Guidelines for Developing an Integrated Converged Digital System

by

Ethan Ross Perdue

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Approved by

Shuwen Tzeng, Chair, Associate Professor of Industrial Design
Christopher Arnold, Associate Professor of Industrial Design
Bret Smith, Professor of Industrial Design

Abstract

The digital landscape is currently fractured due to a variety of reasons. This fractured nature often effects the purchasers of digital devices, as they are forced to continually purchase products within a specific zone of this landscape. For instance, if a device manufacturer makes a proprietary connector that works exclusively with their devices, then users that purchase a device from this manufacturer may be locked into their portion of the digital landscape. Often, design solutions that involve televisions, computers, and mobile devices work well for the one specific device, but these solutions often do not work well with the other two devices. Through the process of digital convergence, these solutions will become better as time commences. Designers must understand the user habits, methods of interaction, and usage statistics of televisions, computers, and mobile devices to design successful convergence solutions. In addition, designers must understand that digital convergence is not simply a combination of devices, but is a process that allows digital content to flow between creator and user more efficiently. In addition, designers must be aware of problems involving technical issues in order to design an integrated system that gives users access to all of their content, regardless of the device in use. To illustrate the purpose of this study, a demonstration involving a dongle device will illustrate how designers can follow these guidelines to create an integrated digital system.

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1.1 Problem Statement

As users of electronics go about their day, they are likely to use any number of devices that feature high resolution screen displays and components found in personal computers. These devices include televisions, mobile devices such as smartphones and tablets, portable computers, and desktop computers. The availability of these devices provides an instant framework for designers. The current landscape of this digital realm is broken into micro-ecosystems that do not work very well with one another. Instead, it is up to the users to adapt as they move from device to device. Designers have an opportunity to design across the digital landscape, creating an integrated system that performs through these devices. As users switch from device to device, they may lose access to some of their subscription services, such as cellular access, pay television, and Internet connectivity. Because of the universal nature of digital technology, this loss of service access could be reduced with current technology and infrastructure. As the product users switch devices throughout their day, these devices do not change in function to suit the needs of the individual. It is up to interaction and industrial designers to bridge the gap between these devices and the user's services. The overall quality of these experiences will not improve until a more user-centric design process that considers all of these devices is implemented by product makers. It is the hope of this study to create a method designers can use to develop an integrated system that functions well across multiple devices.

1.2 Need for Study

A large number of households in the United States have access to digital devices that perform similar functions, contain similar components, and have cross-platform functions available on multiple devices. Devices like televisions, portable computers, desktop computers, and mobile devices are currently in wide use, and can represent the canvas of industrial and interaction designers. Currently, the networks used by these devices are highly fractured, and this fractured state creates problems for device users. By studying the nature and forms of convergence, designers will be able to design products that simplify the lives of digital device users.

By studying the trends and history of devices and services that have converged from multiple sources, designers may be able to better predict what features are necessary to include in new software and hardware designs. These features are often substitutes for previous functions that can either replace or more efficiently allow users access to the same content (e.g. computer email software replacing a fax machine). Focus also needs to be placed on the users, and how they have responded to these changes within the device realm. In addition to the users of these devices, focus also needs to be placed on the stakeholders of television, Internet, and device makers.

The potential solutions to problems found within the digital realm are based on technology innovations and the methods currently used to implement these innovations. Studying these methods will provide a major guideline in methods to implementation with newer designs.

Currently, there is no apparent industry focus on creating a seamless ecosystem that allow users to have full access to their content in all of their digital devices. Most

solutions require service providers to create multiple applications across platforms. From the findings after researching the digital trends, user response, and possible technical applications, it should be possible to develop a methodology that allows designers to develop a long-term solution that allows users full access to their full digital realm no matter what device they may be using.

1.3 Literature Review

1.3.1 Introduction

Within the United States, there is a large amount of digital products and heavy access to digital content. There has been a wide adoption rate of digital products and technology, particularly televisions, computers, and mobile devices. As the development of these technologies progressed, they have adopted similar features that allow a chance of convergence between these devices and the services available. One particular trend among these devices is the addition of a high definition display, though the physical size of this screen changes wildly across these three devices. While a HD display is present in all examples, other trends, such as a capacitive touch screen interface, are mostly absent from televisions and many computers. To create a product or service that will successfully provide users with a seamless digital ecosystem, it must have common properties across the digital landscape. The landscape is currently fractured among brands, services, and digital device architecture. A user's devices may very well be a fractured landscape solely because the user purchased multiple brands and different digital platforms. These brands and platforms often work well independently, but not very well when a user wants access to content across platforms.

In cases where a product from one particular brand provides a platform for third-party products and services to interact or enhance their platform, much planning will be necessary to satisfy all parties involved, especially in regards to stakeholders like content creators, service providers, and corporate entities.

The response to the oncoming digital convergence can be grouped into two separate entities: users and stakeholders. The users are the purchasers of these products and services. They ultimately provide the funding for the corporate stakeholders that develop these products and services. The response of these entities varies greatly, though both respond in the best interests of their situation. A user may want a device to work well and to make his or her life less complicated. The stakeholders will look out for their best financial interests. When the idea of convergence or development of convergent technologies has a potential effect on current corporate infrastructure, there is the chance of blowback from these corporate entities. Most of this blowback is one business or corporation fighting against another corporation.

The current infrastructure is advanced enough to provide a less fractured digital landscape. By using currently available technology, designers could enhance the digital landscape. Instituting new infrastructure or speculating on a hypothetical future is unnecessary and would be too great an endeavor and expense to initialize. Designers can achieve seamless access for devices and services with tools currently available.

Factoring in the currently available infrastructure is a major factor in the development of these design guidelines. However, more information is needed outside of the electronics and design industries. The available infrastructure must work with

design methodology and theory if a seamless system is not only built, but accepted by the base users. The users are a growing number as well. According to The World Bank (2014), the earth has a rapidly growing population, with over 7 billion people alive as of 2013. As more markets open up worldwide, it will be harder for stakeholders to ignore the concept of developing a line of digital products within these categories that is easy to use and provides seamless access across the digital realm.

1.3.2 Current Design Trends

Televisions have a longer history than mobile devices and computers in their current form. It is only in more recent years that digital technology has become a standard part of the television ecosystem. The changing form of the television brought about a change in the purchase habits of users. According to Arlen (1987), smaller and more portable television sets allowed households to purchase sets for bedrooms, kitchens, and other rooms outside the living room. Since the publication of Arlen's book in 1987, personal computer graphics have become on par with television graphics, and mobile devices have been successfully introduced into the market. The function of these other devices allows an opportunity for designers to implement a solution through the use of the screen via convergence. According to Carbonara (1992), television's evolution took part because of "a series of technological stages." This change in stages is not limited to televisions, but also computers and mobile devices. The convergence of technologies is a part of the evolution of these devices.

The experience users have within a mobile ecosystem evolved from a combination of a phone feature and computer components. When Steve Jobs

introduced the iPhone in 2007, he called it "a widescreen iPod with touch controls," "a revolutionary mobile phone," and "a breakthrough Internet communications device" ("Steve Jobs- iPhone Keynote 2007"). The audience was led to believe that he would be introducing three products; he introduced one. Of the major features available on a smartphone, the phone feature is not very impressive when you compare it to the Internet and application capabilities. A smartphone is more of a smart device. Users simply get Internet access through a phone company. The phone feature is one of many available on the device. With the addition of applications, there are endless features that your device may hold. So long as the device is able to be contained within a useable form, it does not matter how many built in features your device contains, so long as it serves the user well.

Wildly successful products have been products that combined features into one product. Sony is a large company with many different products and sub-brands, such as Vaio, Bravia, and Playstation. Part of the huge success of Sony's Playstation 2 was that it could function as a combination of a DVD player and a video game console right out of the box. This allowed users to combine the purchase of a DVD player with a video game console, rather than buying both separately. The combination of these two factors along with the PS2's backward compatibility with previous generation titles allowed Sony to sell 150 million Playstation 2s (Stuart, 2013). The next generation console, the Playstation 3, would not share absolute backwards compatibility with previous generations, and only wound up selling about 80 million units by the time the fourth generation Playstation hit the retail market ("Playstation 3 Sales," 2013).

The Sony Walkman, an earlier convergence device, was a great success, and one could have speculated that Sony would be the leader of portable music for years to come. Edson (2012) describes Sony's position, stating:

> For a number of reasons, Sony gradually lost its way after the Walkman because it lost touch with what customers wanted. Sony made no effort to integrate hardware and software, or move toward convergence of content and services, the defining trend of the Internet era. (p. 89)

Apple wound up dominating this market after introducing the iPod. The successful convergence of devices (working well being part of successful) makes for the successful outcome of design solutions.

Before computing of this magnitude was available in something the size of a deck of cards, adding features to devices meant increasing the size of the device. Often, a device can be plagued with an affliction known as creeping features. In Donald Norman's (1988) book *The Design of Everyday Things* , he states:

> Creeping features is the tendency to add to the number of features that a device can do, often extending the number beyond all reason. There is no way that a program can remain useable and understandable by the time it has all of those special-purpose features. (p. 173)

Mobile devices often avoid this creeping feature phenomenon because users have control of the features a device does and does not have via their application selection. Thus the device conforms to the users, allowing it to work well for users. Ensuring that

the device works well, no matter what the feature may be, is necessary to keep a product line alive. It is now easier to explain how to use a complicated user interface with the resolution of screens available to users today. With word processors or typewriters of the past, adding endless features would be difficult because there was virtually no feedback from these objects until they started printing.

A feature shared by many mobile devices is a capacitive touch screen interface. The touch screen interface is likely to be the dominant user interface for the handheld market for the foreseeable future. It is able to blend the ability to interface with the device on the same real estate as the display. Before the iPhone was even close to coming to market, Donald Norman had his doubts on the use of using touch screen devices. Norman (2004) states:

> Far too many high-technology creations have moved from
> real physical controls and products to ones that reside on
> computer screens, to be operated by touching the screen or
> manipulating a mouse. All the pleasure of manipulating a
> physical object is gone and, with it, a sense of control. (p.
> 79)

He was more likely talking about controls for a car's stereo than the iPhone. He is right; the ability to turn a knob to change channels on a television is taken away by adding a touchscreen interface. The iPhone was designed to be looked at when being used. Your car stereo should not be designed this way. Not all converging technologies are necessarily a good thing.

1.3.3 User and Stakeholder Response

Adoption rates are a very reliable tool to determine the user response for particular devices. The adoption rate among the television, the computer, and the mobile device vary greatly. The television, the oldest of these technologies, has the widest adoption rate with 115.6 million American households (about 95 percent) that own at least one television with access to traditional television content sources ("Nielsen Estimates 115.6," 2013). As of the year 2011, 71.7% of American homes own a computer, the second oldest of these technologies, with access to the Internet (File, 2013). Statistics regarding mobile devices vary because of the categorical nature of mobile devices. 56-61% of American adults have access to a mobile device that is a smartphone or operates on a smartphone platform (Smith, 2013). 34% of American adults own a tablet, which is also a device in the mobile device category (Zickuhr, 2013). It is apparent that the chronological order of the adoption of these devices plays a heavy influence over ownership percentage.

These statistics certainly show broad trends for users. After all, it is these "users" that maintain the TV, computer, and mobile device platforms. They purchase the devices, subscribe to different services, and are a potential audience in many ways. However, the stakeholders' responses give a clear picture into how great (or poorly) the convergence process moves forward. Each device has a history of varying lengths that detail the pain of a process convergence can be, often found within litigation and legislation.

Technology has given users more control over their content. Users have the ability to skip forward on DVR recordings with the press of a button. Software has

allowed the opportunity for users to automatically move past all commercials, and back

to the desired programming. Television stakeholders, particularly advertisers, react by

introducing legislation that would not allow this ability for the audience (Murphy, 2011).

Such an example shows how an industry can slow the process of convergence, just on

one device. Several large television networks attempted to sue Dish Network because

their "Hopper" set-top-box (STB) could automatically skip over commercials (Goldman,

2012). These attempts to control convergence via legislation and litigation only serve to

slow, not stop, the convergence process.

Litigation and legislation are no strangers to the computer industry. Microsoft and

Apple were both known to battle each other in the legal realm (Andrews, 1993), and

Microsoft lost an antitrust case against the United States over how it bundled Internet

Explorer with Microsoft Windows (Economides, 2001). These lawsuits have more to do

with the software and GUI of Microsoft and Apple products than the hardware providing

them. However, other stakeholders have resorted to legal means to fortify their

positions. Verizon, among others, has used the legal system to bring about an end of

net neutrality, and to essentially allow Internet Service Providers (ISPs) to discriminate

against websites, services and applications that run on their networks (Zajac & Shields,

2014).

Mobile devices have been involved with litigation as well. One of the most

famous lawsuits (or series of lawsuits) occurred between Apple and Samsung over

several patent infringements on both sides of the issue (Pepitone, 2013). The lawsuits

between Apple and Samsung are only part of the ongoing litigation known as the

"Smartphone Wars." In addition, Nokia and Google have both been combatants in these

wars (Page, 2012). The newness of this device explains the large amount of lawsuits that have occurred since the iPhone was released in 2007.

1.3.4 State of Current Infrastructure

One interesting topic in regards to the convergence of these devices is their ability to all run within the same network, given certain circumstances are met. Comcast, the largest of the U.S. cable providers, has almost 22 million subscribers (Zhao, 2013). Since their Internet service also runs on their cable television network, computers and mobile devices can also be present within the same infrastructure. Satellite television providers also have the ability to perform as ISPs. Dish Network's Internet access has limits on data allowances, and is not good for online gaming, online video watching, or for any location with an available cable ISP ("Satellite Internet," 2014).

While Dish Network's contribution to the convergence of networks falls far behind Comcast's, they are far ahead of the capabilities of other television service providers in regards to their STBs. Dish Network's "Hopper" STB has the ability the provide television access to Dish Subscribers to remote locations on computers, mobile devices, and to other televisions connected to a smaller "Joey" STB ("Hopper HD DVR," 2014).

The service networks are only a small part of the infrastructure of these devices. The technological infrastructure is just as important, especially when data designed for one device winds up on another device. Web TV is a good historical example of how information designed for one device was displayed on another. For Web TV, Internet

content designed for a computer was displayed on a television format, all with similar

points of contact, such as a traditional keyboard. This format difference caused many

problems for Web TV (Fischer, 2006). However, it is possible to develop a system that

puts information from a computer on a television screen. It is likely that web pages will

not be nearly as dominate of an Internet artifact as it was in the past (Marsden, 2004).

Smaller STBs such as a Roku Box, Apple TV, and others have developed television

system that solely rely on Internet over traditional television content. These more recent

developments limited the services available to the user, but these services appear to

perform the duties required by the users.

As part of the convergence of devices and increases in technologies, some

stakeholders will wind up cut off from the economies that drive these industries. Web TV

service was one of the past victims. Pepper (2004) best explains two parts of these

industries (domestic consumer content revenue, domestic transmission network

revenue), stating that changes in these fields would amount to a "potential restructuring"

of 2/3 of a trillion dollars per year, a massive amount of money.

1.3.5 Digital Design Methodology

A major part of the success of digital products is the ecosystem in which they

exist. The complexity of these systems varies wildly from product to product. By

focusing on good design, a good ecosystem can emerge along side good products. In

the 2009 documentary *Objectified*, revered industrial designer Dieter Rams stated,

"Today you find only a few companies that take design seriously, as I see it. And at the

moment that is an American company. It is Apple." Apple is one of a few mobile device

makers that has been very successful in the implementation of what makes up their

portion of the digital landscape. Apple's focus on the device users works as if every

touchpoint of the user has been considered in their final designs.

One way to consider the touchpoints of the users it to create an ecosystem

diagram. An ecosystem diagram may be useful for a company or designer to use in

order to achieve the level of detail on customer touchpoint design. An ecosystem

diagram is a tool designers can use to develop an idea of how a user interacts with a

particular product. This diagram details all of the touchpoints a user comes across when

he or she interacts with a company or a product. In Jon Kolko's (2011) *Thoughts on*

Interaction Design, he describes what can come from an ecosystem diagram:

An *ecosystem diagram* is a visual representation of a system

or brand, commonly used to describe a set of user

engagement points... The individual product might work well

with other products by the same company, and it might be

compatible with products from partner organizations. Each of

these elements will be designed, and the benefit to both the

user- in predictability and compatibility- and the company- in

customer loyalty, revenue, and centralized support- is

enormous when they are all designed to work in concert with

one another. (p. 48)

If you examine the Apple brand, you can clearly see that Apple has used a

ecosystem diagram, or some other similar model, to design an Apple experience for the

user. Every interaction with the customer has been designed for their experience, even when something goes wrong.

Apple has also placed much focus on their future models. Each model of the iPhone from the initial model to the iPhone 5 has incremental advances in technology. John Edson (2012) discusses Apple's approach in *Design Like Apple*. He states:

> If you continually design quality products, then each
>
> successive one benefits from and adds to the greatness of
>
> the one that came before. The first iPhone in 2007 was a
>
> sales megahit (up to 70,000 units in the first weekend alone,
>
> according to estimates) and so was the iPhone 4S, released
>
> in the late 2011 (4 million units sold in the first weekend).
>
> This despite the fact that the iPhone 4S wasn't a great leap
>
> forward technologically-except for Siri, the built-in personal
>
> concierge-and initially debuted with less-than-stellar reviews.
>
> More important than the number of new features, though, is
>
> the quality of how those new features are implemented. (p.
>
> 82-83)

Apple's focus on design improves people's opinion of the Apple brand. To larger companies, branding is one of the biggest considerations in regard to their product. These companies want their products to be in the vernacular of the customer's mind. Brigitte Borja de Mozota (2003) describes the value of branding in *Design Management,* saying:

Creating a strong brand does pay off, and brands create

meaningful value. Interbrand studied brand value compared

to market capitalization: ratio of brand value as percent of

market capitalization. Nine of the top sixty brands over $1

billion had values that exceeded 50 percent of the whole

company value. BMW, Nike, Apple, and Ikea had company

brand value ratios of over 75 percent. The top ten brands in

2001 were: Coca-Cola, Microsoft, IBM, General Electric,

Nokia, Intel, Disney, Ford, McDonald's, and AT&T. (p. 208)

When it comes to digital devices, users must pick which portion of the digital landscape

best fits them. Often, your choice is iOS, which is exclusive to Apple, and its "walled

garden" ecosystem; Android, which is available on a wide amount of devices from many

different companies; or late release Windows 8, among others. Between Apple, Google,

and Microsoft, Apple has done the best job in creating an ecosystem that best

represents itself as a quality brand.

According to Apple, much of their success comes from the limited models of

products they sell at any given time. We have established that these devices work well

with one another, but there is something missing from Apple that they have left up to

other companies.

Much of Apple's ecosystem design success depends on the automation of

certain features. For example, when you download a song from your iPhone, it

automatically downloads on all other devices tied into that account. Apple has placed

very little focus on the augmentation of their product line. If you want some sort of music

dock, a third-party company must be brought in to fill that void. If you want to make one

of their products more durable, a third-party company is likely to fulfill this need. In

regards to the difference of augmentation and automation Donald Norman in *Emotional*

Design (2004) states:

> Augmentative tools are comforting, for they leave the
>
> decisions and activities to the people. Thus, we can take
>
> them or leave them, choosing those that we feel aid our
>
> lives, ignoring those that do not. Moreover, because these
>
> are voluntary, different people can make different choices, so
>
> that people can choose whatever mix of technology suits
>
> their life style.
>
> Autonomous devices can be useful when jobs are dull,
>
> dangerous, or dirty. Autonomous tools are useful when the
>
> task otherwise could not be accomplished. (Ch. 5 paras.
>
> 26-27)

If Apple were to start designing products to augment their existing products, they could

be even more successful. However, most of their products in this category will need to

be replaced as often as the device is replaced. For example, many of Apple's iDocks

won't work with future generation products. Specific instances where they would work

with two generations of phone would be the dock for the iPhone 3G which would also

work with the iPhone 3GS. The same similarity exists for the iPhone 4 and 4S.

