Massachusetts Institute of Technology - System Design and Management

Can remote collaboration be adapted to the human?

by

Russell F. Wertenberg

Bachelor of Science in Computer Science
Notre Dame de Namur University, 1991

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

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Abstract

Creation, augmentation, and management of knowledge are all based on communication and interaction between people, not machines. The problem is most tools currently used for collaboration are optimized for computer to computer, not human to human, interaction. This causes the participant (in the human world) to adapt to the computer's (machine world) control requirements which often leads to increased anxiety and feelings of powerlessness. Such emotions can diminish and limit a participant's ability to effectively and efficiently collaborate.

Additionally many organizations (including NASA, aerospace companies, other corporate entities) and academia are becoming increasingly aware that senior leaders, managers, engineers, and other key individuals are approaching retirement age. The potential loss of their corporate knowledge has been recognized and ways to capture and transfer this knowledge must be researched, adapted, and implemented before the people that embody the knowledge move on. In fact globalization of the workforce (corporate) and student bodies (academic) has created a similar need to support individuals and teams collaborating and sharing knowledge between remote locations as a core critical requirement.

The problem that has not been effectively dealt with is how to eliminate the barriers to communication currently imposed by the physical distribution[1] of those with the knowledge and those whom can (quickly) benefit from it. Efficient (time and cost effective) and creative solutions must be developed to enable remotely located individuals to comfortably share information and knowledge.

This thesis establishes how current remote collaboration technology forces users to adapt to it and the need to develop a dynamic set of tools (the Collaboration Toolkit) and an associated System Architecture focused on supporting the unique *human* requirements (such as sociological, psychological, and physiological traits) of distributed users.

Thesis Supervisor: Janice Klein
Title: Sloan School of Management Senior Lecturer

[1] NASA, as an example, has 10 Centers and 3 major facilities located in Alabama, California (3), Florida, Maryland, Mississippi, New Mexico, Ohio, Texas, Virginia (2), West Virginia, and is headquartered in Washington, D.C.

Acknowledgements[2]

I must begin by thanking Claire Smith for suggesting I check out PMDP-ALO, little did I know what I was getting into. In a similar fashion I also want to thank NASA, Dr. Ed Hoffman, MIT, and Denny Mahoney for the wonderful opportunity I have been allowed. It is much appreciated and has been life changing. I pray I am able to live up to the trust you have all placed in me.
"Let us think of education as the means of developing our greatest abilities, because in each of us there is a private hope and dream which, fulfilled, can be translated into benefit for everyone and greater strength for our nation." John F. Kennedy (1917 - 1963)

To Tony Maturo and Anita Ibbott for their unflagging support of NASA PMDP-ALO. Without your efforts and diligence this program could not be a success. You allowed me to concentrate on a very different stage of my life and open myself fully to this learning opportunity.
"Learning is not attained by chance, it must be sought for with ardor and attended to with diligence." Abigail Adams (1744 - 1818), 1780

To Jeff Shao and Ted Hoppe, your unselfish support of SDM, and myself, by carefully shepherding us through the MIT maze of rules and regulations is the perfect counterpart to that of Tony and Anita and serves as a wonderful example of the thought to lead is truly to serve.
"I don't know what your destiny will be, but one thing I do know: the only ones among you who will be really happy are those who have sought and found how to serve."
Albert Schweitzer (1875 - 1965)

To Professor Crawley, truly you challenged us to think differently (go PO!) and it has worked, may it continue to do so.
"A teacher affects eternity; he can never tell where his influence stops."
Henry Adams (1838 - 1918), The Education of Henry Adams

To Ben Koo, I will always appreciate our discussions, they have been most challenging. May these continue well into the future. Best wishes for the completion of your PhD. I look forward to the honor of calling you Dr. Koo.
"Learning without thought is labor lost; thought without learning is perilous."
Confucius (551 BC - 479 BC), The Confucian Analects

To Dr. Jan Klein., your steadfast support, gentle persistence, insightful suggestions, and challenges are very much appreciated. I could not have completed this without your guidance.
"Our progress as a nation can be no swifter than our progress in education. The human mind is our fundamental resource." John F. Kennedy (1917 - 1963)

To my new SDM friends from across the globe, especially my learning partners in TOG[3] and FOG[4], may we continue to collaborate and share knowledge.
"Education is a kind of continuing dialogue, and a dialogue assumes, in the nature of the case, different points of view." Robert Hutchins (1899 - 1977)

[2] All quotes in this section, unless otherwise specified, can be found using http://www.quotationspage.com
[3] Dr. Jyoti Mukherjee
[4] Dr. Jyoti Mukherjee, Dr. JC Duh, and Mr. Gordon Johnston

To Dr. Jyoti Mukherjee, we have shared many long MIT nights (has Earl Gray with a biscuit and marmalade ever been more rejuvenating? 8^) completing assignments and partaking in many fascinating discussions. May our friendship last past both of our lifetimes.
"We cannot seek or attain health, wealth, learning, justice or kindness in general. Action is always specific, concrete, individualized, unique." John Dewey (1859 - 1952)

To the three Doctors: Tice DeYoung, Eric Rosenthal, and Richard Solomon. Knowing you three has inspired many of my current thoughts and ensuing discussions have brought a clarity I doubt I could have attained without your help.
"That is what learning is. You suddenly understand something you've understood all your life, but in a new way." Doris Lessing

To my children Will and Lisa. Learning is truly a life long journey. May we continue to share this for decades to come. May your thirst to learn never be quenched.
"Education is not the filling of a pail, but the lighting of a fire."
W. B. Yeats

And most importantly to my Wife Linda, for whom I dedicate this thesis. Without your support and sacrifice this would not have been possible. I have known you for over 25 years and yet it seems as if it has only been a moment. With you by my side all things are indeed possible. Thank you most of all and know that I will always love you.
"The motto of chivalry is also the motto of wisdom; to serve all, but love only one."
Honore De Balzac

"Instead of giving money to found colleges to promote learning, why don't they pass a constitutional amendment prohibiting anybody from learning anything? If it works as good as the Prohibition one did, why, in five years we would have the smartest race of people on earth."
Will Rogers (1879 - 1935)

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Chapter 1. Introduction

1.1. Thesis goal

The primary goal of this thesis is to identify barriers (some prefer to call these limitations or gaps) that currently exist in the communication solutions or procedures used to support interaction between distributed individuals or teams that inhibit or limit their ability to collaborate. The focus will be on identification of human related barriers (e.g. sociological[5], psychological, or physiological) associated with the use of technology, especially barriers to informal interaction.[6]

The secondary goal is to establish the need to create a collaboration toolkit. A critical component of this toolkit will be component interface definitions that will provide the ability to pick and choose components to create unique solutions to fit the current need without loss of (inter or cross) functionality.

To accomplish these goals the need to create a System Architecture will be discussed to establish what participant's (participant/listener/student or facilitator/presenter/teacher) require (i.e. need) and what the current standard(s) for remote collaboration and distance education provides.

This information will then be used to update and identify near term and future improvements that can be made to enhance value for all collaboration participants.

[5] My use of sociology is meant to be broad covering personal and family (private) aspects (e.g. anthropological, cultural and organizational as well).

[6] Barriers to informal interaction are becoming important with the increased awareness that informal interactions are an important component in the process that leads to knowledge creation.

As an aside, distance education is an important topic whenever remote collaboration is discussed because, as you will see from the timeline, in a very real way it was the start of modern day collaboration used by the masses. In that it was transformational to society in a way not unlike the Gutenberg[7] printing press that allowed many access to what had been relegated to the few. For this reason it is easy for me to say distance education and remote collaboration are inextricably linked. More important though is to understand that education has always had at its heart the concept of collaboration because education is the result of discourse. Just remember Socrates and his emphasis that knowledge only came through conversation with another.[8]

> "The meeting of two personalities is like the contact of two chemical substances: if there is any reaction, both are transformed." Jung[9]

1.2. Motivation: Knowledge is the result of communication between people

Creation, augmentation, and management of knowledge are all based on communication and interaction between people. With recognition that the growing global economy has caused governments, academia, and corporations to distribute and/or incorporate team members across the nation and the world, the need to foster remote collaboration has increased.

Taking a two or more day trip to participate in a formal (normally one to three hour) meeting is being viewed with an increasingly jaundiced eye as the impact to overall productivity

[7] In the Time/Life ranking of the most influential people from the second millennium Johann Gutenberg was selected as #1 for invention of the movable-type mechanical printing.
http://www.biography.com/cgi-bin/framcit.cgi?p=http%3A//www.biography.com/features/millennium/topten.html

[8] http://www.greatbooksacademy.org/html/what_is_the_socratic_method_.html , http://www.xrefer.com/entry/553569 , and http://www.philosophypages.com/hy/2d.htm

[9] http://www.quotationspage.com/quotes/Carl_Jung

is evaluated. Even when the advantages of cell phones, portable computers, PDAs[10], and other mobile forms of communication are factored in, the time spent in transit often causes significant loss of productivity which implies lost opportunity. Recent events have also heightened the need to improve remote collaboration as the work continues in distributed locations while the ability and, more importantly, willingness to fly diminishes.

Even if traveling to formal meetings is justifiable and doable, it still does not resolve the need to support informal interactions where much of the creativity and innovative interaction required to generate knowledge occurs. A way to support informal interactions, especially one that is capable of supporting each individual's own learning and interactive style, in addition to formal interactions for distributed groups should prove valuable and will be the ultimate focus of this thesis.

Furthermore, NASA[11] and many other organizations are becoming increasingly aware that senior leaders, managers, engineers, and other key individuals are approaching retirement age. The President's Management Agenda[12] specifically states:

> "Workforce deficiencies will be exacerbated by the upcoming retirement wave of the baby-boom generation. Approximately 71 percent of the government's current permanent employees will be eligible for either regular or early retirement by 2010, and then 40 percent of those are expected to retire."[13]

NASA has increased the emphasis of this human capital issue by stating that 40 to 60 percent of the senior managers, engineers, and scientists will be eligible for retirement in the next

[10] Personal Digital Assistant
[11] National Aeronautics and Space Administration
[12] Available at http://www.nasa.gov/newsinfo/agenda.html
[13] President's Management Agenda, FY2002, page 12

3 to 4 years.[14] Clearly the potential loss of corporate knowledge has been recognized and ways to capture and transfer this knowledge must be researched, adapted, and implemented before it is too late. The development of a dynamic set of tools (the Collaboration Toolkit) based on an extensible System Architecture that can support the efficient sharing, transfer, and augmentation of this tenuous knowledge therefore provides significant additional motivation. This motivation also supports the need to search for a solution that can adapt to (support) the unique requirements of its users since key individuals with knowledge would be able to use this to individually or collectively coach, mentor, and educate a greater number of individuals.

Additionally, some corporations have determined it is more efficient to distribute work to globally dispersed teams. Because of the limitation of technology some corporations have reverted to delegating complete system responsibility to a location because delegation of subsystem responsibility to distributed teams created requirements for interaction beyond the capability of the collaboration tools and solutions available[15].

Finally, my not so hidden motivation is that I am, and have long been, interested in researching the current state of remote collaboration (which includes distance education as a specific instance) to determine if the lofty goal of *Virtual Presence* is yet attainable; and if it is not, how well can it be approximated. Virtual Presence will allow participants to suspend their disbelief of being "there" by being able to adapt to a user's learning and interactive type/traits thereby providing comfortable and sufficient cues to the mind via a majority (if not all) of the

[14] This issue has been raised by both Dan Goldin and Scan O'Keefe (the former and current NASA Administrator) when delivering speeches to the public and Congress.

[15] Otis, Shell, and SUN contacts have all stressed the limitation of videoconferencing and how other means of communication or alternatives (such as delegation of complete system responsibility) had to be developed.

five senses. Many breakthroughs have been accomplished in the last five years or are on the verge of being achieved over the next two years. More yet will evolve. I also propose that ultimately the elegant solution will be, by definition, easily recognizable since it will be the one adopted for collaborative use, regardless of whether the collaboration is local or remote.

1.3. Problem Statement

The problem with most, if not all, applications and processes currently used to guide or enhance collaboration[16] between remotely located participants is that these solutions were normally developed and optimized using only one perspective (e.g. cost/resource, market, technology, psychology, sociology). In other words the solutions are not balanced to take into account a need to support the unique and varying attributes of the participants, instead they are a "one size fits all" solution that can interface with itself but rarely competing solutions.[17] Often the participant (i.e. the human being's) attributes are subsumed to that of the technology used to communicate. In doing so the human is required to adapt to the limitations and controls of the technology. This requires the human involved in remote collaboration to act like a machine, which many[18] have pointed out increases anxiety. Unfortunately I believe the problem is more significant when it comes to collaboration with the intent to innovate, or create/share knowledge. Having the human act like a machine requires the participant to split their attention between monitoring and managing the technology used, adapting to the limitations of the technology (e.g.

[16] The use of the word collaboration in this paper is meant to imply any interaction (discussion, meeting, presentation, training, or any education related class or meeting) between two or more individuals where information is being exchanged. In this sense collaboration is a necessary precursor to the generation of knowledge.

[17] The obvious exception to this is the telephone, but since that was originally developed by a single monopoly the argument can be made that it even applies here since the basic standards have not changed in decades.

[18] Dr. Peter Senge has presented and facilitated discussions on this at SDM and Sloan symposia. To find more about this you can go to http://www.solonline.org

reduced quality or intermittent audio and video), and attempting to participate in the exchange of information. By definition this splitting of attention (concentration) reduces the performance of the participant which effects all participants and artificially limits the possible outcome of the associated interaction.

The problem, therefore, is to evaluate and determine if the machine imposed limitations are still reasonable (justifiable) and if advances in technology and the understanding of human traits (psychological, physiological, and sociological) can be balanced with business need to develop a set of solutions, from now on to be referred to as the Collaboration Toolkit, that can be used to improve the effectiveness, and therefore use, of remote collaboration to support innovation, Knowledge-X[19], and education.

1.4. Thesis Outline

In an attempt to keep this thesis manageable videoconferencing will be used as the current base technology for synchronous (real-time) remote collaboration and engineers will similarly be used as the base human/participant for discussion of psychological types.

This chapter (Chapter 1) provided information on the goal, motivation, and the problem associated with this thesis. The remaining chapters are as follows:

Chapter 2 will provide a historical perspective on remote collaboration.

Chapter 3 will discuss why pursuing solutions that can adapt to the humans involved is important to increasing effectiveness of remote collaboration and discuss the concept of learning styles.

Chapter 4 will propose that collaboration and teamwork are indeed synonyms and discuss some known advantages of globally disbursed teams[20].

Chapter 5 discusses limitations associated with the current solutions used for synchronous remote collaboration.

Chapter 6 will discuss the power of creating a System Architecture and how this can be used to evaluate and identify the gaps associated with current remote collaboration solutions.

Chapter 7 builds off of Chapter 5 and 6. It also introduces new limitations that result from incorporating the need to support human physiology.

Chapter 8 discusses the limitation of using only "best of breed" components in creating an integrated solution and then extends the conversation by proposing some technology that deserves tracking. This chapter concludes with suggestions on how the proposed solutions could be tested and validated.

Chapter 9 will summarize what has been learned and provide suggestions for the future.

[19] Knowledge–X represents the breadth of knowledge related activities within an organization including, but not limited to: creation, accumulation, augmentation, documentation, distribution, and archival.

[20] An example of this is longer workdays. As the team spans the globe it approaches the reality of it always being "primetime" somewhere. So in theory while some sleep work can continue.

"Upon the subject of education, not presuming to dictate any plan or system respecting it, I can only say that I view it as the most important subject which we as a people may be engaged in. That everyone may receive at least a moderate education appears to be an objective of vital importance."

Abraham Lincoln (1809 - 1865)

"Leadership and learning are indispensable to each other."

John F. Kennedy (1917 - 1963), speech prepared for delivery in Dallas the day of his assassination, November 22, 1963

Chapter 2. A brief history of remote collaboration and beyond

This chapter will discuss the technology normally used to support remote collaboration. Initially a history of distance education will be provided to establish why videoconferencing was the natural next step. Then a separate view of the last 20 years will be provided that proposes how the evolution of videoconferencing was based upon a need to support formal communications between individuals comfortable with relatively spontaneous interaction. It will also discuss how even expert users realize the limitations and normally will not use the technology for Human Resource, Intellectual Property, or corporate strategy related discussions. It will also discuss some differences in the way individuals interact (formal versus informal) and how alternative means of communication have experienced increased use because they support requirements videoconference based systems either do not or do poorly.

2.1. The history of distance education

I would first like to provide a brief historical perspective for distance education, which some may consider a precursor that established the need for modern day videoconferencing.

Contrary to popular belief distance education is not a modern phenomenon. It can be traced back to the mid-1800s[21] in England where shorthand was taught by correspondence. This asynchronous

Distance Education Timeline

1837
Isaac Pittman creates correspondence courses for stenography using the Penny Post

1873
Anna Ticknor establishes "The Society to Encourage Studies at Home" in Boston, MA

1890 - 1891
Colliery School of Mines offers a home study course and soon becomes the International Correspondence School

Figure 1. 1800s Distance Education Timeline

[21] http://www.gospelcom.net/bakersguide/timeline.php and http://www.pbs.org/als/dlweek/history/index.html are also the source for the Distance Education Timeline

form of distance education (all correspondence via mail) remained the dominant design for many years until the use of a new technology, radio, was adopted in the early 1920s. Radio was an interesting breakthrough in that it was asymmetric; synchronous from the teacher to the student (via radio) and asynchronous (via mail) from the student to the teacher. In a similar fashion this medium dominated until the advent of TV[22]. In the early 1930s TV based education began, and some can argue through PBS[23] cooking and other shows will remain, the dominant technology for remote education for many decades if measured by the sheer number of people participating. What is interesting about each of these mediums is that the education is one way. And what started out being a way to receive a credential has transitioned into the "norm" for personal edification or hobby related education. This limitation of one-way learning is best explained that the student has no way to talk back and interact instantaneously with the instructor. Therefore while knowledge is being shared, the opportunity for augmentation is limited at best.

In 1965 this limitation was eliminated when the University of Wisconsin Continuing Medical Education department at Madison took advantage of the public telephone system and brought two-way

Distance Education Timeline

1915
National University of Continuing Education Association formed at University of Wisconsin

1921 -1922
Radio technology begins use by Universities

1934
Video introduced! State University of Iowa uses TV for one way communication

1962
AT&T manufactures first commercial modem

1963
University of California System first to apply for ITFS license

1964
Touchtone Phones by Bell Labs

1965
Telephone incorporation allows instruction to be bi-directional

1970
First virtual College Coastline Community College in California

Picturephone by Bell Labs

1978
First Bulletin Board System (BBS) established

1981
Annenberg/Corporation for Public Broadcasting funds development of television courses, PBS then establishes Adult Learning Services

Figure 2. Distance Education Timeline 1900 - 1981

[22] TeleVision
[23] Public Broadcasting System

functionality to distance education. Physicians were now able to "hear the programs and ask questions or make comments."[24] This not only enhanced education content but it was much more efficient for the Doctors since they could save the travel time normally required for their continuing education. Interactive education was born. For understandable reasons demand soon exceeded the capacity of the normal (public) telephone system. This required them to move to a private phone system, which over the next 25 years as requirements and technologies advanced, lead to the deployment in the early 1990s of a video-conference system based on ISDN[25] (in essence the system used by MIT[26] today). Interactive distance education was a hit and no one was looking back.

Distance Education Timeline

1983
Control Data opens Plato Homelink, an online education service

IBM creates the Interactive Satellite Training Network to support corporate training

Time names the computer "Man of the year"

1988
Commercial long distance ISDN from Bell Labs

1989
First online degree programs offered by University of Phoenix

1991
Tim Berners-Lee invents the World Wide Web

1997
The California Virtual University offers over 1,500 online courses

1999
US Department of Education establishes distance Learning Education Demonstration Program

Learning portals establish web presence

Figure 3. Recent Distance Education Timeline

It is interesting to note that while this style of interactive technology was evolving, the next generation of distance education would find its start in the early 1980s, along with the birth of the computer and the Internet. Online education had begun to take form with Control Data and IBM creating solutions to support the need for corporate training. Much like interactive distance education had splintered off of the success of one way (teacher to student (a)synchronous) communication, online splintered off of interactive

[24] http://www.uwex.edu/disted/gooch.htm
[25] Integrated Services Digital Networks
[26] Massachusetts Institute of Technology

as a response to the need of providing training where the staff resided versus having them spend corporate time traveling to a training locations. "Needs" affected "provides." As users wanted more (i.e. increased "needs"), the service provided changed to accommodate evolving requirements (i.e. caused a change in "provides"). In this case the need to efficiently distribute ongoing corporate training deprioritized the "need" for dynamic interaction and in essence effectively changed it to a "want"[27] for a short period of time. Why could this happen? Even in its infancy, the importance of getting timely information efficiently to the most targeted individuals has been a major driver. This appears to essentially be the same reason the University of Wisconsin embarked on integration of teleconferencing for Doctors in 1965.

2.2. The last 20 years

Of interest is that Distance Education and videoconferencing continue to share some interesting common roots: similar early adopters (education and medicine) and a consistent reliance upon emerging communication technology (mail – radio – television – Internet) to enhance, and thereby increase the value of, the provided service.

Videoconferencing Timeline

1920s
Idea to develop a telephone that can see

1930s
First videoconference occurs in New York City using photocells and microphones

1964
AT&T demonstrates Picturephone at the World's Fair

1960s – early 70s
Foreign companies develop video-telephones

1969
Birth of the ARPANET

1971
First transatlantic video telephone demonstration by LM Ericsson

1984
CCITT I.120 (ISDN)

MIT students, Brian Hinman & Jeff Bernstein, co-found PictureTel with Prof. David Staelin

1989
Tandberg offers small group VC in Europe

Early 1990s
AT&T introduces 5 new product lines more advanced than existing desktop offerings

PictureTel improves video quality at reduced costs

Figure 4. Videoconferencing Timeline

[27] In the world of "needs" versus "wants", needs are viewed as requirements while wants are viewed as optional.

In 1984 the CCITT[28] published its recommendation (I.120) establishing the "Principles of ISDN." In the same year modern day videoconferencing can be said to have been born as the result of two MIT students (Brian Hinman and Jeff Bernstein) and a professor (David Staelin) looking at ISDN and realizing a TV signal could be compressed and sent across this new technology.[29] It took about 4 more years for ISDN long distance service to be offered commercially but from that point forward the ability to interact over long distances has never been the same. In some very real ways the move to develop videoconferencing was much more than sending a TV signal that could be used for entertainment or education, it was the opening of a door for businesses. As an alternative to the picture phone, a technology first encountered by some of us while at Disneyland in the early to mid 60s, videoconferencing would find its most important user.

Videoconferencing Timeline

1993
PictureTel enters PC videoconferencing

1994
IMTC formed through merger of CATS and MCCOI.

AT&T announces WorldWorx

1995
PCWG merges into IMTC

Apple introduces QuickTime™ conferencing

Sprint introduces Personal Conferencing Service

1996
ViaVideo founded
PlaceWare formed
WebEx founded

56K modem is invented by Dr. Brent Townshend

1997
Tandberg enters North American Market with products for large groups, telemedicine, and education

1998
Polycom buys ViaVideo
Hinman founds 2Wire

Figure 5. Videoconferencing Timeline, the 1990s

Just as in 1858 when the laying of the Atlantic cable harkened the dawn of real time (instantaneous) global communications[30], in 1969 the birth of the Internet started with the Federal funding of the ARPANET[31] with input in its formative years from Usenet[32],

[28] International Telephone and Telegraph Consultative Committee (CCITT) is now known as the International Telecommunications Union (ITU).
[29] http://faculty.ed.umuc.edu/~meinkej/inss690/acevedo.htm
[30] http://www.internetvalley.com/intval1.html This first cable was a much heralded major milestone but a technical failure since the service lasted but a few days. Subsequent cables were laid in 1866 and lasted nearly 100 years!
[31] Advanced Research Project Agency (ARPA) NETwork
[32] UNIX "User network" is generally believed to have started in 1979 at the University of North Carolina

BITNET[33], and Fidonet[34] (the last three being store-and-forward networks versusversus packet-switched networks like the ARPANET). Bulletin Board Systems (BBS) technology is another key precursor that helped lead to the birth of the web in 1991. All of these separate occurrences had a profound effect on what users expected and ultimately wanted. By the 1990s the early adopters of these technologies were ready to try something new and videoconferencing fit the bill as the next logical extensions of going there without being there. ISDN based videoconferencing sated their appetites momentarily but the initial cost to acquire this new technology coupled with the significant cost of operation limited availability. The net effect was to make ISDN videoconferencing such a prized resource that frivolous use was, by definition, squeezed out to maximize the return on investment by focusing on formal (important) meetings, training, and education since they could all be scheduled in advance. This thought is corroborated by Shell International when they commented in a recent discussion that videoconferencing was used when the users really needed "to see the white of each others eyes" (such as during negotiations) because it will cost ~$4,000/month to lease equipment and provision for bandwidth.[35]

Thomas Allen also corroborated the inherent formal aspects of videoconferencing in his paper on "Architecture and Communication Among Product Engineers"[36] where he wrote:

> "Most video conferencing suffers the additional drawback of being restricted to formally scheduled meetings."

