The Archimedes Legacy
1992 – 2003

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July 2003

Preface 1

The Archimedes Project was established at Stanford's Center for the Study of Language and Information in 1992 as a multidisciplinary research group focused on ensuring that everybody is able to access information regardless of individual needs, abilities and preferences. The Archimedes Project is unique in that it is organized around the communication blockages that limit access, not the disabilities that cause them. The goal is to understand how to provide universal access for everyone

The Archimedes Project developed, and adheres to the following six Guiding Principles:

- Everyone requires help in gaining and effectively using information, not only those individuals who have identifiable disabilities.
- In itself, information is neither accessible nor inaccessible; it is the form in which it is presented that makes it one way or the other.
- To be disabled is not necessarily to be handicapped. Handicaps can often be removed whereas disabilities cannot.
- Handicaps often result from decisions to design tools exclusively for individuals with the "standard mix" of perceptual and motor abilities.
- Designed access is preferable to retrofitted access. A merger of theory and practical expertise is crucial in designing access that fully utilizes state-of-the-art technology.
- Solutions that provide general access can benefit everyone.

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2.1 Knowledge is power

Obtaining information in a timely way can powerfully improve human lives worldwide. It can make the difference, for example, between the success or failure of crops, victory or defeat in battle and life or death when people are injured or ill. We live in an information-centric age and anyone unable to access information from all available channels is at a serious disadvantage.

During the early stages of the information revolution, access was equated with being able to use a computer. Many different adaptive strategies, often far from perfect, were developed to give computer access to people otherwise unable to use one. Today, an almost unbounded variety and quantity of information is available to anyone with the ability to access it. For the people who can use them, a variety of information appliances provide the means for increasing productivity, controlling work and home environments, and enhancing leisure activities. For a myriad of reasons, however, there are large numbers of people who don't share these benefits because they are unable to use the information appliances. In almost all cases, these access problems are caused by information appliances that fail to acknowledge physical and cognitive disabilities, limitations brought about by aging, and lack of literacy. The problems are often exacerbated by personal poverty coupled with a limited regional, or national, information infrastructure.

Except where they have been pressured by laws such as the American's with Disabilities Act or Section 508 of the Rehabilitation Act, the Information Technology (IT) industry has largely ignored the needs of individuals with limited ability to access information. In spite of the enormous aggregate numbers worldwide, the conventional wisdom within the IT industry is that disabled and aging people do not represent a significant market. Another factor is emerging that will very likely compound existing accessibility problems. The sophistication and complexity of today's IT software and hardware are making IT products incomprehensible for many of the people on the planet who are neither disabled or aging.

These problems bring up the question of whether all of the world's people should be expected to struggle with frustratingly complex, unreliable computers and information appliances before they can benefit from the information that technology could offer them. I believe the answer to this question is "No." Well-designed technology shouldn't overwhelm its users. Many third-world citizens, for instance, have embraced the cellular telephone, which can be thought of as the visible part of one of the most complex and powerful systems ever created. Unsophisticated people can use a cell phone because its complexity is hidden behind a familiar and relatively simple telephone hand piece. The Archimedes Project is addressing the challenge of finding ways to apply this strategy to all of the other information appliances. Simple, accessible user interfaces will assure that the potential benefits of our information-centric world are equally available to the technically sophisticated and to the disenfranchised people of the world.

2.2 Enabling Technology

Humans are typically equipped with five senses and the capability for making a broad variety of movements that can modify a person's appearance, apply forces to objects in the surrounding environment, or generate sounds and speech. Failure, degradation, or overloading of any of our senses or physical capabilities reduces our ability to function in the world. Accessibility engineering seeks to provide technologies that augment or, when necessary, replace individual capabilities. While there is no end to the number of ways in which individuals can be impacted by the different combinations of disability type and severity, this is only half of the equation. The world is similarly complex, with untold combinations of devices and processes with which humans must interact. Bringing these two halves of the equation together yields an almost incomprehensible range of unique combinations of user and equipment requirements. In IT terminology, we have a "many-to-many" problem. For example, if we have five disabilities and five target systems to be accessed, we must provide twenty-five unique solutions (i.e. the product of user interfaces and machine interfaces) to cover every possible combination. A better solution is to break the problem into two parts: use a many to one solution to provide interfaces to the disabled users, and a one to many solution to provide interfaces to the target devices. In this case we need only 10 solutions (i.e. the sum of five user interfaces and five machine interfaces) to cover all combinations.

Traditional accessibility solutions are based on the many-to-many strategy. A particular IT device is modified to make it uniquely accessible to a particular individual with a disability. A different one-off solution is required for every person. Such one-off solutions are time consuming and costly to design and implement and, in their own way, introduce new problems such as limiting the user to a specific item of equipment at a fixed location. The continual evolution of IT equipment and software rapidly obsoletes these personalized accessibility solutions.

2.3 The Total Access System (TAS)

Neil Scott, Director of the Archimedes Project, developed the Total Access System (TAS) to overcome the limitations of traditional one-off accessibility solutions. The most significant—and unprecedented—characteristic of the TAS is that it allows different user interfaces to be used with IT devices without requiring any additional software or modification to the hardware. Consequently, it makes IT devices immediately and affordably accessible by eliminating the time and money required for purchasing and integrating additional specialized hardware and software. The simplest explanation for the TAS is that it divides the access problem into two parts that can be more easily solved: (i) An "accessor" that provides the disabled user with an interface precisely matched to his or her particular needs, abilities and preferences, and (ii) a Total Access Port that serves as a "universal interface" to the IT device by emulating standard interface peripherals such as the keyboard and mouse without disturbing the normal operation of the real keyboard and mouse. User inputs generated by the TAS are indistinguishable from the real thing. The IT device is totally unaware that a TAP is connected to it. There are no software drivers in the target IT system, and the TAS is completely independent of the IT device's operating system and any applications running on it.

In addition to providing universal access to IT devices, the TAS also eliminates version obsolescence since the same accessor and TAP can be used with different generations of hardware, operating systems and applications. We made this a design requirement since disabled people do not have the luxury of updating their equipment at the whim of the IT suppliers even if the monetary cost were not prohibitive. Understandably, however, individuals who don't have disabilities and companies also resent being held captive to the costs and hassles associated with version obsolescence. Several large organizations are studying the TAS as a way of breaking the strangle hold the computer industry has over them for forcing costly upgrades.

A US patent was awarded for the TAS in 2000.

2.4 The Intelligent TAS (ITAS)

Ongoing research has led to radical improvements to the TAS that are moving it out of the disability arena and into much larger markets for assisting aging people, improving the delivery of educational materials, making medical information systems safer, making the Internet accessible to illiterate people and increasing productivity of IT in the workplace.

The most significant changes to the TAS relate to making the system very smart. A team of researchers and graduate students have been working on a new Intelligent TAS (ITAS) that moves the TAS concept to a new plane. ITAS provides an end-to-end solution for allowing any type of sensor to control any function on a target IT device. A functional diagram of the ITAS breaks down into five major blocks:

(i) User activities as sensed by microphones, video cameras and various switches and biosensors,

(ii) what the user is doing as analyzed by neural network chips,

(iii) the user's intent is analyzed by a newly invented "Natural Interaction Processor" (NIP) that analyze what the user is doing to determine the user's intention,

(iv) the determination of the proper action by another NIP that is distributed across the accessors and TAPs, and

(v) the communication of the user's intent to the appropriate IT target device via a personal wireless network connecting the accessors and TAPs that uses a new natural language protocol employing words from a published corpus.

While this is a complex process, it is now feasible to perform all of the necessary functions on small, embedded devices. Stanford's Office of Technology licensing has filed two U.S. patent applications covering this new technology.

The ITAS redefines the way people interact with IT by hiding its many complex processes behind a genuinely easy-to-use user interface. The overreaching goal has been to make the interface behave and react just like another person. This is achieved by creating an interface that responds to natural words and gestures. This makes the interface literally disappear, allowing users to focus on what is valuable to them—the information—without becoming distracted, confused, or frustrated by the artifacts of the computer industry.

2.5 Evidence of Contribution

When the TAS concept was proposed in 1989, it was openly criticized by some experts in assistive technology who felt that it gave the computer industry an excuse for continuing to sidestep its collective responsibility in making all IT fully accessible to all disabled people. It is physically and economically impossible, however, for the IT industry to accommodate all of the user requirements across all of the different disabilities. It makes no sense to include access strategies in all computers that compromise their functionality for all users in an effort to satisfy very specialized and rarely encountered needs for relatively few users. The ITAS philosophy recognizes some functions as being useful to the majority of users and therefore belonging in the IT infrastructure, while other functions belong with individual users and are therefore better provided by the ITAS. As time goes on, there will be increasing interest in the TAS by non-disabled users because it simplifies the user interface and improves user productivity.

The goal of the Archimedes Project has always been to improve the quality of life for people with disabilities and to enable them to be competitive in the work place by making their assistive technology as effective as possible. There have been many cases in which the ITAS has enabled disabled individuals to become more productive than their non-disabled peers. One such case involved a woman in her mid-twenties who was born with only one arm. While working as a patient data-entry clerk at Stanford hospital, she developed repetitive strain injuries in her remaining arm. While being trained to use a speech accessor in place of manual data entry she said that she believed it would enable her to become the best worker in her office. When the trainer bumped into her two years later, she told him that she had been promoted to be in charge of data entry training for the whole hospital and added, "when I left my old job, they had to appoint two people to replace me." Archimedes researchers have confirmed anecdotal results like this through formal studies showing that people with disabilities can be as productive, or even more productive than their peers if they are provide with appropriate assistive technologies.

On a much larger scale, the Archimedes lab at Stanford University has become a regular stopover for overseas visitors seeking answers and inspiration, and many universities and corporations have asked to replicate our research and demonstration equipment to enable them to undertake similar user interface research. Overseas researchers spend up to two years working with the Archimedes Project at Stanford to learn about the technology and the philosophy behind it. Over the past five years, Neil Scott has traveled extensively nationally and internationally to describe the TAS at conferences, corporations, professional support organizations, federal agencies, and computer industry think tanks. In the past two years, several large corporations and special interest organizations have shown strong interest in the TAS.

- Ritsumeikan University in Kyoto, Japan, is collaborating on a project that uses access technologies we developed to enable autistic children to speak, to create a new ITAS system that makes gathering, storing, retrieving, and presenting medical information more reliable and therefore safer.

- NTT, one of the largest telephone and data companies in Japan, is investigating the potential for using the ITAS protocol to enable people to use portable telephones to interact with home, office, industrial, and entertainment devices connected to their broadband network.
- A leading equipment and service franchise organization in Japan is studying the possibility of using ITAS to affordably lease access technology to disabled and aging people. The huge diversity of individual needs, and the fact that they change as people age or illness progresses, make it too costly to do this using conventional access technologies. With ITAS, however, they can provide a strategically selected range of accessors and TAPs that can be combined to meet most needs and, when they no longer meet those needs, can be returned to an inventory pool for use by others. If this project works out, it will usher in a global change in the way accessible technology is provided and supported that will make such technology more quickly and affordably accessible and, thereby, improve both the quality of life and productivity for disabled people worldwide.
- Nichimen, one of the world's largest trading companies is evaluating the ITAS as a potential product they could manufacture and market internationally.
- Several of the world's largest database and document-handling corporations are doing collaborative research with the Archimedes Project to investigate ways of using ITAS to improve general access to their products.
- Smaller companies in Japan, New Zealand, and Ireland are exploring ways to design and manufacture accessors. Normally, they would not become involved in the accessibility field because of the complexity of providing complete end-to-end solutions. With ITAS, however, they can focus on providing specialized components without being concerned about the rest of the system.

An article written by Neil Scott for the June 2001 IMP magazine on the use of TAS technology in education was included in the briefing package to a Library of Congress committee studying the future impact of information technology.

The strongest indication about the positive contribution of ITAS is the excitement and enthusiasm it invariably generates when people learn what it does. For example, Boeing’s official visionary, who is looking thirty years ahead, has described ITAS as the solution to a “ten-figure” problem: the productivity of Boeing’s design engineers’ has plummeted because they are overwhelmed by the ever increasing complexity and constant version obsolescence of the interfaces to their CADD workstations. Similarly enthusiastic was a doctor who runs a $1.5 billion-a-year medical system, when he learned of the image-based communicator we made for autistic children. He excitedly pointed out that the same device would be invaluable in every emergency room in helping doctors and nurses communicate with injured or ill non-English speakers.

2.6 Recognition of Archimedes

The Archimedes Project and TAS were recognized as one of the top innovations in computer hardware and software in the 1997 Discover Magazine International Innovation awards.

More generally, the value of Neil Scott's accessibility work was recognized when he was featured in the January 2000 San Francisco Magazine as one of the 15 leading Bay Area futurists who are "shaping how we live, think, work, and play" in the new millennium.

In November 2002, the Silicon Valley Museum of Technology appointed Neil Scott as a life-time Tech Laureate for his work to advance equality for humanity.

2.7 Measurable Outcomes of Archimedes Research

The evolution of a concept like the ITAS, which breaks away from the normally held practices for solving a problem, is strongly influenced by how long it takes for the entrenched experts to acknowledge that another solution is even possible, let alone that it may be superior. In addition, commercial pressures exist to not rock the boat by introducing competitive choices to potential users. It takes years to overcome the inertia of the status quo, particularly in a computer market place driven by innovation or even just the perception of innovation.

Archimedes has conducted formal studies with corporations including Boeing, Hewlett-Packard, Oracle, and Adobe to determine whether the positive results achieved at the individual level can translate into significant improvements in the use of proprietary products at the organization level. There have also been collaborative studies with federal agencies including General Services Administration, Bureau of the Census, Social Security Agency, National Imagery and Mapping Agency, and the National Science Foundation, under the umbrella of the Digital Government Initiative, which aims to improve government through the use of innovative IT. A formal study with the Bureau of Census showed that disabled government employees using the TAS for data entry of the 2000 Census were up to 150% more productive than non-disabled workers using standard data-entry tools.

Archimedes conducted a formal study in Japan over the summer of 2001 to determine whether TAS could enable severely disabled individuals play video games. Making video games accessible is much more challenging than doing the same thing for an office application but this study produced very positive results showing that it is possible for properly equipped disabled players to be competitive with non disabled players.

2.8 Potential Consequences for IT Companies

Companies whose profitability relies heavily on the version obsolescence paradigm, such as Microsoft, might feel threatened by the ITAS. Ideally, however, reducing reliance on version obsolescence should force research and development efforts of both entrenched companies and start-ups to be more truly innovative, resulting in break-through benefits rather than more "me-too" products or insignificantly incremental "improvements" that frequently cost users more in installation hassle than they deliver in useful benefits. An article written by Neil Scott pointing out the problems and costs of version obsolescence (IMP, June 2000) was cited by one reviewer as being a "watershed article."

2.9 Commercialization

The original TAS was licensed to Synapse, a disability access company, in 1997. They have deployed it widely throughout the US and in several foreign countries.

The need for accessibility tools is global. So are the resources for creating them, and, as indicated above, several universities and companies want to replicate the efforts of the Archimedes Project to advance IT accessibility. A 10-week international workshop, called the "Archimedes Access Factory," held during the summer of 2002, focused on completing an ITAS test bed that enables universities and companies elsewhere to contribute to the development of ITAS components that promote accessibility.

Achieving IT accessibility, however, requires more than identifying challenges and supplying solutions. The solutions must reach the people for whom they are intended. There is still an overwhelming perception, however, that the market for accessible technology is too small to be of interest to the major IT companies. In searching for ways to move the technology from the laboratory to the user, we have had several interactions with venture capitalists. Our experience with the VC industry can be summed up by three specific experiences:

(i) After listening to an Archimedes Project presentation about the TAS in 1995, Vinod Khosla, the Kleiner Perkins partner who financed SUN, said that he would only be interested in what we were doing if it didn't include the disability related parts.

(ii) After seeing the ITAS in 2002, another VC explained that the whole concept was too complex to be interesting to VCs. As he put it, VCs gamble on funding products that can be described on a single sheet of paper and sold as identical shrink-wrapped products to millions of customers.

(iii) Early in 2003 we met with a VC to discuss access tools that enable aging people to remain independent in their own home for as long as possible. Throughout the discussion the VC kept saying, "this is great technology but where is the money?" The conclusion was that VCs might finance luxury or convenience tools for wealthy aging people but wouldn't be interested in funding products for aging people with special needs and low incomes.

During the past three years, Neil Scott has worked with a team of volunteers to develop an alternative strategy for getting access technology to the people who need it. Three new organizations have been established to facilitate technology transfer and support for ongoing research:

(i) Archimedes Access Research and Technology International, Inc. (AARTI) was established as a non-profit corporation to design, develop, and test prototypes incorporating technologies originating from Archimedes Project research.