While a phone case may have been useless after a product redesign, other

functions provided by third-party companies have the potential to become waste after a

new format is introduced by the first-party company (Foresman, 2012). When Apple switched from using the 30-pin connector to the lightning cable, many Bose speaker/ docks sold up until that point were locked in a dying format. Not only will the user be forced to purchase another premium device, the old is soon to be waste.

For objects that require interaction design, proper feedback and a good user experience from the device are essential to keeping a user within an ecosystem. If a user has one object that works fairly well, but another company produces a similar product that works better, a user may find that to be a good enough reason to switch products. The old product is now only one or two steps away from the garbage dump.

A designer must consider the ability of the individual using the interface and the information output of the device to the user. In another book by Norman (2007), *The Design of Future Things*, he states, "The proper way to provide for smooth interaction between people and intelligent devices is to enhance the coordination and cooperation of both parties, people and machines" (Chapter 1, para. 35). Norman's comparison of human/device interaction is more similar to a human/horse comparison. Primarily, the difference between these two is that a device is currently unable to instinctively assess a situation and act accordingly, while a horse's survival instincts control these actions very well. Humans and devices are also dissimilar as well. Norman (2007) also states, "The lack of common ground is the major cause of our inability to communicate with machines. People and machines have so little in common that they lack any notion of common ground" (Chapter 2 para. 33).

Humans are currently far from developing devices that share much, if any, common ground with humans. Imagine you owned these three technological devices

from the fictitious Star Trek universe: A tricorder (similar to a tablet), a phaser (similar to a pistol), and Commander Data (an anthropomorphic intelligent robot). You will probably find that you share more common ground with Commander Data than the other two devices. This is based upon the fact he looks and acts like a human, and because he is much more technologically advanced than the other two devices. With digital devices, it is important for the human/device interaction to be natural and intuitive and to have the latest technological advances. Current products are often intuitive and natural to use, but there is often little hope of upgrading them to the latest technology, especially in the mobile market.

It is unlikely that users will find a single device solution to solve their digital needs. While some form of convergence may reduce or eliminate the need for a digital device, a single solution is unlikely. Instead, users will continue to switch from device to device as their needs change throughout their day.

1.4 Objectives of Study

- To develop guidelines that can be used to create a digital integrated system that allows users access to all of their content and services.
- To study how users interact with their digital devices and how this access can be used for convergence design solutions.
- To identify the forms of convergence and the direct effect they have on the digital landscape.

- To understand the technological and business challenges that designers may face when designing an integrated system that uses heavily-guarded content and system access.

1.5 Assumptions

The largest assumption used by this text is that television displays, computer displays, and mobile device displays or some combination of these devices will be necessary for users to view digital content. Of these devices, it is likely that mobile devices like smartphones will feature a touchscreen interface. In addition, mobile devices are very fractured in nature, and it is unlikely to find accurate statistics that account for all of these devices. There is the possibility that some new concept could potentially replace the need for these devices. This text also assumes that content transmitted over various networks will be digital in nature, and that this is the preferred means of transmission. It is also assumed that rational economics will apply to business entities and stakeholders, thus these individuals will always act in their best interests from a financial standpoint. When application submissions are made by designers to these stakeholders, it is assumed that they will reach approval and be available for download.

1.6 Scope of Study

This study will, in general, cover products that are digital, have a screen based interface, and have content distributed through subscription networks. The devices covered will use high-definition color displays that provide the user with a form of on-

screen digital user interface. This study will focus on the trends that have occurred

within these particular markets and how the users have responded to these trends. This

study will also focus on technical and business challenges that face digital convergence.

1.7 Limitations of Study

A large focus of this study will be placed on televisions, computers, and mobile

devices, as they have been widely adopted. Mobile devices will have the shortest

history researched, mainly starting in 2007 with the release of the iPhone. Apple's iOS,

Google's Android, and Windows 8 Mobile are the only three mobile operating systems

that will be covered during this study. Statistics will primarily focus on the population of

the United States. The focus of any network, device, or infrastructure will be digital in

function. Other screen-based devices, such as the Oculus Rift, will not be discussed as

they are not widely used as of the writing of this study.

1.8 Anticipated Outcome

The main outcome of this study is the developed guidelines for creating an

integrated system that designers can use to give users an easier way to interface with

their digital devices and access their services across platforms. This will lead to the

development of a thesis that demonstrates this idea, and is applicable to the electronics

industry. These findings will be published in a master's thesis format. The outcome will

also provide a demonstration of this methodology in conjunction with a current product.

By using the results of this study, the design of digital products will have a more

user centric approach. The results of this study will allow designers to develop an

integrated system that focus wholly on the user instead of the nature of the user interface. Users will no longer lose access to their subscription services as they move from one platform or device to another.

1.9 Definition of Terms

Convergence: the merging of distinct technologies, industries, or devices into a unified whole (Convergence, n.d.). This can include network convergence, convergence of content, and digital convergence.

Digital Content: downloadable or accessible digital data that is viewable on a digital device (Mullan, 2011).

Interaction Design: a field of design that centers on the user interacting with digital devices, networks, and services (Cooper, Reimann, & Cronin, 2007)

Internet of Things: "is a scenario in which objects, animals or people are provided with unique identifiers and the ability to automatically transfer data over a network without requiring human-to-human or human-to-computer interaction" (Rouse, 2013).

Chapter 2: Three Forms of Digital Convergence

2.1 Introduction

According to The Center for Convergence and Emerging Networking Technologies (CCENT), "'Digital Convergence' refers to the profound changes in the structure of media caused by the emergence of digital technologies as the dominant method for representing, storing, and communicating information" ("Welcome to CCENT," 2011). CCENT also defines digital convergence through the use of the three following developments:

1. The coming together, into a single application or service, of information content from sound broadcasting, telephony, television, motion pictures, photography, printed text and money.

2. A growing amount of overlap in the functions that can be performed by different physical telecommunication networks.

3. A growth in the interactivity, interoperability and connectedness of different networks and information appliances in the home and the office.

These three developments essentially describe device convergence, content convergence, and network convergence.

Convergence is a means to an end. It is there to make our lives more convenient and our activities simpler. It allows users to purchase fewer devices and services while retaining access to their content and experiences. Digital convergence is an open-ended process, where new technologies build on old infrastructure. By factoring in these forms of convergence, designers can develop newer methods of creating devices that house similar features, or delivering content in more efficient and innovative ways.

2.2 Digital Device Convergence

Device convergence is a technological advancement that results in a single device, housing, or unit that replaces the need for one or more devices. According to the International Telecommunication Union, consumers enjoy the ability to own one device that saves in size and ownership costs (Papadakis, 2007). Often the intended result of a device convergence is that the new device will replace one or more single function devices the user no longer needs. As time has progressed, so has the occurrence of device convergence. Can device convergence occur to the point where one device is a solution for all digital media and content? If so, what will this device look like and how will it work?

There is much speculation on what form the ultimate digital convergence will take. Verlyn Klinkenborg of the *New York Times* believes that all electronic devices will eventually converge to a single gadget (Klinkenborg, 2006). According to USC professor Henry Jenkins, individuals waiting for a single device solution "will be waiting for a very long time" (Jenkins, 2006). While it is possible to speculate on the future of gadget design, a one device solution is not implementable at this stage. One of the principles of famed industrial designer Dieter Rams is that good design is unobtrusive ("SFMOMA Presents," 2011). Currently, there is no single device solution that could possibly be unobtrusive to users.

There are limitations and external factors to device convergence as well. Size differences among devices are certainly a problem for a single solution design. While it may be possible to combine a television and a mobile phone, a device convergence solution with these devices is obviously silly. Users interact with their digital devices as

well, which currently requires remote controls, mice, keyboards, and more external gadgets. It is unlikely that these devices will be integrated into a single gadget design, but they are likely to be replaced by other methods.

Device convergence is only one part of the solution to digital convergence. It, along with content and network convergence, becomes more streamlined and efficient as time progresses. The human experience with digital devices is what truly converges. It is the human experience that is the focus of design. Humans can also have negative experiences, and negative experiences have their way of being easily remembered (Tugend, 2012). Because of this ability, it is important for designers to create a positive experience rather than a negative experience.

According to Margherita Pagani (2003), there are three questions device makers should ask themselves in order to speculate on the convergence of a device: "1. Is it physically possible to merge the two devices? 2. Is it technically possible to merge the two devices? 3. Will consumers want to use the merged device" (p. 37)? The focus of Pagani's first two questions are concerned with the form of the device, while the third question is more concerned with marketing aspects of design. After all, it is often physically and technically possible for devices to converge, but they do not converge due to the nature of how users interact with these devices.

How can a single solution exist when faced with the "Internet of Things?" This "Internet of Things (IoT)," phrase was coined by Kevin Ashton, and is based upon an idea that objects in your home or environment will be connected to a network that allows for more computer automation (Ashton, 2009). The very nature of this situation is based upon having devices separate, so no single device system could possibly exist. The

dawn of "Internet of Things" is upon us right now. According to Gartner, 26 billion units

that rely on Internet access will be sold by the year 2020 ("Gartner Says the Internet,"

2013). These units do not rely on human input to function in this system. This is still a

part of convergence even though there are so many additions to this process.

The difference between the Internet as we have known it and the IoT is the level

of human input required. The IoT allows devices to communicate with other devices

without the need for human input (Tan & Wang, 2010). It seems that most of the focus

on Internet innovation has centered around faster speeds and more access for users.

The addition of the IoT to the current role of the Internet shows how the Internet has

become an evolving entity (Coetzee & Eksteen, 2011).

It is likely that in the future, devices will be replaced by services. Hypothetically,

the idea of the traditional television experience could be reduced to an application that

streams television service in time block scheduling, totally over the Internet. The

Figure 1: TiVo STB with Remote (Reisinger, 2009)

business model of TiVo is between these two realities. A TiVo STB is not much different from any other DVR. It has similar components and records shows for viewing later. Users cannot simply purchase a TiVo STB, plug it in, and start watching television. Instead, users pay for TiVo service as if they are paying for a content service. Of the various DVRs available, TiVo is notable for several reasons. The TiVo company was one of the first DVR companies to arrive to the consumer market in January 1999 ("History," n.d.). Another competitor, Replay TV, was introduced at the same time, but did not have the same success as TiVo. In addition, Replay TV is no longer in business while TiVo remains in many households nationwide. Even though many DVRs are not TiVo branded, the term TiVo has become part of the vernacular in America. It has become a verb, as if someone recording a program is TiVoing.

If a television watcher gets a DVR from a cable or satellite company, there is likely a fee associated with this device that acts more like a device rental than a charge for services. In some cases, TiVo may be a brand available through these companies, and these cases are different than cases where users purchased a TiVo through retail outlets. Users that purchase a TiVo DVR have the option of purchasing a lifetime subscription for $499.99, or a monthly fee subscription for $14.99 ("TiVo Payment Plans," n.d.). It should be important for users to understand that a lifetime subscription is tied to the life of the device and not the life of the user ("User Agreement," 2013). Instances where the device fails would be covered, but this is not always the case if the device is damaged by the user or damaged through accidents. A user could potentially purchase a TiVo at a retail cost of nearly $200 with a lifetime subscription of nearly $500 for a total cost of $700. Since monthly subscribers are required to keep the subscription

for 12 months, they are paying $180 for a limited amount of time. Users must keep a

TiVo DVR active for 2.7 years before the benefits of a lifetime subscription are met.

What is a user paying for when they have access to TiVo instead of other DVRs

is essentially the TiVo experience. According to Peter Merholz of Core77, factoring in

the customer experience is what sets TiVo apart from its competitors (Merholz, n.d.).

The TiVo experience is now making more progress through convergence within the

mobile device ecosystem. Applications for iOS and Android are now available for

download ("TiVo App," 2014). As they have with their DVR interface, it looks like a great

deal of focus was placed on the app interface.

2.3 Network Convergence

Network convergence is a technological advancement that allows more content

and information to flow through fewer points of access. In the case of digital

convergence, the information is digital in nature. Users may have access to multiple

types of networks. A user with a television, a computer, and a mobile phone typically

has access to a television service network, an Internet service provider (ISP), and a

wireless data network. If these networks combine in function, then network convergence

has occurred.

A device convergence has a direct effect on the users because they have

purchased and own this device. With network convergence, ownership is not required

by the users. Users may own a wireless router, which creates a form of a network, but

do not have any ownership of the Internet network that provides this service. It is likely

that many IoT solutions will work with wireless networks owned by users, as there is a

current network infrastructure in place to implement these design solutions. Internet access is available to almost 75 percent of the US population, and many of these connected individuals connect to the Internet with WiFi networks ("Computer & Internet Trends," 2014). Using these networks as a new infrastructure for IoT devices is a great example of network convergence. Since the IoT is in its infancy stage and is expected to increase greatly by 2020, now is the time to focus on solutions based upon these networks.

There are several ways that networks can converge. If there is a technological convergence, then an advancement has occurred that allows two networks to function on the same infrastructure. Such an example would be the ability for cable television service providers to also provide Internet and telephone access across their existing infrastructure. A business convergence can result in a network convergence as well. A merger between Comcast and NBC resulted in the convergence of content and the

Figure 2: Charter Communications Bundled Services ("Charter Bundles," 2014)

convergence of networks. The overlap of ISPs and content providers was a concern for the FCC because of the potential of ISPs abusing control over the access speeds of rival networks ("FCC Approves NBC," 2011). Any network convergence can result in one of the networks becoming obsolete as well. Network convergence has resulted in the mass exodus of users that rely on over-the-air (OTA) television and traditional landline phones. As of 2013, only 7% of homes with a television rely solely on OTA broadcast television ("Only Seven Percent," 2013). The use of landline access is currently dropping, going from 96% of household with landline access in 1998 to 71% in 2011 (Sparshott, 2013). This is likely to drop more as the population ages and younger individuals enter this market. As of 2012, 60.1% of US adults aged 25-29 years had no access to landline phones (Higginbotham, 2012). While some of these user may subscribe to landline access as they get older, it is likely that many will not.

As stated earlier, there was a high level of content convergence with the NBC/Comcast merger. This is because business convergence does not always affect only one of the three forms of convergence. In regard to device convergence, it did very little to change the landscape of devices available. The convergence of content was much more drastic with the network convergence of Comcast and NBC than any convergence of devices that may have resulted from this merger. In regard to users, the convergence of content is very important because it give users more choice and more access to digital content. More access is directly beneficial to the consumers of digital content.

2.4 Content Convergence

There are several points-of-view as to what constitutes digital content. Since the focus of this document is on devices that feature screens, content is essentially what is viewed on the screen and heard through the speakers at any given moment. This is the driving force of the user's experiences. Content to a television actress would be the digital recordings of television episodes from her past. In fact, her entire business is the creation of content. It is in fact quite a large business. In the realm of video game content, the "Call of Duty" series has generated sales of $8 billion worldwide within a ten year period (Gaudiosi, 2013). This is only one series of games that is available on various platforms.

Content convergence is a technological advancement that allows digital content to be accessed on a device that was previously unable to access said digital content. It is an easy concept to understand. In 2004, little thought was given to television content being easily accessible on a video game console. Ten years later, through the convergence process, television content is now easily accessible on video game consoles with services like Netflix and Hulu. Content convergence is also easily implementable. Since digital information is essentiality a series of 1s and 0s, getting access to the information across this landscape should be easy, in theory. While the convergence of these contents is rather easy, stakeholders are often present within these industries who adamantly protect their copyrights. This complicates the process of content convergence, even though it is easy enough to implement a digital design solution.

The music industry is a group of content creators that know too well how content convergence can have a direct effect on their business. In this case, it was a converging of content that brought about the .mp3 player industry. When users obtained the ability to write digital music information to a compact disc, they eliminated the need to purchase music on a distributed album. It also allowed users to create a "mix tape" on a CD format. Today, physical album sales are trending down, though physical sales are still the most popular format for purchasing music ("The Nielsen Company & Billboard's," 2013). When the device convergence event that gave the world the portable .mp3 player hit, users were able to catalog and organize their entire collection on a digital format on a digital device. The device convergence that gave us the smartphone eventually ate away the .mp3 player market. While these devices come and go, it is the content that remains. Anytime a form of content has been created, it has not been replaced. Instead, it is the method of access that changes. Since the advent of content like movies, audio recordings, and more forms of content, they have become more accessible as the convergence process commenced.

The convergence of music onto digital devices is a great warning for the convergence of other forms of content. Will the convergence of television content to other devices have the same effect on the television industry as it did with music? It all depends on the lessons learned from the music industry. Legally downloading music is now a much easier process than in years past. While digital piracy may always exist, a user will also pay for an easy to use system.

2.5 Digital Convergence Conclusions

It is highly unlikely that a single device solution is possible for digital convergence within the near future. The available digital devices are still specialized enough that any absence would be obtrusive to users. Digital convergence solutions will most likely have Wi-Fi connectivity. The "Internet of Things" will most likely make use of Wi-Fi networks, and these networks are likely to increase in popularity. Design solutions should focus on creating a convergence of content, as this content is what drives the users' expectations.

Chapter 3: Trends Regarding HD Display Device Convergence

3.1 Introduction

According to New Brunswick at Saint John professor Daniel Downes (2005), "Technology (an artifact) causes the problems, while human emotions solves them" (p. 18). It is this emotion that drives the designers involved in the process of convergence. They will shape this new technology and decide how users work with it. As the forms of these converging technologies develop, they may become confusing to new users of these technologies. When you consider a book, one artifact of technology long converged into television and computer content, it is relatively intuitive for a reader to pick up and understand how to use a book (Balsamo, 2011). Eventually, it will become as easy for individuals to pick up and use electronic artifacts as it is to pick up and use a book. Since this study heavily involves the use of high definition screens, it is important to examine the three most heavily used forms of screens. By focusing on trends in the areas of television, computers, and mobile devices, we learn about the goals, wishes, and expectations of the end user.

3.2 Television's Transition to Digital Technology

The opportunities of convergence within the television industry have greatly increased thanks to the digitization of the television format. Since television content is now a digital message being seen on the television screen, it shares common ground with computers and mobile devices. Previous analog methods of broadcasting television required a format conversion before it was viewable on a digital device. The conversion of television signals into a readable format has often been performed by set-top-boxes.

Set-top-boxes (STBs) and Infrared Remote Controls are common parts of the television platform. The form of the television typically maximizes the user's focus on the screen, and is similar in nature to computer monitors. Television content is also separated into traditional methods of viewing along with availability through Internet services. When you consider the addition of television's online competitors, it becomes apparent that the line between individual digital platforms and networks have blurred, and is near ready for a revolution. This revolution will come by way of a convergence between devices; many involving the use of televisions, computers, and mobile devices (Stipp, 1998). The television is the oldest product of these technologies, though it was not always a digital device. The personal computer, both the stationary desktops and portable laptops, came about next, and has dramatically increased its graphics abilities since its inception. Most recently, the popular smartphones and tablets have been very widely received into the technological market, though they are a form of computer themselves.

3.2.1 Black and White to Color: A Brief History of Television

The television has been commercially available since 1947 (Carbonara,1992), though television has only recently become a digital technology. Before June 13, 2009, television stations transmitted their signals on an analog format. The switch to an all digital format allows the broadcast of better picture and sound quality. It has also freed up part of the broadcast spectrum for purposes of wireless communication and public safety communication ("Digital Television," n.d.). Since the switch to digital, all retail

purchased televisions require a digital TV tuner to be built into their design ("How to

Survive," 2008).

While there have been many changes to the technology of the television, there

has also been a large increase in the availability of television content. The early days of

television were dominated by "The Big Three" networks (NBC, ABC, and CBS).These

networks were able to hold on to 90% of the primetime marketshare in 1980, only to

have their combined share drop to 32% by 2005 (Hindman & Wiegand, 2008). In 1980,

there was only an average of about 10 channel choices for Americans (Compaine,

2000). In 2007, users had many more choices, with users having an average of 118.6

channels ("Average U.S. Home Now," 2008). As of November 2013, television service

provider Dish Network had a service package with over 260 available channels

Figure 3: Dish Network Channel Lineup ("Standard HD Channel Guide," n.d.)

