

Effective Collaboration: People Augmented by Technology

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We are entering a new decade in the world of computer technology, and objectives like the creation of trustworthy software, improvement in capability maturity, and the ability to “do more with less” by applying technology wisely are moving from dreams to reality. We now have the technology in most cases, and the issue we face is how to mold it to fit our needs and apply it. Collaboration is at the heart of most of our endeavors, and this article presents a number of ideas on how to collaborate more effectively by wisely augmenting people with technology. It briefly discusses the importance of collaboration for the success of a project, discusses the concept of collaboration, presents a case study in how collaboration in teaching has been augmented by technology, and provides pointers to the technologies which the reader may find useful in increasing the effectiveness of his/her collaborations.

The operation of today’s software-intensive, mission-critical systems can determine a company’s success or failure. Factor in a safety-critical element and these systems can make the difference between life and death. One does not have to look far in our society to see these systems. Communications, finance, air transportation, defense, and medicine are fields that often rely heavily on software-intensive systems, and the consequences of the failure of a key system can be significant.

In many cases, these software-intensive systems are far too complex for a single person or small group of people to create. Collaboration, sometimes on a large, international scale, may be required to create such systems. The greater the number of people involved in an effort, the greater the need to augment them with technology. The technology exists to capture raw data in many forms (written, audio, video, sensory, digital), to index this data to make it easier to retrieve later, to digest volumes of data into succinct and useful information, and to control the distribution of this data and the information derived from it. We need to apply our technology wisely to augment people and make their collaborations more effective.

Collaboration Complexities

Collaboration can take many forms, particularly when you extend the concept to include smart devices as well as people. Let us first tackle the obvious – people.

People working together to achieve a common objective is how we normally think about collaboration. To make such a collaboration work, people require the following:

- A defined objective. This objective may or may not be clearly defined at first, but as the collaboration gets underway it becomes better defined.
- Willingness to collaborate. The collaboration will be less effective if the peo-

ple are not able (possibly due to legal or political constraints), willing, or motivated to collaborate.

- Ability to communicate. At the fundamental level, we communicate through our senses, so the more senses that are

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involved in the communications process, the better. Textual communication in a common language using a common set of terms (which may or may not be well defined) is a starting point. Images (photos, diagrams) can be added to enhance the effectiveness of the communication. Video (video clips, interactive dialog via cameras and sound) enhances it further. Full personal contact, where body language comes into play, brings all the senses (even smell) into play.

Collaboration can take place without anything else; but often it is not effective without adding a few enhancements such as the following:

- The objective must be clearly defined; success in achieving the objective must be measurable. For the collaboration to be effective, the team must be able to analytically determine when the objective has been achieved.
- Communication must also be based on a language with as few dialects as possible using terms with as little ambiguity as possible. Communication must also be captured and made available for future reference in an organized form that is as easy as possible to search. Common threads must also hierarchically organize captured communication so the chain of reasoning can be followed.

Collaboration between smart devices involves a similar set of requirements. One good way to think of these devices (and people, for that matter) is to apply a Task-Object-Event model. In such models, the objective is couched in terms of a task to be performed, and this task may be divided into subordinate tasks, and so on. An object (such as a smart device, person, or team) is assigned to perform one or more tasks. Events (such as the click of a mouse or a manager’s order) trigger the objects to perform the tasks. For smart devices to collaborate, the devices require the following:

- A defined objective. The task(s) to be performed is the objective of a smart device. The task(s) may be expressed as a series of testable, measurable requirements, often with binary quality gates being the basis of deciding success or failure in the performance of the task(s).
- Willingness to collaborate. The interfaces of one object to another must be compatible, based on common standards, and precisely defined to the point where they can be compiled. Smart devices are motivated to collaborate – they are designed to reach out

- and interact with other smart devices.
- Ability to communicate. The smart devices must be connected to each other and employ common communication protocols and data transfer standards to communicate. Smart-device communication based on international standards such as Transmission Control Protocol/Internet Protocol and eXtensible Markup Language (XML) can be extremely effective and rich, allowing a wide variety of data (textual, video, or binary) to be transmitted. Some form of network connectivity based on international standards (such as Universal Serial Bus, 802.11x, and Ethernet) is built into most smart devices.