(ii) AARTI Holdings Corporation was created to license the prototypes to companies worldwide for the manufacture and marketing of prototype-based products.

(iii) The Archimedes Foundation was established as a non-profit corporation to raise funds for ongoing research at the Archimedes Project and coordinate research activities among collaborating organizations in the U.S. and abroad.

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The Archimedes Project has been an evolving mosaic of people. While some were drawn in by the principles embodied in the project, others were attracted by the opportunities to work with cutting edge technologies. The common thread, however, has been a desire to use technology to help humanity.

3.1 Project Members

The size of the core Archimedes team has fluctuated over the years in step with available funding. This section is in roughly chronological order and lists the particular skills and interests the person brought to the project.

Name	Role	Dates	Skills and Interests
Prof. John Perry	Cofounder Co-director	1992 1992-1995	Philosophical direction and building the initial project within the constraints of Stanford.
Betsy Macken	Cofounder Co-director	1992 1992-1998	Administration and liaison with faculty.
Neil Scott	Cofounder Co-director Chief Technologist Director	1992 1992-1998 1992-Present 1998-Present	Conceptual design of the TAS and ITAS, designing and testing prototypes, guiding research and studies, and fundraising.
Cathy Hass	Deafness Research	1992-2000	Interfaces for deaf and hearing impaired individuals.
Greg Edwards	Software Developer	1994-1998	Programming for original TAPs and accessors.
Jan McKinley	Blindness Research	1994-2001	Design of software and interfaces for blind and visually impaired computer users.
JB Galan	Software, Web Design,	1994-2000	Researcher and assistive technology user.
Patricia Devaney	Fund Raising	1994-1998	Liaison and fund raising.
Judy Jackson	Programmer	1995-2001	Software development for accessors and applications of speech recognition.

Kevin Gill	IT Manager	1998-Present	Installing and maintaining the broad range of IT equipment and networks required to run the project.
Isabelle Gingras	Psychology		Designing and managing user studies.
Sile O'Modhrain	Software		Developed the MOOSE Haptic Display

3.2 Part-time Employees

Name	Role	Dates	Skills and Interests
Benjamin Reeves	Software	2002-2003	Speech Recognition.
Ing-Marie Jonsson	Software	1998-2003	Agent networks.
Anne Knight	Writer	2001-2002	Writing and publicity.
Dan Gillette	Educational psychology	2000-2003	Accessor specifications and testing, user studies.
Yoko Kanamatsu	Liason	1996-Present	Introductions and ongoing relationships with Japanese individuals and organizations.
Nina Paley	Animator	2001-2002	Design of special graphical user interfaces.

3.3 Visiting Researchers

Name	Role	Dates	Skills and Interests
Yoshiyuki Goda	Technical/user		
Hiroshi Fujimoto	Engineer		
Eiichi Ito	Engineer		
Koichi Takeuchi	Engineer		
Kazumoto Kondo	Programmer		
Prof. Atsuya Yoshida	Applications Developer		
Prof.Sean O'nualain	NLP and Linguistics		
Mr Yamamoto	Interface design		AIST
Qamir Hussain	Software		
Prof. Tatsuya Mikami	Software		
Chang	Software		

Koji Yoshimoto	Interfaces and applications for blind individuals		
Satinder Gill	Concepts and studies		Gesture analysis
Mei Marker	Software for aging people.		Applications of machine learning systems for Aging people

3.4 Outside Supporters

Name	Affiliation	Dates	Skills and Interests
Barbara Scott			Financial and moral support.
Russell Berg	AARTI Archimedes Foundation		AARTI Board member C0-founder of Archimedes Foundation Long Silicon Valley History
Dr Robt. Walton			Financial and moral support.
Richard Kratz			User testing of original TAS
Patti Moore			Industrial Designer Board member
Dale Hogue			Chairman of the Archimedes Foundation Intellectual Property
Marty Tibor	Synapse		Licensee of TAP Technology
Machiel Van der Loos	Palo Alto VA		Robotics
Remi Vespa	FAVIC		Document management, Neural processing
Yasunari Harada	Waseda Univ.		Video Collaboration System
Prof. Monte Cassim	Ritsumeikan Univ.		Organization of Japanese collaborations
Rifaat Roseik	SuperBase		Promoting ITAS in Europe and providing financial support for visiting student researchers
Richard Tennenbaum	SuperBase		Promoting ITAS in Europe and providing financial support for visiting student researchers
Yasuhisa Yoshida			
William Striggard	MeijoData		Promoting ITAS in Sweden
Babak Hojdat	Dejima		Providing Agent software and financial support for collaborative projects
David Israel	SRI		Connections to SRI

3.5 Student Interns

Name	Role	Dates	Skills and Interests
Christine Roseik			
Natasha Pryor			

3.6 Volunteers

Name	Role	Dates	Skills and Interests
Chuck Borteck	Software Mentor		AARTI Board Member
Rolf Ursin-Smith	Administration Mentor		Ongoing assistance with organizing projects and AARTI Board Member
Russ Berg	Mentor		AARTI Board Member, Archimedes Foundation Board Member
Dick Whitney	Finance Mentor		AARTI Board Member
John Ritchie	Attorney		AARTI Board Member, Archimedes Foundation Board Member
Joop Verbaken	Software Design		Neural Processes
Osnat Lowenthal	Graphics Design		Web site, Document Illustrations
Sandra Horwitz	Administration		Exec Dir., Archimedes Foundation
Nicholas Carrol	Software design		Collaborator
Masaaki Kannamatsu	Hardware Engineer		Developing prototypes

3.7 Stanford Supporters

Name	Role	Organization	Skills and Interests
John Etchemendy	CSLI Director Provost	Stanford	
Prof. Byron Reeves	CSLI Director	Stanford	
Keith Devlin	CSLI Exec Dirextor	Stanford	

Prof. Clifford Nass	Principal Investigator on some Federal Grants	Stanford	
Prof. Dev Parvati	Mentor, Advisor	Stanford	
Prof. Elliott Lewenthal	Mentor	Stanford/Emeritus	
Prof. Marion Lewenstein	Principal Investigator on grant	Stanford	
Prof. Stanley Peters	Advisor	Stanford	
Prof. Pat Suppes	Advisor	Stanford, EPGY	
Prof. Stig Hagstrom	Mentor	SCIL	
Dikran Karagueuzian	Publisher	CSLI	
Luis Mejia	Licensing	Stanford OTL	
Carey deRafael	Licensing	Stanford OTL	
Stuart Gannes	Coordination of programs	Reuters Program	
Dan Flickinger	Linguistics	CSLI	
Jenn Stringer	Collaboration with SUMMIT at Med School	SUMMIT	
Pat Langley	Mentor	CSLI	
Najwa Salame	Administration	CSLI	
Laura Tom	Administration	CSLI/Provost	

3.8 Visitors

Name	Role	Dates	Skills and Interests
Iizuka City Reps	Collaboration Project	2001/2002	
Chika Sekine			
Norika Kondo			

Archimedes Technologies 4

4.1 Overview and Rationale

4.1.1 Origin of the Total Access System (TAS)

Before moving to Stanford in 1992, Neil Scott spent almost five years at California State University, Northridge (CSUN), where he set up and ran a Computer Access Lab (CAL) for students with disabilities. This was the first such facility in the U.S. and for many years it was used as the model by other universities around the United States.

The philosophy behind the CAL was to provide accessible computers that could be used by students with disabilities to do the same work as their non-disabled peers. Approximately forty computers, modified with state-of-the-art access technologies, were set up in several large rooms in the Office of Disabled Student Services and made available to disabled students during normal office hours. Physically disabled students could choose from special keyboards or alternative input strategies such as scanning, Morse code or speech recognition. Blind students could use computers that read text aloud from the screen and printed documents in Braille. Learning disabled students could use simplified word processors with tools such as speech input and output or highlighted words.

Many important lessons were learned from operating the CAL. The maintenance of so many computers with modified input and output technologies and custom software was a nightmare. Version obsolescence was a major problem. Blind users faced a hiatus each time Microsoft brought out a new version of its DOS or Windows operating system and access solutions stopped working. Sometimes the problems were easily identified and fixed but increasingly, the problems turned out to be showstoppers that required a completely new solution to be developed and built.

The most important lesson, however, was that there is a downside to centralizing all of the accessible computers in single location. The Internet, portable computers, and easily networked personal computers had not yet become common. While the accessible computers in the CAL enabled the disabled students to do the necessary work, they were forced to do it in isolation, disconnected from their fellow classmates and resource materials, such as geography databases, that were provided in the classroom.

In searching for a better solution, Neil Scott developed the concept of a Universal Access System that mimicked the concept of a pair of spectacles. He reasoned that the accessibility problem could be broken into two parts: a fixed part that could be permanently attached to the classroom or laboratory computers to provide a consistent machine interface, and a portable part that could be provided to each disabled student and customized to match his or her specific interfacing needs. This idea was developed into a proof-of-concept grant proposal that was awarded a three-year grant from the Department of Education Fund for Improved Post Secondary Education (FIPSE). Work completed under this grant demonstrated the feasibility of using speech recognition to control a target computer by emulating the operation of its keyboard with a second computer equipped with a speech recognition system. The name "accessor" was coined for this computer. While not yet a portable solution, the advantages of the accessor quickly became apparent since it could control any application independently of the operating system on the target system. A wireless version of the Universal Access system was developed using infrared communications but was not cost effective due to the limited speed and high cost of IR components suitable for handling data transmission.

At the conclusion of the FIPSE grant, Neil Scott moved to Stanford as one of the cofounders of the Archimedes Project with the goal of completing the development of the Universal Access System. One of the first developments was a name change. A team of people from IBM met with Neil Scott to object to the use of the word Universal because they felt it use was too sweeping and they did not believe it was possible to make such a device truly universal. Rather than argue with them we changed the name to the Total Access System (TAS) and when asked what it did, we would say it provides universal access to computers. The functional components of the Total Access System are shown in Figure 4.1.

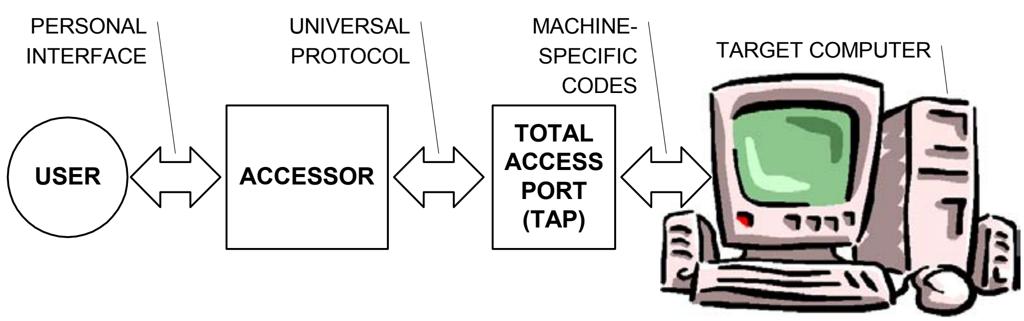

Figure 4-1 Functional components of the TAS

4.2 The Total Access System

The most important properties of the TAS are that all of the machine-specific details are handled within the Total Access Port (TAP) and all of the user specific interfacing is handled within the accessor. The universal protocol connecting the accessor to the TAP enables any accessor to operate with any TAP. The TAP connects to the target computer through the existing keyboard and mouse ports without disturbing the normal operation of the keyboard and mouse. The target computer is not modified in any way and no special software drivers are required. A person with a single accessor can therefore operate any completely standard target computer that is equipped with a TAP.

With Windows becoming the dominant operating system for PCs and the growing popularity of the Macintosh, it became necessary to develop TAPs that emulated both the keyboard and the mouse on each of these platforms. A Mac version was completed in early 1995 and a PC version was completed about six months later.

TAPs were also developed for Unix-based Sun, SGI, and HP workstations during 1996. Accessors and TAPs communicated over a serial cable.

Stanford's Office of Technology Licensing (OTL) made several attempts to license the TAS to one of the major computer companies during 1996—97 but was unable to find interest. It licensed the system to Synapse, a small disability access company in 1997. Royalty income from this license have been small because the company focused on selling a few expensive systems to corporations that had critical access problems when a key employee was struck with Repetitive Strain Injuries. This marketing strategy went against our original goals for widespread marketing of low-cost access solutions.

Archimedes researchers spent several years developing accessors and optimizing them for real world applications in the workplace. The most commonly used accessors used speech recognition and some used a combination of speech recognition to handle the entry of text and commands, and a head tracker to emulate mouse movements. A variety of other accessor strategies such as Morse code and single-switch scanning were demonstrated but not widely deployed.

4.3 The Visual TAP (VTAP)

With functional input options completed, Archimedes Researchers turned their attention to finding a similar external TAS solution that would enable blind and visually impaired computer users to "see" the contents of the screen as enlarged images, hear the contents read aloud as spoken messages, feel textual content as Braille, or feel graphical content as raised images or haptic (force feedback) images. Developing practical strategies for retrieving and screen information and providing alternative display strategies has been significantly more difficult than providing alternative input options. Until recently, processing speed and bandwidth requirements made potential solutions very expensive. Nevertheless, several proof-of–concept prototypes of a Visual TAP (VTAP) were developed to show how screen data could be captured and presented by aural, sonic, tactile and haptic displays.

4.4 Eye Tracking Accessor

Archimedes Researchers started working with Eye Tracking while developing practical communication strategies for Gerry Lieberman, the retired Provost of Stanford, who had developed Lou Gherig's Disease. After a great deal of effort, we concluded that the state-of-the-art eye tracking equipment did not deliver on the promises of the manufacturers and that it was incredibly difficult to set up a practical installation unless the user was completely immobilized. Because Gerry was able to sit up in his wheel chair until the disease became very advanced we were unable to make the system work reliably. By the time he was confined to bed, his eyes had deteriorated to much form him to be able to use the system. In contrast to this, we set up an eye tracker for the football coach Charlie Weidermeyer, who also had Lou Gherig's disease and was completely immobilized in his bed. His eyes were still fully functional and while the system was still being set up and one of the researches was fussing about with the screen, Charlie's first message was, " get out of the way, you are blocking my view of the screen!"

Since these early eye tracking activities, Archimedes researchers have done several studies using a precision eye tracking system to study how people read information on a computer screen. One study for the Poynter Institute investigated the impact of advertising messages when people are reading new from a web page. Another study for Oracle investigated how sighted people interacted with web-based applications. Information from this study was used to guide the layout of application screens to make them easier for blind people to navigate and understand.

Commercial eye tracking equipment is very expensive. The systems we have purchased were in the range of twenty to forty thousand dollars each. During the past two years Archimedes researchers have been developing a low cost eye tracking accessor using a neural network chip to analyze images from a low-cost netcam. The potential cost for an eye tracking accessor using this technology is about two hundred dollars.

4.5 Sonic Displays

Explored concept of a blind person using a head tracker to navigate a GUI interface by having icons produce stereophonic musical chords and arpeggios when pointed to by the head tracker. Uses algorithmic process to create the chords based on the characteristics of the icon. If user doesn't recognize the chord, the system speaks the name of the icon after a delay.

4.6 ASL Accessor

There are many sources of spoken information that are currently inaccessible to deaf people. Multimodal computer presentations and telephone-based Web access systems are two examples in which this situation is becoming increasingly common. However, there are also many low-tech situations in which the same problems are experienced. Person-to-person communications using a telephone, making a court appearance, negotiating an insurance policy, visiting a doctor, meeting with an accountant, being advised about drug side effects by a pharmacist, or attending a lecture at school or university are all situations in which a deaf person would benefit from having a personal ASL accessor.

The fundamental problems facing deaf people fall into the following categories:

- face-to-face communications with people who don't know ASL
- access to spoken information produced by computers
- access to telephone based communications
- learning ASL as a first language for children
- learning English as a second language

Under a small grant from the National Science Foundation, Archimedes researchers demonstrated an ASL Accessor that translated text messages into two-dimensional cartoon-like animations. Initial efforts were focused on creating three-dimensional animations but this was discarded in favor of the 2D representations due to the disappointing images and distracting artifacts resulting from the limitations of the 3D graphics software, particularly when using low powered computers. A professional animator was employed for several months to develop 2D cartoon-like animation primitives that can be pieced together to build ASL messages.

The strategy we adopted for translating text into ASL was not to attempt to perform true word-for-word translation but instead, to determine the intention of the input message and to build an ASL representation of that intention. We were unable to complete an intention detection system during the project and the overall project was shelved. Since that time, however, we have invented a new Natural Interaction Processor (NIP) that determines the intent of a user from natural spoken and gestural language. The NIP will enable the ASL accessor to be completed.