("Standard HD Channel Guide," n.d.). Cable competitor Comcast had channel availability going above 160 channels ("Digital TV,Cable TV," n.d.).

3.2.2 Onset of Digital Technology

The change to a digital format allows the data to be easily transferred to other digital devices with no loss of quality. This format having common ground with other digital devices increases the chance of being a potential convergence device, or replaced altogether. The picture is only one digital trait that is shared shared with computers and mobile devices. When you consider the other components and infrastructure of the television service industry, other similarities with digital devices also appear.

The STB is often present with a pay television service provider and was once completely necessary to access digital content and channels. While it is possible to design a television with the necessary components to convert a signal to a picture format, most televisions sold in the past do not have this technology, but rely on service providers' STBs to use corded connections, like HDMI, to achieve these same goals. For example, 90 percent of Charter Cable subscribers in St. Louis use at least one STB (Gallagher, 2014). Advances within the STB realm have occurred to enhance the television experience. Integrated program guides (sometimes called electronic programming guides) allowed users to be free of the TV Guide and the scrolling channel guide that allowed no user interaction (Gorine, 2002). Such advancements were achievable by introducing low level computer components such as processors, memory, and video processing hardware into STB devices. The addition of storage space via

hard disk drive allowed the STB to record television for viewing later. This method of storage is heavily used within the PC market, and often uses the same hard drive format in both types of devices. For example, Tivo STBs are easily upgradable with external hard drives designed for computer use ("Increased Recording Capacity," n.d.). When you consider that STBs contain so many similarities with computers, you could argue that a STB is a form of computer, though rudimentary and only for specific purposes.

3.2.3 Methods of Interaction

The television's long history has provided consumers with a multitude of physical methods to interact with the television. Knobs, buttons, and switches have all been popular at some time. Early trends of knobs and switches, typically on the right side of the screen, have left an imprint on the psyche of users. One could easily imagine the iconic view of an outdated television screen with these features, topped with "rabbit ear" antennas. Because of this imprint, the icon for a television often looks like older, outdates models of TVs, just as "save" icons use the dated floppy disc as their image. The trends of today have hidden these methods of interaction and places full focus on the screen with a plastic bezel around its edge. While this may frustrate users when they fumble with the controls, changing the channel while searching for the volume button, most people will use the remote control instead.

The remote control is widely considered to be a standard tool included with the purchase of a television. It provides the ultimate experience of freeing users from the necessity of approaching the television to change the channel. Remote controls are also

Figure 4: The First Wireless Remote Control: Zenith Flash-Matic (Palis, 2012)

easily used through tactile means, especially when users are in the dark. Infrared

controllers and receivers have become the preferred method of communication between

television and remote control ("RF Remote vs.," 2008). The STB is also a piece of

television equipment that heavily relies on a remote control for interaction purposes. It is

common for users to have multiple remote controls for multiple devices that work with a

television. (Grimes, 2012) The remote control is currently as necessary a component for

the television as the keyboard is for a computer.

In the future, it will still be necessary for the user of a television to have control of

the television through the use of a remote control. As the television evolved through the

years, so did the remote control. The wireless remote control was introduced by Zenith

in 1955 ("Remote Background," n.d.), and the remote would change over the years from

an ultrasonic signal to a common infrared signal found in many televisions and STBs

today (Arlen, 1987). The remote is a device that works across multiple platforms, though

not all situations are the same. A remote bundled in with a cable box is likely to control

the television to which the STB is connected. The cable remote is less likely to work well with the television than the original television remote, and the same could be said about the television remote working with the cable box.

The methods users take to access television content are very different when you compare web access and traditional TV service providers. The television experience itself is locked into a system of time blocks and scheduling which forces users to schedule their time around TV's schedule. On-Demand content is occasionally available, but the user is locked into whatever service is provided through their television service. The term "On-Demand" is somewhat a blanket term that could cover the the Internet Protocol TV (IPTV) packets sent from the cable company directly to a single STB, or could also be another term for data sent from services like Netflix or Hulu. For the purpose of this document, anything "On-Demand" will feature access to specific programming via traditional TV service providers, and not services available from the web, which will be known as "streaming." In addition to on-demand content, users are also able to record broadcast shows on a DVR for viewing later. One of the most important advantages of watching a recording on a DVR is the ability to skip commercials. It was discussed earlier that the DVR is a response to the technological advances within the broadcast industry along with a convergence of technologies of the cable box and computer system. However, the audience and interests of the content creators have both responded to this industry as well. The ability to skip commercials goes against the interests of generating advertisement revenue, but works well for the television audience. As discussed in chapter 1, television networks and their advertisers have previously worked on congressional legislation to stop this type of technology from

being able to skip commercials (Murphy, 2011). Watching a television program over the Internet allows these interests the ability to control the commercial breaks. Here, the advertisers and networks win while the audience has to once more watch commercials.

3.2.4 Current State of Convergence

The television industry has been hesitant in changing the format of the business they created. Since a great deal of income is based upon advertisements, they stand to lose money if people are skipping advertisements. In Saul Hansell's (2006) article "Convergence; High Anxiety," he asks:

> Will paid download services like Apple's iTunes, not to
> mention TiVo's and their ad-defying fast-forward buttons,
> undercut TV networks' huge advertising revenue? Or will
> video from advertising-supported Web sites become so rich
> that people will drop their cable and satellite subscriptions
> altogether? Or will they just steal what they want by using
> file-sharing software like Bit Torrent?

Since this article was published in 2006, his questions are still unanswered. Another issue with television service providers is the question of users only subscribing to what they want to view in their cable package. If users were able to cherry-pick the channels they subscribe to, many advertising dollars would be lost due to the sharp decrease of a potential audiences.

Regardless of the television industry's wishes, it is very likely that convergence will change the ways users access and watch television, or even the way they access their devices. In 2006, Verlyn Klinkenborg made a drastic prediction, stating:

> But before long, there will be a single slim rectangular device in which convergence is complete. What it is will depend on where it is and what it's near. We will have no idea what to call it, because none of its functions will have priority. Lose it, and you lose everything.

Soon after this article was published, Apple would announce then release the first iPhone. While this was not the single device to replace all other electronic devices, It clearly shows how device convergence is real and is in the happening stage.

The distinct lines that separate the television platform from other devices have been blurred with the widespread adoption of high speed Internet access and what is achievable through these speeds. Broadband access was only used by three precent of users with Internet access in 2000, but increased to 70 percent by 2013 ("Broadband Technology Fact Sheet," 2013). The television, which is considered to be a "dumb" device in today's "smart" device world, has content produced for this specific device that is easily and often accessed through online content providers, like Netflix and Hulu. Ironically, a second STB is often necessary to access this online content for viewing on a television. Having television content presented on a computer has been easily achievable since the 1990s. An example of this feat can be found in the Apple "Macintosh TV" computer that debuted in 1993 ("Macintosh TV," 2012), and will be further discussed later in the chapter.

Home Broadband vs. Dial Up, 2000-2013

Percentage of American adults 18 years and older who access the internet via ...
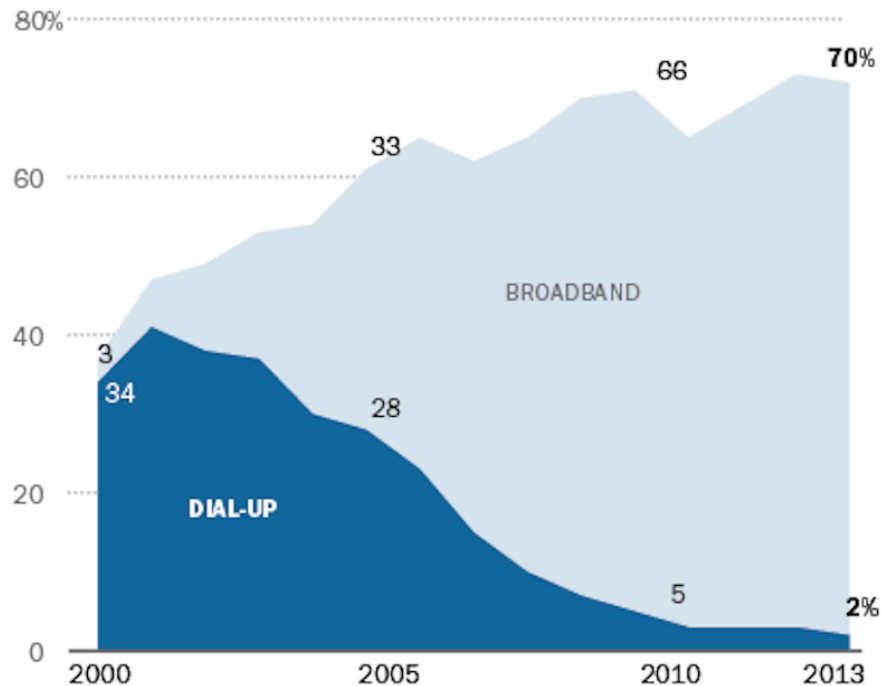
Figure 5: Broadband Replacing Dial Up Connections ("Broadband Technology Fact Sheet," 2013)

Television content is easily displayed on a mobile device and current production computers. Video services like Netflix, Hulu, and Amazon Prime all successfully provide methods of displaying television content on televisions, computers, and mobile devices. The convergence of television content has been much more successful than any device convergence with these three devices. Television does have a successful convergence of networks with Internet service. The network infrastructure of cable television service providers is often the very same network that provides Internet service to customers. As of 2013, Comcast has 21.6 million subscribers of television service with 20.3 million broadband customers on the same converged network. (Stelter, 2013).

It would have been difficult for New York Times author James Gleick to be aware of the advances of digital technology when in 1998 he wrote "Reinventing the Box: Why the PC and the Television Never Shall Meet." One part of his argument states, "And no matter how the technology advances, it's hard to imagine being happy reading paragraphs of text from across the room or watching widescreen movies in a tiny Microsoft window" (Gleick, 1998). He is correct that relying on a television for all computer needs is not desirable. He was correct on the latter part of that statement when he wrote this article, but the increases in bandwidth speed and video compression since then means users can now access full resolution content on demand via the Internet. This higher speed could easily allow online content providers to eat away at the market of traditional television providers. Gleick's point-of-view is now out-of-date, as his model only focuses on the possibilities of web access, not all digital content.

The television was earlier described as a dumb device, however there has been a recent trend of adding low level computing and applications built directly into televisions. Adding functionality to televisions has also been achieved via the use of STBs, and this trend makes accessing more digital content much easier via the television. Google's project formally known as Google TV makes use of a pass-through STB that allows regular television content and Internet content to be displayed on a single input (Aamoth, 2010).

Bringing the Internet to a television set has been a significant step in the evolution of this product. While forms of television and computer convergence have existed for many years, it has only become a popular option in the last few years. There are many choices for individuals that want to add smarts to their televisions. These

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Figure 6: Logitech Revue (Duncan, 2010)

"smarts" are typically Internet features, such as Netflix or an Internet browser, that can be access directly from the television, or through some form of I/O connection. The most important benefit of having Internet connectivity built into the television is the instant access to these features regardless of what input is currently in use. If Internet access comes from a STB, then the television must be switched to the connector displaying images from that particular STB. To avoid this problem, some STBs have been created that allow an HDMI pass through, such as in the joint venture between Google and Logitec that developed the Revue STB.

According to Logitech's CEO, this venture cost over $100M in operating profits (Bohn, 2011). There were several issues that had a negative impact on this device. The price of the device was high, initially at $299 (Weintraub, 2010). This price would soon fall to $99 a month after it was released (Murph, 2011). This lower cost is much closer in price to STBs available three years later.

A potential problem with Google TV is the requirement that hardware partners

must include a full QWERTY keyboard for any STB that runs Google TV (Roettgers,

2014). The end result of this requirement is a lot of crazy designs, such as large

remotes, overly confusing remotes, and remotes that were typical on one side with a

small keyboard on the opposite side. No, it is not easy to enter information with a

Figure 7: Netgear's NeoTV, Featuring Google TV ("Streaming Players," n.d.)

directional pad remote, nor is it practical to have a remote that is needlessly large and

overly complicated for the limited amount of time it is in use.

Even though Google TV failed with the Revue, it is still present in several other

STBs from companies like Netgear and Vizio ("Google TV," 2014). Google TV is also

available integrated with televisions, particularly the LG GA6400 & GA7900 televisions

("Discover LG Smart," 2014). Google TV is only one method used by Google to get into

the living room television set. Google's Chromecast has adopted a different approach.

Figure 8: Google's Chromecast Dongle ("Chromecast," 2014)

The Chromecast is a different animal than most STBs. For instance, it plugs

directly into the HDMI port of a television rather than relying on a corded connection.

One downside of this is that power is not carried through HDMI, so the device still

requires power via USB. There is no pass-through system as well. This means users

must switch inputs to access content through this device. At $35, the Chromecast

device is much more affordable than early Google TV STBs.

It seems that Google learned its lesson from Google TV. Instead of strange

QWERTY keyboards, Chromecast has information entered into its UI via computers and

mobile devices. It works as an extension of Google's Chrome browser, and has built in

features, such as access to content like Netflix, YouTube, and Pandora. The difference

between these two devices is that Google TV is a full blown device that allows for

downloads and does not require other devices to run (Hildenbrand, 2013). While these

two services are related, they are different in these key aspects.

Controlling the living room in this manner has not been dominated by any

particular service. In regards to manufacturers, Samsung has the highest percentage of

market share for smart TVs at 26% ("Samsung Leads," 2013) LG has the next highest

percentage of marketshare at 16% , followed by Sony at 11%. While Google TV may be

on some of the LG and Sony televisions, this is likely to change. LG plans to build a

differentiated user experience for their television purchasers (Levy, 2014). Though as

stated earlier, these components cost money. Users may very well purchase televisions

that do not have Internet features, but then rely on STB options provided by companies

like Google. While no great solution exists for the remote option, it is unlikely that users

are wanting to add another remote to their living room.

3.2.5 Statistics: Access to TV Content

Television is the oldest of the three technologies discussed in this chapter, and is

widely adopted across the United States. Though there have been many changes to the

form and the technology of the television, the ways users interact with the television has

changed little. It is still a mostly passive experience that focuses on a full-screen picture

most of the time it is in use.

The pay television industry is still a behemoth. Over 90% of American homes

subscribe to a traditional television service provider, but an estimate of 4.7 million of

these households shut off their television service in 2013 (Bajaj, 2013). This very much

backs up the fact that 32% of Netflix subscribers planned to cut down or totally remove

cable service in 2011 (McMillan, 2011). This is not a new trend, through it is increasing

in numbers as the years move on. Also according to McMillan, in Q3 of 2010, Time

Warner Cable had lost 155,000 cable subscribers while Comcast lost 275,000 users. These figures are more that double the subscriber losses from a year earlier.

There is also a possibility that members of the television audience may retain both traditional and Internet access to television content. When you consider that 71.7% of American households have Internet access (File, 2013) and 96.7% of American households own a television ("Nielsen Estimates," 2011), It is likely that many of these users will have access to both forms of content because people prefer the diversity of content more than they focus on the convergence of digital technologies (Fischer, 2006). While they may have some form of access to their content, getting it on all devices is currently unlikely.

3.2.6 Alternatives and Substitutes for Television

The ease and convenience of allowing users to control their schedules has left a profound effect on the content consumer. While the traditional TV series model causes users to wait weeks for their content to be broadcast, Netflix has achieved huge successes with allowing users to view entire seasons of programming immediately (Chmielewski, 2013). When shows like *House of Cards* or *Orange is the New Black* were available, users could watch marathon sessions of episodes without waiting. According to Netflix co-founder Mitch Lowe, releasing an entire season of television content at a single time undercuts the buzz created when released weekly. Regardless of the business feasibility, this product serves users well by allowing them immediate access to whatever content they wish to view.

The methods of interaction with a television are more suitable for a browser than a searcher, and it works quite well for these browsers. Accessing content through the Internet is different. A searcher is able to quickly search for content, and has a chance for multiple sources to provide the service. In addition, the content selection can be presented to the user as if he or she is a browser. A hunter of content through the television service will be very limited in instant access

There is no doubt that the availability of online content has a direct effect on the television industry. As of 2011, almost half of all Americans now watch some form of video entertainment online (Indvik, 2011). Viewing recorded shows has maintained a 31% growth, and almost three fourths of American homes have both a television and Internet subscription service ("Cross-Platform Hotspots," 2011).

While the DVR is still a newer part of the television industry architecture, it has appeared in a great many homes. 40% of homes in the United States have at least one DVR and of this percentage, 34% of them have multiple DVRs ("DVRs Now in 40%," 2010). When this study was performed in 2010, almost 90% of television watching occurred during realtime. According to DVR company TiVo, only 38% of television watching occurred during realtime, and the number shrank to 27% for users that subscribe to services like Netfllix and Hulu Plus (McMillan, 2010).

Television itself is likely going to have a metamorphic shift, or be replaced by Internet access means. Alan Pierce of Technology Today has stated, "For many analysts in the consumer electronics field, the question is not if broadband TV will replace cable and satellite service, but when" (Pierce, 2010). Never before has it been possible to converge the television industry with the Internet, such as it is now.

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Services such as Netflix and Hulu Plus are substitutes for traditional cable and satellite television, though neither is currently in a state to fully replace the other with no loss of content. A convergence, in this case between traditional and Internet television, allows users to choose between the products that offer these services (Greenstein & Khanna, 1997). In the case of television content, the audience can choose between traditional and Internet television sources, based upon the product the user has chosen to buy. In cases of direct access to content online content, a user must have a computer, mobile device, or a television with an Internet connected STB or built-in technology. For direct access to television service, it is necessary to have a traditional television setup or a substitute, such as a computer with a television tuner.

3.2.7 Hardware, Peripherals, and Connection Tech

It is very difficult to design interactivity to a television because of the nature of the television experience. The television is a passive experience in almost every way, and designing a highly interactive experience in this passive system is difficult because of this (Curran, 2003). An interactive program guide is a good example of how television was made smarter. Users had to subscribe to a magazine like TV Guide, or watch a scrolling list such as the TV Guide Channel, to know what was currently or soon to play on television. This interactivity made searching and browsing for content much easier for the television user.

When you consider the impact video games has had on adding a level of interactivity to a television, things become more complicated. Yes, there is a big difference in the attitudes and goals of the users who play video games and the users

that watch television. The passive interaction of the television user is replaced by the active interaction of the video game console, all on the same type of screen. Games, like other media such as television, music, and movies, are available to play on the television, both forms of computers, and mobile devices. Video games have also become more advanced as the years progressed, especially when you consider the highly interactive menu systems that players must navigate outside of any actual gameplay. Apart from the core interface that may be found on a console, games often have their own interface that vary from title to title. Though the focus of a game is not on the interface layer that sits between the user and the game content, but on the actual content (Montfort & Bogost, 2009).

Bridging the gap between video game consoles and what is commonly know as Interactive Television (iTV) to create a single entity is more complicated than it sounds. Yes, both a cable or satellite box and a video game console can both be considered a type of STB, but the level and method of input changes drastically when you consider the user. Consider the methods users must adhere to when interacting with an iTV and a typical video game. The video game user has access to a gamepad or joystick that is designed to be used in a very active role. The remote control associated with a television has a different design. It is meant to be used with a single hand for only a brief amount of time. Both remotes and gamepads can be used within a passive system, such as watching a movie, with relative ease. However, the gamepad is better to use than a remote control as the interactivity level increases because it was designed for this very purpose.

Figure 9: Nintendo Wii Remote ("Nintendo Wii," n.d.)