[33] Because It is Time NETwork, created in 1981
[34] In June 1984 tom Jennings released Fidonet software to interconnect FidoBBS sites.
[35] This comment was gathered during a teleconference interview with individuals working for Shell International in the Netherlands.
[36] "Architecture and Communication Among Product Engineers" 1997, WP Number 165-97 http://www.mit.edu/~mariats/WebSiteReadings/Chapt_4_WP%20No%2031.pdf

Allen went on to say that videoconferencing only supports the first (coordination) of three types of technical communication (please see Table 1. Three types of technical communication) and that the other two types are "seldom communicated through formal meetings."[37]

Three Types of Technical Communication	
Classification	Description
Type I	Communication to coordinate the work. (COORDINATION)
Type II	Communication to maintain staff knowledge of new developments in their areas of specialization. (INFORMATION)
Type III	Communication to promote creativity. (INSPIRATION)

Table 1. Three types of technical communication[38]

The next natural step was to find a way to allow more people to take advantage of a highly valued but limited resource by making it more available, and in making it more available the possibility of supporting informal communication. The perceived "need" for pervasive formal and informal connectivity (as already manifested in the explosion of pagers and then cell phones) had already created the "want" to be able to virtually get in touch with anyone, anytime, and from anywhere. By moving videoconferencing from dedicated (autonomous) systems to a component within a desktop PC meant a reduction in cost but more importantly brought forward the possibility of one on one conversations (something that was possible with large group systems but not frequently taken advantage of). In 1993 PictureTel entered the PC videoconferencing market. Soon after AT&T created WorldWorx™ to provide videoconferencing services. This helped AT&T to form an alliance with Apple, IBM, Intel, and Sun Microsystems to provide compatible products and within a few more months AT&T announced the world's first real-time voice, video, and data communications for multiple

[37] ibid.
[38] ibid.

participants on one call.[39] The availability issue was now being partially addressed but video-conferencing was still tied to ISDN. Using ISDN always will mean limited availability when compared to normal network or telephone availability, and unknown operational costs due to per minute usage charge. Videoconferencing was getting better but more was needed to approach an anytime-anywhere service.

It is at this time that most of the various components needed to realistically support this "want" started to merge. Computers were faster and plentiful, users were familiar with the web, breakthrough in miniaturization of video cameras led to new price points, and standards groups were forming to help. More and more corporations and homes were being connected to the Internet. Modem speeds were improving and in 1996 the 56k modem was invented.[40] This faster rate reinforced that more than just data could be efficiently transmitted over POTS[41] Videoconferencing had proved its value in the boardroom, the question was could it prove itself in the worker's room or cubicle. People without easy access to videoconferencing were looking for alternatives that would take advantage of something in plentiful supply and some found them in Instant Messaging (IM) solutions.

More seasoned netizens[42] will remember that DEC VAX VMS and UNIX supported a capability to chat with another via the "talk" command[43] on the host computer, or to a user on another similarly networked computer, that dates back to the early 1980s. To us this was an oft used

[39] http://www-personal.umd.umich.edu/~carlson/VHistory.htm
[40] http://inventors.about.com/library/inventors/blmodem.htm
[41] Plain Old Telephone Service (i.e. the copper wires used in virtually every home for telephones) http://www.webopedia.com/TERM/P/POTS.html
[42] netizens are NETwork citIZENS
[43] http://www.ualr.edu/~gblane/cpsc1370/handouts/email/vaxcom.html , http://9x.tc/9x/rawtext/9X_VMS1.TXT

precursor to IM that made our daily life more efficient. The problem with IM is you have to type, and no one I know can type as fast as they talk. In an effort to catch up to the speed of talking everyone takes shortcuts (e.g. uses phonetic abbreviations, slang, acronyms, symbols, graphical representations of emotions, etc.) while typing. This then requires another individual to be aware of the meaning of these shortcuts as well as business related acronyms (please see Table 2. Examples of shortcuts often used in typed conversations, page 27) one uses to bridge the gap between the spoken and written (typed) word. While IM can be a reasonable solution for some information exchange it still cannot approximate a real conversation in the way videoconferencing can.

In the mid-to-late 1990s videoconferencing pioneers realized, like others had in the past, that the future was right there on their desktops in front of them. It had the connectivity associated with IM, the data that usually required sharing, the familiarity of a daily used tool, and the video capability they had already incorporated into their product line. No, I am not talking about the phone, it was the desktop computer. Of course there were still many obstacles to be solved. The need for better video quality, less delay, increased ease of use, and (increased) portability to name a few. ViaVideo (founded in 1996) sold its technology to Polycom in 1998 and when it delivered its product a breakthrough was achieved. There now existed a PC based solution that was portable (some say it can fit into a pocket… a **big** pocket), easy to hook up (standard USB connection), and it delivered better audio

<u>Videoconferencing Timeline</u>

2001
Polycom buys PictureTel

2002
Tandberg establishes ACE Architecture to support multivendor collaborative (web-data-voice-video) communications

Q3 2002
VC Market share:
Sony 8%
Tandberg 28%
Polycom 54%
VC Revenue:
Tandberg leads Polycom

AOL receives patent for IM services technology

Q4 2002
AT&T, IBM, and Intel form Cometa networks to provide wholesale national wireless broadband access service

Figure 6. Videoconferencing Timeline, into the new century

and video than previously experienced for any PC-based solution. It also supported ISDN and IP[44] networked connections. Currently most feel this is still the best of breed solution for a desktop.

Another issue was also brewing in the videoconferencing world, interoperability. Although standards abounded, initial interoperability standards could be marginally satisfied if the videoconferencing system could interact with the identical model and manufacturer. This meant that choosing a vendor normally defined whom you could talk to. This point is being accentuated in the early 2000s as the trend towards IP based videoconferencing increases.

Since the late 1990s Polycom has been expanding through acquisition of companies and technology (please see Figure 5. Videoconferencing Timeline, the 1990s and Figure 6. Videoconferencing Timeline, into the new century) it needs to respond to this increasingly competitive market. Tandberg entered the American videoconferencing market approximately 5 years ago (1997) targeting the classic foundation for distance education and videoconferencing: medicine and education, and large (corporate) meeting rooms. While its market share is approximately half (28%) that of Polycom (54%) in Q3 of 2002 according to the Wainhouse Research Bulletin volume 3 #39 it is interesting to note two things. First is that the videoconferencing market currently is largely a choice between two companies that control approximately 82% of the business. The second is that Tandberg, much like Avis, is trying harder right now as noted by it taking the revenue lead in Q3 of 2002 from Polycom (Sony with an 8% market share is third, and VTEL with a 2% market share in fourth). Could it be that

[44] Internet Protocol, basically provides the rules (e.g. format and addressing) to deliver packets of data between points

Tandberg's establishment earlier this year (2002) of an Architecture for the Collaborative-Communications Enterprise (ACE) that "embraces open standards, promotes multi-vendor interoperability, and leverages existing network infrastructure"[45] is making the difference?

afaik	As far as I know		jid	Jabber identifier
afaict	As far as I can tell		j/k	Just kidding
afk	Away from keyboard		k	Okay
atm	At the moment		lol	Laugh out loud
bbiab	Be back in a bit		l8r	Later
bbiaf	Be back in a few (minutes)		msg	Message
bbl	Be back later		n/m	never mind
bbs	Be back soon		n/p	no problem
b/c	Because		oAo	over and out!
bf	Boyfriend		omg	oh my god
brb	Be right back		oob	out of band
bsod	Blue screen of death		otoh	on the other hand
btw	By the way		oww	oops, wrong window!
ciao	Italian for goodbye		otp	on the phone
cul8r	See you later		pita	pain in the a**
cya	See ya		pov	point of view
f2f	Face to face		pw	Password
fubar	F***ed up beyond all recognition		rotfl	rolling on the floor laughing
fwiw	For what it's worth		rsn	real soon now
fyi	For your information		rtfm	read the friendly manual
g	Grin		thx	Thanks
gf	Girlfriend		tia	thanks in advance
gmta	Great minds think alike		tla	three-letter acronym
gtg	Got to go		ttfn	ta ta for now
hth	Hope that helps		ttyl	talk to you later
ianal	I am not a lawyer		wb	welcome back
imho	In my humble opinion		wtf	what the f***?!
imo	In my opinion		wtg	way to go!
iow	In other words		xfer	Transfer
irl	In real life		ymmv	your mileage may vary

Table 2. Examples of shortcuts often used in typed conversations

Even with the downturn in the economy associated with September 11, 2001 the videoconferencing sector is on track to have approximately $550M in factory revenues in 2002.

[45] Tandberg Corporate Fact Sheet, September 2002
http://www.tandberg.net/sendFile.asp?FileID={8F574DF4-5FE8-46CF-8FA9-715D13874231}

"Only the curious will learn and only the resolute overcome the obstacles to learning. The quest quotient has always excited me more than the intelligence quotient."

Eugene S. Wilson

Chapter 3. Why adapting to the human is important

This chapter will discuss the importance of humans in any collaboration. Namely that without two or more humans communicating you cannot create knowledge! It will also provide information regarding the unique learning styles of engineers and how knowing this can be used to enhance communication that should lead to an increase in innovation and knowledge-X.

Lastly, this chapter discusses the value of teamwork, the challenge of replicating this for distributed teams, and if there are any unique advantages (and yes, detriments) to use of globally distributed teams.

3.1. Ok, so *why can't humans adapt* to the computer (hardware)?

Computer technology (hardware and software) and functionality are capable of evolving at absolutely astonishing rates. Just think of Moore's Law:

> "The observation made in 1965 by Gordon Moore, co-founder of Intel, that the number of transistors per square inch on integrated circuits had doubled every year since the integrated circuit was invented. Moore predicted that this trend would continue for the foreseeable future. In subsequent years, the pace slowed down a bit, but data density has doubled approximately every 18 months, and this is the current definition of Moore's Law, which Moore himself has blessed. Most experts, including Moore himself, expect Moore's Law to hold for at least another two decades."[46]

Compare this to how much a human being has evolved since Moore made this statement. Last time I looked around humans were much like they have been for a few millennia, let alone the last 40 years. Anthropologist's tend to agree with this thought by the way. So if humans are evolving at a glacial pace when compared to computers and software (please see Figure 7. Integrated Circuit versus Human Evolution), is it not reasonable to think that something humans

[46] http://www.webopedia.com/TERM/M/Moores_Law.html (this was modified: Sunday, March 22, 1998)

create and control could be made to adapt easier to something that has not fundamentally changed in thousands of years?

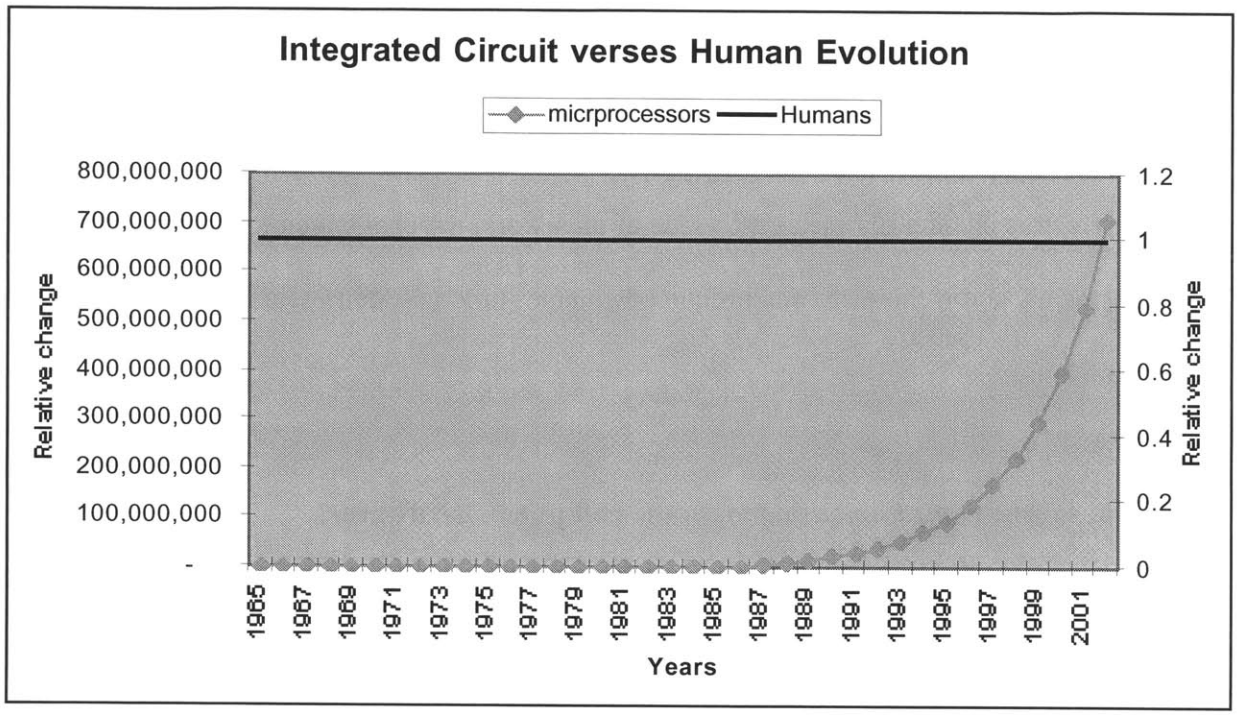

Figure 7. Integrated Circuit versus Human Evolution

When you look at the growth of computer hard disk capacity in terabytes (trillions, or millions of megabytes, or 1024^4 bytes) world wide over the last few years, you discover a similar logarithmic growth (please see Figure 8. Worldwide hard disk market, page 31) pattern as Moore predicted for integrated circuits. This implies that logarithmic growth might be a relative norm for computer related technology during the time frame. Even if computer technology is frozen today, the net growth in capability (IC density, processor speed, data storage, network throughput, etc.) within the last decade is astonishing.

Brass tacks, humans have significant limitations regarding communication input and output when using computers as compared to the capabilities they use normally in their daily life (please see Table 3. Comparison of how humans use the 5 senses (plus 1) to communicate with humans versus computers/technology, page 32).

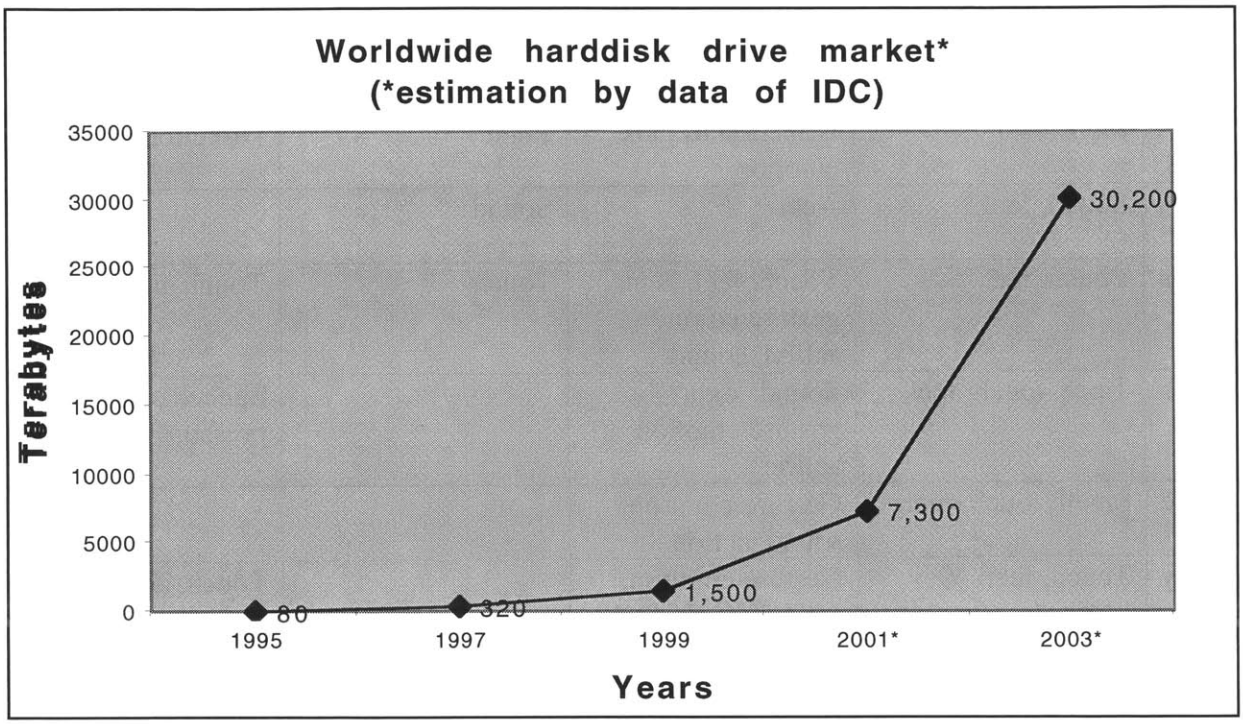

Figure 8. Worldwide hard disk market[47]

Normally humans use the five senses in a coordinated fashion to navigate their way through a life based on interacting with others. Communication input for a human is normally through eyes (sight), ears (sound in), hands (feel), and nose (smell). Communication output is similarly via the mouth (sound out), hands (touch, sign/gesture, action/motion, sound), eyes (emotion and direction of glance), or other type of body language/function.

[47] http://www.netvalley.com/intval_intr.html

When it comes to communicating with a computer the basic set of input devices used to receive information is a significant subset. The primary input is via the eyes (sight), and to a significantly lesser amount ears (sound) or, for and even smaller group, hands (touch[48]). To output information to the computer a human uses hands (touch or write) and to a lesser extent the mouth (speech or puffs) or eyes (movement or gaze).

	Normal Human to Human interactions		Human to Computer interactions	
	Input (receive)	Output (transmit)	Input (receive)	Output (transmit)
Eyes	Sight, feel	Direction of gaze, emotion	Sight	Direction of gaze
Ears	Sound, feel	Action	Sound	
Hands	Touch, feel	Touch, feel, sign, gesture/emotion, action, sound	Touch	Touch, action
Mouth	Taste, touch, feel	Sound, sign, gesture/emotion, action		Speech/sound, air pressure
Nose	Smell, touch, feel	Gesture/emotion, sound, action		
Body	Touch, feel	Gesture/emotion, action, touch, feel, sound		Touch, action

Table 3. Comparison of how humans use the 5 senses (plus 1) to communicate with humans versus computers/technology

As you can see humans are used to much more sensory input than a computer normally provides for communication. When humans interact all senses (and the body) are normally involved and the feedback is processed and balanced to provide understanding. Compare this to communicating with a computer where one sense normally becomes the dominant (either sight or touch) conduit for receiving (input) information and another (touch or a type of action) for transmitting (output) information. One would think a broader, or more balanced way of

[48] Examples of touch feedback include pressure/texture from the keyboard and a Braille device,

exchanging information with computers could be found to enrich the interaction and take advantage of a human's inherent capabilities used daily.

Combine this with the realization that the understanding of the way humans "work" is continually improving and there is an opportunity to discover how compatible some of the very efficient methods developed for a computer to represent information are when matched to a human's input mechanism (i.e. the five senses). In Chapter 7.2 [Mismatches with current solution on page 91] these mismatches between the way information is provided to a human and the way a human expects to receive it will be discussed.

3.2. Why are humans important to collaboration?

Collaboration is defined as "to work jointly with others or together especially in an intellectual endeavor."[49] Therefore, especially when used in this thesis, collaboration is the exchange of information or knowledge between people (i.e. humans). This might lead you to ask why collaboration is important to education or Knowledge-X? It is only through collaboration that knowledge can be created.

Knowledge deals with the acquisition of truths or facts. The reality of this is that the only way you know if you have achieved the capture of a truth or fact with any level of certainty is to ask someone else if they agree or already know the fact to be true. This is already a time-honored process in most academic communities. Therefore, in a very real way, knowledge is

[49] Definition supplied by http://www.m-w.com/cgi-bin/dictionary and as appears above in Chapter 3.2 Why are humans important to collaboration?

always about something associated with the past since it requires validation or review by others to truly establish it. That is why collaboration is so important, it is the process that elevates what was previously known as data to the higher value of knowledge.

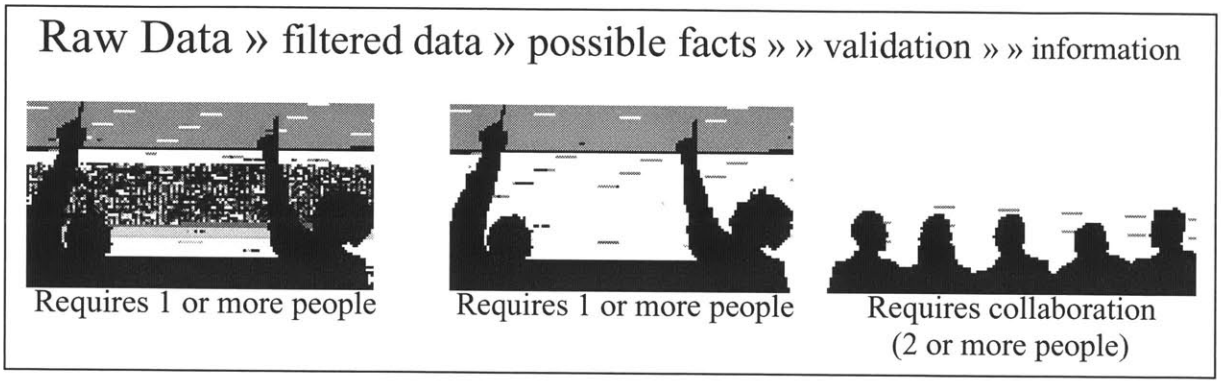

Figure 9. Human involvement in transforming data to information

Computers can gather, collect, associate, otherwise augment, share, and even create data. Data is initially created through the monitoring of output by a sensing device (including human organs). The output includes both useful and irrelevant or redundant data and must be processed to be meaningful. Data can be manipulated, sometimes too easily, and the subsequent sharing often (re)creates so much data so quickly one might mistakenly think the computers are collaborating. But they are not because data in and of itself has little value other than being a *possible* fact. Data is a starting point for information, not an end point. It is from which a conclusion or fact can be determined or inferred. It takes a human to be involved in the process to separate the relevant from irrelevant and determine if anything that remains is usable.

Information results from a sharing or communication of facts and knowledge, not the sharing of "raw" data. Humans therefore are important to collaboration because it takes a human

to transform data into facts; and then it takes two or more humans to qualify some of those facts as truths, thereby creating the knowledge that can be subsequently shared as information.

3.3. Are engineers so different to work with?

Though engineers tend to bring a unique perspective to any conversation they still fall within the bounds of psychometric and psychological type tests. Whether it be MBTI[50], TKI[51], FIRO-B[52], CPI™[53], PTPS[54], or some other 360° or holistic personality, organizational, or effectiveness evaluation, you will find engineers fit as well as any other individual. You also can quickly determine that, at least within NASA, it appears that male and female engineers share many similar traits, even more so when you look at the subset classified as project managers using MBTI (Females 50% ENTJ/ENTP, 25% ESTJ; Males 25% each ENTJ, ENTP, ISTJ).[55] While it is true that there is a skewing for engineers (50% ENT, 25% STJ), virtually every type is represented when compared to the general population[56] so there is not a cause for alarm. Contrary to the belief of some, engineers are people too and subject to the same reality of having strengths and weaknesses when it comes to having a conversation/communicating their thoughts to another.

But collaboration is about more than mere conversation, collaboration has a significant element of learning or education associated with it. Since collaboration is rooted in the exchange

[50] Meyers-Briggs Type Indicator
[51] Thomas-Kilmann Conflict Mode Instrument
[52] Fundamental Interpersonal Relations Orientation – element B
[53] California Psychological Inventory
[54] Parker Team Player Survey
[55] Gender in Project managers: Are NASA Women and Men Project Managers Equal?, Gerald Mullenburg, DBA, NASA, Ames Research Center

of information (qualified facts or knowledge) with other people, and often in an intellectual pursuit, I will next discuss learning styles to determine if this perspective contains a basis for differentiation.