4.7 The Intelligent Total Access System (ITAS)

The ITAS incorporates distributed intelligence to eliminate the need for users to learn a script of how to perform tasks on desired target devices.

See Section 8.2

Summary of Achievements 5

Archimedes at Stanford is primarily a research project that explores ways for making technology more useable and affordable by removing barriers to access. It does this by studying user needs, developing potential solutions, and then testing and evaluating the solutions.

Traditional access strategies are focused on disability-specific solutions delivered on a case-by-case basis. This is a labor-intensive and costly way to provide access and solutions are rapidly outdated due to the planned obsolescence of commercial Information Technologies. Archimedes has been devoted to developing a universal access strategy that works across all disabilities and is not made obsolete by evolutionary changes in the equipment that is being accessed. This research resulted in the development of the "Total Access System" (TAS) that enables a person to use a personal access device, called an "Accessor" with any supported technology.

The TAS was licensed to Synapse in 1996. Synapse specializes in accessibility solutions for enabling physically disabled people to work competitively in normal jobs. The TAS has been the centerpiece for Synapse solutions and Archimedes worked closely with them to meet demanding needs in professions that include writers, scientists, engineers, doctors, secretaries, and students. Many of these people were suffering from injuries caused by repetitive motion and invariably held high-level jobs before they became injured. In most situations, the TAS was the only available solution that enabled them to return to full productivity in their old job.

Speech recognition is one of the most important tools for enabling individuals with physical disabilities to function competitively in the work place. Most of the high performance speech systems, however, are available only on Windows PCs. This places people working in other computer environments, such as Sun and Mac, at a severe disadvantage. Using the TAS to connect a PC based speech recognizer and in some cases, a head

Companies using the TAS

- Allstate
- Autodesk
- Bank of America
- Boeing
- California State Automobile Association
- Digital Equipment Corporation
- Hewlett-Packard
- IBM
- Intel
- Lam Research
- Lockheed Martin
- Lockheed Martin Skunkworks
- Lockheed Missiles and Space
- Merck & Co.
- Miljodata, Sweden
- MITI, Osaka, Japan
- NASA
- National Security Agency
- Oracle
- Pacific Bell
- San Francisco Chronicle
- San Francisco Examiner
- Siemens - Rolm
- Silicon Graphics
- Stanford Hospital
- Stanford University
- Sun Microsystems
- Synopsis
- Wells Fargo Bank
- Sony

tracker also, to any other type of computer, Synapse has become the industry leader in providing speech-based access solutions. They have provided multiple installations for each of the companies listed in the adjacent box.

A patent for the TAS was received in July 2000. Experience and feedback from the diverse range of users and applications encountered in the companies using TAS has influenced the development of a new Intelligent TAS (iTAS) that is simpler and more intuitive to use than the original system. The new iTAS was licensed to AARTI early in 2003.

5.1 Proof-of-concept projects

Archimedes has done several proof-of-concept projects for federal agencies:

(i) The National Imagery and Mapping Agency (NIMA) is responsible for creating 3D maps from aerial satellite photographs. The photographs are machine processed to create a 3D wire-frame hypothesis of the ground covered by the photographs. A photo analyst then uses 3D photographic images and a 3D mouse to correct each vertex in the wire-frame. This is extremely time consuming, requiring two thousand hours to process an image representing approximately two square miles. The major component in this task involved annotation of the image features in a database. A TAS based system was used to demonstrate a 60% reduction in the time required to annotate the images.

(ii) Under a grant from the National Science Foundation (NSF,) Archimedes developed an animated cartoon-based method for generating American Sign Language on a computer screen. The techniques developed for this project are being employed in several new applications that enable people who are illiterate or cognitively impaired to use computers in a text free mode.

(iii) The Total Access System triggered the establishment of the V2 Universal Access working group for the National Committee for Information Technology Standards (NCITS).

5.2 Studies

Archimedes has organized and conducted several studies to evaluate the TAS as an access and productivity-enhancing tool.

(i) Joint study with Stanford, Boeing and Hewlett-Packard to demonstrate the effectiveness of the TAS for enabling workers with repetitive motion injuries to be rehabilitated in their original jobs. A pilot study was completed successfully but the main study was cancelled because the manufacturer discontinued the DOS-based speech recognition systems used in the pilot and the performance of the Windows-based replacement was too poor to give credible results.

(ii) Study for the Bureau of the Census to evaluate the TAS as a tool for returning physically disabled people to their jobs in the National Processing Center (NPC) that handles all of the Census data entry and analysis. This study showed that some of the disabled workers who used TAS had higher productivity than their non-disabled peers.

(iii) Archimedes designed and conducted a study for Iizuka City, Japan, involving the development and testing a total access system for video game consoles. The Total Access Game Interface (TAGI) developed as part of this project enabled severely paralyzed individuals to play action video games at normal speed. Parts of this system are now being manufactured and marketed in Japan.

5.3 Client Support

In addition to developing and supporting the introduction of the TAS, Archimedes has worked on a variety of projects to assist individuals with specific needs.

(i) Developing and supporting custom technology for the Stanford University Provost who had ALS (Lou Gherig's disease.) Our technology enabled him to access the Internet and continue to communicate with other people for almost four years. ALS is a constantly changing disease that necessitates steady progression of the supporting technology. In this case, this involved special keyboards, speech recognition, speech synthesis, head tracking and eye tracking.

(ii) The retired football coach of Los Altos High School also has ALS. Archimedes assisted him to set up and use an eye tracking system.

(iii) Archimedes developed tablet computer based communication devices for several people with ALS and MS.

(iv) Ongoing development of the tablet computer communication system resulted in a new augmentative communication system for children with Autism. AARTI has almost completed the testing of the pre-production prototype and has begun the production and marketing phase on behalf of the sponsor "Cure Autism Now" (CAN) which is one of the main Autism support organizations in the United States.

This is not an exhaustive list of Archimedes achievements but it does show the breadth of technology that has been developed. The new iTAS provides a framework for mixing and matching any of the previously developed access strategies to create new accessibility and productivity tools.

5.4 Potential products

Potential products arising from the iTAS include:

(i) The iTAS test bed for use by HCI researchers to develop and test new human/computer interfaces.

(ii) iTAP modules that connect to standard computers, communication devices, appliances and fixtures such as doors and windows to make them compatible with iTAS.

(iii) Intelligent Accessors that gives people their own personal interface for use with any device that has an iTAP.

(iv) Low-cost tablet computers for use as an accessor in non-disability applications that include education, access to the Internet for illiterate people, medical monitoring systems and home control systems.

5.5 Licensing

Stanford's Office of Technology licensing is actively promoting the iTAS and already has serious interest from several national and international companies. The first license for ITAS has been awarded to AARTI.

5.6 Recognition

Archimedes has received international recognition for its innovation in computer engineering:

(i) The Archimedes Total Access System was recognized as one of the five top innovations in computer engineering and electronics in the 1997 Discover Magazine Innovation Awards.

(ii) Neil Scott, Director of Archimedes at Stanford, was named as one of the futurists who will define the way people think, work, live, and play in the new millennium in the lead article in the January 2000 edition of San Francisco magazine.

(iii) Neil Scott and Archimedes at Stanford were honored at the 2002 International Tech Awards organized by the San Jose Tech Museum and the United Nations. Neil Scott was made a lifetime Tech Laureate of the Tech Museum.

Summary of Grants 6

The research of the Archimedes Project has been supported by grants totaling almost two and one-half million dollars from funding agencies, foundations, corporations and individuals. Some additional funding was received from CSLI during the period 1991 to 1998 to bridge gaps between grants. There has been zero support from CSLI since 1999. The Office of Technology Licensing provided a $25,000 grant in 2003 to support the completion of specifications for the Natural Interaction Processor.

Fundraising for Archimedes has been extremely difficult because its research program doesn't fit the standard pattern of research supported by federal agencies like the National Science Foundation (NSF) and the Department of Education (DOE). Looking back, we see several reasons for these difficulties.

(i) In the early days of the Archimedes Project, grant proposals were padded with CSLI faculty who had no links to disability and were not credible to peer review panels.

(ii) The technologies we were developing were outside the currently accepted paradigm for providing accessible interfaces. Peer reviews kept suggesting that the solutions we were developing could not be achieved with current technology even when we had already demonstrated successful proof-of-concept prototypes.

(iii) When we did get funding, it would cover only the new parts of the concept up to the point where we showed that it worked. This would normally be the point where business would take over and convert a proof–of-concept prototype to a product. This was at the height of the dot com era and business was not interested in specialized interfaces for disabled and aging people. In other words, if an idea still required substantial research but we had proven that the concept was valid, it was then deemed by the peer review panels as being too practical to receive further funding from organizations like the NSF.

In spite of the difficulties, we were able to keep a relatively steady stream of grants coming into the project.

6.1 Summary of Grants

(i) IBM Corporation, 1991, $50,000 for developing accessible information kiosk.

(ii) Dole Foundation, 1993, $50,000 for investigation of access to GUI for blind computer users.

(iii) Packard Foundation, 1994-1996, $300,000 for ongoing research into universal accessibility for disabled computer users.

(iv) Ford Foundation, 1995, $100,000 to develop access to GUI for blind computer users.

(v) Montgomery Foundation, 1997, $100,000 for disability access research.

(vi) General Services Administration and Bureau of the Census, 1998-1999, $250,000 for studies and research related to improving accessibility for disabled employees in federal agencies.

(vii) Poynter Foundation, 1997, $150,000 for eye tracking study of how computer users interact with information displayed on computer screens.

(viii) National Science Foundation, 1999, $50,000 for exploration of computer generated graphics to represent American Sign Language.

(ix) Walter Hewlett, 1999, $50,000 for a music control interface disabled children that used movements of the vocal chords to control a music synthesizer.

(x) Iizuka City, Japan, 1999, $100,000 for proof of concept study to show physically disabled individuals could control video game consoles.

(xi) Oracle Corporation, 1999, $50,000 for eye tracking study of how sighted and blind people interact with Oracle software screens.

(xii) Dejima Corporation, 2000, $45,000 for study of intelligent agent applications to accessibility interfaces.

(xiii) Iizuka City, Japan, 2000, $350,000 for collaborative project to develop a new interface to the Sony PS2 PlayStation console to make it accessible to severely disabled individuals.

(xiv) National Science Foundation, 2000-2003, $900,000 for development of the Intelligent Total Access System (ITAS) for applications in Digital Government.

(xv) Montgomery Street Foundation, 2001, $100,000 for ongoing accessibility research.

(xvi) Stanford Office of Technology Licensing, 2003, $25,000 to support completion of Patent application for Natural Interaction Processor.

(xvii) There have also been numerous small gifts and grants to support particular student projects, conference participation, and so on.

Archimedes Support Infrastructure 7

Funding has been an ongoing challenge for the Archimedes Project. Four main reasons for this become apparent over time.

The first was that Archimedes was rocking the boat in the disability access field by developing solutions that fell outside the currently accepted practices of modifying the products supplied by the computer industry. The comments from peer review panels for rejected grants made it clear that the expert reviewers didn't believe that there could be simpler and better solutions than what they were currently producing. Some federal grant funding was received while the research was perceived as new and experimental but this dried up when it became "too practical."

The second reason was that people and organizations couldn't or wouldn't accept the idea that a single access strategy could work across all disabilities. Individual researchers and assistive technology suppliers have traditionally focused on single disabilities. This led to a great deal of overlapping research with specialized versions of the same thing showing up in each disability market. Many hackles were raised when Archimedes proposed that a single universal solution was possible.

The third reason is that commercial organizations have been slow to recognize the value of making IT accessible. They had no perception of people with disabilities or problems related to aging representing a worthwhile market. When informed that there were more than forty-five million people with disabilities in the U.S., their usual response was that it took too much effort to reach a sufficient number of people with identical needs. For the few companies that were enlightened, there was usually an inherent "not invented here" attitude that had them locked into conventional solution strategies. It is only in the last few years that corporations have begun to realize that ITAS makes huge markets available to them by cutting across the differences between disabilities and between disabled and non-disabled people. They are beginning to realize that forty-five million disabled people and sixty-five million elderly people represent a significant marketing opportunity.

The fourth reason is that most people seem to think that while it is admirable to develop access solutions for disabled and aging people, paying for it is someone else's problem. Some would say that it was the responsibility of the computer industry but that industry is built on differentiation of products and custom user interfaces, and built-in obsolescence. The last thing they want is a product like ITAS that makes all of their products look and behave the same and defeats obsolescence. Others would say that an institution like Stanford, which is perceived as wealthy, should be directly supporting this type of research.

When taken as a whole, there were enough exceptions to the conventional wisdom to keep some money coming into Archimedes but there was never sufficient to attack the problems as aggressively as we would like. Rather than spin wheels trying to convert the establishment to a new way of thinking, Neil

Scott began exploring other strategies for funding the Archimedes Project. Two strategies were explored in detail. One was to franchise the Archimedes Project to overseas commercial and academic organizations that were impressed by the principles upon which it was founded, and had expressed an interest in having their own Archimedes Project. The other was to set up a not-for-profit corporation for the purpose of soliciting grants and gifts, facilitating technology transfer by developing and licensing prototypes based on Archimedes inventions, and coordinating collaboration with other research organizations.

After several fruitless rounds of negotiations with groups in Japan and New Zealand, we concluded that the idea of franchising the Archimedes concept was not going to work because other organizations researching disability and aging issues were facing similar funding struggles. It became clear that a different model would be necessary to facilitate collaboration, one in which collaborating research organizations would pool IP and receive an appropriate proportion of any licensing profits. In other words, we would all work together to earn our way. To do this however, required a mechanism for technology transfer and product marketing.

A volunteer team of retired IBM and Hewlett Packard executives and technologists worked with Neil Scott to implement the second option of setting up a not-for-profit organization. This led to setting up and incorporating Archimedes Access Research and Technology International, Inc., (AARTI) in 2000. While AARTI was successful in negotiating a $100,000 grant for the Archimedes Project from the Montgomery Street Foundation, it quickly became evident that the functions originally envisaged for AARTI were mutually exclusive. Donors were reluctant to donate money to an organization that was developing potentially valuable product prototypes and collaborators were suspicious of an organization that had vested interests in the results of collaborative research. Overcoming these problems necessitated the establishment of two further organizations: AARTI Holdings, a for profit corporation to gather and license IP, and the Archimedes Foundation, a not for profit corporation dedicated to raising funds to support research and development of access technologies for disabled and aging people, and coordinating international collaboration. The relationships between the four resulting organizations are captured in the “Circle of Fulfillment” diagram shown in Figure 6.1.

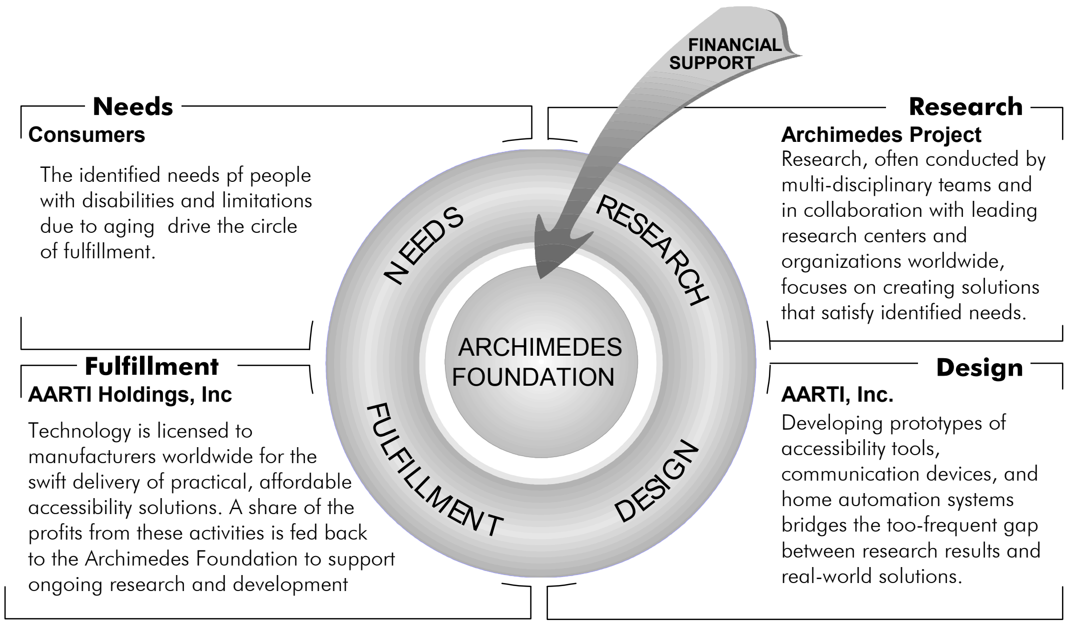

Figure 7-1 The Archimedes Circle of Fulfillment

Each of the four organizations that make up the circle of fulfillment are responsible for a specific set of functions:

(i) **The Archimedes Project –** Identifying user needs and researching appropriate technology-based solutions in collaboration with Archimedes Projects at other participating universities.

