this framework to other categories of technology products that are more single-purpose. A preliminary consideration of gaming consoles Ninentendo Wii versus Sony Playstation or Microsoft Xbox 360 seems to indicate that the model would still apply. A detailed study of these products along the framework developed in this paper would nonetheless be interesting.

A second area would be to further explore the concept and design of convergent devices. One idea to focus this exploration would be to consider innovative design methods such as offering users the ability to customize the features and functionality to meet their needs, perhaps even in a dynamic manner. Another would be to follow the "progressive disclosure" method. Google is a classic example of this. Their main page has a simple text search box, but users have access to more sophisticated and advanced features as and when they need to use them. These advanced features do not clutter the main page or overwhelm the user.

A third area for further exploration would be a more exhaustive survey to reconcile findings from the current, limited set that users' prefer convergent devices yet perceive that smartphones carry more features than they need. Are convergent devices really the future or would users be better off with "information appliances"?

Appendix A

Survey Questionnaire and Responses

Question 1
Select one of the following options to indicate your purchase behavior with respect to technology products

Answer Options	Response Frequency	Response Count
Early Adopters	10.1%	8
Mainstream	60.8%	48
Late Adopters	27.8%	22
Don't know	1.3%	1

Question 2
What mobile phone do you currently own? (If you own more than one phone, select the option that best represents your primary phone)

Answer Options	Response Frequency	Response Count
Basic phone	25.3%	20
Feature rich phone	29.1%	23
Smartphone	45.6%	36
Other (please specify)		2

Question 3
If you currently do not have a smartphone, why not? (select all that apply)

Answer Options	Response Frequency	Response Count
Too complex	19.5%	8
Lack of user-friendly interfaces	9.8%	4
Lack of stylish design	0.0%	0
Inconvenient size/form factor	19.5%	8
Lack of required features/functionality	7.3%	3
More features than I need	61.0%	25
Too expensive	51.2%	21
Other (please specify)		7

Question 4

Do you use your phone primarily for:

Answer Options	Response Frequency	Response Count
Work	1.3%	1
Personal	34.2%	27
Both	64.6%	51

Question 5

Imagine you were in the market for a new phone. How would you rank the following phone attributes in terms of importance to your purchase decision? (1 - least important; 5 - most important)

Answer Options	1 - Least Important	2	3	4	5 - Most Important	Response Count
Overall Quality	0	0	2	33	43	78
Price	1	5	21	23	28	78
Ease of use	1	2	10	25	40	78
Recommendation from friends	4	17	23	27	5	76
Popularity	23	16	26	9	3	77
Style/design	6	2	14	32	23	77
Battery life	2	0	10	27	38	77
Productivity features - email, to-do list etc.	3	10	14	26	24	77
Entertainment features - music/video player	14	13	21	21	8	77
Messaging features - email, IM, MMS	3	11	9	22	32	77
Mobile web access	5	5	13	26	28	77
Browser quality	4	8	16	28	19	75
Camera resolution/quality	9	15	27	15	11	77
Screen resolution	1	7	22	36	10	76
Size/weight	0	3	11	37	27	78
User interface	1	0	10	34	28	73
Availability of 3rd party applications/games	26	18	17	11	5	77
Familiar user interface	6	10	24	25	10	75
Availability of familiar applications	7	13	19	27	11	77
Other (please specify)						2

Question 6

Select one device for each statement to indicate your PERCEPTION of the following devices, whether based on first-hand experience or not.

Answer Options	iPhone	BlackBerry	phone (if not a BlackBerry	Can't say	Response Count
Is a better phone	36	13	6	24	79
Is better at playing music and video	63	4	1	11	79
Is better at accessing email/messaging	21	40	2	16	79
Has a better camera/takes better pictures	30	14	7	28	79
Has a better web browser	57	3	1	18	79
Has better applications/applications that are more	40	16	10	13	79
Is easier to type on/better keypad	16	41	8	14	79
Is more stylish	64	4	4	7	79
Is better for my image/status	36	13	7	23	79
Allows me to be more productive	16	37	7	19	79
Allows me easier/better access to information online	42	12	3	22	79
Has better games	57	2	1	19	79
Costs less	5	21	35	18	79
Has longer battery life	3	24	19	33	79
Has higher quality	34	13	7	24	78
Has better screen resolution	54	4	1	20	79
Comment					8

Question 7

Select one device for each statement to indicate your PERCEPTION of the following devices, whether based on first-hand experience or not.