Most readers of this thesis will be familiar with the 16 classic psychological types associated with MBTI that is derived from Carl Jung's that serves as a base for so many personality and preference models. It turns out that some also use MBTI to classify individual learning styles.

ISTJ	ISFJ	INFJ	INTJ
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP	ENTP
ESTJ	ESFJ	ENFJ	ENTJ

Table 4. The MBTI Personality Type Matrix

There are at least three other models in use. The Kolb Learning Style Model, Herrmann Brain Dominance Instrument (HBDI), and the Felder-Silverman Learning Style Model.

	Concrete	Abstract
Reflexive	Type 1 (why)*	Type 2 (what)
Active	Type 4 (what if)	Type 3 (how)

*(learning type characteristic question)

Kolb Learning Styles

	Cerebral	**Limbic**
Left Brain	**A**: logical analytical quantitative factual critical	**B**: sequential organized planned detailed structured
Right Brain	**D**: visual holistic Innovative	**C**: emotional interpersonal sensory kinesthetic symbolic

Herrmann Brain Dominance Instrument (HBDI)

Table 5. Kolb Learning Style model and the Herrmann Brain Dominance Instrument

[56] Females generally cluster in four type ESFJ/ESFP/ISFP/ISFJ = 56.3%, and males tend to ESTJ/ESTP/ISTP/ISTJ = 41.7% of the time, ibid.

Both the Kolb Learning Style model and HBDI use a 2x2 matrix to classify a person's learning preference. In the Kolb model the four types are characterized by questions typical for this type of learner and provides suggestions to instructors attempting to "teach around the cycle." The HBDI focuses on a person's relative-preference for thinking and is based upon the way a person's brain truly functions when doing tasks.

Preferred Learning Style		Corresponding Teaching Style	
sensory / intuitive	perception	Concrete / abstract	content
visual / verbal	input	Visual / verbal	presentation
inductive / deductive	organization	Inductive	organization
active / reflective	processing	Active / passive	student participation
sequential / global	understanding	Sequential / global	perspective

Table 6. Felder-Silverman Dimensions of Learning and Teaching Styles[57]

Professor Richard Felder has been writing about the "Learning and Teaching Styles in Engineering Education"[58] since 1987. The original paper co-authored by Linda Silverman takes a slightly different approach since it looks not only at learning but teaching styles. For this reason I will use the Felder-Silverman approach as a basis for understanding collaboration styles. I believe this is doable due to the fact that collaboration has at its heart the sharing of information so others may learn.

[57] Engineering Education, 78(7), 674 – 681 (1988). with modifications specified by Prof. Felder in his June 2002 preface incorporated. . This 1988 paper is also the most frequently cited paper in articles published in the Journal of Engineering Education over a 10 year period

[58] ibid.

This paper's conclusion reinforces that engineers are not that different from the rest of humanity and that the learning styles of most engineering students is incompatible with the teaching style of most engineering professors in several dimensions.[59] What is interesting about this finding, as well as those in other papers by Professor Felder, is key incompatibility points turn out to be echoed in comments SDM students have submitted in some course evaluations.

> "Engineering professors usually orient their courses toward Introverts (by presenting lectures and requiring individual assignments rather than emphasizing active class involvement and cooperative learning), iNtuitors (by focusing on engineering science rather than design and operations), Thinkers (by stressing abstract analysis and neglecting interpersonal considerations), and Judgers (by concentrating on following the syllabus and meeting assignment deadlines rather than on exploring ideas and solving problems creatively)."[60]

The interesting point here is that if professors do employ this teaching style then they are teaching in a fashion that is most conducive for learning by an INTJ, and INTJs represent only ~0.8% of the female population and ~3.3% of the male population. The suggested correction is not to determine each class makeup incrementally and adapt the teaching style to it, but to present information in a way to satisfy the learning needs of students in each category during each class. That way every student is being communicated with in a compatible way for at least part of the class and, in theory, they can also learn to be comfortable receiving information in more than one style. This teaching style is referred to as "teaching around the cycle."[61] I believe this suggestion is also directly applicable to remote collaboration.

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[59] ibid., 680

[60] Richard Felder, "Matters of Style" ASEE Prism 6(4), 18 – 23, (December 1996); quote is modified only by the capitalization of the MBTI preferences.

[61] ibid.

If the remote collaboration technology used supports only one learning style, I contend it similarly supports only one type of individual comfortably. Therefore if you want to create an environment that is conducive to the active participation of most individuals in a style comfortable to them, a functional equivalent of "teaching around the cycle" (i.e. collaborating around the cycle) must be found. The added twist that I continue to propose is to extend support for the normal interactive traits most currently discussed by others (usually involving support for psychological, sociological, and physical location/time zone) to include support for the physical attributes of the human as discussed in Chapter 3.1 (on page 33). This topic will be discussed in some detail in Chapter 7 (starting on page 89).

"Learning is not compulsory... neither is survival."

W. Edwards Deming (1900 - 1993)

Chapter 4. Collaboration is people working together as a team

This chapter begins by showing that positive (successful) collaboration is just another word for teamwork. It then discusses the value of teamwork, the challenge of replicating this for distributed teams, and if there are any unique advantages (and yes, detriments) to the use of globally distributed teams.

4.1. Collaboration requires people who want to talk!

Merriam-Webster defines collaborate thusly:

> "One entry found for collaborate.
> Main Entry: col·lab·o·rate
> Pronunciation: k&-'la-b&-"rAt
> Function: intransitive verb
> Inflected Form(s): -rat·ed; -rat·ing
> Etymology: Late Latin collaboratus, past participle of collaborare to labor together, from Latin com- + laborare to labor
> Date: 1871
> 1 : to work jointly with others or together especially in an intellectual endeavor
> 2 : to cooperate with or willingly assist an enemy of one's country and especially an occupying force
> 3 : to cooperate with an agency or instrumentality with which one is not immediately connected"[62]

All three definitions require multiple people (i.e. a team) to interact in a willing fashion for the benefit of one or all. Most interesting to me is the third definition that implies the interaction crossing boundaries, be they corporate, political, or physical. A possibly more succinct way to define the intent of collaboration was provided by Mr. Václav Turek on the 2002 SDM International Business Trip (IBT): "You have to want to communicate!"[63]

[62] http://www.m-w.com will be used for all definitions in this paper unless otherwise cited
[63] Mr. Václav Turek is responsible for Operations at Otis a.s., Czech Republic

Videoconferencing it turned out is a vital tool for the ongoing success of Otis a.s. since it allows the Manufacturing and Logistics Center in Breclav, Czech Republic, to have continuous and timely interaction with its regional headquarters in Berlin, Germany. It was also important because the participants can visually assess each other's mood and better interpret the meaning of what was being said by reading each other's body language, expressions, and gestures in real time (i.e. synchronously or immediately). This is a key advantage when you understand that English, a non-primary language for most participants, was normally used for these meetings. Therefore the use of videoconferencing not only provides the means for efficient communication, it is also a tool used to enhance understanding.[64]

An example of how Otis a.s. uses this for their benefit is when Breclav participants connect to the weekly status meeting in Berlin, provide their report and receive updates, and then excuse themselves from the remaining two or so hours of the meeting. This efficient use of videoconferencing saves time in the meeting as well as travel (several hours round trip by car). More importantly it allows the information from the meeting to be shared with others in Breclav significantly faster than if the meetings were attended in person.

There appears to be only two topics Otis will not discuss over videoconference, corporate strategy (e.g. roadmaps and organization) and personnel benefits (e.g. compensation and evaluation). Following this rule there were only three face to face meetings required in the first six months of 2002. One last point, Breclav management was so committed to the concept of

[64] Thereby bypassing the problem encountered by other companies relying more on teleconferencing, the propensity to misunderstand the spoken (or written) word in the absence of visual clues. Shell is having to develop ways to train their staff to listen better (to understand intent and emotion) to overcome this very real problem.

collaboration that they quickly decided that videoconferences with the regional HQ and other Otis entities needed to be conducted in a single language between principles (i.e. not through interpreters). They committed to, and succeeded in, learning English in one year and from that point on no interpreters have been used (German is used for purchasing though). Videoconferencing is an integral contributor to the success of the Breclav facility because it allows local management the advantage of routinely collaborating with their regional HQ counterparts. This allows them to be more responsive to corporate requests and strategy without having to bear the burden (overhead) associated with actually being there (where the meeting is physically).

I have initially focused on this real world success story because it epitomizes the need for collaboration and implies how individuals located almost 200 miles apart can still work effectively as a team. If you doubt how important this interaction is to the Breclav facility please know it was not lost on them. The Breclav management understood the need and potential power of approximating face to face collaboration (i.e. working as a team with the regional HQ) so much that to accomplish their goal of learning English within one year they took classes on weekends. Now that shows an understanding of the importance of talking to, and cooperating with, someone else. I believe this also fits the Merriam Webster definition for teamwork:

> "One entry found for teamwork.
> Main Entry: team·work
> Pronunciation: 'tEm-"w&rk
> Function: noun
> Date: circa 1828
> : work done by several associates with each doing a part but all subordinating personal prominence to the efficiency of the whole"[65]

[65] http://www.m-w.com/cgi-bin/dictionary

This example highlighted how videoconferencing provided an enhanced ability to understand another's thoughts or position on a topic because normal visual clues were present. Colloquially this is often called "looking another in the eye" and refers to a humans ability to use visual clues, emotional artifacts, or body language to aid in the understanding of the intent of the speaker/writer. Videoconferencing also provided another benefit in that it is a means of synchronous (i.e. without an unmanageable delay) communication between the participants which allows for the immediate resolution of misunderstandings. In this case synchronous visual interaction is preferable to the use of non-visual means for communication[66]. Therefore by reducing the occurrence of misinterpretation, using videoconferencing has the additional benefit of helping build trust faster. Building trust is a recognized key component to effective teamwork and collaboration. Because trust can be built it will also allow participants to achieve, or if they had previously met the other participant maintain, a type of familiarity that will enhance their corporate, as well as academic, exchange. For this multi-national company, as well as many others, videoconferencing is rapidly becoming a corner stone for teamwork and collaboration.

4.2. The value of teamwork

Ever since ancient times people have known that people working together are more powerful than people working separately. Zeno of Citium, a 3rd century BC Greek philosopher, wrote

> "The reason we have two ears and one mouth, is that we may hear more and speak less."[67]

[66] Examples of non-visual communication include asynchronous means such as e-mail, and synchronous means such teleconferencing or as data sharing via an application like IM or NetMeeting

[67] http://www.quotationspage.com/quotes/Zeno

To Zeno of Citium it was obvious that people are configured to interact and that much good can be learned from listening to others. Another wise old Greek weighs in with an even clearer story on the strength of people working together.

> The Bundle of Sticks (an Aesop fable)
>
> An old man on the point of death summoned his sons around him to give them some parting advice. He ordered his servants to bring in a faggot of sticks, and said to his eldest son: "Break it." The son strained and strained, but with all his efforts was unable to break the Bundle. The other sons also tried, but none of them was successful. "Untie the faggots," said the father, "and each of you take a stick." When they had done so, he called out to them: "Now, break," and each stick was easily broken. "You see my meaning," said their father. Union gives strength.

"Union gives strength" (Aesop)[68], "Walk with wise men and you will become wise, but the companion of fools will fare badly" (Proverbs 13:20)[69], "United we stand, divided we fall" (Dickinson)[70], "It is not in numbers, but in unity, that our great strength lies" (Thomas Paine)[71], "A house divided against itself cannot stand" (Lincoln)[72]. All of these inspirational thoughts through time share a common theme that by working together, or as we would say today collaborating, there is an advantage. In fact our very concept of civilization is built upon this premise , that the establishment of communities where large groups of people work together will provide order and stability for mutual protection and benefit.

What we call teamwork in this modern era is a time-honored concept that has been much discussed using other names or recognizable imagery such as a house, union, unity, or even

---

[68] http://www.aesopfables.com which should allow you to find the following http://www.pacificnet.net/~johnr/cgi/aesop1.cgi?1&TheBundleofSticks

[69] http://www.nccbuscc.org/nab/bible/index.htm will be used for all cited biblical references

[70] From the time of the American Revolution and credited to John Dickinson http://www.bartleby.com/66/2/16602.html

[71] from Common Sense, 1776, http://www.bartleby.com/133/4.html

[72] In Lincoln's speech on June 16, 1858 he cited the bible Mark 3:25 or Luke 11:17

walking. The interaction or grouping of individuals has to be correct though for this to work in a positive fashion as noted above in Proverbs 13:20 or as offered in Ecclesiastes 4:4-12

> 4 Then I saw that all toil and skillful work is the rivalry of one man for another. This also is vanity and a chase after wind.
> 5 "The fool folds his arms and consumes his own flesh"--
> 6 Better is one handful with tranquility than two with toil and a chase after wind!
> 7 Again I found this vanity under the sun:
> 8 a solitary man with no companion; with neither son nor brother. Yet there is no end to all his toil, and riches do not satisfy his greed. "For whom do I toil and deprive myself of good things?" This also is vanity and a worthless task.
> 9 Two are better than one: they get a good wage for their labor.
> 10 If the one falls, the other will lift up his companion. Woe to the solitary man! For if he should fall, he has no one to lift him up.
> 11 So also, if two sleep together, they keep each other warm. How can one alone keep warm?
> 12 Where a lone man may be overcome, two together can resist. A three-ply cord is not easily broken.

There is much we can learn about teamwork by listening to the wise words of the past. Reassuringly, I also hear their resonance in modern day thought. In a paper Dr. Jan Klein has co-authored with Dr. Astrid Kleinhanns is the cogent thought:

> The benefit of a team is not derived merely from the presence of diverse intelligence; it is created within a collaborative team effort that results in a better outcome than the best individual team member could achieve… The key is to create this synergy, but to do it as quickly as possible to avoid adding additional time to team members' busy schedules.[73]

This thought that a team can actually aspire to a level of achievement better than that attainable by any of the individual participants could accomplish on their own is in accord with other current thoughts. The "IQ of a group is higher than the IQ of the brightest individual"[74] is a very harmonious thought proposed by Dr. Alexander Laufer in his model called IQ Plus.

[73] Closing the Time Gap in Virtual Teams, Janice A. Klein & Astrid Kleinhanns, to be published in *Creating Condition for Effective Virtual Teams*, Cristina Gibson & Susan Cohen [eds.], Jossey-Bass/Wiley, 2003
[74] http://appl.nasa.gov/knowledge/ask/march_01/post_con_re.htm

Basically, Dr. Laufer believes if you bring experienced people together to collaborate (e.g. talk, share stories, and test new ideas) the effective collective IQ of the group will be greater than any one individual's IQ. These current thoughts resonate with those from the teachers, scholars, orators, and leaders of the past. Interacting effectively with a team increases the opportunity for success, innovation, creativity, and exceeding expectations. My experience shows these teams are also "a whole lot" more fun to be involved with.

From Before Common Era (BCE) to the current age where hardly anything can be described as common, there is unanimity in the thought that teams working together positively increase the value of their output. If anyone questions this, please take a look around and see how much of what you do or use daily is the same as it was a decade ago, let alone 50 or 100 years. If you notice a difference then you are noticing the result of teamwork and collaboration.

4.3. Ok, teamwork is valuable but must this (can this) be replicated remotely?

Understanding that teamwork is critical to the success of virtually every endeavor is one thing, but must this (can this) be replicated remotely? The answer is, of course, yes and yes. Though the second yes (can this be replicated) is going to require some work by individuals more learned than myself. But, as I hope you will agree, individuals that will achieve more if they collaborate with others to achieve the goal of enabling remote collaboration/teamwork.

"If there's one thing that you need it's that your team needs to be singing off the same page of music. And that's never been the case with this company."
-- Thomas Jermoluk, former CEO of Excite@Home.

Figure 10. Corporate need for team collaboration.[76]

With regards to why this must be replicated remotely, I offer the following. Thomas Jermoluk[75] is an extremely successful individual having held senior management positions in several major high tech corporations. Even with his significant experience it appears he may have met his match when @Home merged with Excite. Teams that should work together had trouble talking with each other (please see). Management expertise on its own cannot ensure success; teams need to work together in a positive, harmonious fashion, or, in other words, teams need to collaborate.

Why is this an appropriate citation you might ask? Excite and @Home were next door to each other. Literally a walk across parking lots separated them. So the distances do not have to be great to impede face to face collaboration. I remember discussing this thought with someone a few years ago that knew of a Xerox PARC study that looked into the barriers to communication caused by horizontal (down the hall or in another building) and vertical (floors within same building) separation. It turned out that the barrier to communication with a vertical separation of one floor was almost equivalent to that of individuals in another building. I believe horizontal separation exceeding 100 feet also produced a similar effect when there were no common shared resources (e.g. printer, water cooler, bathroom, etc.).

[75] Mr. Jermoluk sits on the board of several companies http://toshiba.shutterfly.com/about/bio_sub_jermoluk.jsp http://www.pbs.org/wttw/ceoexchange/episode_101/tjermoluk_bio.html and http://www.smartpipes.com/AboutUs/TomJermoluk.asp

[76] http://zdnet.com.com/2100-1105-504020.html?legacy=zdnn

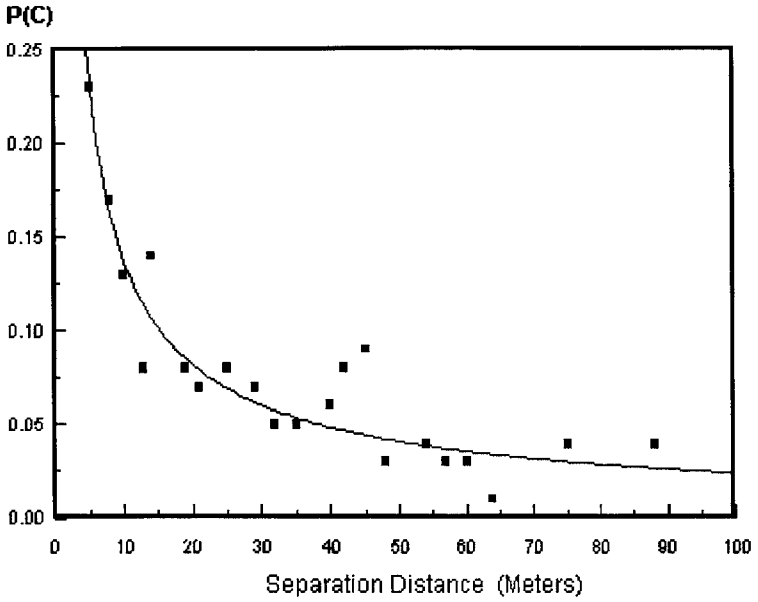


Figure 11. Probability of communication as it relates to physical separation[77]

While I have not been able to find the PARC citation the report by Thomas J. Allen titled "Architecture and Communication Among Product Development Engineers"[78] corroborates these thoughts. Allen's perspective is to discuss the effect architecture has on technical communication and shows "how the probability that two organizations' members will communicate regularly declines rapidly with the distance between their work locations."[79]

Figure 11 and Figure 12 are but two examples of the numerous reported findings which support this common sense statement.

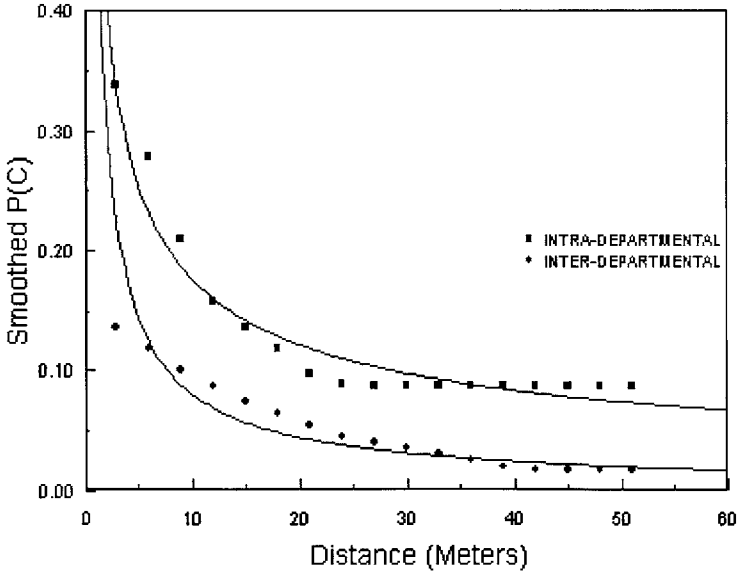


Figure 12. The effect of sharing a department and physical separation on the probability of communication[80]

[77] September 1997 WP Number 165-97, http://www.mit.edu/~mariats/WebSiteReadings/Reading_for_May_6.htm
[78] ibid.
[79] ibid.
[80] ibid.

This thought is also concisely echoed on the Native American Distance Education community web page.

> "Distance Learning takes place anywhere that physical distance is between the student and the instructors. Distance Education is the result of distance learning."[81]

The need to deal with creating an environment that supports distributed teams so they can collaborate will never be more pressing than it is now for the Government. As noted above (on page 11) the President's Management Agenda (PMA) provided motivation for this thesis. It turns out it did in more ways than one. Chapter 2, pages 17 and 18, of the PMA discusses the need for the Government to be market based and compare the cost of in-house performance to that of the private sector through the use of full cost estimation. In response to this the Federal Activities Inventory Reform (FAIR) Act requires agencies to assess their susceptibility to competition from the private sector. On January 3, 2002 OMB released the official final round of 2001 outsourcing lists that revealed that approximately 40% (428,341 positions) of Government jobs were potentially available for outsourcing.[82] The current intent of the Bush administration is to rely

> "on accurate FAIR Act lists for use in its competitive sourcing initiative, which requires agencies to compete 15 percent of all jobs on the inventories by October 2003."[83]

With such a commitment it is reasonable to assume most, if not all, Government agencies will need to develop similar abilities as other national and global companies (e.g. SUN, Shell Oil, Ford, Boeing. etc.) have for maximizing the benefit of outsourced labor and distributed

[81] http://www.eot.ahpcc.unm.edu/Community
[82] http://207.27.3.29/dailyfed/0102/010302m1.htm
[83] http://207.27.3.29/dailyfed/0302/031202p1.htm

workforces. One need only look at the growth of the innovation consulting service sector, 1-800 or helpdesk service providers (a good amount of which are now offshore), and other web-based service providers to understand that in the future the focus will be on whether or not the job is getting done, not where it is getting done. This implies the need to increase coordination (a Type I communication within the scope of videoconferencing according to Tom Allen, please refer to Table 1. Three types of technical communication, page 23) activities. This need for increased communication and coordination has been confirmed in discussions with individuals working with, or for, SUN and Shell Oil on global teaming. The increase in global partnership combined with the reality that there are excellent individuals available to work around the world means we cannot ignore the need to develop tools to help distributed teams work effectively. This leads to a belief that if one uses the appropriate technology, then working with someone down the hall need not be that much different from working with someone that is across a city, state, continent, or ocean. Distance in collaboration, in fact, has more to do with one's mental model than it does with the physical separation. Just think of the last time you made a long distance phone call or sent an e-mail, did it matter how far the recipient was from you?

So again yes, the ability for teams to work together and collaborate must be supported. And the need to do this for distributed teams seem to be a high priority, even if the distribution is measured in hundreds of feet rather than hundreds of miles.

4.4. Remote collaboration can increase the value of a team?

If collaboration when distances are close (less than 200 feet) appears to be understood as an issue, what makes you think people thousands of miles apart will put forward the effort to

collaborate? Why go through the hassle of developing better tools if people have shown they do not want to do this? Because collaboration is the key to success for any organization, now and in the future. One need only do a search of the web to see how synchronous distance education is now a component used by grammar and high schools across the United States[84] and the world to understand how important. There are even multiple International[85] organizations dedicated to the enhancement of this critical resource. If you look at this in light of Grammar and High Schools being notoriously under-funded (at least in the United States), then the expending of limited resources to sustain and enhance an ability to take advantage of knowledge remote from their location implies high value. Their sole goal is to enhance the education of the students they are responsible for.

Industry also appears to understand the advantage (often with respect to competition) of using resources that are not local to a given site. In talking with individuals associated with Shell and Sun it was obvious that these organizations understand the need to incorporate the knowledge and skills of individuals wherever they can be found. In some cases (e.g. outsourcing of a service like answering calls for a 1-800 help or order line) the motivation may be financial. In other cases it might be to take advantage of specific skills associated with an individual or team where relocation to a place where a team could be colocated is not tenable (for personal, family, professional, as well as financial reasons). These motivations were clearly expressed in discussions with both SUN and Shell. Of interest both corporations have a decidedly different approach how to deal with them and foster interaction between (globally) distributed teams.

