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Integration of Mobile Technology into Museum Education: A Discussion of the State of the Art

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INTEGRATION OF MOBILE TECHNOLOGY INTO MUSEUM EDUCATION: A DISCUSSION OF THE STATE OF THE ART

by

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Abstract

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This thesis is an attempt to examine the current state of mobile technology use in museum education programs. Mobile technology is fast becoming the communications and learning medium of choice. Since its inception, there has been an entire generation born into today's digital and wireless world. This project endeavors to present the latest understanding of where mobiles fit into the general culture, museum visitor experience, and particularly into museum education. We will examine literature concerning the digital generation and their mobile use tendencies, the viewpoint of museum professionals, and what the future may hold for mobile communication devices and museum education. Perspective has also been drawn from survey of museum professionals for a recent international online conference on mobile device use as well as a limited evaluation specific to this thesis. Lastly, this thesis presents a hypothetical museum education program combined with the accompanying mobile technology infrastructure. The wireless network design is based on personal experience, and the technology used is actual off-the-shelf equipment that can be purchased by any institution. At the end of the thesis is a chronology of Information Technology development and evolution. It is included as an addendum along with an accompanying glossary of technical terms as added foundational information for the non-technical reader.

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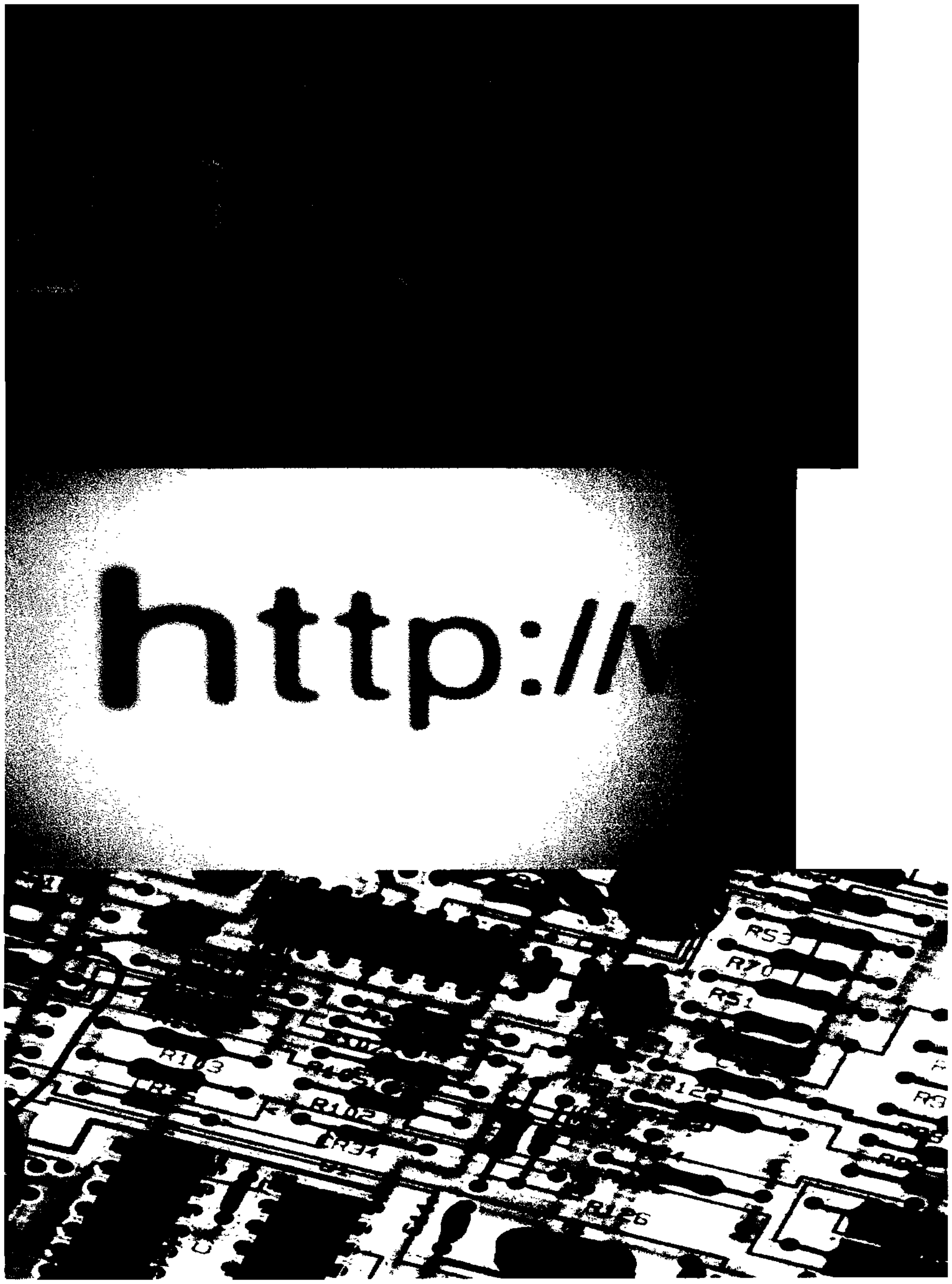

Table of Contents

1.0 Introduction **1**
1.1 Thesis Focus 3
2.0 Background **9**
2.1 Why Do We Need to Know This Stuff? 11
2.1.1 Context and Definition 14
2.2 The Native, the Settler, and the Immigrant 19
3.0 Perspective **23**
3.1 Driving Factors That Museums Need to Consider 24
3.2 The Viewpoint: Literature Concerning Mobiles and Museums 29
4.0 Closer Study of Mobiles and Museums **42**
4.1 And the Survey Says 43
4.2 A Recent Limited Evaluation 48
4.2.1 The Methodology 50
4.2.2 The Quantitative Results 53
4.2.3 The Qualitative Questionnaire and its Analysis 59
4.2.4 Interpretation 59
5.0 Museum Programming and Technology Use **59**
5.1 The Exhibit 60
5.2 The Program: How to make it Museum *and* Educational 62
5.3 The Technology: Build it and They Will Come 71
5.4 Digitization is a Key Element 78
6.0 Food for Thought **80**
6.1 Changing Times and the Digital Native 86
Appendix A – Evaluation Matrix **88**
Appendix B – Evaluation Survey Instrument **91**
Appendix C – Evaluation Qualitative Questionnaire **93**
Appendix D – Museum Education Program Instructions **96**
Appendix E – Museum Education Program Investigator's Worksheet **98**
Appendix F – Museum Education Program Investigator's Head **101**
Addendum: The Technology **102**
What *is* This Stuff Anyway? 102
The Electronics 103
The Computer 107
The PC to the Server 112
The Internet 123
The Mobile Device 134
Digitization and Storage 139
This is What the Stuff Is 145
Glossary of Technical Terms **147**
Works Cited **152**

LIST OF TABLES & FIGURES

Tables

Number	*Page*
Table 4.1-1 Term Differentiation	46
Table 4.1-2 Comparison of Four Major Objectives	47
Table 4.2.2-1 Technology Choice and Application	52
Table 5.3-1 Equipment Requirements and Cost	76

Figures

Figure 5.3-1 Wireless Network Access	75
Figure A1Vacuum Tube Technology	103
Figure A2 ENIAC c. 1947	104
Figure A3 Transistor Construction	104
Figure A4 IC Chip Construction	106
Figure A5 Portions of ENIAC at the NMAH	112
Figure A6 The MIPS ALTAIR at the NMAH	114
Figure A7 The Apple I at the NMAH	115
Figure A8 The Apple II at the NMAH	116
Figure A9 The Commodore PET 2001 at the NMAH	116
Figure A10 The IBM PC 5150 and the Apple Macintosh Classic	120
Figure A11 View of a Blade Server	121
Figure A12 A 19x84 inch Server Rack with Slide-out Monitor	122
Figure A13 One of Google's First Server Bays	122
Figure A14 Hand Drawn Map of the 1977 "internetting" Demonstration	129
Figure A15 1973 Prototype Motorola DynaTac Cellphone	136
Figure A16 First Commercial Portable Cellphone 1983	136
Figure A17 A-to-D Conversion	140
Figure A18 Hard Drive with Disc	144
Figure A19 Hard Disc Formatting	145

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1.0 Introduction

Museums today have to deal with a rapid and significant shift in the general public's use of Information Technology (IT). All of a sudden, the world has gone mobile. The move towards mobile information technology is the result of the convergence of three earlier key technologies that have come of age over the last thirty years: the cellphone, the PC, and broadband access infrastructure. This merging has created a high-speed wireless and mobile world, in which almost everyone is connected to everyone. Never in the history of humankind has the population at large been so connected over such a vast area of the planet. It has enabled instant access to information and the ability to share it just as instantly. Mobile devices seem to have invaded all aspects of our lives. They are with us in our homes, our workplaces, our shopping malls, and at our cultural gatherings. Mobility and information access has never been so easy; everyone has become connected all the time.

What this means for cultural institutions, and particularly for museums, is that the public has a growing expectation that mobile handheld technology will be part of the experience. There is no doubt that visitors are bringing the devices with them and finding ways to use them even if there is no formalized process to do so. It may be as simple as taking a picture of an object or artifact for later exploration and sharing; or it may involve looking something up on the Internet to improve the understanding of an object. Museums need to try and get ahead of the curve of mobile device use and decide how they wish to integrate handheld technology. This is true across the visitor demographic spectrum, but especially for the generation born after 1980.

Digital Natives, as this generation is sometimes referred to, have adopted and adapted to mobile technology quicker than any other form of technology to date. They have integrated it into their everyday existence to an immense degree and are pushing the envelope of how and where it is used. Digital Natives are filtering their worldview through handhelds and are changing the way they acquire and assimilate information. This will have a large impact on this generation's educational experience. How will museums adapt to this development as more and more school age visitors attend museum educational programming? There is no doubt that demand will rise for handheld integration. The question is: are museums prepared?

The issue of preparedness for museums and museums professionals can be measured by the way they understand mobile communications technology and their comfort level in its utilization for programming goals. There are those in the profession who have experience and an aptitude for creatively utilizing technology. The American Association of Museums (AAM) includes a standing committee on technology and annually confers its MUSE awards on innovative technological application in various institutions. But, this may be the exception more than the rule. Lack of exposure and technical education as well as perceived cost can be formidable barriers to true integration of Information Technology and especially to an understanding of how and where mobiles fit into the equation. This is substantially true for small to medium sized museums that may see mobile integration as a daunting task. Eventually, the barriers that seem to present themselves to a portion of the museum profession will have to be addressed. If the Digital Natives are becoming the museum visitor of the future, how they interact with the world around them will have to be taken into account. It is logical to assume that they will bring with them the technological tools that manage their information processing.

Up to very recently, the focus of mobile Information Technology in museums has been its utilization for the general exhibition experience. The argument of this thesis is that it may be even more important to focus on museum education programs. School age visitors, at which most programming is aimed, are Digital Natives. By using mobile technology in their school programs, museums can put themselves at the forefront of mobile device use, and possibly showcase for the formal classroom how effective a tool it can be. This thesis aims at demonstrating that things are changing very quickly; that museum professionals need assistance in the form of training and education; that it does not take an extensive knowledge of mobile technology to apply it to educational programming; and that the supporting IT infrastructure design need not be complicated nor expensive. To achieve this aim we will explore, through literature and survey, the current perspective of Information Technology use in museums focusing on mobiles. In addition, we will present as example an educational program that considers how mobiles can be part of the mix. As an addendum, we will review the evolution of Information Technology to show where it came from and how various technologies converged to create what we understand as the broad category of Information Technology and how it generated the always wired, always connected world we live in. The ultimate goal of this thesis is to raise some consciousness concerning mobile technology and museum education, and to trigger further study into how best to accommodate that trend.

1.1 Thesis Focus

In order to effectively assess the importance of mobile technology and its possible impact on museums, we need to examine some basic data regarding its use as well as museum professionals' current understanding of this technology. Section 4.0 of this thesis will look at information garnered from a limited evaluation that provides some quantitative and qualitative data that may help to assess the current perspective of museum professionals. Reference will also be made to data from a survey conducted by *Learning Times* in 2010 that focused on handheld technology use in museums internationally. The survey was an outgrowth of a second online conference on the subject held this year. These data tell us a good deal about the current state of technology in museums and provide a platform for this thesis, which aims at making the following points:

1. It is essential for museum professionals to take mobile technology seriously as it is a pervasive tool in the hands of their most coveted audience, Digital Natives, which is the generation arriving after 1980.
2. The potential for mobile technology to augment and enhance the museum experience is limitless if those who apply it understand how it can be integrated.
3. The focus of mobile technology should not only be on exhibits, but also on education. For the target generation with which museums are concerned, children and teenagers, it is the way they interface with the world and each other. Leveraging its use is akin to staring the Digital Native in the eye and gaining their attention.
4. Mobile electronic technology is relatively inexpensive. There are ways to take advantage of its use in the museum with off-the-shelf concepts that do not necessarily require expensive customized configurations. This thesis will include an example of that possibility. It begins with taking advantage of

digitized collections and archives that museums have been processing for over a decade.

5. Because mobiles are an instrument of powerful communications and information transfer, we need to examine the process by which it may be leveraged as educational tool. In order to emphasize this, we will look at a particular example of how to layer an educational program onto the mobile infrastructure.

To support the points stated above, we begin in Section 2.0 with a discussion of the reasons why we as museum professionals should care and commit to mobile devices in our institutions. We need to examine and understand the new human relationship to information-based technology and its power and pervasiveness. We need to define users such as the Digital Native as well as the Digital Settler and Immigrant. The tags refer to the generational breakdown of Information Technology (IT) users based on experience and comfort level. Particular emphasis will be placed on Digital Natives, as they are the learners of today and leaders of tomorrow. Museum educators need to have a basic understanding of how Digital Natives view their world and the nature of the technology they have already integrated into their lives. They perceive differently, think differently, and act differently from any other previous generation. If we are to focus on the educational experience of the Digital Native, then understanding this paradigm is crucial. It is incumbent upon museums as educational institutions to know the digital generation's tendencies and preferences and leverage these for maximum educational effect.

Section 3.0 will explore the museum professional's perspective through some recent literature. The spectrum includes an article in *MUSEUM* magazine specifically focused on examples of mobile use from a handful of institutions as well as extracts from a recently published anthology discussing the experiences of the contributors. In addition, we will examine the trends of mobile use for school age Digital Natives based on a study from the Pew Internet and American Life Project. Also included is a report from the Joan Ganz Cooney Center supporting educational adoption of technology based on early childhood development and elementary education. Lastly, the Horizon Report 2010 Museum Edition addresses Information Technology trends in museums specifically as well as the issues surrounding adoption.

Section 4.0 is the heart of the thesis and will examine the museum professional's perspective directly through survey and limited evaluation. We will first conduct an analysis of the *Learning Times* survey for the Museum and Mobile Online Conference II that was held in spring 2011. The conference focused on mobile use in museum settings, and in support of the conference, an extensive international survey was performed that has relevancy to the discussion. In addition, a limited evaluation was performed in the summer of 2010 specifically for this thesis, which included a smaller survey than the one for the Mobile Online Conference. The limited evaluation is oriented particularly towards determining mobile use and their integration into museum education programs. It provides a snapshot of the present state of mind of the museum professional and what is currently being attempted. The discussion includes an outline of the critical questions that are the underpinnings of the evaluation and are referenced in Appendix A of this document. After establishing the critical questions, an overview of the methodology and the instruments utilized is provided. The instruments used for the evaluation include a quantitative survey posted online for respondent access (Appendix B), and a qualitative questionnaire (Appendix C) sent to those respondents who volunteered. We will look at both the quantitative and qualitative data gathered and provide some analysis of what the respondents contributed. In addition, we will look at some conclusions that may be drawn from any patterns that make themselves evident. Because this is a limited evaluation, and not a full study, we will be careful not to extrapolate major trends or interpretations for the museum environment as a whole. The hope is to focus on commonality of thought, experience, and perspective that could be used to trigger wider study, or foster ongoing discussions within the museum profession.

Section 5.0 explores a hypothetical school age educational program aimed at the middle years Social Studies classroom. It was developed around an actual temporary exhibit at the New York State Museum running from July of 2009 to March of 2010. The discussion will provide the program structure, its intended New York State learning requirements, and how mobile technology and the associated infrastructure could be leveraged for these types of activities. The intent is to provide an exemplar that employs relatively low cost technology infrastructure to foster student museum/classroom learning, while taking advantage of the Digital Native's tendencies. In a subsection we will provide detail of the technology directly involved in mobile integration including its supporting infrastructure. We will delineate what it takes to put together a fairly inexpensive configuration using off-the-shelf technology, and what that architecture might look like. In this portion of the thesis we will help to define what the technology is, and for assistance, may refer to the glossary of terms provided after the final section of this document.

Section 6.0 will examine the implications of everything previously discussed, and layout the main challenges to introducing mobile technology in museums, namely, lack of training and experience on the part of museum educators, the financial concerns, and management support. Ultimately, the goal of the thesis is: (1) to stress the importance of mobile technology for museums and the museum profession; (2) to show that its widespread use in museums is not in the distant future but imminent; and (3) to demonstrate the educational possibilities of mobile technology, which young museum-goers have already incorporated into their lives.

To provide a broad context, a general discourse of Information Technology (IT) is provided in an addendum. It includes what it means to be digital and the evolution of Information Technology. It details the chronology of computers, the cellphone, and the Internet and defines the technical pieces that comprise Information Technology. As with any discussion of technology, there are terms and acronyms that are peculiar to its environment. A glossary of these terms is provided after the addendum.

In order for mobile technology to work as a portal to museum content, there is a need for its digitization. The addendum also covers this subject area as it discusses the move in cultural institutions, including museums, towards storing and archiving digitized information over the last decade and a half. This has brought with it a myriad of possibilities for access and exhibition. Additionally, digital formatting has created the potential for educational programs to utilize these files housed within museums. All information-based technology, handheld or not, requires a virtual digital rendering of objects and artifacts in order to accurately represent them for the museum visitor. Metadata (adjunct information) about any object, artifact, or exhibit can be presented as written text and/or pictorial display. All aspects of information content, whether text, picture, or video, can be transferred into standard data formats that can be easily accessed by mobiles. Information access is the key to any meaningful program developed around objects and artifacts, and it is the unseen technology infrastructure that makes it all possible. In addition, this information access may not be limited to merely what is displayed on the exhibition floor, but to stored objects and artifacts that may never be in rotation for conservation reasons or in limited rotation due to exhibition timing requirements.

This final and additional piece to the thesis is intended to provide a window into the broad and rich history of Information Technology, and to illuminate for the uninitiated, the incredible technology that allows all of us to connect and communicate at will. Hopefully, this will create some understanding for the reader about the technology with which Digital Natives have such a comfortable relationship.

2.0 Background

Much of the following discussion of electronic-based communications technology comes from personal experience. After attending college as a Liberal Arts student majoring in History, I joined the U.S. Navy where I received my technical training as an Electronics Technician. I spent seven years on active duty becoming proficient in many types of electronic systems, but was primarily a communications specialist in data as well as voice systems support. I was able to leave the Navy the year the AT&T divestiture took effect in 1984. Over the next twenty-seven years, I spent a good portion of my time in the Coast Guard Reserves maintaining my technician's skills while earning a military retirement. In parallel to my reserve time, I have had an interesting and fulfilling career as a civilian. I have held positions as network designer, operations and project manager, major account salesman, and then as post-secondary teacher and education program supervisor. I have subsequently been lucky enough to parlay my experience into a small business partnership within the communications-networking field, which has afforded me the opportunity to pursue my original goal of historical research and teaching. This brings us to the present time and the focus of this thesis. My personal goal is to create some kind of synergy between communications technology, education, and the museum. As educator, I am not interested in, nor designed for, the formal education environment of the public school system. I personally feel that the construct of the *informal* educational experience is much more conducive to school age learning. Incorporation of object-based educational experience provides a more concrete underpinning for primary level educational needs, and a more holistic approach to secondary level critical-thinking learning. Museums are the environment from which this philosophy has sprung. The very nature of their design has created the possibility for enhanced learning that can be integrated into the formal educational process. That connectivity can be generated through the information technology that is so pervasive in today's world.

One of the most important technologies of the 20th century is the Personal Computer (PC). It has brought the power of information down to the masses from its original perch in both government and business arenas. Ultimately, PCs have become physically interconnected to create today's Internet. The outcome of this development has been information storage and transfer. Because PC use can be static and humans are mobile creatures, the need for mobile access eventually brought us the handheld version.

With the culture's ever-increasing dependency on mobile Information Technology, museums have an opportunity to tap into its power and mobility. Not only can they expand on the information provided in exhibits, mobiles can be used to: 1) gain the attention of the generation born into this world, and 2) enhance the educational experience for them by connecting into a vast network of information utilizing the skills Digital Natives already have with the technology. Making use of existing text and digitized versions of actual objects, education can cross the boundary between museum and school as students access this information with the device that is almost always with them. Integrated programs can be developed that stretch over the school calendar and meld with educational standards. This could lead to learning that is more effective and ultimately develops better critical thinking skills at the secondary and post-secondary levels of a student's life.

If museums are willing to take up the challenge of mobile Information Technology integration, there is a warning they must heed in order to be effective in the end. The most important lesson I've learned in quick order as a specialist in communications technology, is that technology in general is at its best when it serves a purpose, a need, or solves a problem. This requires that the purveyor of technology be sensitive to the perspective of the end-user. It becomes incumbent upon the professional to, in effect, understand the end-user's business, to understand the end-user's problem or goal. And it helps immensely to understand the psychological relationship we all have with Information Technology if an individual or group plans to incorporate it into some new arena. To accomplish the goal of integration then, museums must understand information technology's place and ensure that it is an enhancement and not a mere adjunct.

2.1 Why Do We Need to Know This Stuff?

Today museums find themselves in a state of transition peculiar to Information Technology. The questions are: (1) how do museums incorporate and manage a technology that is already part of the culture in which they reside; and: (2) can museums learn the lesson that good technologists have, that is, to ensure that information technology serves a purpose and not its own sake? To illuminate the answers, we must first define what museums are and what niche in society they occupy. Webster's New Collegiate Dictionary defines museum as:

> *n* [L *Museum* place for learned occupation, fr. GK *Mouseion*, fr. neut. of the Muses, fr. *Mousa*] : an institution devoted to the procurement, care, study, and distribution of objects of lasting interest or value; *also* : a place where objects are exhibited (1979)

The American Association of Museums (AAM) provides the following on their website ("What is a Museum?"):

> ***The International Council of Museums (ICOM) defines a museum as:***
>
> *A non-profitmaking, permanent institution in the service of society and of its development, and open to the public, which acquires, conserves, researches, communicates and exhibits, for purposes of study, education and enjoyment, material evidence of people and their environment.*
>
> ***The federal government in the Museum and Library Services Act defined a museum as:***
>
> *A public or private nonprofit agency or institution organized on a permanent basis for essentially educational or aesthetic purposes, which, utilizing a professional staff, owns or utilizes tangible objects, cares for them, and exhibits them to the public on a regular basis.*

In comparing the definitions, one can see a slight difference between Webster's dictionary and the two provided by the AAM; the latter include the word *education.* Today, museums are not only traditional repositories of collections, but almost all museums include education as part of their mission. On a global scale, museums can also be looked at as institutions of cultural heritage. They have as a common thread the task of human self-reflection no matter where on the planet they may reside. This speaks to the commonality of human experience and perspective. Humans also have as commonality of experience the development of technology and the need to communicate. Communications can take many forms and there is no doubt that museums do communicate. They communicate the ideas of history, science, and art, and almost everything else that involves human knowledge and understanding. The most effective museums are those that connect with their visitors and communicate ideas in the most engaging manner. Connecting to the audience requires that the communicator understands how to gain the attention of the receiver and how to impart information utilizing the best means of delivery. This is where museums of today need to focus their attention. They need to understand how the culture at large is connected and how information is delivered and filtered. In a modern world, the form this takes is through the mobile handheld device that allows for access to a vast reservoir of stored information and the linking over long distances.

So how should the museum profession look at communications technology, and why is it so important? The rate at which our technology changes has continued to accelerate in the last few decades. There is scarcely a minute that goes by when some piece of knowledge or information is acquired and then transmitted. The more we create information, the more we want to communicate it, and as consequence, the more we refine our technology in fulfilling this goal. That trend is not likely to cease. Museum professionals need to understand what communications technology is and then use its power to reach out to their visitors.

The communication technologies that have already been employed by museums have been adapted over time. From audio tour systems, to computers, to flat screen monitors, more museums have tried to increasingly employ as much technology as possible in order to enhance the visitor's experience. As corollary, more and more museum visitors are bringing with them an extensive personal experience with technology. Their lives outside the museum are dominated by electronic technology, and particularly with communications technology. Today, hardly anyone goes anywhere without a communications device.

In order for museums to best serve their public, they must take into account the public's expectations and attempt to take advantage of the way in which visitors communicate and learn. Museums should not implement communications technology for its own sake, or because they feel they should keep up with current trends. The process should be thoughtful and purposeful. This requires understanding the audience for which the technology design is intended and the specific educational needs it is to serve. It also requires some level of knowledge on the part of the museum professional about Information Technology.

2.1.1 Context and Definition

Technology has played an important role in human evolution and cultural development for millennia. From the first crude implements used by human ancestors, to the latest gadgets that govern our lives today, the term technology refers to every tool that humans have developed to manipulate their environment in order to ensure their survival. Today, almost every human activity includes some form of technology; from toasters to telephones, technology surrounds and envelops us. We have inherited a comfort level with our technology that is the result of the discovery and development of countless generations. Today, the meaning of the term technology has, in common parlance, been narrowed to communications technology. This is a specific type of technology that is electronic-based and is primarily aimed at storing and communicating information and ideas.

The form in which our current and most important technology takes is fairly new. According to the Merriam-Webster dictionary, the term electronics was newly coined in 1910 and is, “a branch of physics that deals with the emission, behavior, and effects of electrons (as in electron tubes and transistors) and with electronic devices.” The Cambridge dictionary states that electronics is: “The scientific study of electric current and the technology that uses it.” Electric current refers to what people know as “electricity,” and is technically understood in physics terms as the flow of electromagnetic energy. The basis of electromagnetic physical theory is the electron and its flow through a conductive (electrically oriented) path. Again, reaching to the dictionary for definition, the electron can be defined as: “a stable subatomic particle with a charge of negative electricity, found in all atoms and acting as the primary carrier of electricity in solids…Electrons orbit the positively charged nuclei of atoms and are responsible for binding atoms together in molecules and for the electrical, thermal, optical, and magnetic properties of solids” (Webster’s).