(ii) **Archimedes Access Research and Technology International, Inc. (AARTI)** – Designing, developing, and testing prototypes incorporating technologies originating from Archimedes Project research. These product prototypes incorporate third party technology and IP where necessary. AARTI fosters international collaboration by creating alliances between itself as a licensor and among universities, product developers and manufacturers worldwide. To help affiliates swiftly become operational, AARTI offers training and consulting services such as seminars on accessibility, project management tools, process control strategies, design information, legal requirements, and Web site assistance. Alliances exist with organizations in Japan, the UK, New Zealand, and Ireland.

AARTI has licensed the ITAS from Stanford University and is planning to develop hardware and software modules that will be useful in a broad range of applications. Sharing these modules with its collaborators will help establish a standard that streamlines prototype development and eliminates costly technology re-invention, speeding the development of products urgently needed by huge numbers of people throughout the world.

(iii) **AART I Holdings. Inc.,** -- Licensing prototypes to companies worldwide for the manufacture and marketing of Archimedes-based products. A secondary function is to gather IP so that licensees for Archimedes

Products do not need to negotiate separate IP licenses with all of the participating organizations.

(iv) **The Archimedes Foundation** – Raising funds for ongoing research at all of the Archimedes Projects and coordinating research activities among collaborating organizations in the U.S. and abroad.

Potential Applications 8

8.1 ITAS

The Intelligent Total Access System (ITAS) provides external access to any computer or IT appliance. The ITAS consists of two devices: a personal accessor that handles all user interaction and an Intelligent Total Access Port (ITAP) that interacts with the device that is being accessed. A universal wireless protocol enables any accessor to operate with any ITAP.

ITAPs emulate the existing input devices on the computer or IT appliance that is being accessed. The standard input devices continue to function normally and the ITAS functions are transparently inserted into the input data streams. The accessed IT device requires no special software or drivers to be installed and is completely unaware of the input modalities employed by the user.

Accessors make it easy for people to interact with any computer or IT appliance using motion and gesture sensors, head trackers, eye trackers, special switches small and large vocabulary speech recognizers, touch pads, standard keyboards, chordic keyboards, scanning interfaces and Morse code.

In addition to handling the physical interaction process, the ITAS also interprets linguistic information (words and phrases) to identify user intent. It translates the intentions of the user into task definitions and transmits commands wirelessly to the devices that are to be controlled. When the ITAS receives an ambiguous or incomplete command, or determines that there is no device to perform a requested command, it communicates with the user in natural language to disambiguate the command.

The ITAS is the first practical implementation of what Stanford has named *Intent Driven Systems (IDS).* IDS has been made possible by a new component called a *Natural Interaction Processor (NIP)* that enables the ITAS to recognize natural text, speech and gestures and translate them into commands that are recognized by the target device. An Integration Manager (IM) is added in front of the NIP (IMNIP) to combine multiple inputs and thereby enable users to build commands from multimodal input actions.

ITAPs have been developed for a variety of standard target devices and more will be created as needed. The goal is for ITAPs to be standard on all devices.

- The ITAS is the first implementation of an Intention Driven System (ITS) that uses a Natural Interaction Processor to support intuitive interaction with any target device using natural text, speech and gestures.
- The ITAS implements true Universal Accessibility since any accessor can operate with any ITAP and enables any type of user interface to be used with any type of target device.

- Accessors can be used independently or in any combination to provide unique personal solutions matched to needs, abilities and preferences.
- Multiple input modalities can be merged automatically thereby enabling a person to choose the optimum input strategy for each situation.
- Personal accessors enable a person to have his or her preferred interface with them at all times.
- Users no longer need to learn a script before they can begin using a new target device.
- Manufacturers of target devices are not required to know about the special interface requirements of potential users.

8.1.1 Operating Principles

The operation of the ITAS can be considered at two separate levels. The functional level provides a reliable connection between a person and a target device, and the user interaction level interprets human intentions and translates them into commands for the target device. The basic operational steps used in the ITAS are depicted in Figure 1.

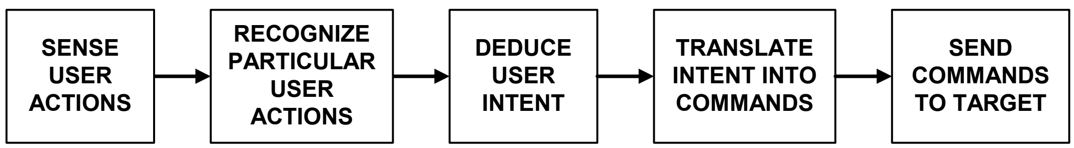

Figure 8-1 Basic Operations Performed by the ITAS

Operations at the user interaction level are totally automatic and are independent of the computer platform, operating system, and applications used in the target device. The functional components required to achieve this are depicted in Figure 8-2

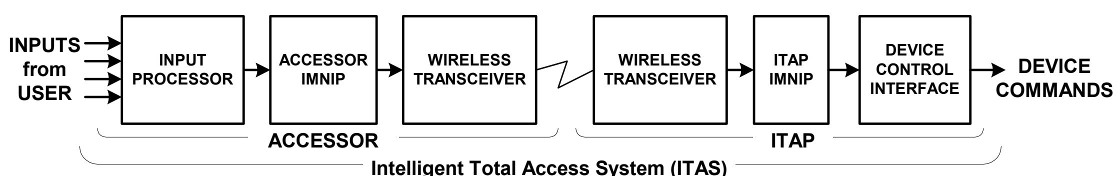

Figure 8-2 Major Functional Components of the ITAS

8.1.2 System Components

The Intelligent Total Access System (ITAS) consists of two major components; the ITAP that connects to the target computer or IT appliance, and the accessor that handles the interface requirements of individual users. The accessors and ITAPs communicate with each other over a high-speed, spread spectrum wireless system using a standardized ITAS protocol.

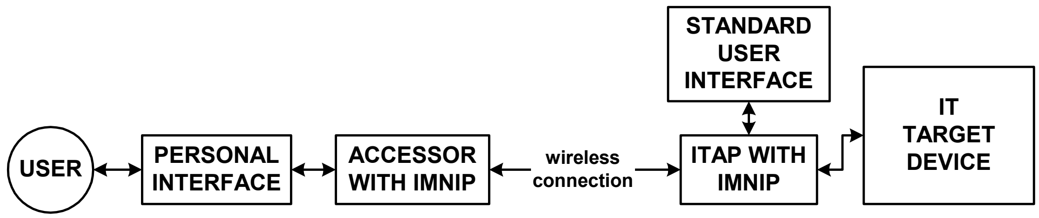

Figure 8-3 ITAS Connecting User to Target IT Appliance

8.1.3 ITAPs

An ITAP translates between the ITAS protocol and the proprietary protocol required by a target system. Wherever possible, the ITAPs emulate standard input devices such as a keyboard and mouse. ITAPs exist for interfacing to the PS2 and USB ports on a PC, to infrared inputs on audiovisual equipment and the X10 modules that are used to control appliances. Where there is no clearly defined standard, it is possible to configure an ITAP to emulate the actual buttons and switches that control the device.

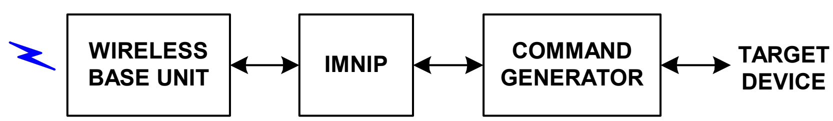

Figure 8-4 Major Components of an ITAP

There are three major components in an ITAP

- The Wireless Base Unit provides streaming data communication with one or more accessors. The operation of the wireless system is fully automatic and is invisible to the user. The current design allows an ITAP to service up to four accessors. Natural language messages are used between accessors and ITAPs.
- The IMNIP is a newly developed embedded Natural Interaction Processor that combines and decodes messages from up to four accessors to identify commands for the attached target device. The IMNIP can decode commands consisting of single words, phrases with words in any order, and phrases in which words must be in a defined order.
- The Command Generator translates command requests received from the IMNIP into the codes required to perform the command on the target device. The command requests can specify single commands or groups of commands (macros

8.1.4 Accessors

An accessor translates user activities into commands for an ITAP. Individual accessors may be designed to handle a single input modality or may combine several complementary modalities such as speech recognition and head tracking.

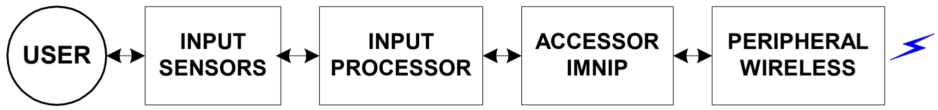

Figure 8-5 Major Components of an Accessor

There are four major components in an accessor.

- Input Sensors such as switches, microphones sonar, cameras, detect user actions.
- The Input Processor amplifies and processes input data received from sensors and transforms electrical data into words that describe the current actions of the user. Typing and speech recognition inputs automatically generate words. Other input modalities are processed to generate word-based descriptions, such as a pointing device naming the object that is pointed to instead of an x,y,z direction vector.
- The Accessor IMNIP merges input data into strings that represent the intent of the user. The IMNIP is effectively a word filter that eliminates all words that have no meaning to the attached ITAPs. The overriding purpose of the IMNIP is to enable users to describe their intentions in their own words and gestures by recognizing the words that express the intent and sending them to the ITAP that can carry out that intent.
- The Peripheral Wireless provides bi-directional communications with any ITAPs located within a range of ten meters. Messages can be broadcast to all of the ITAPs or sent to a specific ITAP. The wireless communications are fully automatic and transparent to the user.

8.1.5 Wireless System

The ITAS wireless system is a bi-directional, multi-channel, spread spectrum software radio. While similar to other spread spectrum wireless systems, such as BlueTooth and 802.11x, the ITAS system was optimized to handle multiple real time user inputs with low latency. It is implemented as a two-chip system that can be embedded in small low-cost devices. The ITAS wireless protocol is designed to provide long-term system stability immune from the ongoing changes to the commercial wireless standards.

8.2 Embeddable IMNIP

This section describes a technique for implementing an Integration Manager and Natural Interaction Processor that can be implemented in conventional desktop and notebook computers or embedded in small microprocessor-based control devices. While specifically designed for the Archimedes intelligent Total Access System (ITAS), the IMNIP can be used in any situation requiring a person to command and control a computer-based device. The IMNIP operates independently of the input modality and is able to integrate inputs from multiple sources such as keyboards, speech recognizers, touch panels, Morse code and gestures. The strategies developed for the IMNIP provide significant advantages over earlier agent based NIP designs.

- The prototype IMNIP merges and decodes up to four input message streams. This can be generalized to support any number of message streams.
- Individual characters are parsed as they are received thereby eliminating the need to buffer strings of input data.
- The IMNIP can simultaneously parse multiple word lists.
- All IMNIP operations are driven by pointers into tables and arrays. This eliminates string manipulations and provides instantaneous translation from an input command to an output event.
- The IMNIP can be implemented equally well on large computers and small embedded microprocessors.
- The IMNIP design is scaleable and can support any size corpus of command words.
- The IMNIP decodes single word commands, multiword commands, macro commands and embedded multiword device names.
- The IMNIP filters out unwanted words that precede or follow a macro or are embedded within a macro.
- The IMNIP can separate and act upon macros and parameters contained within a single message.
- There is no mode switching between macros and isolated words
- The IMNIP enables simple devices to communicate efficiently using text messages.
- The IMNIP makes "Intention Driven Technology" feasible and practical.
- The system can support multiple languages

The IMNIP performs all of the message merging and decoding functions for the new Intelligent Total Access System (ITAS). The proof-of-concept prototype ITAS system is shown in Figure 1. While this shows a single accessor feeding a single ITAP, the ITAS is designed to simultaneously support up to four accessors and four ITAPs as shown in Figures 3 and 4. In some cases, a single ITAP, such as the House ITAP, can control multiple target devices.

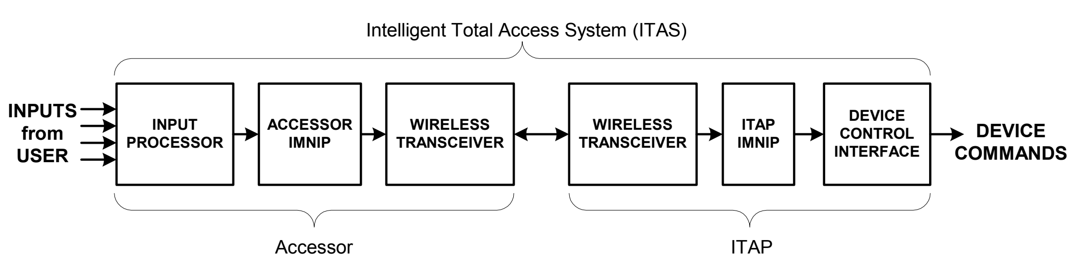

Figure 8-6. ITAS Containing Two IMNIPs

Two slightly different implementations of the IMNIP are used in the ITAS. Accessors use an Accessor IMNIP to reduce the range of words contained in user-generated commands. It achieves this by translating synonyms into words that are contained within the ITAS corpus, and eliminating words that have no meaning within the current context, Each ITAP has an ITAP IMNIP that merges command messages from multiple accessors, decodes individual command words, and parameters, and expands multiword macros into sequences of commands.

One way of explaining the operation of the IMNIP is to think of it as a word filter that extracts predefined keywords and macros from messages that are input by the user. This type of word filter is necessary since device designers have no control over the words that might be input by a user while each device requires a specific command for each function it is able to perform. The traditional solution to this problem is to force the user to learn scripts containing the exact words and phrases required to perform each command on each device. Fundamental flaws with this solution include:

- Interaction is not intuitive
- Every command requires a separate script
- There is a steep learning curve
- People are reluctant to learn scripts
- Different scripts are required for each application
- It is difficult to combine multiple input modalities
- Separate scripts that initiate an operation must be from commands that provide parameters.

In contrast, the IMNIP allows users to describe an intended outcome in his or her own words and the system will perform all of the necessary steps without requiring the user to know what those steps are or to participate in their execution. Traditional solutions focus on providing whatever is required by the device to perform a particular task without taking into account the abilities and preferences of the user. A single IMNIP can be used if all combinations of potential users and potential devices are known in advance. Serial operation of IMNIPs in as shown by the left-to-right arrows in Figure 4, enables systems to handle ad hoc combinations of users and target devices. The first IMNIP handles user dependent details, and the second IMNIP handles device specific details. Parallel operation of IMNIPs as depicted by the four accessors or the four ITAPs in Figure 4, makes it possible to combine multiple input modalities or output devices without needing to combine all of the necessary information to one place. The first IMNIP translates intuitive user messages into a compact well-defined intermediate format that can be efficiently and unambiguously decoded by a second IMNIP to generate the control codes required by a particular device.

As depicted in Figure 8-2, a user can generate any input word or phrase either directly or indirectly. After passing the input though an Accessor IMNIP, only words or synonyms that are included in the ITAS corpus will survive. Filtered messages from multiple accessors can be directed to a single ITAP in which the IMNIP will integrate the messages into a single stream, extract command words, parameters, and macros, and generate the stream of output control codes necessary to achieve the intended outcome.