Winston William Hodge (1995) argues in his book "Interactive Television" that a television remote "should be as simple as possible to operate" (p. 16). His solution is a single button remote that uses a laser to interact with the menu system of an interactive television. He goes on to describe a level of interaction between the users and the television when they pick up the remote. While interaction between a user and a device based upon initial touch is an interesting concept, the idea of a single button to control everything by requiring the users to point and adjust their arms accordingly would probably not work well for long periods of time or for the elderly. When you consider the functionality of the Nintendo Wii gamepad and the remote described by Hodge, the functionality of the remote/gamepad is very similar. Instead of a laser, the Wii uses infrared technology in combination with Bluetooth wireless to interact directly with the television ("How does the Nintendo Wii Remote Work?" 2012). The Wii remote does

contain an accelerometer, which would be suitable for Hodge's remote control to function the way he intended. The Wii wound up being a beloved console and has sold over 100 million units worldwide ("How Does the," 2012). Users seemed to appreciate the immersive experience the Wii provided through their remote control system. While these two descriptions are similar, it is still more appropriate to call the Wii's remote control a hybrid television/video game console remote.

Currently, there is no single solution method that allows users access to all of their content through a single system. However, it is possible for product creators to work with currently used components and methods to develop a seamless system. Clever methods are often used to enhance a feature or develop a workaround to an existing problem. Consider a common problem with satellite television. While a cable

Figure 10: Dish Network Hopper and Joey (Burger, 2013)

connection allows users to plug directly into the cable line and have basic access, satellite users must get content from a STB because television sets are not able to decode the satellite signal. This can be a problem when a user wants multiple televisions to play the content provided by the satellite company. Typical solutions to this problem are to branch out the connection to multiple televisions, which means a user changing the channel in one room changes it in another room, or to pay extra for multiple STBs. However, recent developments have brought about a way to solve these issues.

Dish Network is a satellite television service provider that has over 14 million subscribers (Hannan, 2013). It has developed a STB named The Hopper, and it has taken a direct approach in the convergence of television content over multiple televisions, computers, and mobile devices. The Hoper has the ability to play live and recorded television on computers and mobile devices through a Wi-fi network. It also acts as a hub to smaller STBs which wirelessly plays the content from the central unit.

3.3 Personal Computer Era Convergence

The personal computer (PC) is a device that is more immersive than the television. The television experience is passive in nature, while the PC experience often requires active attention. The PCs of today are very different than early punch card computers. The inclusion of a graphic user interface was a strong first step to the convergence of televisions and computers, though early models had a very low resolution and color availability when compared to televisions. Many failures exist in early attempts to physically converge these two devices.

The PC market eventually branched into two main forms of computers: the powerful desktop and the portable laptop. Currently, there is a high level of content convergence and network convergence between the PC and the television. There are lower levels of device convergence, though it is easily possible, though not convenient, to have full television service on a PC.

3.3.1 Punch Card to PC: A Brief History

While elements of the very early televisions still remain on current televisions, the computer is just the opposite. Early computers were too large and specialized for home use, but were more likely to be found in Universities and large businesses ("The Early History," n.d.). Many featured a punchcard interface, and required much work from the users and operators.

Figure 11: Olivetti-Underwood Programma 101 ("Olivetti Programma 101," 2014)

The size of the computer has shrunk since the early computing days. One of the first desktop computers was the Programma 101, which debuted in 1965 ("The Incredible Story," 2012). There was no GUI and its form now looks closer to modern adding machines than a computer. It did little more than basic arithmetic and cost $3,200 ($20,000 when adjusted for inflation for 2012). However, the large price meant it was designed for business, and was not truly a consumer commercial endeavor.

Figure 12: Xerox Star ("Digbarn: The Xerox Star 8010," 2014)

It would take more than 15 years before a computer was built with with a GUI and other features found in modern computing. The Xerox 8010 Information System (also known as the Xerox Star) was released in 1981. It had a GUI with a window style interface that featured icons and folders ("Xerox Star," n.d.). It also featured a two-button mouse, ethernet networking, and had an early form of e-mail. Though the screen

had form similarities with CRT televisions, there was still a large difference between the graphic capabilities of this computer and the capabilities of the television.

3.3.2 Increasing Graphic Capabilities

Today's computer monitors and television sets have become more similar in capability than previous years. While color television was common during the debut of the Xerox Star, it would be years before computers could display color graphics on same level and affordability as television, though there would be many attempts at computer and television device convergence.

Figure 13: Magnavox Odyssey 2 Gaming Console ("Magnavox Odyssey 2," n.d.)

Video Game consoles share many components with the computer industry, and could somewhat be classified as a computer. If you consider that a QWERTY keyboard is naturally part of the computer experience, then a device like the Magnavox Odyssey 2 is surely an early attempt at a device convergence. It was introduced in 1978, had a

resolution of 160x200, and could be played on standard definition consumer televisions though with only 16 colors ("Odyssey 2," n.d.). The built-in keyboard makes this console more unique, as many consoles either have no keyboard, or can function perfectly without a keyboard. It cannot be considered a market success when compared to the video game industry today. The Magnavox Odyssey 2 only sold about 1 million units by 1983. Sony's Playstation 4 sold that amount the day it was released (Haywald, 2013). The comparison of televisions and game consoles of the late 1970s are still quite different than the comparison of televisions and personal computers. As computer technology increased, the ability to merge the two devices increased as well.

Figure 14: Apple Macintosh TV (Roberts, 2013)

In 1993, Apple released the Macintosh TV, an early example of a television converged with a computer (Bangeman, 2013). Like many Apple products, it was an all-in-one desktop with the components in the same housing as the screen. The inclusion

of a TV tuner allowed individuals to have a functioning computer and television in one design. Television content was only viewable in full screen mode, and no other computer content could be displayed while the television feature was in use. The device failed, with only about 10,000 units being produced. The high price of the device, when compared to more powerful computers of equal price, and the lack of expandability probably had a major influence on this failure. The device was on the market for only four months before it was discontinued, however, it was possible to add a TV tuner to other Apple computers after this device was discontinued. Apple would eventually develop the Apple TV, a STB that extends the services of iTunes from a computer to a television, though it is not a fully functioning computer.

3.3.3 Onset of Portable Computing

It may seem natural to think that as the size of computer decreased, the portability of the device would increase. While this is true, it would require changes to the form of PCs. PCs would eventually branch off into two major categories. The desktop computer is a stationary device, and often has higher power and more expandability than the portable laptop computer. Both would shrink in size and weight as the devices matured. Though the present form of laptops would go through many changes as the device matured.

One of the first forms of laptop computers is the Osborne 1, though it does look very different than todays laptops. This design was to be more of a portable desktop computer than a laptop computer. Dual floppy drives and a recessed area to store discs dominated the screen area while the actual screen was a 5 inch CRT display that

Figure 15: Osborne 1 Portable Computer ("Osborne 1 computer," n.d.)

features 52x24 text resolution ("Osborne 1 Computer," n.d.). The next year, the GRiD

Compass 1101 would be released, and it would revolutionize the form of the laptop

computer. This design had a larger screen that allowed 80x24 text resolution, though

there was no trackpad that is found on contemporary laptops ("GRiD Compass," n.d.). If

you consider design elements that are in almost all laptops sold today, the earliest

Figure 16: GRiD Compass 1101 ("GRiD Compass," n.d.)

example of a contemporary laptop is the Apple PowerBook 100 series. It was released

in 1991, though it did not have a touch trackpad, but instead a trackball; the screen
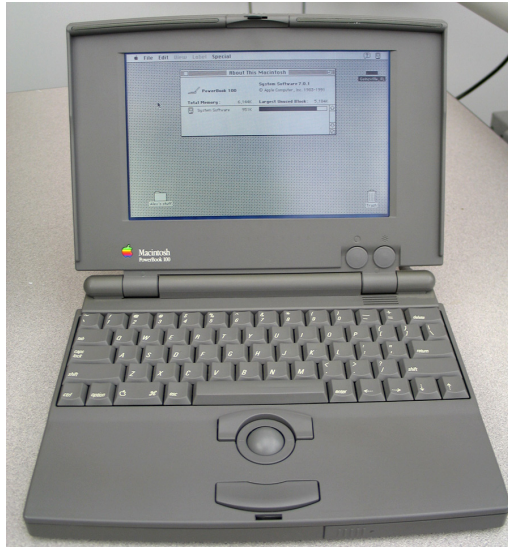
Figure 17: Apple Powerbook 100 (Mura,n.d.)

dominated the upper landscape, hinged at the rear of the device, featured palm rests on both sides of the trackball (Mura, n.d.).

3.3.4 Expansion of PC Components to Other Devices

As the development of computer technology continued, many components of PCs, such as memory, processors, storage drives found their way into other devices. Single function devices like digital watches, calculators, and mobile phones share some of these components with computers. Earlier in this chapter, we discussed how DVRs and STBs use interchangeable computer components for expandability.

As the IoT continues to grow, more and more computer components and methods will be in use from more and more devices. While the sole purpose of the Internet has been user based for many years, the Internet was restrictive in nature (Wirtz & Wehrle, 2013). Opening the Internet to more and more devices eliminates this

restrictive nature. Though these networks are not truly components, it shows how the

advent of these new devices will connect through computer methods.

3.3.5 Methods of Interaction

The primary methods of interacting with a computer is with a keyboard and

mouse, though the trackpad is also noteworthy because of its inclusion in many laptops

and the availability of Bluetooth trackpads. Other methods do exist, but none are as

popular as the mouse and keyboard.

3.3.6 Current State of PC Convergence

Watching traditional television on a computer screen has never been a very

popular when compared to watching on a television screen, though services like Netflix

has increased the level of television content watched on computers and mobile devices.

There has been a high level of convergence of content between the two devices, but

nothing noteworthy has even been introduced into the market. Smaller STBs from

companies like Apple and Roku have been introduced, but both devices have little

computer functionality though they do share computer components (Detwiler, 2011).

WebTV was a novel approach at the time, but was doomed to failure because of its sole

focus on web browsing with no higher computer functionality. In addition, using the

television for all web needs is not very desirable for users. Similar functionality is now

available in other devices, such as web browsing on video game consoles, though web

surfing on a computer is still a more popular option.

3.3.7 Statistics: Access to Computer Content

Though computers are the second oldest of the technologies discussed, they do not have quite the same percentage of adoption rates as televisions. By the year 2011, 75.6% of United States households had a computer, which is much higher than the 8.2% of individuals that owned a computer in 1984 (File, 2013) This is a moderate increase from 61.8% in 2003, according to the same study. Of the 75.6% of households with a computer, 71.7% had access to Internet.

Access to Internet and computers has become a bit of grey area. Users may have Internet access through a mobile device or use a tablet exclusively as a computer substitute. Age has much to do with computer and Internet access. Individuals that were aged 65 and older had an adoption rate of 61.8% for computer ownership, and only 45.5% of these aged individuals had Internet Access (File, 2013)

3.3.8 Alternative and Substitute Methods of Computing

Tablets and mobile devices are the most likely alternative source of computers. These devices have similar components to computers, but lack the functionality and have different forms of software than computers. Newer devices, such as Chromebooks, take the form of a laptop computer, but instead lack the functionality of a traditional computer (Chacos, 2013). These are used by individuals that want access to the web and limited functions like email and video services.

Game consoles have developed the ability for users to gain access to the web and other Internet services, though these devices are often more limited in functionality than mobile devices. Users will most likely have access to the web, but will be extremely

limited outside of this area, such as software choices. While other substitutes were designed to be a substitute to a traditional computer, the primary focus of game consoles is for playing video games. The Internet function is secondary, and would not be a preferable method of connecting to the Internet if there was a computer alternative.

WebTV is the most likely true substitute for a computer in the traditional sense. The WebTV device was designed to be cheaper than a computer, and used the television as the primary monitor. It was limited in scope and never caught on the way other alternatives have. It was at best designed for elders who were an already dying market when this service was released (McCracken, 2013).

3.3.9 Hardware, Peripherals, and Connection Tech

With the exception of most televisions, the devices in this document share similar forms of hardware, such as internal components like processors and hard drives. The most popular methods of interacting with computers is with a keyboard and mouse. Alternatives for the mouse include trackpads and touchscreens, though the mouse is most popular. However, if you need to type and you desire to type quickly, the keyboard is still the gold standard.

Computers can connect to the Internet through both wired and wireless methods. Most wireless connections involve a wireless router, though some devices like Lenovo's ThinkPad X1 Carbon laptop have built-in hardware that can connect to cellular networks (Shah, 2012). Most devices also contain some form of Bluetooth connectivity, though that is mostly used to connect peripherals without the use of cords.

3.4 Mobile Device Convergence

Smart phones are not new to the consumer electronics industry. Early smart phones were expensive, and designed for business use instead of consumer use. The iPhone changed this after its release in 2007. In Chapter 1, the release of the iPhone was described as three objects: a phone, a new iPod, and an Internet communicator ("Steve Jobs- iPhone Keynote 2007," 2007). Of course, they were already converged into the one device. The lower level OS on these devices require less powerful hardware than desktop OSs ("iOS," 2013). Since less power is needed to run mobile OSs, they are a great option to have installed on tablets than full desktop operating systems. However, some tablets, such as Microsoft's Surface Pro tablets, run a desktop version of Windows ("Microsoft Surface Pro," n.d.). Tablets would eventually eat into the PC market, and eventually forced out the short lived netbook (Martin, 2013). Capitative touch screens have replaced many buttons on smartphones. PC components and capabilities allow users to connect Bluetooth keyboards, though mouse functionality rarely or does not exist in these operating systems.

3.4.1 Cell Phone to Smartphone: A Brief History

Though there have been many early methods of remote access to telephone service, the focus of this history will start with the first generation (1G) of wireless telephone technology which was first widely adopted during the 1980s. Earlier mobile phones did exist, though battery life was short and charging time was extremely long.

Motorola released the first of the DynaTAC series in 1984. The model (8000x) was the first to be widely available on the commercial market. It would go on to become a pop culture icon seen in many movies, and is widely known as the "Zack Morris

Figure 18: Motorola DynaTAC 8000X (Ha, 2010) and IBM Simon ("RIM BlackBerry 5810 Specs,"n.d.)

Phone," due to its appearance on the popular NBC show, *Saved by the Bell*

(Munchbach, 2011). Overall, this device was not able to replace landline phones. The

phone was heavy (weighing 2 pounds), the price of the phone was almost $4000, it had

a talk time of 30 minutes, and standby time of 8 hours (Carpenter, 2005).

Battery life would increase and the size of the mobile phone would go on to

decrease over the next several years. Devices and service plans would become

affordable for more consumers, and eventually, cell phones would eat away the market

share of traditional landline phones (DeGusta, 2012). The abilities of cell phones would

increase as well. In 1994, IBM released what could be described as the first

smartphone. The IBM Simon Personal Communicator had features found on many

smartphones today, such as a touchscreen interface (via stylus) and multiple features

such as fax and email functionality (Sager, 2012). Though it was not a success, it early

on defined the trend of what smartphones would eventually become.

3.4.2 Design Trends of Mobile Devices

Though the Simon had a touchscreen, it would take some time before that would

become the main method of interaction. Often, the earliest devices had physical buttons

and touchscreens were activated with a stylus. Before the form of the current

smartphone was developed, there were many different forms available to users. Nokia's

Communicator (1996-2007) series looked like a regular mobile phone, though it could

flip open in the middle via a clamshell feature to reveal a QWERTY keyboard and an

LCD screen ("Nokia E90," 2007).

Figure 19: Nokia E90 with Clamshell Feature ("Nokia E90", 2007)

Blackberry smartphones typically had no flip or clamshell feature. Early models,

such as the 5810 (2002) featured a screen with a QWERTY keyboard underneath

(Brown & Brown, 2002). Such a design would be prevalent on most of their phones until

the release of the Storm model in 2008 (Arar, 2008). At the time of the Storm's release,

Figure 20: Blackberry 5810 (PDAdb) and Blackberry Storm (Amazon)

the iPhone was only available to AT&T customers (Hansell, 2009). This means that the

Storm was merely an alternative iPhone for users within the Verizon network.

The release of the iPhone in 2007 was a watershed moment for smartphones

and traditional cell phones as well. The adoption rate of smartphones has steadily risen

since its release, and the trend of having a capacitive touchscreen is almost universal

among mobile device creators (Ion, 2013). The device itself contains features that have

replaced a great number of devices (some potentially). The popularity of wristwatches

has decreased since the release of the iPhone, as people opt to check the time on the

phone itself (McFarlane, 2010). The effect this type of mobile device has is far reaching,

and is fully unknown how many industries will be effected by this relatively new

technology. It certainly helped bring the tablet into the consumer market, with their

similar forms and infrastructure.

3.4.3 Methods of Interaction

While there are still multiple devices that contain physical buttons, many users have adopted a mobile device that is similar in form to the iPhone. That is, there is a large screen for the users to view and interact with, there are very limited amounts of buttons, and fewer physical methods of interacting with the device. As the technology has matured, the ability to interact with the device with voice commands has become a reality, though most still use traditional methods.

The ability to interact with a mobile device via camera is in its infancy, and currently is in limited use. It is currently difficult to speculate the future of this method of interaction, though it has many potential impacts. One of the most important is the potential of replacing passwords by relying on biometrics instead. Devices may one day have the potential of recognizing their owners instead of requiring passwords to keep the device.

3.4.4 Current State of Mobile Convergence

While some manufacturers have developed independent methods of cross-platform functions with their digital devices, they vary wildly in how users access features. In 2005, the New York Times described the digital landscape in an article titled Digital Convergence Still Elusive, stating:

> According to Harbor Research, a San Francisco-based firm
> that specializes in home automation, the progress is
> haphazard and barely perceptible. In a report on digital
> convergence in the home, Harbor described current efforts

as "a fragmented landscape full of narrow-point solutions,

time-sink gadgetry, entertainment obsession and software/

platform incompatibility." (O'Brien, 2005)

Since this article was written, the mobile revolution occurred. Now the mobile

device is just another piece of the digital landscape. While the face of the product is

similar across mobile brands and platforms, the way it works with users is not. The size

and portability of the mobile device does allow the opportunity for the device to be used

to interact with other platforms.

3.4.5 Statistics: Access to Mobile Device Functions

Mobile devices are the newest of the technologies discussed and they are also

one of the fastest growing devices relative to their market availability. The interesting

trait about these devices is that they are the most physically converged, with the

potential to replace computers, cell phones, cameras, PDAs, and more.

As stated earlier, mobile devices are currently the fastest growing segment of the

devices covered in this document. While this will eventually level off, it is also

noteworthy to understand that their adoption rate dwarfs the adoption rate of television,

landline phones, and computers when these devices initially debuted (Farago, 2012).

However, it is difficult to find accurate statistics that show the full picture of mobile

device ownership. This is because most statistics will group the devices into categories

like smartphones, tablets, and other devices like Apple's iPod Touch. Thus, statistics

must be grouped individually among these segments, though the primary focus will be

placed upon smartphones and tablets. Other devices are too fractured, and could consist of devices like the iPod Touch, Playstation Vita, Nvidia Shield, and more.

A total of 91% of adults in the United States own a cell phone with 56% of American adults owning a smartphone ("Mobile Technology Fact," 2013). The adoption rate of smartphones outpaced the adoption of computers, Internet access, and social networking during their debut years (Mlot, 2012). Though the adoption rate of smartphone was very fast it is likely to be outpaced by the adoption rate of tablets (DeGusta, 2012). In May of 2010, only 3% of American adults owned a tablet. By May of 2013, that number increased to 34% (Zickuhr, 2013).

3.4.6 Alternative and Substitute Access to Function

Smartphones themselves have no real alternative, other than devices like feature phones which have limited functionality. The closest alternative based upon the form of the device would be mobile devices that do no have a phone feature, such as an iPod Touch or a handheld gaming console. Often, these devices will share the same operating system as a smartphone, such as the operating system in Apple's iPhone and iPod Touch.

A tablet itself could be considered an alternative to a computer. But much like their smaller counterpart, they do not truly have a substitute. Devices like Google's Chromebook could be an alternative to a tablet, but they do not share a similar form. The popularity of Netbooks has dropped dramatically because of the availability of tablets ("Why Tablets are," 2011). Netbooks are closer in form to laptops, though their price point is almost the same as many tablets.