By the end of the 19th century, physicists and engineers had learned to manipulate the flow of electrons from their stable orbital paths around the nucleus of atoms to an unstable state where they move through space from one atom to another. This is what we know as electricity. With this leap of knowledge a little more than a century ago, and its practical application over subsequent decades, our lives have changed in significant ways.

The devices that can be categorized as electronic utilize elements that manipulate the flow of electrons (electricity), a capability that became viable with Thomas Edison's development of a working electric, incandescent light bulb and its generating power source in 1879 ("The Thomas Edison Papers"). Yet, the device that Edison developed could only be considered electrical. A light bulb does not really manipulate the flow of electrons as true electronic components do but only takes advantage of the electromagnetic flow and transfers that energy into light emitting heat. Electronics did not come of age until another 19th century scientist and inventor, Guglielmo Marconi, was able to assemble the components others had developed into the first working wireless communications device patented in Britain in 1897 ("The Marconi Collection"). In doing so, he was able to send telegraph signals over distance using electromagnetic energy harnessed through the first truly electronic system. Although today we think of "wireless" technology such as our cell phones and computer networking devices as *new* technology, the concepts and initial applications were first established in these early days of radio. What is innovative today is the state of electronic components that allow for use of less power (electrical energy), the ability to store energy (the battery), and the small size and mobility of our electronic devices.

In the last few decades, electronic components have become part of many systems and devices that are integral to our daily lives. They are in our cars, heating and cooling thermostats, medical systems, and communications devices. It is the pervasiveness of these components and almost limitless combinations that make electronics as important and powerful as they are. In particular, these components become *very* powerful when they are applied to devices and systems that store and convey human thought. An exponential increase in information and knowledge has occurred in recent human history because of the application of electronics in relatively inexpensive configurations. Consider this: a standard scientific calculator that can be purchased for less than $20 on the average, has immensely more processing power than the systems aboard the Apollo 11 space craft that brought men to the moon and back. Also consider that the processing power of the Personal Computer (PC) of a decade ago costing upwards of $3,000, has been exceeded a thousand fold by a device known as the iPhone that fits in one's hand for the cost of around $200.

Electronic-based systems are a direct function of the development of electronic components. Over time these components have become less expensive to produce and more powerful in their capabilities. This holds true for Information Technology as well, "Smaller/cheaper" is the battle cry of companies that design and manufacture these systems, and they are only responding to the demand of the public. As a consequence, the Personal Computer has evolved and morphed into its handheld and mobile cousin. Science fiction is now becoming science fact. The Star Trek™ communicator of the iconic 1960s television show has come to fruition. In fact, the use of sleek handheld devices has gone beyond the television show's military functionality to one that allows everyone who can afford it instantaneous connection for long distance interaction. Additionally, unlike the TV show, the handheld device has now become essentially a computer that connects not only human-to-human, but human-to-information.

The backbone of Information Technology is the Internet, which delivers instantaneous news, analysis, and knowledge. The access point for Internet users up to now has been the PC. The PC is a ubiquitous tool throughout the nation and a good portion of the world. It has invaded our workplaces, our school systems as well as our homes. They are as numerous as the televisions in our houses and the vehicles in our driveways. Where once a single television and a single vehicle were sufficient for the typical American suburban family of the 1950s and 60s, we now have TV sets in every room and multi-stalled car garages. Today, in parallel with that growth, each member of the family typically has their own PC, and unlike the television, it is an extremely interactive device. Users communicate through the PC to other more powerful computers that comprise the Internet and in turn receive information. In the last two decades, PCs have become mobile in the form of laptops, but mobility is relative. It has been the handheld device that has become the portal of choice for these global networks. With their extreme mobility, which goes well beyond the laptop, they have ultimately stretched the definition of information connectivity.

Students today see computing and communicating systems in a manner that is similar to the way earlier generations viewed pencil, paper, and print. But electronic-based Information Technology is much more powerful in its ability to process and disseminate information, good or bad, than any previous technology. Being powerful and convenient, people are now utilizing mobile information devices everywhere, and in particular, today's students are bringing them along to every destination. If computers, and specifically handheld versions of them, are now invading all aspects of our lives, then it is only incumbent upon adult educators to leverage their use and their power to teach. One educational institution that might be able to take advantage of that power is the museum.

Where else but in a museum could there be the perfect marriage of information, knowledge and a device that conveys it all to a young student? Long before the Internet, museums were the original repositories of information and understanding. It goes to reason that museums *plus* the Internet means powerful educational possibilities for everyone, and especially school-age students. A good museum educational program that is connected to the classroom, the Internet, and the museum's own database (local Internet), can begin to teach, not only subject matter more effectively, but stimulate the younger generation's thinking about the tool that Information Technology is. Because of its mobility, the mobile version of Information Technology can only enhance the museum educational experience if integrated properly into its programs. It may require a paradigm shift for the museum discipline, but for educational programs, handheld mobile devices can be used efficaciously as well as cost effectively. It will require some study and strategic planning, but it is possible to take advantage of a technology that seemingly has no end of possibility in sight.

2.2 The Native, the Settler, and the Immigrant

If museums are to become the place where people, and particularly *young* people, take advantage of extensive collections and educational possibilities, the professionals involved need to understand with whom they are dealing. The target audience for most educational programming in museums is school-age children. The demographic issues are significant because of the relationship between this group and the technology they are used to interacting with. Age and/or generation most often dictate the type of information device and the skill-set that the user brings to the table. Beyond that, what is also significant is the cultural and psychological connection between the user and the technology, as it determines how a museum will have to communicate with the person who owns the device.

In 2008, John Palfrey and Urs Gasser published *Born Digital: Understanding the First Generation of Digital Natives*. They describe this generation as those born after 1980 when the original social networks of bulletin boards became available on a burgeoning Internet. In particular, they define this group as having "access to networked digital technologies" as well as "the skills to use those technologies" (*Born* 6). Both authors are lawyers specializing in information, the law, and technology. They attended Harvard Law School around the same time and became members of the Berkman Center for Internet & Society at Harvard University (Berkman *People* webpage). Together the co-authors produced what amounts to a sociological study of the generation that grew up with electronic-based Information Technology. Their thesis is predicated on the fact that the Digital Native knows of no other way of existence, and their perception of the world they live in is cognitively different than those that came before them. Palfrey and Gasser state it like this:

> "There is one thing you know for sure: These kids are different. They study, work, write, and interact with each other in ways that are very different from the ways that you did growing up. They read blogs rather than newspapers. They often meet each other online before they meet in person. They probably don't even know what a library card looks like, much less have one; and if they do, they've probably never used it. They get their music online—often for free, illegally—rather than buying it in record stores. They're more likely to send an instant message (IM) [these days a text message] than to pick up the telephone to arrange a date later in the afternoon. They adopt and pal around with virtual Neopets online instead of pound puppies. And they're connected to one another by a common culture. Major aspects of their lives—social interactions, friendships, civic activities—are mediated by digital technologies. And they've never known any other way of life" (*Born* 6).

To compound the issue of Digital Native perspective, the rate at which the technology they use changes can be staggering. This is evidenced by the statement in the quote above referring to instant messaging, or "IM-ing." This is almost a passé form of communications that is only a few years old. Texting, or text messaging, is now de rigueur. In order to tap into this generation, museum professionals, and specifically museum educators, need to take what Palfrey and Gasser say to heart. This is not a passing phase or some anomaly; the front-end of this generation are already adults, the back-end is even deeper into the culture described above.

The generation that preceded the Digital Native fairly easily stepped into this world, and in some ways helped shape it. Palfrey and Gasser tag this group the Digital Settlers. Born in an analogue world, yet one including electronic devices, this group is then only added to the population of Natives that come armed with mobile devices. They are also comparatively sophisticated in their use of digital technologies including the Internet (*Born* 8). Through electronic-based, mobile devices, Digital Settlers are tethered to each other and vast quantities of information. Recently, the term "CrackBerry" has been added to the lexicon referring to the constant use by adults of the popular BlackBerry device that allows for Email and text communications. Equating its addictive qualities to crack cocaine, use of the BlackBerry and similar devices has been banned in some company business meetings because they cause inattention. There is even a website dedicated to the BlackBerry user known as CrackBerry.com with the tag line: "The #1Site for BlackBerry Users (& Abusers!)."

By contrast, the third generational grouping is known as the Digital Immigrant. They have come to the digital universe late in life and may have some rudimentary skill-set, but by and large, they avoid, shun, even shun digital device use. They are the butt of so-called "clueless user" jokes, and in some cases may actually get caught up in true Internet scams (Palfrey & Gasser *Born* 8). But this demographic is relatively small compared to the Digital Native and Digital Settlers. What does this mean for museums, and particularly museum education programming? The combined population of Digital Natives and Settlers indicates that mobile device users are becoming more significant as time goes by. By default, these devices are being brought with them to the museum. Programming that is aimed at this population, and particularly at Digital Natives, must take their perception of the world and the way they mediate it into account.

Digital Natives were born into an environment that included Email and texting as opposed to "snail-mail." They travel the subways and streets with earbuds attaching them to MP3 devices like the iPod, which hold and play hundreds of digitized music tracks. This most likely implies that they don't know what an LP record is (possibly something in a museum). They live their lives "online" and connected. They are digital and only understand the world in this fashion (Palfrey & Gasser *Born* 8). As reemphasis on the Digital Native's perspective, Palfrey and Gasser state it like this:

> "Unlike most Digital Immigrants, Digital Natives live much of their lives online, without distinguishing between the online and offline. Instead of thinking of their digital identity and their real-space identity as separate things, they just have an identity (with representations in two, or three, or more different spaces). They are joined by a set of common practices, including the amount of time they spend using digital technologies, their tendency to multitask, their tendency to express themselves and relate to one another in ways mediated by digital technologies, and their pattern of using the technologies to access and use information and create new knowledge and art forms." (*Born* 8).

For museum educators the last sentence is significant, and particularly, the latter *part* of the last sentence referring to access of information in making new knowledge and art form. If the Digital Native mediates his or her world through digital, mobile devices, then it is only logical for educators to understand the mindset.

3.0 Perspective

Why should museum professionals consider mobile technology? If there is common agreement that it is time to incorporate mobiles into museum visitorship, how should an institution go about integration and for what purposes? Various publications ranging from a recent anthology to magazines such as *MUSEUM* and *Smithsonian* have focused on mobiles. Most discussions of mobile technology use are centered on visitors and exhibitions. Very little writing has been aimed directly at mobiles and museum education programs specifically. To gauge whether it makes sense to integrate mobile technology into museum programming, it may be advantageous to explore this concept based on study of the relationship between mobiles and the target demographic that comprises the Digital Native. We will take a look at one of many recent studies on Information Technology trends and Digital Natives by the Pew Internet and American Life Project. This particular study was specifically aimed at teens and mobile devices and may be helpful in understanding why it is important for educators to consider mobile use while planning museum programming targeted for them. In addition, we will also present interesting findings from the Joan Ganz Cooney Center. This Center was commissioned to look at early childhood development and elementary education exposure to technology. The resulting report was that there were some significant trends that could be useful in education, as young Digital Natives grow older. Teenage Digital Natives are only the beginning of mobile technology integration; continuous waves of successive users are on the horizon for museums to consider.

Are museum professionals ready to take advantage of mobile technology? After a look at an article in MUSEUM magazine, we examine a recent anthology, *Creativity and Technology: Social Media, Mobiles and Museums*, published in the spring of this year. Contributions included generally highlight current museum professional thinking. As example, we examine three essays that present a cross-sectional perspective of where mobiles are seen as fitting into the museum experience. The essays represent the experiences of some prominent institutions.

Lastly, information from the Horizon Report 2010 Museum Edition will help to shed light on general trends in museums concerning technology and social media. The report covers a five-year, medium term look at technology trends significant for museums and presents some compelling considerations. Within its broader perspective is the question of mobiles and what issues stand in the way of museums taking effective advantage of interesting possibilities.

3.1 Driving Factors that Museums Need to Consider

"The mobile phone has become the favored communication hub for the majority of American teens." This is the opening line of a Pew study report dated April 20, 2010 for the Pew Internet and American Life Project. It leaves no doubt as to where communication is moving to and how it will look in the future. The report states that 75% of 12-17 year-olds have cellphones, which is a significant leap from the 45% of 2004. It goes on to emphasize, "Those phones have become indispensable tools in teen communication patterns" (Lenhart 2). Interestingly, there is also a statement as to how schools view mobile devices: "Most schools treat the phone as a disruptive force that must be managed and often excluded from the school and the classroom." And yet, irrespective of regulation, teens still use their mobiles in various ways and at various times during the school day (Lenhart 4). In fact one teen in the study is quoted as saying: "I have unlimited texts . . . which is like the greatest invention of mankind" (Lenhart 9). This is proof positive of the enormity of the change. Much of this change can be attributed to the versatility of mobile devices. In a few short years, the cellphone has become the mobile, multimedia device that makes information access and knowledge acquisition almost effortless in comfortable hands. The report defines from its study just how versatile it is (Lenhart 5):

"Cell phones are not just about calling or texting – with expanding functionality, phones have become multimedia recording devices and pocket-sized internet-connected computers. Among teen cell phone owners:
Teens who have multi-purpose phones are avid users of those extra features. The most popular are taking and sharing pictures and playing music:
• 83% use their phones to take pictures
• 64% share pictures with others
• 60% play music on their phones
• 46% play games on their phones
• 32% exchange videos on their phones
• 31% exchange instant messages on their phones
• 27% go online for general purposes on their phones
• 23% access social network sites on their phones
• 21% use email on their phones
• 11% purchase things via their phones"

Even though the report does not speak to cultural institutions specifically, the picture the study provides is relevant for museums as well. The Digital Native seems to have an ingrained aptitude and affinity for mobile communications devices and they see the world around them through this prism. Good or bad, this is the new paradigm.

In addition to studies of teen usage trend, there are educationally based studies that have looked at the significance of technology and learning. Aptitude tends to be enhanced by early exposure in child development. The Joan Ganz Cooney Center commissioned a report focusing on digital media and early childhood and elementary education. A couple key factors have come to light. The first has to do with media exposure and developmental processes: "As children move through the elementary grades, media consumption appears to rise and they become habitual multitaskers. As they play video games or visit new virtual worlds, elementary school children may also be sending text messages on their cell phones, listening to iPods, and keeping an eye on the TV screen" (Shore "The Power" 18). In light of this learning phenomenon, the study also delved into the educational impact and how to deal with the growing trend. It state: "A growing body of research suggests that interactive media have the potential to support reading readiness, literacy skills, and content area learning in mathematics, science, and social studies" (Shore "The Power" 20). In order to ensure comprehensive learning for all of these young Digital Natives, researchers are reaching back to cognitive basics by looking at the impact of digital media at this early stage of development. They are examining how digital media affects "active learning, metacognition, and verbal memory" (Shore "The Power" 20). It seems that elementary students will take active control of their learning experience because of their interaction with digital media. They will adjust the pace and difficulty of the material allowing themselves to stay more engaged in the activity. This leads to more effective learning since digital media provides a metacognitive strategy through feedback, and verbal memory skill support through a visual context reinforcing naming of unfamiliar objects. Young learners at this developmental stage are more concrete and visually oriented; visual modes can scaffold verbal memory for those who are just beginning as well as poor readers struggling with advancing (Shore "The Power" 20).

The result of this early exposure to digital media for museums is that these will be the students that come to museum education programs. It may not be feasible to develop mobile integrated programming for elementary level students, but their learning practices will make them highly skilled Digital Natives by junior high and high school. At these stages of development, the two groups are either on the verge of cognitive and critical-thinking learning or right in the middle of it. This is the point where leveraging the mobile in museum programming is most critical. Since the device is so integral to their existence, they will either be turned on or turned off to the educational experience according to that prism. It may be advantageous to go with the Digital Native's rhythm. The goal is to grab their attention through the device, and not force them to unlearn a decade or more of learning strategies and modes. Palfrey and Gasser categorically state that:

> "Just because Digital Natives don't learn things in the same way that their grandparents did does not mean that the way that they are learning is not as effective. There is no evidence to suggest that they are learning less than their grandparents did, or that they are more superficial in their learning. In fact, Digital Natives are quite sophisticated in the ways that they gather information. The people to be worried about are those who are growing up in a digital age but who are not learning these sophisticated information-gathering and information-processing skills, or creating things of their own based on what they learn and sharing it with others." (216).

Born Digital was written with formal education and the classroom of the future in mind. The authors caution: "Teachers and administrators need to get serious about figuring out how kids are learning, and they must build digital literacy skills into core curricula" (Palfrey & Gasser 229). This also translates for the informal educational environment that Digital Natives find themselves in at museums.

General support for mobile devices can be found in the Horizon Report 2010 Museum Edition published by The Marcus Institute for Digital Education in the Arts is part of the New Media Consortium (NMC) programming. The report was created by the Horizon Project's Museum Advisory Board, an international body of experts from the areas of museums, education, and technology. The report's focus was on emerging technologies, which it states will be significant for museums in terms of use and impact in the near future (Horizon 3). The report identifies six key trends and practices, of which four are particularly significant for museums and technology in the years 2011-2014 (Horizon 5):

- **Rich media** – high quality images, videos, and audio
- **Digitization and cataloguing** – visitors' expectation of access to high quality media
- **Wireless, mobile, and personal portable network access** – visitors expect real-time access in all places and at all times; frustrated when unable to do so in various places
- **Access to non-museum information resources** – instant connection to adjunct information by visitors; no longer satisfied as passive audience lead by curators or educators

The Advisory Board reviewed a substantial array of current articles, interviews, papers, and new research. They determined that the challenges are many, but the most significant for museums are (Horizon 5):

- **Too few museums are crafting comprehensive strategies for technology use**
- **Funding is done outside operational budgets** – Any museum not making a concerted effort towards "continual investment" in a technology future is risking its engagement with an ever increasingly "networked audience"
- **A lack of synergy between technology use and staffs** – "The notion that museums must…provide Internet and mobile services is too often seen as frivolous or unnecessary."
- **A lack of museum educator training** – Inadequate technology training at the university level, few choices for professional development, and the need to keep education staff current, "is creating a vacuum of skills just when they are needed most."

Among the many of technologies on the report's "to watch" list, are mobile devices. It states that: "Mobiles represent an untapped resource for reaching visitors and bridging the gap between the experiences that happen in museums and those out in the world"

(Horizon 6). The report goes into detail about various technologies, what they mean to museums, and adoption time frames. The predication is that mobiles and social media are earmarked for near term adoption, meaning one year or less, and that:

> "These trends and challenges are a reflection of the impact of technology in almost every aspect of our lives. They are indicative of the changing nature of the way we communicate, access information, connect with peers and colleagues, learn, and even socialize." (Horizon 8).

Ultimately, museums should be poised to take advantage of mobile technology and should do so as soon as possible.

3.2 The Viewpoint: Literature Concerning Mobiles and Museums

An interesting article appeared in the May/June 2010 issue of *MUSEUM* magazine titled "Get Smart(phones)". Writer and editor Laura Donnelly-Smith's title is a mock exhortation to museum professionals about catching up to the trend of mobiles in museums. Her article provides examples of mobile use from various institutions. This is in contrast to visitors upon entering the museum being ordered to "...silence and stow their cell phones" (33). According to Donnelly-Smith, museums are now targeting the 20-to-40-year-old demographic and this is quickly becoming the group that has integrated mobiles into their daily lives. Several museums including the Minneapolis Institute of Art (MIA), the Brooklyn Museum, the Dallas Museum of Art, The Indianapolis Museum of Art, and the Santa Barbara Museum of Natural History were highlighted in the article as innovators in mobile technology integration.

The first example, the Minneapolis Institute of Art (MIA), moved into a free iPhone app in the fall of 2009 aimed at examining African art in more "nontraditional ways." The MIA's app can be used on or off-site, and includes more extensive information on the collection and the ability to provide visitor feedback through online survey about the

African Art exhibit. Users can comment on the galleries and make suggestions for their reinstallation at later times. The application was an internally designed project through the museum's interactive media department and was done with Apple approval. One of its key features is a virtual lamellophone. The app version was designed after the Democratic Republic of Congo thumb piano, and it plays and sounds much like its real world counterpart (Donnelly-Smith 33 & 34).

The Brooklyn museum developed BklynMuse interactive tour experience. It too was developed in-house. The application is predicated on computer relational database concepts where simple information or selection is entered and related topics or adjunct information is made available without having to understand how the information is stored. Visitors can create a virtual, customized gallery tour by entering objects or artworks on display and related suggestions pop up. If a visitor flags a favorite, the application retains that for recommendation to others. Users can create their custom tour by motif as well; in this case, the software can supply objects and artwork that fit the criteria. If visitors wish to preload their tour, they can visit the website and select related objects into sets and then access or share them via their mobile (Donnelly-Smith 33).

Released in August of 2009, BklynMuse is in its second revision as of March of 2010 with a third being planned. The driver for modification comes from suggestions by visitors. One such user driven update allows object set-creation and comment while on site in the galleries. Visitors can interact with the collection database directly on their mobiles without having to go to the museum's website first. The Brooklyn Museum also went as far as putting its collection online and then releasing the Application Programming Interface (API) for BklynMuse, which is essentially the code programmers need to enhance or modify the application. The result was a freeware or shareware application for the iPhone allowing offsite users to virtually go through the collection; thus, extending the museum's reach to those who may not be able to attend in person (Donnelly-Smith 33-34).

If in-house application design is too complicated or expensive, then the Dallas Museum of Art's smARTphone tours might be something institutions could consider. It debuted in the summer of 2009. The mobile tour includes the standard information about any particular piece, but in addition, supplies adjunct material in order to deepen the visitor's understanding and experience. The intent for the museum was to move away from the standard audio tour and technology to provide a more flexible experience that wasn't a typical museum structured tour. According to Director Bonnie Pittman, "By adapting an everyday technology as a museum interpretive tool, we are expanding how our public can interact and learn more about the art in our galleries in an accessible and familiar way" (Donnelly-Smith 34). The tour application can provide such things as an audio clip of Wendy Reves discussing her passion for collecting; all while the visitor is in the gallery amongst the Reves art collection. The Dallas Museum of Art's handles technology accessibility in an interesting way. If visitors do not have access to a mobile device, they can barrow one from the museum for the duration of their stay. And like so many other institutions, website access is important as well. All the mobile tours are available online for the virtual visitor (Donnelly-Smith 34).

TAP is the name of the multimedia-guided tour at the Indianapolis Museum of Art. Built for the iPhone and iPod Touch, its goal is to enhance the "Sacred Spain" exhibit experience for visitors to the museum. Like other interactives, TAP provides supplemental information to objects in the form of video and audio files. Visitors can see and hear interviews with exhibit designers and curators to get a behind the scenes feel for what they may be viewing. Plans by the museum include additional tours of other exhibits in an effort to expand the technology reach for the institution (Donnelly-Smith 35).

Acknowledging that mobile technology may be more pervasive in art museums, Donnelly-Smith includes in her article the Santa Barbara Museum of Natural History. Like some of the others, this is a museum with in-house expertise and they developed a free application for the iPhone and iPod Touch to serve as a "digital field guide" for the "Butterflies Alive!" exhibit. This application includes an audio tour, but its interesting aspect and cool factor is its capability to provide magnified digital images of the butterflies actually flying around the visitor in exhibit (Donnelly-Smith 35). The impetus for mobile technology inclusion at Santa Barbara was succinctly stated by Easter Moorman, the museum's marketing and PR manager: "Anyone older than a kindergartener is a 'digital immigrant.' But the next generation are 'digital natives,' and for them, museums need to fit in the palm of the hand. The experience of visiting a museum should go beyond the walls" (Donnelly-Smith 35).

Ultimately, Donnelly-Smith acknowledges the difficulties with mobile technology integration, including cost and technical know-how, but in the end, she quotes Shelley Bernstein, Chief of Technology for the Brooklyn Museum: "The more information we can put in multiple formats, the better. People can choose how they use it. That's a complete win in my book" (35).

Creativity and Technology: Social Media, Mobiles and Museums is a newly published anthology. Released in 2011 through MuseumEtc, it includes contributions from a prestigious group of professionals, and as its title suggests, is focused on social media and mobiles. Each essay attempts to explain the possibilities of social media or mobile devices in a museum context. One such writing: "The iPhone and Its Use in Museums" is intended to examine "...whether museums should consider the iPhone as a threat, or as a tool with which to achieve their goals" (Valtysson et al 107). This particular essay is from a trio of collaborators from the IT University of Copenhagen. The team included Bjarki Valtysson, Assistant Professor in the Design-Culture-Mobility-Communication (DCMC) group, Nanna Holdgaard, Ph.D. candidate, and Rich Ling, Professor and sociologist. Although their work was not based in the United States, it does have general application for museum visitors and the relationship to mobile devices.

In the essays opening, Valtysson et al state the decision to narrow their study to iPhone users was predicated on museums' focus for application design on these particular devices ("The iPhone 106). One reason for the iPhone and its premiere status has been the lack of competition up to now. It is only recently that major manufacturers have added Google's Android software to a suite of smartphones that may give rise to alternative devices for museums to consider. In any case, Valtysson et al presented a view from the public Scandinavian museum in how the profession is attempting to accommodate the influx of mobile devices. The team wanted to "frame the discussion" within the "political climate in which Scandinavian public museums operate" ("The iPhone" 106). By correlating the political will behind public museums, the most available mobile applications, and the data traffic from iPhone users, the team believed they could determine whether museums should look upon mobiles as advantageous or not.

Since Scandinavian public museums must respond to government politics, they find themselves driven to include the public in defining and contributing to museum content. The idea was to turn the passive visitor experience into one that is more active and *inter*active. Scandinavian public museums determined that the Internet along with digital and mobile communication devices fit nicely into this strategy (Valtysson et al 107). Museum directors as managers have been incentivized to attract external sponsorship and increase visitorship and revenue. They must also be able to quantify the results. To meet these goals, attraction of the "trendy segment of the population" was considered the way to fulfill them. This meant going after the iPhone user considered to be the "creative class" ("The iPhone" 108). As a result, public museum policy theory determined that iPhone use could make it more attractive for museum visitorship, and that the users were also potential donors. This in turn would allow the museums to change their image as well as satisfy their goals ("The iPhone" 109). But Valtysson cautioned: "However, little attempt is made to explain and conceptualize what kind of use is preferable, why increased user involvement is positive, and in the museum context, what kind of use is considered appropriate" ("The iPhone" 108). If there was to be a full-scale attempt to include mobile device use for visitor input and interaction within public museums, then what were to be the parameters?

