A Vision for a New Direction in Common Applications of Computing

ABSTRACT

The purpose of this paper is to point out the potential for a new direction in common applications of computing, one the that is not strictly market-driven and could be designed to be more specific to each individual user's needs. Comprehensive descriptions of digitization, computation, and the combinatorial nature of technology are laid out and placed into the context of our past and future technological development. A study of past visions of technology's potential that were specifically non-market-driven clarifies that these options are and always have been available, though they frequently have not been realized. The reader will see that our current state of technology affords the opportunity for these alternative paths, and will hopefully recognize the value of adopting such developmental methods.

I. INTRODUCTION

The majority of the capabilities the human race has gained through digitization of information and applying computational methods to this digitized information is not being utilized by our current state of computing. This is not because of any lack of ideas for non-market-driven alternatives, but rather because demand for and a general acceptance of economically based transactional devices has led us to this state.

More holistic, if not humanitarian, alternatives have always existed. Vannevar Bush's ideology in general was expressive of a desire for intellectual uses of computation, particularly in his account of the Memex device and other examples if human intellectual augmentation. Alan Kay's Dynabook exhibited similar characteristics as an educational tool for children and potentially for adults as well. Now we find ourselves in a position where the miniaturization of integrated circuits and the variety of devices, from wearable technology to mobile devices, has enabled an embodied paradigm for interacting with computational machines. At this point, technology users have an opportunity to influence the development of new forms of technologies that will undoubtedly shape future iterations of similar technologies that will emerge from the developments we will see in the immediate future.

II. ORIGINS OF MODERN COMPUTING MODELS

Digitization

The ability to digitize information is profound not only for the spread of information but also on many philosophical levels as well. Without getting too much into philosophical meanderings, relevant questions include: *what within the human being represents a barrier for digitizing information?* and *how does a digitized representation of the world compare with its analog original?* To take any analog object and break it into a series (a very long series, typically) of yes-or-no questions is a somewhat intuitive tactic, even reminiscent of the children's guessing game "Twenty Questions." The game did not really consist of guessing, though; the question-asker's objective was to eliminate possibilities one question at a time, until the only option left was a very specific instance in the question-answerer's mind.

These "possibilities" that are eliminated in the children's game are parallel to Information Theory's definition of *entropy*. Warren Weaver offers the following definition in his introduction to *The Mathematical Theory of Communication*, a definition he describes as a collection of concepts from Claude Shannon and Norbert Wiener: "entropy is related to 'missing information,' inasmuch as it is related to the number of alternatives which remain possible to a physical system after all the macroscopically observable information concerning it has been recorded" (Shannon & Weaver 3). It is easy to see how the "missing information" concept is similar to the children's game, but it hopefully also seems more clear that any piece of information, as long as it describes something about the analog world, could be open to digitization.

The implications of a capability like this are endless, from completely recreating our world as it is, to creating vastly different worlds, to recreating our own world for the most part, only with subtle differences. The expanse of variety of type and purpose for these differences is open to human imagination. Aside from science-fiction-like accounts of building virtual worlds that are not perceptibly different from our own, the opportunity for us to manipulate information and signals to do many different things exists, whether we are thinking in humanitarian terms of capitalist terms. The current state of our usage of computing and its potential is wasteful in terms of the opportunity cost lost by not pursuing more alternative, less strictly market-driven capacities.

Computing

What people have meant and understood by the term *computing* in the past has varied vastly. As used here, *computing* and *computation* should be understood generally, as "the manipulation of numbers and symbols according to established procedures" (Barba & Osborn). The chart below offers some additional context for thinking about the consequences of and reasons for our current state of computation, but the main focus of this paper relies on the general definition given above.