Answer Options	iPhone	BlackBerry	phone (if not a BlackBerry	Can't Say	Response Count
Is more compatible with my lifestyle	28	18	24	7	77
Provides an interface that I am familiar/comfortable	32	16	18	11	77
Has features that I am familiar with	27	18	25	7	77
Is more compatible with other devices/software that I	27	21	8	20	76

Question 8

Select one device for each statement to indicate your PERCEPTION of the following devices, whether based on first-hand experience or not.

Answer Options	iPhone	BlackBerry	My current phone	Can't say	Response Count
Is easier to use	42	8	15	14	79
Has features that are easy to access/understand	43	8	15	10	76
Has new features, but ones that I can easily	49	7	5	18	79
Comment					0

Question 9

Select one device for each statement to indicate your PERCEPTION of the following devices, whether based on first-hand experience or not.

Answer Options	iPhone	BlackBerry	phone (Other)	Can't say	Response Count
Is used by more people	21	43	5	10	79
Is used by more people I know	26	39	7	7	79
Is more popular	61	7	4	7	79

Question 10

Select one of the following options to indicate your preference for feature-rich versus single-featured mobile devices:

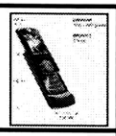
Answer Options	Response Frequency	Response Count
I prefer to carry devices dedicated to performing single functions e.g. phone, mp3 player, gps	21.8%	17
I prefer to carry a convergent device, such as a smartphone, that does it all	78.2%	61

Appendix B

Comparison of current feature-rich phone

Sources:

1. Top 5 cell phones based on PC World Ratings: http://www.pcworld.com/article/125396/top_10_cell_phones.html, May 2008, just prior to iPhone 3G release
2. http://www.lge.com/products/model/detail/env(vx9900).jhtml
3. http://www.motorola.com/consumers/v/index.jsp?vgnextoid=c1137ad373e89110VgnVCM1000008406b00aRCRD&vgnextchannel=8b871df4f3d89110VgnVCM1000008406b00aRCRD&vgnextfmt=alt
4. http://www.samsung.com/us/consumer/detail/spec.do?group=mobilephones&type=mobilephones&subtype=verizonwireless&model_cd=SCH-U740ZAAVZW&fullspec=F

	Motorola Rizr Z3 	LG eNV 	Samsung Alias 
Features	Email SMS MMS Web browser	Wireless Sync E-mail (BREW® E-mail Client) Text Messaging (SMS) Video/Picture Messaging (MMS) Mobile Web 2.0 Web based email and instant messaging (IM)	email Text Messaging (SMS) Video/Picture Messaging (MMS) instant messaging (IM)
Tools	Business card reader, calculator, calendar	Verizon navigator (GPS) Calculator, calendar, address book	AGPS (Assisted GPS) Calculator, calendar, address book
Memory	20MB + microSD upto 2G	micro SD	micro SD
Form Factor	Slider	Horizontal flip with full QWERTY keyboard	Dual flip - standard flip and horizontal flip w/ full QWERTY keyboard
Downloadable content	Games, Ringtones	V CAST Video – stream and download video clips, V CAST Music – download and play full-length songs (WMA files)	V CAST Video , V CAST Music
Camera	2.0 MP, digital zoom, video recording	1.3 Megapixel with digitl zoom, Video recording	2.0 Megapixel Autofocus Camera with Flash, Video recording
Network	2G - GSM	3G - CDMA EVDO	3G - CDMA EVDO

Appendix C

BlackBerry Evolution

Source:

http://na.blackberry.com/eng/devices/ - device specifications for individual devices