Valtysson *et al* seemed concerned that the public museum focus on iPhone use was more about the fetishism than its utility. As example, they referenced museums such as the Smithsonian, the Brooklyn Museum, the Van Gogh Museum, and the Louvre as touting their iPhone apps and attempting to be first. This was something that the team felt was more about connecting to the cachet of the Apple brand than being innovative. In studying the phenomenon, it was apparent that iPhone apps tended to be available from the mostly larger and more prestigious museums, and that the applications were merely augmenting what museums already did by disseminating curator based educational information. The implication is that no real determination of how to apply mobile devices was really attempted. The assumption by some large museums and Scandinavian public museum policy is that iPhone users bring with them a built-in aptitude that is advantageous for the museum ("The iPhone" 112-114).

Ultimately, Valtysson et al determined that there might be potential for iPhones and their counterparts; as example, content development is flexible. It could be tailored towards the individual or group and it could command some depth or remain succinct in nature. In addition to content handling, visitor feedback through direct comment, survey, or tracking visitor movement by using the GPS tracking function could be useful to museums as well ("The iPhone" 117 &120). But in the end, Valtysson *et al* cautioned that iPhone, or any mobile device integration, is a double-edged sword. Catering to political pressure for the "creative class" to provide user generated content requires that museums give up some control over the narrative of the cultural heritage they possess. Curator driven content is documentable and backed with expertise; general public commentary, the volume of which could be daunting, would require extra research effort and filtering. In the end, Valtysson *et al* determined that by sticking to dissemination and education, museums could utilize mobile devices to fulfill goals dictated by political trends, and yet remain the gatekeeper of empirically based narrative.

In 2006, the Liberty Science Center (LSC) received a National Science Foundation (NSF) grant for a project named *Science Now, Science Everywhere* (SNSE) (Katz et al 347). Pronounced like the Japanese word sensei, meaning master or teacher, the SNSE project was a collaborative effort between the LSC, Rutgers University Center for Mobile Communications Studies, and the Institute for Learning Innovation (ILI). The Rutgers team was the research partner and was to focus on teen use of mobiles generally as well as use in the SNSE project un the particular. The team performed onsite observations over time in order to get a sense of where and how mobiles fit into the exhibition experience. The ILI's objectives were to conduct formative and summative evaluations to augment the data gathered by the Rutgers team (Katz et al 349-350). The LSC had undergone extensive renovations and expansion beginning in 2005. It decided to incorporate the SNSE project designs into its facilities. The goal was to enhance visitor experiences via use of communications technology infrastructure. This opportunity became part of the grant supported study (Katz et al 349). The LSC reopened in July of 2007 with a number of exhibits melded into SNSE. The main exhibition showcase for the SNSE technology was *Eat and Be Eaten*, a predator/prey oriented experience that incorporated audio content to be accessed through mobile devices. Besides *Eat and Be Eaten*, two other exhibitions were enhanced with SNSE technology: *Communication*, a look at human language evolution, and *Breakthrough*, a temporary exhibition space focused on multimedia. After the initial installations and upon reopening, the LSC would include additional SNSE audio stops. There were thirty-six in total along with "one text-in bookmarking feature, two text-in exhibit interactives, one multimedia messaging service (MMS) exhibit interactive, and the camera phone challenge" (Katz et al 349).

With all this in place, the Rutgers team began the study of mobiles and informal learning within a science center.

Logically, one would think that a science center, particularly one recently renovated and redesigned to accommodate integrated technology, would be the logical place for mobile device use in the visitor experience. But study and evaluation of the project led to some unexpected findings.

James Katz was one of the principals in the Liberty Science Center (LSC) SNSE project, and was the lead author of the essay: "Mobile Phones for Informal Science Center Learning: A Socio-Technical Analysis" as well as one of the editors of the anthology. In assessing the impact of mobiles at the LSC during the study period, Katz asked the question, "Are SNSE users different?" He stated in the essay that previous studies of this nature had mainly focused "on art and historical institutions," and that, "much of the development of mobile phone functionality is currently directed for use within those institutions" ("Mobile" 353). He went on to hypothesize that "the SNSE project differs from traditional mobile free-choice learning in that it is situated in a science center, and thus the audience composition may be significantly different than in art and historical institutions" ("Mobile" 353). He believed that visitors to the LSC were there in a more "socially connected capacity.". This implies that, at the outset of the study, Katz was differentiating the science center audience from the other museum visitors. Katz went on to state that the data from the study showed this social propensity because "a majority of visitors" interviewed (72%) were there in groups comprised of adults and children (Mobile 354). In addition, he believed this hypothesis was reinforced by observations conducted during the museum's *community evenings* program, which were designed for disadvantaged school age children and their parents. The observations determined that the visitors were inclined towards extended stays of three hours or more (55%) with an additional group (31%) staying two to three hours. He also stated that the majority of the interviewed visitors (60%) were returnees, and, "while these data paint a picture if the LSC visitor, and highlight the socially embedded nature of the visit, it may well be that they vary from visitors to arts, history, or other cultural institutions" ("Mobile" 354). This is a key extrapolation since Katz himself immediately stated that, "Unfortunately, we do not have data that bear directly on this point" ("Mobile" 354). The significance of the hypothesis that science centers are somehow different than other institutions becomes a key factor later in the study's conclusion.

After the opening hypothesis, what followed was a detailed description of the study's analysis. According to Katz, the study's interviews showed there were little differences between SNSE users and non-users in such categories as demographics, group type, or time spent at the center. This also held true for crowding levels, age of users, education level, or previous visits (Katz 354-355). Two differences did seem to come to light during observation and subsequent interview: males were more likely to use SNSE than females, and SNSE users tended to visit the Liberty Science Center website more so than non-users. It was also observed that SNSE users were more social in their interactions than non-users. They seemed to take advantage of the audio tracks by sharing the mobile device amongst themselves, and they tended to be more conversational when involved with texting exhibit feedback or content suggestion. Other differentiators that came to light included some adult respondents stating that they thought it not appropriate to use mobiles in the science center unless it were an emergency (although many were also observed using the device as a coordinating tool to manage the group). Teachers were also observed telling visiting students to turn their phones off and put them away for later use. This indicated that the teachers tended to hold more traditional school-oriented views about mobiles and student activity, and indicated a possible a differential between formal and informal educational environments despite the explicit intent of the SNSE project. Signs directing users as to how to include their mobile device were posted in the lobby, but somehow they were interpreted as prohibiting the activity (Katz 356-357).

Logistical issue like the ability to hear the audio once it was accessed and SNSE technology breakdowns also became evident through the post-visit research study. What the LSC ultimately found was that the summative report showed that SNSE use was only 2% overall. A third of the non-users stated that they did not know that SNSE was available to them when asked about the technology experience. The report also broke down non-user response as follows (361-362):

- 44% said using their phone in the museum was appealing
- 17% were focused on childcare
- 15% did not want to incur call charges or fees
- 9% were not interested in participating in specific activities
- 9% were unclear about what the SNSE activity was
- 9% did not bring a cellphone with them
- 6% did not know how to use the handheld to participate

It appeared that encouragement to use SNSE through the available signage was not very effective. It is perhaps because the reason was that, as Katz *et al.* put it, the "user is not primed either to interact with exhibits using the mobile phone or to gain information in this manner" ("Mobile" 362).

In conclusion, the authors asked: "why bother?" (Katz 374). For Katz *et al*, the realization that the large and general integration of mobiles into visitor's lives did not translate for an informal learning environment such as the LSC. Their thought was that the social nature of mobiles as a communications system was conducive to the social nature of people in general, but not in a museum setting. Because they believed that the Liberty Science Center visitor was different than those for art and historical institutions, they felt that the mobile device got in the way of peculiar social aspects of informal learning in science centers. To accommodate their concern, the authors recommended design of interactive exhibit activity to be more socially oriented. They suggested one such direction could be "multi-person game-like offerings" as well as "capitalizing on the memory-making that individuals do through picture-taking" (Katz 373). The second major issue to address was the appropriate use of mobile devices. Although many visitors did not use it to interact with the exhibits, they *did* use it for personal reasons, and were told by guards to cease and desist (Katz 370). This only added to the confusion. The answer for them seemed to be that this environment may not be absolutely ready, and that mobiles are not the panacea that museum professionals seek. Yet, Katz *et al* also concluded that future technology and social evolution may lead to a path where they merge as a useful tool in museums and science centers such as theirs ("Mobile" 374-375).

In "Click History: Wherever, Whenever", Kathleen Hulser of the New-York Historical Society (N-YHS) and Steve Bull of Cutlass, Inc. had a much different experience than either the Scandinavian public museums or the Liberty Science Center. The authors presented a case for digitization of collections in order to allow access anytime and in anyplace and that museums of all types should open their collections to mobile access. They write: "Museums in general own a plethora of objects that no one ever sees, and could never conceivably be presented in real exhibitions" (Hulser & Bull

205). The authors also argue that the advent of handheld devices has changed the way museum visitors think about objects and exhibits. They talk about the possibility of mobile devices to provide context: "Museums ought to be more than pleased that their long-term agenda of restoring context to objects is happening in such an unanticipated fashion" (Hulser & Bull 207). And they also remind the reader that mobiles expand the outreach of the museum, as they refer to "encounters with the collections as something happening in unrestricted time and space" (Hulser & Bull 209). What the uncontained museum experience means, is that it may be incumbent upon institutions like N-YHS to fully digitize their collection, including objects that usually stay buried for scholarly or object preservation purposes. The authors see the impetus to follow through on this idea because the mobile and "its parent, the computer, have radically revisited assumptions about viewer attention" (Hulser & Bull 207). They point out that museum conventional wisdom has been that the young have a short attention span, but museums are not "absorbing the fact that the museum visit now includes experiences that are before, during, and after an actual bodily walk-through" (Hulser & Bull 207).

In presenting the case for more access through electronic media, the authors came up with some interesting observations and references. One of the contentions is that the mobile "public thinks in terms of vignettes rather than large scale exhibitions" (Hulser & Bull 207). This tendency may have developed because of Internet browsing behavior. In order to describe this natural phenomenon and its relationship to digitized and accessible collections, Hulser and Bull allude to cognitive theories that support short-form knowledge operation. While the traditional museum construct of exhibition is a long-form knowledge acquisition process, Hulser and Bull contend that, "the icon fluency of the web has garnered credibility for cognitive theories that view knowledge as an accretion of small bits" (211). This has created an environment that includes "before-and-after explorations, side paths, collaborations, virtual collecting, gaming, and urban exploring" (Hulser & Bull 211). Because of this, Hulser and Bull see the museum audience as innovators in showing how interaction with the collection can be new and unrestricting. As example, they cite a N-YHS teen tour based on the *Lincoln in New York* exhibition. This was developed by a group of high school summer interns. In addition, two young female teens created a "chanted history poem" based on "the consequences of the Kansas-Nebraska Act." These students were all under the age of seventeen (Hulser & Bull 211).

Hulser and Bull see that electronic media, and particularly the mobile, as encouraging collections interaction in a non-time constrained fashion and "in small or large doses" (212). Ultimately, they believe that mobile and social media technology will only widen user collaboration, and that future generations may drive the museum experience into unknown directions.

4.0 Closer Study of Mobiles and Museums

The previous section examined some key studies, all of them fairly recent, of the use of mobiles in a museum context. There has also been some recent professional conferences, surveys, and evaluations of mobile technology in museums. We will look at two such efforts; one is a survey performed as part of an international conference on mobile technology and museums, the other is a limited evaluation specifically performed for this thesis.

4.1 And the Survey Says...

The Museum & Mobile Online Conference II was held in the spring of 2011. This was the second conference in what is expected to be a series of conferences on mobile use in museums. The survey work for the conference was begun the year prior and reflects the latest attitudes and thoughts of a sample cross-section of museum professionals internationally. The2011 annual survey and conference were an outgrowth of the first one held by Learning Times in June of 2009 (Handheld Conference Online website). The latest survey and conference was co-produced by Loic Tallon and *LearningTimes*. Tallon has been integral in championing mobile device use in cultural institutions for the last few years. Responsible for project design and strategy, he is founder and principal in Pocket-Proof, a U.K. based consultancy that specializes in mobile solutions for cultural institutions globally. Tallon is also co-editor along with Kevin Walker of *Digital Technologies and the Museum Experience: Handheld Guides and other Media,* a publication utilized as reference for this essay (Pocket-Proof website).

The survey produced for the 2011 conference was made available to the general public as an embedded PowerPoint presentation via the conference website (http://www.museums-mobile.org) under the tab "Survey". The survey results were based on 738 international responses (the following discussion of survey detail is referenced to the conference survey webpage by slide number). In examination of the survey presentation, one is immediately struck with the opening slide (Museum & Mobile 2). It shows a tag cloud that provides a visual of the most important words used in the survey responses to the question: "What excites you most about mobile interpretation for museums?" This visual technique has become fairly common lately and can provide a sense of the more important general concepts of a question or survey. The word's physical size connotes the number of times it was found in the responses; the larger a word appears, the more it was used by the respondents. In the Museum & Mobile (M&M) survey, the important words are: **visitors**, **content**, **experience**, **museum**, and **new** in roughly that order with **visitors** by far the largest and most important. As in all surveys and questionnaires aimed at museum professionals, the visitor is central to their answers.

The survey's objectives were four fold (M&M slide 4):

1. Determine the objectives of an institution's use of mobiles for interpretation
2. Challenges, perceived and real, in delivering an interpretive tool
3. Determine important future functionality as deemed by the institutions
4. Aspects of mobile interpretation that require further knowledge sharing

Solicitation for participating was based on the previous year's survey respondent list, MCG and MCN listservs, both *LearningTimes* and MuseumMoble.info newsletters as well as Twitter and Museum 3.0 discussion boards (M&M slide 5). It was noted that the survey was not based on a standard random sample, and its results should be used for directionality only. According to the presentation, response was triple of what it had been in the previous survey (slide 5).

The analysis categorized the respondents based on a range of first-hand experience with mobile interpretive tools. There were three categories used for the institutions surveyed (M&M slide 8):

- Museums, yes have mobile
- Museums, no mobile, but plan to
- Museums, no mobile, and no plans to

In addition, there was a category for Vendor/Researcher: "vendor or researcher in a museum field related to mobile interpretation." These classifications remained throughout the presentation. For those institutions that already had experience with mobile interpretives, they numbered 222, or 30% of the respondent pool. No experience, but planning to, included 171 or 23%, and no experience and no plans were 267 or 36% of the total (M&M slide 8). Country of origin and the institution type included 80% from the U.S. (n=590), 5% from the U.K. (n=37), and 4% from Canada (n=31). The total number of countries responding was 27 (M&M 10). The institution breakdown by type was as follows: History Museums 35% (n=232); Art Galleries 23% (n=149); Monuments and Historic Sites 8% (n=56) (M&M slide 10). History Museums had by far the highest percentage reporting that they did not have mobile interpretive tools, *and* had no plans to pursue them (53%). Art Galleries (52%) seemed to be the most accepting of the technology based on their implementation rate (M&M slide 10). Further analysis of the survey report showed that 49% of the respondents belonged to institutions that had an annual attendance of less than 50,000 per year, and 10% had over one million. There was a correlation between annual visitorship and likelihood of current mobile interpretive use or plans to do so. Over 50% of sites that had 250,000 or more visitors per year used mobile interpretives, and only 20% of institutions having 50,000 or less availed themselves of the technology. Looking at the graphic on slide 14 of the presentation, two categories seemed to remain fairly constant respective to institution visitorship size: "Yes, have mobile" and "No mobile, but plan to". The detail shows size at six ranges of annual visitorship: Less than 5,000; 5,000-50,000; 50,001-250,000; 250,001-500,000; 500,001-1 million; More than 1 million. The top four visitorship ranges seemed to show a consistency in actual use of mobiles: approximately 49% on the low end to approximately 55% on the high, while planned use of mobiles ranged 20%-29%. The lower two categories: less than 5,000 and 5,000 to 50,000 visitors per annum showed a large disparity of use: approximately 4% for the former vs. approximately 22% fro the latter. Additionally, both visitorship categories had a very high percentage of having no plans to consider mobile interactives (M&M slide 14).

Slide nineteen compared the type of mobile interpretation tool between institutions that have already implemented versus those that are planning (M&M). Table 1 shows the five categories that have the widest disparity based on how the respondents answered.

Terms Having the Greatest Differences		
	Current Use vs.	**Planned Use**
Audio Tour	76%	48%
Interactive Experience	22%	47%
Social experience	39%	12%
Link with Social Network Sites	9%	33%
Smartphone Application	21%	40%

Table 4.1-1 - Term Differentiation

In examining the percentages of Table 4.1-1, it appears that "interactive experience," "link with social network sites," and "smartphone application" are interpretive tools that are easier to plan for than actually implementing. The survey did not elaborate on why this was so and it appeared that no follow-up question was used to determine the outcomes. "Audio tours" and mobiles as "social experience" appear to be categories more practical to implement than even the planning stage implies. Again, there was no follow-up as to why the data may imply this interpretation.

The next interesting survey question concerned the type of interpretive experience either implemented or planned to be implemented. By far the largest percentage answered "audio tour." Those already having a mobile audio tour were at almost 80% and planners were just under 50% (M&M slide 20). The next highest percentages were for "it was free" (≈61% installed; ≈54% planned), "visitors use their own hardware" (≈51% installed; ≈70% planned), "In-gallery Experience" (≈51% installed; ≈53% planned). The lowest percentages were for "temporary exhibit only," "links to social network sites," and "use museum's WiFi network" (M&M slide 20).

The survey also looked at the most important objectives for mobile interpretive tools. Again comparing current use and planned use, the top four objectives in Table 4.1-2 were (M&M slide 22):

Four Most Important Objectives		
	Current Use	**vs. Planned Use**
Provide Supplementary Info	**60%**	**58%**
Diversify Offerings to Visitors	**53%**	**56%**
Institution's Experimentation with Engagement	**49%**	**57%**
Create a More Interactive Experience	**47%**	**53%**

Table 4.1-2 – Comparison of Four Major Objectives

The disparity in objectives between the implementers and the planners is not that wide. The most important goal appears to be providing supplementary information to visitors for exhibits they may interact with. An interesting disparity appeared in two objectives not in the top four. Vendors/Researchers chose "Satisfying Visitor Demand" as "very important" by a two to one margin compared to institutions currently using or planning interpretives (37% vs. 17%) (M&M slide 24). In the second, both Vendors/Researchers and institutions planning mobile interpretives agreed on "Attracting New Visitors" (50%

and 45%) as "very important" compared to institutions that have already implemented mobile technology (28%) (M&M slide 24). Comparing objectives by institution type shows that "to create a more interactive experience" was by far more important to science & technology museums than to others. Monuments & historic sites emphasized, "to attract new visitors/visitor types", while art galleries were most interested in "to keep up with current trends" (M&M slide 27).

4.2 A Recent Limited Evaluation

In an attempt to make a direct connection directly between the museum profession's perspective on mobiles and educational programming, a limited evaluation was performed within the context of this thesis. The intent was to test a theory about the lack of focus on mobile devices and museum education programs for school age visitors. It is probable that more familiar technology such as computers and touch screens are being utilized more so than mobiles for museum education. The tactic then was to develop questioning that moved from general types of technology use towards mobiles, and from general application, possibly exhibit-based, towards museum educational programs in particular. The first half of the evaluation included a survey to try and quantify the pattern, and the second half was a qualitative process to probe for further detail in the museum professional's mind and to evoke the motivational aspects of their perspective.

4.2.1 The Methodology

The limited evaluation was a mixed method design beginning with a quantitative survey posted online through SurveyMonkey®. The follow-up was a qualitative questionnaire of open-ended questions that examined attitudes in a bit more depth. Both quantitative and qualitative processes were not based on standardized random sampling, and analysis is not based on statistical methods of standard deviation. The entire exercise was meant to be directional and to evaluate trends only. The respondents were chosen by utilizing the Museum-Ed.org listserv. By specifically targeting museum educational professionals, it significantly narrowed the field. An open invitation was sent on July 12, 2010 via Email requesting participation in the quantitative survey located at the SurveyMonkey® URL (http://www.surveymonkey.com/s/GPSQR2H). The self-administered survey was available to respondents from that date through August 30, with the last response posted August 22. A total of 74 responses were received. At the end of the survey was a request for volunteers to be contacted for the follow-up, qualitative questionnaire.

To construct the instruments used for the survey and the questionnaire, a matrix of guiding questions was developed (see **Appendix A**). The matrix was designed to delineate the structure and direction of the limited evaluation. The guiding questions contained in the matrix were used to identify which instrument type was to be used in attaining meaningful responses for both the quantitative and qualitative aspects of the evaluation. The matrix also helped the design of the survey and questionnaire by strategically asking about electronic-based technology (i.e.: computers, touch screens, etc.) and mobiles in the context of museum exhibition and education programming. The guiding questions in the first half of **Appendix A** were meant for the quantitative self-administered survey. From that came the actual survey instrument in **Appendix B**. The second half of the matrix in **Appendix A** was designed as the guide for the qualitative instrument. The intent was to elicit answers that were based on intrinsic issues such as motivation, perspective on barriers to technology use, and comfort factor with technology. In addition, the last two guiding questions were about inducing an opinion of future use of both more common electronic-based technology and of handheld technology.

The opening solicitation and questions were posted on SurveyMonkey® exactly as constructed in **Appendix B**. The survey questions were designed to be closed-ended except for question number five, which was a request for a brief description of any electronic-based technology used at the responding institution. Each respondent was asked to choose their answers to questions one through four based on their specific knowledge. Four response set points were provided to assist the participants in assessing their institution's level of technology integration: "Never"; "Rarely"; "Sometimes"; "Frequently". Question number six was a solicitation for volunteers to be contacted for the follow-on qualitative questionnaire. An assurance of anonymity was provided in an effort to create a comfort level and to elicit as many volunteers as possible.

The qualitative questionnaire instrument is found in **Appendix C**. The first two sets of questions have been divided into Use and Non-Use sections. The intent was to make it easier for the responder by allowing them to focus on the area that corresponded to them directly. The section labeled General was for all responders to participate in as these questions corresponded to direct experience, comfort level, and an opinion concerning future trend. Questions five and six were constructed to be answered in two parts, specifically directing thought about technology use towards exhibition and then educational programming.

4.2.2 The Quantitative Results

If we look at question number one: "**Does your institution include the use of any electronic based technology such as computers, displays, touch screens, or audio systems integrated into exhibitions?**" a total of 38.8% (n=25) responded "Frequently" while an additional 40.5% (n=30) responded "Sometimes". The combined result for some level of use for these types of systems for exhibitions was over 79% of respondents. Those that answered "Rarely" or "Never" were almost evenly split with 12.2% (n=9) and 13.5% (n=10) respectively. As we move to question two: "**Does your institution include the use of PDA/smart handheld technology integrated into exhibitions?**" a major shift occurred. Out of the total, 74.3% (n=55) responded "Never", 8.1% (n=6) answered "Rarely", and surprisingly, 14.9% (n=11) said "Sometimes"; only 2.7% (n=2) checked "Frequently". Clearly, mobiles are the exception rather than the rule in the responding institutions. Question three: "**Does your institution include the use of electronic based technology such as computers integrated into educational programs**?" resulted in 43.8% (n=32) saying "Rarely" and 21.9% (n=16) responding "Never". That's a combined 65.7% negative response. As for the remaining responses, 20.5% (n=15) fell into the "Sometimes" category and 13.7% (n=10) indicated "Frequently". The response pattern to this particular question may suggest some merit to integrating some form of technology into educational programs. But the key question is number four: "**Does your institution include the use of PDA/smart handheld technology integrated into educational programs?**" a majority 79.7% (n=59) responded "Never"; another 9.5% (n=7) said "Rarely". "Sometimes" was stated by 6.8% (n=5) and "Frequently" garnered 4.1% (n=3) responses. This showed that at the moment mobiles are rarely applied to museum educational programs.

Question number five was less quantitative and was devised to elicit a more descriptive response on what and how technology was being used in the responding institutions: "**If any electronic based technology is used in your institution, please**

provide a brief description of what it may be and its utilization." Interesting patterns in technology choices and applications emerged in the answers provided to this question. A total of 86.5% (N=64) responded out of the 74 that participated in the survey. A scan of the responses for key terms (Table 4.2.2-1) resulted in quite a spectrum.

Key Terms in Question 5 Responses	Number of Times Term Appears
Video	18
Touch Screens	16
Computers	13
Audio Guide/Tour	13
iPod	10
Kiosk	8
Social Media	3
Video Conferencing	3
iPhone	2
Website	2
iPad	1
WiFi	1

Table 4.2.2-1 – Technology Choice and Application

Following are some samples of responses to question five, which show how some of the technology is applied in the responding institutions:

> "F[l]at screen monitors in larger exhibitions with interpretive information (one or two times/year on average); computer cart of 20 laptops, 15 digital cameras used in workshops (mostly teens) where users draw, make collages, animation projects based on art in galleries; see AIC Web site on internet-based programs (Education > Online Resources)"

> "DialogTable in the entry area. This dynamic new interactive storytelling and social learning tool allows multiple users to explore topics and relationships suggested by works of art in our collection."

> “Rotating digital photo frames (along with photos, we save panel text as jpegs and load this too....flip automatically on an adjustable timer); & push-button sound effects.”

> “micro-sties for special exhibitions, website for school and family programs that integrates arts and core curriculum that can be used in the classroom, as a resource for educators, or by students in leisure time, kiosks in exhibitions that use computers to allow visitors to watch video or take a brief "quiz" or play a game, i-pods, cell-phone tours, and audio guides also utilized. currently writing a grant to get funding for the use of ipads piloted during homeschool workshop tours.”

When we examine the responses specific to mobiles such as, iPods, iPhones, and cell phones, the most common application is audio tour or guide. One response that included the iPhone had an interesting commentary on ease of use and demographics:

> “iPhone apps, Mobile apps and iPad touch screens. We have found it to be fast, easy to use and by far superior to old wands and other expensive out-dated technology. Surprisingly, our technology seems to be most popular with users over 55 years old - which breaks the stereotype of young people being the only ones who want technology.”

Only one response specifically alluded to education:

> “We have started to use iPods (video and audio) frequently into our exhibitions. Also, we have a program where high school students create video podcasts about their interpretations of artworks and big ideas in art. These podcasts are on iTunes and utilized during a tour with other high school and middle school studnets [sic].”