Category	Focus	Examples
Computation	What can and cannot be computed	Classifying complexity of problems in terms of the number of computational steps to achieve a solution
Communication	Reliably moving information between locations	Information measured as entropy. Compression of files, error-correcting codes, cryptography
Coordination	Effectively using many autonomous computers	Protocols that eliminate conditions that cause indeterminate results
Recollection	Representing, storing, and retrieving information from media	All storage systems are hierarchical, but no storage system can offer equal access time to all objects. All computations favor subsets of their data objects in any time interval
Automation	Discovering algorithms for information processes	Most heuristic algorithms can be formulated as searches over enormous data spaces. Many human cognitive processes can be modeled as information processes
Evaluation	Predicting performance of complex systems	Most computational systems can be modeled as networks of servers whose fast solutions yield close approximations of real throughput and response time
Design	Structuring software systems for reliability and dependability	Complex systems can be decomposed into interacting modules and virtual machines. Modules can be stratified corresponding to their time scales of events that manipulate objects

Peter J. Denning's categorical breakdown of the characteristics of computation "is designed to give a scientific definition of the field" (Denning 370).

Once information has been broken down into representable, binary units, it is open to manipulation by computational methods. Instead of optimizing the efficiency of transactions through the internet and using digitized information, opportunities abound for manipulating those units of information. Examples of these opportunities include the development of less market-driven technologies and more user-specific technologies tailored to the needs of each particular user. A requirement for moving toward user-specific paradigms is, however, that users are aware of the capacity to create these technologies and begin to voice a desire for them.

Combinatoriality

Historically, development of new technologies has occurred when currently available components are combined to serve a new purpose. Brian Arthur's term *combinatorial evolution* refers to this very idea. "The overall collection of technologies bootstraps itself upward from the few to the many and from the simple to the complex," he writes, "We can say that technology creates itself out of itself" (Arthur 20). A consequence of this is that technology's development is dependent on parent technologies that contribute to the development of the new technology. Furthermore, technology's development is also path-driven because a new development is reliant on the components that have been identified as being useful for specific functions. The more complex the technology is, the more its parts and the parts that compose those parts have been honed and designed for a particular set of purposes (Barba & Osborn).

For example, consider the technological development of the internal combustion engine, which perhaps most notably has been applied for the purpose of transportation. From a relatively simple design used in the first generation of automobiles (and a variety of previous iterations of combustion type machines), we have arrived at the jet engine, which is powerful enough to carry people across oceans. Looking back, it may appear that the human race has collectively been modifying the engine with the goal of optimizing travel time and distance, and that further developments will be made as we address this objective. However, this state of mind and the advancements that are now recognized as being significant for transportation were all based on an assumption that *people should be able to travel quickly and over long distances*. Not everyone would agree with this assumption even now, and even if a majority of people currently would agree that it is useful to travel far and quickly, that opinion grew out of repeated successes at improving this capability and the initial decision to use internal combustion for this purpose. The phenomenon of internal combustion itself can be (and has been) applied in a variety of ways, yet transportation is arguably the most significant.