3.4.7 Hardware, Peripherals, and Connection Tech

There is virtually no difference between the internal components of mobile devices and computers. They both have memory, storage, processors, and similar connection methods ("What are the Hardware," n.d.). This allows for some crossover of peripherals from computer devices. Most, if not all, tablets can connect to a keyboard via Bluetooth, though fewer connect with mice. This varies between the operating systems available for the users. Mobile devices have many accessories, such as cases and keyboard docks, though they are limited in the number of peripherals that can be used with the device. Some, such as the Microsoft surface, have the ability to connect USB devices. Other devices are extremely limited in the number of devices that can connect to the device.

3.5 Display Device Conclusions

While the television device will remain a popular device, the levels of access to traditional television content will decrease as more Internet based alternatives appear. It is likely that this will be a slow descent, as users prefer the level of choice that traditional and Internet services will both provide. The television device will continue to increase in Internet connection ability. It is less likely that a device convergence of televisions and computers will be widely accepted, though the computer itself is a good supplement to television access. For instance, the computer is a poor replacement for the living room television, but is a great alternative to have instead of a bedroom television. The utilitarian nature of the computer will keep the form and methods of interaction alive for the foreseeable future. Mobile devices will eat away at the computer

market, though it will not eliminate it any time soon. The size and portability of the

mobile device will make it a likely choice to use when interacting with other digital

devices and services.

Chapter 4: Technology Challenges Facing Convergence Design

4.1 Introduction

While a good designer's primary focus is the user experience, it cannot be his or her only focus. Technology is a major factor in the design of digital devices and designers are limited by currently available technology. It is also restrictive in size, thereby forcing the form of the device to be built around its components. It is restrictive in capability, though it has a very bright future. It is a future that is predictable, though many futurists' predictions have been quite wrong. Designers must work within the bounds of technology, which provides many hurdles. This chapter will focus on three specific challenges.

The first challenge is that designs must work with the current infrastructure available to the end user. Convergence design solutions must fit within these bounds. If these infrastructures were not considered, design solutions would fail to be implemented. Next, potential solutions should focus on the reduction of wires. There are many wires available for the digital real. They provide power, data, audio, and video transmission. Though many forms of wires fail to provide all four needs. Wireless technology is not at the point where it can replace the use of wires, though the convergence process will one day achieve this result. A designer must also account for any lack of standardization within their designs specific realm. The use of standardized parts and components causes less fractures for the users' digital landscapes.

Other problems, such as problems within the business community, may face the convergence process. Designers have little control over these entities. Through the convergence process, some business interests will be threatened with obsolescence. It

is beyond the control of designers to face these entities, so designers should focus on problems they can control, or simply circumvent the issue at any time possible. Regardless of the business entities, convergence will occur.

4.2 Designing for a Current Infrastructure

One of the biggest hurdles to the implementation of new methods of device creation and content distribution is the current infrastructure present in the industries of television, computers, and mobile devices. As stated earlier, the current digital landscape is fractured. Ultimately, when a user makes a choice to purchase one particular devices, he or she is making a choice to be within specific ecosystems. For example, a user that purchases a computer with Windows as the operating system will not have access to software that is exclusive to Apple's OS X. The television ecosystems and mobile device ecosystems also have similar problems. The end result of new methods and designs must be able to fit within the currently available infrastructures and use available technologies. Current technologies are not instant because the replacement cycles of these devices vary wildly. If one device is normally replaced after many years of ownership, it may be difficult to persuade users to purchase the latest technologies if the device still has many years of use available.

Any potential design solution must be useable with the currently available infrastructure or be introduced concurrently as part of the infrastructure. But what makes up the infrastructure within potential design solutions? With digital device design, there are three areas of infrastructure worth particular focus. The first, software infrastructure, consists of the operating systems and programs found on these devices. The software

infrastructure is digital only, and has no tangible form. The second is the hardware

infrastructure, and consists of devices, components, connectors, and peripherals that

have a physical presence outside of software. The third area, network infrastructure,

accounts for the methods used to access digital content and services. According to

Senior Investment Analyst Jeffrey E. Fulmer, "Infrastructure systems or networks of

interrelated components are the analogous arteries and veins attaching society to the

essential commodities and services required to uphold or improve the standards of

living (Fulmer, 2009). Designers must make use of these veins.

4.2.1 Software Infrastructure

Because the focus of this document is digital devices that feature screens,

software infrastructure is very important. Components that make up software

infrastructure exist strictly as digital information. The operating systems on computers

and mobile devices are very important parts in the software infrastructure. Often,

programs and files that work with one OS will not work with another. Therefore,

designers and programmers must release their applications on multiple operating

systems to increase market penetration.

The software infrastructure has the ability to provide platforms for device makers,

designers, and software engineers. The scale of a platform can change from platform to

platform. In simple terms, a platform can refer to an operating system, such as Apple's

OS X or Windows XP, and can refer to what software can be used on a computer

system ("Platform," n.d.). When you consider the difference between the Windows

operating systems and the Apple operating systems, the addition of devices into the

platform separates these two companies. In order to access the Apple platform, users must be using an Apple device. A lawsuit between Apple computers and computer maker Psystar has ensured that the only way to access the Apple platform is to purchase an Apple device (Ha, 2009). The options of accessing the Windows platform is more open, as Microsoft's platform is available across a range of device makers.

To design a system that works across the digital landscape, cross-platform solutions can be used. Cross-platform software has the ability to run separately on various platforms, such as a word processor that works in Windows and OS X (Crossplatform, n.d.). A document saved on one platform should be readable on another platform without a file conversion. Platforms are not only operating systems, but can be other entities as well. Designing web applications is an automatic cross-platform design because many browsers are able to display the same information regardless of what platform the browsers use.

The HBO Go service provides a great example of content convergence and cross platform functionality. The first release occurred in January of 2008, accessible to a small portion of HBO subscribers in regional locations (Levin, 2008). By 2010, this service expanded to most subscribers of HBO and was accessible through web browsers (Drawbaugh, 2010). Since then, HBO Go has become available on other devices. In 2011, service was available on Apple's iOS and Google's Android OS (Honig, 2011). As of March of 2014, HBO Go has become available on gaming consoles, specifically the PS3 and Xbox 360 with PS4 and Xbox One availability expected later (Makuch, 2014).

HBO's methods for releasing this application makes perfect sense for releasing a design in currently available software infrastructure. The size of the computer market was obviously the deciding factor to release a web service over other means. When releasing a service like HBO Go across the digital landscape, it is smart to start with the widest access methods first. More individuals have access to a web browser than access to a gaming console like the PS3 or Xbox 360. After the service has been developed for one platform, the designers can then design a cross-platform service that reduces the fractured nature of the digital landscape.

Like many other parts of the digital realm, software infrastructure is highly fractured. There are different operating systems available to device users which vary for a variety of reasons. With mobile devices, the most popular operating systems are as follows: Android with 75% of market, iOS with 17.3%, Windows Phone with 3.2%, and BlackBerry OS with 2.9% (Edmonds, 2013). If a designer was motivated by simple rational economics, then he or she would likely release their application in the order of highest to lowest percentage of OS market share. It is likely that some of the lower percentage operating systems may not get an application at all. This has negative consequences for the users of those operating systems. For a truly great user experience, users must have access to their subscriptions across all devices.

As users go about their day, they are likely to interact with several different operating systems on their devices. Their desktop computer has a desktop OS while a mobile device has a mobile OS with a very different interface. Microsoft has attempted to bridge this device gap with the release of Windows 8. The interfaces of Windows 8, Windows Phone, and the Xbox series all share a similar UI previously known as Metro,

but now known as Modern (Chang, 2012). This interface, via Windows Phone 7, won an Industrial Designers Society of America IDEA gold award for excellence in the Interactive Product Experiences category, and thus was well received critically (Clayton, 2011). Replacing the desktop interface with this new Modern interface changed the methods Windows users were accustomed to for the last 20 years (Paul, 212). This is a very great example of a design problem within the digital realm.

The software infrastructure is only a single layer of the digital infrastructure. This infrastructure exists entirely within the hardware infrastructure, which is much larger in scope and scale. But as part of any successful infrastructure, one part supports the others. The software infrastructure cannot exist without the hardware infrastructure, just as users cannot access digital content without the network infrastructure.

4.2.3 Hardware Infrastructure

There are many different types and various branches of infrastructure available to users daily. The electric power infrastructure is of particular importance to digital devices, as it is used to power these devices. Designers must understand the infrastructure of digital devices in order to design a products that is easily distributable and usable. If a designer was negligent in his or her knowledge of infrastructure, problems can arise. As silly as it sounds, imagine if a designer did not factor in the electric infrastructure when designing a device. Users would have no method of powering their devices.

The devices themselves and any tangible method of interacting with these devices makes up the hardware infrastructure. For example, the Apple devices

discussed in the last section makes up part of a user's hardware infrastructure while Apple's operating system makes up part of the software infrastructure. In addition, any method of connecting to the device, such as keyboards, cords, and cables is also part of the hardware infrastructure as well. Cords, cables, and the connectors that join them with devices had to be implemented before becoming part of the hardware infrastructure.

Consider the USB connector, which was first brought to the market in the 1990s (Garfinkel, 1999). This industry standard connector was able to remove the need for many different forms of connectors that were used to connect devices to computers. It was up to hardware makers to include this connection technology with their designs to create this part of the hardware infrastructure. The form of USB has changed little, though USB has developed speed improvements as the technology progressed. In addition, it is also backwards compatible, so devices that are USB 1.0 can function in a USB 3.0 port, which are visually identical to one another.

One could easily assume that rapid levels of innovation and lower costs of electronic devices would cause an increase in the replacement cycle of devices like televisions, computers, and mobile devices. Televisions have the longest replacement cycle of these devices. As of May, 2012, televisions worldwide are replaced every 6.9 years (down from an average of 8.4 years) while US households replace their sets closer to every 6 years. ("Global TV," 2012). Computers have the second longest replacement cycle, and are replaced on an average of every 4.5 years (Leather, 2011). With mobile devices, the replacement cycle could vary. Mobile phones in America are replaced almost every two years (H., Victor, 2011). Tablets are a relatively new device

when compared to other devices, so finding accurate statistics is not as easy as televisions, computers, and other mobile devices. It is unlikely that a tablet will last longer than a computer because of the mobile nature of the device. Since they are not subsidized by phone carriers, they will probably be in use longer than most cell phones. Therefore, the lifespan could be anywhere from 2 to 4.5 years in length.

Figure 21: A Cathode Ray Tube Television Set (Goble, 2011)

Several factors have decreased the length of time before user replace a television. Cathode ray tube (CRT) televisions are being, or have been replaced by users with flat panel televisions (Sutton, 2012). Flat panel televisions have a much smaller physical imprint than CRT televisions, even when they have a larger screen size. The price of televisions has decreased as well. A 32 inch flat-panel television cost an average of $435 in 2Q of 2012. A year earlier, the price was an average of $546 (Tuttle, 2012).

Lower prices are most likely associated with televisions that have limited features. These would perform only the most basic functions, such as receiving inputs from other devices to produce the associated picture and sound. Televisions that have converged with devices that give users access to Internet services will naturally cost more, as manufacturers must include more hardware, software, and components. There is also a trend that manufacturers, particularly Samsung, is increasing the amount of Internet connected TVs it will be offering up for sale (Chen & Wingfield, 2014). However, there is likely to always be a market for simpler televisions at a lower price, especially since STB solutions are so prevalent. Why should a user purchase a new television when Internet access to their current television is available for $35 via Google Chromecast, especially when it has been far from 6.9 years since they purchased their current television ("Chromecast," 2013)?

The replacement cycle of computers is shorter than television, but still rather long at 4.5 years. Computers in their nature are advanced, and much more so than the best of Internet connected televisions. However, the market for computers is shrinking, largely due to the increase in demand for lower cost tablets ("Gartner Says Worldwide PC," 2013). The market for PCs is unlikely to disappear anytime soon, as their forms work very well with human hands (add more information).

Smartphones have a relatively short replacement cycle. As stated earlier, most American users replace their smartphones every two years. This length of time matches the two-year contract most users sign with their cellular service provider. The benefits of purchasing a subsidized cell phone clearly plays a major role in this rapid replacement cycle. One of the benefits of having such a rapid replacement cycle is that newer

technologies can be introduced very easily. Though, of course, anything added must work with the current infrastructure.

Updating the hardware infrastructure is a slow process. Any solutions must be released concurrently with products to be viable. Consider the concept of wireless charging. Data is easily transferrable through wireless means, yet mobile devices still require a plug port to charge the batteries of the device. An alternative to power cords for devices is inductive charging, also called wireless charging. Inductive charging is a technological breakthrough that allows an electromagnetic field to wirelessly transfer an electrical current over very short distances (Molen, 2011). Inductive charging has the potential to end the need of plugging in a device. While inductive charging is not a new technology, it still has not truly become part of the digital infrastructure. For this technology to become part of the digital infrastructure, it needs a wide level of distribution and adoption. Device makers can easily add the receiving end to their devices, but getting the charging pad distributed will not be as easy. If device makers bundle a charging pad with their mobile devices, then it is likely that the pad will be large enough to charge only one device. Users must also purchase a second charging pad to add charging locations around their homes. If users travel a great deal, then charging while away from home will bring up some issues as well. Since these charging pads must be plugged into the wall, a simpler solution for users is to take a cord with them as they travel. Since the digital landscape is highly fractured, will all inductive charging pads work with all inductive receivers found within digital devices?

The point of this example is that adding to an infrastructure is not easy, but can be done concurrently with new device releases. It may be much easier for designers to

create a product that works with the new and old infrastructures. Several mobile devices have been sold that feature a wireless charging ability with a corded option as well (La, 2013). There is also a good chance that adding a new component to the infrastructure may leave part of the previous infrastructure obsolete.

Consider the addition of Apple's Lightning cable and the issues that its introduction created. Before the addition of this cable, many of Apple's devices were charged with their proprietary 30-pin connector. The 30-pin connector was first introduced in 2003 and is being phased out by the new lightning cable (Goode, 2012). Any charging station or accessory that was dependent on the 30-pin connector was instantly obsolete or needed some form of adaptor to work with newer Apple Devices. Though this change in infrastructure is bothersome for users, there are advantages for these users as well. Smaller connectors allow designers to create smaller devices. In addition, Lightning cables are functional regardless of connector orientation. USB devices cannot be connected upside down.

4.2.4 Network Infrastructure

While designers may have a degree of control to hardware and software infrastructures, they have relatively little control over network infrastructure. Metaphorically, the network infrastructure is like a roadway while designers are like a driver. A driver has control over what vehicle is driven (hardware infrastructure) and has control over what cargo is in the vehicle (software infrastructure). There may only be a small number of roadways (network infrastructure) for this driver to arrive at a destination.

It is best for a designer to factor in the network infrastructure for their design solutions. In chapter 1, we discussed several forms of networks in regards to network convergence. These networks themselves make up the digital network infrastructure. Examples for televisions include cable, satellite, and OTA networks. Examples for computers and mobile devices include Wi-fi network and ISP networks. Any design solution from designers should include the use of these networks, as exclusion could leave users stranded within the digital landscape.

4.3 Wires and Wireless Issues

Though there is a trend for devices to run with fewer wires, they are still necessary in the current infrastructure system. Wires ultimately serve four purposes. The first three purposes of wires is to transmit data, audio, and video. These wires come in the form of USB cords, coaxial cables, and HDMI cables. The final purpose of wires is solely for power usage. While there are four purposes of cords, they do not necessarily exist separately. USB cords are capable of transmitting data and power. Speed and efficiency have kept the use of cords popular, even when wireless options are available. It is important for designers to understand how they can use cords with their designs. Cords after all are a large part of the user experience with digital devices.

4.3.1 Wired Issues

Though wireless charging options may become the standard for powering devices, it is not currently ready for wide adoption. Until then, designers will need to continue using connectors with their devices. These connectors are easily just as

fractured in nature as the rest of the digital landscape. By understanding the history of these connectors and how they work, designers will be able to design better future connectors to solve design solutions. There are a great many different types of cables used in computers and other electronic devices. Because of the broad use of proprietary cables from device to device, only widely adopted cables will be the focus of this section.

Ethernet Crossover Cable: The Ethernet cable is similar in shape and function as the phone cable used in landline telephones and dial-up modems. It's primary use is for data transmission. The connection ends are noticeably larger than phone cables. The Ethernet cable, in its first form, was first introduced in 1973, and its purpose is to be a fast method to connect hundreds of computers. It is currently in use on over 85% of the world computer population as of March 29, 2007 ("Ethernet History," 2007).

Figure 22: An Ethernet Crossover Cable ("Belkin 25-Foot Cat6 Ethernet Cable," 2014)

The large stature of the ethernet cable reinforces the idea that more data travels through the cable than a phone line. However, it did not always resemble the form it is now. In the 1980s, an ethernet cable was coaxial in form, similarly to cable television.

The RJ45 connector that is currently in wide use for ethernet cables, was also developed during the 1970s ("The History of Computer," 2008). The actual name of the connector for ethernet cables is 8P8C, meaning 8-position-8-conductor, and is only similar in size as the RJ45. This form of connector features a living hedges that causes the cable to snap and lock into place. More recent connectors do not feature henge, but relying on friction and nesting to keep the cord in place.

Three Prong Power Plug (NEMA 5-15R): The method of powering most computers and electronics is one of the oldest method for all plugs and connectors discussed. It's sole purpose is for power. The three prong plug as we know it today was invented in 1928 by Philip F. Labre, but did not become popular until the 1962 revision of the US electric code. (Mennell, 2009) The now obsolete two-prong plug was invented in 1904, and since this form is still functional, though not grounded, we will look at this
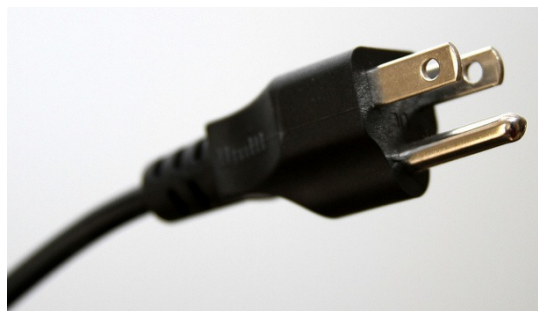

Figure 23: A Three Prong Power Plug; Standard for the United States (Mazzoni, 2011)

as the introduction year.

While one end of the the plug has remained relatively unchanged, the other end varies wildly. Depending on the device being powered, the opposite connector end can be secured magnetically, frictionally, through locking devices, or can be wired directly to the device.

FireWire (IEEE 1394): The use of FireWire cords in computing began in 1995 and continues as of Feb 2013 ("What is FireWire," 2008). It originated as a high speed data transfer method. It was much faster than early USB speeds. It provides a similar role to a USB devices, though USB devices requires a bus master to be present, FireWire does not. An increase in the speed of USB connections has decreased the need for FireWire ports, and is likely to fall out of consumer use if USB speeds increase. Firewire has the ability to transmit audio, video, power, and data.

Figure 24: FireWire Connector (Scheffel, 2005)

USB: The USB cable is currently in its third generation and provides a 5 Gbit/s transfer rate ("Brief USB Overview," n.d.). This increase over the 12 Mbit/s from the first generation is quite substantial, and puts USB 3.0 on par with the transfer speeds of FireWire. Implementing a USB system into a peripheral device has been a much lower cost option throughout the history of USB and FireWire. One of the largest benefits of USB is that it eliminated the need for dedicated serial and parallel ports for computers ("USB History," n.d.). This means that peripherals like keyboards, printers, and other devices can share the same plug instead of having ports dedicated to specific devices.

Figure 25: Standard USB Connector (McKay, 2013)

DisplayPort: DisplayPort was first developed in 2006 by the Video Electronics

Standards Association (VESA) (White, 2006). The Mini DisplayPort was introduced by

Apple in 2008, and is used across several brands of computers ("New Macbook Family,

2008). The main advantage of DisplayPort is the transmission of high definition video

and sound on a cable with such a small connector. There were competing video

Figure 26: Standard DisplayPort Connector (Evans, 2014)

methods introduced in the years around 2008, such as Mini-VGA, Mini-DVI, and Micro-

DVI, all of which do not transmit sound with video.