Overall, the original hypothesis appeared to be valid. Use of more familiar technology *was* higher than mobiles specifically, and application of mobile devices in educational programming was almost non-existent. Although we may not be able to extrapolate these findings to all museums, they do provide patterns that should provoke further interest in the relationship of mobile devices and museum education.

4.2.3 The Qualitative Questionnaire and its Analysis

Of the 74 total respondents, 32.4% (n=24) volunteered to assist in the qualitative portion of the limited evaluation. It was decided that the best methodology for gathering the input was to e-mail the questionnaire (Appendix C). Since the instrument format was Microsoft® Word®, the respondents could easily insert their answers into the document and return e-mail them upon completion. This would allow participants to perform the exercise on their own schedule. Of the 24 volunteers, 37.5% (n=9) actually took the time to fill out and return the questionnaire. The overall response rate was 12.2% when factoring against the total number of respondents to the quantitative survey.

Analysis of the questionnaire responses resulted in some very interesting insights. The overall trend was that a fair number of museum educators were comfortable with Information Technology and even mobile devices. They stated that most of the efforts at their respective institutions were targeted for exhibitions. The educators utilized what they could, and in some cases, were able to procure various electronic-based systems to enhance their programs. It did become apparent that, save for one museum, mobiles were not consciously part of the educational experience for visiting students.

As seen in **Appendix C**, the first two sections were intended to make it easier for respondents to answer by focusing on only that section pertained to them. The split was supposed to be between "Use" and "Non-use". Almost all respondents chose to answer both sections assuming the questionnaire was looking for issues concerning how their institutions dealt with using or not using electronic-based technology. This did not negate any intended fact finding, but did provide a richer tableau of what was happening at these institutions.

By far, the most common response to integration of electronic-based technology was audio for exhibits, whether tour-based or for information augmentation. The second most common answer was touch screen utilization. This was followed by PCs and videos with projection systems and PowerPoint presentations considered last. The latter was more integrated into educational programs as opposed to the exhibits. Some original applications of technology included one institution's use of digital photo frames with rotating images, and another using video conferencing for distance learning. When it came to mobile integration, only one museum used it in an education setting. Two museums were *planning* mobile device use, one for audio tours and one for podcast application. One museum utilized YouTube and the SCVNGR game app for mobiles directly integrated into their education programming. SCVNGR is a virtual scavenger hunt gaming product developed for iPhone and Android devices. Users can download it at www.scvngr.com. Other than this specific museum, none of the others targeted mobiles as educational tools.

When responding to questions three and four (**Appendix** C) about driving factors for technology use, the common responses ranged from: "be more contemporary" and "use a medium more familiar to school age generation," to "revenue generation," "enrichment," "savings," and "engaging". One responding institution was an innovative art-based museum that made extensive use of technology. It was a contemporary art museum where the young artists tended to integrate electronic technology into the art pieces themselves. The museum in turn saw this as its driving factor for technology use in its exhibitions. Use of various forms of technology was in keeping with the experience, which then translated into technology integration into the art museum's educational programs. Their response to technology use in education programming was: "For educational programming, technology is driven by the project. We try not to use technology just to use technology, but only if it's the best way to help our audience engage with a particular idea or exhibition." This particular museum saw use of technology as an organic process to be seamlessly integrated.

Responses to questions about barriers to technology use, elicited a very discernable pattern. By far the most common answer was cost and staffing, sometimes collectively referred to as resources.. This was followed by experience and knowledge, although one respondent seemed to include management as well by saying: "Cost & lack of senior staff and board understanding." Another institution stated that they were, "a public museum directed by the city: all computer access governed by city policy – much of the Inet access is heavily filtered." The implication here is that sometimes the lack of technology integration is not so much a staff issue as one of management. A corollary to that is another response that cited a "lack of understanding in Ed Dept and no willingness to push boundaries," clearly showing frustration at the responder's own department. In addition, the word "support," or lack thereof, was used regularly in many of the responses, but it was not clear whether the context was monetary, technical, or more closely related lack of commitment. In general, lack of support could be interpreted to mean a lack of vision on the part of stakeholders and decision makers, but without explicit statements from the responders it is just conjecture.

The first four questions in the General section addressed experience with both common electronic-based technology and mobiles. They were also about the responder's comfort level with designing programs for these technologies. Most of the answers were oriented around personal experience in their everyday lives. Any professional experience was not predicated on formal training; instead, on-the-job-training seemed to be the only way to gain any professional application of technology. A few respondents stated they attended seminars and conferences on the subject, and one mentioned following the Museum Computer Listserv. Familiarity ranged from the obvious such as PCs, to the next most common, PowerPoint, and then video and audio files. One response included experience with distance learning technology, another with an iPhone app, and still another with an mp3 audio file. Most did not feel qualified to design programs with a technology component, although they would be willing to do so with outside assistance, citing consultants as a support mechanism. One respondent stated that a touch screen application was successful because of a summer student's technical capabilities. Two responses alluded to the institution's attitude when it came to technology integration when designing programming. One of them stated that they were not comfortable at their present location, but maybe elsewhere, and the other stated that it "depends on the institution."

Questions five: "**As a museum professional, what is your view of the future for electronic based technology (i.e. computing, audio, display, etc.) as it relates to the museum experience?**" and six: "**As a museum professional, what is your view of the future for smart handheld technology as it relates to the museum experience?**" left room for future promise. These queries were designed to elicit a personal reflection, and to determine an implication of future trend and possibilities in museum technology application. Although there may be a general lack of professional experience, not one respondent stated that we should avoid technology use in museum exhibition, and only one stated that mobiles had no place in educational programming. There appeared to be general support conceptually, and a sense that technology use is the future for museums. One respondent stated that they saw more podcasts for educational use, and another summed it this way: "need for Museum Ed professionals to be trained which will lead to more integration." The majority agreed with this response: "My belief and hope is that museums are moving towards a more participatory experience, and that technology is a means for this to happen." Question six focused specifically on mobiles. The response trend was that mobiles had a "strong future" and were good if used to "supplement information." A few responses alluded to visitors as "techno-savvy," implying they would put pressure and demand on museums for integration. When it came to educational programming, the trend was much like this response: "If the audience is school age information could be presented that way." This was the first indication of an acknowledgement to demographic issues concerning mobile use.

Although there was general consensus as to the positive future of technology and mobile devices particularly, there were some cautionary statements:

> "I think the smart handheld technology as a place in museums if museums, again, can stay current with the quickly changing technology. I find it difficult to answer these questions from an exhibition view point because as an educator the programs I develop interpret the exhibits and often are in the exhibits. It's hard to separate the two." (Public Museum)
>
> "Lots of possibilities, but it's a maze of possibilities and sometimes I think we get lost in the maze." (Community Museum –local history)
>
> "I think we'll see more museums using smartphones, but I think it's important that this technology become only one of many ways to access art in museums. It's vital that we still maintain docents, hands-on interactives, artist talks, panels and lectures, film screenings, partnerships with other institutions, etc. so that we have a well-rounded menu of programming for all kinds of learners." (Contemporary Art Museum)

One respondent summed it up this way: "[There is] need for Museum Ed professionals to be trained which will lead to more integration."

4.2.4 Interpretation

What the limited evaluation did not do was purposefully survey the institutions by type, size, or region. So in that sense, it was not a detailed and extensive exercise. The limited evaluation was also not meant to be a hard statistical analysis of the museum professional's attitude towards mobile technology on a national scale. The evaluation *was* meant to look at indicators and current trends from the viewpoint of museum educators.

In general the responses did not show an unwillingness to utilize some form of electronic-based technology. In some cases, the applications were quite interesting and innovative. What does seem evident though is that the original hypothesis was proven to be true. Although there may have been a scattering of unique and educational applications of mobile devices, they were still not prevalent in most institutions and were not integrated into educational programming as a matter of course. Mobiles, if integrated at all, were most often applied to exhibits and the general visitor experience.

5.0 Programming and Technology Use

In this section we will explore the possibility of a museum education program that utilizes a technology overlay. The intent is to show that educational programming is about knowledge acquisition focused on exhibits, objects, or artifacts, and technology is the tool that can assist in achieving that goal. What follows is a museum program aimed at middle school students, specifically grades 7/8, which also takes advantage of mobile technology along with its accompanying infrastructure. The program is based on an exhibit that was held at the New York State Museum at Albany, N.Y. and integrates learning standards for New York State students.

The New York State Museum is part of a triad of institutions that include the New York State Archives and the New York State Library. All three institutions fall under the aegis of the Office of Cultural Education (OCE), which is part the New York State Department of Education (Office of Cultural Education website). Both the archives and the museum have collections related to New Netherland, the original name for what later became the Colony of New York under British rule. The Museum designed and managed the exhibit utilizing its own artifacts and those borrowed from the Archive's collection as well as a few lent by outside sources. The fact that the state Museum, Archive, and Library are interconnected organizationally provides a distinct advantage to accessing adjunct material for students involved with a museum centric educational program.

The program designed around the exhibit is specific to this thesis and was never actually implemented. It is to be solely used as an example of what may be possible in terms of museum education and the application of mobile technology. What follows is a description of the exhibit, the education program built around it, and in a separate section, the design of an actual infrastructure that could accommodate the use of mobile technology integrated into the activity.

5.1 The Exhibit

The *1609* exhibition ran from Friday July 3, 2009 through March 7, 2010 World at the New York State Museum in Albany, N.Y.as part of the Quadricentennial of Henry Hudson's voyage to the New (*"1609"* webpage). Its main theme was the clash of cultures and its legacy. The tag line on the exhibition banner at its entryway and on its website read: "Two worlds collided in 1609 as Henry Hudson sailed up the 'great river' and met the Native People of New York." The exhibition had its own dedicated space, and upon entering, one could sense that it emulated a Montessori classroom. Although the room itself was rectangular, the use of floating divider walls and stepped platforms provided a sense of curvature and contour, and included interactive stations at varying levels for the visitor to engage in. Cutting a diagonal across the center of the entire space in the carpeted floor, and moving from front right-hand corner to back left, was an outline (actual size and shape) of the Halve Maen, or Half Moon, Henry Hudson's vessel that made the voyage west from the Netherlands. This allowed visitors to step into the outline and get the significance of the smallness of a vessel that had to cross 3,000 miles of open water. In the center of the space was a display of a dugout canoe, which was to represent the state of Native American transport technology in contrast to the European. Some displays were designed as stations with which the visitor could interact. Objects, pictures, graphics, and copies of primary source documents were either along the wall space, or hanging from the ceiling. The general layout was very much like an open classroom with age appropriate displays ranging from elementary school level to adult. Varying light levels and effects lent a theatrical quality to the exhibition. In addition to the main exhibition area, and off to the left, was a small square gallery that housed some primary source documents from the Dutch colonial era arranged in display cases and along the wall space. The space made use of low-level lighting that reminded one of an art gallery.

One of the main goals of the exhibit was to refocus the traditional emphasis in the colonial history of the Northeast United States. The exhibit had two key elements: to dispel commonly held myths about the Dutch colonial experience, and help deemphasize the dominant story of the colonial English in the Northeast territory. The English experience became the significant historical narrative partly because many of the surviving Dutch documents were written in 17th century Dutch language that was difficult to translate. Due to the work of the New Netherland Project (NNP), and its director, Charles Gehring, that has changed. He is the leading expert in the Old Dutch language and was able to translate most of the 12,000 documents housed in the New York State Archives over the last thirty years (NNP website). Armed with a new understanding, the exhibition was able to provide a much more nuanced story of European first contact with Native Americans, and how the two cultures coexisted in the late 17th century. The focus of the exhibition was predicated on Native American culture and its encounter with the Dutch. It was also narrowed to early contact and the Algonkian language-family tribes that were ensconced in the territory stretching from Manhattan, up the Hudson River, and to what is now Albany, N.Y. Particular attention was paid to the most significant of the Algonkian speaking peoples, the Mohicans of eastern New York State.

The exhibit can still be viewed on the website of the New York State Museum at: http://www.nysm.nysed.gov/exhibits/special/2010/1609.cfm. By clicking the link at the bottom of the webpage, the viewer is taken through to another webpage with detail about the exhibition. A key feature of the virtual floor plan allows the viewer to click on the blue target buttons. It opens a digitized panoramic picture of the exhibit space, and each subsequent click rotates the gallery in a 360° POV manner. The webpage also has a quiz section and a video archive related to the history that is featured in the exhibition.

5.2 The Program: How to Make it Museum *and* Educational

The following is a hypothetical educational program designed for the actual exhibit that was installed at the New York State Museum between the dates described above. There were no specific programs developed by the education staff at the museum during its run, and the State Archive and Library digital databases were not interconnected with the museum via an Information Technology infrastructure as assumed here. What follows is an example of programming that can work in a setting such as the one detailed above with or without any technology integration. The point being, that good educational programming must be developed first, before one can take advantage of any and all technology overlay.

The New York State Museum Presents The History Detectives: A Program for Middle School Students

The Clash of Two Cultures

Key Understanding:
The impact of first contact between Native Americans and the Dutch exploration had a large influence in the development of New York State and American history.

Program Goals:
The program focuses on the significance of first contact between the Dutch traders and settlers of colonial New York State, and the Native American peoples who had inhabited the land for thousands of years prior. Its intent is to create an understanding of the cultural encounters and clashes that became an integral part of New York State and American history. Developing an understanding of the impact of cultural conflict and how it shaped subsequent events is key to developing young students' perception of the world around them. In addition, the activities in this program are aimed at both Social Studies and Language Arts education standards and objectives for New York State middle school (grades 7/8) students. The intent is to encourage critical thinking and writing skills in order to express acquired ideas.

Program Objectives:
The goal for this program is to underscore the required classroom objectives in Social Studies that deal with New York State and American history. Students in the

middle-years (7/8) in the New York State educational system begin to explore larger concepts and ways to express them. By utilizing a large exhibit, the ambition is not only to support subject-matter knowledge-based learning, but also to encourage an open minded approach to history and the ability to express that knowledge in a group setting. Our hope is to take advantage of the social nature of this age group and foster individual effort contributing to a teamwork approach.

Educational Rationale:

This program design target is the age group that spans the middle school years (grades 7/8) as defined by New York State standards. Certain characteristics of this age group are evident in their behavior and knowledge processing capabilities. The tendency is to define oneself by the social connectivity to peers and contrast that identity to others in school, at home, and in the wider social context of everyday living. Developmentally, this age group makes concrete connections to knowledge but they are also just developing the ability to deal with abstract concepts and thinking. The time to couple these aspects of their developmental stage with rational processes is critical at this point in middle-schoolers' lives. Transition into adulthood requires the ability not only to acquire knowledge, but also to analyze and synthesize intricate concepts and transfer that new understanding towards even deeper, more significant experience.

The learning experience is aimed at leveraging the child-like desire for fun and group-based activity with the more adult oriented critical thinking processes that will eventually be needed by students as they continue their development and education. The program is based on sociocultural contextual learning theory that takes into account the natural developmental process that the middle school age group is transitioning through. The focus is to utilize interpersonal, linguistic, logical, and spatial intelligences to assist the students in skill-set acquisition and critical thinking application. In addition, museum professionals along with the classroom teacher will assist in the activities as guides towards the intended objectives.

The Program:

This is a 90-minute program designed to foster critical learning through utilization of multiple resources. The student activity will involve the current New York State Museum exhibit, *1609*. It is part of the larger celebration of the 400th anniversary of the Dutch East India Company expedition that culminated in the the sailing of Henry Hudson into New York Harbor and river that bears his name today. The objective is to connect the use of the exhibit activity to the classroom curriculum for the middle school-based age group. A pre-visit packet will assist the classroom teacher in preparing the students for the trip and activity once at the museum. As an option, a museum education staff member can come to the classroom, on an availability basis, to assist in the preparation. The underlying idea of the activity is that the class (up to 30) act as a detective division investigating the "incident" of Henry Hudson's sailing into present day New York Harbor. The premise is based on the PBS show "The History Detectives", in which a team of professionals receive ideas for investigation of the historical background of specific objects owned by viewers. In this case, the intent is to use the entire class as a detective division much like a real police force. Prior to the visit their teacher will arrange the division into detective squads. Each squad is tasked with "investigating" aspects of the adventure with an eye towards gathering information about both the Native Americans and the Dutch, the chain of events, artifacts, and eventually the result of the contact between the cultures. This will be accomplished through use of the exhibit as well as mobile access to the associated New York State Archives and Library in a search for adjunct material. The student detective investigators will be able to use their mobile's web browser application to connect to webpages on the combined Museum and Archive internal information network in order to locate additional text, image, and video-based information.

Once the "evidence" is gathered, the squads formulate an interpretation of the events and each will provide a report to the Detective Division Commander (the teacher). This is accomplished back in the classroom, where the entire "division" (class), through their "squads", discuss what they saw, did, and subsequently understand about the Native-American and Dutch colonial experience.

Classroom Instructional Material as Part of Pre-visit Packet

"Pre-visit

In the classroom, the teacher, with or without museum education staff assistance, will prepare the class with an overview of the exhibit. The pre-visit packets will have the teacher information, instructions to be read to the detective squads, exhibit layout map, and a number of detective note sheets with the detective "head" on it. Also ensure that students have their mobile devices with data access. It is not required that each student have one. Devices can be shared amongst the squad members, and the museum has devices to lend that are pre-set for use with the exhibit and program. The class, acting as the Major Case Detective Division, will be broken into multiple detective squads. Each squad will be assigned a particular aspect of the investigation (see detective worksheet below). The exhibit is divided into seven areas of understanding to investigate. Squads can choose their areas of understanding to investigate or be assigned one by the commander (teacher) prior to the museum visit.

On-site at the Museum

1. **Orientation** - Gather in the lobby of the museum building for quick orientation and passing out of exhibit maps; reconfirm detective "squad" composition; ensure everyone has something to write with; access to mobiless and an Investigator's Information Head (see attached). (15 minutes)
2. **Detective Work** – Students will be lead to the exhibit area and detective squads will be positioned in their respective sections. Squads will examine displays for information based on the categories of investigation (see worksheets) and the questions to consider for their categories. Each detective working in partnership, and with the squad as a whole, should organize the investigative work and discuss their findings. Detectives will utilize the "head" to write, draw pictures, or utilize personal symbols of what information is pertinent to the "case." Any mode of note taking is acceptable as long as each detective can interpret his or her findings at the time of the investigative report. Access to the online Archive and Library is available at the exhibit via mobile devices and their web browsers; detectives are required to use this at least once in locating supporting information. Continued access via the Internet is available for follow-up investigation verification back at the "detective squad room" (school/classroom). (75 minutes)
3. **Squad Room Work** (classroom) – Each squad will compile their information and discuss their findings and prepare as a group an investigative report. The squads will have Internet access back at the "Major Case Squad Room" (classroom) to the exhibit webpage and archive for follow-up investigation verification as deemed necessary by the commander (teacher). Squads will then present their

findings to the division (class) as a whole for consideration, and the commander (teacher) will then assist in determining the complete picture of events, causes and effects, and final interpretation of the "major case" surrounding the clash of cultures. Time allotted and integrated reference to classroom lessons are at the discretion of the teacher."

Program Interpretation

The program outlined above is based on age appropriate learning theory and state educational standards. The intent is to have students utilize various aspects of the exhibit and search for further corroborating information located in the vast digitized database of the state Archive and Library. By connecting the concrete information that comes from interaction with objects and artifacts to classroom learning, strengthens the ability to cognitively interpret information. Archived material, though digitized, has a powerful and supporting role. Learning to search for disparate pieces of information in many possible forms and associating them will reinforce the nature of cognitive thinking for this age group. All the exhibition elements along with adjunct material from the Archive could have been used by students with mobiles had the museum management and designers chose to do so while the exhibition was still on display.

The tools alluded to above, the "Investigator Head" and the guiding questions delineated into seven areas of investigation are to be found in **Appendices E** and **F** respectively. The instructions read by the teacher to the class in the guise of the Detective Division Commander are in **Appendix D**. All of these make up the pre-visit packet. Both the general questions in the Commander's instructions and the Detective Worksheet are open-ended requiring cognitive processes and critical thinking to understand, and the note taking procedure allows for the students' differing approaches to information recording and the process of synthesis. Symbolizing can be a personal process, so the flexibility to use pictures, text, or any other means takes the pressure of rigid conformity off the student as an intermediate step of communication. Yet, ultimately the student must be able to translate their symbolizing of acquired information for others. So a bridge to standard communication must be made. As a final step to their reporting, the students must cooperate as a group in their respective "squads" in developing a report utilizing standard writing skills they have learned in the classroom. They will also have to collectively verbalize their findings and understanding in group discussions with the class as a whole. This informal, museum-based educational program makes the connection to standards-based formal educational goals within the classroom and helps teachers teach the processes of critical thinking via resources not available to schools.

The mobile access is means to acquire a wider array of information than even what is provided by the exhibit. Digitized format of archived information provides some level of flexibility in the choices of information. Text, still image, or video can accommodate different learning styles of a fairly large and diverse group such as a middle school class. Choice of information and what form that takes will eventually feed into the interpretive phase, which is back at the classroom, and those choices may determine the outcome of the understanding. The final activity of reporting findings is based on interpretation of gathered facts, whereby the choice of facts can be interpretive as well. The program is a collaborative effort yet allowing for individual endeavor and contribution. It accommodates different intelligences and learning styles. Ultimately, all the students involved should come away with both a macro and micro understanding of the events during the Dutch Colonial period. And the key is that they were allowed to utilize the technology with which they mediate their ordinary lives with as opposed to being told to ignore the one thing that has their attention most of the time.

The design of the program combines both high-tech and low-tech elements. Students are asked to look, listen, and read, in order to then record on paper with pencil (the detective head) what they've observed. The mobile device does not change that fact, but only enhances access to information not readily available in the exhibition.

By melding mobile devices and the exhibits, the learning environment is normalized and can even be perceived as fun. It can also teach children that mobile devices are tools that are effective in learning and can be used for learning purposes even if they are not in the classroom or museum setting. Additionally, it imparts a message of appropriate use by making mobiles acceptable in traditionally unacceptable venues. But certain constraints must still be imposed that are appropriate to the situation. The teacher and museum education staff will have to monitor mobile use by checking students' work like any other classroom activity. Short IM breaks can be interspersed with the assigned activity to alleviate the pressure for students' attention to wander. The mobile device must be viewed as a two-way portal. Information access and communication is an outbound process, but the teacher can pull the students' attention through the device indirectly by allowing but defining how mobiles are properly used in a given setting. In this case, a student is not necessarily thinking of texting their friend about whatever is in the forefront of their mind. The teacher is now mediating the students' focus towards what is important. In this situation, they are gaining educational satisfaction by using a device not normally allowed in an educational context. The bottom line is that the teacher has student concentration on the immediate activity without having to modify behavior through punishment. This is not to say everything is perfect. It will take classroom management effort on behalf of the adults. The assumption cannot be that the students should be left to their own devices now that they are in a happy state. Education should be fun, but the "field trip" trap is not uncommon in museum outings irrespective of mobile devices. Teachers cannot just dump their class on the museum staff and assume they do not need to participate. At the very least, supervision and guidance will always be appropriate in any educational setting, and one that includes familiar technology is no exception.

5.3 The Technology: Build it and They Will Come

The museum educational program outlined above includes access to digitized collections in an archive and a library. The infrastructure required can be designed with off-the-shelf, standards-based equipment. An example of a configuration that would satisfy the kind of mobile device connectivity to stored information can be based on what is known as an intranet. An intranet is a scaled down version of the Internet. The Internet is a global network that is generally classified as a **Wide Area Network** or **WAN**. A complete definition of the technical terms used here and written in bold font can be found in the glossary included with the addendum. A Wide Area Network is not what is needed to accommodate an in-house application such as mobile device access for a museum. In fact, it is safer for a museum to have a separate Internet webpage access not linked to any in-house system that stores a digitized database for internal access. The network that would accommodate this internal access application would be classified as an intranet because of its strictly internal nature. In fact, it is a much better strategy to separate both Internet and intranet connectivity for security and control reasons. The concept that is being proposed would be standalone and dedicated.

An intranet is built on a network configuration known as a **L**ocal **A**rea **N**etwork or **LAN** (also see glossary). A **LAN** is just what it implies; they are local to the site where they are installed. **LAN**'s are obviously smaller than **WAN**s, the networking systems are slightly different and less expensive, and they serve an end purpose like access to a database. In fact, typically a **LAN** allows access to a **server** (see glossary) for PCs and mobiles. A **server** usually is a fairly powerful computer (it could possibly take the form of a regular PC) that is dedicated to some service that users need connection to. The server takes its name from its function; in this case the intranet dedicated to database access would have a database **server** in it. These are the basic concepts for creating access to digitized information, whether it is text, image, or video files. The size and cost of this intranet is dependent on specific technical requirements.

Provided next is a hypothetical design based on certain assumptions for the hypothetical program discussed in the previous section. To accurately ascertain what is needed in any real situation for a given institution, professionals usually perform a site survey. For larger institutions, that expertise may be in-house; for medium to smaller museums, it is part of the proposal process. Below are some basic assumptions that could represent a real exhibition space like the one for the *1609* exhibit at the New York State Museum at Albany.