III. PAST EXAMPLES OF LESS MARKET-DRIVEN, MORE USER-SPECIFIC MODELS

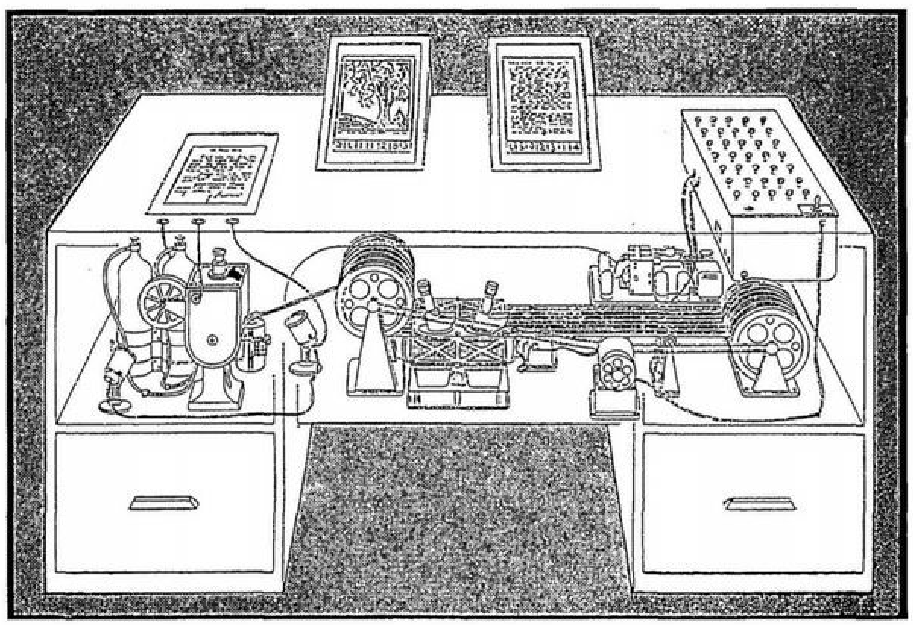
Vannevar Bush's Memex

In 1945, Vannevar Bush published his visionary essay "As We May Think" in *Life* magazine, in which he outlined plans for a number of theoretical devices he hoped to see realized. Some of these seemed to be material for science fiction at the time, while others seemed more possible considering the state of technology and also appeared relevant in terms of considerable advancements in information processing. Among the latter was the *Memex* or

Memory-Extender machine. The sketch below offers some technical information about how the device would work if built in the form of a writing desk. The following is a brief summary to supplement the image.

A preliminary assumption is that the Memex has access to all the knowledge and information available to man, stored on microfilm. On command, the Memex pulls up any piece of information onto one of the viewing screens; Bush uses an example in which the user is reading about the Turkish bow, which will work here as well. In reading about the Turkish bow, the user finds him/herself thinking about another topic, perhaps directly related, perhaps completely unrelated. Just as easily as s/he accessed the document about the Turkish bow, the user pulls up information on this other subject at which point a link is made between the two documents, tracing the user's line of thought from one document to another. The Memex is also capable of recording any side notations or thoughts the user may interject him/herself. In this way, a user creates his/her own "trail of association," which could also be shared or "uploaded" onto microfilm for other users (Bush 44-46).

Figure 2.3. Memex in the form of a desk would instantly bring files and material on any subject to the operator's fingertips. Slanting translucent viewing screens magnify supermicrofilm filed by code numbers. At left is a mechanism which automatically photographs longhand notes, pictures and letters, then files them in the desk for future reference (*Life* 19(11), p. 123).



Sketch and description of the Memex from Bush's essay "As We May Think" (Bush 44).