Hundreds of different kinds of smart devices exist today based on common technologies like the .NET Framework, the .NET Compact Framework, and the Java Virtual Machine (JVM). These smart devices include personal computers (PCs) such as desktops, laptops, tablet PCs, personal digital assistants (PDAs), automobile PCs, and more; portable digital music players (often with voice recording capabilities); portable digital video players; cell phones; convergent devices (like PDA/cell phone combinations such as the Smart Phone); and a variety of customized devices now being embedded into other devices such as microwave ovens, televisions, and the walls of a house.

One of the key features of .NET and the JVM is that extensive collaboration facilities based on industry standards (such as XML and Web services) are built-in. This provides an infrastructure by which the smart devices may collaborate, and augments the collaboration capabilities of the people using them as well. Let us look at a few examples now on the drawing boards.

Imagine first-grade students in a classroom utilizing smart devices such as tablet PCs. The teacher is instructing the students in printing letters of the alphabet. They are writing on their tablet PCs while the teacher monitors their work from a console at the front of the classroom. As Johnny mistakenly forms a “b” backwards, the teacher sees it immediately and corrects Johnny’s efforts on the spot. The teacher also sees about half of the students making the same mistake, so he or she opens up a dialog with the entire class about it.

Imagine also a smart home. Johnny returns home from school gaining entrance through the front door by a reti-

nal scan. Signals are sent to unlock the door, turn on the entry lights, post messages to Johnny on a display screen inside the home (with emphasis placed on the priority messages), and begin playing Johnny’s favorite music. The home contains a collaboration of smart devices.

On a grander scale, consider the F-35 fighter aircraft program run by Lockheed Martin Aeronautics that incorporates smart technology. Sponsored by partners and supported by subcontractors in several countries, a Web-based information portal server is used to divide this large community into its interest areas and allow information to be exchanged, shared, and organized on a global basis. Information that should be visible to all participants is readily shared, and information particular to specific groups in this project can be shared without the other groups seeing it.

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Technology-Based Collaboration in a Teaching Environment

Microsoft not only develops a variety of technologies and programs to support collaboration for its customers, but also uses its own products internally. These collaboration tools are often used extensively internally and by its partners before the public at large sees them.

I recently attended a class at our main campus in Redmond, Wash., and it provides a good example of how collaboration between people (in this case, students and teachers) augmented by technology (such as smart devices) can work. The class was diverse, consisting of more than 100 students from 24 countries. English served as the common language, although the speakers had to be reminded from time to time to speak more slowly. The following sections describe this

environment.

Hardware and Class Environment

The classroom was in Building 43, a controlled-access building. Students were given smart card badges containing a computer chip that could be scanned by the door entry mechanism to allow access. Students were cleared for access to some parts of the building and not others; their movements were tracked. The badges also plugged into the students’ laptops and tablet PCs to log them into their computers.

The cafeteria, with its waterfalls and garden, is located adjacent to Building 43, and also required smart card access during normal hours (cafeteria employees may use their smart cards to get in after hours). Building 43 has both Ethernet (at 100Mbps) and wireless access points (at 10Mbps). The classroom was filled with tables that provided power and Ethernet access points at every seat. Should a partial network failure occur (such as an Ethernet router failure), the alternate network was immediately available.

More than half of the students used laptops, while the other half used tablet PCs. Almost all the students had PDAs or Smart Phones (integrated PDA and telephone) as well. I found it interesting to note that the tablet PCs, with their handwriting and sketching input capability, made it easier and were less distracting for taking notes during class than the laptops. Finally, the instructor podium was like something out of Star Trek – videotapes, DVDs, and CDs (audio and digital) were fed to the computer in the podium and displayed to the students on a large screen and sound system at the front of the room.

The staff for the course included a main instructor (who stayed with the students as a common point of contact throughout the entire course), several guest instructors, an administrative assistant, and an on-call hardware/software support group. Course material was prepared using a variety of desktop publishing tools, database servers, Web-based information portals, and operating systems as well as the video production studios on the campus. Many of our partners also played a role, preparing sections of the course using their own resources.

The Software

From the start of class, the main instructor was at the podium showing the students the Sharepoint Portal Server site and how to access the portal. Through the portal, the students could sign up for the

course e-mail distribution list, download slides and videos of the presentations and related material, download course programs and data files for their devices (laptops, tablet PCs, and PDAs/Smart Phones), perform evaluations of the course elements as they occurred, follow Web links to material related to the course, and upload material (such as homework) for the course. The main instructor also provided his e-mail address and the e-mail address of the administrative assistant.