Design Assumptions

- Wireless network for a museum open exhibit space; maximum dimensions: 100x50
- Movable or floating partitions with some floor-based display cases

- Building ceiling height 20' with possible tiled, drop ceiling at 10'
- Users to access database for streamed viewing with added download capability
- File formats include text, image (jpeg), video (mpeg)
- Support of multiple classes of service for differing traffic (types based on data format)
- Support of 200+ simultaneous users

Proposed Solution

Ruckus ZoneDirector 1160 Wireless LAN Controller

- Network management device: Ethernet, Fast Ethernet, Gigabit Ethernet
- Tiered WiFi service, auto-tuned, centralized management
- Ruckus Smart/OS (installed) provides: smart wireless meshing, guest networking, hotspot authentication, dynamic WiFi security
- Wizard-based configuration (minimal expertise needed)

Ruckus 7353 Wireless Access Point

- Dual radio/Dual channel 802.11n (2.4GHz/5GHz)
- Extended range and throughput capabilities
- Access for 100 users/radio; 200 users/unit (simultaneous)
- Network meshing capability

Dell Poweredge T110 Tower II Server

- 2.4GHz Intel® Xeon® Processor
- 4GB memory
- 500GB hard drive (expandable to 4TB)
- Fast Gigabit Ethernet network connection
- Microsoft® Windows® Server Operating System

Netgear ProSafe 8-port 10/100/1000 Gigabit Switch

- 4x4 port configuration – 4 port PoE

The significant features of the above proposal are the speeds at which the data can be handled. This is a Gigabit (1 Billion **bits** per second) system, which is extremely fast. It takes eight digital **bits** (a **byte**) to represent a single character such as is printed on this page. The network as configured will handle a billion bits on one second. This should provide enough speed to handle many simultaneous connections of streaming or downloading information. Streaming is just what its name implies, information bits that are transferred as long as there is a connection and only end when the connection has ceased. Downloading is a process by which the information is transferred from server to mobile in order to be stored for later playback. This process is finite, in that the transfer ends when all the data is completely copied to the target device. The Ruckus ZoneDirector is the equipment that manages these download and streaming processes. It will also manage the Access Points, which are what the mobiles communicate with directly. Three are recommended for the space and user criteria stated above. Wireless communications is based on the Wide Fidelity (WiFi) standard. Wifi uses Radio Frequency (RF) technology much like broadcast radio, television, or even walkie-talkies. The wireless systems, including the mobile device, must have a radio transceiver in it in order for two-way communications to occur. The RF signal produces a pattern out the antenna, which determines the area the wireless signal covers and how strong it is in any particular point within the space. Therefore, to provide smooth and continuous coverage of a 100'x50' space, and to ensure the signal makes it around any obstructions in the room such as the floating partitions, three of the Ruckus 7353 Access Points are recommended. The Access Points can handle 200 simultaneous users per unit for a total of 600 for the complete configuration, and they will automatically tune and synchronize the internal WiFi radios to create a meshing architecture. This would allow a larger institution to have many school age groups working at one time.

The Netgear Gigabit Switch is the data traffic cop and supports PoE, which is important. PoE stands for Power over Ethernet; **Ethernet** being the data communications protocol (see glossary). This provides electrical power over the actual Ethernet data path to the Access Points that have to be mounted up high in strategic locations about the space. PoE alleviates the need for separate power outlets that would add cost and require the devices to remain fixed in their positions near electrical outlets. This option allows for WiFi reconfiguration as needed, depending on the exhibition design and space architecture. The Access Points could be moved if required without concern for electric outlet placement.

Last but not least, the Dell PowerEdge T110 II Server is a powerful computer where all the information resides and where everyone wants to get to. It is configured with 500 Gigabytes of storage to start and can expand up to 4 Terabytes (trillion bytes), an extreme capacity that could house the entire museum collection database if needed.

The final network configuration would look like Figure 5.3-1 with the pricing outlined in Table 5.3-1. The grand total is $4,254.00 before shipping. There would be additional labor and cost if in-house expertise were not available. The installation should take no more than one workday. This proposal would satisfy an exhibition for most upper-end medium or large institutions and this would not be an inordinate expense.

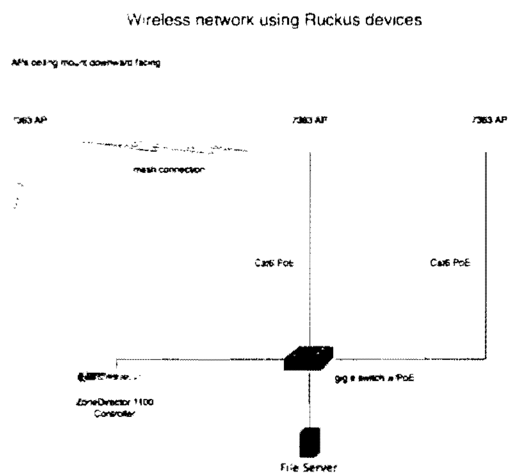


Figure 5.3-1 Wireless Network Access

Some savings could be realized if one of the 7353 Access Points were pared from the configuration. The application could still accommodate almost 400 simultaneous users and still provide dynamic coverage to alleviate dead spots. Two Access Point devices would act as backup for each other in case of an outage. The price would then drop to $3,654.00.

Ruckus Zoneflex 7363	3	Wireless Access Point	$600.00	$1800.00
Ruckus ZoneDirector 1100 Controller	1	Smart wireless LAN controller	$1024.00	$1024.00
Netgear ProSafe 8-port 10/100/1000 Gigabit Switch	1	10/100/1000 Gigabit Switch with 4-port PoE	$130.00	$130.00
DELL PowerEdge T110 Xeon X3430	1	2.4GHz 4GB 2X2GB 500GB SATA Windows server 2008, gig-e interface	$1300.00	$1300.00

Table 5.3-1 Equipment Requirements and Cost

Small museums could implement a wireless network with database access utilizing the following equipment as example:

<u>Dell Inspiron 580s</u>

- Intel® Pentium® G6960 processor (3MB Cache, 2.93GHz)
- 4GB of memory
- 500GB hard drive
- 10/100/10000 Ethernet network connection

The cost of the above system would be $550.00 and it has the same amount of memory, hard drive capacity, and network speed as the starting configuration of the PowerEdge server. The major difference would be that the latter has a much more powerful processor and can scale up to extreme levels. The only item that would need to be added to the Inspiron PC is the server software, which can be obtained for no cost. For this configuration the suggestion would be to not use Microsoft® Server, but another **Operating Systems** (OS) (see glossary) known as Linux. Many contend it is more stable and operates better than Microsoft® OS products. In fact, much of the Internet actually runs on Linux. The software can be obtained free of charge at the Ubuntu website (http://www.ubuntu.com/). Linux is known as open source software that is free to the public domain. Open source software is non-proprietary and specific to one manufacturer and can be updated by any qualified software engineer to share globally. Many groups and institutions support it and keep it up to date. This would remove the necessity to purchase Windows® Server software and save a few hundred dollars. The final piece required for this low-end solution is something to manage the WiFi connections. A simple router such as the Linksys E2500 that retails for $100.00 would suffice. It could accommodate 20 to 30 simultaneous users in a range of 30 to 50 feet comfortably. The overall system pricing would be about $650.00 for the equipment. Modifying the PC configuration and utilizing a lesser model for the router could attain cost savings. But careful consideration for the amount of users accessing the database and the acceptable delay in data transfer speed should be noted.

In either of the scenarios above, the technology used for the infrastructure of a wireless network for database access was configured with off-the-shelf systems. Items can be purchased directly from the manufacturers' websites, or through retail distribution outlets. Additional costs would include cabling and choices of product support through extended warrantee if desired, but these are not inordinate expenses either. The overall pricing of any configuration is commensurate with the network and institution's size. Creating an environment that includes wireless capability in support of museum educational programming need not be overly customized, expensive, or frightening. Hardware and software exist as off-the-shelf products, and there are professionals who can consult, source the systems, and install them at reasonable, packaged pricing. Maintenance at a fair price can also be included if no in-house expertise is available. In the final analysis, the ability for an institution to integrate some form of wireless connectivity to a digitized database for school age children to learn from is absolutely viable and should be considered wherever possible.

5.4 Digitization is a Key Element

The portal for Information Technology is the mobile device, but the infrastructure that makes the mobile effective is everything else behind it. The electronic components, the computers, the servers, and the Internet, all make the handheld a powerful and mobile technology. The information storage and access that make up the Internet can be duplicated on a smaller scale for museums to emulate. This is known as an intranet, a networking architecture that was discussed in the previous section as the information infrastructure for the typical museum application. For museums to take advantage of this infrastructure, they must digitize and electronically store the objects in their collection. The collection has to exist in a virtual format in order for it to be accessed by mobile devices.

Digital representations that are in standard formats are perfectly viable for use in the context of exhibit presentation as well as access for educational programs. Creating an environment in a museum separate from the collections management and preservation systems, but reutilizing digital representations that may already exist, is absolutely possible. Which means museums could leverage digital technology for educational purposes. It is technically feasible to create the digital database needed to implement the kind of infrastructure previously discussed, and can be as simple as taking a picture of an object with an inexpensive digital camera. Downloading the images to computers has become standardized and fairly simple as well.

Whether it is for collections management or preservation, a good many museums have already gone down path of digitization. Most museums use basic computing technology and software for collections management purposes. Software programs like PastPerfect® have the capability of storing a digital picture of objects entered into the database along with the associated metadata. Another driving factor of digitization is the need to preserve and protect while still maintaining access to important collections. Howard Besser is a noted expert on digital preservation. He is professor of Cinema Studies and director of New York University's Moving Image Archiving & Preservation Program, as well as senior scientist for Digital Library Initiatives for NYU's Library. Besser has written:

> "A digital image collection can increase awareness of, and facilitate access to, analog collections and thus serve both an educational and a promotional function...It can indirectly facilitate the conservation of original artifacts, because use of a digital surrogate can decrease wear and tear on the original, although it should be noted that, conversely, the additional awareness created by the availability of a digital surrogate can actually increase demand to view the original" (Introduction to Imaging 31)."

Impetus for digitization on a large scale has come from the federal level. The Library of Congress has been the driving force behind the National Digital Information Infrastructure and Preservation Program (NDIIP) established in 2001. A 2006 Library of Congress Bulletin stated that Congress had appropriated a total of $99.8 million for the project in order to:

> "...encourage shared responsibility for the collection, selection and organization of historically-significant cultural materials regardless of evolving formats; the long-term storage, preservation and authentication of those collections; and rights-protected access for the public to the

> digital heritage of the American people" ("Digital Projects and Planning" par1).

The NDIIP has been funneling National Science Foundation (NSF) money into universities' and research centers' computer science research programs. The idea has been to support study and strategic planning aimed at creating collaborative efforts in digital preservation processes.

With this major push from the government, libraries and museums have seen incentive to digitize. Many have already made the effort to some extent and some have provided access to their digital collection online. *Where* education happens is not as important as *how* education happens. This is a key factor, and starting with digitized collections, it may be possible for museums to be the harbinger of a new educational model. One that includes how the new generation that was born digital learns and accesses the world around them.

6.0 Food for Thought

A focused awareness about Information Technology began in museums with the publication of *The Wired Museum* in 1997. It was the first time that an anthology spoke directly to the impact and possibilities of advancing electronic technology as it pertained to the museum experience. Some of what was written then may be considered period specific, but a good portion of the essays discussing the impact of computers, digitized databases, and the Internet was prescient. The publication is still the foundation for the museum profession's examination of an evolving technical world and their place in it. Katherine Jones-Garmil, then Assistant Director for Information Services and Technology at the Peabody Museum, was editor and contributor. She wrote about the impact of three decades of computing in *The Wired Museum*'s first essay, and in it she referenced the book *Being Digital* by Nicholas Negroponte, Director of the Media Lab at MIT:

> "Computing is no longer the exclusive realm of military, government, and big business. It is being channeled directly into the hands of very creative individuals at all levels of society, becoming the means for creative expression in both its use and development. The means and message of multimedia will become a blend of technical and artistic achievement. Consumer products will be the driving force" (*Laying* 48).

Information technology has deeply integrated itself into mass culture and has even found its way into the fine arts. This speaks to the pervasiveness and creativity that Negroponte was alluding to. It is true that the driving factors are no longer government or big business. Information Technology has become democratized just as the generation that developed the PC foresaw. It appears now that the Digital Native will determine how culture and society are going to evolve with Information Technology. Museums need to understand this. As was discussed earlier, Digital Natives mediate their world differently than the Digital Settler who is today's adult authority. Use of mobile technology is not a fad or a growth stage that Digital Natives will leave behind. It is now ingrained in society at large, and the Born Digital are leading the way. These Digital Natives will be the visitors and museum professionals of tomorrow. It is incumbent on us, the current generation of museum professionals, to shape how mobile technology will be used in cultural institutions of the future. Contrary to some establishment thought, trying to ban Information Technology from the classroom and the museum will not stem the tide of change. And punishment as a tool of behavioral modification is the least effective method to employ. What is left for education and museum professionals to do is to gain the trust and attention of Digital Natives by accessing the portal through which they mediate their world and to incorporate it into the learning experiences in which they are engaged.

Training

One way for museum professionals to gain the upper hand on mobile technology use is to address their understanding. The limited evaluation showed us that there is a level of willingness, but experience and comfort are major factors in how mobile technology is used, particularly in museum education. One key possibility is training. Jones-Gamil wrote of the need for training in *The Wired Museum* stating, "There is obvious advantage to having the curator or registrar get direct experience with the technology" (Laying 53). Guy Hermann, Director for Information Services Mystic Seaport, echoed the same in his essay; "Shortcuts to OZ". He titled one section: "TRAIN! TRAIN! TRAIN!" It opened with: "The last critical ingredient is training," and concluded: "If we want to make the tools as useful as possible and if we want to make sure people understand the tools and the way they can apply them to their jobs, we must commit to continual training. Users need to be taught about new technologies gradually, continually and persistently" (Shortcuts 89). As editors of *The Digital Museum: A Think Guide*, Herminia Din and Phyllis Hecht wrote in their contributing essay," Preparing the Next Generation of Museum Professionals", the museum educator "may need a strong knowledge of current educational uses of digital media; the ability to develop and oversee all interpretive programming of podcasts, blogs, and audio tours…and a strong interest in working collaboratively" (Preparing 12). It is interesting to see that four years after their essay was published, that the multimedia applications the authors enumerated are all accessible via mobiles. The two go on to discuss the need for technology coursework in museum studies programs. Din and Hecht suggest that what is especially needed in these courses is an understanding of how technology can integrate into the museum experience, and to achieve that goal, hands-on training should be integral if success is to be attained. They suggest that this may be achieved through cross-discipline education using a variety of university resources, or even contract with outside sources to bring that expertise to the programs (Preparing 15-16). The authors ultimately make the case for a more concerted educational effort if the future museum professional is to attain more comfort with Information Technology use.

Training should be looked at in two distinct layers: 1) nuts-and-bolts technology overview and 2) application orientation. Comfort level is a function of familiarity and perspective. Museum professionals, and educators especially, need some form of technical training. They do not require an expert's level but enough of an understanding to allow for creative development of programming. Online tutorials and beginner level seminars are available at reasonable cost and could be utilized as professional enhancement through the museum where individuals are employed. One of the questionnaire respondents had stated they had only personal experience with the latest technology but followed-up on their own through seminars, online articles, and listservs. If it is possible to self-educate to the point of rudimentary understanding, then any concerted effort on an institution's part to support some formalized version would not be that difficult.

Once educators have a basic understanding of the physical requirements for wireless communications, how to integrate technology into programming is more of a creative process than a technical one. Educators already know how to develop programs. The hypothetical program in Section 5.2 was designed to educate first, irrespective of technology use. It had elements of Piaget's developmental stages, Gardner's multiple intelligences, Vygotsky's scaffolding, and Bloom's Taxonomy. Museum educational programming has always been grounded in educational theory. Ultimately, utilizing mobile technology just becomes an overlay to enhance the experience for an audience that has an affinity learned at an early age.

Experience and Support

After training, actual hands-on involvement is what is needed most to hone the skill-sets of museum educators attempting to integrate mobile technology into their programming. Utilizing mobile devices is a design process that is application and end-user oriented. Meeting the requirements of the user is the goal of even the best technologists; design should always be from the ground up and satisfy the end-user's needs.

To attain that goal, institutions large and small first need to commit and make the investment in the infrastructure. Educators can then take advantage of the training they will have received and begin to create a program environment that is conducive to learning for the Digital Native. The commitment to building the infrastructure need not be elaborate or expensive. As we have pointed out in Section 5.3, the nuts-and-bolts of the wireless infrastructure are based on WiFi standards, and at the lowest end, can be purchased off-the-shelf at places like Best Buy® or Office Depot®. Most institutions have already committed to digitizing their collections; even the smallest museums can afford PastPerfect® as a collections management tool, which includes the insertion of standard digital images into the database. If this is already planned for or in place, then the same digital images using the same standard formats will suffice for a standalone database. Access would be provided by off-the-shelf WiFi technology listed in Section 5.3. The wireless network should be sized according to budget and need.

Once the technical infrastructure is in place, it is up to the staff to make good on the investment. In Section 3.2 we contrasted two very different experiences, that of the Liberty Science Center and the New-York Historical Society. The LSC invested a large sum of money, and despite the fact that it is a science center and that a large study was performed, the institution seemed to miss the target. Their conclusion was that investing in mobile technology appeared not worth the effort because of the results of the survey study. The perspective they had going into the project as well as their expectations were not aligned with the paradigm of the end-users. And none of what was implemented was aimed directly at museum education programming. It would have been better if the LSC had used a less expensive and simpler approach, which might have bought the staff time to analyze what the needs of their visiting constituency were and how mobile devices could be used in context with the exhibitions. The antithesis was the New-York Historical Society. Here the staff created activities with education as their cornerstone. The staff even included museum students in the creative process as is evidenced a teen tour of the *Lincoln in New York* exhibition by summer high school interns (Hulser et al Click History 210). This was a creative way of involving Digital Natives in the education of Digital Natives. Most of the integration of mobile technology was low cost and low level, and predicated on the already digitized collection, which Hulser emphasized is a basic requirement for all museums. It allowed N-YHS to extend the museum experience beyond the walls of its building into activities that included downloaded walking tours. Thus, extending their educational reach out into time and space away from institutional confines. The mobile device can be the perfect tool to reinforce that experience, especially for school age visitors who are involved with museum/classroom activity. In the long run, the N-YHS seemed to have gotten the perspective right and appeared not to be afraid to experiment with their collection, the technology, and their educational goals.

6.1 Changing Times and The Digital Native

Museum professionals need to evolve with the public they serve and foster an environment in which people can learn on their own terms. Today, that means coming to terms with the common dependence on communications technology. The youngest generation is the first to have grown up with powerful Information Technology. Going forward, all generations will soon be Digital Natives. It is time for museums and the professionals in them to realize this and to develop programming suited for this new public.

Ted Friedman in his 2005 book *Electric Dreams* stated: "Why do we think what we think about computers? A computer is just a tool. Or, more specifically, a medium—a means of processing and communicating information" (Electric i). Although Friedman focused on computers when he wrote that statement, it applies to all Information Technology, including the mobile. The operative term here is medium; connoting a middleman, a facilitator. Marshall McLuhan, a philosopher, observer, and social commentator, may have said it best. In the 1960s, he observed the changing nature of what he called "electric technology" and its affect on the socio-cultural aspect of the population at large. In doing so, McLuhan coined the term: "The Medium is the Message." In his book, he succinctly commented about the influencing nature of our technology and its life-changing aspects:

> "The medium, or process, of our time—electric technology—is reshaping and restructuring patterns of social interdependence and every aspect of our personal life. It is forcing us to reconsider and re-evaluate practically every thought, every action, and institution formerly taken for granted. Everything is changing—you, your family, your neighborhood, your government, your education, your job, your relation to 'the others.' And they're changing dramatically" (*The Medium* 8).

Approximately, one hundred and fifty years ago, the United States embarked on a path of industrialization. Everything changed. Today we are on the cusp of another major shift in the technological paradigm as we welcome this latest generation of advanced technology. Only this time, it is aimed at the heart of communication and understanding, the very essence of human existence. If museums and other cultural institutions are to survive and thrive in the foreseeable future, it is up to us at the crossroads to understand and shape what that future is to be. Because one overriding factor remains, everything *will* change.

Appendix A

Evaluation Matrix – Museum Professional's Technology Perspective and its Integration into the Museum Experience

Guiding Questions	**Self-Administered Survey**	**Qualitative Questionnaire**
How prevalent is utilization of electronic-based technology (computing, audio, display, etc.) in the museum visitor experience?	X	
How prevalent is utilization of PDA/smart handheld technology as interface in the visitor experience?	X	
How prevalent is utilization of electronic-based technology (computing, audio, display, etc.) in museum educational programs?	X	
How prevalent is utilization of PDA/smart handheld technology in museum educational programs?	X	
To what extent do museums use electronic-based (i.e. computing, audio, display, etc) technology?	X	
To what extent do museums accommodate PDA/smart handheld technology?	X	

Appendix A

Evaluation Matrix (cont'd) – Museum Professional's Technology Perspective and its Integration into the Museum Experience

Guiding Questions	**Self-Administered Survey**	**Qualitative Questionnaire**
What is/are the motivating factor(s) for use of electronic-based technology (i.e. computing, audio, display, etc.) in the museum visitor experience?		X
What is/are the motivating factor(s) for use of PDA/smart handheld technology in museum educational programs?		X
What are the barriers or reasons for non-use of electronic-based technology (i.e. computing, audio, display, etc.) in the museum visitor experience?		X
What are the barriers or reasons for non-use of PDA/smart handheld technology in museum educational programs?		X

Appendix A

Evaluation Matrix (cont'd) – Museum Professional's Technology Perspective and its Integration into the Museum Experience

Guiding Questions	**Self-Administered Survey**	**Qualitative Questionnaire**
How comfortable or familiar are museum professionals with electronic-based technology (i.e. computing, audio, display, etc)?		X
How comfortable or familiar are museum professionals with PDA/smart handheld technology?		X
What is the museum professional's opinion of the future for electronic-based technology (i.e. computing, audio, display, etc)?		X
What is the museum professional's opinion of the future for PDA/smart handheld technology?		X

Appendix B

Technology Integration Into Museum Educational Programs

Dear museum professional, we are conducting a limited evaluation of how technology fits into the museum experience, and specifically, for educational purposes. We would appreciate a few minutes of your time in filling out this brief survey. Your response will be most helpful in developing a basic understanding of technology use in your institution for inclusion in a larger evaluation effort. Thank you.

1. Does your institution include the use of any electronic based technology such as computers, displays, touch screens, or audio systems integrated into exhibitions?

____Never ____Sometimes

____Rarely ____Frequently

2. Does your institution include the use of PDA/smart handheld technology integrated into exhibitions?

____Never ____Sometimes

____Rarely ____Frequently

3. Does your institution include the use of electronic based technology such as computers integrated into educational programs?

____Never ____Sometimes

____Rarely ____Frequently

Appendix B

4. Does your institution include the use of PDA/smart handheld technology integrated into educational programs?

____Never ____Sometimes

____Rarely ____Frequently

5. If any electronic based technology is used in your institution, please provide a brief description of what it may be and its utilization.

***6. If you are willing to be contacted to participate in a follow-up qualitative evaluation based on your responses via telephone interview during the months of August and September, please provide your e-mail address and/or telephone number. Your contact information will not be used for any other purposes. If you are not interested in participating in the qualitative portion of the evaluation, please indicate your wishes.**

Appendix C

Qualitative Evaluation of Technology Use in the Museum Experience

This is an instrument to determine the motivations for utilization and non-utilization of technology in museums. The goal is to gain understanding of the museum professional's perspective on electronic based technology in relation to museum exhibition and specifically for educational purposes. Further, this qualitative phase of the larger evaluation attempts to gain a glimpse of what the museum professional's perspective is on smart, handheld technology, and what they think might be the future for these devices as it relates to visitors and museums. This questionnaire is a follow-up to the self-administered survey, and the respondents represent the percentage of volunteers interested in participating in the qualitative portion of the evaluation.

The questionnaire is divided into three parts: questions aimed at technology use, questions for non-use of technology, and general questions about experience and perceptions relating to technology. Please answer as best as possible those questions of use and non-use that pertain to your current institution. The general questions should relate to all respondents, as they are assessments of current perception and understanding. Please insert your responses below the questions and provide as much detail as you feel is necessary to ensure clear understanding for the evaluation. In participating in this project, your assistance is most helpful and appreciated.

Technology Use

1. **If applicable, how has your museum integrated electronic based technology (i.e. computing, audio, display, etc.) into:**

    a. **Exhibition experiences?**

    b. **Educational experiences?**

2. **If applicable, how has your museum implemented smart handheld devices and infrastructure into:**

    a. **Exhibition experiences?**

Appendix C

b. **Educational experiences?**

3. **What has been the driving factor/factors for integration of electronic based technology (i.e. computing, audio, display, etc.)?**

    a. **Into exhibitions?**

    b. **Into educational programs?**

4. **What has been the driving factor/factors for integration of handheld smart technology?**

    a. **Into exhibitions?**

    b. **Into educational programs?**

Technology Non-use

1. **What have been the barriers for non-use of electronic based technology (i.e. computing, audio, display, etc.)?**

    a. **In exhibitions?**

    b. **In educational programs?**

2. **What have been the barriers for non-use of handheld smart technology?**

    a. **In exhibitions?**

    b. **In educational programs?**

General

1. **As a museum professional, what is your experience with electronic based technology (i.e. computing, audio, display, etc.)?**

2. **As a museum professional, what is your comfort level in designing a program integrating electronic based technology (i.e. computing, audio, display, etc.)?**

3. **As a museum professional, what is your experience with smart handheld technology?**

4. **As a museum professional, what is your comfort level in designing a program integrating electronic handheld technology?**

Appendix C

5. **As a museum professional, what is your view of the future for electronic based technology (i.e. computing, audio, display, etc.) as it relates to the museum experience?**

    a. **Exhibitions?**

    b. **Educational programs?**

6. **As a museum professional, what is your view of the future for smart handheld technology as it relates to the museum experience?**

    a. **Exhibitions?**

    b. **Educational programs?**

Appendix D

<u>Instructions to be read by the Commander of the Detective Division (teacher)</u>

Detective squads will use their worksheets as guideline for the investigation process at the museum. Please follow the instructions of your detective commander (teacher), and ask for assistance from the museum staff if there is any confusion about the exhibit. They will not help you with answers directly, but can provide clear understanding of the exhibit displays and information.

Pease refer to your squad's subject area on the worksheets for the guide questions pertaining to your investigation. The Commander (teacher) and the museum staff can help with question clarification if needed. Good luck in your investigation...

Find your squad's area of investigation below. Use as many display items and labels from the related exhibit section as is needed to help in answering the questions and statements. Use as many "Investigator Heads" for note taking as you need; just keep in mind, you need to organize your notes in order to contribute to the report. There is access to the "Treasured Documents" room containing real documents and replicas; this is a resource that is available to all squads. In addition, there is access to the in-house WiFi network to the New York State Archives and Library that can be used to look up additional information in the form of documents, pictures, and videos. This access will be available later online from back at the "Detective Division Headquarters" (your school) at the discretion of the Commander (teacher). So use as many source types as possible and the network at least once.

Appendix D

Once you complete your investigations as best you can, the squad should take some time at the museum to discuss the information gathered and organize it so an investigative report can be compiled back at the "squad room" (classroom).

General Questions for the Whole Detective Division to be Discussed After the Investigation

1. What was the reaction of the native peoples to first sighting the ship and the Europeans? Who did they believe the Europeans were at first and why? What do you think led the Native Americans to believe what they did?

2. How should you treat alien visitors?

3. What were the results of the encounters with the Henry Hudson expedition in the lower part of the Hudson River versus the upper part?