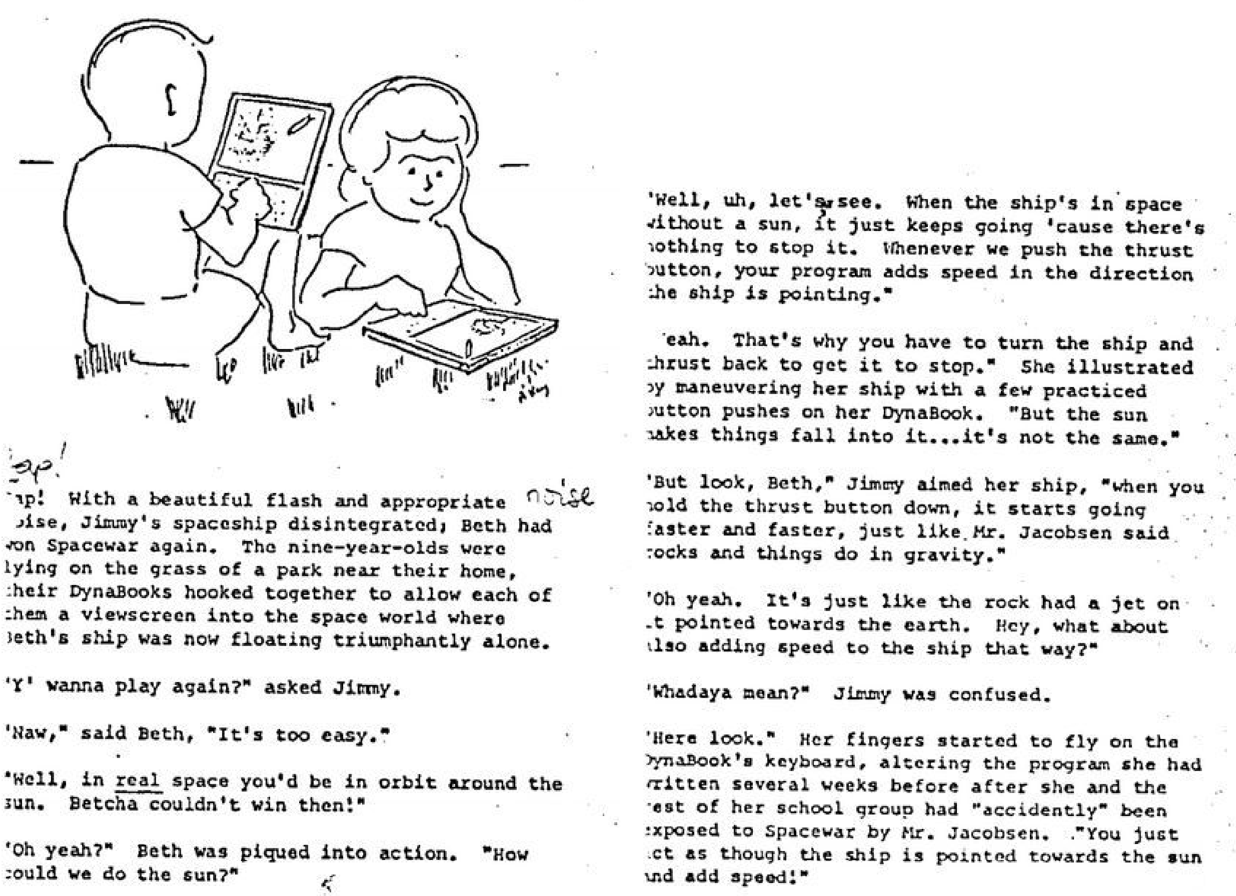
Bush's Memex was a theoretical device for organizing information that offered a variety of consequences if a network of users was to adopt the technology. One of the Memex's affordances that has been realized in some capacity is the concept of *hypertext*. In the context of the Memex, hypertext reflects the link between two documents that would enable a user to jump back and forth between the documents. In his original proposal for the World Wide Web, Tim Berners-Lee describes hypertext in terms of the original coinage of the term by Ted Nelson as "human readable information linked together in an unconstrained way" (Berners-Lee). This rough definition does not, however, include the implication of modern hypertext that links only operate in one direction; that is, after clicking a link, the previous page is only re-accessible through the user's "Back" button, which is not directly connected to the previous page in actuality, but to the user's entire search history.

The search history function available in web-browsers also fails to encompass a large part of the functionality offered by Bush's Memex. Though the entirety of a user's web searches are recorded for later reference, there are no direct links between sections of documents, and the essential link between specific concepts within documents is not clear. Bush's concept of "trails of association" emphasized the value of *subjective association*, or of different, user- specific ways of thinking about a set of concepts or topics. What is lost then, in our modern version of hypertext and in the way it is used on the Web today, is the proliferation of different ways of thinking about and associating concepts. "Trails" were meant by Bush to be shared with other users, to be used as guides for showing someone else how the original user connects ideas; proliferation and sharing of individual "trails" could consequently produce a more "crowd-sourced," less centralized framework for understand a variety of topics, and to imagine an organized database of such individual "trails" using information available on the web seems to offer the opportunity for outside insight into the thought processes of an individual.

Alan Kay's Dynabook

Alan Kay's original proposal for his Dynabook opens: "This note speculates about the emergence of personal, portable information manipulators and their effects when used by both children and adults. Although it should be read as science fiction, current trends in miniaturization and price reduction almost guarantee that many of the notions discussed will actually happen in the near future" (Kay 1).