Thunderbolt: Intel and Apple's Thunderbolt cable was born out of the Mini

DisplayPort. One of this connector's killer features is the ability to daisy-chain up to six

devices, so multiple devices can be plugged into one port without the need of a hub

("Thunderbolt Technology for Developers," n.d.). Thunderbolt's capabilities allow it to

transfer data, sound, video, and power, which makes Thunderbolt a very versatile

connector. Another positive aspect of Thunderbolt connectors is that both ends are

identical, meaning users will not have to fumble with the cord to choose the correct male

end ("About the Thunderbolt," 2013) This is a relatively new connector, and has been in

use since early 2011 (Dilger, 2011).

Figure 27: Apple and Intel's Thunderbolt Connector ("Apple Thunderbolt Display review," 2011)

HDMI: The High-Definition Multimedia Interface was introduced in 2003, and has

been quickly adopted by the television industry ("The First HDMI," 2003). The main

benefit of the HDMI cable is the transmission of data, audio video through one cord,

though it does not transmit power. Previously, audio and video had been split between

DVI and VGA on the graphical side, and other means on the audio side. HDMI is currently in its second generation, and has the ability to use first generation cables in second generation applications ("Introducing HDMI 2.0," n.d.).
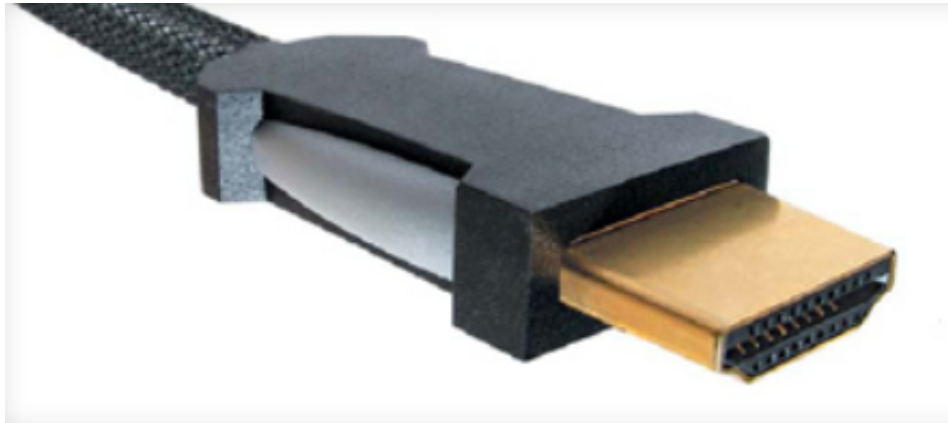
Figure 28: HDMI Cable (Morrison, 2012)

3.5 mm audio: The 3.5 mm connector is also known as the phone connector or colloquially as the headphone jack. This is a very popular option to deliver audio, as it is available in a small size, provides stereo sound, and is already widely adopted.

Figure 29: 3.5 mm Audio Connector ("Headphone Jack," n.d.)

The 3.5 mm connector has been used in all Apple iDevices, from the first iPod to the most recent iPad, and it is present in many computers and devices that may require

headphones. The older, larger 6.35 mm connector was first introduced in 1878, and is likely the oldest connector still currently in use (Phone Connector, n.d.). The smaller 3.5 mm connector functions similarly, but is reduced in size. This is likely the oldest connector technology currently in use on modern electronics.

It is likely that designers will currently use some form of connector listed above in their final design solutions, though many more are available. While cords and connectors like these may not always be in use, their presence gives designers a few insights as to what makes them successful. For example, you may have noticed that the phone connector has been in use in one form or another for a much longer time than other connectors. Why has there been little to no innovation with this form of connector? A large benefit of this connector lies in its simple form. While other cords must be situated perfectly to provide a connection, this form can be plugged in and twisted with no loss of connection. There is truly no wrong method for plugging in this form of connector. Other connectors certainly cannot be moved one they are in place.

As stated earlier, anytime a wire is needed for a digital device, it serves one of the following purposes: power, data, audio, and video transmission. As technological capability has increased, the amount of purposes fulfilled by a single wire has increased. It is apparent that there is a trend that audio, sound, data, and power will all be used in a single connector, such as the Thunderbolt connector. If this trend continues, then it is likely that the days of HDMI are numbered, as HDMI does not transmit power or data, but audio and video instead. The lack of power is a great issue for HDMI, especially when you consider the STB alternatives that plug directly into HDMI ports, such as Google's Chromecast and Roku's Streaming Stick. While both of

these devices do allow users to connect to the Internet via television, they require power

from a USB port that may or may not be available on a television (Moskovciak, 2014). If

no USB port is available on the television, users must plug it directly into a power outlet.

If a connector like HDMI is to survive, then power and data will be necessary

additions in future generations of HDMI. If a designer was to create a device similar to

the Chromecast or Streaming Stick for use with Thunderbolt, the power problems with

HDMI would be solved, and there would be potential for a pass through system that

would not require users to change inputs to access the Internet over the television.

While there is a trend that devices will be less dependent on wires, it could be a

long while before wires are eliminated. Currently, it is possible to have full connectivity

on mobile devices and laptops, provided these devices are connected to wireless forms

of Internet and contain a charged battery. If wires wind up being totally eliminated, then

surely wireless solutions will present some problems as well.

4.3.2 Wireless Issues

Going to a more wireless system should be a goal in simplifying the ways users

interact with these devices. Transmitting screen and sound uses up bandwidth, and will

increase with higher definition video like 4K/UHD. There is potential to use several

different methods of transferring data, such as a wireless HDMI video transmitter

system, which may have security issues as well. Goals are necessary to help create a

better system. There must be no lag when interacting with the device in question. Wired

mice and keyboards work well because users notice no difference between the amount

of time of a keystroke and it appearing on the screen. Adding just a fraction of a second to that amount of time, and the system becomes noticeable, and quite annoying.

The word "wireless" itself is a great example of a misnomer. This is because the world "wireless" may mean any number of things. A mobile device is often called a wireless device while WiFi Internet is also called wireless. With the wide adoption of built in wireless antennas in laptops, they have become a wireless device, though things can still be plugged into these devices. The process of convergence may one day give society a truly wireless device, but it has not done so yet.

Range, of course, is a great issue with wireless technology, and it is range that separates commonly used forms of wireless technology. WiFi networks are rather robust in size, and are designed to be a central connection hub for an entire location (Levy, 2001). Bluetooth is separate from WiFi, though mostly for its range. Bluetooth devices have a range of 10 meters, thus they are associated and used with and around other devices ("Bluetooth Frequently," n.d.). Near field communication (NFC) devices have an even shorter range at 4 centimeters ("NFC and Contactless," n.d.). It is the range if these devices that determines their purpose and level of interactivity. As the range of wireless technology increases, the level of user interactivity with these technologies decreases.

The current infrastructure of typical Wi-Fi routers centers heavily upon the creation of a wireless local area network (WLAN). Computers and other devices can connect to this WLAN, which gives these devices access to Internet service. Access to a WLAN is generally restricted to the individuals that set up a wireless access point. If the range and capability of a WiFi network is greatly extended, say to the size of a city,

then the need for a WLAN is reduced, as users will opt to connect to this network instead of creating their own.

Many users may be satisfied connecting to a community access point through their digital devices. Benefits of WLANs, such as the ability to access files on other computers, can be done through a community wireless gateway via cloud services. For example, individual files can be shared over the Internet through a service like Dropbox ("Dropbox," 2014). Implementation methods of community based Internet access varies. In Chicago, Comcast is creating a large scale implementation of WiFi hotspots by using currently existing equipment in customer's homes (Channick, 2014). Individual cities like Iowa City have installed free wireless Internet access points ("Free wireless Internet," 2014). While more access and certainly free access are benefits for users, a system like this may not work well with the Internet of Things.

Interference is the next issue with wireless devices. With more and more devices relying on more and more wifi networks, it is also likely that the wireless spectrum will be crowded. If we are at the dawn of "The Internet of Things," then this will certainly become a major issue.

4.4 Designing with a Lack of Standardization

Of all the technical issues that may plague digital convergence, a lack of standardization has the most to do with business tactics. When similar technology companies develop similar ways of performing tasks, they may chose a proprietary system to potentially increase profits. For example, wireless charging currently has three standards for recharging: Qi, Power Matters Alliance (PMA), and the Alliance for

Wireless Power (A4WP) (Wood, 2014). Three different standards means that some

devices that are able to charge wirelessly will not work for particular wireless chargers.

There is also a lack of standardization with power plugs, chargers, and many

other wired solutions. While one end of a charge cord may easily fit in any power outlet

or USB slot, the other end could feature a proprietary connector that only works with

specific devices. Apple, who has featured a proprietary 30-pin or Lightning cable with

their iDevices, has been under pressure from the European Union to switch to a micro

USB connector (Baker 2013). Earlier, Apple had included an adapter with iPhone sales,

but has since ceased including the adaptor with iPhone sales (Foresman, 2011).
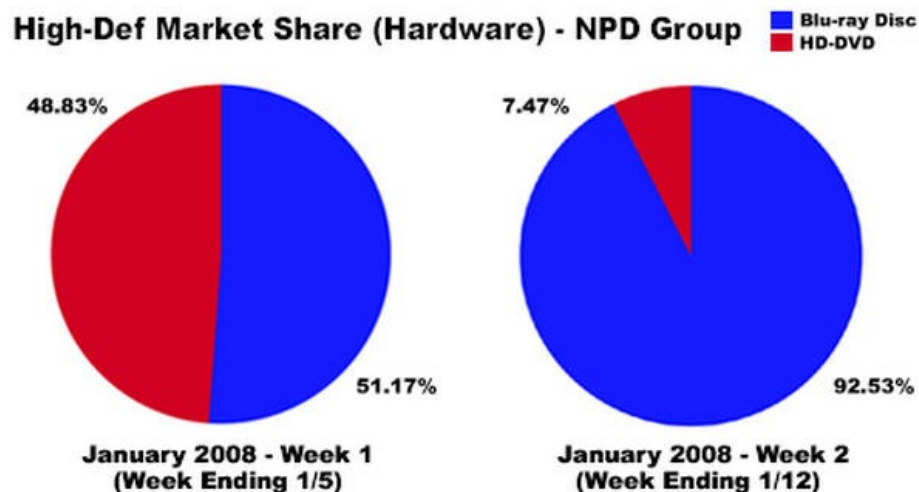
Figure 30: The Fast Descent of HD-DVD Against Blu-ray (Moskovciak, 2008)

The implementation of standards is not an easy task. There are many examples

of standards that have failed over the years. After the Blu-Ray format went head-to-

head with HD-DVD, Blu-Ray became the industry standard while HD-DVD was

eventually abandoned ("HD DVD- the 10," 2009). Standards fail and thrive for a variety

of reasons. According to a paper published in 1989 by Martin Weiss and Marvin Sirbu,

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there are several success factors for the implementation of standardization. The paper reads:

> The results suggest that the size of the firms in the coalition supporting a technology and the extent to which they support their position through written contributions are significant determinants of technological choice in the standards decisions studied. The market share of the firms in the coalition was found to be significant only for the buyers of compatible products, i.e., the monopsony power was significant, not the monopoly power. In addition, the technologies whose sponsors weighted market factors more highly than technical factors were more likely to be adopted in the standards decision studied. The proponents of both the adopted and non-adopted technologies were found to have equal belief in the overall technical superiority of their technical alternative, even after the decision. The installed base of a technology and process skills were not found to be significant predictors of the committee outcome (1989).

In the case of Sony's Blu-Ray format versus Toshiba's HD-DVD format, it was a previous convergence that helped Sony to win this format war. The convergence of a Blu-Ray player with the PS3 console allowed Sony to have a foot in the door with many consumers (Pope, 2012). These PS3 owners provided an early infrastructure for the Blu-Ray format. In addition, Sony also owns a major film studio, and was certainly able to release their movies onto this format with ease ("HD DVD- the 10," 2009).

Chapter 5: Technological Convergence Proposed Guidelines

5.1 Introduction

Technological convergence is not simply an advancement that allows device users access to more content on fewer devices. Instead, convergence is part of a process that allows users more freedom to access content through service providers via users' digital devices. It is a social change in addition to technological advancements. Jenkins (2006) describes this process in *Convergence Culture,* stating:

> Convergence does not occur through media appliances, however
>
> sophisticated they may become. Convergence occurs within the brains of
>
> individual consumers and through their social interactions with others.
>
> Each of us constructs our own personal mythology from bits and
>
> fragments of information extracted from the media flow and transformed
>
> into resources through which we make sense of our everyday lives. (p. 3)

It is the content that is displayed on digital devices that matters most to device users, not the devices themselves. Designers have very little control over this content though the content is often predictable for the intended device. Designers do have high levels of control over these devices and the methods of accessing this content. Accessing this content is the purpose of owning devices like televisions, computers, and mobile devices. Individually, these devices do their jobs wonderfully. Attempts to converge these devices into an integrated system is currently weak at best. The final design solution for an integrated system should allow users to retain access to their devices, services, and networks when they are away from these entities.

The goal of this chapter is to showcase design guidelines developed from the information found in chapters 1-4. These design guidelines will include the use of

televisions, computers and mobile devices as portals for designers to implement

convergence solutions through content, device, and network convergence, all while

avoiding problems and pitfalls that plague these devices. The final methods for users to

access all parts of their digital landscape should be transparent and unobtrusive in

nature.

5.2 Guidelines for the Digital Convergence Device

      While the focus of this study has been on devices that feature screen

technologies (TVs, computers, mobile devices), the proposed solution makes use of

these screen without the addition of a fourth screen. The successful implementation of a

digital convergence device will depend upon the following:

      1. *There must be compatibility between the convergence system and the screen*

based digital devices that links access to traditional television content, computer

access, and mobile device access. The system must also function if a user chooses not

to own one of these technologies.

        The convergence device system will give users access to the other

     devices within their digital landscape. While current devices have some stopgap

     method of giving users access to their other devices, an integrated system does

     not currently exist. For instance, users may only have access to a small portion

     of their computer files that are accessible on mobile devices. Also, Cloud

     methods of storing files have been implemented, but often relies on monthly fees

     and the chance for an invasion of privacy. An integrated system would instead

     have the potential to give users access to all of their computer files and functions.

In the case of television, an integrated system would give users access to traditional television content on computers, mobile devices, and other televisions. In the case for computers, it should be possible for users to have access to their main computer system available on television sets connected to the Internet.

In chapter 2 it was made evident through the CCENT's definition of convergence that "The coming together, into a single application or service," ("Welcome to CCENT," 2011) was necessary for an integrated system to exist. A single service or application cannot exist if televisions, computers, and mobile devices are not major factors in the design of an integrated system.

One problem that may face convergence is that not all users have access to all of the digital devices. In chapter 3, it was shown that of American homes, 96.7% has access to a television, 75.6% has access to a computer (of which 71.7% has access to the Internet), and 56% has access to a smartphone. Statistics from chapter 1 show that 34% of American adults have access to a tablet, though this is not linked to the smartphone statistics. To reach the widest number of users, an integrated system must function if one of these devices is not owned by the user. It is likely that television will play a greater role in a convergence system because of the wide adoption rate of this technology. Most likely, a user will be without a mobile device or a computer.

2. *The convergence device system must give users transparent access to their digital content, devices, and service subscriptions by displaying an ideal minimum of 720p resolution or a user optional minimum of 480p resolution if congestion interferes*

with system transparency. Either option should ideally allow no loss of sound quality, or negligible loss if the user experiences congestion.

Essentially, the 720p level of access to high definition video with stereo sound would be minimum standard acceptable to a user. In certain instances, users may opt for a 480p resolution, especially if displaying the high resolution would result in performance lag or drain a user's bandwidth monthly allotment. Many websites that stream video has a max resolution of 720p ("Resolution," n.d.). Ideally, the convergence system would be able to perform at the highest resolution technically possible at any time.

According to the wireless issues discussed in chapter 4, having a lag in performance would create a negative experience for device users. Such a lag is negligible if the user is engaged in activities like watching a video or listening to music, as these activities do not require active participation. If the user is engaged in an active experience, such as navigating a desktop interface or remotely playing a video game, the lag would create a negative experience. As stated in chapter 2, negative experiences have the ability to leave a sting impression on the mind of the users. This is to be avoided when designing the way a user navigates an integrated system.

Essentially, the goal of this guideline is to create a positive experience that ultimately enables a high level of content convergence (chapter 2) among the devices in question. By having content available and usable on these digital devices, users will have a less-fractured landscape.

As a screen gets smaller in size, it becomes less necessary to have higher resolutions. In addition, the farther away a viewer is from a screen, the less necessary it is for higher resolution. The small screen size of a mobile device is able to display a 480p image with a much better user experience than a very large HDTV. Since a stationary television will most likely be near an Internet connection or have Wi-Fi access, then data transfer speeds will be high enough to display a HD image. With the slower speeds associated with wireless cellular service, 480p resolution on a mobile device may be likely, but will be acceptable.
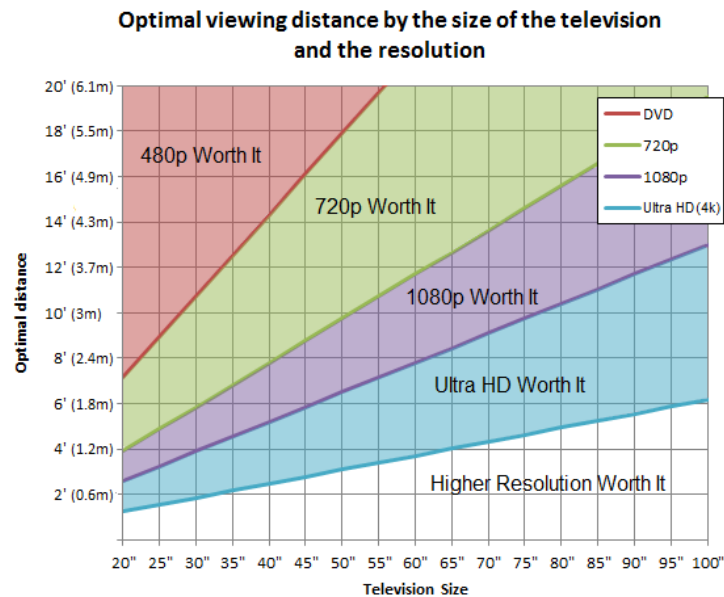

Figure 31: Distance, Screen Size, and Resolution Chart (Prindle, 2013)

3. *The convergence device must function in the currently available software, hardware, and network infrastructures. This includes working with devices purchased within the last 5 years, devices currently available for purchase, and products likely released 12 months from the present.*

For any successful implementation of a convergence device designed to perform as a platform, it must be functional within the currently available software, hardware, and network infrastructures. If the device was unable to do this, then it runs the risk of being limited to fewer screen devices that have the newest technology rather than working for the masses. If the device is part of a system that adds to the currently available infrastructure, then it must work with the new and old infrastructures concurrently.

These points were illustrated throughout section 4.1 of chapter 1. The software infrastructure consists of operating systems and the availability of specific applications on various platforms, such as the availability of a Netflix application on iOS, Android, and Windows 8. The hardware consists of physical connectors and the devices themselves. The network infrastructure consists of Wi-fi networks and wireless data plans.

4. *The convergence device must use standardized parts, components, and systems to be an integrated system.*

It is relatively easy for users to unwittingly purchase a device that uses proprietary parts that are not industry standards. Instead, users may be more focused on the apparent features of a product, such as screen size and battery life. The use of standardized parts allows a greater amount of interconnection between devices and the accessories that go with these devices. Devices will be able to share ports and content more easily if they are manufactured with standardized components. Such an example was made in section 4.3 of chapter 4 with Apple's use of proprietary connectors with their iDevices.