NOTE:
Highlighted cells indicate major changes compared to previous generation

	2002 58x, 65x, 67x	2003 62x, 72x, 77x	2004 71xx	2005 87xx	2006 Pearl (8100)	2007 Pearl 2 (81xx), Curve (83xx), 88xx	2008 Bold	2008 Storm
Features Available	Email, Phone, SMS, Corporate Data Access, Wireless internet, Organizer	BlackBerry Messenger		MMS, Wireless Calendar	Camera , Media Palyer	GPS, WiFi	Media player - Video format support: DivX 4, DivX 5/6 partially supported, XviD partially supported, H.263, H.264, WMV3 Audio format support: .3gp, MP3, WMA9 (.wma/.asf), WMA9 Pro/WMA 10, MIDI, AMR-NB, Professional AAC/AAC+/eAAC+	Media player - Video format support: MPEG4 H.263, MPEG4 Part 2 Simple Profile, H.264, WMV Audio format support: .MP3, AAC, AAC+, eAAC+, WMA, WMA ProPlus
							Video Recording, BlackBerry Maps, HTML support for email; MS document viewing and editing	
Keyboard	Backlit QWERTY keyboard	Backlit QWERTY keyboard	SureType® technology	Backlit QWERTY keyboard	SureType® technology	SureType® technology, Narrow QWERTY, Standard QWERTY	QWERTY	virtual keyboard
Navigation	Thumb-operated trackwheel and ESC key	Thumb-operated trackwheel and ESC key	Thumb-operated trackwheel and ESC key	Thumb-operated trackwheel and ESC key	Thumb-operated trackball and ESC key	Thumb-operated trackball and ESC key	Thumb-operated trackball and ESC key	touchscreen
Display	High contrast monochrome screen	High resolution full-color display supporting over 65,000 colors	High resolution backlit LCD display, supporting over 65,000 colors	Color display, backlighting, light sensing screen	Color display, backlighting, light sensing screen	Color display, backlighting, light sensing screen	Half VGA resolution 480 x 360 pixel color display, Transmissive TFT LCD	480 x 360 pixel color display, Transmissive TFT LCD
Memory	8 MB flash memory	16 MB flash memory	32 MB Flash	64 MB Flash	64 MB Flash; support for MicroSD	64 MB Flash; support for MicroSD	128 MB Flash, 1G onboard memory, support for microSD	1298MB Flash, 1G onboard memory, support for microSD
Network	2G (GSM/GPRS/CDMA2001x)	2G (GSM/GPRS/CDMA2001x)	2G (GSM/GPRS/CDMA2001x)	2.5G (GSM/GPRS/EDGE)	2.5G (GSM/GPRS/EDGE)	2.5G (GSM/GPRS/EDGE)	3G (GSM/GPRS/EDGE/UMTS/HSDPA)	3G - CDMA EVDO

Bibliography

1.*http://www.sramanamitra.com/2008/11/22/design-that-moves-business-apple%E2%80%99s-%E2%80%9Covernight%E2%80%9D-success-part-3/.* [Online]

2. **James Utterback, ... [et al].** *Design Inspired Innovation.* Hackensack, NJ : World Scientiific Pub, 2006. TS171.D465 2006.

3. **Buxton, William.** *Sketching user experiences : getting the design right and the right design .* Amsterdam ; Boston : Elsevier/Morgan Kaufmann, 2007. TS171.B89 2007.

4. *Converging Perspectivess: Product Development Research for the 1990s.* **Sanders, Elizabeth B.-N.** 4, s.l. : Design Management Journal, 1992, Vol. 3.

5. *Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change.* **Tushman, Philip and Anderson, Michael L.** s.l. : Administrative Science Quarterly, 1990, Vol. 35.

6. **Christensen, Clayton M.** *The Innovator's Dilemma.* s.l. : Collins Business Essentials Edition, 2006.

7. **Moore, Geoffrey A.** *Crossing the Chasm.* New York : Harper Collins, 1999.

8. **Rogers, Everett M.** *Diffusion of Innovations.* 2003.

9. **Norman, Donald A.** *The Invisible Computer.* Cambridge, MA; London, England : MIT Press, 1998. QA76.5.N665 1998.

10. History of the PDA. *History of the Computer.* [Online] [Cited: January 16, 2009.] http://www.historyofthecomputer.net/pda.html.

11. **O'Malley, Chris.** Simonizing the PDA. *Byte.* 1994. Vol. 19, 12.

12. *Innovation and Dominant Design in Mobile Telephony, pp 305-324.* **Koski, Heli and Kretschmer, Tobias.** 3, s.l. : Industry and Innovation, July 2007, Vol. 14.

13. **Butter, Andrea and Pogue, David.** *Piloting Palm : the inside story of Palm, Handspring, and the birth of the billion-dollar handheld industry.* New York : John Wiley & Sons, 2002.

14. Big Hit or Sculley's Folly? (The Newton Personal Digital Assistant). *Fortune.* 26 July 1993.

15. **Hill, G. Christian.** First Hand-Held Data Communicators are Losers, but Makers Won't Give Up. *The Wall Street Journal.* 3rd February 1994.