[84] The University of Wisconsin is a good place to discover the current state of distance education. http://www.uwex.edu/disted/home.html and specifically for K-12 http://www.uwex.edu/disted/k12.html

[85] The International Council for Open and Distance Education http://www.icde.org and the International Centre for Distance Learning http://icdl.open.ac.uk are two of multiple examples.

In a discussion with individuals from Shell International they made an interesting comment that technology is not the bottleneck to collaboration, it is the people. Later on it was revealed that they do not use videoconferencing (standard or desktop) much because it was not delivering on its "promise." The reality of signal delay (for audio and video) and poor picture quality proved to be too distracting during meetings and they were now relying on teleconferencing. The problem with teleconferencing is you cannot see the other participants and Shell is trying to determine if they can teach people to listen with extra sensitivity for subtle tones to aid in determination of the intent, or the state, of the speaker. In essence they are asking participants to act in a style similar to Sherlock Holmes[86] and not hear more than other participants but to be aware of what they hear. This is a laudable, and hopefully attainable, goal but let us not loose sight of the fact that teleconferencing is used to support collaboration among distributed teams is due to a limitation of videoconferencing solutions. In essence, unlike Otis a.s., their specific implementation got in the way of conversation because it was noticeable to the point of being distracting to the participants. Distracting participants means they are not able to focus on what they are discussing. Not being able to focus implies substandard, or arbitrarily limited (in this case by technology), performance which puts at risk the success of the team. Therefore it is understandable the Shell decided to go with another solution as the primary means of communication for distributed teams even though it posed another problem. Apparently Shell believes it can "fix the participants" (i.e. teach people to hear more) more efficiently (e.g. time, cost, control) than attempting to fix videoconferencing.

[86] Sir Arthur Conan Doyle had Sherlock Holmes remark in *The Adventure of the Blanched Soldier* "I see no more than you, but I have trained myself to notice what I see."

SUN has a different approach to the support of distributed teams rooted in the way they distribute the work. During my discussion it was obvious that SUN had similar issues with videoconferencing and also agrees that the ability to clearly communicate thoughts is critical. The major difference is SUN decided it was most efficient to distribute work by charter (ceding total responsibility for a deliverable item or concept to one location) rather than splitting responsibility for a deliverable, say along system or subsystem lines, between distributed locations like Shell. SUN felt that an additional advantage of distributing work by charter was that the increased responsibility allowed them to attract (or retain) better employees. Sun's approach allowed the communication between distributed individuals or groups to be more in the style of reporting and coordination, or as Tom Allen would characterize a Type 1 that can be accommodated within the current limitations of videoconferencing.

Both corporations understand the value of collocating teams but have also discovered the advantage of purposely locating teams in different time zones allowed work to be accomplished in a sequential or synergistic fashion. An example of this is a project, or related set of tasks (such as joint development, development and validation, or report and review), that is started in one time zone (A) and worked on until close of business upon which it is then transferred to another time zone (B) that is beginning its work day. This type of process takes advantage of the notion that it is always normal[87] "primetime" somewhere in the world, which means they do not have to require anyone to work odd hours (e.g. the graveyard shift). Work can be handed back and forth thusly until the project is completed if there is good collaboration. Sun and Shell

[87] Normal, in this case, refers to hours of operation that fall between 0600 – 1800 for a given time zone thereby not requiring a shift differential for early or late work hours

International both corroborated the notion that the success of this process of virtual collaboration depended on good team communication and coordination.

Taking advantage of this style of work (virtual collocation) is not without some risk though. A simple example is if management requests an immediate update for work being accomplished in a significantly different time zone (e.g. one on the opposite side of the world). The project of task lead will need excellent communication skills to explain why they might need to wait 24 or more hours for some of the information to be provided. The reason, of course, is the same as why work can be accomplished quicker, minimal or non-overlapping work hours. In theory (and depending on the work schedule associated with a given location) one could choose two or three time zones carefully so that a corporation will always have at least one component operating in "prime" time.

Reaping the value of a distributed workforce is not just a challenge for the education or corporate sectors. The U.S. Government also has employees and (due to the implementation of the FAIR Act an increasing number of) contractors located across the nation, around the world, and for NASA literally (floating) *around* the world (and elsewhere in Space). In a recent discussion at NASA, Ames Research Center, on collaboration the following mind-map (please see Figure 13. Ideas for collaborative technology advancement at NASA, ARC, page 57) created by Dr. Sal Rositano reveals how important the "Coll-Coll "[88] working group views this need to develop new ways of collaborating, both within the Center, NASA, Government and outside organizations. Discovering how to take improving remote collaboration so we can take

[88] Coll-Coll is a NASA, Ames Research Center, cross-discipline/function working group focused on collaborating about collaboration

advantage of concepts like virtual collocation will be a key component in achieving the future goals of NASA, as well as those in the President's management Agenda of a reduced cost of government for American taxpayers.

Lest you think supporting a distributed workforce is a small requirement, consider this fact attributed to the Yankee Group discussing the need for faster wireless communication.

> The concept of public LANs may be ripe, considering 14 million people will work remotely at customers' sites by 2004, according to the Yankee Group[89]

This estimate of 14 million only refers to individuals the federal government would call contractors or corporate representatives. Just think how large the number is if all those working within an organization that are not local to each other are included. Especially when you understand that a separation of as little as 100 feet impacts collaboration.

There is good reason, however, to be skeptical about claims that distance makes no difference to R&D work. One reason is provided by the findings from studies of work that show that informal, unplanned, ad hoc communication is extremely important in supporting collaboration.[90]

[89] http://www.informationweek.com/story/IWK20021205S0002 As far as I can tell this number does not include the untold number of additional people working within global corporations in distributed fashion.

[90] R.E. Grinter, J.D. Herbsleb, and D.E. Perry, The Geography of Coordination:Dealing with Distance in R&D Work, International ACM SIGGROUP Conference on Supporting Group Work, GROUP '99, 1999. Phoenix, AZ. ACM Press, pp. 306 – 315, ISBN:1-58113-065-1, http://doi.acm.org/10.1145/320297.320333

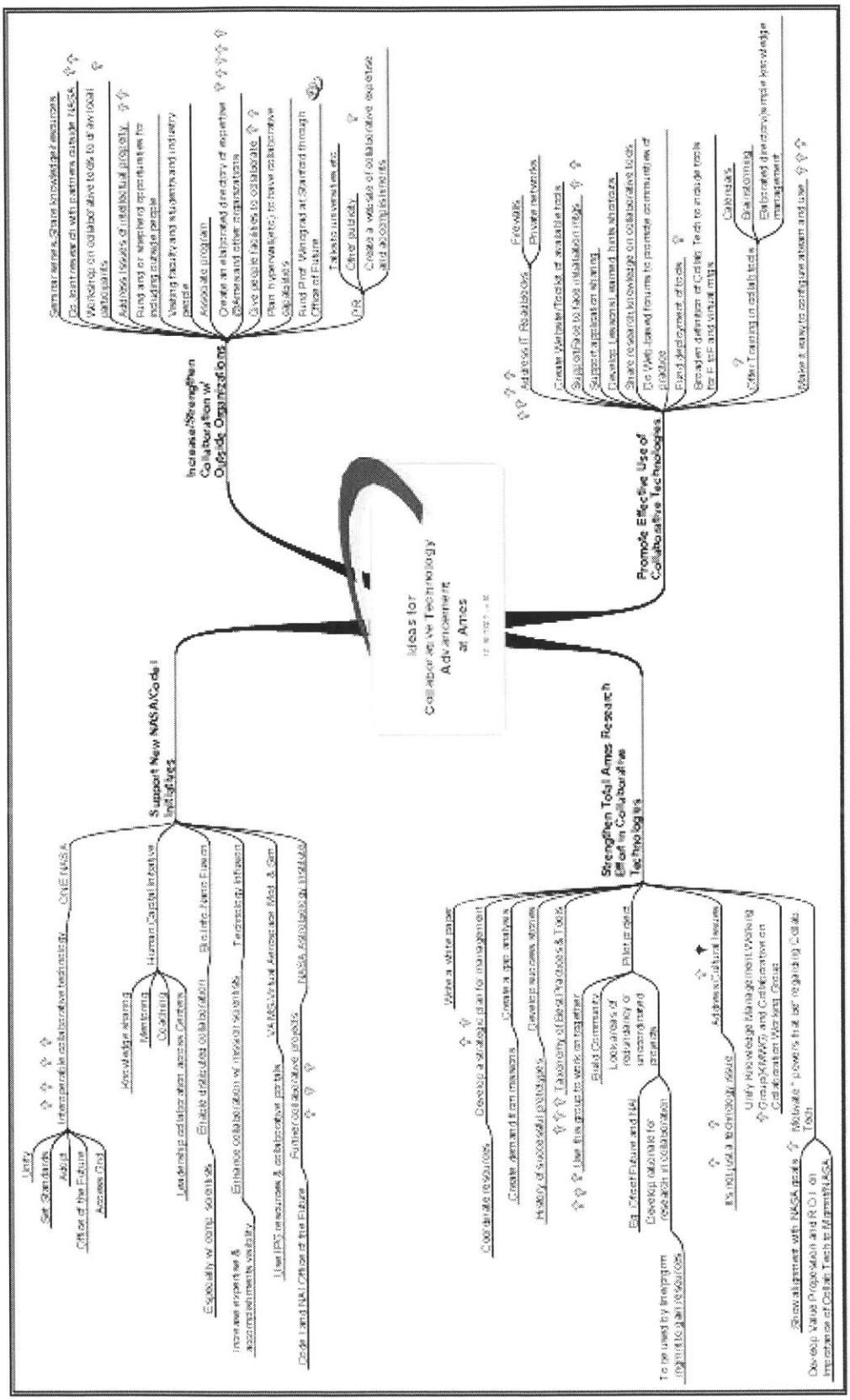


Figure 13. Ideas for collaborative technology advancement at NASA, ARC

Gritner and her co-authors cite several studies showing the importance of informal communication (in one case that developers spent more than 15% of their time on informal communication) and how informal communication breakdowns (which increase with distance) could lead to misinterpretation of design rationale or conventions. Additionally they say:

> These findings suggest that informal communication plays a critical role in coordinating R&D work. Therefore, one of the central problems of distributed development is generated by the fact that distance profoundly reduces the amount of such communication [2, 1 1-14]. The primary reasons for this reduction appear to be fewer opportunities and higher cost.[91]

This brings us full circle. There is a clear link between collaboration, both local and remote, and the success of an organization. Additionally, acknowledging the importance of collaboration includes a need to support formal and informal communication. All of this points to the need to develop a balanced solution that can support the unique *human* requirements (such as sociological, psychological, and physiological traits) of the distributed people that need to collaborate.

Just as we know there are no panaceas, it is not reasonable to believe there is a single (vendor) solution capable of meeting the dynamic requirements of an organization or person. Creation of the Collaboration Toolkit is being proposed as a way to meet this requirement. The toolkit's foundation will be a system architecture that defines a set of component interfaces to enable the ability to pick, choose, and integrate the components required to create unique solutions to fit the current need without loss of (inter or cross) functionality.

[91] ibid

Chapter 5. Why can't any of the current solutions be used to solve all my collaboration needs?

With the value of collaboration (local and remote) now established, this chapter will identify gaps between participant's requirements for effective synchronous collaboration and what is currently provided by video-conferencing. It will additionally identify how some of these gaps are addressed using other solutions but at the cost of creating different gaps.

5.1. Videoconferencing, we know the good and need to know the bad

Videoconferencing is a tool valued by many that allows individuals and groups to meet when they need to without having to bear the significant burden (time and cost) associated with travel. It has a similar ability to bridge distances (and time zones) as the telephone or videophone. Literally you can meet with people located on every continent in the world on any given day and not miss watching the local evening news at home.

As with most innovation, success brought increased requirements with increased use. Customers wanted to take advantage of this technology and simultaneously connect with individuals, or groups of individuals, at more than two locations. This "want" required additional hardware and increased the complexity of configuration. Though any two sites could directly connect to each other by "dialing" it required the use of an MCU[92] to interconnect three or more locations. This meant not only would at least three end parties have to coordinate their call with each other, now they would have to coordinate their meeting time with the operator of

[92] Multipoint Control Units are used to connect two or more videoconferencing units together into one single videoconference call by determining each unit's capabilities at utilizing the lowest common denominator for all. Also some MCUs can only interconnect 4 locations so if more than 4 locations want collaborate a tiered connection between MCUs might be required.

the MCU. Increased coordination that includes a third party service usually implies a reduction in spontaneity and some loss of schedule control, especially if the third party service required is in limited supply. Thus the incorporation of an MCU to meet requirements affects configuration, availability (scheduling with a limited resource), performance (lowest common denominator of participants), and reliability (higher probability of failure/problem due to increased complexity).

While the extra coordination an MCU requires can be viewed as a barrier to informal and spontaneous discussions it did not prove to be one to the growth of acceptance to use videoconferencing for formal meetings and education across long distances. Formal meetings and classes (academic or corporate) both share an important characteristic that the schedule is well known in advance. Both also tend to use a presentation (one to many) style of delivery, which is most tolerant of the multi-second delay normally associated with videoconferencing. In some very real ways the technology and cost of use (personnel, resource, and incremental network/service) worked together in a symbiotic fashion to create an impression that only important and formal meetings should be the norm for its use. Frivolous conversations were not excluded as much as squeezed out by the natural tendency of participants and organizations to maximize the return on the money and time invested of a limited resource. All of this (implementation, service model, etc.) also points to the optimized user of videoconferencing being a spontaneous individual who is capable of being an extrovert (i.e. someone who can "think on their feet" and is not shy about talking) to minimize "dead" air. The real result was a high cost per use, limited supply service that in fact saved money when compared to the travel costs normally associated with such an interaction.

This point was clearly made by Lee Roy Gaspard, Jr. at the IEEE[93] Region 5 Technical Conference on April 19, 2002 in his presentation titled "Video Conferencing at Shell, Overview & Status, Practical Approach for Videoconferencing over a Corporate Global IP Network." In 2001 Shell used their 45 managed videoconferencing room systems to hold 2,872 multi-point videoconferences with 331 different locations involving 10,000 people and saved £7,100,000 and 28,750,000 km of travel. This Return On Investment (ROI) is so significant that it is used as example of how Shell is a Green workplace.

This does not mean videoconferencing is a panacea though. Even with such significant savings ISDN based videoconferencing still has conspicuous flaws. Some of the components used to create a solution, though being best of the current breed, have notable limitations due to legacy decisions (e.g. financial, market, technical, business, etc.). These limitations are associated with use: configuration, availability, reliability, and performance.

There is possibly another, manufacturer instead of user based, reason for the emphasis on the formal nature of group videoconferencing, revenues. A review of past Wainhouse Research Bulletins revealed that for the last several quarters an average of approximately 96% of the overall revenues for this industry came from the sale of group systems. During this period the quarterly desktop system revenues varied between 3.2 – 4.7%.

[93] Institute of Electrical and Electronics Engineers

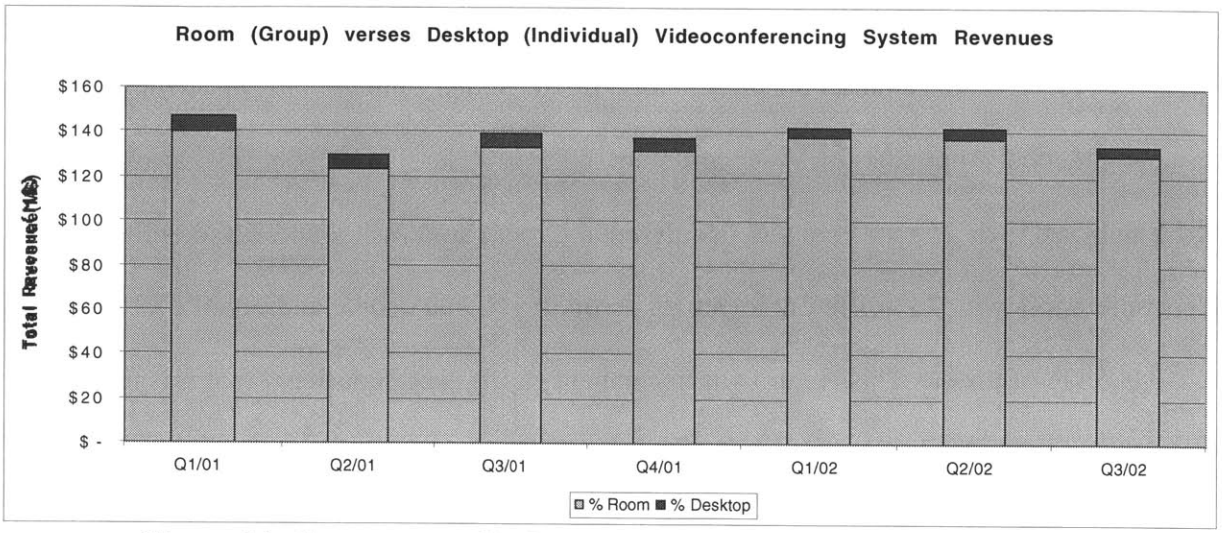


Figure 14. Group versus Desktop Videoconferencing System Revenues

The point possibly becomes more interesting when you realize that group systems represent about 67% of the total units sold for the same period (desktop units varied between 27.7% - 33.8% during this period). 96% of revenue for 67% of units sold. I do not have access to profit information so I cannot confirm if there is a similar ratio but it does provide a ring of truth to a comment I received from an individual working in the industry. The comment was in essence, we follow the money. It implies that a reason the desktop and home application of videoconferencing (including past incarnations of videophone[94]) has not taken off is that market has not shown a willingness to spend money like there is within companies and large corporations. As most technology managers know, if you want to infuse new technology get the boss hooked first, then watch the individual want turn into a corporate need.

[94] Sharper Image is currently challenging this thought by offering the Beamer Phone video station set for $499.95 http://www.sharperimage.com/us/en/catalog/productview.jhtml?pid=50883700&pcatid=4&catid=43480400

Even if it is not true that the desktop and home market is lagging behind that associated with room or group users, the perception of it being true may be enough to affect major videoconferencing manufacturers.

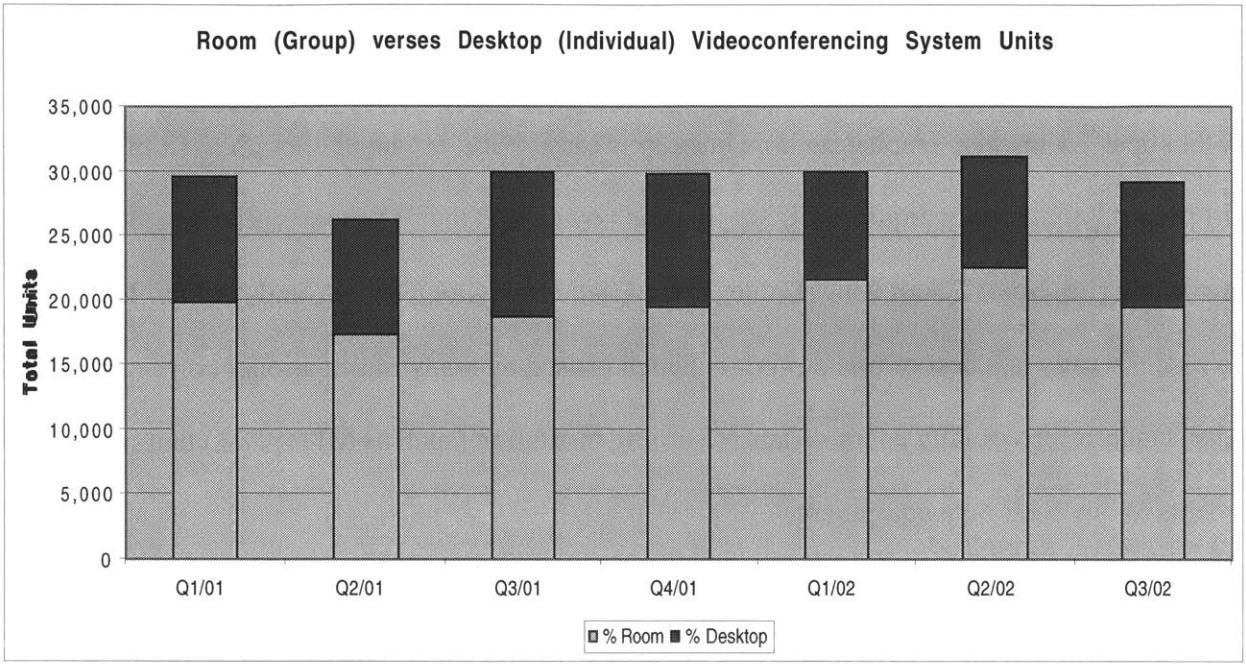


Figure 15. Group versus Desktop Videoconferencing units

The reality is that desktop systems can in fact be used for formal meetings. They also have a couple of advantages over the larger dedicated group videoconferencing solutions. Desktop computers are normally already connected to a data network and some of those desktop systems are portables.

Portability of videoconferencing had to be one of the design considerations for the ViaVideo™. It is advertised as "…brings business quality video communications into your office - in a package only 3 inches wide and specifically for personal use."[95]

Figure 16. Via Video™

Polycom reinforces how this system "can be taken anywhere" and is capable of 30 fps [96] at 384 kbps![97] They also emphasize how hookup is easy, that it is "small enough to fit in your shirt pocket," that it only requires a USB port and power, and that it supports all forms of IP networking (Ethernet, Token Ring, Cable, DSL, Frame Relay, FDDI, T-1, and ATM). The ViaVideo™ truly is a best of breed product which is used by many multinational corporations and a standard for virtually every distance learning institution (such as MIT-SDM) that requires students to buy their own equipment.

Why is Polycom stressing the support for IP networks you might ask. Why might there be a need to move from ISDN to Internet based collaboration? Availability and reliability! ISDN was relatively new when videoconferencing was introduced, required special dedicated circuits, and the related tariffs did not favor commodity pricing. It required technical staff to install, maintain, and operate. Additional staff (or a third party) was required to provide MCU support. This meant the perceived total cost (tangible and intangibles such as aggravation) of supporting the operation could have proved prohibitive for all but the most important meetings.[98]

[95] http://www.polycom.com/products_services/products_groups/0,1422,pw-186-186-72,00.html
[96] frames per second
[97] kili-bits per second, or thousands of bits per second.
[98] Not only were the videoconferencing systems of limited access, but due to the associated minute per minute charge (some of us derisively call this the bit rate tax, a sure way to constrain use for any communication service) for ISDN and associated support services, time was now directly quantifiable as money.

ISDN has also never really caught on in the United States as it has in Europe, and even where it is used the infrastructure is showing signs of stress. As virtually every distance SDM student has experienced and Shell has documented[99] most ISDN videoconferences experience some sort of service interruption before the scheduled session completes. Therefore reliability is a real, some say primary, issue for evaluating a move from ISDN based videoconferencing.

While availability is not as severe of a limitation as reliability is proving to be, ISDN still requires a dedicated circuit to be installed and tested. Compare this to the ubiquitous possibilities of connecting a computer to the Internet. POTS (used to connect a computer to an ISP[100] via a modem connected to a standard analog telephone line), DSL (used to connect home or business based Ethernets to the Internet), cable modems (used to connect home or business based Ethernets to the Internet via existing cable TV networks), and other corporate solutions all provide a ready path to an IP network. Even when a person is on travel most (business or major) hotels now have high speed Ethernet access available in the room. Throughout the world there are Internet cafés that provide network access at modest costs. In a little over thirty years of existence the Internet has grown from an interconnection of 4 systems to over 160,000,000 systems (please see Figure 17. Growth of the Internet, page66).

[99] Lee Roy Gaspard, Jr. at the IEEE Region 5 Technical Conference on April 19, 2002, slide 12 in his presentation titled "Video Conferencing at Shell, Overview & Status, Practical Approach for Videoconferencing over a Corporate Global IP Network." Shell also conducted a six month investigation to confirm the vulnerability of BRI ISDN systems.