Such an act can be difficult when dealing with device manufacturers that have a vested interest in selling consumers proprietary components. Sony, who won the Blu-ray vs. HD-DVD battle but lost the Betamax vs. VHS battle, has often used proprietary components in their design solutions. One such example is their use of Memory Stick over the more commonly used Secure Digital (SD) card. Sony's use of their proprietary Memory Stick was mostly exclusive to Sony branded products (Playstation PSP, Sony digital cameras, Sony Vaio computers, et al.), which means that users could not uses these cards in almost all devices that were not manufactured or licensed by Sony (Buley, 2010). Such an act runs the risk of alienating customers, and unfairly trapping them in an ecosystem because of their previous financial investment in earlier products.

5. *The convergence device must make use of one cord that transmits data, audio, video, and power. If the power supplied by this cord does not meet power needs for the device, then a second cord dedicated to power is acceptable.*

While there is a trend for device makers to use fewer cords, it is still necessary for digital devices to use at least one cord with their design solutions. Still, the advent of Bluetooth and Wi-fi has allowed the number of digital device cords to be reduced. Designers should use as few wires as possible with potential design solutions, though they should stop short of using no wires until the infrastructure is ready for such solutions.

As stated in chapter 4, any time a wire is necessary, it fulfills at least one of four requirements: power, data, audio, and video transmission. Some wires, such as power cords, perform only one function. Others, like USB, transfer power

and data. HDMI cords have the ability to transfer audio, video, and data, but currently lack the ability to transfer usable power. This lack of power through HDMI ports poses a problem for the increasing trend of using dongles to add Internet connectivity to televisions. Because of this, dongles like Google's Chromecast must have a USB connection solely for the purpose of power (Greenwald, 2013). Often, there is a USB port present on televisions, but not always. If there is no USB port, users must plug their device into a power outlet. Most advertisements for these devices omit this issue, and show users simply plugging in the device as if there is no other requirement.

Chapter 6: Application of Design Guidelines

6.1 Concept Introduction

The focus of this chapter will be on two entities required to apply these guidelines in a real world scenario: the convergence device and the application required to interface with the device. The purpose of the device is to act as a hub that transmits data from portal to portal while the application is the tool users interact with to control the flow of this data. The hypothetical convergence device will be referred to as the "x-Link," which is an acronym for "cross-life integrated network controller." In addition these entities will be individually linked to the five guidelines introduced in chapter 5.
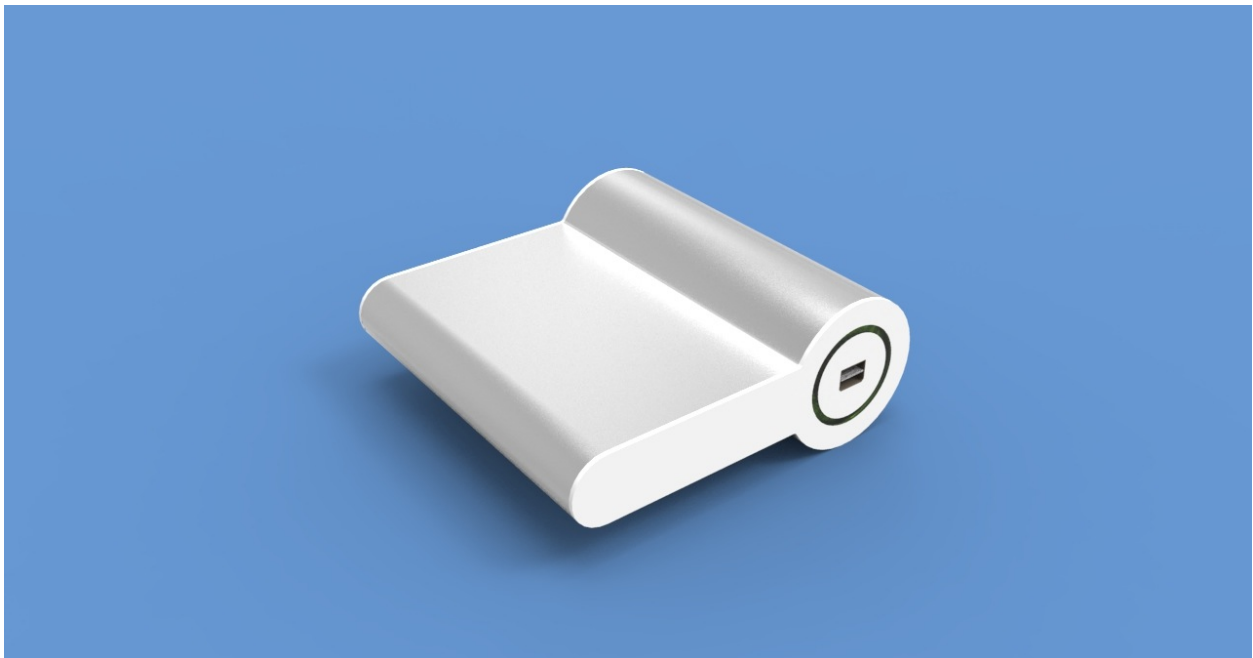
6.2 Hypothetical Convergence Device: x-Link

Figure 32: The x-Link with Thunderbolt Connector Visible

6.2.1 x-Link Introduction

The x-Link is convergence device that acts as an audio/video pass-through system. Ideally, one end of this device would be plugged into a STB, which would provide the audio/video content, while the other end would be plugged into a television, which would display the
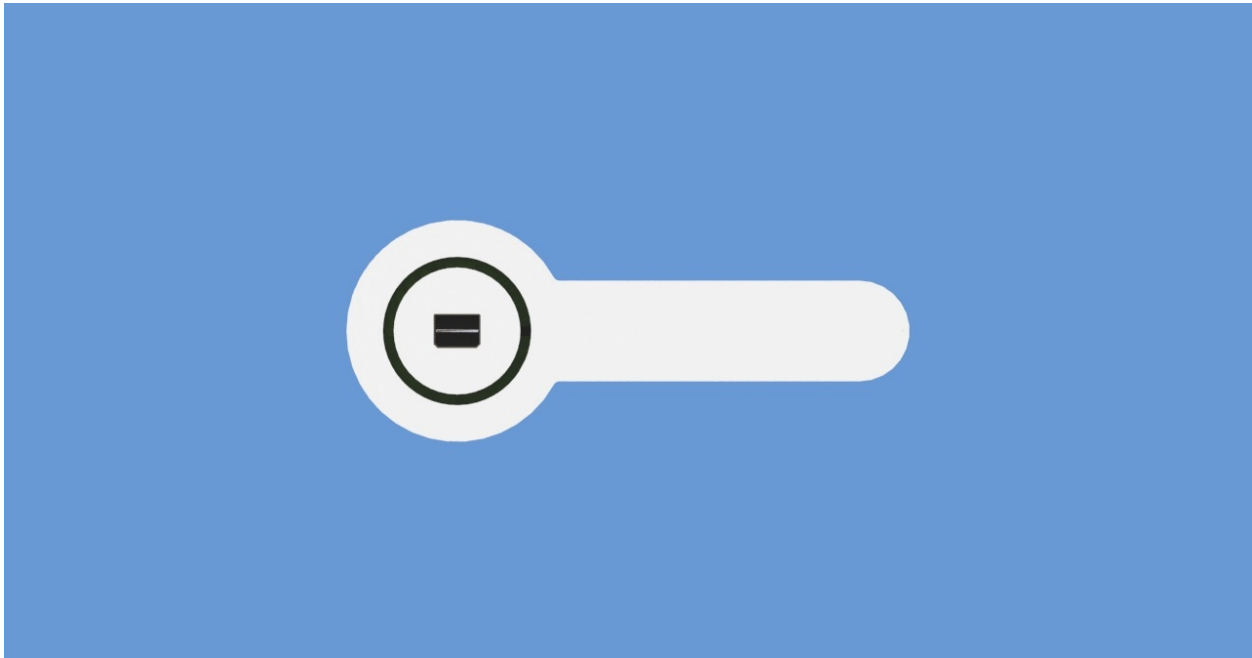
Figure 33: x-Link Side View

audio/video content as it normally would. The purpose of this system is to transmit digital information from the audio/video source (STB) to a user's other digital devices. In addition, other devices can control the functions of the television and STB through the data connection provided by the x-Link connections.

6.2.2 x-Link Hardware Design

The size of the x-Link is small enough for the system to be used as a dongle device. It is roughly 3.25" by 3.5" with a larger circular section on one side. The purpose of this section is to allow the users to be tactually aware of the device when they reach behind their television or STB to physically interact with the device. The x-Link features two Thunderbolt ports as the physical connectors on both ends of the device. Lighting on both ends of the device allows users to visually confirm whether a the device is working, (green light), initializing (yellow light), or suffering from a problem (red light). In addition to the Thunderbolt physical connectors, the device also features Wi-Fi and Bluetooth connectivity. The Wi-Fi connection allows the device to

be accessed by users in the home network and at remote locations via cellular wireless and Internet connections. The Bluetooth connectivity allows users to incorporate accessories, such as gamepads, keyboards, mice and Bluetooth headsets, with the x-Link device.
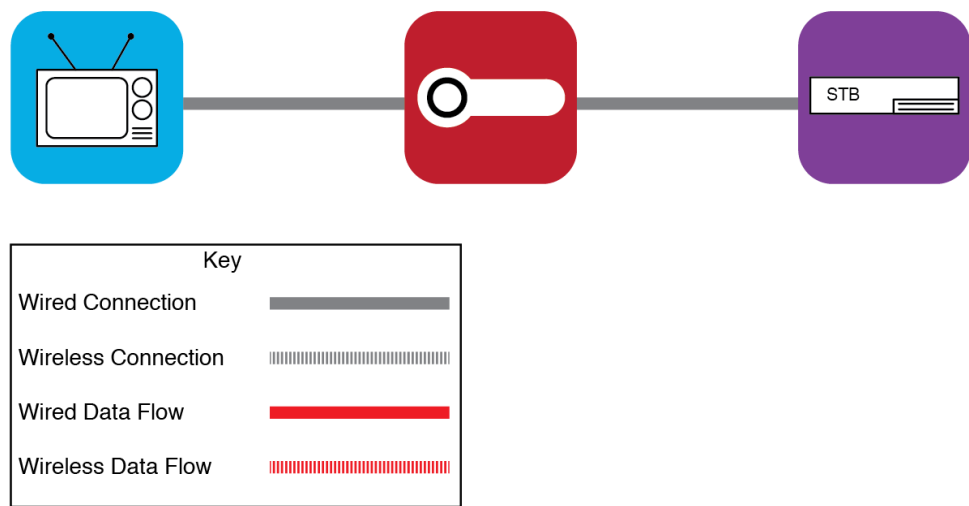
6.2.3 Ideal Setup

Figure 34: Ideal x-Link Setup with TV and STB Connected

The ideal resting place for the x-Link system is plugged in between the television and the STB that is providing audio/video content for the television. This location gives the device a direct link to the content provided by the television service provider. This also allows the x-Link to be paired with widely available televisions, which we know from chapter 3 are available in 96.7% of American homes. Since this device is a pass-through system, users will still be able to use television and STB remote controls to change the channel and operate the television, as if the device was not present.

An alternative location for the x-Link would be between a computer video output and desktop monitor video input. The user would not have access to television content, but would
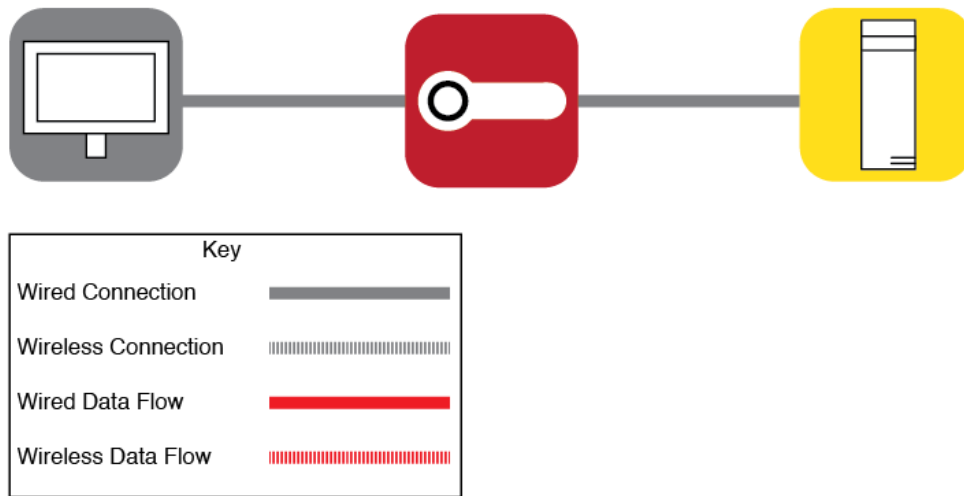
Figure 35: Secondary x-Link Setup with PC and Monitor Connected

have other available uses, such as controlling the computer with a mobile device or mirroring

mobile device content to a computer screen. Both of these actions are available without the

need of a device like the x-Link, but can be achieved with separate applications. In this case,

the appeal of the x-Link is a system that can do both without the need of multiple applications

and could be achieved without the computer running.

6.3 Portal Device Interaction Overview

Working under the ideal setup (x-Link located between the television and STB audio/

video source) a number of connection options are available for users of the x-Link service.

These options will allow computers, mobile devices, and additional televisions to connect to the

x-Link convergence device. These other devices will be allowed to display the content intended

to display on the television via the content from the STB.

Computers and mobile devices will both be able to connect directly to the x-Link via a

Wi-Fi network. The connection of these two devices will allow them to control the television and

STB, essentially functioning as a second remote control. In addition, the connection to the x-
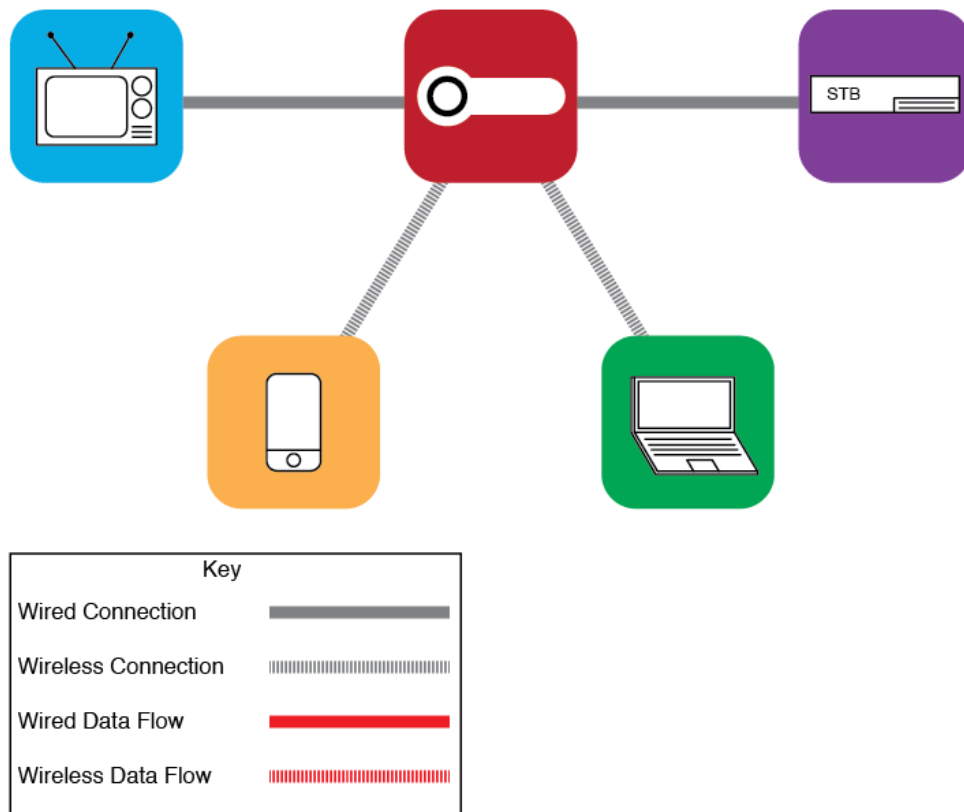
Key	
Wired Connection	
Wireless Connection	
Wired Data Flow	
Wireless Data Flow	

Figure 36: Full x-Link Setup with Computer and STB connected directly with Wireless Mobile and Computer Connections

Link would also allow these devices to access television content from a remote location. Finally, these devices would also be able to output their content on the television screen.

6.3.1 Mobile Connection and Use

The factors involving mobile devices are the simplest to comprehend because there is little use in displaying computer content on a mobile device screen. In this case, most mobile devices would be too small for users to interact with on a desktop user interface. In addition, there is little need for a user to display the content from one mobile device to another, as this content is already conveniently located on the device in use. Television on mobile devices is
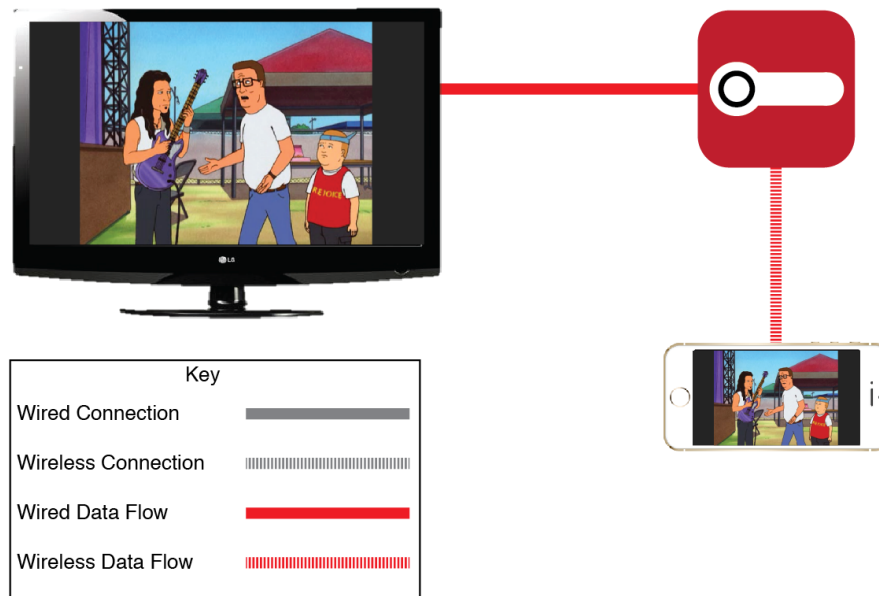
Figure 37: x-Link Mobile Screen Sharing on Television

essential, as the portability of mobile devices and their always connected nature allow them to be great portals to access television content.

The greatest use of mobile content on other devices is screen sharing. If a user wanted to display a web page on a larger television screen, it could easily be done through mirroring. In addition, a user could output a video from a mobile device to a television screen. This form of mirroring would allow the x-Link to access services like Netflix without downloading an application directly to the convergence device.

As seen in chapter 5, the mobile device offers the highest level of utilitarian purposes when compared to computers and televisions. Possibly the greatest service the mobile device performs with the x-Link system is that of a control device. The size of the mobile device allows it to be easily used as a secondary mobile device. In instances where a user wants to search for a future television show or scan a program guide, a mobile device would perform much better than a STB's program guide. It is often cumbersome for a user to perform a search by using a

remote control. Performing these actions on a mobile device allow users to search for content

without taking a television out of a fullscreen mode. In addition, user mistakes are easier to

remedy on a mobile device than a remote control. Remotes often force users to use a d-pad to

select individual letters, or use the number pad to select individual letters by repeatedly pressing

a number associated with three letters of the alphabet (for example, pressing the "2" button

three times to get the letter "c").

Figure 38: Remote with D-Pad and Numerical Pad

The capacitive touchscreen that is often present in mobile devices allows the mobile

device to function as a trackpad as well. This is most useful when the television is displaying

content from a computer source. In addition to the trackpad features, a virtual keyboard could

easily automatically pop-up when a text box is selected.

6.3.2 Computer Connection and Use

As discussed in chapter 3, efforts to combine computer functionality with television have

not really caught on in mainstream use. Older solutions like WebTV are no more, and having

television content directly on a computer system has worked for a niche market at best. The

functionality of computers with the x-Link will allow easy access to computer content through the

television portal.