As the course progressed, the portal was updated with information from the class; for example, after the introduction of the students, statistics on the demographics of the student body were posted on the portal. Prior to the class, the students' laptops and tablet PCs had been configured for secure access to the company's intranet (wired and wireless), and software had been installed to allow the students to play the videos and view the other class material.

Communication Vehicles

The course was highly interactive, employing a wide variety of technologies to communicate with the students and help them learn. The students were already motivated to learn the material, and the technology greatly aided the learning process, making it both efficient and fun.

Presentations were vivid and highly animated, extensively employing color and animations effectively in both the slides to enforce the messages and in full-motion video to supplement the slides where reasonable. In some cases, the material was too large for a class of over 100 students to download efficiently, thus CDs and DVDs were distributed instead.

Video-oriented simulations were included on CD for some class exercises. Students ran the simulations, viewing videos and interacting with them, causing the sequence of videos and questions posed to the students to dynamically alter the simulation in response to the correct and incorrect answers they submitted.

Technology Control

One key feature of teaching in this environment is that the instructor had to maintain firm control of the students' use of their devices (laptops, tablet PCs, and PDAs/Smart Phones) during the class. There was a distinct tendency for students to want to use them during lectures when their attention should be focused on the front of the room; this proved to be a distraction to the instructor and the other

students unless it was controlled.

Surprisingly, pen and paper were still used – particularly for those students without tablet PCs. The PDAs (using handwriting and voice dictation), the tablet PCs (using handwriting and handwriting recognition, speech recognition, and voice dictation), and pen/paper were the methods of capturing notes during the lectures. I imagine that future classes will be entirely based on pocket and tablet PCs; with digital ink, pen and paper can finally become a thing of the past.

After the Course

From the first day, the instructor announced that the course portal and e-mail distribution list would be available to the students for up to a year after class completion. Special announcements of updates to the material would be sent to the students through the e-mail distribution list and a course newsletter. Updates

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to the material would be posted, and the students could use the portal to stay in touch.

Hybrid audio/digital CDs were distributed to the students so they could go over the material while driving their cars or working with their PCs (the digital part of the hybrid CDs included transcripts of the audio part). Updates to these CDs would be mailed to the students periodically.

Most students downloaded material from the company intranet to take back with them. In my case, I downloaded about 1.8G bytes of material knowing that I would have high-speed Internet access to these resources after I returned home. Other students had Internet access as well, but, due to their location, it was less reliable or not operating at a high speed. A student from South Africa, for example, brought in a USB 2 disk drive with 250G bytes of storage and down-

loaded over 130G bytes of material to take home.

With such a diverse group, the dual nature of the digital divide was evident – all students were on the positive side, having access to the Internet, but some students had slow-speed (56K baud or less) while others had high-speed (200K baud or more) access. With large volumes of material, the speed of access can make a difference.

Information was also provided in a format suitable for use on smart devices (particularly PDAs and Smart Phones), and the students installed this information during the class. The smart devices were also filled with task lists of ideas for the students to pursue when they returned home. Finally, the students were encouraged to take the follow-on class after returning to their jobs.

Foundation Tools and Technologies

While the previous scenario took place in a classroom setting, the same technology can be applied in a virtual setting in which the participants are geographically scattered. Obviously, it would make collaborations much more effective in virtual enterprises where people are geographically distributed. In addition, while many large companies have extensive resources to call upon (such as video production studios), many tools are available that allow both small companies and individuals to set up their own collaboration mechanisms inexpensively.

Conferencing tools can be used to broadcast live video among several groups or individuals through the Internet. These tools also support an electronic white board that allows participants to draw diagrams using multiple colors (perhaps a different color for each participant) on a common board that all can see. Voice communication, of course, is included. To set this up, a server is required and common conferencing tools (or conferencing tools based on common protocols and standards) must be installed on each client.

Several video capture and editing tools are available to create video productions using just a PC with a Web camera or digital movie camera. Extensive editing and publication capabilities (including publication onto a DVD) are included. To set this up, a PC with an optional video capture card and the video capture/editing/production software is required.

Courseware authoring tools are available to create rich interactive presenta-

tions that the instructor can run in class to augment his or her presentation, and the student can run at home. These tools also allow the instructor to set up Web sites that allow the students to acquire homework and submit answers to homework, take exams, and interact with other students.