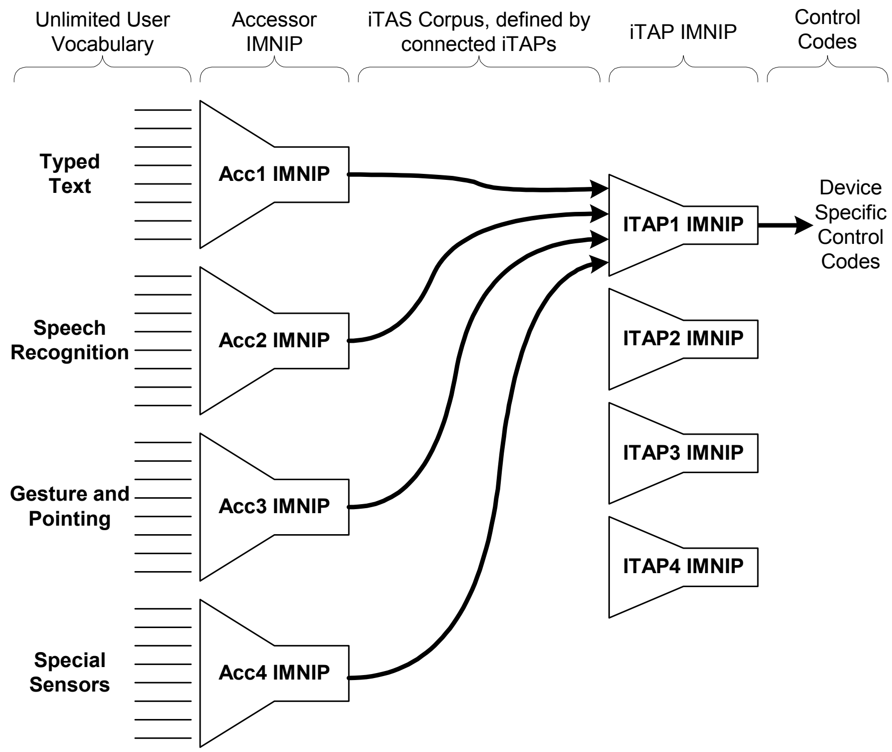

Figure 8-7 Word Filtering performed by IMNIPs

Figures 3 and 4 show the relationship of the IMNIP to Accessors and ITAPs in the ITAS. While the basic operation is the same in each case, there are significant differences in the organization of the parsing trees and the ways in which the outputs are encoded.

8.2.1 Accessor IMNIP

The Accessor IMNIP, as depicted in Figure 3, must not only handle unlimited user inputs that may contain many synonyms, it must also handle a wide range of ITAPs, some of which may never have been encountered before. This flexibility is achieved by providing three parsing trees that are traversed in parallel. The first is an application tree containing a predefined application-specific corpus (ITAS, in this case) that provides a vocabulary for performing all of the normal system functions. It includes words that are commonly recognized by all ITAPs, and all commonly encountered synonyms. Synonyms are translated into their corresponding base word to reduce the range of words sent to the ITAPs. The second is a personal tree containing user-specific words and macros, and extensions to the corpus provided by ITAPs that are permanently available to the user. The third is a temporary extension tree containing word and macro extensions to the corpus that are added on the fly whenever the system interacts with a new ITAP. The temporary extension tree is usually discarded at the end of each session but the user may opt to transfer its contents to the personal tree if the ITAP is to be used frequently. Distributing the corpus in this way over three trees minimizes the amount of processing required to maintain the integrity of the permanent corpus while providing the flexibility to extend it at any time.

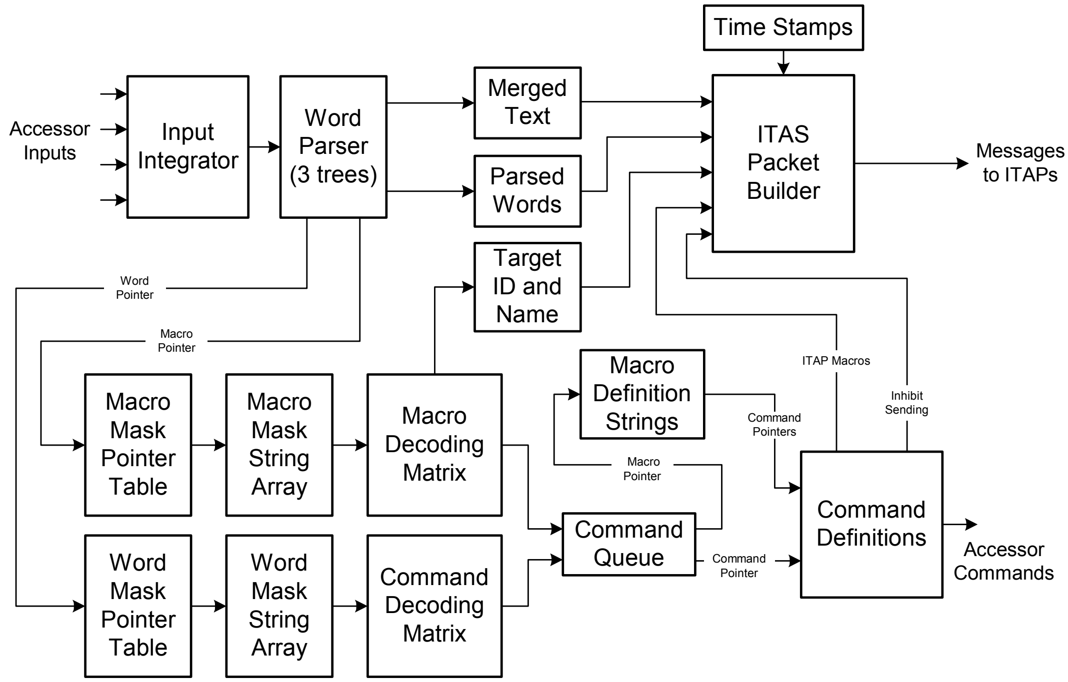

Figure 8-8 Block Diagram of an Accessor IMNIP

8.2.2 Outputs Generated by An Accessor IMNIP

The following table shows the relationships between inputs and outputs that can be generated by an Accessor IMNIP.

	INPUTS	OUTPUT GENERATED
1.	Individual Characters that are not recognized as part of a supported command or macro.	Packets containing individual characters that are sent to an addressed ITAP.
2.	Individual words that are not recognized as part of a supported command or macro.	Packets containing individual words that are sent to an addressed ITAP.
3.	Individual words that are recognized as parts of commands.	Command packets that will be recognized by the IMNIP in one or more addressed ITAPs.
4.	Individual words that are recognized as parts of an accessor macro. An accessor macro may generate commands for the accessor itself, commands for one or more ITAPs, or ITAP macros for one or more ITAPs	Single or multiple commands for controlling the accessor. e.g., “dictate mode,” command mode,” etc. Single or multiple commands for one or more ITAPs. Single or multiple ITAP macros for one or more ITAPs.

5.	Individual words that represent numerical values.	Zero – nineteen → add value Hundred, thousand, etc → multiply by value
6.	Individual words that are to be excluded from the messages produced by the accessor.	No output is produced by the accessor
7.	Individual words that negate the rest of a message e.g. "Don't turn on the TV.	No output is produced by the accessor

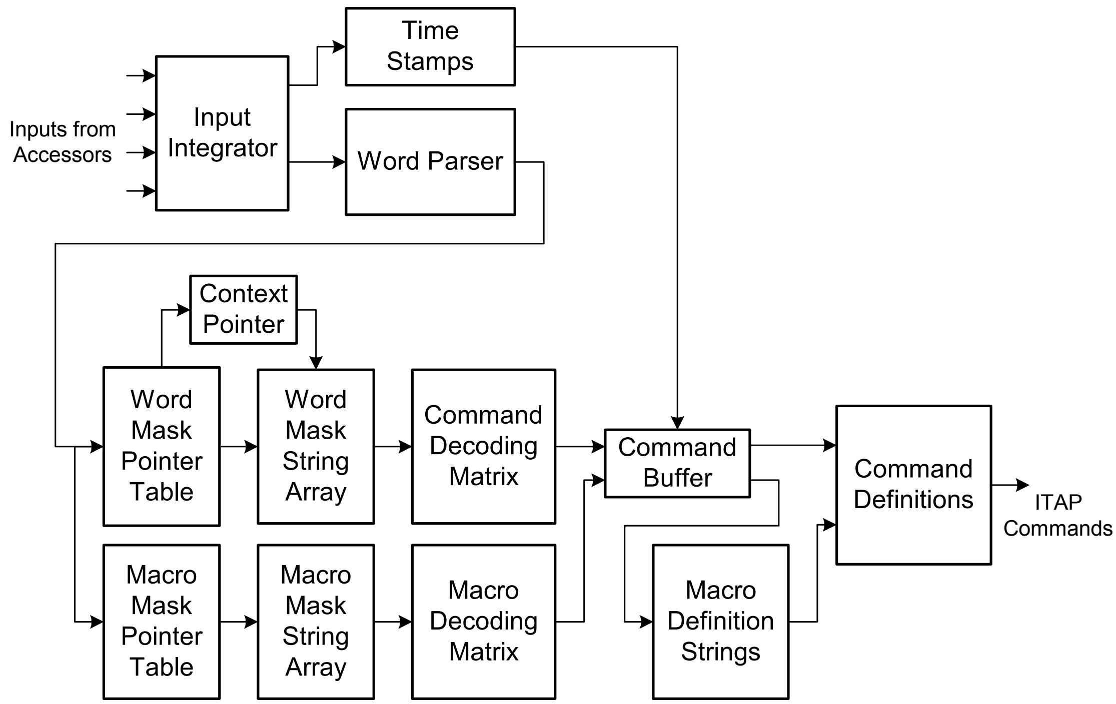

Figure 8-9 Block Diagram of an ITAP IMNIP

8.2.3 ITAP IMNIP

The ITAP IMNIP, as depicted in Figure 8-9, must handle simultaneous inputs from up to four accessors. The corpus of words recognized by the ITAP is defined by the words required to describe all of the output commands and macro phrases.

8.2.4 Accessor and ITAP Configurations

Accessors and ITAPs can be matched to the level of complexity that is to be handled. Any level of accessor can operate with any level of ITAP. Not all capabilities will be available within every combination.

ACCESSOR	ITAP
Small Accessor ➢ Small, portable, low power, embedded processor ➢ Switch accessor ➢ Morse Code accessor ➢ Motion sensing accessor	**Small ITAP** ➢ Intelligent interfaces for small appliances and lamps ➢ PC interfaces with minimal macro support
Mid-Level Accessor ➢ Portable device such as hand-held or notebook computers or high performance embedded processors ➢ User dependent speech accessors with medium size vocabularies. ➢ Intelligent video sensors for simple gestures	**Standard ITAP** ➢ House ITAP controlling groups of similar appliances ➢ PC interfaces with high-level macros for applications such as Word.
High-Level Accessor ➢ Fast notebook, desktop and high-performance embedded processors ➢ Large vocabulary, user independent speech recognition ➢ Image recognition sensors for complex gestures	**Specialized ITAP** ➢ ITAPs designed for proprietary systems ➢ Complex CADD systems ➢ Industrial control systems

8.2.5 Advantages of the IMNIP

- The IMNIP provides a practical means for enabling people to control devices within their environment using their own words and gestures.
- The ITAP Distributes Interface Intelligence across all of the accessors and ITAPs in a system. The accessors handle all human interface functions and the ITAPs handle machine interface functions.
- Any electronic device that can be controlled by human input is a potential target for the IMNIP.
- Devices equipped with an IMNIP know how to interpret human language commands within a corpus that is matched to a defined context.
- Humans know what they intend to have happen but they don’t necessarily how the steps required to make it happen.
- Accessors are normally designed to handle a single input or output modality but may also be designed to handle several complementary modalities.
- Individuals may use a single “accessor” or multiple accessors to express their intentions using combinations of their own personal speech and/or gestures.
- Individual ITAPs are designed to match a particular type of target device such as a PC or a smart house interface.
- With an ITAP, IT device designers do not need to create unique interfaces for all of the different potential users.

8.2.6 Applications of the IMNIP

The breadth of potential applications for the IMNIP is very large. The following descriptions of potential applications provide indications of how the system can be used within different home, workplace, and public space scenarios. In each situation, the IMNIP functions are distributed between devices that interface to the user or operator and devices that control the target computer or computer driven device.

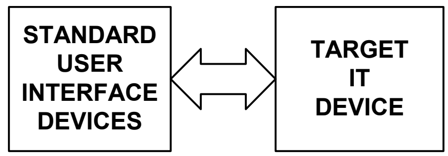

Figure 8-10 Standard User Interfaces on an IT Device

Figure 8-10 depicts a standard IT Device that is equipped with a standard user interface. While there are many variations in the ways in which the standard user interface might be connected to the target device, they are almost always functionally similar to the arrangement show in Figure 1.

Figure 2 depicts the way the IMNIP functions are incorporated into a system. IMNIP functions are separated into two parts; one that handles interaction with the user and one that handles interaction with the target device. The two parts may be connected by cable or wirelessly.

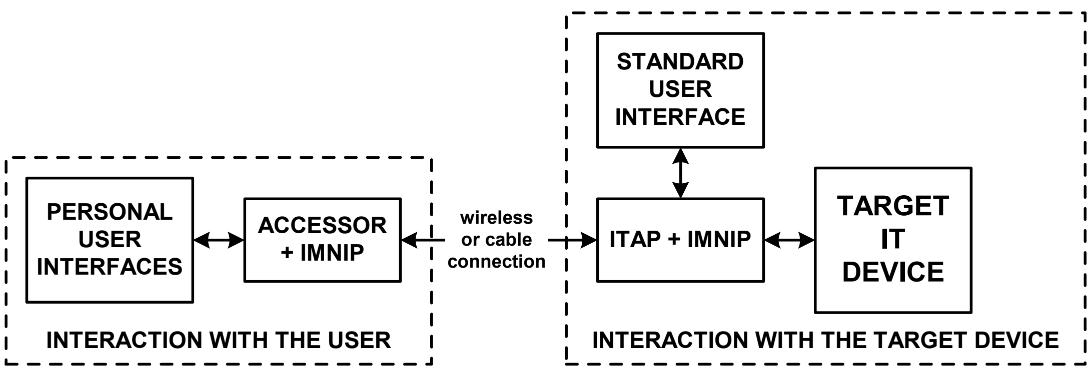

Figure 8-11 IT Device with Accessor and ITAP

8.2.7 Potential Application Areas for Intent Driven Interfaces

8.2.7.1 Appliance interfaces.

Appliances equipped with an ITAP containing an IMNIP will respond to natural human commands supplied by an accessor. Since an appliance manufacturer can’t possibly know all of the words that might be used by their customers, the natural language decoding is performed in two stages. The IMNIP corpus in an ITAP is limited to a carefully defined selection of words and phrases but this can be extended where necessary. Synonyms are handled by the accessor IMNIP. A simple appliance, such as a lamp, requires a simple ITAP IMNIP capable of handling words such as on, off and an identifying name. More complex appliances with many controls, such a kitchen aids or AV equipment, may require command words and phrases that define single commands, and multiword macros that define groups of commands.

8.2.7.2 Interacting with an intelligent infrastructure.

A smart infrastructure is any environment that is set up to support a particular activity. It can range from a physical space, such as a building or a room, through to a software environment set up to support a particular activity such as a CADD system for designing airplanes or automobiles. Every controllable device or object in a smart infrastructure will have a word or phrase defined for each command that can be performed. Objects that are brought into the infrastructure contain their own corpus of command words and phrases. Wherever possible, the manufactures will represent commands with words chosen from the defined ITAS corpus. Where essential, they can add extension words, phrases, or macros.

8.2.7.3 Industrial control systems.

Industrial control systems are similar to the two previous examples but, for safety reasons, will require much more stringent definitions for the words that are included in the ITAP IMNIP corpus.

8.2.7.4 Intuitive interfaces.

Accessors can be designed to map to a broad range of user words and phrases to the stringently defined corpus used in an ITAP. Synonyms can make interfaces more intuitive by enabling the user to express their intentions differently in different situations or contexts.

8.2.7.5 Interfaces that accommodate the special needs of people with disabilities or limited capacity due to aging.

There are growing legal requirements for equipment and software to be accessible to individuals with disabilities. Access to IT devices is now a civil rights issue. Equipping IT devices with ITAPs and giving appropriate accessors to people with disabilities represents the most flexible way to accommodate people with widely differing needs, abilities, and preferences.

8.2.8 Potential IMNIP Product Areas – This is not a complete list

8.2.8.1 Private Spaces

Individuals have different needs, abilities, and preferences for how they interact with the objects around them. This invention enables a person to develop a preferred strategy for interacting with objects based on intent, and (ii) use the same personal interaction strategy with everything they want to control.

Smart house infrastructure will support smart equipment a person brings into the house. The person will be able to use the same private access strategy to control and interact with any device that is added to the infrastructure,

Audiovisual system interfaces can be dramatically simplified and made more capable at the same time if they respond to user intent rather than requiring the user to perform a sequence of sub tasks.

Smart appliance manufacturers can never know the preferences of all potential users. The IMNIP will enable them to focus on the functionality of the appliance and provide single basic natural language interface. Individual accessors will extend the natural language to accommodate individual interaction strategies.

Security systems must be simple to use and provide unambiguous interpretation of user intentions when they are being turned on, and they must also be able to interpret and report dangerous situations when they are armed.

Smart filing cabinets can use IMNIPs to keep track of what they contain, know what has been borrowed and by whom, and enable a person to locate specific contents by intuitive keyword searches.

8.2.8.2 Public Spaces

ATMs must be able to identify a customer, perform a variety of transactions, accept deposits and documents, and dispense money. All of these functions can be improved if the ATM can unambiguously determine the intentions of the user.