There are similarities between the computer's function with the x-Link and the mobile

devices functions with the x-Link. Just like mobile devices, screen mirroring on the television will
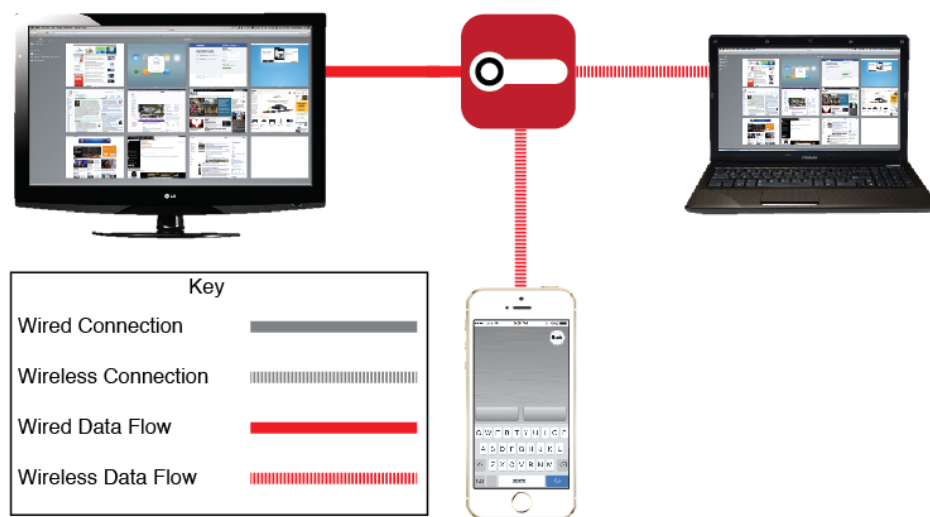
Figure 39: Screen Sharing a Computer Interface on a TV with Mobile Device Acting as a Trackpad

easily allow computer content to become accessible through the x-Link. The concept of controlling this function with a mobile device was earlier discussed. Such a solution is necessary if the computer in use is at a separate location. If users have access to a computer while at the television, then the computer itself can be the control device. The Bluetooth connectivity of the x-Link would also allow users to connect a mouse and keyboard, if this is their desire.

Just as mobile devices would be able to play television content, the computer would be able to as well. Computers could expand on the functionality of the mobile device as well. It is very difficult for mobile devices to have multiple programs running on screen at one. Computers can do this with great ease by simply having multiple windows open at once.

6.3.3 Television Connection and Use

The television itself has little use as a tool. Attempts to use the television as a tool has failed, such as Google TV, which sought to morph the remote control into an oddly shaped remote/trackpad/keyboard. Instead, the television is an entertaining device, and will be used as

Figure 40: Direct Screen Sharing a Computer to a Television

one for most of its function time. The mobile device and the computer are better tools to function with the television.

Still, the television content and features of the x-Link are the killer features. No longer will users lose this content when they leave their homes. However, many homes have access to multiple televisions. Users that have multiple televisions located throughout the home could purchase multiple x-Links which would allow them to wirelessly transmit the television content from the STB to other televisions. With this setup, the x-Link would require only one of the two Thunderbolt cables to be plugged in to a device (the secondary television). The benefits of this would allow television content to be consumed without the need to run wiring throughout the home.

Mobile devices and computers must have the means to play television content through applications. They must have all of the functionality typically found on a STB, such as a program guide, the ability to schedule recordings, search features, and the ability to channel surf, of

course. For example, the following figures represent a user entering the search term "King," followed by a series of selections intended to play and record an episode:
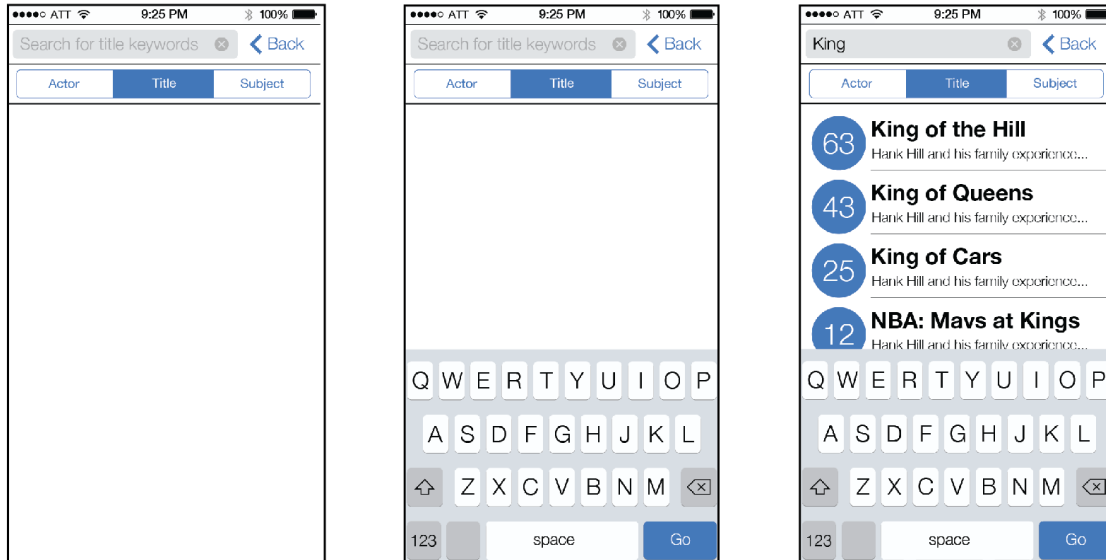

Figure 41: (Left to Right) Open Search Query, Selecting Search Bar, Typing "King"
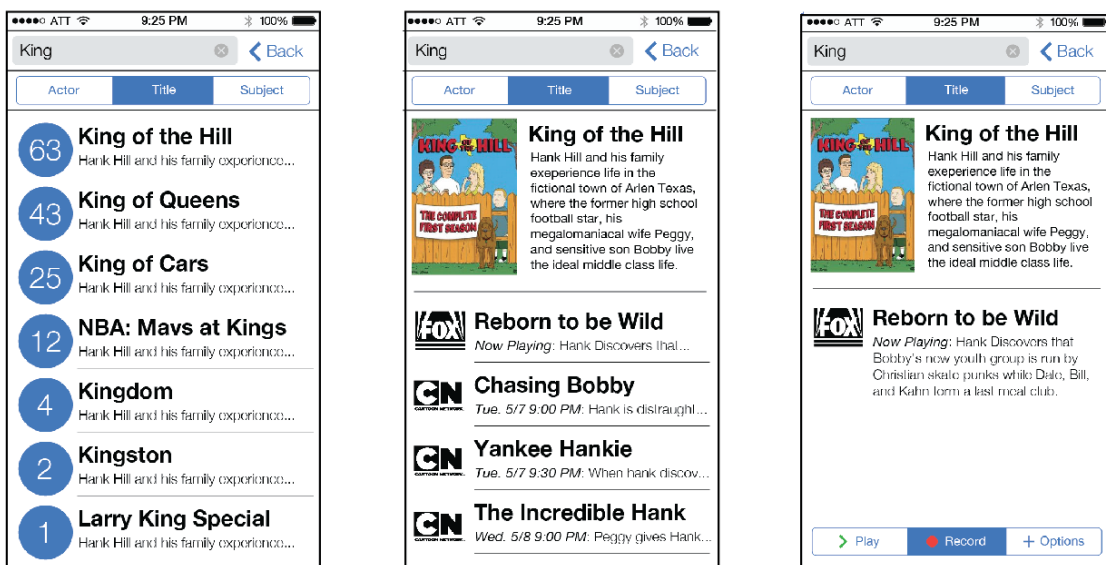

Figure 42: (Left to Right) Removing Keyboard, Selecting Series, Selecting Episode
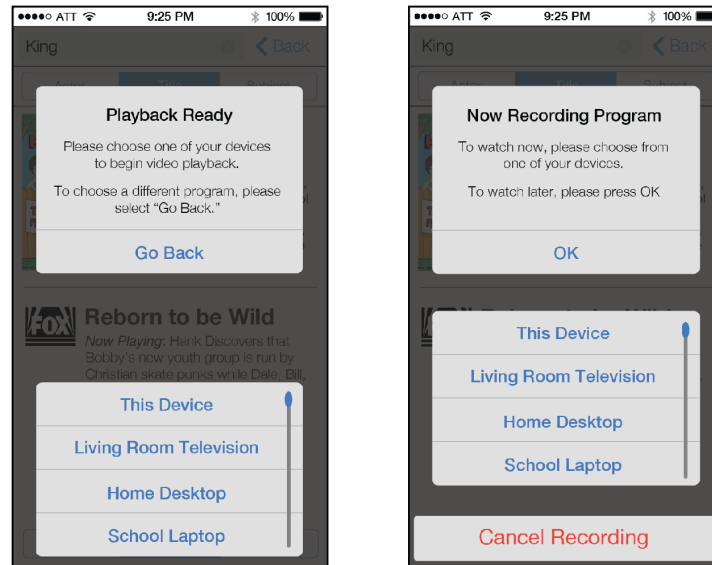
Figure 43: (Left to Right) Playback Screen, Recording Screen

6.4 Relation to Guidelines

Though this system has obvious perks and advantages, it is still important to link these perks and advantages to the five guidelines introduced in chapter 5.

6.4.1 Issue of Compatibility

The first guideline states that, "*There must be compatibility between the convergence system and the screen based digital devices that links access to traditional television content, computer access, and mobile device access. The system must also function if a user chooses not to own one of these technologies.*" The x-Link's ability to add Internet connectivity to the television gives all three devices common ground on this ability. Such a feature allows these systems to be compatible on a Wi-Fi network. The figures throughout section 6.2 detail this compatibility very well. Without a Wi-Fi network, the x-Link as a convergence solution will not work at all, or work poorly if the user is depending on a mobile device as a hotspot.

The issue of a user not owning one of these devices is a very real issue. At 96.7% of United States market penetration, it is safe to assume that these users have access to a
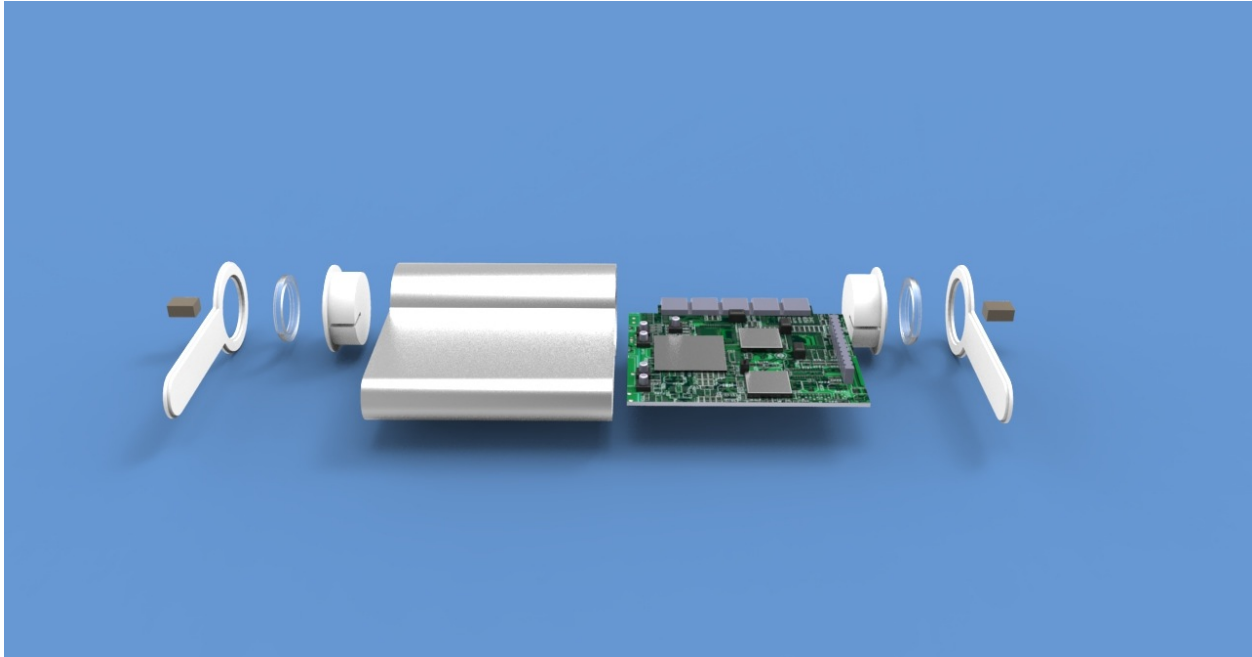
Figure 44: x-Link Exploded View

television. 75.6% of U.S. households have access to a computer, though about 71% of these users have Internet connectivity. Mobile devices, specifically smartphones, are available to 56% of U.S. households. For any convergence solution to truly work, it must function if a user does not own one of these devices.

A user will still have access to the convergence system if one device is not present, though the experience of this device will not be present in this individual's digital landscape. A user without a mobile device will not be able to mirror a mobile device's screen, control the television with a mobile device, or output television content to a mobile device. If this user owns a computer and had Wi-Fi connectivity, then these functions will be available through the computer. A user that does not have a computer will lose the functionality of the computer. Still, the user will be able to interface with the device through the use of a mobile device, provided the x-Link is connected to a Wi-Fi network. With these abilities still in place when a computer or mobile device is missing, then the x-Link functions with the first guideline.

6.4.2 Issue of Resolution

The second guideline for creating an integrated system states that "*The convergence device system must give users transparent access to their digital content, devices, and service subscriptions by displaying an ideal minimum of 720p resolution or a user optional minimum of 480p resolution if congestion interferes with system transparency. Either option should ideally allow no loss of sound quality, or negligible loss if the user experiences congestion.*"

Having an image displayed in a high definition format is a benefit for the user. As the definition of the picture increases, so to does the file size necessary to transmit the data. In a user's home Wi-Fi network, the issue of lagging is not much of an issue. The speeds of a Wi-Fi network are sufficient to transfer the data necessary to view the images on any number of devices. On a home Wi-Fi network, users will most likely experience screen resolutions higher than 720p.

The issue of congestion is more apparent when users are not connected to their home Wi-Fi network. Regardless, if users are connected to the Internet, they are likely to have access fast enough to receive a 720p resolution. If not, the image could be downgraded to 480p, though this is not the ideal user experience. The most likely scenario where a user would experience 480p would be in instances where they were connected to a cellular network on their mobile devices. The lower resolution would be less noticeable on such a small screen.

6.4.3 Issue of Infrastructure

The third guideline for creating an integrated system states that "*The convergence device must function in the currently available software, hardware, and network infrastructures. This includes working with devices purchased within the last 5 years, devices currently available for purchase, and products likely released 12 months from the present.*" The most obvious issue of this particular device's validity is the choice of Thunderbolt connectors instead of HDMI

connectors, as there are currently very few, if any, televisions and STBs that feature this form of connection.

The advantage of Thunderbolt technology is that it performs all four functions possible for wired connections (power, data, audio, and video). The infrastructure most likely associated with televisions and STBs from five previous years is the adoption rate of HDMI. HDMI only provides three of the four functions of wires (all but power). Thunderbolt's backward compatibility with the Mini DiplayPort connector makes Thunderbolt the likely choice for the future. Since this backwards compatibility is easily outputted in an HDMI format, Thunderbolt connections have the potential to work with HDMI televisions and STBs.

To use with this HDMI infrastructure today, a dongle apparatus will be necessary to power the x-Link. This dongle would require two connections on one end (power and HDMI) with a Thunderbolt connection on the other end. The other side of the device could simply have a Mini-DisplayPort to HDMI cable plugged into the output of the x-Link and the television set input. The Wi-Fi and Bluetooth connectivity of the x-Link also allow this device to easily work with the present infrastructure.

The Thunderbolt choice is a choice to ensure that it may be possible for the device to work in the future form of the hardware infrastructure. It is the position of this thesis that there will be a wide adoption of a connector technology that performs all four wire functions. Thunderbolt is a likely choice because of the power advantages over USB and the backwards compatibility with Mini DisplayPort. Such a choice would bring about a higher level of convergence, as one wire form could be used with all three forms of digital screen-based technology. Instead, the landscape is currently fractured with HDMI for televisions and USB for computers and mobile devices.

6.4.4 Issue of Standardization

The fourth guideline states that, "*The convergence device must use standardized parts, components, and systems to be an integrated system."* As stated previously, the x-Link makes use of Bluetooth and Wi-Fi standards, which are easily adoptable. In addition, the x-Link also works well with the widely used HDMI format. While Thunderbolt may be considered a proprietary connector held between Apple and Intel, its ability to morph to a Mini DiplayPort allows the device to function with standardized parts and components all around.

6.4.5 Issue of Cord Use

The fifth guideline states that *"The convergence device must make use of one cord that transmits data, audio, video, and power. If the power supplied by this cord does not meet power needs for the device, then a second cord dedicated to power is acceptable."* With the eventual adoption of a corded technology that makes use of all four intended purposes of wires, a solution like the x-Link will work in accordance with this guideline. This includes the present use that requires a secondary power source that is not found out of the HDMI connector. The current infrastructure still requires a cord to transmit the audio and video data from the STB to the television. The x-Link makes use of this cord. Yes, it will require one cord from the STB and one from the television, but it still functions as if there is only one cord. A direct power cord that is required for the HDMI ecosystem still falls within acceptable use of corded technology, according to this guideline.

6.5 Guideline Checklist

The follow provides a concise view of the five guidelines, and how these guidelines are applied by the x-Link system.

Convergence Guidelines	Guideline Application
There must be compatibility between the convergence system and the screen based digital devices that links access to traditional television content, computer access, and mobile device access. The system must also function if a user chooses not to own one of these technologies.	-WiFi connectivity -Bluetooth connectivity -HDMI compatibility -Thunderbolt connectivity -Functions sans computer -Functions sans mobile device -Functions sans television
The convergence device system must give users transparent access to their digital content, devices, and service subscriptions by displaying an ideal minimum of 720p resolution or a user optional minimum of 480p resolution if congestion interferes with system transparency. Either option should ideally allow no loss of sound quality, or negligible loss if the user experiences congestion.	-Maximum resolution on home Wi-Fi network -720p resolution via Internet connection -480p during network congestion -480p on mobile devices
The convergence device must function in the currently available software, hardware, and network infrastructures. This includes working with devices purchased within the last 5 years, devices currently available for purchase, and products likely released 12 months from the present.	-HDMI output option -Wi-Fi connectivity -Bluetooth connectivity -Thunderbolt connectivity
The convergence device must use standard-ized parts, components, and systems to be an integrated system.	-HDMI connectivity -Mini DisplayPort connectivity -Thunderbolt connectivity -Wi-Fi connectivity -Bluetooth connectivity
The convergence device must make use of one cord that transmits data, audio, video, and power. If the power supplied by this cord does not meet power needs for the device, then a second cord dedicated to power is acceptable.	-Thunderbolt powers 10A power from both ends -Secondary power option available if there is no Thunderbolt port on connected device

Figure 45: Table of Convergence Guidelines and Applications

Chapter 7: Study Conclusion

7.1 Future Relevance and Recommendations for Study

The x-Link itself is a hypothetical example of how a convergence device can easily be developed and implemented with the goal of furthering the convergence process while also having wide adoption abilities. It is impossible to speculate on whether Thunderbolt technology will be the replacement of connectors like HDMI and USB. In addition, as the convergence process moves forward, solutions like the x-Link may become unnecessary if a similar technology is built directly into televisions or STBs. Regardless of the relevance of the device itself, the guidelines are intended to remain relevant throughout the convergence process.

The development of this form of technology is untested and there are benefits of this system that the writer has not mentioned earlier in the text. While the launch of this platform is unlikely, a trial device and service using the proposed guidelines would determine the validity of these guidelines.

7.2 Implications and Applications of Study

The form of the x-Link shares similarities with the trend of using dongles and miniature STBs to add Internet connectivity to televisions. It will be the designers' discretions that choose the form of a convergence device solution. The purpose of these guidelines acts to highlight the needs involved with an integrated convergence system. In addition, these guidelines may act as a roadmap that allows individuals not familiar with design, such as engineers, to develop a reality based solution that further continues the convergence process.

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