The term "information manipulator" here seems almost purposefully vague, but regardless of the any sub-textual meaning Kay may have intended, the device and capabilities he describes are creative and varied. Additionally, the main purpose of the Dynabook is as an educational tool, and similar to the Memex, Alan Kay's proposal for his Dynabook device emphasizes aspects of the device that are indicative of humanitarian, non-market-driven motives. In the proposal, Kay explains his vision for what computers were at the time and what they would become. "One would hope that [a computer] would be both a medium for containing and expressing symbolic notions," he writes, "and also a collection of useful tools for manipulating these structures, with ways to add new tools to the repertoire" (Kay 3). The second part of this definition reflects the idea of the computer as medium for manipulating other media and as a generative tool, one that is capable of consistently producing new methods of manipulating the media in question. The Dynabook was theoretically a learning device for children, a book "that was active (like the child), rather than passive" (Kay 1). Though immediate developments in technology after Kay's proposal did not necessarily reflect advancement toward this educational goal, experimentation with the affordances of video games are currently being explored as a teaching aid.



ap! With a beautiful flash and appropriate noise
oise, Jimmy's spaceship disintegrated; Beth had
von Spacewar again. The nine-year-olds were
lying on the grass of a park near their home,
heir DynaBooks hooked together to allow each of
hem a viewscreen into the space world where
Beth's ship was now floating triumphantly alone.

'Y' wanna play again?" asked Jimmy.

'Naw," said Beth, "It's too easy."

"Well, in real space you'd be in orbit around the
sun. Betcha couldn't win then!"

'Oh yeah?" Beth was piqued into action. "How
could we do the sun?"

'Well, uh, let's see. When the ship's in space
without a sun, it just keeps going 'cause there's
nothing to stop it. Whenever we push the thrust
button, your program adds speed in the direction
the ship is pointing."

'eah. That's why you have to turn the ship and
thrust back to get it to stop." She illustrated
by maneuvering her ship with a few practiced
button pushes on her DynaBook. "But the sun
makes things fall into it...it's not the same."

'But look, Beth," Jimmy aimed her ship, "when you
hold the thrust button down, it starts going
faster and faster, just like Mr. Jacobsen said
rocks and things do in gravity."

'Oh yeah. It's just like the rock had a jet on
it pointed towards the earth. Hey, what about
also adding speed to the ship that way?"

'Whadaya mean?" Jimmy was confused.

'Here look." Her fingers started to fly on the
DynaBook's keyboard, altering the program she had
written several weeks before after she and the
rest of her school group had "accidently" been
exposed to Spacewar by Mr. Jacobsen. "You just
act as though the ship is pointed towards the sun
and add speed!"

This hypothetical example from Kay's Dynabook proposal shows children who have learned to use, program, and manipulate the synthetic environment created within the Dynabook. On another level, the Dynabook is also allowing them to learn about the physical science of the analog world and relate it to the digital environment they have become interested in. (Image from Kay 2)

IV. CURRENT BARRIERS TO AND OPPORTUNITIES FOR ADVANCEMENT

The Danger of Appification

In *The Future of the Internet and How to Stop It*, Jonathan Zittrain describes a "counterrevolution [that] would push mainstream users away from a *generative* Internet that fosters innovation and disruption, to an *appliancized* network that incorporates some of the most powerful features of today's Internet while greatly limiting its innovative capacity—and, for better or worse, heightening its regulability" (Zittrain 8). Inherent in this statement are some very scary notions about our privacy and susceptibility to outside influence and control when it comes to our online activities, but more immediate than these concerns, in fact, and something that is currently taking place before our eyes but probably without our noticing, is the "appliancization" of our computational devices, which at this point, refers mostly to mobile devices. Other theorists have referred to this same phenomenon as "appification," but the two terms refer to the same thing: the conversion of computational devices to usage for primarily transactional purposes. Whereas the first PCs and the ideology of many of the early evangelists of the power of computing recognized a *generative* characteristic of computing (that is, the ability to manipulate information in order to create new programming and new ways of manipulating the information), the current state of computing, which involves mobile devices primarily, reflects more a picture of our use of computation to perform specific tasks, many of them involving an economic exchange. Instead of a device that has been tailored to my own needs or specifications (or even better, I have programmed the device myself to perform certain tasks), we are left with a set of "apps" that have been defined for us to perform select functions, and nothing else.