Information kiosks must be able to quickly identify required information and respond in ways that are most meaningful to the user. This can be most easily achieved if the kiosk is able to quickly learn the intent of the user.

Interactive signs that respond to user intent in places like airports could provide departing passengers with information about security requirements, gate locations and passenger loading, etc., and for arriving passengers, instructions for going through customs, locating baggage and finding the gate for connecting flights.

Interactive displays in museums, malls and shops must attract, engage, and extend the people who use them. This invention directly impacts the engagement by making the system reactive to intuitive human interaction activities such as speaking, pointing and gesturing. A strong engagement phase will enhance the extend phase by enabling the person to go away clearly remembering the purpose of the display rather than the difficulty of figuring out what to do.

Interactive shopping (either live or online) would enable a potential customer to quickly specify and locate a desired product, learn more about the product through interactive enquiries, and negotiate an acceptable transaction. Suitably programmed IMNIPs could ensure that automated transactions give a customer the same level of satisfaction they would get from being served by a courteous and knowledgeable sales assistant. The advantage of IMNIP in this application is that different products or departments can use their own corpus of words.

Information over the Phone such as instructions for locating a shop or restaurant or finding a product would be improved by an intuitive interface that enables the user to unambiguously specify what he or she is looking for.

Automated phone answering systems would be less objectionable if they could respond directly to user requests such as "connect me to Joe." Commercial services like Wildfire do some of this but are still quite lame when it comes to interpreting user commands.

Interactive Help Desks can be made easier for the operator and the person making the request for help. The operator will be able to move more easily through the complex structures of interlinked cause and effect knowledge.

8.2.8.3 Education

Educational computer applications have generally failed to provide promised benefits because they require the student to place too much emphasis on learning how to use the computer. By effectively hiding the operational details of the computer, IMNIP enables students to focus on learning the subject materials.

Intention Driven Environments for Active Learning (IDEAL) provides a rich framework for computer based leaning that gives the teacher and student access to learning materials and enables them to interact with live, real-time experiments. Each person using the system is able to use their own private interaction strategy to perform the same learning activities.

Just-in-time learning will be made more intuitive by the IMNIP since the student is able to frame questions intuitively and can use an input modality that doesn't conflict with the task that is being performed. Bandwidth can be conserved by sending intent back and forth between the source and destination and translating the intent into actions locally.

Interactive Experimental Apparatus can be integrated directly into computer based learning programs. There is a move to use simulations in place of real physics or electronics apparatus. Interpreting student commands with an IMNIP makes it possible to perform real hands-on experiments as conveniently as using simulations.

Game controllers are the interface of choice for a large number of young people. An IMNIP can be used to interpret the outputs from a game controller as keyboard and mouse inputs for a standard computer or as pointing, gesture, and chordic keyboards for an accessor that is to be used with ITAS.

Distance Learning can be simplified by making real-time control of the system easier and managing the integration of local and remote resources.

8.2.8.4 Entertainment

Home Theaters bring together a variety of advanced audiovisual apparatus and are usually equipped with one or more relatively complex remote controls. An IMNIP can reduce the complexity of issuing multifunctional commands.

Video games have become the dominant entertainment industry product. IMNIPs can enhance the capabilities of game consoles and controllers by adding multimodal input and output capabilities and the ability to interpret commands expressed using natural language and gestures.

Interactive multi-modal games – most existing video games are limited to a single user and a single input modality. Games that have additional input modalities, such as speech recognition, use specially written software that requires additional adapters that work only with that software. An ITAS with IMNIP can be used with any game to add speech recognition, head tracking, special pointing devices, etc.

Intelligent toys can use IMNIPs to enable them to respond to natural commands from their owner or respond differently when controlled by someone other than their owner.

8.2.8.5 Medical Applications

Patient monitoring and support systems must provide different interfaces for each group of people in the chain that supports the patient: doctors, nurses, caregivers, and patients. While each group has different levels of education and different views of the information that is being collected, the information that is stored in a database must be consistent. Commands for browsing the database selecting information will also be different f or each group. Similarly, when information is retrieved from the database it must be presented in a form that is suitable for each group. IMNIPs provide the translations of commands and the different views of the information.

Alternative control strategies for medical instruments are being adopted for medical instruments to enable doctors to adjust settings without using their hands or interrupting what they are doing with the patient. There is a growing problem in that too many instruments are using the same modality, such as speech recognition in inconsistent and uncoordinated ways that lead to confusion. ITAS with IMNIPs can resolve this problem by enabling the doctor to identify the instrument that is to be controlled by speaking its name or looking at it and talking to it as if it were a person..

Medical image analysis requires complex manipulation and navigation through 3D graphics. An IMNIP enables the user to integrate speech, movement, squeezing and gestures to perform the control functions in ways that seem very natural to the operator. A prototype 3D graphics control system has been developed by integrating a chordic keyboard, remote pointing functions and an IMNIP into a modified video game controller.

8.2.8.6 Support for Aging Populations

IMNIPs are the key to enabling aging people to remain independent as they begin to lose capabilities due to the aging process. The complexity of conventional computers has prevented the following applications from being widely adopted but this can be overcome by using IMNIPs to provide interfaces that respond to natural language and gesture commands.

Smart house environments that enable aging people to continue to operate appliances, open and close doors and windows, use entertainment and telecom devices

Smart monitoring systems for medical safety and health.

Interactive schedulers that are easy to maintain and provide unambiguous reminders of appointments and instructions for what is to be done.

Stuff tracking to help people remember what information and objects they have stored and how to find it.

Pill minders are required to enable people who are on complicated or critical drug regimens to keep track of their medications and to take the correct pills and medicine at the correct time.

Nutrition planners are necessary to ensure that aging people plan and eat nutritious food Malnutrition is a leading complication for many aging people, particularly males who have lost their spouse.

Alzheimer’s support systems are required for people in the early stages of Alzheimer’s disease to augment failing memory and assist with navigation. An IMNIP interface to a GPS system, for example, could provide simplified instructions for finding the way to the store and back home again.

8.2.8.7 Mobility

Intent driven wheelchair controllers that use an IMNIP would provide physically disabled people with more modality options for controlling their wheel chair, reduce the amount of effort required for entering commands, and eliminate ambiguities and mistakes that could lead to dangerous situations.

Car Telematics enable a driver to control other devices and activities while driving a car. The IMNIP would reduce the cognitive load on the user and the amount of driver distraction that occurs when they are entering commands into the telematics system.

Interactive wayfinding combining GPS and IMNIPs in an interactive navigation system to enable a person to negotiate the best path to a destination based on personal preferences and priorities.

8.2.8.8 Industrial Applications

CADD systems are a critical tool in industries such as automobile and airplane manufacture. The complexity of the CADD system user interfaces has become so challenging to the designers that it is causing a severs bottleneck in the design process. IMNIP can solve this problem through the simplification that results from making interfaces that respond to user intent.

Front ends to database systems could be simplified by using IMNIPs to convert unstructured user input into the formal query language used by the DBMS for interactive storage, browsing and retrieval of information.

Smart professional measuring instruments that respond to natural input commands such as, "read the dc voltage on probe seven," would increase convenience and productivity for people whose hands are already busy when measurements or adjustments are necessary.

Controlling robots would be made simpler and safer by using IMNIPs to integrate and translate multimodal user inputs into unambiguous commands. The Macro capabilities of the IMNIP would enable an operator to use simple phrases to instruct the robot to perform complex tasks.

8.2.8.9 Telecommunications

The Short Message Service (SMS) provides the ability to send and receive text messages to and from mobile telephones. The text can comprise of words or numbers or an alphanumeric combination. Depending on the character set that is used, a single short message can be up to 160 characters of text in length. Software exists for encoding rich text messages to sms, sending through the cell phone and converting it back to rich text. Using an IMNIP at each end and sending intent rather than content would increase the amount of information that can be sent within each message and enable the received intent to be represented in whatever language or format best suits the user. One example would be using intent to drive animated cartoon figures that present for deaf people or combinations of icons and sign language for people who don't share a common language.

8.2.8.10 Military Applications

Training Operators of sophisticated equipment. In addition to reducing the amount of training required to operate sophisticated equipment, the IMNIP can also make the training process more efficient by integrating live and recorded lessons and simulations with real-time hands-on practical experience.

Military equipment has become extremely sophisticated, necessitating extensive training for military personnel. Current techniques for reducing the complexity of the user interfaces in this type of equipment are limited in scope and are not particularly robust when operators are in high stress situations. IMNIPs address both of these problems by enabling the operators to use multiple modalities that can be varied to suit the particular situation. The word filtering capabilities of the IMNIP can reject additional words or gestures that might be added to commands during high stress activities.

Specialized training for tasks such as defusing unexploded ordnance can be merged with just-in-time training or step-by-step instructions in live situations. An IMNIP can reduce the complexity of non-critical tasks while requiring critical tasks to be specified precisely. In other words, the training system becomes an intelligent interactive prompt when necessary.

Remote operation of standard equipment is impossible for people wearing protective clothing when working with chemical or radiological weapons. Chordic keyboards, speech recognition, and a variety of pointing devices can be designed into protective clothing along with IMNIPs to translate natural inputs into commands for operating standard test and communications equipment.

Remote control of surveillance vehicles, UAVs and robots can be simpler and more intuitive when IMNIPs are used because the operator can describe the intended activity and the system will automatically generate the commands necessary to carry out the intended actions. There is less likelihood of mistakes if operators are able to express their intentions using their own words, phrases and gestures.

8.3 IDEAL Classroom

IDEAL: Intention Driven Environment for Active Learning

The concepts presented here are completely generic but the need in the area of Math and Science education is critical.

8.3.1 Creating a New Environment for Learning Math and Science

According to the recently published report, "The Silent Crisis, " from BEST, a three-year partnership of government, industry and academic leaders that is focusing on Building Engineering and Science Talent, there is a critical and growing demand for skilled technologists in the United States that cannot be met by existing education strategies. For the United States to maintain its leadership in the information revolution, the teaching of math and science must be treated as a necessity, not a luxury. Many of working engineers and scientists who created the information revolution are close to retirement and there are not enough qualified young people available to step into their positions. Not only is the total college-age population much smaller than a few decades ago; the percentage of students majoring in math, physics, chemistry, computer science and engineering is shrinking as they shift to other non-technical majors. As overseas countries become competitive in technological innovation, industry in the United States cannot rely on the current practice of attracting foreign talent to make up the shortfall. We must revitalize the education system and attract more students into math and science classes at all levels of the educational process.

Correcting this problem will be a major challenge since it is not just a matter of having a too few students, there is also a shortage of qualified, inspirational teachers. We will need to develop solutions that simultaneously address the needs of both the students and the teachers.

We believe the key to achieving this is to create a radically new learning environment that takes both the teacher and the students on an exciting voyage of discovery in which knowledge and experience are seamlessly blended and delivered at a rate determined by the individual learner. Video game developers long ago recognized that children and young adults learn by doing and playing. Our challenge is to create learning environments that are as immersive as video games while going beyond their virtual nature. This requires a drastically different approach from what is being done today.

Computers have been installed in schools for almost two decades with the promise they would revolutionize education but, all too often, children spend an inordinate amount of time learning how to use classroom computers, and too little time focusing on what they are supposed to be learning. This is not only a sad outcome; it is a dreadful waste of resources and time!

Driven by the right sort of software, and connected to the right types of resource, computers can become fantastic windows onto anything in the universe. They could become microscopes to look at the building blocks of nature and the elements of life; telescopes to look at anything from just across the road to the edges of the universe; or time machines for journeying back through the history of man or the evolution of the universe or exploring what the future might hold. James Burke, through his "Connections" column in Scientific American and his TV series of the same name, demonstrated how much more memorable things become when you see how one event leads to another, and are then able to understand the dependencies. With all the computers with Internet connections that are already in schools, why isn't this already happening? The simple answer is that today's computers get in the way. They are anything but intuitive, and the windows they provide are cluttered and murky.

The problems inherent in trying to use conventional computers and operating systems to build intuitive, interactive learning environments are deeply rooted and too big to be eliminated by simply rearranging existing resources. No matter what the proponents of conventional computing strategies may say or do, the underlying model is flawed and can't be fixed by adding more layers of software.

So, what can we do? We must first look beyond the current practice of using computers designed for offices or homes. They are still too difficult to set up and use in educational applications and they employ operating systems and data structures that do not provide the necessary flexibility and reliability. Second, we must look at how information is encoded, stored, searched, browsed and retrieved; much of the knowledge required to revitalize education exists but has been ignored through the focus on hardware rather than the desired result: an educated human. Third, the quality of educational information is strained; the best teachers are often compelled to use dubious textbooks, where the IDEAL system can offer them access to the most lucid minds available.

The computer industry adds another layer of complexity to this situation. The profitability of this industry is based on short-term planning, marketing that compels user's to lust for speed, and version obsolescence. Software and hardware companies play a constant game of leapfrog that makes it necessary for consumers to upgrade regularly. While many schools already have classroom computers, they rarely have the resources for constant upgrades so they find themselves on a resource-draining treadmill driven by obsolescence. Faced by ever increasing complexity and incompatibilities, teachers are reluctant to invest time and effort into preparing computer-based class materials when the computers keep changing and there is no assurance that materials can be reused with future classes. The overall result is that most of the computers currently in schools are poorly matched to educational needs, under utilized, and outdated.

Archimedes at Stanford has developed new computer access technologies that have the potential to revolutionize the use of computers in education. Students can be immersed in highly interactive, media-rich, learning environments in which:

- They are able to move seamlessly between live or computer-based lessons, with consistent and familiar access to stored knowledge.
- They can learn how things work through simulations and practical hands-on experimentation.

There is a twofold goal for this system: The first is to build a solid understanding of underlying concepts and theories by presenting clearly defined concepts, underlying theories, examples of applications, mathematical visualization tools, and simulations. The second is to reinforce the learning experience through simultaneous hands-on practical experimentation, simulations and mathematical verification. While these learning strategies could be applied to almost any field of education, we believe quantifiable results and an urgent and widely recognized critical need make physics and mathematics an ideal choice for proving this new concept.

8.3.2 An IDEAL Approach to Educational Computer Systems

We are proposing a new computer system specifically designed for educational use in which students and teachers are immersed in a collaborative learning environment in which each participant has a personal interface matched to individual needs and preferences, and independent of the underlying computer systems and the applications that are being used. Specialized experimental apparatus and measurement modules can be added in a plug and play fashion to match particular learning activities without disturbing any of the user interfaces.

These capabilities are made possible by our new ***"Intention Driven System" (IDS)*** that redefines the ways in which people can interact with computer based devices. The GUI interfaces commonly used on personal computers present users with a smorgasbord of icons, menus and choice boxes from which the necessary commands must be selected in the correct order to perform a desired task. The IDS makes computers easier to use by eliminating the need for users to know the detailed steps involved in performing each task. To get a feel for the significance of this, think of what is involved in starting the engine in a modern car compared to doing the same thing in an early vintage car. Today, it is very straightforward, we turn the ignition key and the engine starts. In a vintage car there are many steps that must be performed in certain ways and in the correct order: make sure the hand break is on and the gears are in neutral, set the choke based on air temperature and altitude, set the hand throttle to a fast idle, advance the spark, get out of the car, insert the cranking handle in the front of the engine, grasp the handle of the crank properly so that you won't break your thumb if the engine backfires, carefully turn over the engine to judge the compression stroke, crank the engine until it starts, remove and stow the crank handle, climb back into the car and adjust the controls over a period of time until the engine is running smoothly. The contrast between IDS and contemporary GUI computer interfaces is similarly striking. With IDS the user only needs to say or type a command in natural language or make a gesture and the system will identify and perform an intended task or sequence of tasks.

Figure 8-13 shows how the IDS deduces user intent and translates that intent into commands that instruct the computer to perform the functions necessary for completing the intended task. The target device can be any type of computer or appliance. If the target device is a TV, for instance, the user can control everything about the TV by giving commands such as "turn on the tv," "select channel 28," and so on. Commands like this are fine if people remember what to say and different people know to which words were chosen by the designers to represent each task

Experience has taught us, however, that people do not like memorizing scripts that specify what to say, and different people do not necessarily call things by the same name. A TV, for example, can also be called a television, television set, TV set, tele, idiot box, boob tube, and so on. An interface must be able to correctly recognize all of the names that apply to each device or function and all of the ways for using those names in meaningful commands. For example, the IDS will correctly interpret as "TV on" commands such as: "please turn on the tele," "I want to turn on the television set," or "I would like to watch TV now." The output of the IDS is not limited to single commands. A single command can initiate a whole sequence of interrelated tasks.