[100] Internet Service Provider

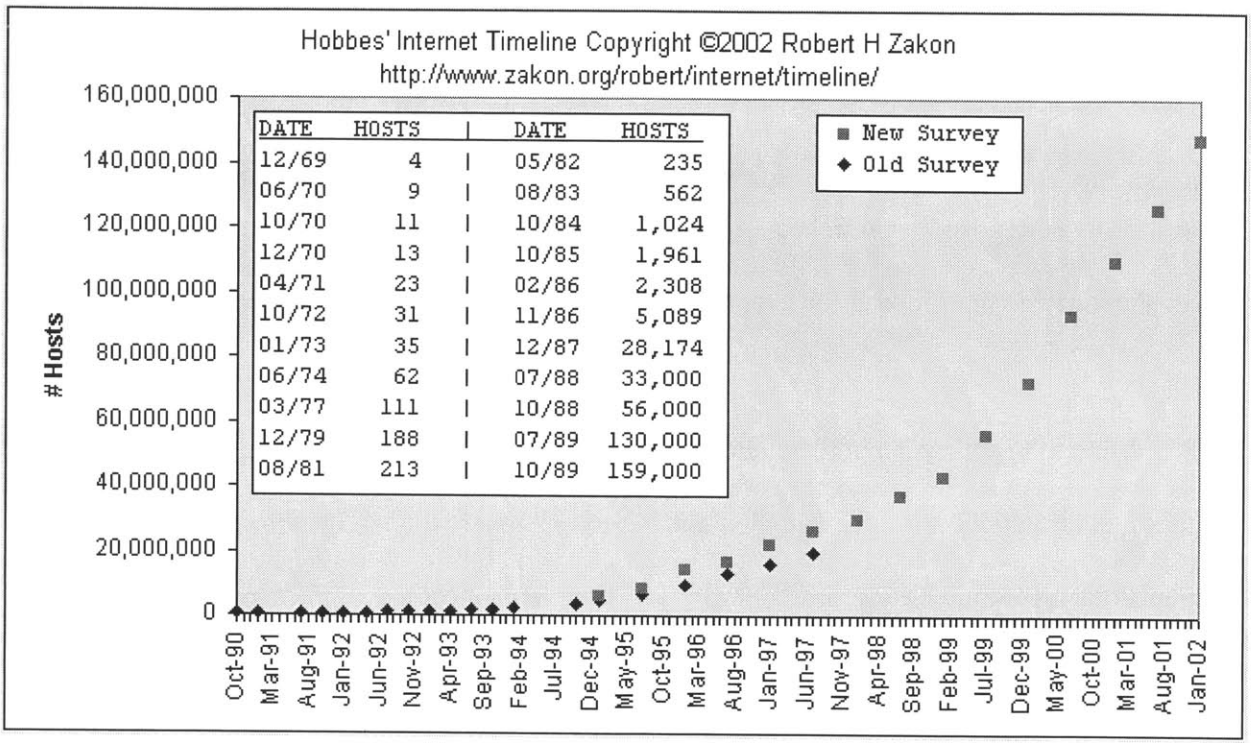


Figure 17. Growth of the Internet

The Internet is also quite robust which speaks to one aspect of reliability. Even earthquakes, such as the Loma Prieta in October of 1989 or the Northridge in January of 1994, or severe weather that can disrupt normal utilities (such as power and to a lesser extent phone) have little affect on the Internet.

Even with readily available access to reliable IP networks and the apparent best of breed status of ViaVideo™, this combination still does not resolve all of the legacy limitation issues. Performance and reliability remain issues due to legacy limitations of the protocol used to transmit data. IP is still a "best effort" protocol (when combined with TCP[101]) and does not yet

[101] Transmission Control Protocol, provides the rules (e.g. content/validation and order) that enable hosts to create the data stream required to send and receive IP packets

effectively provide PoS and QoS[102] for any data stream. PoS and QoS are important because without these priority and quality controls for the videoconference IP data stream, normal IP network congestion can easily interfere with performance (network throughput). And since an individual using an IP videoconferencing solution will often connect via an MCU, degradation of performance affects all videoconference participants. The IEEE has been working to establish these standards for several years. PoS, or 802.1P, (as part of IEEE 802.1D) and QoS, or 802.1Q, were both published in 1998 and are currently being updated (as 802.1Y and 802.1Z respectively). Even with updated published standards it will take a few more years before the equipment that comprises the Internet will be upgraded to support QoS and PoS reliably. Therefore, even though moving to IP network based solutions does help resolve availability limitations from multiple perspectives, it does not eliminate performance and reliability concerns.

There also remain issues for individuals with disabilities. Visual or hearing impaired participants may also experience problems using videoconferencing due to limitations associated with videoconferencing standards. As an example please compare the standard videoconference standards of QCIF and CIF with computer and television video standards (please see Table 7. Comparison of Video Resolutions on page 68).[103]

[102] Priority of Service is IEEE 802.1P (published as part of 802.1D) and Quality of Service is IEE 802.1Q. http://grouper.ieee.org/groups/802/1/

[103] *NTSC and PAL digital information is theoretical. NTSC signal effective pixels are 640 x 480 because of the need to subtract horizontal and vertical synch pulse (i.e. 720 – 80 and 525 – (2 x ~23) respectively.

Standard	Width	Height (lines)	Frequency
QCIF	176	144	Varies
CIF	352	288	Varies
VGA	640	480	Varies
SVGA	800	600	Varies
XGA	1024	768	Varies
SXGA	1280	1024	Varies
UXGA	1600	1200	Varies
NTSC analog		525	60 Hz, interlaced
NTSC digital*	720	480I	29.97Hz/frame
PAL analog		625	50 Hz, interlaced
PAL digital*	720	576i	25 Hz/frame

Table 7. Comparison of Video Resolutions

QCIF[104] and CIF[105] are the standard formats for videoconferencing established to be compatible with both NTSC[106] and PAL[107] TV signals. The problem is the images are either so small that it challenges comprehension or when enlarged to fill a screen capable of handling much higher resolution too grainy or blurred. This loss of image sharpness and contrast is, in essence, the loss of information and can impede in the ability of an individual to read lips, signing, or sometimes body language (e.g. facial expressions). Such a loss increases the fatigue factor of any participant, but especially the visually impaired, as they expend energy trying to discern what is being visually presented to them.

An additional reason for blurred images is the reality of converting video signals from analog to digital. The conversion process is not perfect and there is a certain percentage of signal loss each time an image is converted. When this is done several times, as often is required to

[104] Quarter Common Intermediate Format. 144 lines of 176 pixels
[105] Common Intermediate Format, also called FCIF or Full CIF, 288 lines of 352 pixels
[106] National Television Standards Committee, this is the standard for US television as a composite video signal with a refresh rate of 60 half frames (interlaced) per second. Each frame contains 525 lines.
[107] Phase Alternating Line, this is the standard for European television. It is a composite signal with a refresh rate of 50 half frames per second. Each frame contains 625 lines.

move an image between locations, the effect is noticeable. As an example I will use a standard SDM distance class at MIT. A teacher would begin class and start a PowerPoint presentation. Now the PowerPoint file is by definition digital, and this gets converted to analog so it can be projected (loss 1). Then the professor, as part of the discussion, moves over to the projected slide to make a point and this image goes through one (analog to digital loss 2) or two (analog projection to analog camera to digital loss 2 or 3) more conversions before it is sent to the distant student, which requires it to be compressed (more loss), and ultimately decompressed and then converted from a digital to analog so it can be viewed, or projected, as a analog signal on a television. The net effect of the numerous conversions and (de)compressions was an image that was viewable (if you can call it that) at the remote locations where 24 point font was not legible. Oh by the way, analog to digital to analog conversion does not just cause loss of image quality (i.e. decreased resolution of an already reduced resolution image) but it can also introduce artifacts (e.g. noise, ringing, etc.) which further occlude the actual image.

In a similar fashion the audio signal provided in videoconferences can be troublesome at times. With automatic noise canceling clipping speech, signal (de)compression, networks dropping packets and delay interrupting speech, or something as simple as a bad microphone or muting mishaps eliminating speech the frustration of participants struggling to participate increases rapidly past annoyance. Some systems will allow the user to reconfigure audio to have a higher priority (i.e. maintain more bandwidth) as network performance degrades, but this requires user intervention and has an associated cost of decreasing the bandwidth available for the video transmission and reception.

Please do not take me wrong, videoconferencing is a very powerful tool, can save corporations, academia, the medical community, professionals, students, and individuals both time and money when used correctly. But the limitations of this solution have been surfacing in an increasing fashion. For these reasons, along with concerns regarding the security of the videoconferencing data stream, certain types of meetings (e.g. negotiations, corporate strategy, human relations, etc.) are rarely, if ever, conducted via videoconference even by some that are strong advocates its use.

Lastly, a generic problem with most videoconferencing solutions that remains is cross-platform[108] support (i.e. it only supports a single computer platform, one using Microsoft operating systems). Large room (group) systems use dedicated hardware (sometimes incorporating a Microsoft operating system enabled computer), desktop (personal) ISDN-based systems require installation within a Microsoft operating system enabled computer, and the best of breed USB capable ViaVideo only works with Windows 98 (also 98 SE and 98 ME), and Windows 2000. When Polycom was asked about supporting UNIX in the future their reply was they have no plans to do so.

Supporting only dedicated or a single manufacturer's operating system significantly limits an individual's ability to collaborate in this world. Just think what it would be like if your Motorola cell phone would not be able to call a Nextel Nokia, Ericsson, Samsung, or the analog phone each of us has in our home. This limitation will also be solved in the future, of that I am sure.

[108] Cross platform means a solution that supports multiple computer operating systems (e.g. UNIX, Mac, and Microsoft Windows/NT/XP variants)

5.2. If one size doesn't fit all, are there alternatives?

Succinctly put, yes. But each of the alternatives currently available that meets an individual's specific need has its own limitations. In some very real ways the alternatives provide a "one size fits all" solution just like standard videoconferencing. Each takes advantage of the Internet to distribute the signal to increase the opportunity for participation.

Here is a quick overview of the benefits and limitations for the alternatives discussed below. Instant Messaging (IM) is wonderful for real time chatting and exchange of data but its support of real time audio and video is of lower quality and not suitable as the only solution to be used for business or education applications. Data (web) conferencing has many advantages as long as the event (presentation, training, class, etc.) and the interaction between the audience (class) and the presenter are well scripted. This alternative best supports communication in one direction (i.e. a one to many), can support controlled participant comments (and questions) and information gathering but has distinct disadvantages if the presentation requires dynamic interaction between all participants. Streaming media players are wonderful for canned events that require, or allow, no feedback such as a "State of the corporation," generic announcement, advertisement, or normally scheduled programs (e.g. news, radio, television, etc.) since they have no provision for real time feedback. Understanding this reality is an additional motivation to establish the Collaboration Toolkit.

For some one of the variants of IM provide a handy anywhere anytime solution to exchanging thoughts with another. All major versions support cross platform exchanges and some allow interfacing between web based and application based participants (non-exclusion is critical for effective collaboration). All support near-real time exchange of typed phrases, data

(half and full duplex voice and low-end video may also be supported), and some now offer (either directly or via third parties) secure options. Secure options include active encryption of the IM data stream up to the option of procuring server software that allows a company to provide a corporate specific IM service.

According to some[109] AOL created IM in 1989 but Mirabilis (acquired by American Online in 1998) claims the distinction for pioneering the technologies that allowed millions of individuals to interact on the web. Their product was ICQ ("I **SEE-K YOU**").[110] This claim appears to have some validity since the patent Mirabilis filed in 1997 (number 6,449,344), and transferred to AOL in 1998, was granted in September of 2002.[111] The new functionality that this generation of IM provides is cross-communication platform support[112] for an instantaneous transport of a person's written word (along with emotions-icons[113], images, and data files) in a one to one, one to many, or many to many format (the later two are accomplished via chat rooms).[114]

While IM does support near instantaneous interactions its use is primarily for informal interactions. If you want to make a formal (one to many) presentation using software like PowerPoint then another solution, commonly known as data conferencing should be used.

[109] http://www.thestandard.com/article/display/0,1151,18853,00.html
[110] http://www.icq.com/company/about.html
[111] http://www.informationweek.com/story/IWK20021219S0006
[112] IM compatible clients now include computers (UNIX, Mac, and Microsoft operating systems), PDAs, and cell phones
[113] Emotions icons allow for a one way communication of a persons state, but the inherent problem is that they are controlled by the "speaker," not the receiver's perception. Therefore it can be used to mislead.
[114] Voice, and to a lesser extent video, is also supported but at rates not conducive for anything other than leisure use.

As we all know, standard videoconferencing can render a crisp slide illegible at the speed of light. Requiring prior distribution of the slide package can prove troublesome to coordinate (both in distribution and navigation during the presentation)), precludes timely updating of information, and introduces loss of document control (i.e. the control of the slide being viewed is with the participant, not the presenter). The reality of this style of presentation is that the presenter wants to be in total control, both of the spoken voice and image that the participants see just as if all participants were in the same venue.

Now you might wonder why a person or corporation would want to loose the advantage of a face to face interaction to make this presentation over the Internet instead of in an auditorium or classroom? The benefits outweigh the detriments. Most benefits come from increased efficiency and participation due to better use of resources. Instead of booking rooms (with the associated complimentary participant snacks and staff travel) and travel to present (or attend) at locations across the United States, or across the globe, the web can be used to reach individuals at the work at their desktop. Multiple sessions can be scheduled so participants can choose a convenient time because all they need to participate is access to the web and a phone. This equates to higher attendance and saves everyone travel time and expenses. Participants remaining at work locations also allow for incorporation and dissemination of newly acquired information quicker to peers. So not only does this add up to more people attending for less effort on everyone's part, it also fosters collaboration because information can be shared more effectively when it is fresh which implies better capture of knowledge. A classic win-win situation.

Who provides these alternative data (web) conferencing services? Many web based companies[115] are attempting to provide this service, but the apparent leaders of the pack are PlaceWare®[116] (supports web based conferencing, presentations, and education) and WebEx™[117] (supports web, video, and teleconferencing). Web conferencing normally uses a combination of a browser compatible web interface to push data/digital information and a standard telephone to deliver audio (you are politely asked to mute your phone). The service provided has tangible value for the presenter and participant alike.

Ease of use is a primary benefit. Participants already know how to use a phone and their knowledge of the computer is only entering the correct URL[118] into a web browser (a doable task for most individuals by now that can be further automated by making the URL "clickable" in an e-mail). Also being browser, rather than application, based this means of collaboration by definition has cross platform support. I do not know of anyone that has attempted to participate in a web conference using a web-enabled cell phone but in theory that might be possible also.

In this same vein WebEx is suggesting the Microsoft TabletPC[119] (produced by Acer) for use as a portable conferencing tool. Microsoft is not the first out with this type of technology, Vadem's Clio[120] is a similar large screen (slightly smaller than 8.5" x 11") format solid state PC with versions of Microsoft applications and built in handwriting (print, cursive or a combination)

[115] As of this time there are at least 56 general purpose real-time web conferencing options, since October 2002 there has been at least twenty new entries to this field.
For an up to date list please refer to http://www.thinkofit.com/webconf/realtime.htm
[116] http://main.placeware.com/index.cfm
[117] http://www.webex.com
[118] Uniform Resource Locator
[119] http://www.microsoft.com/windowsxp/tabletpc/default.asp and http://global.acer.com
[120] http://www.pocketpccity.com/hardware/Vadem-Clio-C-1050-2000-10-12-ce-hpcpro-spec.html

recognition has been available since 1998. The Sony Vaio Picturebook[121] is another interesting variant in that is has an integrated camera that is capable of still or video images (it also comes with a privacy shutter for times you do not want to share an image 8^).

Availability of the presentation as well as of potential participants is another benefit increased by using the web. Since there is no longer a physical location one has to travel to, participants can attend any of the presentations offered in a language they understand. Not having to travel also translates into more participants because less time is required to participate and no, or little, management justification is required. The relative ease of virtually attending also allows those unsure of the value to participate long enough to determine value and then decide. Lastly, because the documentation is built into the web conferencing process, asynchronous participation of those unable to make the scheduled web conference is a realistic possibility.

Information exchange (between the presenter/presenting team and participants), gathering, and documentation are arguably increased versus a face to face meeting. Since participants have to login to the virtual presentation, certain information is immediately available (e.g. number of participants, names, affiliations, etc.) to the presenter, and, to a lesser extent, the participants. Participants can raise their hand electronically if they would like to comment or have a question (try this if you are in the back of a darkened room filled with a hundred participants, it is easy to get overlooked when you are in person). The process available allows the comment or question to be dealt with by the presenter audibly or an assistant via an interface similar to IM in a discrete fashion. If the comment or question requires indication or emphasis on a presentation slide or white board, this information is easily "pushed" to all participants for viewing within their browser.

[121] http://www.dynamism.com/c1mzx/main.shtml

In a similar fashion presentations can be modified "on the fly" to add emphasis, or correct a typo. Immediate polls can also be taken to evaluate the audience (e.g. understanding, need, mood, information, etc.) and gather statistics. Again, all of the information (participants, presentation, questions, etc.) is immediately documented through use and, in some cases, can be played back at a later time. The disadvantage of this solution is lack of video for the participants and only low quality video for the presenter (though available, this option is rarely used).

A less capable, single direction (i.e. only lecture or push of interaction, no interaction or feedback) option for using the web is also available through the use of streaming video. Examples of this technology include: Apple QuickTime[122], Realplayer[123], Windows Media player[124],all of which are capable of receiving streamed audio and video on an individual's desktop via a proprietary application. All have free cross-platform multimedia players but charge for their streaming media server software/service. This alternative shares the efficiency aspects of web conferencing related to availability (efficient use of all participant's time, travel, etc.), and is often used to replay a previously recorded event (speech, presentation, class, etc.). What is rarely accommodated when this type of application is used for a live presentation is feedback from remote participants. I gave one of the first live web-broadcast (using RealPlayer compatible streaming software) training sessions from NASA, Ames Research Center, that had participants from across the United States in the late 1990s. We attempted to use a phone line to incorporate questions from the field without evidence of success. In 2001 NASA streamed a live speech by NASA Administrator Goldin from NASA-Headquarters using RealPlayer compatible software. It

[122] http://www.apple.com/quicktime/download
[123] http://www.real.com
[124] http://www.microsoft.com/windows/windowsmedia/download/default.asp

was a true multimedia event with participants within the headquarters auditorium, at other Centers viewing the presentation via standard and satellite video network feeds, and others, like ourselves located at MIT, using the Internet. For remote users questions were gathered via an audio stream associated with the video network or from electronic submission. Though the audio comments and questions were heard, electronic submission proved troublesome once again. This time the questions made it through in a fashion, the problem was they were abridged when provided to the Administrator in a fashion that changed the meaning. This does not mean streaming media should not be used for such events, just that more work is required to support interaction from remote locations if that is desired.

Streaming media is also, some would say best, used to distribute audio and television (e.g. radio, music, news, infomercials, etc.) programs over the web. This is a perfect application since no one expects either a radio or television program to accept immediate comments (even though there is a tendency to do so in most households). There is a free alternative to QuickTime, RealPlayer, and Media player under development in France called VideoLan.[125] It is available on the web and provides a free cross-platform player and free (almost) cross-platform server software.[126]

So if you believe analogous issues had to be resolved then the time for this breakthrough is right now. In reality (hindsight being closer to 20-20 than foresight) the hurdles were somewhat higher but the rapid growth of technology more than offset the difference in complexity. Web-

[125] http://www.videolan.org and for the client software http://www.videolan.org/vlc

[126] Interestingly, this application seems to be developed for UNIX and the ported to the other operating systems. Apple client support is currently for OS X, which is a UNIX variant Server software is still under development.

based education is a reality and will soon be available and demonstrated by MIT when MITWorld[127] is fully functional.

"Never stop learning; knowledge doubles every fourteen months."

Anthony J. D'Angelo, The College Blue Book

[127] http://web.mit.edu/mitworld

Chapter 6. The power of System Architecture

This chapter provides a brief overview of the concept of System Architecture and discusses why establishing a clear and extensible architecture for remote collaboration is important. Examples include the ability to abstract fundamental research for practical use, the establishment of requirements (which also implies identification of gaps), and increasing the likelihood of extensibility due to a better definition of sub-component interfaces.

6.1. Why is establishing an Architectural Vision important?

The short answer is that creating a clear vision of the Architecture is necessary because it allows participants to maximize their personal understanding and potential by sharing a unifying theme of system-level goals achieved through the appropriate abstraction of concepts and details unnecessary to the creation of a solution.

A more formal answer is that in order to achieve the thesis goal System Architecture concepts (abstraction, decomposition, and supersets) will be used to create a new, shared mental model and identify the interfaces required. Additionally, it will also be used to integrate existing base research (which will be abstracted) with other published work that establishes different learning and teaching styles[128] (which may also be abstracted) to create a consistent, extensible, and adaptable user (human-machine-organizational) interfaces (the superset).

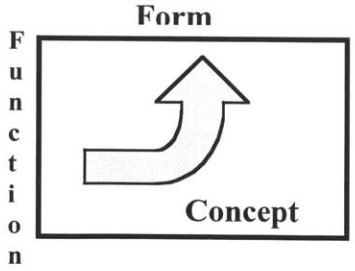
Lee and Messerschmitt, from University of California at Berkeley, provided a cogent statement as to the importance of establishing an architecture in their cover feature article on

[128] http://www2.ncsu.edu/unity/lockers/users/f/felder/public/Learning_Styles.html

"Engineering an Education for the Future" that appears in the January 1998 issue of the IEEE Computer magazine.

> "Arguably the most important phase of the design process, after the definition of goals, is the definition of the architecture. Architecture refers to the partitioning of functions into modules and the choice of abstraction defining the interaction of the modules.
>
> A successful architecture makes the internal workings of the modules as independent of one another as possible. A successful architecture will exploit or promote reusability by either applying previously designed components or defining components that are sufficiently configurable to be reused in the future. Failing to reuse previous designs can cause a project to drown in complexity. Detractors will often argue that making components reusable compromises their efficiency or performance. But failing to do so has much more dire consequences: It makes only trivial designs feasible.
>
> The design of architectures, with relevant concepts and theories and many design experiences, should be a part of every designer's education."[129]

As you can see they feel a benefit of establishing a successful architecture includes complexity management that can minimize, if not eliminate, arbitrary barriers to success. This view resonates well with the research Professor Edward Crawley is doing to refine, augment, and extend the concept of System Architecture into a discipline. His proposed view of system architecture is:



"The embodiment of concept, and the allocation of physical/informational function to elements of form, and definition of interfaces among the elements and with the surrounding context.

...

To deliver value, we must architect the whole product system"[130]

Figure 18. MIT ESD concept»function»form

[129] Edward A. Lee and David G. Messerschmitt. Engineering an Education for the Future. IEEE Computer Magazine, 31(1):77-85, January 1998. http://ptolemy.eecs.berkeley.edu/papers/98/curriculum/computermag.pdf

[130] ©Professor Ed Crawley and Ben Koo, System Architecture Evaluation, DRAPER LAB. Research Project, Fall 2002 mid-year review, December 18, 2002, slide 7 and 10 respectively

The integration of concept allows for the establishment of intent, which is the essence of all architectures. Intent links design to (i.e. must be the source of) requirements. As you will see in the next section, this is a very useful attribute. As a matter of fact, requirements that deviate (i.e. are misinterpreted, misunderstood, or purposefully modified to be expedient) from intent are the problematic elements in product development

The need to establish a system architecture may have been summed up best in an October 2001 NASA, Glenn Research Center, paper by Eubanks and Prahst where they stated:

> "To move forward, we must establish agreement on Agency intent for Team Collaboration architecture and standards."[131]

This is a well put thought for it is true for the probability of having several individuals (*especially* engineers) independently evaluate and implement compatible and interoperable solutions to meet the same requirement without the stability of a system architecture, would be less likely than winning the super lotto. Possible, but if it happens don't stand next to a window during a lightening storm.

6.2. How can it be used to identify gaps in technology?

For me one of the critical clarifications made by MIT is the clear linkage of intent to the practice of System Architecture. Intent is an interesting word because it comes from the 13th Century Latin intendere (to stretch out) and is a synonym for intention. Merriam-Webster defines intention thusly:

> One entry found for intention.
> Main Entry: in·ten·tion

[131] Team Collaboration Architecture and Standards Directions, Steve Prahst and Steve Eubanks, October 2001

Pronunciation: in-'ten(t)-sh&n
Function: noun
Date: 14th century
1 : a determination to act in a certain way : RESOLVE
2 : IMPORT, SIGNIFICANCE
3 a : what one intends to do or bring about b : the object for which a prayer, mass, or pious act is offered
4 : a process or manner of healing of incised wounds
5 : CONCEPT; especially : a concept considered as the product of attention directed to an object of knowledge
6 plural : purpose with respect to marriage

synonyms INTENTION, INTENT, PURPOSE, DESIGN, AIM, END, OBJECT, OBJECTIVE, GOAL mean what one intends to accomplish or attain. INTENTION implies little more than what one has in mind to do or bring about <announced his intention to marry>. INTENT suggests clearer formulation or greater deliberateness <the clear intent of the statute>. PURPOSE suggests a more settled determination <being successful was her purpose in life>. DESIGN implies a more carefully calculated plan <the order of events came by accident, not design>. AIM adds to these implications of effort directed toward attaining or accomplishing <her aim was to raise film to an art form>. END stresses the intended effect of action often in distinction or contrast to the action or means as such <willing to use any means to achieve his end>. OBJECT may equal END but more often applies to a more individually determined wish or need <his constant object was the achievement of pleasure>. OBJECTIVE implies something tangible and immediately attainable <their objective is to seize the oil fields>. GOAL suggests something attained only by prolonged effort and hardship <worked years to reach her goals>.