4. Are the current names for the regional locations the same as the Dutch and the Native American? If not, what were some as example? What might be some of the differences between the Dutch and Native American names for the same places?

5. What was the original purpose of the Hudson expedition? Was it successful? In what ways was it, and what ways was it not?

Appendix E

Investigator's Worksheet

Squad Level Areas of Investigation

Explore Cultural Interconnections:

1. What Level of cooperation was there in Dutch Niew Nederlandt (New York) between the Native American and the Dutch? What cultural differences existed at the time?

2. Did the two cultures value the same types of ideas and things? Find out and explain how they were different, the same, or both.

3. What do *you* value that others who may be different don't? Why?

Explore Native Responses to European Contact

1. Find out how the different Native American tribes reacted to Dutch influences in the region?

2. How did the cultures view ownership? In what ways were they the same or different, or did they relate at all? Explain.

Explore Historical Perspective

1. How did historians view the Dutch colonial period in New York State? How do they view it today?

2. In what ways are the Dutch and English colonial experience different?

3. What was the key Dutch cultural trait that had the most influence on their experience; what was the impact and long-term implication?

Appendix E

Explore Geography and Cartography

1. Determine the similarities and/or differences between maps and globes of Dutch colonial time and today.

2. What were the changes that may have occurred over time? Why?

3. What were most maps' geographical concepts based on? Why were they, or were they not viable (usable and successful)?

Explore Native American and Dutch Culture

1. How did the different native tribes live in the river region? Find examples of housing and implements and compare their design and use.

2. Compare the Native American and Dutch housing and implements in the same way as Number 1.

3. Compare how the Native American and Dutch provided for themselves (example: food).

Explore Language

1. Determine the names for places, animals, and things for the native tribes in the river region as well as the Dutch.

2. In what ways did the languages meld (combine)?

Appendix E

Explore the Modern View

1. What became of the Eastern Algonquin and Iroquois tribes?

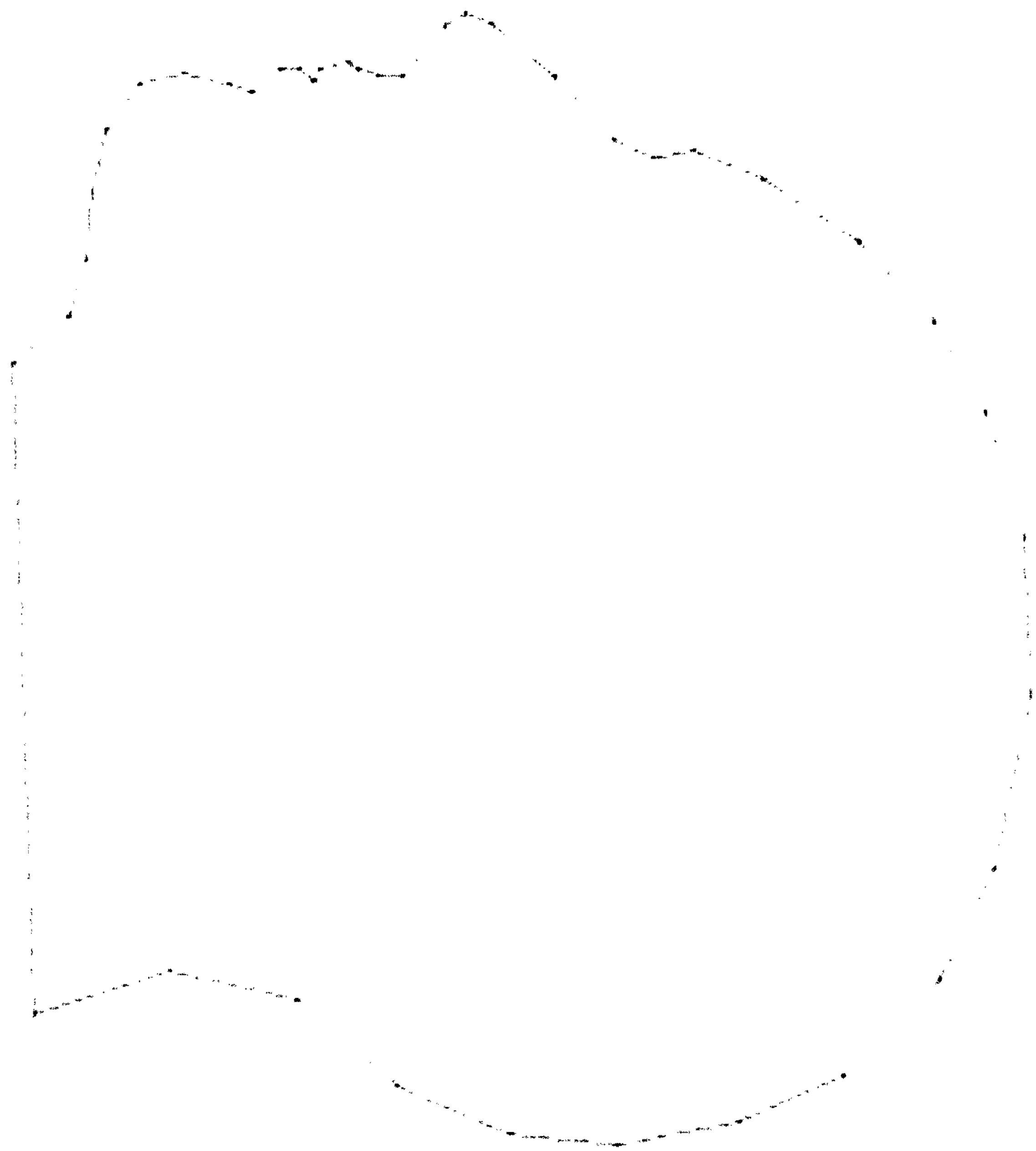
2. Whose literature were the Mohican of the Upper Hudson River incorporated into? How were they portrayed?

3. How does that portrayal align with what we know today?

4. What literature is the Dutch portrayed in, and how does that compare to what you've found out?

Appendix F

Investigator's Head – write, draw, or symbolize the information you gather



Addendum: The Technology

Up to this point, the discussion has centered on the importance of museum professionals' attention to the growing trend of information and mobile technology use. The case has been made that there needs to be a shift in awareness and appreciation of the extent to which mobile information devices have become integral to society; moreover, that it is incumbent upon museum professionals to take this into account when deciding on educational possibilities. But understanding how to effectively accommodate the school-aged visitor in educational programming requires an added discussion of the constituent pieces that comprise Information Technology's infrastructure and the gateway that mobile devices are for access to stored knowledge. We will look closely at what makes up Information Technology specifically. As was discussed in the concluding section to this thesis, training and familiarity will foster a sense of comfort. This addendum is a tutorial on what Information Technology is and how it evolved. Much of what is based on education and personal experience as an information networking professional in a previous career path. Because the discussion is rather technical, a glossary is provided to define major technical terms set in **bold** text.

What *is* This Stuff Anyway?

Today's communications technology is actually an amalgam of many things. It can be simply categorized as **Information Technology**, or IT for short. In examining what IT is, the conversation is best centered on its basic constituencies consisting of the computer, the Internet, and the mobile device. Why this categorization? Almost everyone today accesses and interacts with stored information via these systems. But first and foremost, it is the electronic component that is at the fundamental core of IT systems. The following sections lay the groundwork for electronic-based, Information

Technology and hopefully provides a deeper understanding of the systems and devices we all use on a daily basis.

The Electronics

The change in electronic components over time has enabled the efficient and cost effective deployment of IT systems in today's environment. Developed over 100 years ago, this new technological form began to shift the importance and focus away from the mechanical technology of the 19th century Industrial Age. Electronics is predicated on manipulation of electromagnetic energy, and at first, came in the form of vacuum tubes (Figure A1). All electronic devices manipulate the flow of electrons based on specific

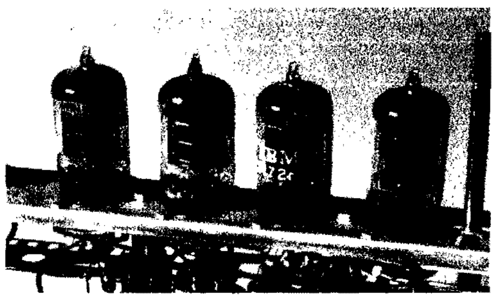


Figure A1 - Vacuum Tube Technology

physical characteristics for specific physical results. Vacuum tubes are constructed with high-grade glass and particular conductive metals forming the internal electrodes. The entire assembly is then encased in a vacuum cavity to limit interaction with atmospheric gases that could change the results of the components' intended actions. The issue with this type of electronic device is that it uses a thermionic process that requires input electrical power to heat the electrode elements resulting in internal electron flow ("Electronics" webpage). Ultimately, adding many of these building blocks together in a confined space results in an inordinate amount of heat, uses a fair amount of input power to gain a resultant performance, and can take up considerable real estate depending on the system one is constructing. As example, The U.S. War Department announced in

February 1946 the development of ENIAC (Figure A2), one of the first large-scale, general computing systems. Designed by a team at the Moore School of Electrical Engineering at the University of Pennsylvania, it required almost 18,000 vacuum tubes, weighed 30 tons, and resided in a room that was 30 by 50 feet (U.S. War). Eventually, it was the

Figure A2 - ENIAC c. 1947

chase for more efficient components that used less input power and could be manufactured at less cost that changed everything. The result was the **solid-state** device that began the era of smaller, cheaper, better.

In 1948, William Shockley led a team of Bell Lab scientists in developing the first really workable **solid-state** device known as the **transistor** ("The Silicon Engine" webpage). Figure A3 below demonstrates various types of transistors manufactured.

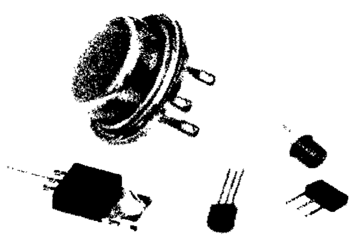


Figure A3 - Transistor Construction

This generation of electronics utilized crystal-based elements such as silicon to manipulate the flow of electrons. Their construction consisted of a substrate base of silicon mixed with various conductive heavy metals formed in layers that provide the whole device with electrical conductive properties. Once an input source of electrical energy was applied, the result was the flow of electrons in the same fashion as a vacuum tube, but at much lower power levels, internal heat, and cost (Brain, "How Semiconductors Work"). In the early deployment of these **solid-state** devices, also known as **semiconductors**, they were built as separate and discrete components much like vacuum tubes were. They had to be wired together to form the complicated circuitry that was an electronic system. By 1954, a company called Texas Instruments had developed processes for mass production of **semiconductor** components and started a wholesale change in the electronics industry ("Timeline" webpage). What this meant was that the goal of smaller, cheaper, better could be attained. But just using arrays of smaller electronic components was not enough. Eventually, the push to get rid of **semiconductors** as discrete components led to another major shift in electronics evolution.

To truly take advantage of **solid-state semiconductors**, the next measure was to take the layers of heavy metal infused silicon and make them even smaller. In doing so, manufacturers such as Texas Instruments could stack more and more material in a single space and discard the discrete component architecture altogether. This would save more physical space within the electronic system, require less power, and economies of scale would make everything less expensive. In the 1960s, electronic component development moved towards this integration concept. Why *not* get rid of the single **semiconductor** junction in a standalone casing? That's what engineers began to do, and by 1970, the **Integrated Circuit** chip (IC) was born. Now, in a single enclosure, thousands of transistor connections and associated electronic components could be made to do in miniature what many square feet of space did in earlier configurations (Chandler,

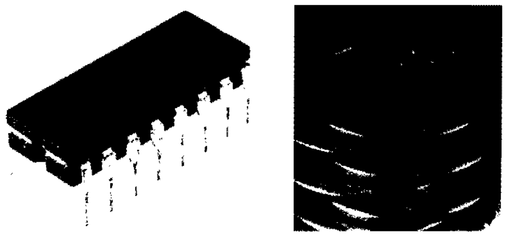


Figure A4 – IC Chip Construction

"Transistors" webpage). As a result, 1971 saw the advent of Intel's 4004 **microprocessor** (Figure A4), a complicated form of **Integrated Circuit** chip, which gave rise to the microcomputer; or, as it became more popularly known, the **Personal Computer** (PC). In figure A4 above on the right side, sitting on a stack of pennies, is the internal workings of a **microprocessor**. As can be seen, they are extremely small; yet, they have an incredible amount of **transistor** junctions. **Transistor** junctions per unit of area in **IC**s have doubled in quantity approximately every 1.5 years (Chandler, "Transistors" webpage). Because of the miniaturization of multiple electronic components into a single space, **IC** technology would eventually move from the 4004's 6,000 transistor connections to millions and then billions in today's versions (Brain, "Microprocessors" webpage).

Once the basic electronic devices were perfected, it was only a matter of time before engineering designers created digital-based electronic systems. By using large quantities of high-grade building blocks, with an almost infinite number of configurations, engineers developed the Information Technology that would eventually connect us all.

Either of the forms of electronic components, whether vacuum tube or **solid-state**, could be turned on and off at any given time, in any given order, to produce a pattern of manipulated electricity as it flows around the inside of an electronic system. This gave birth to the concept of "digital", meaning to count as discrete components the groupings of "on" and "off" states representing the "1s" and "0s" (**bits**) of logical mathematical processes (Friedman, *Electric* 38). The patterning of these 1s and 0s as **binary** code then symbolize the ideas and concepts of human information. They can be represented through monitors as pictures or words, and stored as magnetic patterns on a **hard disk drive (HDD)** for later use. This effectively is the state of modern electronic systems of all types; advanced components configured to control the flow of electricity, virtually providing end functionality. Some of the most sophisticated current electronic systems today tend to be our information systems, and they utilize the technology described above in the most sophisticated fashion.

The Computer

Computers are effectively the backbone of all things information; they process and store whatever is put into them. The current generation of electronic computers is based on those originally developed for breaking German military code during WWII but their basic concepts are actually centuries old.

Computer systems were born out of mathematical ideas; some were even designed on paper long before they were ever built. One such computing system was known as the Babbage Engine. The 19th century saw the need for voluminous calculation tables for various purposes. Astronomical, construction, insurance, engineering, and finance tables became ever more important. Accuracy was the key component, and making and proving the tables was hard and tedious work. In 1821, mathematician Charles Babbage working with astronomical tables and finding numerous errors was purported to state, "I wish to God these calculations had been executed by steam" ("Babbage Engine" webpage). By 1840, Babbage had completed drawings and specifications for an automatic calculating machine, but was never able to actually build one. A genuine version of Babbage's Differential Engine No.2 *was* completed to the original specifications in 2002 at the Science Museum in London. It is eleven feet long, weighs 5 tons, and is made of 8000 mechanical parts. It actually works and has vindicated Babbage as a pioneer in computing systems ("Babbage Engine" webpage).

The modern versions of computing systems are predicated on the electronic components discussed in the previous section. At first, computers were electromechanical, then vacuum tube based, and as **solid-state semiconductors** were perfected, the shift to smaller less expensive machines that use less input power became possible. The first generation of computing systems was known as mainframes. They were large and tended to be centrally located in business, government, or university organizations. To use them, programmers had to input information directly into the machines via switches and **patch cord** connections; as a result, the skill-set required precluded the average person from direct operations. Another weakness of these early machines was the inability to store information as memory. That functionality was not available until almost 1950 with the development in Britain of the Electronic Delay Storage Automatic Calculator (EDSAC). It was the first viable memory based system that could process up to 714 operations per second ("Timeline/1949" webpage).

The 1950s saw significant advancement as electronic components continued to forge ahead, and notable mathematicians joined the race to improve computing capabilities and performance. One such person of note was Grace Hopper. She started her career in the 1930's as professor of mathematics at Vassar College after having earned her B.A. in mathematics and physics at the same institution, and subsequently, an M.A. in mathematics at Yale. Hopper eventually acquired a Ph.D. from Yale as well in 1934, and left her position to enlist in the United States Naval Reserves in 1943. Working along side her male colleagues, Hopper learned to code the large electromechanical machines the Navy used to compute ordinance tables needed to fire large guns accurately over distance. This experience led her to join the Harvard faculty after WWII where she developed the first programming software that allowed for English language interfacing with computers. Why this is significant, is the fact that it was a major leap forward in human-to-machine interface capabilities. It would lead many decades later to the average person being able to use a computer without the need for advanced degrees in mathematics ("Oral History...").

Although there were many start-up companies after WWII aimed at computer system manufacture, the 1960s saw International Business Machines (IBM) become the preeminent player in the market. The company had been around in various forms since the 1880s, but had quickly moved over to the new technology that was **mainframe** computing during WWII ("History of IBM"). In fact, it was on the systems developed by IBM in conjunction with Harvard University that Grace Hopper had the opportunity to create the advanced human-to-machine interface software language ("Oral History...").

The 1950s saw a major increase in computer processing time for businesses and universities alike, but computers still required data processing operators to input requested tasks from the various departments of an organization. These requests were run over night and were known as **batch processing** jobs. A request for computing time was made via a data processing technician after the input instructions were punched into **punch [tab] cards** making holes like a roll on a roller piano. An automatic card reader would then read the light patterns streaming through the holes to do the actual input work. The outcome would be available at a later time producing a stack of printed-paper with the resulting information. Ted Friedman in his book *Electric Dreams* quotes John Kemeny, a noted early computer program developer:

> "Machines were so scarce and so expensive that man approached the computer the way an ancient Greek approached an oracle…A man submitted his request…and then waited patiently until it was convenient for the machine to work out the problem. Only specially selected acolytes were allowed to have direct communications with the computer" (85).

It wasn't until the middle 1960s that IBM flirted with the idea of distributed data processing.

The first attempt at distributed access to the big mainframes in the computer rooms of companies was based on flawed organizational theory. Teleprocessing, as it was coined, assumed that the executives of companies would be inherently interested in viewing real-time financial information about their respective organizations. What IBM did not understand was that in that era, executives did not type, nor would they want to learn; that's what secretaries were for. As for **real-time data**, that's what mid-level managers worked with, but no study was performed to determine if computer access was a useful and acceptable tool for them. Ironically, even IBM executives did not use computers; they only sold them. What did happen as the decade of the 1960s came to a close was a concerted effort to provide access for the trained, professional businessman. It would be the army of M.B.A.s of the next business generation that used quantitative data to make decisions that would put computing access to good use (Cringely, *Accidental* 42-43).

The half step to distributed computing was computer time-sharing. It allowed each department in an organization to be wired with a video display terminal and a keyboard. Users were connected directly to a control unit via the same kind of cable that is used for cable TV today providing what was considered high-speed access. English language input forms would appear on the screen of a departmental worker requesting the data to be processed. Once the enter button was pressed, a refreshed screen would show any result and/or the next input form. Large data requests would still have to be performed by the data entry group in the computer room, and an extensive stack of folded computer paper with green and white stripes would be delivered to the requester's office or cubicle the next morning. This mode of operating is understood from personal experience. It came to a peak in the late 1980s, and it existed until the concept of true distributed computing took hold, a radical departure from distributed *access*.

The Baby Boom generation of engineers came of age by the late 1960s, and by the early 1970s, was putting to good use the Woodstock philosophy that drove the times. All things old were not necessarily good, and all things new were about openness and sharing. Why not apply this to computing? Who says that computing should be a hierarchical affair? Up to this point in time, the office minion workers "requested" data from the great system hidden inside an air-conditioned space known as the computer room, with its limited physical access save for the special few. The leap from distributed access to distributed computing would take hold fairly quickly, as the latest generation of electronics that was the **Integrated Circuit (IC)** and the philosophy of the times converged. It would eventually involve staid business practitioners such as Xerox and IBM as well as the Silicon Valley cowboys who became the legends of today's high-tech industries.

The PC to the Server

The ENIAC system has been designated the first true digital computer, and to underscore its importance, parts of it reside in the National Museum of American History (NMAH) of the Smithsonian Institute (Figure A5) ("ENIAC" webpage). But the digital

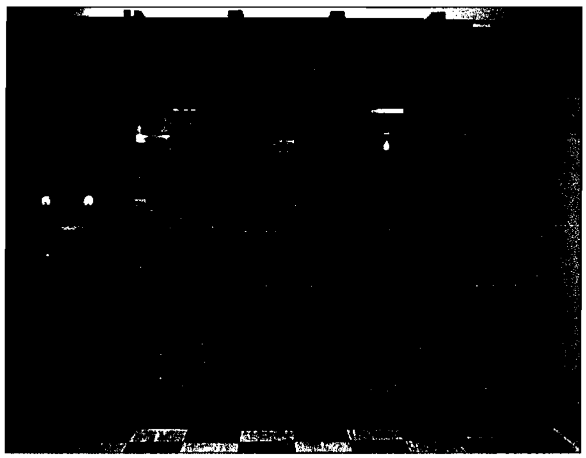


Figure A5 – Portions of ENIAC at the NMAH

age in today's consciousness can be traced back to the inception of the **Personal Computer** (**PC**). Its birth is not necessarily the result of linear development or history, but an amalgam of competing views of computing and the purposes it was aimed at (Friedman, Electric 82).

The idea of the "home computer" came about in 1965 when Jim Sutherland, a Westinghouse engineer, cobbled one together enclosed in wood and weighing 800 pounds. It took up various rooms in his house including the kitchen and living room. Known as the ECHO IV, Westinghouse decided to publish its existence and its futuristic implications. *Where* the "home computer" would ultimately reside was up for debate; in order for technology to succeed, it needed purpose, not just cool. Honeywell, a respected technology company still in existence today, decided it to would play the "home computer" game as well. The company determined that the kitchen was the target location for this technology of the future, and produced the Honeywell Kitchen Computer complete with built-in cutting board (Friedman, *Electric* 82). Ironically, today's modern kitchen is probably the most computer free room in the house.

Miniaturization would be a major key to success for the PC, and what became to be known as the "**killer app**" would take the **PC** from some futuristic concept to practically applied technology. The **IC** electronics discussed earlier would be the first stage in making the "home computer" into the **Personal Computer**. Gordon Moore, a **semiconductor** engineer from the 1960s and one of the founding members of Intel, saw that the silicon substrate of these devices was doubling the number of transistor junctions almost every year to year-and-a-half. This equates to increasing the speed at which the device can process by two-fold each time, all while reducing the size of the over all systems. This became known as "Moore's Law", something that is essentially still in play today (Friedman, *Electric* 87). But the *real* breakthrough came when Intel developed the 4004 programmable microprocessor in 1971. It was the first flexible **IC** that did not need to be customized for function in a computer. Its programming capabilities allowed it to cover a range of tasks all in relation to the system it was designated for (Friedman, *Electric* 91).

As a result of the microprocessor advent, the first true **PC** can be traced to the ALTAIR 8800 (Figure A6). It used the next generation of Intel chip known as the 8080 and was plastered on the cover of the January 1975 issue of *Popular Mechanics* with the headline: "Project Breakthrough!" It was available through mail order as a kit

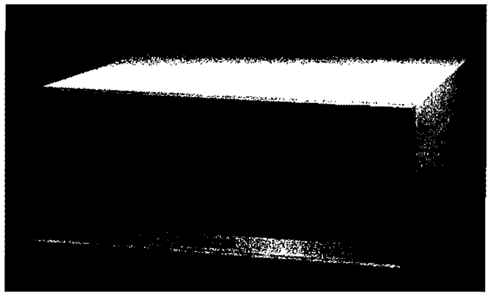


Figure A6 - The MIPS ALTAIR 8800 at the NMAH

from Micro Instrumentation Telemetry Systems (MITS) of Albuquerque, New Mexico. It plainly required a technical person to build it. There was no keyboard or monitor; the human-to-machine interface consisted of the lights and switches on its front panel. The 8800 was programmed by moving the switches according to a predetermined binary code and "reading" the results through the combination of lights (Friedman, *Electric* 92-94). Although the system was a bit too impractical for average use at the time, the ALTAIR's significance was its impact on the generation of engineers at the major research universities of California and elsewhere.

Electronic hobbyists quickly picked up on the $395 ($498 assembled) system and drove sales to 4,000 units in just three months ("ALTAIR" webpage NMAH). One such group that wholeheartedly dove into the microcomputer concept was the Homebrew Computer Club of Bay Area California. Its members emanated from research institutions like Stanford University and were a techno-version of the Counter-Culture movement. Their bi-weekly meetings would consist of computer technology discussions and its changing face in light of the ALTAIR. "You may have noticed some strange things happening in technology lately. Ordinary people have been gaining the use of technology that was previously limited entirely to the use of experts," declared *Computer Notes*, an ALTAIR user newsletter of the time (Friedman, *Electric* 97). Although actually *working* with microcomputers still required some engineering expertise, the *idea* of computing access for all, essentially the democratization of technology, began the real revolution and drive towards the **Personal Computer**. One of these egalitarian Homebrew hobbyist members was Steve Wozniak, a co-founder of Apple Computers, whose company was key in the **PC** revolution.

Wozniak teamed up with Steve Jobs and founded Apple in 1976 about a year after the ALTAIR made its way into the consciousness of the techno-geeks. Jobs was the visionary and Wozniak the talented engineer, and later that year, they released a customized version of a personal computer designated the Apple I (Figure A7). The electronics sat in a wooden box, but had what the ALTAIR lacked, a keyboard. It only sold a few copies, but the Apple I's real importance was that it was a steppingstone for what was to come (Friedman, *Electric* 102). By 1977, The Apple II (Figure A8) was a more commercial version of its wooden cousin; the purchaser did not need to assemble anything, but the system was command-based. That is, a user had to type in actual software commands to manipulate the machine, still something that the less technically oriented might not be able to do ("Apple II" webpage). The real push towards what

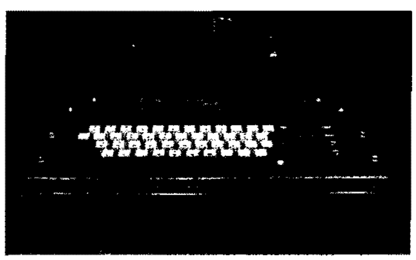


Figure A7 - The Apple I at the NMAH

would be recognizable today as a **PC** came when Commodore released the PET 2001 (Figure A9) just prior to the Apple II. It had a built in keyboard, but for the first time, an integrated monitor was part of the package. Like the Apple II, it was still

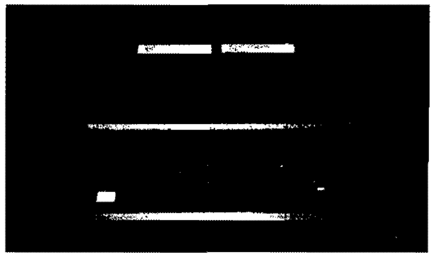


Figure A8 - The Apple II at the NMAH

command-based, but had a built-in cassette player that allowed for data storage

Figure A9 - The Commodore PET 2001 at the NMAH

("Commodore" webpage). While this line of development was progressing through the 1970s, some parallel efforts were taking place elsewhere, that would create a convergence to eventually produce what we take for granted today.