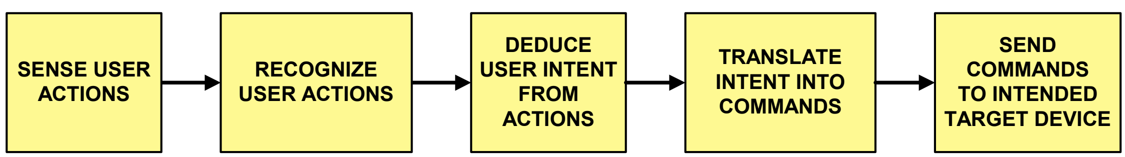

Figure 8-12 Functional Components of an Intention Driven System

In the learning environment that we envisage, computers are just one of many devices that must be controlled by the students and teachers.

- What if a teacher could use intuitive voice and gestural commands to search for, and load selected video clips onto her tablet computer, display them on the main classroom screen using a hand gesture, toss them with a gesture to a student's wireless handheld device, and edit them by dragging and dropping using head and eye movements?
- What if a student could control a microscope by voice commands, send the image to her tablet computer, edit the image with speech and pointing commands, flick it with a gesture to her neighbor's wireless handheld device, and drag down a relevant simulation and animated image from the main screen using a hand gesture?

- What if a student could interact with an electronics circuit by saying commands like: "read the DC voltage on pin six of the op-amp," "show me the frequency spectrum on pin six of the filter chip," or "set the audio oscillator to one Kilo Hertz"?

This is precisely what IDS enables us to do. What would otherwise require long detailed lists of step-by-step instructions are reduced to a simple sentence expressing the user's intention. The student can focus on what they are doing and why rather than how. With carefully structured IDS learning environments, we believe students will be able to focus on the message rather than the artifacts of the presentation. Teachers will be able to craft the messages to provide the most effective mode of delivery, remembering the old adage, "what I hear, I forget; what I see, I remember; what I do, I understand."

Figure 8-14 shows a block diagram of the IDS educational environment configured for teaching mathematics and physics. In conjunction with the SUMMIT Project at Stanford Medical School, we have chosen the name IDEAL for Intention Driven Environment for Active Learning.

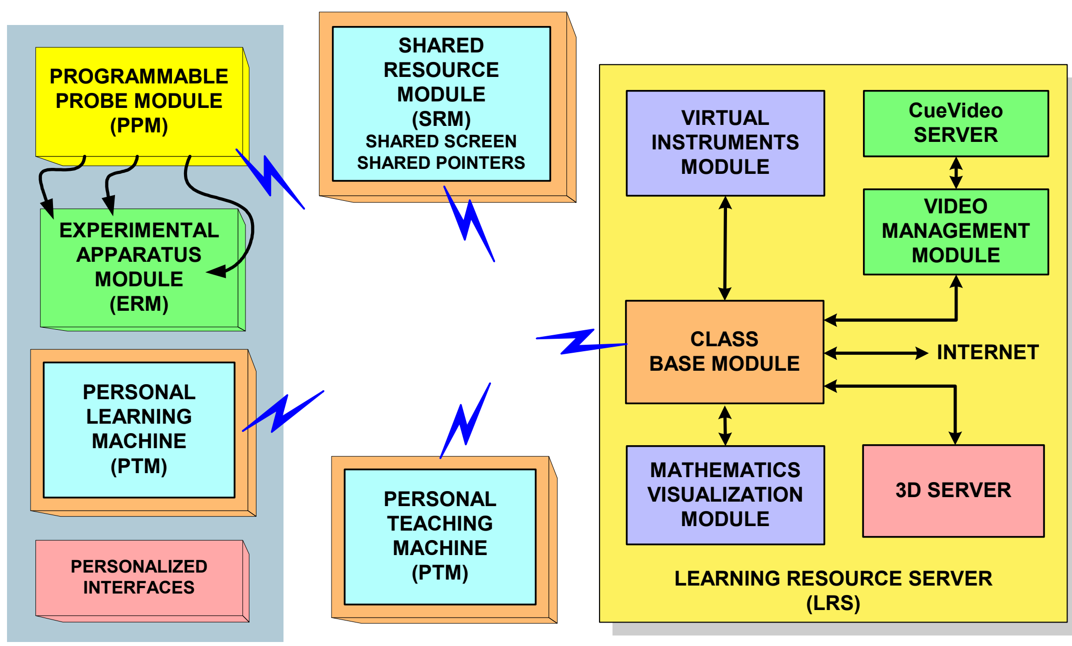

Figure 8-13 Components of an IDEAL Classroom

An IDEAL classroom will be much less intimidating than contemporary computer-equipped classrooms. Apart from shared resources such as screens and printers, and personal tablets, all of the classroom computer system components will be in a closet or a back room and effectively invisible to the students and teacher. Fixed resources are wired directly to the classroom computer system and portable equipment such as the tablet computers used by the teacher and students and the student experimental apparatus are connected wirelessly. The wireless system is fully automatic and not at all like Email or conventional networking. Information can be passed from one person to another using simple human language commands or gestures. The focus is on providing what the people need in order to behave naturally, not on what the machinery needs to do. Where necessary, IDS automatically supports additional interaction modalities to accommodate the special needs of students and teachers with disabilities.

8.3.3 Next Steps for IDEAL

The Archimedes Project has devoted more than a decade to creating special interfaces for people with diminished capacities due to disability and aging. In the process, we were surprised to find fully fit people calling us, demanding those exact same interfaces. It appears that in the process of building devices individuals with disabilities, we were building devices for all.

It is time to begin using these enabling technologies to eliminate man-made disabling situations caused by contemporary personal computers. We have already developed proof-of-concept prototypes of the building blocks that make the IDEAL classroom feasible. Now we need to build an IDEAL classroom and test it with real students and teachers working with real learning resources. We have identified many different individuals and organizations that can, and want to contribute to creating the components and resource materials that will be necessary to make wide deployment possible. When we describe the system to teachers, their first question is "when can we have it?"

- The need for more science, mathematics and engineering students is clear.
- The need to provide better support for teachers is clear.
- The failure of contemporary classroom computers is clear.
- The potential benefits of engaging students in exciting learning environments are clear.
- The building blocks for building an IDEAL classroom have been developed.
- There will be huge commercial possibilities for companies as standard products emerge.
- Financial support is required to get the process started.

8.4 TECHNOLOGIES THAT HELP PEOPLE COPE WITH AGING

A global crisis is looming due to the aging of the world's population. Thirty million people in the United States and twenty-three million people in Japan are over the age of sixty-five. Old rules about retirement are failing. Countries can no longer afford the traditional strategy of placing aging people in supported care facilities at the first sign of them not being able to cope. Even if countries could afford the costs of supported care, there are not enough young people available to look after the aging population.

Appropriate technology will be the critical factor in managing this crisis. It is imperative that we develop a supportive infrastructure that enables aging people to remain independent for as long as possible while maintaining an acceptably high quality of life. Technologies are needed for:

- Providing independence without isolation.
- Managing aspects of daily living.
- Mental stimulation through puzzles, games and ongoing learning.

- Providing a safe and secure environment.

While many aging people are quite comfortable with the use and maintenance of off-the-shelf computers, there are many for whom the computer is an utter mystery. For these people, computers must be more like simple appliances that perform an obvious function and have simple, easy-to-operate controls.

Technology holds the key to aging with dignity but there is still a great deal of work to be done before it will become a practical choice for the large population of aging people who could benefit most.

8.4.1 Background to the Aging Crisis

As shown in Figure 8-14, the average life expectancy in many of the advanced countries has tripled during the past two hundred years. For a lot of people, however, idyllic visions of elderly people spending their later years enjoying a well-earned retirement have not materialized. While medical advances have alleviated many of the diseases and conditions that have traditionally impacted the health of aging people, little progress has been made with devastating diseases like Alzheimer's and dementia. Health is only one factor impacting the quality of life for aging people. Financial and societal problems also limit the ability of aging people to live a long and enjoyable retirement. Information technology is usually portrayed as an enabler that has a positive influence on quality of life. There are many techno phobic aging people, however, for whom technology is quite disabling. There are also many technology based devices that can't be used by aging people – electronic gadgets with buttons that can't be operated by a person with arthritis, control panels that are incomprehensible to a person with failing eyesight, or telephones that are too complex for a person with failing memory or cognitive abilities.

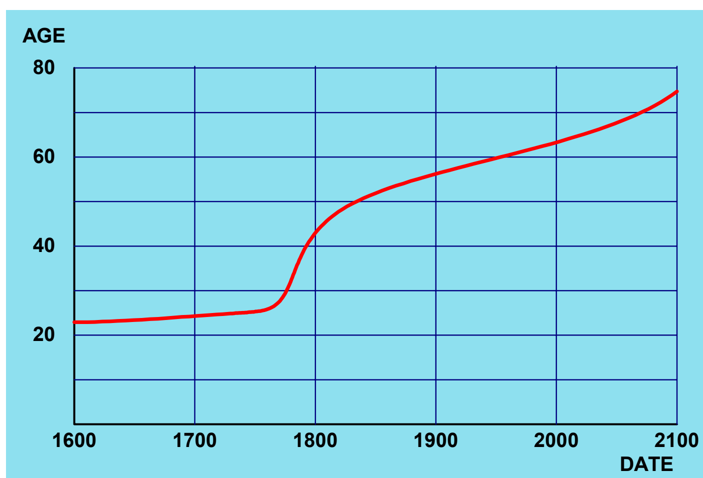

Figure 8-14 Life Expectancy at Birth

Most people prefer to spend their final years in their own home but all too often, these years are spent in a nursing home. While there are many people who can no longer look after themselves, and for whom a nursing home is the only realistic option, there are others who, if given the right kind of support, could continue to live independently. Nursing care is a labor intensive and expensive undertaking that is beginning to drain the resources of many communities. Apart from the direct costs, however, there is another significant societal change that is compounding the problem of providing nursing care for elderly people. As shown in Figure 8-15, the birthrate in many countries has dropped drastically over the last fifty years and there is now a severe shortage of young people prepared to look after aging people.

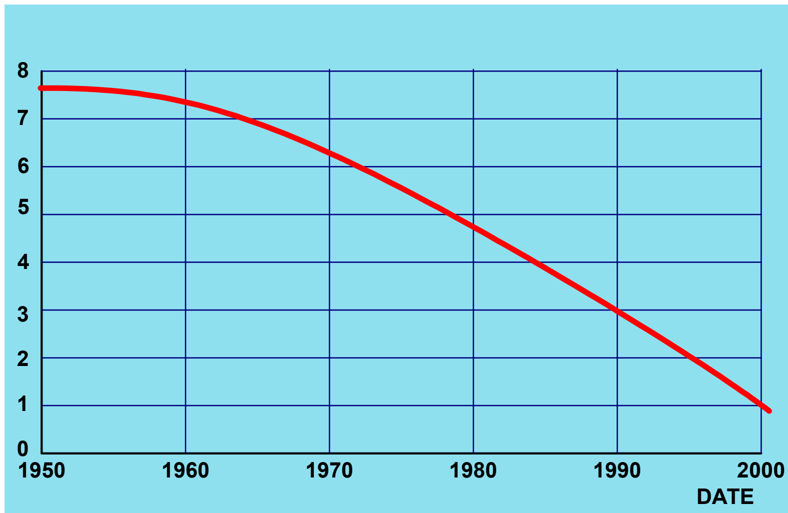

Figure 8-15 Declining Birthrate

Figure 8-16 shows how the number of Americans of age 65 or over has increased since 1950. The current total is close to thirty million and it is predicted to reach more than seventy million by 2050. Similar trends are found in all of the developed countries. Japan, for example, currently has more than twenty two million people over the age of sixty-five. Japan does not have enough nursing homes or staff to cope with the demand and there is a twenty-year waiting list to get into a nursing home. The shortage of both professional and unskilled support staff has become a global problem that will require computer-based solutions.

Many grown children feel they have a responsibility to look after their aging parents. But the collapse of the nuclear family, working mothers, and the wide dispersal of family members limits traditional solutions such as such as children moving elderly parents into their homes and looking after them. When children believe their aging parents can no longer look after themselves, moving them into a nursing home may be seen as the only viable option. The decision to do this is often triggered by a single event such as a medical crisis that arises when an aging parent is confused by a doctor’s instructions or forgets to take their medication.

Apart from medical and health considerations, there are many other quality of life issues related to personal management such as hygiene, nutrition, exercise, leisure activities and connections with family and friends.

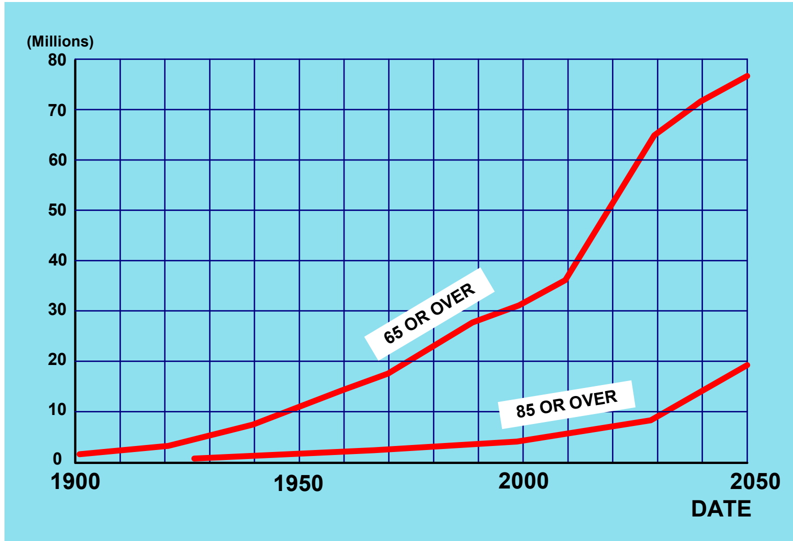

Figure 8-16 Growing Numbers of Aging People in America

There are a many compelling reasons for developing ways to enable aging people to live independently in their own homes for as long as possible. We believe that appropriately designed technology can make this possible. The key is not to use technology merely as a replacement for all of the traditional coping strategies but rather to use it as an augmenting and coordinating tool. Technology can be used to leverage human effort and involvement. It is all too easy to visualize exotic technology enables an aging person to live independently in his or her own house but unless it is done properly that independence could result in extreme loneliness.

Technology that helps aging people live independently will touch on all aspects of their lives. Most of the tools necessary to do this already exist but they are spread across separate products and disciplines. Synthesizing these tools into a fully supportive system for aging people is a major challenge but we believe it can be done using technologies originally developed by the Archimedes Project at Stanford to help people with disabilities. The following section summarizes a broad range of problems typically encountered by aging people and discusses the technologies that can be used to solve those problems.

8.4.2 Appropriate Information Technologies

Information technology is rapidly becoming an integral part of work, education, and daily living. Most work situations are dependent on some form of computing and more than half of all households in the United States have personal computers. Prices have fallen significantly during the past year and low cost Linux computers are becoming available through stores like Wal-Mart. Computer-based controllers are being incorporated in many of the appliances and tools used to perform routine tasks. In some cases, the computer is added to improve performance, reduce costs and simplify the operation of a product while leaving user interface basically unchanged and essentially hiding the complexity of the technology from the user. More commonly, however, embedded computers are added to commodity products with the intention of creating new marketing opportunities through the addition of new features and innovative changes to the user interface. The net result is that new products are becoming more complicated and are increasingly difficult to understand, set up, and use. Frequent changes to the user interface are particularly challenging for older people who are less likely to have had previous exposure to computer-based technology and may no longer see, hear or remember things so well. Miniaturized keyboards and controls, for instance, are difficult for people who no longer have the nimble fingers of youth. There are at least four ways in which computers could be used to help aging people.

- Augmenting capabilities that are degraded due to the aging process.
- Replacing capabilities that have been lost because of disabilities.
- Supporting the normal activities of daily living.
- Providing access to support services that help people cope with the aging process.

Within each of these potential application areas, there are many subcategories with many interlinking relationships. Designing systems and applications to support all of the potential needs presents the research community with two overriding challenges. The first is to determine and prioritize all of the potentially beneficial technologies aging people might use in their daily lives. The second is to develop operational procedures and user interfaces that can be easily understood and used by aging people. Meeting these challenges will require answers to the following questions:

- How and where could technology help people cope with aging?
- Why do some people, particularly older adults, have difficulty integrating technology into their daily lives?
- What types of user interface are most effective for aging people?
- How do the needs of a person change with increasing age?
- What guidelines are needed to enable product developers and manufacturers to balance cost, capabilities, usability and longevity?
- What methods should be used for teaching aging people how to recognize where and how they can use technology to their advantage?

The aging process impacts people differently. Some people are able to adapt and take the changes in their stride while others require help to cope. At some point, a person may lose the ability to live independently and find it necessary to enter a care facility. Technology developers must design for both independent and supported living. Some solutions will be unique to each situation and some will apply to both.