16. **Wildstorm, Stephen H.** The Little Dynamo Pilot's Big Plus. *Business Week.* 25 March 1996.

17. **Hill, G. Christian and Carlton, Jim.** Telecommunications (A Special Report). *The Wall Street Journal.* 11th February 1994.

18. **Bergman, edited by Eric.** *Information appliances and beyond :interaction design for consumer products.* San Francisco : Morgan Kaufmann Publishers, 2000.

19. **Mossberg, Walter S.** A Palm-Size Computer That's Easy to Use and Cheap - Finally. *The Wall Street Journal.* 28 March 1996.

20. **Pollack, Jordan B.** Can Palm Pilot Be More Than a Datebook. *The Wall Street Journal.* 2001, 9 july.

21. **Mossberg, Walter S.** A New Wireless Device Delivers Your E-Mail Right Into Your Hands. *The Wall Street Journal.* 2000, 10 February.

22. **Tam, Pui-Wing.** How an unknown high-tech company turned its new gadget into a big hit. *The Wall Street Journal.* 2001, 25 June.

23. **McCracken, Harry.** Elegant Palm VII, Tasty BlackBerry Pager. *PC World.* 1 August 1999, Vol. 17, 8.

24. **Frankel, Alex.** The Willing Partner. *Technology Review Publisehd by MIT.* July 2005.

25. Push E-mail - Wikipedia, the free encyclopedia. [Online] [Cited: March 18, 2009.] http://en.wikipedia.org/wiki/Push_e-mail.

26. **Tam, Pui-Wing.** How an Unknown High-Tech Comapny Turned its New Gadget Into a Big Hit. *The Wall Street Journal.* 25 June 2001.

27. BlackBerry - Wikipedia, the free encyclopedia. *Wikipedia.* [Online] [Cited: March 18, 2009.] http://en.wikipedia.org/wiki/Crackberry.

28. **Peterson, Andrea.** Messaging Miss Manners. *The Wall Street Journal.* 2000, 26 April.

29. **Heinzl, Mark.** A New Crop of Gadgets Challenge the BlackBerry. *The Wall Street Journal.* 2005, 2 November.

30. **Crockett, Roger O., Edwards, Cliff and Ante, Spencer E.** How Motorola Got Its Groove Back. *Business Week.* 8 August 2005.

31. **Singer, Michael.** Motorola Q, pink Razr for the holidays. *CNETNews.com.* 2005, 23 September.

32. **Boehret, Walter S. Mossberg and Katherine.** The Mossberg Solution: Smartphones Get Smarter. *The Wall Street Journal.* 2006, 7 June.

33. **Weaver, Courtney.** Does Selling Fast Equal Selling Well? *BusinessWeek Online.* 16 August 2007.

34. **Krazit, Tom.** Coming to Grips with the IPhone's Design. *Cnet News.com.* 2007, 27 August.

35. **Vascellaro, Jessica E.** BlackBerry Maker Laucnches Consumer-Focussed 'Curve'. *The Wall Street Journal.* 2007, 3 May.

36. **Thornton, Carla.** Palm vs. Pocket PC. *PC World.* 2001, Vol. 19, 4.

37. **Prince, Marcelo.** Managing Success. *The Wall Street Journal.* 2001, 15 October.

38. **Nadeau, Michael.** PDAs Bounce Back Slowly But Surely. PDAs are evolving into useful business tools. High prices and inadequate infrastrucutre remain obstacles. *Byte.* 1995, Vol. 20, 6.

39. **Mossberg, Walter S. and Boehret, Katherine.** The Mossberg Solution: Smartphones Get Smarter. *The Wall Street Journal.* 2006, 7 June.

40. **Meth, Clifford.** PDAs: What will it take to satisfy users? *Electronic Design.* 1994, Vol. 42, 26.

41. **Loe, Simon.** PDAs strive to define their mission and user base. *Electronic Engineering Times.* March 29, 1993, p. 20.

42. **Davies, Michael.** 15.905 Technology Strategy for SDM, Class Notes.

43. Pager Maker Gets Patent for E-Mail Delivery. *The Wall Street Journal.* 2001, 18 May.

44. http://en.wikipedia.org/wiki/Cellular_networks. [Online]