Xerox Corporation was quietly amassing some amazing technical breakthroughs that would be the foundation for everything that ultimately came true for the **Personal Computer** and the Internet as well. At a facility in Palo Alto, California near Stanford University, Xerox, in early 1970, assembled a group of extremely talented engineers who had a prior track record of computer development. The complex where this team resided was known as PARC, the Palo Alto Research Center, and as early as 1973, the team had produced a small **Personal Computer** dubbed the "Alto" that displayed an animation of *Sesame Street's* Cookie Monster. From 1973 through the next two years, they would also develop the **bit map** display, the **Graphical User Interface (GUI "goo-ee")**, the laser printer, and the software language **(protocol)** that would eventually run the Internet

(Hiltzik, *Dealers* 12-13). Xerox practically invented **PC** technology and a way to communicate with it long before other key players duplicated these efforts and brought it all to market. What this meant, was that for the first time, a small computer had a pictorial display with **icons** and pop-up menus. The **icons** could be manipulated with a **mouse**, a technology invented in 1963 by Doug Engelbart while at Stanford Research Institute, but not patented until 1970. The term "**mouse**" came about when the first prototype was built; Engelbart thought the connecting cord looked like a tail making the whole device look like its namesake ("Father" webpage). Because of all these technological connections, the human-to-machine interface would no longer require an advanced technical degree, or a hobbyist's savvy to actually use a computer. People would eventually be able to "point–and-click" because of the marriage of Doug Engelbart's mouse and Xerox's **GUI**. Xerox laid the groundwork for the modern **PC**, but it would subsequently takeoff because of two potential business giants and one giant company. By the late 1970s, Steve Jobs, Bill Gates, and IBM would define and mass market the work that Xerox had done up to that point.

Apple had become successful with the Apple II product line, and by 1979, it made the company viable. That viability was predicated on a particular **killer app** that was released in October of that year. A "**killer app**" is a "**killer app**lication" that compels users to buy a machine just to run the program; for Apple, it was VisiCalc. VisiCalc was an application program written specifically for the Apple II by Dan Bricklin and Robert Frankston. The partners started a company called Software Arts around their creation and began selling VisiCalc, which was essentially a virtual ledger sheet and calculator all wrapped into one (Friedman, *Electric* 103 & Cringely *Accidental* 68). Programs like this became known as spreadsheets, and unlike IBM's earlier attempt in the mid-1960s aimed at CEOs, the newly minted MBAs that were spilling out of America's business schools could now manipulate the business quanta that were the building blocks of corporate commerce. *Now* there was a reason to have **PC**s on every businessman's desk, and Apple took advantage of that, but Steve Jobs not being one to sit still, was already looking towards the future. Big changes were coming, but it would be based on the **PC** world that Xerox envisioned.

In December of 1979, Steve Jobs and a team of Apple engineers received a tour of the Xerox PARC facility. Once Jobs saw the direction that Xerox was taking microcomputers, he immediately scrapped all the work Apple was doing on its next generation of machines and redirected it towards what would become their most successful computers, the Macintosh line (Cringely, *Accidental* 189). Xerox's Alto had profoundly affected Steve Jobs, and *now* the direction **PC**s would go in, would include a **GUI**, a **mouse**, and a keyboard separate from the base unit. In parallel with Apple's efforts, IBM had seen the business possibilities of microcomputers. The decision by one of the largest companies in the world was to lead to the battle royal for **PC** supremacy.

By 1980, IBM set up the equivalent of Xerox's PARC in Boca Raton, Florida. The key difference between the microcomputer design effort and the rest of IBM business ventures was that this group was fairly autonomous and was allowed to be as nimble as necessary in order to compete with the Silicon Valley wiz kids. So, they set a deadline of one year to develop a PC from scratch. The way to do that was to use parts and designs that were nothing special, nor proprietary; everything was off-the-shelf including 99% of the **IC** chip sets inside the box. But what IBM *did* need was the software to run the whole thing; *that* they could not develop in the short amount of time allotted. This meant IBM had to go into business with one of those wiz kids who fortunately did not reside in Silicon Valley, but had the same business perspective and cowboy attitude: enter Bill Gates and Microsoft (Gringely, *Accidental* 126 &131).

The IBM team at Boca Raton erroneously thought that Microsoft, a fairly new company, developed and sold what is known as an **Operating System (OS)**. An **Operating System** is the software that is the traffic cop inside the computer. It manages how other software and associated functions through the hardware (i.e.: keyboard, mouse, and monitor) are handled by the **Central Processing Unit (CPU)** that is the brains of the **PC** operation. Bill Gates offered to set the record straight, and shunted IBM towards a company called Digital Research that was already in that business by the late 1970s. In the meantime, Gates was able to do business with IBM because an **Operating System** needs a subset of software to actually work inside a **PC**. This was something that Bill Gates and Microsoft *could* supply. The software language was known as BASIC, something developed years earlier and put into the public domain. It allowed for programming the computer to perform various functions as well as acting as the agent that mediated the "1s" and "0s" inside the electronic circuitry. The significance of the serendipitous connection between IBM and Microsoft was that Digital Research was not timely in responding to IBM's request. So, IBM went back to Microsoft to see if they could supply a complete package, which included BASIC as the machine language bundled with an **OS**. In attempting this, Bill Gates and Microsoft went shopping themselves and settled on a product named QDOS produced by Seattle Computer Products that was very similar to what Digital Research had produced. Bill Gates struck a deal and bought QDOS from Seattle Computer Products for $50,000. It was a gamble, and if the deal with IBM had fallen through, Microsoft possibly would not have recovered. In any case, it worked and Microsoft became *the* supplier of software to IBM for their **PC** venture (Cringely *Accidental* 132-134). QDOS became known as MS-DOS and the rest is history as IBM crushed most other competitors except for Apple.

In 1981, IBM released its first PC model 5150 (Figure A10) ("The Birth..." webpage). This would change everything with computing, and quite possibly, how people interacted with the world in general. Three years later, Apple premiered the Macintosh (Figure A10) with a lavish Super Bowl commercial invoking George Orwell's *1984*, and IBM upgraded its product to the more powerful PC-AT running Microsoft software ("Timeline/1984" webpage). These two would go head-to-head for the next two decades until IBM sold its PC business, by then known as ThinkPad, to China's Lenovo Group Limited in 2004 ("2004" webpage). The IBM AT and Macintosh machines had all of Xerox's innovations, while Microsoft parlayed the point-and-click, icon driven architecture into billions along with another Xerox design known as **WYSIWYG** (wizzy-wig). The latter software translated the words and pictures displayed on the monitor to something that resembled exactly what you would see in print. Both companies

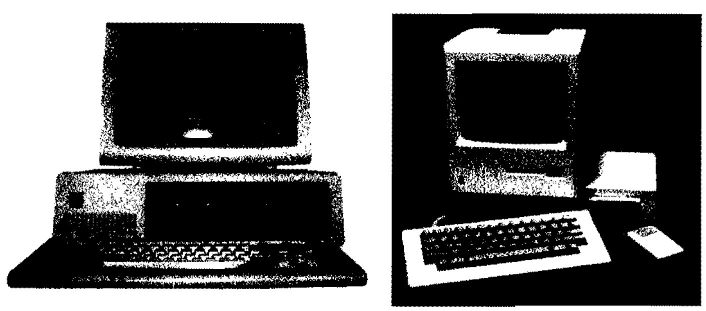


Figure A10 - The IBM PC 5150 and the Apple Macintosh Classic

perfected all these innovations, and as a result, Microsoft of course ended up with Windows (Hiltzik, *Lightening* 289). In 1979, Bill Gates hired Charles Simonyi, a creative software writer who was part of the Xerox PARC crew. He brought with him the aforementioned **WYSIWYG**, which he created, and a penchant for application software. Simonyi would head application development for Microsoft. The result would be Microsoft Word and Excel, two applications that became the anchors for the Office suite of applications that most computers use today (Cringely, *Accidental* 111-112 & Hiltzik, *Lightening* 289). Eventually, Xerox tried to market their innovations, but it was too little, too late. What could have been the cornering of the entire **PC** market merely became bad business decision-making.

The evolution of mainframe and **PC** computers eventually led to today's **servers**. Any **PC** today can be used as a **server** in terms of functionality since they are fairly powerful systems, but large scale data file handling, printing, or computer network security requires even more powerful machines than just a plain old **PC**. Today we use blade servers (Figure A11) as the backbone to large computing needs in-house and to service Internet websites. The computers are built compactly allowing the units to be

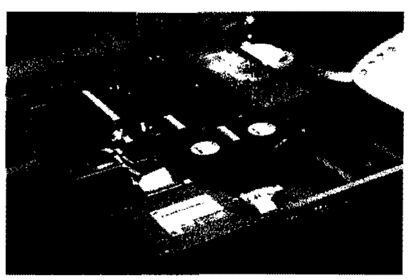


Figure A11 - View of a Blade Server

slid into a 19"x84" rack (Figure A12). A blade server rack is really an array of computers working in concert on any specific function required. The overall computing architecture we use in this server-based world is known as **peer-to-peer**, distributed

Figure A12 - A 19x84 inch Server Rack with Slide-out Monitor

processing, where all computers talk directly to each other and access higher functioning systems like those pictured above. One of the first major deployments of blade-servers was in the original Google network of the late 1990s. Unlike like their competitors, Google decided not only to concentrate on software that would run the searches users requested, but to build their own hardware as well. The logical idea would have been to buy large, expensive processing systems and focus on the software, but cofounders Larry Page and Sergey Brin, both Stanford University computer science graduate students, had a different concept. They had a team of engineers take a number of PC motherboards,

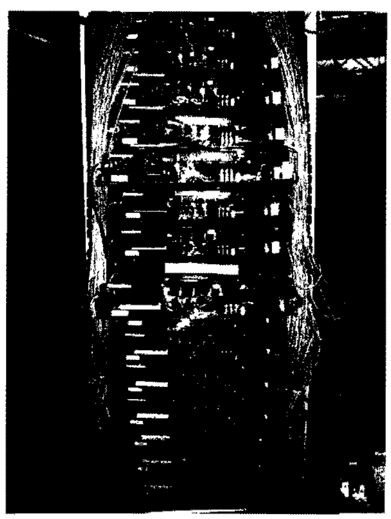


Figure A13 - One of Google's First Server Bays effectively the complete internal workings of a microcomputer, and laid them into racks on corkboard to separate them physically. Then they connected them all together with **patch cords** to basically create an array of processing units that could work together processing extremely quickly (Figure A13) (Stross, *Planet* 48-49). This server architecture along with devices known as **routers** became the Internet backbone design and provides all of us with the information we all seek.

The Internet

Suffice it to say, like computers, it took a lot of people as well as some timing and luck and a lot of effort to create the Internet. The Internet's beginning goes back to the early 1960s as a concept for many computer scientists at research centers like MIT, Stanford, and UCLA. But the trigger for the eventual outcome, like all things large and with national consequence, was the federal government. Just as computing systems started as government subsidized efforts during WWII, so too the Internet was born of concerted and focused government intervention.

In 1962, J.C.R. "Lick" Licklider was writing memos about the idea of an "intergalactic network" where computers could access and share information for research purposes. He was a research professor at MIT who would become the first director of the Information Processing Techniques Office (IPTO) within a fairly new government entity known as ARPA ("Internet History" webpage). The Advanced Research Projects Agency resided within the Defense Department, and funded and administered development of cutting edge technology that had military implications. ARPA was created in 1958 by directive in response to the Soviet Sputnik satellite launch that started the Cold War technology race (U.S. DoD & Van Atta "Fifty…"). The Cold War conflict included more than just competition in space-based technology though. Computing was at the heart of any advanced research in those days, and information was as good as gold. Although by this time the United States was far advanced in computing technology, Licklider's idea was not completely new. An earlier mathematician and scientist, Vannevar Bush, thought about information and how the human mind dealt with it in relational, or associative, processes. His ideas came about in the 1930s, but it wasn't until he wrote an essay titled "As We May Think" for the July 1945 issue of *Atlantic Monthly*, that he outlined this concept explicitly. Referring to a device known as a memex (possibly "memory exchange"), Bush discussed in the essay the way a person could access and call up a "library" of information using an electromechanical device with keyboard and levers, correlate and update that information, and restore it all for later use. Many of the computer scientists whose eventual work on what became the Internet attribute their understanding and vision to Vannevar Bush.

By the end of his two-year tenure at the IPTO, Licklider had started the process that would become the **ARPANet**, the Advanced Research Projects Agency's connective network of research computing resources that linked both government and research university computers. Licklider contracted with MIT, UCLA, and Bolt, Beranek, and Newman (BBN) to build the architectural platform that would become the ARPANet, but by 1964 he returned to MIT ("Internet History" webpage). By the late 1960s, the basic concepts of earlier development were being put into practice, and it appeared that computer-to-computer communications could work in practical application. To get to the practical phase of the colossal project, disparate elements had to fall into place, like the incorporation of British scientist Donald Davies' **packet switching** theory into the architecture. Packet switching would become the blueprint for all future digital networking. The network architecture would include packet-communicating devices that "front-ended" all the processing systems (the computers) by sitting between them. This would allow a way to access the information stored on the computers. Each communicating device was a **node** in the overall network. The front-end devices were designated Interface Message Processors (IMP) managing the packet switching. The ability to move the information around and correlate it was borrowed from work that Doug Engelbart had done at Stanford Research Institute (SRI) ("Internet History – the 60s" webpage).

Engelbart and his team had created a way to do research on the computers in their laboratories. The drive to do this came from ideas predicated on his exposure to Vannevar Bush's "As We May Think" article. He, along with computer visionary Ted Nelson, another Bush disciple, saw the need for an electronic library concept with the ability to correlate information and quickly get to it all. Nelson, who had a degree in philosophy and a master's in sociology, focused on the human-to-machine interface issues conceptually ("Internet Pioneers" webpage), while Engelbart, the engineer and scientist, looked at the same issue from a technical and practical perspective. Both came to the same kind of conclusions around the same time. Nelson coined the terms "**hypermedia**" and "**hypertext**" attempting his own digital library language, while Engelbart developed oN-Line System (NLS) at SRI ("Internet History" webpage). By 1967, Nelson's concepts and Engelbart's programming were incorporated into the ARPANet project. Engelbart then reached back to the mouse, his earlier idea for manipulating computer information on screen, and patented it because now there was a requirement to connect the human to the machine in a unique way. That same year, the first thirteen locations on the ARPANet were announced and Engelbart's SRI was on the list as the first of two ("Internet History" & "A Lifetime Pursuit" webpages). The connection target was the ILLIAC IV, the most powerful supercomputer up to that time; it was built under contract for NASA, and it would be made available to major research centers around the country. The following year saw Engelbart and SRI demonstrate NLS and the mouse ("A Lifetime Pursuit" webpage). Then on October 29, 1969, UCLA, along with SRI situated on the Stanford University campus, "logged-in" for the first time to successfully complete the first peer-to-peer computer connection ("Internet History – the 60s" webpage).

All this early development up to that point would become the rudiments of the Internet. Early ARPANet consulting firm, Bolt, Beranek and Newman (BBN), had won the contract to build the IMPs, which later evolved into today's networking technology. And what Nelson and Engelbart envisioned because of Vannevar Bush, was the basis for the actual transmogrification of the ARPANet into the Internet.

In the 1970s, ARPANet expanded and honing the **protocols** that handled the computer communications became an issue. The computing languages, although packet in structure, tended not to be standardized as new computing centers were added to the network. In the meantime, Robert Metcalfe and partner David Boggs at Xerox's Palo Alto Research Center (PARC) had been concentrating on networking all of the microcomputers built by Xerox engineers in their facility. These efforts would become significant to the final steps needed for the Internet.

Metcalfe was a graduate student at Harvard in the early 1970s, and had also been working as a part time engineer on the ARPANet. He was directly responsible for the

IMP communication devices and became a valuable commodity by 1972. After Harvard, Metcalfe took a position at PARC and almost immediately was assigned to network all the new Alto PCs that had been built at there. Eventually Metcalfe had begun to toy around with a packet-based process that the University of Hawaii was using to integrate all *their* computer centers spread among the islands. Dubbed ALOHAnet and modeled after the ARPANet, the university was sending information via radio transmission back and forth with a homegrown **packet protocol**. Metcalfe used the basic construct, but modified it for transmission on copper cable links, and in 1973, wrote the first memo to PARC's patent attorney's describing "Ether Network," or **Ethernet** (Hiltzik, *Dealers* 144-148). Both he and Boggs perfected the protocol and it was deployed internally at PARC with Xerox looking to interconnect all their computing around the country with this homegrown **protocol**. In parallel, the ARPANet engineers were trying to solve the same issues; Metcalfe and team were invited to meet with ARPA personnel to discuss what they might be working on. Xerox company lawyers forbade providing any proprietary ideas about PARC's network. Excited about their progress on network computing, Metcalfe et al ended up providing assistance to their ARPA counterparts through veiled conversation and indirect sharing of concepts in an attempt to circumvent the lawyers' concerns. After all, research is a free and open activity; it is meant to be shared by all, even if lawyers don't agree. Eventually, the ARPA team developed **T**ransmission **C**ontrol **P**rotocol **(TCP)**, something that was similar to **Ethernet** (Hiltzik, *Dealers* 220-221). By 1980, **TCP** was modified to include an **I**nternet **P**rotocol **(IP)** as an adjunct, making the whole **TCP/IP** suite more robust and dependable. **Ethernet** became the standard and **TCP/IP**, or **IP** for short, became the implementation. **IP** is what all computers and the entire Internet use today to seamlessly connect us all to each other and the information we seek.

By 1974, ARPA had fulfilled its initial mission of overseeing development of a research computer network. In the meantime, the National Science Foundation (NSF) was supporting a computing and research network as well. Funding was flowing through the NSF to universities doing basic research and similar efforts of computer connectivity and information sharing. By the late 1970s, there were various computer networking efforts all aimed at providing access for basic research, of which the ARPA and NSF efforts were the most ambitious. The idea to connect the networks of connected computers seemed a logical next step. In 1977, this logical step resulted in a demonstration accomplishing the idea of internetworking. The test consisted of sending messages from a van belonging to Doug Engelbart's Stanford Research Institute (SRI), through the Radio Packet Network in San Francisco across the U.S. on the ARPANet, to University College London through a network using satellites called SATNET (Figure

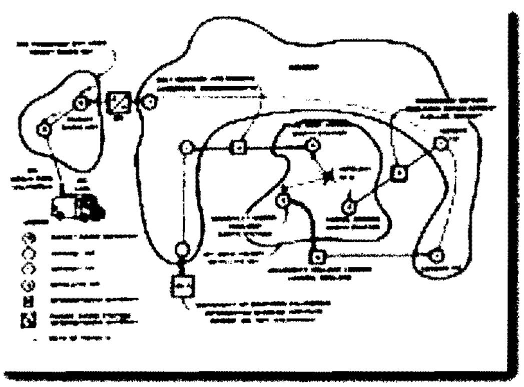


Figure A14 - Hand Drawn Map of the 1977 "internetting" Demonstration

A14). Those involved dubbed the concept "internetting", and for the first time, computer communications went international. The following year, ARPANet as a developmental experiment was officially complete, and the next few years saw efforts aimed at fostering the idea of free and open access to computing for research purposes ("Internet History/the 70s)" webpage).

ARPANet continued to grow in the decade of the 80s, adding NASA, the Department of Energy (DOE), and other government agencies. Support for "internetting" picked up momentum because of this. Two things happened in 1983 that solidified the path towards today's Internet though. The Department of Defense (DoD) decided to split away from ARPANet over security concerns and created a classified version deemed MILNET. In turn, the DoD decided that ARPANet would remain an open public network for research. The second important event was a plan presented by the NSF titled: "A National Computing Environment for Academic Research". It was a response to a report from a year earlier alerting NSF management and the federal government in general, to the fact the American scientists had to travel to Europe for access to U.S. designed and built supercomputers. In response, Congress authorized and mandated the NSF to address this issue, and spearhead an effort to make supercomputing availability for U.S. scientists a priority. The 1980s saw the NSF fund and begin to manage research computer networking directly. On March 9, 1999, then Vice-President and potential candidate Al Gore sat down to an interview with Wolf Blitzer of CNN. Among the discussions of the economy, President Bill Clinton's impeachment, and China, just a few minutes into the questioning, Blitzer asked what the differences were between him and then potential challenger, former senator Bill Bradley. The response was interesting, because it included an allusion to the Internet that set the tone for the upcoming campaign. Part of Gore's response to the question was:

> "...I've traveled to every part of this country during the last six years. During my service in the United States Congress, I took the initiative in

> creating the Internet. I took the initiative in moving forward a whole range of initiatives that have proven to be important to our country's economic growth…" ("Transcript…")

This one sentence reference to "creating" the Internet became an issue in the 2000 presidential campaign. In the early 1980s, it was the junior senator from Tennessee, Al Gore, who ensured the funding for the NSF to build out its research-computing network. No matter who took credit for "inventing" the Internet, and there was plenty to go around, the trajectory for it was set. Acceleration towards a national, then global, open access network linking virtually anyone to anyone was almost a foregone conclusion by the end of the 1980s ("Internet History/the 80s" webpage).

High-speed access between **nodes** for the ambitious supercomputer networking was made possible because of communications service providers like ATT. Timing can be considered everything in certain instances. In January of 1984, the divestiture agreement that the Justice Department and ATT consummated two years before came into full effect. As a result, much of the high-speed, digital communications infrastructure that was once internal to ATT was made available to the business public and government entities in monthly leasable increments ("A Brief History…" webpage). In addition, the development of digital networking equipment by companies like BBN (an original player in the ARPANet), made it possible for large corporations, research universities, and the Government to build their own high-speed digital networks. ATT became a major supplier of the specially conditioned lines that were needed to provide what was to become the **backbone** of these networks. The result of all this timing was a shift from government support predicated on a network developed for *government* research, particularly military, towards one that was more open and aimed at pure *scientific* research. The development work and funding efforts of ARPA, whose name changed to

DARPA by the early 1970s (Van Atta, "Fifty…"), are not to be looked at as insignificant. ARPA was the incubator, but the Internet began to move into its final days of gestation because of the NSF and the opening of competition between ATT and its competitors making high-speed interconnection available. The result is that by 1985, the NSF announced contract awards of five supercomputing centers:

- Cornell Theory Center (CTC), directed by Nobel laureate Ken Wilson;
- The John Von Neumann Center (JVNC) at Princeton, directed by computational fluid dynamicist Steven Orszag;
- The National Center for Supercomputing Applications (NCSA), directed at the University of Illinois by astrophysicist Larry Smarr;
- The Pittsburgh Supercomputing Center (PSC), sharing locations at Westinghouse, the University of Pittsburgh, and Carnegie Mellon University, directed by Michael Levine and Ralph Roskies;
- The San Diego Supercomputer Center (SDSC), on the campus of the University of California, San Diego, and administered by the General Atomics Company under the direction of nuclear engineer Sid Karin.

The significance of this singular event is more about what came afterwards. The regional computing centers were to be the hubs of regional computing networks, providing connectivity to researchers for the cost of access. These individual spider webs of computing networks would eventually become interconnected themselves and evolve into the Internet ("Internet History/the 80s" webpage).

The NSF-funded regional networks had names such as JVNCNET, SDSCNET, SURANET, BARRNET, and NYSERNET ("Internet History/the 80s" webpage). At their cores were the regional supercomputers that science research so desperately wanted to reach. One of these networks, the New York State Educational Research Network (NYSERNET), developed access for the entire state university system. There are thirty-four campuses in total within the State University of New York (SUNY); four are university centers. These four are the largest and most important when it comes to research. Buffalo, Binghamton, Albany, and Stony Brook were to become hubs on

NYSERNET. The state Office of General Services, the equivalent of the federal GSA, was to work on the NYSERNET **backbone**. The target was Cornell University's supercomputers because Cornell is part of the state system through its agricultural land grant college. From 1986 to 1989, this author led the design of the networking pilot program for the State University of New York (SUNY) itself, which was an integral part of the NYSERNET effort. As part of the head-end of the SUNY system's administration, my department was responsible for connecting the thirty-four campuses to each other, and to ensure that the four University Center hubs accommodated the NYSERNET supercomputer access. The goal was the "internetting" that was proven a few years earlier by the pioneer computer researchers. This regional "internetting" went on all over the country during the middle to late 1980s setting the stage for what was to come by early 1992.

From 1986 through the end of the decade, these regional supercomputer networks made up what was to become known as NSFNET. General funding for the **backbone** and network management resided within the aegis of the NSF. The network expanded fairly rapidly under its oversight. Service provider competition between the likes of ATT, MCI, and Sprint began driving down the cost of high-speed digital links during this period. Consequently, expansion began to increase almost exponentially. Standardization began to take hold and companies like Cisco Systems would become major players as **IP** transport was pulled into the global standards ("Internet History/the 80s" webpage). In 1989, the number of hosts jumped from 80,000 in January to 160,000 by November. That same year, Tim Berners-Lee at CERN proposed to move away from the hierarchical construct of network trafficking of information. The constant churn of expansion and change within the NSFNET put stress on the way in which information was accessed and shared. Berners-Lee decided to reach back to the **hypertext** concept of earlier pioneers like Ted Nelson. In doing so, he would present the World Wide Web (WWW) architecture for language software that treated the entire "internetting" universe as just that, a global "web" of interconnectivity. The **hypertext** protocol allowed for different computer **hosts**, on different interconnected networks, with disparate **operating systems**, to jump into the web and communicate across the information universe in a common way; thus, standardizing easy access to one and all ("Internet History/the 80s" webpage). For his efforts, Berners-Lee was eventually dubbed the father of the World Wide Web.