8.4.3 Technology to Promote Independent Living

The goal of independent living is to enable elderly people to remain in their own home for as long as practical without denying them the support and advantages they would receive in a care facility. This requires looking beyond stereotypical computer applications such as scheduling and financial management. Functions that increase the ability of aging people to live independently fall within the following categories:

- Maintaining a sense of being in control

- Maintaining personal health
- Maintaining a state of general well being
- Coping with the changes brought about by aging

8.4.3.1 Maintaining a Sense of Being in Control

Each of the following factors impacts an individual's sense of being in control.

- Environment – an aging person must be able to interact with and control all of the devices and appliances in their living environment in spite of deteriorating physical and mental capabilities.
- Finances – managing money, paying bills, investments, taxes, and so on.
- Mobility – getting out and about and finding the way back home.
- Security – knowing that there is protection against unwanted intrusion and knowing that help can be summoned for any dangerous or abnormal situation.

Each of these broad categories breaks down into many subcategories. Many of the necessary functions can be handled through appropriately designed web sites if the aging person is able to use a suitable computer and web browser. Tablet computers with interfaces modeled on accessible computers developed for people with disabilities are emerging as a viable option for aging people who are unsure about computers or have age related problems that make conventional keyboard and mouse interfaces difficult to handle.

8.4.3.2 Maintaining Personal Health

Personal health depends on managing medical conditions, diet and exercise.

- Many medical conditions can now be remotely monitored. The challenge is to incorporate necessary the support for gathering, storing and transferring data to a central facility. Self-testing is now available for many conditions that can't be monitored remotely.
- Many elderly people must adhere to a strict regimen for taking their medication. This presents a major logistics burden for many aging people – collecting pills and medicines separately on schedules controlled by their HMO, organizing the pills and medicines into doses to be taken at specified times throughout the day, remembering to take each dose of pills and medicines at the correct times, and knowing what to do when they miss a dose.
- Adhering to preventive medical programs such as vaccination against influenza and pneumoccocal disease and mammograms.
- Handling emergency situations such as sudden onset of pain or other symptoms, coping with a fall, or forgetting to take medication at the correct time.
- Planning and maintaining a healthy and nutritious diet.
- Planning and maintaining an appropriate exercise program.

8.4.3.3 Reaching and Maintaining a State of Well-being

A sense of personal well-being is achieved when a person feels healthy, secure, and happy with his or her situation. There are obviously a great many factors that can contribute to or detract from this.

- Inclusion – maintaining interactive relationships with family, friends, and supporters. Loneliness is reported as one of the most serious problems of aging. Technology offers new alternatives for creating connections to family and friends and creating new interactive communities. Older people who are socially active are reported as having better emotional and physical health.
- Participating in peer activities
- Involvement in decision processes
- Access to individuals or groups through the Internet
- Stimulation – regular mental challenges and stimulating activities are important for maintaining mental alertness, good memory, and reasoning ability.
- Leisure – may consist of many types of passive and active activities.

8.4.3.4 Accessing Resources for Coping With Aging

There are many agencies throughout the country that provide support services for aging people. A potential application for computer-based communication tools could enable aging people to access many of these services from their home. The following list shows the range of topics serviced by these agencies throughout the United States. Developing effective interaction strategies that will allow aging people to access these services from their home will open up many interesting research and collaboration opportunities.

Issues related to aging include:

- Stress Management
- Grief & Loss
- Anxiety
- Depression
- Sexual Dysfunction
- Substance Abuse
- Cognitive Impairment
- Loneliness/Isolation
- Self-esteem
- Life Change/Adjustment Issues
- Marital and Family Issues
- Relationship Issues
- Dementia

8.4.4 Technological Solutions Based on the ITAS

Simple tasks like turning on a lamp or changing the channel on the TV can become difficult or even impossible if a person can no longer use his or her hands. Reading information from a web site or looking up a phone number in the telephone directory becomes difficult as sight deteriorates. Hearing the doorbell or using the telephone may be difficult due to failing hearing. Increasingly, computers offer the best option for augmenting or replacing failing capabilities but there is a major underlying problem. Off-the-shelf computers do not have the capabilities required to handle the diversity of different needs presented by an aging population. Fortunately, disability access researchers have been wrestling with these problems for more than twenty-five years. The Archimedes ITAS provides an ideal solution to the problems faces by aging people. Archimedes has focused on three specific examples of how the ITAS can be beneficial for aging people: (i) universal accessor, (ii) environmental control, and (iii) medical management strategies.

8.4.4.1 Universal Accessor

The basic concept of an accessor is that is provides its user with a personalized set of input and/or output interfaces that match his or her needs, abilities, preferences and culture. A well designed accessor will provide personalized access to computers, appliances, entertainment systems, ATMs, Information Kiosks, elevators, street lights, wheelchair or scooter controls, and so on. Preliminary research suggests that an accessor based on a tablet computer can be configured to perform many of the functions required by an aging person. Many of the strategies envisaged for this application have been demonstrated in a tablet-based communication device recently completed for autistic children.

8.4.4.2 Environmental Control Systems

Environmental control systems support the ability to control physical devices such as TVs, VCRs, audio systems, lamps, doors and drapes within a person’s living or working environment. An infrared TV remote control provides a good example of both the solutions and the problems of environmental control. For a person with normal hand dexterity and vision, a well-designed, universal remote control provides a convenient way to turn devices on and off and adjust their settings. It is a different story, however, when the person can’t operate the buttons because of arthritis or recognize options due to failing eyesight. The ITAS provides the core for building highly adaptable remote controls that provide a broad range of user input and output options matched to individual needs, abilities, and preferences.

While computers have the potential to solve many of these problems, they have become the root cause of problems for many aging people whose special needs are largely ignored by the mainstream computer industry. Operational complexity, illogical operating strategies, low reliability and limited real-world options can make even the simplest tasks daunting for many aging people. Building on access tools developed for people with disabilities, Archimedes Researchers have designed home-control technology that responds to the natural speech and gestures of each user.

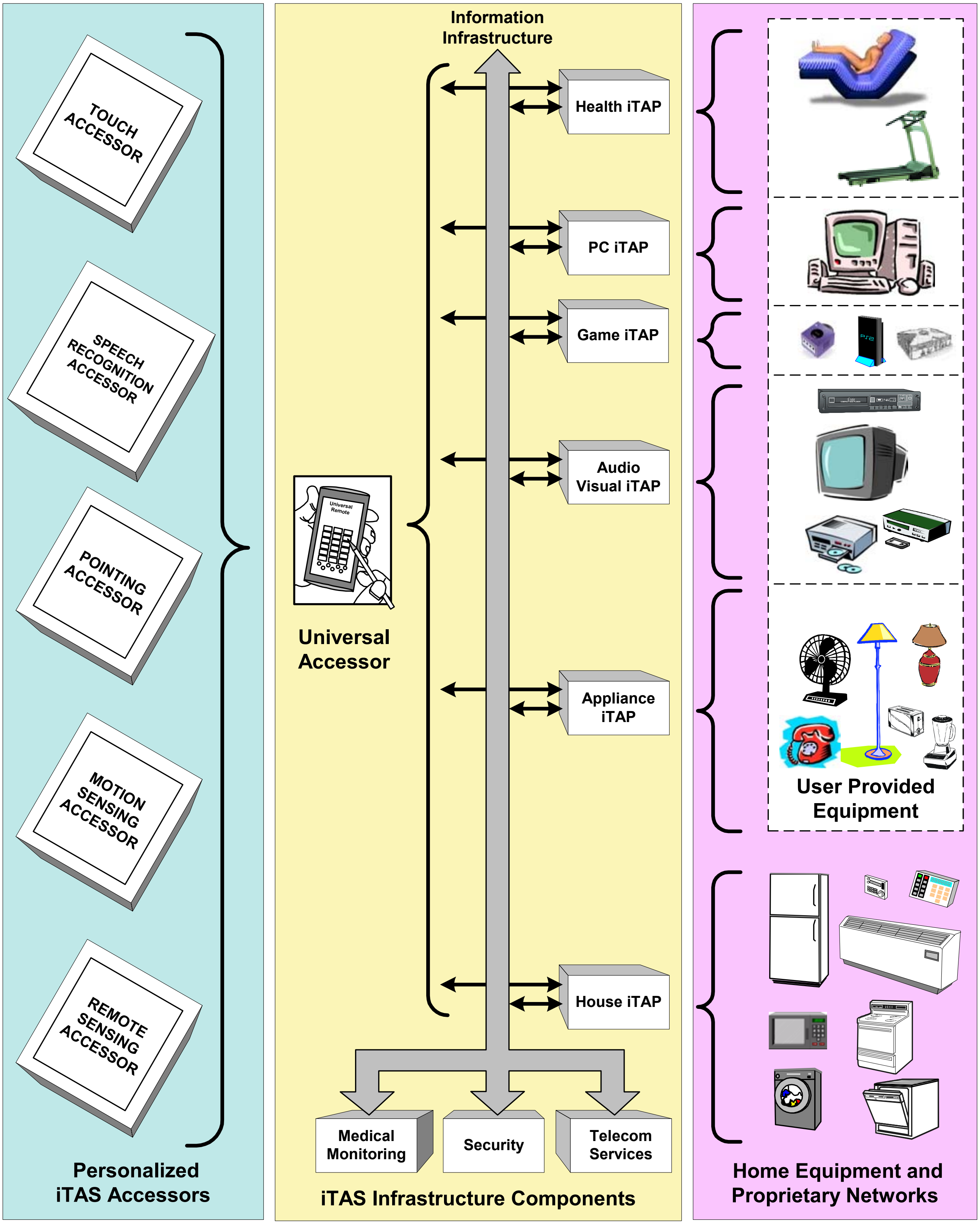

Figure 8-17 ITAS Provides Universal Access to Household Devices.

Figure 8-17 shows the functional components of a comprehensive ITAS home control system that satisfies the requirements advanced earlier in this section. After discussing this system with a Venture Capitalist we believe a slightly oblique strategy will be required to gain the interest of appliance manufacturers and building owners. Rather than targeting aging people who desperately need this system to remain independent, it will most likely be necessary to focus on luxury and convenience aspects of the system for rich aging retirees. Part of the attraction for them will be that the smart house will be ready for interfacing special accessors should one of the occupants become physically disabled due to arthritis or a stroke, for example. The information infrastructure is included to provide additional services that can be leased or sold to the occupants by the building owner, thereby assuring the owner of a steady income. Prototypes of most of the required ITAS components have been built and tested.

8.4.4.3 Medication Management Strategies

This section describes the concept of a Pill Minder that ensures people receive the correct medications at the correct time. Technologies and strategies developed for the pill minder can be applied to many other

8.4.4.4 Problem Statement

Increasingly, patients are required to follow complicated regimens that involve combinations of prescription drugs that must be taken at precisely determined intervals and for specific durations of treatment. While some consumers have the necessary ability and self-discipline to manage a complicated drug regimen, many don't. This is an increasingly significant problem among elderly people. Many people fail to understand the crucial importance of taking medications at particular times or the need to complete a course of drugs. Simple assistive devices, such as plastic pill-organizers from a drug store help some people, but only if the users or their helpers have the ability or take the time to load the compartments ahead of time and if they remember to take them at the proper times.

In addition to the reduced efficacy that results from improper use of a drug, potentially life-threatening dangers can arise from accidental dispensing of the wrong drug or the accidental combination of incompatible drugs.

8.4.4.5 Proposed Solution

We are proposing an end-to-end solution that dramatically reduces the complexity of administering a particular drug regimen, and significantly increases the likelihood that the consumer will follow and complete the regimen. Additionally, the system builds in safety factors that are missing from existing dispensing and delivery strategies.

In formulating a solution, we have made a number of assumptions about existing products and practices that are likely to be continued for some time.

- Tablets and capsules will continue to be the primary delivery method for most self-administered drugs.
- Improved delivery mechanisms, such as time-release capsules, will come into use but the bulk of the medications will remain in simple tablets and capsules.
- Pharmacists will continue to be responsible for dispensing drugs and monitoring compatibility and safety issues.

- Patients need assistance in remembering to take the right drugs at the right time.
- Pharmacists will continue to make occasional mistakes in dispensing drugs.
- We have also noted some trends:
- Drug regimens will continue to become more complicated
- The efficacy of drugs will depend on rigid adherence to specified dosages and schedules.

The proposed solution has four major components:

1. A professional dispensing tool that enables pharmacists to assemble individual drug regimens in disposable pill organizers. A variety of safety and verification strategies are incorporated into the design of the dispenser.
2. A disposable pill organizer that holds the daily or weekly drug supply for individual consumers. Individually sealed and labeled cups contain the drugs that are to be taken at each specified time. The cups are assembled into a tamperproof package that cannot be easily opened manually.
3. A dispensing tool for the consumer that releases individual sealed cups from the pill organizer at the correct times. This device will provide a range of operating modes that depend on how rigidly the prescribed regimen must be followed. Options will range from an internal alarm clock through to a computerized release and checking strategy controlled by a computer in the pharmacy that dispensed the drugs.
4. A computerized control and monitoring system that sends pager messages at specified times to remind individual users to take their medications along with control signals that instruct the pill organizer to release a specified cup containing the dose that is about to be taken. Motorola is soon to introduce a two-way pager that would enable the pharmacy to signal when pills are to be taken and for the pill minder to send an acknowledgement either when the pills are taken from the minder or the user presses a button to confirm they have been taken.

Obviously, patients will benefit from the proper administration of drug regimens. But it is the drug companies who have a large financial stake in ensuring that users comply with the requirements for administering a drug regimen. To a very large extent, the efficacy of a drug, and hence the market value of the company, depends on how closely the consumer follows the recommended dosage and schedule. The development, manufacturing, and delivery of the proposed system should be of interest to large drug companies.

8.4.5 Design Concepts

8.4.6 Conceptual Options for signaling the consumer

The pill container is supplied with a dormant timer that is activated when the lid is first opened. Timing data stored in the timer is matched to the recommended regimen for taking the drug and will trigger an alarm at the prescribed times.

The Pill container contains a timer that is programmed at the dispensary. The starting time can be either programmed into the timer or triggered by the user opening the container for the first time.

The programming data is provided with the pills and loaded into a timer owned by the patient. The timing data could be triggered by barcodes or stored electronically.

8.4.6.1 Disposable Solutions

The basic component is a sealed package containing a single chip timer/memory, an audio transducer and a battery. The timer is programmed to generate a pattern of beeps after a prescribed time interval. There are several ways for this device to be used:

- One timer per prescription: A pellet containing the preprogrammed timer is dropped into the pill container when the pills are dispensed. The timer is programmed to emit an alarm at prescribed intervals after it is activated.
- One timer per dose: The timer is sandwiched in a foil lid for prepackaged doses of pills. Individual timers are preprogrammed to generate an alarm at the prescribed times for the individual doses. A visual indicator (electrochemical color change or flashing led) may b included in the package to tell the user which dose to take.
- A single timer is incorporated into a package that holds a prescribed series of doses. Foil patterns on the lid of the container allow the timer to indicate which dose to take and to sense when the dose is removed from the package.

8.4.6.2 Durable Solutions

A more elaborate timer is housed in a device that can be loaded with a package of prescribed doses. The timer may be programmed in a variety of ways:

- The user programs the timer manually
- The package of doses conveys the information as a bar code or as electronic data in a tiny flash memory
- The timer obtains the timing data over the phone lines.
- The timer obtains the timing data by wireless pager technology

The last two options provide a path for interactive monitoring to ensure the doses are being taken at the correct times.

What have we Learned? 9

9.1 Summarizing the Stanford/Silicon Valley Experience

9.1.1 NOTES for preparation of this chapter…

"Simple" solutions require sophisticated technologies to make them practical.

Preconceived perceptions of who is responsible for providing solutions are hard to overcome

Revisit the Arch principles and take note of where we are in relationship to them.

Most people live in denial that they would ever become disabled or that they will be incapacitated by aging.

Passing the baton… Many of the young people who have been enthusiastically involved in doing projects that will help humanity eventually go in another direction to follow the money.

Continuity of:

- objectives
- purpose
- Effort
- Improvement
- Acceptance
-

Opening the door to Mainstream applications – change the perception from creating tools for disabled people to making tools that make IT easier for everyone and increase productivity for everyone.

How do we use this technology to impact the lives of people

Continuity in areas of need

In its rush to innovate, the computer industry literally creates handicaps within the general population : an inability to intuitively use many of these innovations.

We have built the infrastructure with ITAS– now it is time to apply it to the needs of people.

US has been the center of technical innovation -- transfer of primacy has already taken place -- Indian Institute of Technology outranks top US universities.

???