Desktop publishing tools provide the resources for creating the slides, documents, databases, and spreadsheets that may be needed. Free viewers are often available for download, so the clients do not have to have the full suite of desktop publishing tools installed on them. Tools for collaboration, providing e-mail, a calendar, task list, and contact list support, both locally and through the Web, are also needed.

Behind these tools are fundamental technologies that form a very effective infrastructure for collaboration:

- The .NET Framework (for larger smart devices like laptops and tablet PCs), the .NET Compact Framework (for smaller smart devices like PDAs and Smart Phones), and the JVM provide common virtual machines with a wide array of reusable components for application programs to exploit. These commercial frameworks from Microsoft and Sun are used by most developers to provide common virtual platforms that transcend the physical computers (Windows PCs, UNIX workstations, mobile devices) as well as the Internet (allowing the frameworks to extend to Web servers).
- XML provides a common way to store and transport data, retaining the rich context of the data in the process.
- Web services provide a common way to share resources and capabilities without concern about the location of those resources or capabilities (they may be on the same computer or on different computers without any impact to the application code). With Web services, a single cell on a spreadsheet can be tied to other cells on spreadsheets around the world, allowing a change at one location to be automatically viewed at other locations.

With these fundamental technologies in play, the door to more effective collaboration in both the enterprise and the classroom is wide open! But our current foundation tools can still be improved. Organizations such as Microsoft Research and Lucent Technologies (formerly Bell Labs) are investigating potential technologies in a wide variety of broad areas, including but not limited to the following:

- Management of digital photographs

and full-motion videos, including the ready extraction of useful information from them.

- Online communities.
- Next-generation smart devices.
- Mobile computing.
- Speech recognition and meaning interpretation.
- Signal processing.
- Databases and information mining.
- Ubiquitous computing (making the usage of computers transparent to humans).
- Intelligent reasoning and decision making.

Conclusion

Collaboration among people augmented by today's technology is taking off like wildfire across the world, bringing the global community closer together in many ways. More and more effort is being poured into making this technology adaptable to different needs, 99.999 percent reliable and beyond, and secure to the point where the users can trust the technology to support and protect their privacy. Collaboration among large numbers of people, sometimes in different countries, is becoming more common, and collaboration is often required to develop many of our software-intensive systems for mission-critical, and sometimes safety-critical, applications.

Collaboration is taking place between both people and smart devices, often augmenting the people with smart devices and other more advanced technologies. A real-world example of collaboration in a teaching environment was presented in this article, and in this example, smart devices and technology significantly augmented people. This is happening today!

Many foundation tools and technologies are available today to support augmented collaboration. But we clearly do not have all the answers, and an increasing amount of research is being done to enhance our ability to collaborate by augmenting people.

Large volumes of material related to the topic of collaboration and technologies in support of collaboration are freely available to the public on several Microsoft Web sites:

- <www.microsoft.com> is the main entry point for all information from Microsoft Corporation.
- <<http://msdn.microsoft.com>> is the Microsoft Developer's Network with detail upon detail about the technologies, including the .NET Framework, the .NET Compact Framework, XML, Web services, and the new open shared

source code.

- <<http://research.microsoft.com>> is Microsoft Research, with details and contacts for more information on Microsoft's research thrusts such as online communities, mobile computing, and much more.
- <www.msnaa.net> is the Microsoft Academic Alliance, a vast resource of material and information for all educators from the Microsoft Corporation.
- <www.mainfunction.com> is a resource sponsored by Microsoft for educators in high schools.

Supplementary material related to this article can be found on my university Web sites at <<http://unicoi.kennesaw.edu/~rconn>> and <<http://cs.spsu.edu/rconn>>.◆

About the Author



Richard L. Conn has more than 20 years of experience in software engineering, project management, and education. Conn is currently a university liaison for Microsoft, serving as an ambassador between Microsoft and many universities and participating on industry advisory boards for several universities. He also teaches as an adjunct professor for the Computer Science and Information Systems Department at Kennesaw State University and the Computer and Software Engineering Department at Southern Polytechnic State University. Conn has taught graduate school at the Air Force Institute of Technology in electrical and computer engineering, and at Monmouth University in software engineering. He has designed Capability Maturity Model Level 4 software engineering processes for Lockheed Martin Aeronautics, served as a government consultant working for The MITRE Corporation, served on the Federal Advisory Board for Ada, and contributed to the Department of Defense Software Reuse Initiative as a distinguished reviewer.

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