These definitions all help clarify why the inclusion of intent is the lynchpin. Intent ties the architecture back to the goal, or objective, of satisfying the requirements. You might ask "Whose requirements?" Again Professor Crawley clarified this concept by decomposing "consumer" into three "agents" for use in the new Architectural Object Process Model (AOPM) (Please see Figure 19. Architectural Object Process Model Example, on page 83).

In this new model there are three types of agents (what used to be called consumers) used to facilitate the Architecture analysis. They are: Customers (participant, buyers, users, etc), Operators (e.g. producer, service provider, etc.), and Beneficiaries (e.g. the corporation, society,

investors, workforce, etc.). These "personality" types are assigned to a collection of interacting agents to better capture and visualize the possible scenarios in a complex environment. Therefore by splitting the consumer into three separate agents AOPM is better able to discern, or understand, the intent of the need (requirement). It also reveals the internal reasoning dynamics of consumer decision process. Please note that even if the consumer is an individual, that person could still embody all three types of agent roles.

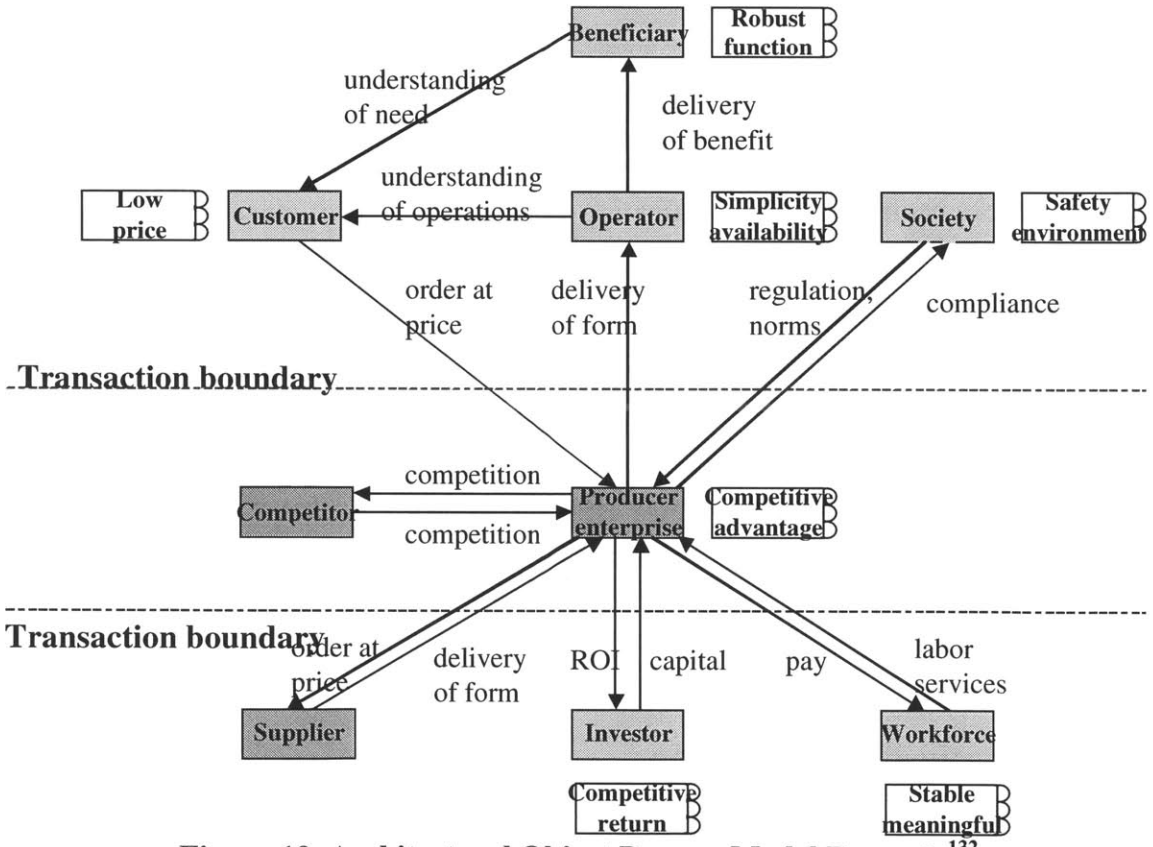


Figure 19. Architectural Object Process Model Example[132]

This works to the advantage of using an agent-based analytical framework to identify the

[132] ibid. , slide 12

interactions between intent, not just specific persons. In the case of the Collaboration Toolkit, the intent of the service is to approximate face to face (or personality to personality, as noted each individual may be wearing multiple "hats") interaction as close as reasonably possible. Therefore the AOPM will be able to focus the analytical process on intent (usually described as a noun with modifiers, e.g. adjectives, adverbs, verbs) and use these to describe processes (functions described by verbs and adverbs) which are then used to define the standards associated with the objects (generic and specific systems described using nouns and adjectives). The result is an uncensored list of processes that can be matched to the existing capabilities of a given technology. After a set of available technologies (application or objects) have been applied to the model, any process or intent not accommodated (satisfied) is by definition a gap. Therefore gaps can be determined by evaluating the established needs (requirements) versus the availability of solutions that can be used (and integrated) to meet these needs.

Going back to the discussion of the importance of incorporation of intent; I would propose summing it up for this case this way. Requirements are the driver for function and ultimately form.

6.3. Why extensibility is important

A good System Architecture yields another very important attribute. The definition of interfaces (called interactions by Lee and Messerschmitt). By spending the time to comprehensively define the interfaces one clearly supports the concept of reuse touted by Lee and Messerschmitt in the quote above. In the agent-based analytical framework mentioned above, interfaces truly represent various instances of a value proposition. When you take into

account the dynamic nature of communication (all of the rapidly evolving forms) as well as the evolving ways individuals want to collaborate; it would be a fool's errand to think a static architecture or standard defined today would be of much use for very long.

By assigning "personality" types to a collection of interacting agents, we could better capture and visualize the possible scenarios in a complex environment. By doing this even if we have no idea of what people will do in the future (but we do know there will be people involved), we should be better able to anticipate their probable (re)actions. Having an architecture analysis based on the personality of agents will allow for better adaptation to the unknowns that will occur in the future. Therefore this will provide for a continuity of thought and action, which should provide an enhanced opportunity for supporting collaboration and taking significant steps toward achieving the ultimate goal of virtual presence.

6.4. A sample AOPM

Unfortunately, at the time of the completion of this thesis AOPM is still in its creation stage. Its theoretical concepts will still be used in the next section to show how most human traits (psychological, physiological, and sociological) have not been supported by current technology.

The following is my interpretation an OPM of the organization and processes that might be required to work on creation of a sustainable Collaboration Toolkit (please see Figure 20 on page 86). This chart was inspired by recent work done by Professor Crawley and Ben Koo. An organization is required to solve the larger issue because it crosses so many boundaries (e.g.

technology, psychology, sociology, physiology, anthropology, etc.) and without mutual understanding a holistic solution has little chance of being created.

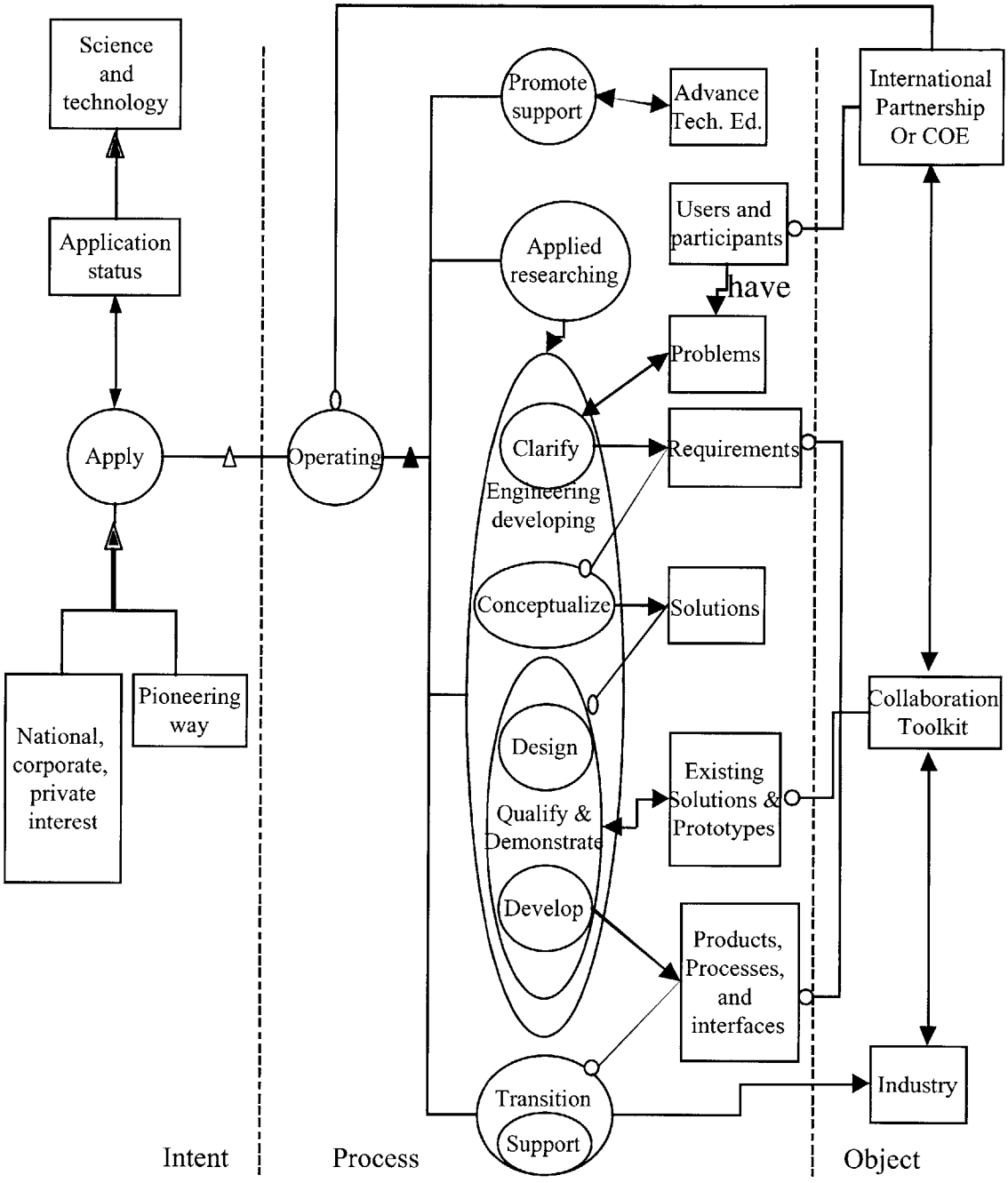


Figure 20. Proposed Collaboration Toolkit Organization Architecture[133]

[133] ibid. this proposed architecture is derived from what appears on slide 20

Starting from the upper left you see an object box labeled "Science and technology." This is meant to represent new science and technology concepts usable for collaboration under development. These concepts require evaluation to see if any are mature enough to be applied (the connection to the operand "application status"). If any are, then those concepts can be moved into the "apply" process. This is where a concept can be mapped to the intent (need or want) of a pioneering activity or any of a myriad in specific interests willing to support or help facilitate the ensuing process. With the intent now mapped to concept it is ready to begin the multistage process that goes from validation of concept to validation of application (i.e. does the product/component/technology fulfill the intent/meet the requirement). If it successfully completes this stage the process then completes with a transition to an organization (labeled industry in this example) for support and incorporation into the Collaboration Toolkit where it will be available for use.

The process section is of interest because it reveals the interrelationships (shown as feedback/provides links) between international organizations or Centers of Excellence (COE) and a refinement of requirements (human problems clarified to distill intent that is then transformed into a requirement). Requirements are then abstracted to maximize the opportunity of being mapped for use by a solution for incorporation into a design that can be used in a prototype or a different existing solution. This application then needs to be verified and validated. This is to ensure performance meets the standards and interfaces spelled out in the interface and other requirement definitions established by the Collaboration Toolkit Architecture. In fact the multiple feedback/provides connections from the Collaboration Toolkit is meant to

show the value of well defined standards being able to facilitate the successful completion of such a process.

Though it may seem complicated I feel it will take such an interdependent and cross-functional organization collaborating to create and sustain the Collaboration Toolkit. The telephone may still be the best example of what is capable of being achieved through the rigorous development of strong, well defined, and standards based architecture. The telephone dominant design (handset with speaker and microphone connected to a base system) established in the late 1890s is still in use in most homes and businesses around the world today. It has proven capable of evolving with the needs of its users, who happen to be the same people that might want to collaborate remotely. For this reason I believe it would serve us all well if a similarly strong architecture is developed for the collaboration toolkit.

Some of the symbols in Figure 20 may not be familiar to you. Please use the following information to aid in the interpretation of the relationships.

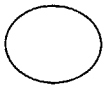

Provides, as in input or a specific function

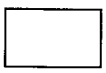

Specializes to (or specific instance of)


Decomposes to (breaking an object subcomponents)


Characterized by (specific instance of the need for)


Direction of information or process flow


Process or activity (action or verb)


Object or operand (noun)

Chapter 7. Are there even more limitations in the current standard?

With the advantages and limitations of various collaborative applications already established in Chapter 5, [Why can't any of the current solutions be used to solve all my collaboration needs? (begins on page 59)], this chapter will discuss new limitations associated with the need to support human traits.

7.1. Show me the gaps!

If the AOPM tool was available it would have highlighted several areas of everyday face to face (personality to personality) collaboration (interaction) unsupported by current solutions. This includes the lack of support for psychological traits already discussed in Chapter 3 [Why adapting to the human is important, starting on page 29)] above. Primary discussion would center around visual input for the human since that is the basis for delivery of information from the computer or video display system. Auditory input to the human would also be discussed because this is a secondary information path from the computer and of high importance to all audible collaboration systems. Of interest, audio for collaboration is often rated as a higher priority than video, as was the case with Shell Global Virtual Team members when they abandoned videoconferencing for the most part and substituted long teleconferences. The following sections will use this perspective to discuss the "provides" versus "needs" gaps and assess whether any of the previously discussed solutions, or a publicly known new solution, can be applied. It will then briefly look to see if any of the new gaps can be eliminated using another existing application, tool, or process.

As a reminder, it was presented in Chapter 5 that the current prevalent solutions used for synchronous collaboration were ISDN based videoconferencing (dedicated system and to a lesser extent PC based); IP based videoconferencing (which introduces the possibility of portability), data conferencing solutions (e.g. WebEx, PlaceWare, as well as others), and Instant Messaging.

<table>
<tr><td rowspan="2"></td><td colspan="2">Level 0</td><td colspan="3">Level 1</td></tr>
<tr><td>Intent</td><td>Concept</td><td>Intent</td><td>Process</td><td>Object</td></tr>
<tr><td rowspan="3">Documentation and knowledge capture</td><td rowspan="2">1. What are the current goals?</td><td rowspan="2">2. What concepts are embodied</td><td colspan="3">3. What is the current architecture?</td></tr>
<tr><td>3a. Design intent capture?</td><td>3b. Principles of operation and processes used?</td><td>3c. Diagrams, drawings, and specifications?</td></tr>
<tr><td>Documents</td><td>Documents</td><td colspan="3">Documents, drawings, or oral history?</td></tr>
<tr><td rowspan="2">Analysis</td><td rowspan="2">4. Goals, mission statement, separate needs from wants, analyze requirements as operand and transformation attributes</td><td rowspan="2">5. Analyze the concept as process and object</td><td colspan="3">6. Analyze current architecture</td></tr>
<tr><td>6a. Intent linked to an understanding of current goals</td><td>6b. Process/object and object/ suppressed process</td><td>6c. Object/hierarchy Object/topology Object/suppressed implementaiton</td></tr>
<tr><td>Critique</td><td>7. Validate the goals. Are they:
complete
consistent
representative
solution neutral</td><td>8. Validate the concept (s)</td><td>9. Is there an appropriate mapping of intents (used to link goals to objects)?</td><td colspan="2">10. Validate the architecture. Does it:
deliver primary value process?
deliver other value process?
interface cleanly?
decompose elegantly?</td></tr>
</table>

Figure 21. Proposed architectural analysis framework[134]

Figure 21. Proposed architectural analysis framework reveals the value of decomposition by ensuring the intent is used to link goals (needs) with objects (provides). It also shows how one must decompose at least one additional level (i.e. going deeper) to continue on to the next stage of architectural development.

As we learned in the previous chapter intent is "a concept considered as the product of attention directed to an object of knowledge." The intent of collaboration is the free and open

[134] ibid. This framework is a modification of what appears on slide 19

exchange (formal and informal) of information between humans that can take place anytime, anywhere, and without the participants having to think about anything other than the information being exchanged (i.e. not about how, such as using a technology). The intent of collaboration between participants remote from each other requires a bit more clarification in that its intent is the approximation of local collaboration as close as possible. This means the communication system should be as transparent as possible (i.e. require little or no management monitoring, or maintenance during use). The audio and video signals need to be reliable, impart no perceptible delay, and provide a clean (free of technology artifacts, aberrations) accurate (no signal clipping and is frequency/color correct image) reproduction. A new requirement would also be identified explicitly during the application of an agent-based tool capable of discerning intent from three different perspectives and the need to support the style (derived from the need for "free and open") of interaction. Style implies characteristics which maps to human traits (psychological, physiological, sociological.).

As you might notice these requirements are generic, not tied to any given technology or application. The associated weaknesses they reveal in current solutions are, for the most part, the result of legacy decisions, some made decades ago, for sub-components of the complete solution.

7.2. Mismatches with current solution: reliability and delay

The lack of reliability for both ISDN and IP networks have already been discussed above in Chapter 5.1 where it is pointed out as a legacy issue that also has a deleterious affect on delay. Specifically with respect to ISDN, reliability appears to be an issue associated with increased use

(versus a hard or physical break in the cabling or network). This increase implies there is an over subscription of the required resources available (or subscribed to). Over subscription does not always result in a failure normally associated with reliability issues though, it also can impart additional delays due to congestion at bottlenecks (e.g. this is analogous to rush hour traffic slowing your trip to or from a location) which at times can look like a transmission failure. For this reason reliability (signal failure) and delay (increased latency) are often indistinguishable to the user. IP networks share a similar problem.

Marconi has recently announced a new videoconferencing system based on ATM networks (which has as part of its legacy QoS). This means there is a solution that is capable of delivering higher grade audio and video with signal latency of < 150 ms. This duration or less of a delay appears to be manageable (minimally intrusive) when compared to the 1 – 4 second delays sometime experienced with current videoconferencing systems ISDN or IP).

7.3. Mismatches with current solution: Accuracy

There are a whole host of legacy issues surrounding the accurate reproduction of video and audio signals. Accuracy problems associated with the display of colors can be traced in two different directions. The limited understanding of human physiology and how to provide information in a contextually appropriate fashion (i.e. how a human expects to receive it). how the human eye works, and the physical manufacture of the display device. Both are legacy issues dating back decades.

If you look at the way a television or computer monitor is manufactured the first thing you discover is that the phosphors they use are of a higher color temperature (measurements have ranged from ~6,000K - 10,000K) so that the displays can be brighter. Cinematography and television studio work is normally shot under tungsten lamps which have a color temperature rating of 3,400K, which is roughly equivalent to the brightness level one hour after dawn and one hour before sunset. The problem is, without a correcting filter the colors displayed on the monitor or TV will not match the color of the image transmitted (e.g. this is why whites do not appear white and flesh tones can look unnatural).

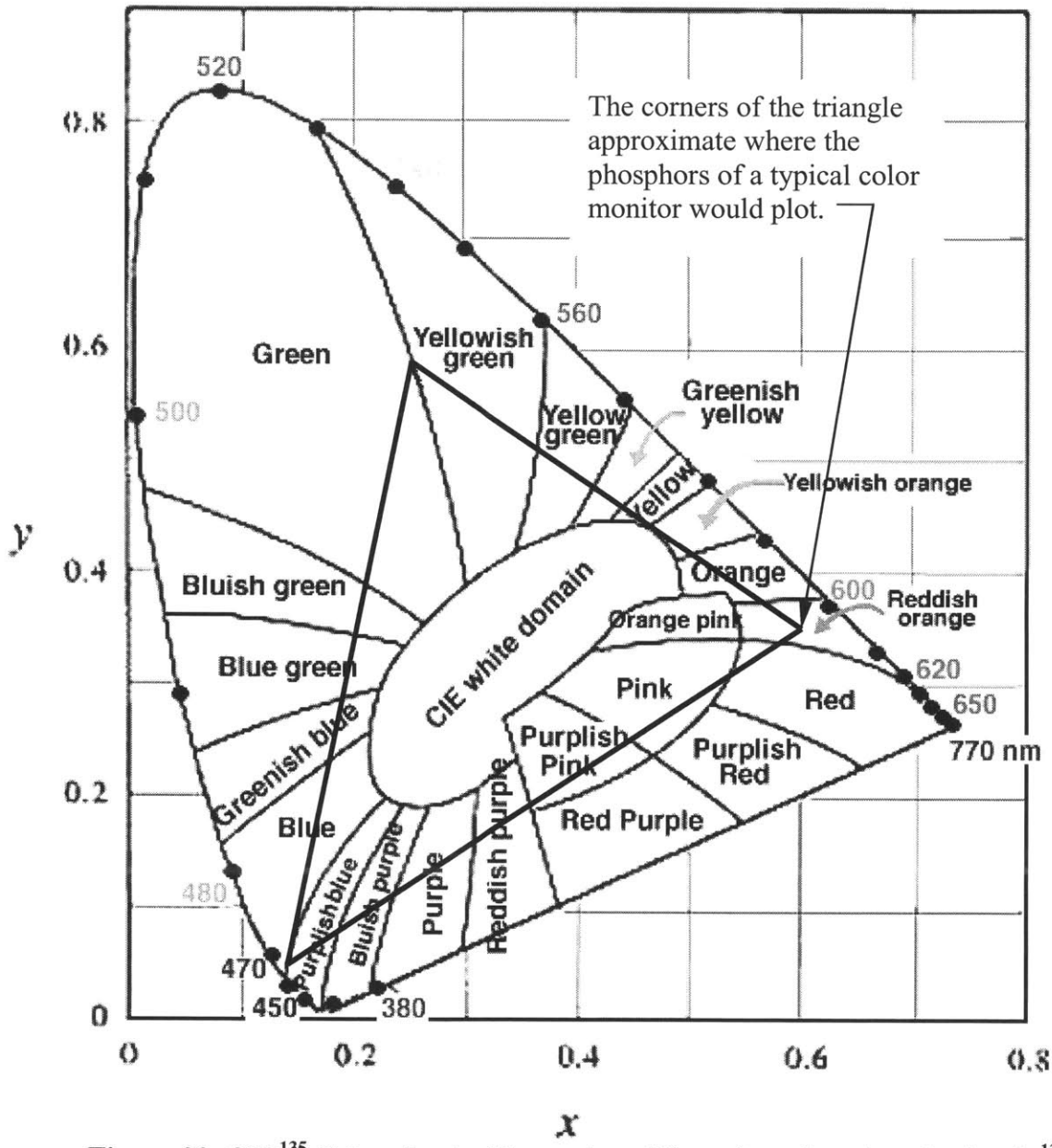


Figure 22. CIE[135] Color chart with overlay of "monitor phosphors" triangle[136]

There is a second problem with the phosphors. If you refer to Figure 22. CIE Color chart with overlay of "monitor phosphors" triangle on page 94, you will observe a triangle superimposed on top of the CIE color chromaticity diagram that represents the colors a human

[135] COMMISSION INTERNATIONALE DE L'ECLAIRAGE (International Commission on Illumination)
[136] http://webvision.med.utah.edu/imageswv/KallColor10.jpg Image has been modified with the overlay of monitor phosphor triangle information.

can see. The triangle represents the *subset* of colors that can be created using RGB (Red Green Blue) phosphors. Therefore even if you have a color corrected display unit, you still cannot display all of the colors that the human eye is capable of seeing. Oh, and if you are using a TV it is worse because analog TVs interlaces the displayed image. This means the image you see has actually been split into 525 vertical lines and then grouped into two frames. One frame contains all the even lines, the other frame all the odd lines. Then the frames are shown in an alternating fashion with one frame is displayed every 1/60th of a second.[137] Additionally, though an NTSC TV can display 525 vertical lines with the rough equivalent of 640 pixels of width, because of the way NTSC encodes the signal only ~100 unique colors can be displayed at any given time. The selection of RGB for color TV and computer displays, as well as NTSC encoding are examples of legacy decisions that continue to impact image quality and accuracy.