Because the NSFNET became the vehicle for free and open research, the original ARPANet was no longer necessary. Although the ARPANet was the incubator, all military functions were ported over to MILNET and civilian use was usurped by the NSFNET. As a consequence, the ARPANet outlived its usefulness and the lights were turned out in 1990. That year saw 300,000 hosts as part of the NSFNET, with an increase to 7,500 different networks comprising the "web", and a jump to 1,000,000 hosts transmitting over 1 trillion **bytes** of information per month in 1991. The following year, the term Internet entered the general lexicon, and 1992 became its official birthday. Two students at the University of Illinois at Urbana-Champaign got together and took Tim Berners-Lee's hypertext concept one-step further, to develop the first true web **browser** application using **H**yper-**T**ext **M**arkup **L**anguage (**HTML**). Larry Smarr and Jim Clark created MOSAIC and founded Netscape within a few weeks of development. Now the general public as well as the scientists, mathematicians, and physicists could access almost limitless information. No longer did a person need an advanced degree to navigate the information highway the Internet became. And since 1992, what was a doubling of **host** sites and access points each and every year would become a doubling every three months ("Internet History/the 90s" webpage). Today, the Internet has become an incredible changer of culture. It is so integral to everyday life that it seems as though it was always available. Anyone can access it with a communicating device. Its impact has been global and profound; it, along with the computing and communication systems that *comprise* the Internet, has changed the world forever.

The Mobile Device

Unlike the computer, the cellphone as precursor to the modern mobile device did not require a specific killer application to make it necessary in the public consciousness. The cell phone was straightforward and not that difficult to use. There was a familiarity to it. It was basically a phone and everyone knew how to operate one of those. The major difference was obvious, it was wireless; yet, it was still a phone. The driving factors for acceptance were cost and the ability to call anyone, anywhere. These were simple objectives for the companies that chose to pursue cell phone technology as a business.

Wireless technology has been around since Marconi and his first successful transmitting system in the 1890s, and the concept of two-way mobile communications has been in the public consciousness since the days of the Dick Tracy comic strip. In 1946, the author, Chester Gould, introduced the American public to the two-way wrist radio (Roberts, Dick Tracy 38). This solidified the idea of personal, mobile communications. Up to that point, only the military and police had mobile radios, and even though Dick Tracy was a police investigator, there was something about his wrist radio that caught the imagination. It could be possible for mere civilians to use the cutting edge technology as a personal communicator. A little more than twenty years later, Star Trek provided the form personal communications would actually take once the science was practically applied to the technology in the real world.

The first successful commercial attempt to apply wireless technology concepts to phone calls actually happened in Sweden in 1956. The Swedish telephone technology companies TeliaSenora and Ericsson developed a wireless system after WWII and tested it in 1951. Since the electronics of the day were bulky and expensive, the application was aimed at vehicles; thus, the car radiophone made its debut by the middle of the 20th century. Radiophone technology was not new since it was available on ocean going vessels in the 1930s. Ericsson's system was designated Mobile Transmission System A (MTA), and boasted an automatic switching capability that most landline based networks did not yet have. Although radiophone systems were in development and deployed in the late 1940s, automatic switching is what made Ericsson's version unique from earlier attempts to equip vehicles with radiotelephone technology. The result was that an operator connection was not required, and the MTA was fully integrated into the public switched telephone network (PSTN) (Tekniska Museet, "Mobilen 1950-60" webpage). This allowed for crossover between the wireless and wired phone system connections. Since the technology and its use were fairly expensive, and distances limited, the first applications found their way into police force communications as well as the military.

In the United States, ATT Bell Labs was also homing in on wireless telephony around the same time as Ericsson. The thought process was more about personal mobility, but yet again, the bulky and costly state of the electronic components (particularly the antennas needed at the time) presented a barrier to practicality.

Eventually, ATT also opted for the car version in the 1950s (Levinson, Cellphone 31). But the communication device that could be held in the hand and carried in the pocket was not a dead idea. ATT did not pursue this form of mobile communications, but Motorola did.

Founded in 1928 by brothers Joseph and Paul Galvin as Galvin Manufacturing, Inc., and located in Chicago, IL, the company would eventually change its name to Motorola by 1947. In 1973, the company's director of research and development (R&D), Martin Cooper, would make the first "cellphone" call to Dr. Joel Engel, his friendly rival at ATT. ATT eventually caught the bug of telecommunications mobility as well, and the two companies spent hundreds of millions of dollars beginning in the late 1960s trying to develop the technology (Levinson, Cellphone 31). Motorola won the race by a nose, and in 1973 the prototype was available (Figure A15), and by 1983, the first commercial version of a cellphone hit the market (Figure A16) ("About Motorola - Timeline" webpage). According to a 2009 survey by CTIA - The Wireless Association, as of June 2010 there were 282.8M subscribers in the U.S., with a 93% penetration rate and 24% of

Figure A15 1973 Prototype Motorola DynaTAC Cellphone

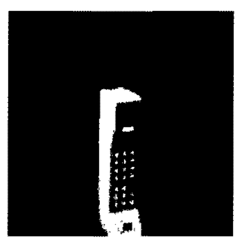


Figure A16 First Commercial Portable Cellphone 1983

that as wireless-only households. The growth in usage has been immense in just under forty years ("CTIA Media" webpage). But the real game-change would come when how we all would use the cellphone shifted from mere voice communications to ubiquitous information access-or of data, and transmitter of ideas in various formats.

It has been the evolution of the cellphone over the last decade into "smartphone," then into mobile device, that has brought about the most significant change in how we communicate and even think. The power of the latest generation of electronics and the drive by users to do more with the pocket-communicating device has opened new possibilities of how we interact with information and each other. The journey to today's devices began in the early to middle 1990s, when of all companies, stodgy old IBM developed Simon in conjunction with Bell South, and ATT introduced EO (PC Magazine – Personal Communicator). These were multifunctioning cellphones that had added applications such as an address book, calendar, email, note pad, faxing capability, and maybe a few games. Eventually digital cameras and digital video recording were added along with MP3 players and texting. The smartphone was essentially an amalgam of a Personal Digital Assistant (PDA) and a basic cellphone. PDAs had been around for a few years when the hybridizing concept was being born. Palm, Inc. was the premiere PDA company from the late 90s into the 2000s, and its Palm Pilot was the electronic tool that replaced almost every businessperson's Filofax® or Day Runner®. The mash-up of cellphone and PDA may seem inevitable with 20/20 hindsight, but it was not a forgone conclusion. The Simon was expensive and clunky, and it wasn't until electronic chip technology caught up to the concept did the possibility become evident.

The next iteration of smartphone, and great leap forward, was the BlackBerry in 2002 (PC Magazine – Smartphone). Its main function was Email, and it was primarily useful to large business concerns, but the true game-changer was Apple's iPhone in 2007 (Honan "Apple"). The iPhone was the first handheld platform that had an **IC** processor like an actual computer. This meant that an **Operating System (OS)** could be employed making the possibilities for functionality almost limitless. For the first time, a person could hold in the palm of their hand a fairly powerful computer for a few hundred dollars. It was also architected like a PC, in that applications could be written for it and loaded into the device at a later time. Even though PDAs used processors, they were essentially fixed functioned and outside developers couldn't really add on to the device. The iPhone concept was to essentially put a Macintosh computer in every hand, have them access the Internet, record events, and send and receive information in various formats. The iPhone was a handheld computing device that happened to have a cellphone function as part of its suite of capabilities. Competition was not far behind though.

In 2005, Google, the major search engine and software company, bought Android, Inc., a start-up that was developing an **Operating System** for handheld hardware manufacturers to use in their devices (Elgin "Google Buys Android…"). The difference between Google's and Apple's approach is that Apple owns the device and the **OS** inside. Android is the first third party open system version **OS** that attracted companies like Motorola and Korea based HTC to build devices around the software. Where Apple opened the door, others have followed. With the advent of the iPhone, the cellphone evolved into a computing device that communicates and manages information. Now the mobile digital device is connected with the Internet as well as phone service, and functions like texting, GPS, and **WiFi** are part of the norm. In addition, there are an incredible amount of third party applications that can be added by downloading them over the air. Now, for a few hundred dollars, users have access to more information than ever before while maintaining their mobility. We are no longer stuck at a desk or any other fixed place while we gather and manipulate information. Even with a laptop we are not as mobile as we think. This is the first time people have become truly mobile while staying connected to information and each other at distance.

Digitization and Storage

The technology of digital imaging has evolved radically over the past several decades, but what it means to be "analog" or "digital" requires some understanding and definition. As defined, analog means the comparability of one thing to another. In the case of the physical universe, all energy and particle matter travel in smooth and continuous waves. These waves are continuously variable and comparable in their opposite polar transitions. Examples of natural analog phenomenon can be understood in our perception of light wave-particles as they travel through space and create the images in our minds of the world around us. It can also be understood as we hear the acoustical wave-energy moving through air molecules that we identify as sound. This is the natural state of things, and in human attempts to reproduce or represent what we think and perceive, we initially developed technology that emulates the smooth and continuous, transitional wave-action of the energy around us.

The antithesis to analog is digital formatting. It is the pulsing of something on and off, much like flicking a light switch to pulse the light in a room. Each pulse represents a discrete **bit** of information, the collective pattern of which can represent any kind of information imaginable, particularly if the patterns utilize mathematical language in their representation. This is the man-made domain of digital technology, and many devices emulate this functionality. If an information signal is naturally analog it can be converted to digital; conversion requires representation of discrete bits of analog information that ultimately make it digital. Analog-to-Digital, or A-to-D, conversion uses the basic technique of wave sampling and mathematical representation of a predetermined number of points on the analog curve. Much of the information of a wave is ignored in this process. This is known as the sample-rate, and if the sample-rate could be made high enough, our minds fill in the minute gaps of missing information (Figure A17) (Wilson "Computer").

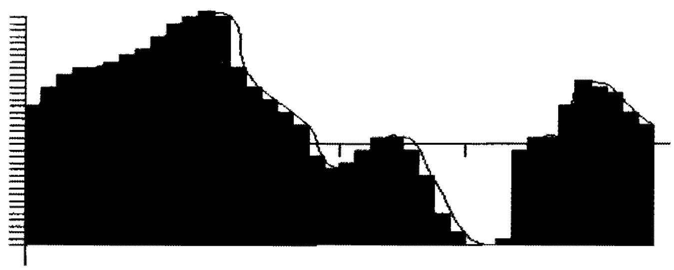


Figure A17 – A-to-D Conversion (HowStuffWorks)

Packing and storing these bits of information is much more efficient than storing analog forms and can be done in less space at less cost than analog. Ultimately though, what we are really discussing is the manipulation of electromagnetic energy. Electricity in its natural form as lightning follows the physical laws of wave-energy, but as digital in our electronic-based technology, we are effectively pulsing "on" and "off" the energy in patterns that mathematically represent ideas and information. One very powerful application of digital technology is digital imaging. It can be defined as:

> "A field of computer science covering digital images, images that can be stored on a computer ... Digital imaging is a wide field that includes digital photography, scanning, and composition and manipulation of bit-mapped graphics ("Definition")."

The first apparent use of digital imaging took place in 1951, when the first videotape recorder was used to capture live images from television and then convert them into electric impulses. The impulses were directly transferred onto magnetic tape ("History of the Digital Camera"). NASA originally used this technology in its space program of the 1960s by first capturing images on videotape, and then transforming the images into digital formatting using computers. However, a problem with this quickly revealed itself, as the transference into digital images apparently resulted in signal interruption and loss during the process. This fostered the development of the first digital cameras, which made digital images right from the start rather than converting images on videotape using computers. The accomplishment was achieved by converting light rays into electronic signals known as pixels. The term was first used in relation to digital imaging by Fred C. Billingsley of CalTech's Jet Propulsion Laboratory (JPL) in the mid-1960's (Lyon "A Brief History of Pixel" 1). It is of no surprise that, while this technology was extremely useful for NASA's space program, it was not practical for everyday use, as the technology was still unaffordable for the general consumer ("Viva").

During the 1970s, the technology of digital imaging made slow advances. Studies done by Kodak, Canon, and RCA were able to convert light into digital images in a way similar to that used by NASA in the 1960s. A landmark in the evolution of digital photography occurred in 1979, when Emory Kristof used an "electric camera" to take photos of underwater life for an issue of National Geographic ("Viva"). Yet, digital photography was still being used for only science and exploration. Pixel technology became the focus of digital imaging by the early the 1980s, as it became the domain of **Integrated Circuit (IC)** microchips. This allowed computers, and digital cameras at a later date, to work more reliably and affordably ("Viva").

Oddly, the technology of scanning of photographic prints developed more quickly than taking digital images themselves. By the mid to late 1980s, photographers could take photographs and then scan them for conversion into digital images. The digital camera of this era was still out of reach for most consumers. Eventually, cheaper consumer electronic versions became available due to lowering electronic component costs, and by the 1990s, digital cameras started their wider use in public hands.

To produce an image from a digital photograph the following steps are necessary. A digital image is composed of a series of either dots or squares called *pixels*, which originate from the words picture elements. Each image is comprised of a series of many pixels that contain shades of grays and colors, and are placed in a consecutive order to form a composite, which creates a complete digital image. The information contained in these pixels is obtained by the digital imaging device taking samples of the colors and light intensities of objects at regular intervals. Within a given area, the more the pixels, the higher the quality and accuracy of the digital image. The more pixels present within a digital image per unit of area such as an inch, the truer that image is to the original object; this is known as "resolution" (Besser 3). A digital image is only as good as the device it is viewed on, so resolution in viewing is as important as the development process. A viewing device must have at least as many pixels as the same area covered by the digital image. Otherwise, the viewed image will be of lesser quality than the digital image taken. More simply put, the quality of the digital image viewed is closely related to the quality of the device being used to view it (Besser 15).

Regardless of the size of the digital image created, the image eventually needs to be saved in one of many formats depending on the use of the image. Digital images can take up a lot of storage space depending on the resolution and color variation. Therefore, various compression methods are used depending on the need for visual quality. TIFF (Tagged Image File Format) files are highly desirable for preservation purposes because the image is uncompressed in a format that represents all the information at the time of creation. Compression becomes an issue when storage or transfer of digital files is required. Digital image compression generally applied is about noting of redundant information. The pattern of redundancy is held in mathematical equations known as algorithms, which describe the sampling in comparison to the original. The mathematical algorithm gets more complicated as the amount of compression increases. Common formats of image digitization and compression are Joint Photographic Experts Group (JPEG) and Graphics Interchange Format (GIF). The decision as to which type of digital compression depends on the quality versus storage capacity and the image's color pixel makeup. For example, GIF formatting works better when color is repetitive, and JPEG, a more complicated algorithm, handles pixel variation much more efficiently ("Why..." webpage).

Information within the digital files that connote their format determines what they are and how they are to be handled by electronic processing systems such as computers or mobile devices. The files themselves have designators at the end of their names following the period or dot. For most images the common extensions are .TIFF, .jpg, or .GIF depending on formatting. Portable Document Format (PDF), which is common for printed documents, but can be used for objects as well, is effectively a picture of a document or an object. A document may also have images already imbedded in it; therefore, the PDF will represent the document as a single file appearing as it is printed.

The most common form of digital electronic storage, particularly on a mass scale, is the **hard disc drive (HDD)**. After the electronic analog signal has been converted, or an image has been born digital, it has to be stored using a magnetic pattern that represents the digital file. A highly polished aluminum disc (or large platter for extreme amounts of storage) is covered with a magnetic coating. It is encased in a drive system with its own processing electronics, and spins via a small electric motor as information is magnetically transferred through electrical connection utilizing the read/write arm and the tiny magnet at its endpoint. This principle is not much different than that of the original sound recording technique perfected by Thomas Edison; only, instead of carving grooves in wax or plastic, magnetic patterns are created on the disc that represent information (Figure A18 (Brain "Hard Disks").

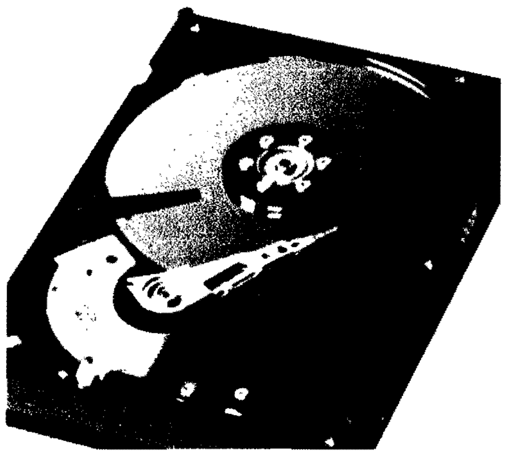


Figure A18 - Hard Drive with Disc (HowStuffWorks)

Before any information can be written, a hard disc must be virtually formatted. Therefore, a virtual, logical storage space must be created in order to manage file information. Since everything is accomplished magnetically, nothing is really touching. A hard drive is formatted for much the same reason a large box store such as Home Depot® or a large warehouse is formatted, so items inside can be categorized for storage and retrieval. Much like an empty warehouse, a hard disk needs order and labeling. Figure A19 represents what cannot be seen on the surface of a hard disc. The magnetic surfaces are arranged into tracks (yellow) and sectors (blue), and can ultimately be grouped into clusters depending on storage needs (Brain "Hard Disks"). All information from the device that controls this system, typically a computer, has to be processed according to these conventions. Thus, our ideas and information are relegated to magnetic patterns on a polished piece of aluminum. Alternate technology known as flash drives use the electrical pulses representing the digital files to store information

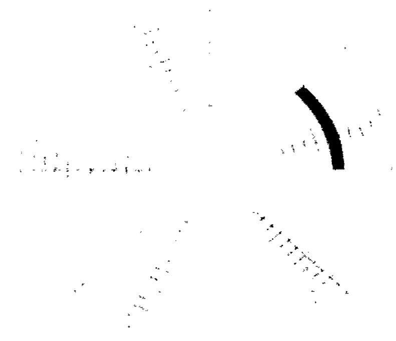


Figure A19 - Hard Disc Formatting (HowStuffWorks)

without the need for the mechanicals such as miniature electric motors and magnets. Flash drives are made of the same stuff as the electronic chips that process digital information inside a computer, but flash drive technology is limited in capacity and costs much more per unit than the current hard drive technology (Tyson "Flash Memory").

This is What the Stuff Is

It is hoped by this author that this truncated history of communications technology development helps with a basic understanding of what it is and where it came from. Not every contributor was named, and not every development was explored in the timeline. The main goal has been to provide explanation and some level of comfort with the technology that every one of us is exposed to and interacts with on a daily basis. Tutorials for the non-technologist need not be too scary or complicated. As a result, it should not make it complicated for museum professionals concerning Information Technology use. It is possible to provide, in various forms, the training necessary for museum professionals to gain the knowledge and comfort factor required to make those decisions informed ones. Ultimately, the desire is that the above example has opened the door for those who wish to lead the effort of shaping the path of the digital generation.

Glossary of Technical Terms

All term definitions were taken from the following references: McGraw-Hill Dictionary of Electronics; Wiley Electrical and Electronics Engineering Dictionary (see Works Cited).

backbone 1. The connections that form the major pathways of a communications network, large or small. These handle the bulk of the traffic, and generally communicate at very fast rates, often over great distances. 2. A network topology in which the **backbone** is the hub to which all subnetworks are connected. Used, for instance, in medium sized **LAN**s.

binary A number system with 2 as its base that uses only the digits 0 and 1. Binary logic is based on one of two states, "off" or "on," or 0 and 1, respectively. The binary system is the numerical coding used in most digital computers.

bit An abbreviation for *binary digit*. There are two: 0 and 1. A bit is the basic data unit of most digital computers. A bit is usually part of a data byte or word, but bits can be used singly to control or read logic "on-off" functions.

bit map The bit pattern stored in a computer's memory that corresponds to the pixel pattern to be displayed on the computer's monitor where each pixel is being represented by one bit.

byte From the expression "by eights." A group of eight contiguous bits (binary digits) treated as a unit in computer processing. A byte can store on alphanumeric character.

batch processing In computers, a technique in which data to be processed is coded and collected into groups prior to processing.

central processing unit (CPU) The heart of a computer system that executes programmed instructions. it includes the *arithmetic logic unit* (ALU) for performing all the mathematical and logic operations, a control sections for interpreting and executing instructions, and internal memory for temporary storage of program variables and other functions. see also *microprocessor*.

Ethernet A widely-used high-speed LAN [protocol] defined by the IEEE 802.3 standard. Ethernet can use a bus or star topology, utilizes CSMA/CD [Carrier Sense Multiple Access/w Collision Detect], and transmits data in variable-length frames [packets] of up to 1,518 bytes. There are various versions, the most common using coax cables [obsolete], while others use twisted-pair wiring [most common], or fiber-optic cable. Depending on the version, Ethernet can support data transfer rates from 10Mbps [Mega bits per second] to over 100Gbps [Giga bits per second]. Also called **Ethernet network**.

Graphical User Interface (GUI) The capability for human intervention in the formation of graphics on a computer display with a combination of window displays, menus, icons, and a mouse or trackball.

hard disk (drive) A magnetic storage medium used in computers, which consists of one or more rigid platters which rotate at very high speeds. Each of these platters, which are usually made of aluminum, is coated with a material which enables information to be encoded by alternating the magnetic polarity of minute portions of the surface on each side of said platters, using read/write heads. Its abbreviated **HD**. Also called **hard disk drive (HDD), hard drive**, or **rigid disk**.

host (computer) 1. Within a network, a computer that provides users with services such as access to other computers and/or database, and which may also perform control functions. Over the Internet, for instance, a host computer may be accessed by a user from a remote location who seeks access to information, email services, and so on. 2. Any computer connected to a network, such as a **TCP/IP** network.

icon On a computer screen, a small displayed image which serves to represent something else, such as a file, program, disk drive, function, and so on. Icons are used in **GUIs**, and are usually accessed, moved, or otherwise manipulated by using a pointing device such as a **mouse.**

integrated circuit (IC) A monolithic semiconductor device that contains many active components (diodes and transistors) and passive components (resistors, capacitors, and inductors) which function as a complete circuit.

Information Technology (IT) The field dealing with the gathering, processing, manipulating, organizing storing, securing, retrieving, presenting, distributing, and sharing of information, through the use of computers, communications, and related technologies.

killer app Abbreviation of **killer app**lication. A computer application that is just dynamite.

LAN Acronym for **L**ocal **A**rea **N**etwork. A computer network which is limited to a small geographic area, usually ranging from a single room through a cluster of office buildings. A LAN consists of a group of **nodes**, each comprised by a computer or peripheral, which exchange information with each other. In addition to sharing data resources, users can communicate with each other, usually through emails or chats, and share peripherals such as printers. LAN connections may be physical, as with cables, or wireless, as with microwaves or infrared waves. There are various LAN access methods, including Ethernet, Gigabit Ethernet, and token ring [obsolete]. Common topologies include bus, ring, and star.

mainframe A term that now designates a large computer system compared to a workstation, personal computer, or minicomputer. it is capable of performing massive data-processing tasks such as telephone switching or bank transactions.

microprocessor unit (MPU) 1. A central processing unit (CPU) fabricated on a single large integrated circuit chip, containing the basic arithmetic, logic, and control elements of a computer that are required for processing data.

mouse A computer peripheral whose motion on a horizontal plane causes the cursor on the computer monitor's screen to move accordingly.

node 3. Within a communications network, a device, such as a personal computer, printer, or server, which is connected to, and is able to exchange information with other devices. Also called **network node**.

Operating System (OS) The software which runs all the software and hardware of a computer. It is the first program the computer loads when powered on, remains memory-resident, and continually controls and allocates all resources.

packet Also called **data packet** or **information packet.** 1. A block of data transmitted between one location and another within a communications network. 2. A block of data of a specific size, such as that transmitted in a packet-switching [or routed] network.

packet switching In a communications network, the transmission, routing, forwarding, and the like, of messages which are broken into **packets**. Since each contains a destination address, each of the packets of a single message may take different paths, depending on the availability of channels [paths], and may arrive at different times, with each complete message being reassembled at the destination.

patch cord A cord, equipped with connecting terminals such as plugs, utilized for patching. Also spelled patchcord.

peer-to-peer (computing) Computing in which the resources of multiple machines interconnected by a network, such as the Internet, are pooled. Its abbreviation is **P2P**.

Personal Computer (PC) A computer based on a microprocessor central processing unit (CPU) intended for personal use in home or office.

protocol A set of conventions for the transfer of information between computer devices. The simplest protocols define only the hardware configuration, while more complex protocols define timing, data formats, error detection and correction techniques, and software structures.

punch [tab] card A card which holds 80 or 96 columns of data, each representing one character, used by computers with card readers. [Originally developed by IBM and known as tab cards,] this is a practically obsolete storage medium.

real-time The performance of computation during the time of a related physical process, so the results are available for guiding the physical process. it is typical of industry control.

real-time data Data presented in usable form at essentially the same time the event occurs. the delay in presenting the data must be small enough to allow a corrective action to be taken if required.

real-time operation Computer data processing that is fast enough to be able to process information about events as they occur, as opposed to batch processing that occurs at a time unrelated to the actual events.

router In a communications network, or multiple interconnected networks, a device or software determines where packets, messages or other signals travel to next. A router, using resources such as header information, algorithms, and router tables, establishes the best available path from its source to destination.

semiconductors A class of materials, such as silicon and gallium arsenide, whose electrical properties lie between those of conductors (e.g., copper and aluminum) and insulators (e.g., glass and rubber).

server Also called **network server**. 1. Within a communications network, a computer whose hardware and/or software resources are shared by other computers. Servers, among other functions, control access to the network and manage network resources. There are various types of servers, including application servers, file servers, network access servers, and Web servers.

solid-state A reference to the electronic properties of crystalline materials, generally semiconductor—as opposed to vacuum and gas-filled tubes that function by the flow of electrons through space, or by flow through ionized gases. solid-state devices interact with light, heat, magnetic fields, mechanical stress, and electric currents.

TCP/IP Abbreviation of Transmission Control Protocol over Internet Protocol. A set of protocols which enable different types of computer systems to communicate via different types of computer networks. It is currently the most widely used protocol for delivery of data over networks, including the Internet.

transistor A generic term covering a class of solid-state devices that are capable of amplification and/or switching…a transistor can be a discrete device or it can be integrated into an IC.

WAN Acronym for **W**ide **A**rea **N**etwork. A computer network which encompasses a large geographical area, such as a city or country, with some WANs, such as the Internet, covering the globe. A WAN may be a single large network, or consist of multiple **LAN**s, with connections between **nodes** utilizing dedicated lines, existing telephony networks, satellites, or the like.

WYSIWYG Abbreviation of **W**hat **Y**ou **S**ee **I**s **W**hat **Y**ou **G**et. The ability to display on a monitor text and graphics exactly as it would appear if printed. In actuality this is only approximated, as printers tend to have much higher resolution than monitors.

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