Of course most people do not have the skills or possibly even the attention span to learn the full history of programming languages at this point. To hope that everyone in the world with access to a computational device would be capable of or even willing to learn to program that device to work specifically for their own needs would be a lost hope. The desire for the user-specific device is still there, arguably. If basic programming skills were taught in schools, though, along with an account of the possibilities of computing, a new generation of generative computers (both human and machine) would be a possibility.

Affordances of Embodied Interfaces and the Internet of Things

The Pew Research Center's recent poll on the future of the internet received the following account from J.P. Rangaswami, chief scientist for Salesforce.com: *"People will engage with information using all of their senses: touch and feel, sight, sound, smell, and taste—using them in combination, more often than not. Wearable, connected devices will become embedded more and more in our bodies, more like implants, as in the [Google] Glass becoming more like contact lenses. As that happens, our ability to use nerve impulses to engage with information will expand dramatically. We will see today's connected devices become smaller and smaller and slowly merge into the part of the body from where the particular sense related to that device operates" (Anderson).*

The above quote sets out a forecast for technology that represents a jarring yet highly possible goal for our current capabilities when it comes to computing. Outside of the potential positive effects for humanity that can be offered by an embodied version of the state of computational thought, it is important to remember again that the forces driving this kind of development are still combinatorial in nature and largely market-driven. An embodied interface offers the opportunity for humans to interact with machines in a way that utilizes a combination of the five physical senses, as well as of other yet-to-be-determined "senses." Examples of these other "senses" could include human memory, proprioception, and temperature recognition, but the list is not limited to these and to determine a finite set of "senses" that could be included within the definition of “embodiment” would only hinder development in these areas. Again, we are reminded of the potential of computing that must be unveiled through human creativity and ingenuity.

Aside from embodied computing’s potential for the normal user, the combination of sensory functions that could be used and modified, even tailored to the individual specific user, presents the opportunity for individuals who were previously incapable of using the common interface styles that have dominated computing for decades. The blind, for example, have widely learned to depend on a combination of their other senses besides vision to navigate the world and participate in everyday life. When it comes to computers, though, a blind individual runs up against the problem that the modern, standardized methods of computing rely heavily on a graphical user interface, one that presents information visually. To circumvent this problem, screen reading programs have been developed to enable the visually-impaired user to access onscreen information through audio channels. Many of these programs are very expensive, but free open sourced versions are currently available too.

NonVisual Desktop Access screen reader program

Despite, the obvious benefits of these programs, a more efficient, intuitive, and natural method of interacting with a computer would incorporate all of the senses a blind individual has learned to rely on. It is important to remember here that the methods blind individuals have developed for surviving in the world involve auditory and tactile sensing on a level not immediately available to sighted individuals and function in subjective ways developed by the individual him/herself (Serino et al. 642). This fact leads to the conclusion that the most efficient embodied interface for a visually impaired individual would be one that has been designed or at least modified to optimize the individual’s personal use, largely independent of, though likely similar to, the systems used by other individuals. Needless to say, a detailed user-specific interface would be ideal for any individual, regardless of physical ability, but the opportunity for humanistic development of technology is apparent in this example. Regarding the combinatorial nature of technology, it is clear that the embodied interface has arisen as an ideal form of human-computer-interaction only because we are now able propose some realistic iterations of it. Whereas the early stages of computing led to the development of the GUI, mouse, and various on-screen display methods, those methods have since been developed to a point where they can be integrated with other sensory interface designs to form versions of the embodied interface. Embodiment of this kind would not have been possible decades ago without the refinement of the components that contribute to a full embodied system.

V. CONCLUSION

What follows from this is that we are and have always been in control of technology, which now more than ever pervades the lives of human beings throughout the world. If there is something we want from technology, it is ours to take; however, it is also clear that there are factors like the combinatorial state of available technologies at any given time that govern what is possible in terms of development. Past ideas and proposals that do not map directly to anything currently available as a device in our time have shown us that there is potential for branching out the development of technology from its current general iteration as transactional in nature. On the same note, new paradigms like the concept of the Internet of Things and embodied interfaces present a potential turning point for technological agendas. It is important to remember that these things take time, and the first step toward the development of technologies that better serve the development of the human race as a whole is beginning to think differently about what we can and should be doing with the technologies currently available to us.

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