While I am on this subject it might be interesting to note that digital images, both for display on computer monitors and televisions is recorded at approximately 30 fps[138]. Motion pictures are recorded at 24 fps though. Why? Because they wanted movies to look more life like. 24 fps is approximately equal to the operating frequency of the human eye.

[137] 1/60th of a second was chosen so the picture would not flicker when our 60Hz lights are on in the room. In Europe with 50Hz power frames are displayed every 1/50th of a second.

[138] For NTSC digital interlaced TV, each frame set (remember there is one for even, one for odd) actually runs at 29.97 fps to be exact.

Speaking of how the eye works. Most people think the rods and cones in our eyes detect RGB, if that was true then we might have a similar color map as the triangle for color monitors on the CIE table. In fact it appears that our rods and cones might work differently than most believe.

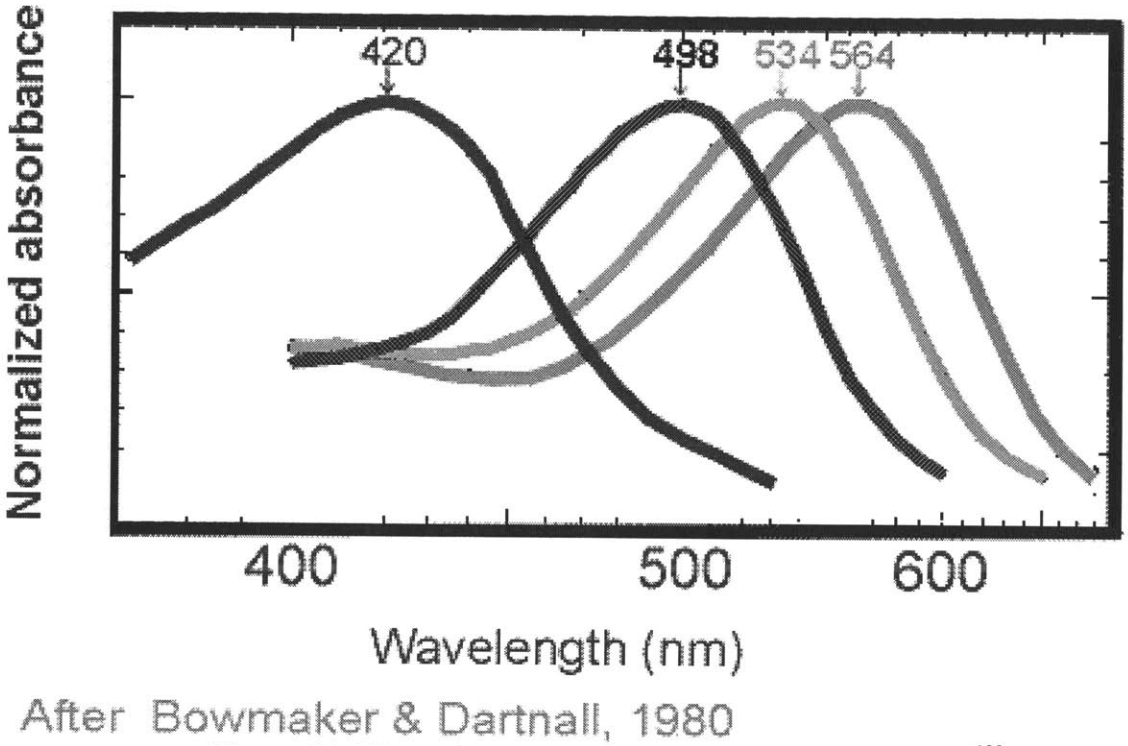


Figure 23. Photopigment absorbance for rods and cones[139]

> "They found four classes of photopigments as shown in the above graph. The colors of the curves do not represent the colors of the photopigments. The wavelength of maximum absorbance is indicated at the top of each curve. The 420 curve is for the short wavelength cones, the 498 curve is for the rods, and the 534 and 564 curves are for the middle and long wavelength sensitive cones respectively."[140]

[139] http://www.yorku.ca/eye/specsens.htm
[140] ibid.

What I find truly interesting about Figure 23 are the peaks. 420 is violet, 498 is blue green, 534 is green, and 564 is yellow! If you want to look just at the cones it looks like this, notice hardly any red sensitivity for the long wavelength cones associated with *red* sensitivity.

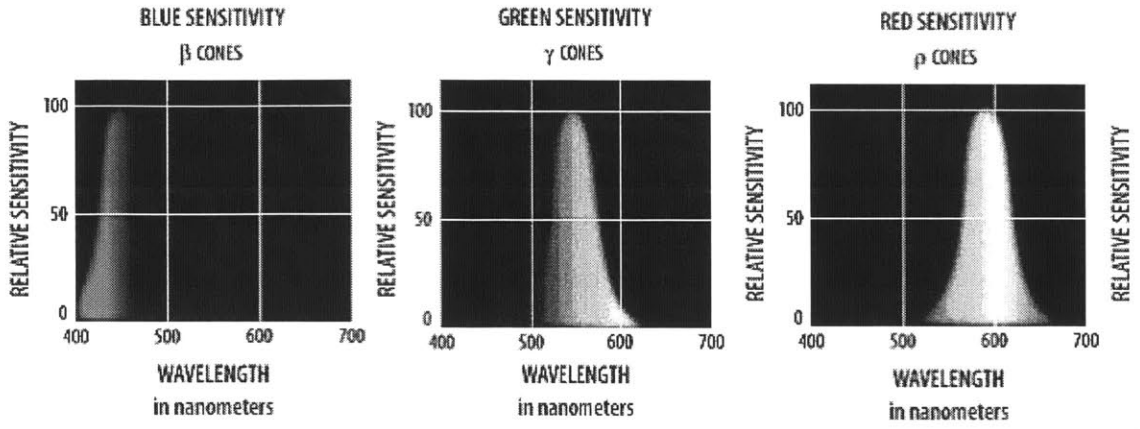


Figure 24. Relative sensitivity for short, medium, and long wavelength cones. .[141]

So why are monitors RGB? Well as far as I have discovered, because it worked as an effective compression system for the transmission of *most* colors. Figure 25 illustrates how RGB can be mixed in an additive fashion (used by color monitors and televisions) to create other colors and how it is also the result of subtractive mixing (as is typical of printers).

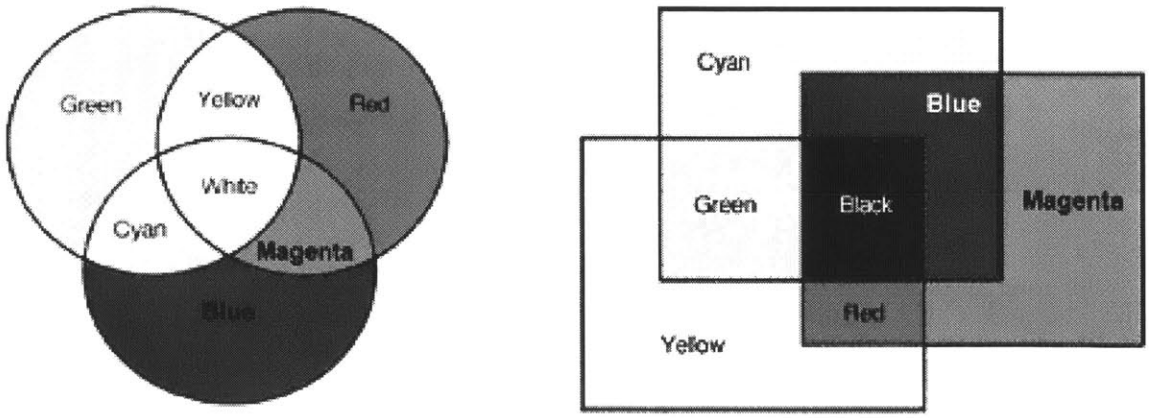


Figure 25. Additive (circles) RGB makes CMY, Subtractive (rectangles) CMY makes RGB

[141] http://www.extremetech.com/article2/0,3973,13766,00.asp

An exception is the color deep purple that is well below blue. It turns out there are other researchers that are attempting to verify whether or not humans can perceive the presence or absence of IR and UV. It is interesting to note that some believe that UV might actually be a cause of hazing in our vision. Therefore UV might be a cause for loss of image sharpness[142] as well as damaging to the eye.

Accuracy of sound reproduction is discussed by John Watkinson, an internationally recognized authority on sound, in a paper where he proposes

> "... to show that all that is needed to demonstrate dramatic improvements in loudspeaker realism is a scientific approach based on a thorough study of the human auditory system. This alone defines the performance criteria and meeting those criteria is just a matter of engineering rigor.
>
> Information theory has been of great service to the engineering community in predicting what will happen in real signal paths or channels, leading to the design of higher performance systems. In my work on loudspeakers I have used information theory as a tool to understand what is happening and, not surprisingly, found it extremely relevant. What is surprising is that the approach appears not to have been used earlier. This may be because a scientific approach cuts across the traditional empiricism." [143]

Watkinson's work has resulted in the development of a system that can reproduce spatially accurate sound (some refer to this as 3D sound). I have been informed he is working with an American concern as well as with a company he appears to have co-founded Celtic Audio.[144]

Of interest to note it that Marconi's new ViPr (Virtual Presence) system has incorporated what I will describe as positionally correct (i.e. the voice from the participant on your left will

[142] It appears rigorous science may actually someday back up the claims may be some sunglass manufactueres such as: http://www.shopcyberworld.com/blublockerviper.htm
[143] http://www.celticaudio.co.uk/technical2.htm
[144] http://www.celticaudio.com

come out of the left speaker, a participant on the right from the right). Although this is not spatially correct sound in the style of the system created by Watkinson, it is a solution available today for implementation that at least attempts to complement a natural human cueing trait.

7.4. Mismatches with current solution: *natural* selective access or process filtering

There may also be a mismatch between the way information is being provided to a human and the way a human expects to receive it. Chris Chabris of Harvard has (co)authored several papers on this, and related, topics looking at this from a psychological perspective. One of the topics deals with the concept of "HOW NOT TO BE SEEN: the Contribution of Similarity and Selective Ignoring to Sustained Inattentional Blindness"[145]and another on "Change or Situational Blindness."[146] An investigation of the reasoning behind this might yield some interesting information with regards to a human perception of what they see versus what has actually been seen. There is evidence these are not the same.

Michael H. Herzog and Manfred Fahle have co-authored a paper on how the responses of cortical neurons can be influenced strongly by "a context surrounding the target" in a paper titled "Effects of grouping in contextual modulation."[147] This compliments well the research by Chabris and makes me wonder if some information that is easily viewed by those local (i.e. in the room or classroom) that in essence cannot be seen at times by remote participants. The issue

[145] http://www.wjh.harvard.edu/~cfc/Publications.html Most, S.B., Simons, D.J., Scholl, B.J., Jimenez, R., Clifford, E., & Chabris, C.F. (2001). How not to be seen: The contribution of similarity and selective ignoring to sustained inattentional blindness. Psychological Science, 12(1), 9-17

[146] ibid. Simons, D.J., Chabris, C.F., Schnur, T., & Levin, D.T. (2002). Evidence for preserved representations in change blindness. Consciousness & Cognition, 11(1), 78-97.

[147] NATURE |VOL 415 | 24 JANUARY 2002 |www.nature.com © 2002 Macmillan Magazines Ltd , 433-436 http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v415/n6870/abs/415433a_r.html

may indeed be similar to looking through a venetian blind, if part of the data is present in a location or fashion where it is not capable of being recorded **or** displayed for reasons of technology, physiology, or psychology; then the data is lost to our perception. The interesting note is that Chabris' work has proven that if the data is being filtered by our mind, then the memory is recoverable and can be reintroduced to our perception of what has occurred. The reality of this occurring was best documented in the paper by Chabris et al "Evidence for preserved representations in change blindness. Consciousness & Cognition."

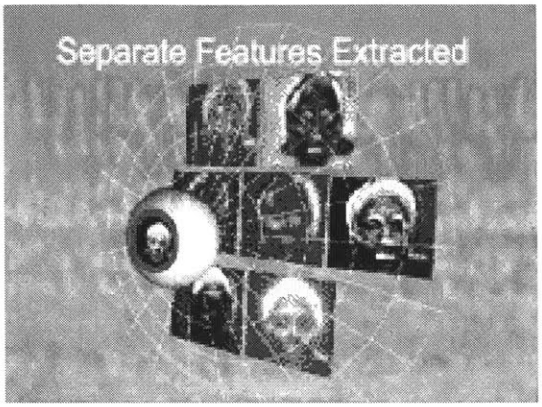
> "One participant's response was particularly interesting. After reporting no change to the open-ended questions, when asked about the presence of a basketball, he said ''oh . . . that's right! So did you pass the ball off to somebody? ... I didn't notice that.'' That is, he reported both having had a representation of the presence of a ball and not noticing the ball's removal."[148]

This implies that even when we do see something sometimes we are not allowed to consciously perceive it.

In a similar fashion the research of Frank Werblin, at the University of California, Berkeley, into how there appears to be parallel processing of multiple (possibly 12) distinct and unique images *recorded* by the eye also supports this thought. He actually believes that the metaphor of our "eyes being like a camera" taking images for our mind to see may be more poetic than real.[149] Figure 26 shows how Werblin believes the 12 different type of ganglia are utilized in an independent and unique fashion to document specific types of information that is later integrated by the brain.

[148] Simons, D.J., Chabris, C.F., Schnur, T., & Levin, D.T. (2002). Evidence for preserved representations in change blindness. Consciousness & Cognition, 11(1), 78-97. Page 85 http://www.wjh.harvard.edu/~cfc/Simons2002.pdf

[149] http://www.berkeley.edu/news/media/releases/2001/03/28_wers1.html



Seven of the dozen separate movies that the eye extracts from a scene and sends to the brain.
Frank Werblin image

See video page showing how the eye processes images and sends them to the brain.

Figure 26. An example of what our eye might actually be seeing[150]

In essence Werblin believes that the brain takes the sparse information it receives from the multiple simultaneous views and merges it with memory to create what each of us perceives as our view of the *real* world. When this thought is combined with the work of Chabris and others that appear to verify that though we do see everything, we do not always have conscious access to the information, it should be easier to understand why so many are now starting to question the concept of sight.

For reasons I will explain in the next chapter, I believe base research still needs to be accomplished, then validated for applicability before being applied to resolve many of these

[150] ibid.

identified areas of concern. On the subject of human traits, especially physiological with regards to sight and how it ties to cognition (or what we think we see), I believe much work has to be done. Psychological traits are much better understood but validating how best to apply them remains an issue.

Education is what survives when what has been learned has been forgotten.
(*B.F. Skinner*)

Chapter 8. Technology and solutions to be considered

This chapter will discuss the creation of a collaboration toolkit containing applications and associated technologies that must be integrated in a balanced fashion to be adaptable the unique requirements of individuals or teams that need to collaborate. When attempting to optimize any architecture, many choices must be made between choosing formal or informal tools, processes, and paradigms to be used in creating the final design. As in life, a responsible and intelligent use of moderation (i.e. finding the unique balance between the extremes that will satisfy the specific requirements) will often lead you to an optimal solution. A brief discussion of why a solution based solely upon the integration of best of breed components will be also provided.

The ultimate goal of the Collaboration Toolkit is that it contains components that can be used to support reasonable forms of remote collaboration anytime and anywhere to support the increasing mobility of users. For this reason a proposed key component for inclusion in the Collaboration Toolkit is the ability to support heterogeneous platforms (i.e. we should not consider mandating a single vendor based solution as being reasonable) as well as integrate with other applications and technologies. Also, at this time proposed components will be considered to support relatively fixed locations.[151]

[151] Relatively fixed locations is meant to imply work or home office environments, not necessarily in client or hotel rooms or other truly mobile locations (such as cabs or sidewalks) that, as noted in Chapter 4.4, [Remote collaboration can increase the value of a team?], will eventually be part of the requirement.

8.1. Collaboration Toolkit proposal should be focused on balance (or why sometimes BoB isn't)

Most engineers have heard the statement "better is the enemy of good-enough" or "goodness does not mean perfection." There are other similar anecdotes but they all boil down to the same notion that any solution can *always* be improved. A good architect, just like a good engineer, needs to know when the proposed solution is "good enough." When the AOPM tool becomes available I believe it will help solve this ongoing qualitative dilemma by in fact providing a way to quantitatively answer some of the questions (i.e. using intent (concept), is the function allocated to the form?) regarding whether or not a requirement has been satisfactorily met.

Some current and proposed solutions (there are many that can be cited, even some from NASA, Ames Research Center) believe that the path to an optimum solution is based on integration of "Best of Breed" (Bob), which I like to call BoB-X.[152] When in doubt and being pressed by upper management to solve an urgent or high priority issue, designers are known to state that "we are going to use BoB technology" to fix/enhance/solve the issue. A relatively recent document states "we have focused on the best of breed/multi-vendor approach"[153] because it should be more agile and responsive in meeting the requirement. This type of statement has helped more than one technology manager, myself included, to persuade upper management to support a given direction in the past. It is used in so many situations successfully because it

[152] BoB-X is meant to represent an attempt to combine all of the variants of BOB out there including the different BOB communication solutions and BOB application software, etc.
[153] citation excluded to protect the "innocent"

sounds plausible and it is a normal part of marketing lexicon[154]. That doesn't mean it is a true statement though, just that it is the functional equivalent of a "wishful thinking theorem" in math.

The reality is, an integration of BoBs can result in a nightmare if you are not careful. Every architect must be cognizant of the very real responsibility to create an optimal solution. Some may fall into the honey trap of just choosing the Best of Breed for each of the individual technologies required to be integrated into the final product feeling this will result in the best "sellable" solution. The rationale might be thought of as "How can this not be the best solution since it is comprised of the best individual solutions."

Well the answer and problem lies in the thought. The inherent weakness is in viewing the final product as just a compilation of individual pieces. In fact the real requirement for the final product is often, if no always, an integration of sub-components that must interface with each other in a synergistic fashion. Therefore a holistic, agent-based architectural approach that focuses on ensuring the integration and maximizing the ability of the sub-components to work together to accomplish the goal will lead to an optimized solution. This thought has been recognized by others.

> "Best-of-breed integration can be a manageable problem with an architecturally sound solution." [155]

[154] an example of this being an overused term http://www.risnews.com/issue/july02_best_of_breed.htm Please note the irony of stating that "We looked at it as a search for a best of breed enhancement to JDA," he says. And the parade of vendors was on the march" How could they all claim to be a BoBs if they are in the same field?

[155] http://www.darc.com/software/2ndLevelArt/News/best_of_breed.pdf

Therefore establishing a good architecture is a key to future success (an echo and additional confirmation of Lee and Messerschmitt) and that it may involve the use of some components that are not BoB for an individual technology but are the best at integrating with the other (possibly BoB) technologies required for the creation of a balanced and holistic solution.[156]

For this reason the ability to integrate with other tools must be a prime requirement considered when evaluating any component for inclusion in the Collaboration Toolkit.

8.2. Technologies that warrant review, and R&D to consider tracking, for inclusion

Several technologies will be briefly presented in this section with a reason as to why I am suggesting it warrants review and continued observation. For more information on any of these technologies, along with an associated url, please see the associated section in Reference Information (this section begins on page 123) towards the end of this thesis.

Portfolio Wall. from Alias | wavefront™, is a currently available, gesture based "digital corkboard" type of interface for collaboration that has been designed to be integrated with large touch screen technology systems. It allows for the easy manipulation of data files and images based on standard gestures. It provides an interesting take on a different human computer interface that may resolve some current issues with the ease of making multimedia presentations to a team. Please see [Currently available technology: Portfolio Wall from Alias Wavefront] page 123 for more details.

[156] This concept, a mixing of BOB and non-BoB components has been openly discussed in the press. http://www.destinationcrm.com/articles/default.asp?ArticleID=1930

ViPr from Marconi is currently available and touted as a Virtual Presence System. Without quibbling over the definition of virtual presence, it is a significant step forward for network based videoconferencing because it is real time (voice and video latency < 150 ms). With significantly improved imaging (1280 x 768), CD quality (16 bit) sound that is positionally correct (i.e. the participant's on your left voice will come out of the left speaker, etc.) built in Type 1 security features, video and data integration, desktop and conference room models, it addresses all of the basic concerns associated with videoconferencing except mobility. The system will run best on an ATM network, but it has been stated it will also run on an Ethernet that supports 802.1p/DiffSERV. Please see page 124 for more information.

The Nomad Augmented Vision System from Microvision Inc. appears to be available and is an interesting new take on head/helmet mounted heads-up display in that the image is actually scanned into your eye. This allows computer-generated images to be superimposed on top of what the user is actually viewing. In theory this could be adapted in the future to support the creation of a virtual environment where remote participants would be virtually displayed in the correct relative positions as you rotated your head by incorporating head position monitoring as part of the Collaboration Toolkit. Please see page 125 for more information.

John Watkinson's work on accurate (spatially correct) reproduction of sound. He takes a very scientific approach with apparently amazing results from those I have interviewed that have heard it. I have been told he is working with a U.S. company now but his basic theory is available online by going to http://www.celticaudio.com and selecting technical articles. Please see page 127 for an excerpt from one of his technical papers that discusses results from a

demonstration. Spatially correct sound without the need for headphones represents a major step forward in creating a more natural environment for participants of remote collaboration. As you saw above, Marconi has incorporated "relative position related" sound to approximate this useful attribute for users of their recently introduced ViPr (Virtual Presence) communication system.

If you were a fan of the Earth Final Conflict[157] science fiction television series you would have seen a "global" (a personal communication and information portal, yes it also had GPS) that literally appeared to be based on a flexible screen technology similar to what can be seen in

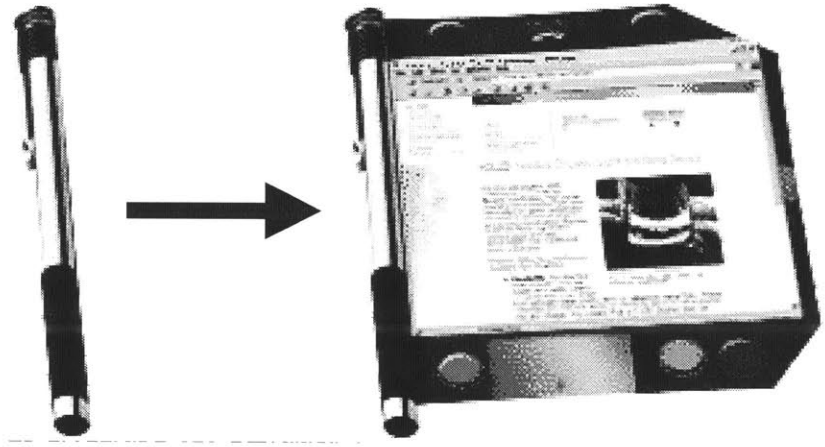


Figure 27. Similarly a recent movie about the red planet included flexible maps that appeared to have the ability to process information.

Figure 27. An example of flexible screen technology[158]

There appears to be two companies doing research and development on technology that could be used to in essence create the "global." Cambridge Display Technologies (founded in 1992 and developing Light Emitting Polymers or LEPs) and the Universal Display Corporation (founded in 1994 and developing Organic Light Emitting Devices or OLEDs). Both companies

[157] http://www.efc.com/
[158] http://www.universaldisplay.com

appear to understand the potential for flexible screens to be used to enhance virtual interaction by creation of a flexible visor that a user could look through. For this to work without causing the user disorientation, this system will also have to be able to track head movement to ensure the collaboration information is spatially correct. An interesting difference between the two (whether it is a reality I cannot confirm) is UDC's use of organic compounds instead of LEPs to generate the image. Could this be the first 'green' video display system? Please see page 127 and page 128], respectively, for more information.

Research being undertaken by Stanford by the Interactive spaces (i-Space) group bears review. One of the doctoral candidates is Milton Chen (http://graphics.stanford.edu/~miltchen) who has published research on "Leveraging the Asymmetric Sensitivity of Eye Contact for Videoconferencing" and "A Low-Latency Lip-Synchronized Videoconferencing System." He also published an interesting paper on the "Design of a Virtual Auditorium." What makes Milton's work interesting is that it appears he is open to making his solutions cross-platform and he is attempting to find a way to accomplish his videoconferencing/collaboration goals using standard Internet (high speed Ethernet) connections. He is collaborating with the NASA Learning Technology Project on some related issues (such as compression of PC based videoconferencing signals, prioritization of speech, and finding a way to enable his application to securely traverse multiple firewalls). If he is successful this will be a significant step closer to truly portable high quality videoconferencing that could be used for any type of collaboration.

Research being undertaken to correct the visual/color aberrations that result from the temperature of the light emitted by the phosphors on video display systems. The concept is to

use filtering to correct this imbalance (similar to what s done in photography).to correct visual aberrations imposed by the use of phosphors that do not accurately replicate the conditions used to transmit the image (i.e. lighting).[159] Television, computer monitor, and similar devices have been measured as high as 10,000K while the lighting used in cinema and TV production uses 3,400k lights and daylight at noon is 5,500k

8.3. Testing and Validation proposal

Qualitative measurements may be the easiest to gather but may also prove to be the most reliable evidence of the success of the collaboration toolkit when it is made available for use. If people do not feel like they have derived significant value from its use, then it may be used, but only reluctantly. This is the exact case for some reluctant Shell global distributed team members when it comes to desktop videoconferencing and teleconferencing. The telling anecdote was that "generally people feel they are much less productive in virtual team mode." Part of this feeling may have to do with the need for increased documentation but regardless, as long as this feeling persists management will have to continue their active involvement in an open and visible fashion.

I would propose that the best measurement of success is voluntary use. If the toolkit has value you will know it is a good, when it is consistently used to support *any* collaboration (local as well as remote).[160] You will especially know you are successful if the users find innovated and unanticipated ways to take advantage of the provided solution.

[159] This work is being undertaken by Eric Rosenthal and Richard Solomon
[160] A concept proposed by Dr. Barry Leiner, Ames Research Center in a Knowledge Management Working Group discussion.

Lastly, developing a way to quantifiably measure improvement associated with specific components within the toolkit may prove more challenging and require research if anyone is interested measuring beyond frequency of use and type of collaboration. One could hypothesize that, much like Milton Chen of Stanford has done to determine the asymmetric sensitivity of eye contact some basic research can be done to determine if there are measurable improvements in the user/participant's ability to focus or be creative during a collaboration session. It might turn out to be easier in the long run to see if a measurement of brain activity can be used to compare collaboration using current standard solutions versus a solution comprised of Collaboration Toolkit components.

Education is what happens to the other person, not what comes out of the mouth of the educator.
(*Miles Horton*)

Chapter 9. Conclusion and thoughts of the future

This chapter will discuss what has been learned and where hopefully this thesis might lead in the future (fostering or inspiring the need to take a holistic view of remote collaboration and the need to collaborate across traditional discipline boundaries to validate collaboration methods and tools).

As an aside, I ascribe to the traditional belief that the more you learn the more you realize how little you really know. As a result of this thesis I have successfully increased my knowledge by increasing the realization of how little I know and now, unfortunately, may be approaching a similar realization that I do not see and possibly might not hear what I do see and hear. Such is the stuff of education.

9.1. Conclusion: what have I learned?

The simple statement is much has been learned. Briefly, that it appears possibly important components of communication, and therefore of collaboration, may have been overlooked due to previous limitations of our collective understanding of human physiology.

To say the least there is now significant debate going on in some sectors regarding how the eye functions. Is it based on rods and cones that see RGB? No, I do not think you will find many people ascribing to that notion. But most do think we see in color and, with rare exceptions are trichromats. There is a growing body of evidence that makes me question this thought. I think a careful review of the data, not all of which is truly that new, shows that when you look at the sensitivity peaks for both rods and cones there are four individual peaks. Take

into account that it appears that, few though they are, there is a reasonable probability that tetrachromats[161] (which by definition is the Mother of a colorblind child- normally a son) do exist.[162] Extend it a bit further with the reality that people appear to be able to perceive the presence or absence of UV dyes in apparel (yes, Nike shoes do look to be a brighter white than others). Yet other researchers feel there may be a similar sensitivity for IR. If they are even partially correct, then I can honestly question if we actually see what our mind apparently is telling us we do.

Magicians, and certain less savory people, seem to already know this and take advantage of that fact with regularity. Maybe Marvin Minsky did put it best when he said

> "It would be as useless to perceive how things 'actually look' as it would be to watch the random dots on untuned television screens."[163]

I would have to say Minsky's thought fits in well with the research findings of Frank Werblin, "the finely layered processes of retinal neurons, carries about a dozen different representations of the visual world."[164] Additionally, when you combine these individual snapshots, as he has done in the lab, what you get is not what we perceive as sight. Truthfully, it does not matter to me exactly what the process is as long as it can be modeled (i.e. abstracted) in a way that allows this knowledge to be used to improve the ability of computer (machine) based systems to provide information to the user (human) in a fashion the human is accustomed to receiving that type of data. This is the potential of establishing a balanced system architecture that is developed using agent-based object process modeling and why I believe it should be used.

[161] Tetrachromats have color vision based on 4 channels while trichromats have color vision based on three channels
[162] http://www.redherring.com/index.asp?layout=story&channel=70000007&doc_id=1910013991
[163] http://www.frasi.net/contents/aforismi/l/It-would-be_363844.asp
[164] http://mcb.berkeley.edu/labs/werblin

A similar argument can be made with regards to how sound is presented to a human using the work of Watkinson. I believe we all already understand that much of the sound that enters our ears is filtered out (this is sometimes called filtering out background noise). "Single hand" sailboat racers often discuss this phenomenon. They say if you sail out of sight of land for two days and turn around that you will start to hear a deafening roar as you approach land once more. And that it takes only about a day after docking for the silence, the filtering out of the noise of civilization, to return. It appears that this filtering is possibly a defensive (anti-noise or overload) mechanism not required when you are experiencing the solitude of the seas. I believe we all hear selectively, just think of a time where you heard your name spoken across a noisy crowded room, or the pained cry of your child. Both will instantly and instinctively draw your attention. Therefore I propose it is entirely reasonable to that sound information that crosses, or gets close to, the threshold of being classified as noise, will not be heard without the participant exerting a significant effort to hear more. A consequence of such an effort is that the participant would then have to consciously (manually), rather than subconsciously (automatically or reflexively) separate the information from the noise which constrains their ability to participate.

9.2. What is being proposed

There is a need to foster (facilitate) collaboration between several organizations (yes, similar to the Collaboration on collaboration working group created by Val Watson at NASA, Ames Research Center) to research, develop, integrate, test, and validate some of the fundamental issues discussed in this thesis. I believe some of this work is already being done

within academic institutions, industry, and the federal government, but in an uncoordinated fashion. This implies that increased value for all would result from collaborating.

I also believe that in order for this collaboration to take place there must be a tangible unifier. I believe that the development of an agent-based Architectural Object Process Model has the potential of performing this task because of the inclusion and clarification of intents gathered from multiple perspectives.

9.3. Where can you go from here?

A resonable next step would be the establishment of a value proposition white paper. This intent of this document would be to show how the true power of creating an adaptable collaboration system architecture is its flexibility to support both formal and informal interactions. This means that a Collaboration Toolkit based upon this architecture would be able to support the following capabilities:

- virtual mentoring: where constrained individuals (such as unique corporate knowledge holders) can share their knowledge with other individuals or groups regardless of physical location
- virtual collocation: where distributed teams can spontaneously interact regardless of physical location
- virtual doorway: where pervasive collaboration technology can link rooms regardless of physical location to allow casual and effortless exchange of ideas and information
- and other virtual approximations of local collaboration and interactions

The key to this extensibility is being able to customize the collaboration user interface, which allows participants to develop a comfortable *discipline* that will support more effective interaction, creativity, and innovation.

9.4. A remaining question: Anything missed? Could we be trying to present too much information?

This falls under the principle of architecture "just because you can, doesn't mean you should."[165] With the rapid growth in technology as discussed above in Chapter 3 [Why adapting to the human is important, starting on page 29], it does not take a leap of faith to understand that the capabilities available today can provide more information faster than ever before. "Information overload" entered our lexicon several orders of magnitude of "technology capability" increase ago. I propose that it should now become a requirement to validate how all information is being presented to see if it is appropriate and efficient for the intended (or anticipated) use. This thought is reinforced by discussions with Professor Chris Chabris of Harvard.

Additionally, one need only look to the Arts to discover individuals well versed in the craft of supplying just enough information in the right fashion to allow "a willing suspension of disbelief" to occur in the participants. In this case participants range from readers of fiction, to movie or theater-goers, to people that go on a ride at the amusement park. All willingly allow themselves to suspend their disbelief that something is not really happening.

[165] Developing a set of principles of architecture is a traditional challenge, and a completion requirement, from Professor Crawley for his System Architecture class, ESD 34j.

The people responsible for architecting these performances have spent enormous amounts of time determining exactly what can be eliminated, what must be included, and what must be modified to present the information to the consumer (i.e. participant) in a way it can be accepted as natural or real. You can uncover some of these tricks if you ever walk on a stage. You will discover that the props are built to lead your eyes quicker towards what would be a normal vanishing point to enhance depth (i.e. they change the perspective to something you would expect to see if indeed the depth was there). If you talk with an actor made up for the stage you will see how exaggerated (garish) the makeup looks up close but it works due to the stage lighting and the actor's separation from the audience (again the difference understanding perspective and expectation makes). The challenge here would be to see if an analogous technique can be developed that worked for participants that are both local and remote to a given collaboration point because each might be expecting a different perspective.

The individuals responsible for making these decisions for the performing Arts as a group probably understand more about human traits (physiological as well as psychological) than anyone outside of a few specialized medical fields. If a link can be made between this community and those that are responsible for architecting the next generation of collaboration tools all (architects, corporations, sponsors, and participants) would benefit in ways few could predict. It has the earmarks of being a classic win-win-win situation. Lest you think this idea is too farfetched, please understand that the DOD has already hired video game creators to help in the development of avatars to enhance the realism of situational training.

I specifically think there is much we can learn from animators. In a discussion with Marshall Monroe he shared part of the story about how he was able to interview Mark Davis (the creator of Bambi, Cruela De Ville, and Tinkerbell among other memorable characters). Apparently classic practitioners of animation are taken back by some of the new animation because so much more is cluttering up the screen than it has to. When Disney was starting out to learn the craft, they took a 90 minute movie and carefully evaluated it frame by frame. They were able to catalog and quantify exactly what needed to be included and for how long; and what was not needed. Supposedly as their joint knowledge grew these animators discovered many things, like exactly how long to pause the hapless "toon" suspended midair to elicit the laugh before they completed falling off the cliff. Their science is that exact. Please remember that this science was not based upon collaboration but a one way communication (presentation). That does not diminish its potential contribution value because from it we could learn how information was presented in a way people expected to receive it.

Just think of what could be learned in how to present images and other information in a format that is optimized for a person to receive it with nothing extraneous to get in the way of the intent. It may indeed turn out that "less is more"[166] when it comes to the efficient and effective presentation of information.[167]

These are but two examples of nontraditional areas that should also be evaluated to see if benefit can be derived from what they have learned.

[166] Mies van der Rohe, originally regarding architecture! http://www.askoxford.com/quotations/138
[167] This reminds me of the quote "A picture is worth a thousand words" which is attributed to Napoleon "Un croquis vaut mieux qu'un long discours."Fr., on http://quoteland.com/search.asp

So once again, if the key to overall success is being able to customize the collaboration user interface, which allows participants to develop a comfortable *discipline* that will support more effective interaction, creativity, and innovation. Then the key to determining what is required to allow the participant to feel comfortable when using may lie in collaboration with across non-traditional disciplines, such as the Arts *and* the Sciences.

Finally, the key to being able to effectively customize any integrated solution is the clear and complete definition of all required interfaces, and that is the heart of the establishment of a strong System Architecture.

> "Education is like a double-edged sword. It may be turned to dangerous uses if it is not properly handled."
>
> Wu Ting-Fan

Setting an example is not the main means of influencing another, it is the only means.
(Albert Einstein)

If you enjoy what you do you'll never work another day in your life.
(Confucius (551-479BCE))

Reference Information

The following pages will provide additional, vendor supplied, overviews or information on the technology or concepts that I have recommended worthy of tracking.

Currently available technology: Portfolio Wall from Alias Wavefront

http://www.aliaswavefront.com/en/products/portfoliowall/index.shtml

PortfolioWall, winner of Computer Graphics World innovative product of the year 2001, is a revolutionary technology that enables teams to view, share, annotate, manage and make decisions on visual digital assets more effectively than ever before.

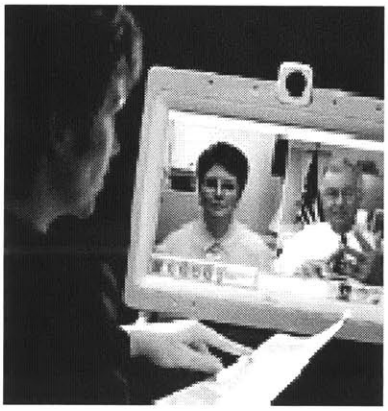
Designed to operate on large touchscreen systems, PortfolioWall builds on and extends the metaphor of a digital corkboard - a dedicated large-scale display that houses images, movies, animations, 3D models, and most other digital files important to modern digital design and production.

PortfolioWall provides an elegant solution to a wide range of users- executives, managers and design teams - and redefines the nature of collaboration. With PortfolioWall teams will experience:

PortfolioWall emphasizes simplicity and ease of use. It enables people to get into closer contact with digital assets by pointing, touching and tapping their way through 2D and 3D images and animations

Currently Available: ViPr from Marconi

ViPr from Marconi http://www.marconi.com/html/products/virtualpresencesystem.htm



Virtual Presence System

As close as you can get to "being there," the ViPr™ Virtual Presence System from Marconi provides virtual presence communications for defense and intelligence networks (including Type 1 encrypted networks) for management of multi-site operations.

Applications include:

Real-time multimedia intelligence briefings
Command and control communications
Theater meetings
Training
Distance learning
Real-time telemedicine
Information dissemination for real-time emergency management preparedness
Command, control and coordination for real-time emergency management response
Other federal, state and local government collaborative work

Unique attributes

Straightforward and intuitive - ViPr avoids the need for training and specialized technicians.

Unmatched quality - ViPr's high-resolution, real-time video and fully synchronized, clear channel audio allow for natural conversation without uncomfortable delays.

Simple to use - ViPr's touch screen technology eliminates the need to recall complex combinations of keypad symbols (*, #) and numbers to access features and directories.

Always "on" and highly reliable - ViPr connects point-to-point or contacts multiple parties for event-driven collaboration (a major advantage over booking a video conferencing room). Multimedia communications - ViPr is fully capable of interworking with a PC for data collaboration, using Microsoft NetMeeting to allow whiteboarding and application sharing.

Immediate access to video - ViPr can be configured for simultaneous viewing of live video (such as CNN and MSNBC) and pre-recorded video feeds.

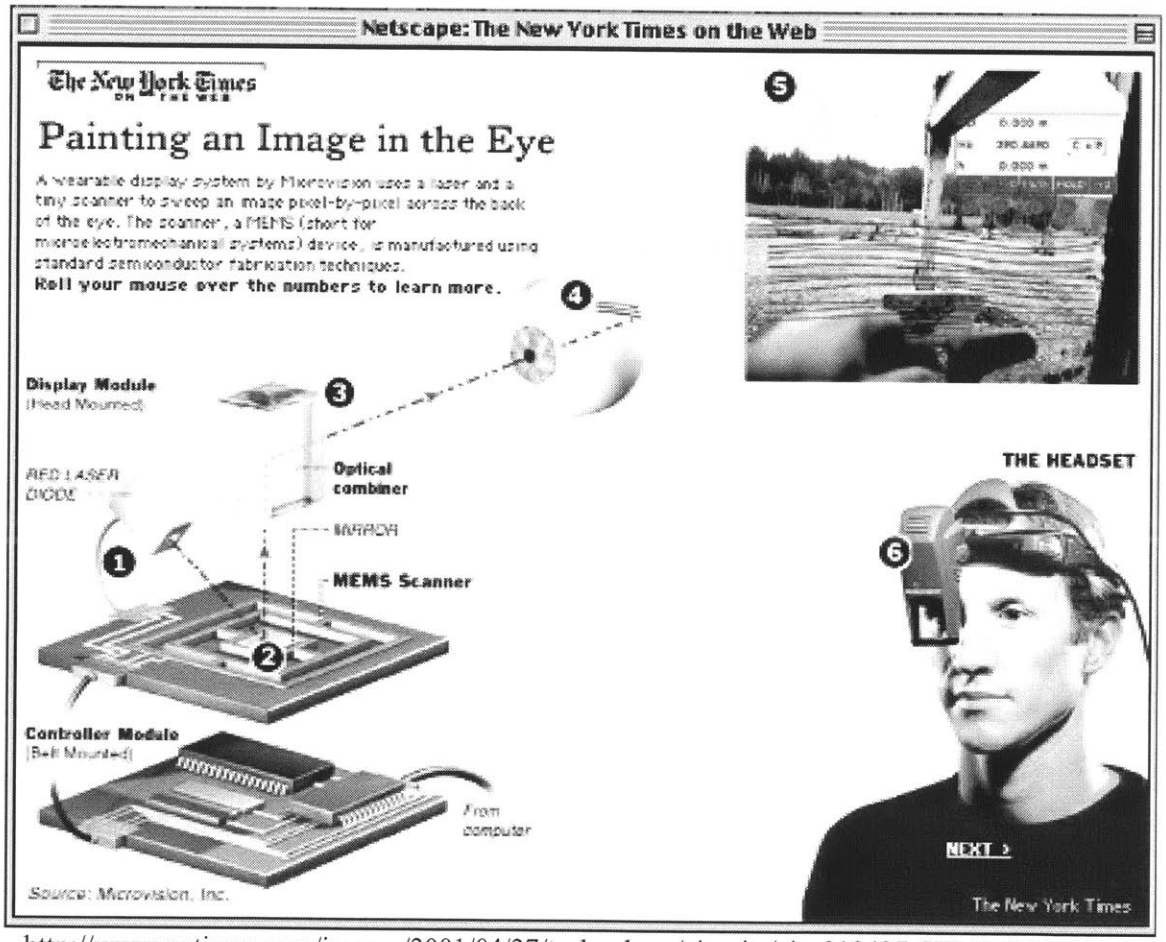
Secure communications - ViPr is able to operate over high-speed encrypted networks.

Available but probably requires more development to integrate: The Nomad Augmented Vision System from Microvision Inc.

claims is that it literally sweeps a beam (image) one pixel at a time across the back of the eye (see through) http://www.microvision.com/prod_nomad.htm

The Nomad Augmented Vision System provides users with the ability to achieve an entirely new level of man-machine interface. Worn in front of the eye, the Nomad System displays images and data that appear to the users to be floating directly in front of them. It is as if the very air before you becomes a 17-inch computer screen. Through our patented technique of projecting images directly onto the user's retina, the Nomad System superimposes data or

images on what is viewed without hampering the user's vision. This is extremely advantageous to users who require access to information directly at their point of task. The Nomad System eliminates the viewing and performance display limitations of large and bulky stationary computer monitors or small and unreadable portable devices. The Nomad Augmented Vision System enables you to access information…anywhere.



http://www.nytimes.com/images/2001/04/27/technology/circuits/cir_010427_HEADSET_00.html

Soon to be available technology: Spatially correct sound from Watkinson

The following is an excerpt from a technical paper available at

http://www.celticaudio.com or directly via http://www.celticaudio.co.uk/technical2.htm

> "In order to test these theories, we have built a number of active loudspeakers, both electrostatic and moving coil. These exhibit minimum phase, including through the crossover region, and are free of reflections in the sub-700 microsecond trading region. Not surprisingly the imaging is much more accurate and actually reveals what is going on spatially. It is possible to resolve the individual voices in double-tracked vocals where the panpots on each track have been in slightly different places.
>
> ...
>
> The effects are not subtle and do not require "golden ears". We have successfully demonstrated these effects to an audience of about 60 in a conference room on more than one occasion; hardly the ideal listening environment, but all heard it. One of us (Watkinson) was asked in one demonstration if this was only relevant to classical recordings so the demonstration was repeated with a Bruce Springsteen recording and again all heard the difference."

Technology still in R&D: LEPs from Cambridge Display Technologies.

http://www.cdtltd.co.uk

Cambridge Display Technology, found in 1992 Cambridge Display Technology, CDT, is the initial developer of light emitting polymers, LEP, and is now leading industry efforts in their research and commercial development. These unique, light-emitting compounds are being developed for a broad range of existing and emerging display applications, and are set to significantly change the products we use to view the world - starting in the very near future.

CDT expects that LEP technology will be used in current product markets like mobile communications, computers, and consumer electronics. Ultimately, LEPs have the potential to be

an alternative to the cathode ray tube - the display technology used in conventional televisions and computer monitors. LEPs will also become the technology of choice for new products such as virtual reality headsets, a wide range of thin, lightweight, full color portable computing, communications and information management products, and flexible or conformable displays. http://www.cdtltd.co.uk/aboutframe.asp?fileName=/STORE/aboutus/0_about%2520us%2520final_files/about%2520us%2520final.htm

Technology still in R&D: OLEDs from Universal Display Corporation

http://www.universaldisplay.com/about.php

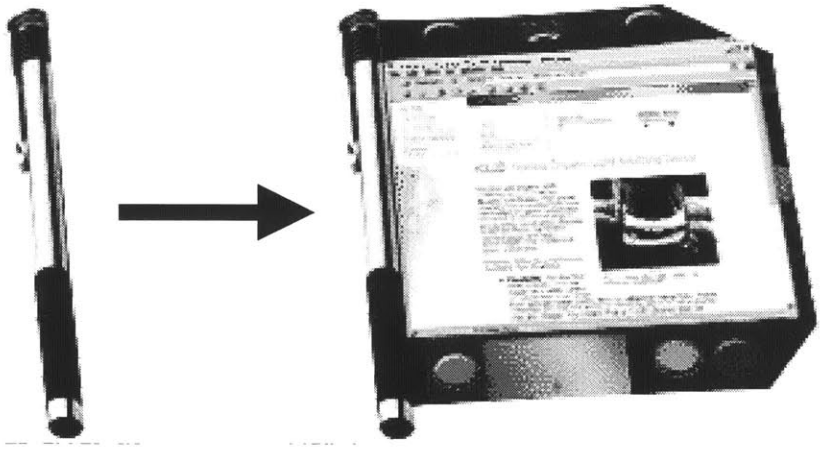
Founded in 1994 Universal Display Corporation (UDC) is a world leader in the development of innovative organic light emitting device (OLED) technology for future generations of flat panel displays, lasers and light generating devices. Through transformational research and advanced engineering, we are developing proprietary technology that should not only provide dramatically enhanced display performance but should do so at lower cost relative to other display technologies.

Since our founding in 1994, UDC has collaborated with world-renowned researchers from Princeton University and the University of Southern California to develop leading-edge OLED technology for which UDC has the worldwide, exclusive license rights to develop, manufacture and market products, and to sublicense those rights, based on their patents in this area.

As of year-end 2000, UDC has built an intellectual property portfolio that contains over 100 issued U.S. patents, over 50 U.S. patents pending and numerous international patents issued and pending. These include Princeton, USC and UDC inventions as well as the OLED technology portfolio that we recently licensed from Motorola.

In addition, UDC is building a world-class team to develop and commercialize OLEDs. In late 1999, we moved into a new corporate Pilot Line and Development facility in Ewing, NJ. This 11,000 square foot facility is designed to facilitate UDC's continued leading-edge technology development, the fabrication of commercial prototypes, and technology transfer to its manufacturing and customer partners.

To support this, the Company has also been awarded a number of Federal and State Government research contracts. UDC has received a $1.5 million program award under the U.S. Department of Defense, Defense Advanced Research Projects Agency (DARPA), Flexible Display Program. UDC is also a member of the United States Display Consortium where it is actively leading efforts to build domestic infrastructure for the emerging OLED industry.



Je n'ai fait celle-ci plus longue que parce que je n'ai par eu le loisir de la faire plus courte.
(Blaise Pascal)