J Internet Serv Appl (2010) 1: 3–5
DOI 10.1007/s13174-010-0005-8

FOREWORD

A half-century makes a difference

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Published online: 20 April 2010

What a difference a half-century has made in the evolution of information processing! In the 1960s our ability to process information using computers tended to revolve around numerical processing, mathematical modeling, mundane computations (payroll, inventory, accounting) and numerically controlled machines. In the ensuing 50 years, everything has changed. Machines have gotten faster, cheaper, smaller and portable. Computing power can be embedded in virtually anything (buildings, houses, appliances, and even our bodies). The Internet and the World Wide Web applications have created an infrastructure that highlights every conceivable form of digital information and, perhaps most important, the relationships among these ethereal quanta. Any bit of information can be related to any other bit of information and it is the relationships that inform the texture of the 21st century information era.

We have entered into a new period in the evolution of the Internet. We can see an Internet of "things" emerging. Wireless communication, coupled with programmable edge devices and massive "cloud computing" capacity, is bringing computing power to virtually anything that can house some form of computational and communications capability. Our "smart" mobile devices (I hesitate to call them "phones" any more) can see, hear, feel and speak. They can participate in the real world almost in the way we do. In fact, they can even do things we cannot. In a recent and extraordinary presentation at TED[1] the speaker demonstrated that one did not need expensive laptops and notebook computers to engage computing power. All that is needed is a camera and a high quality, head-mounted projection system and, of course, substantial local processing power. The camera can "see" gestures and the projection system can display on any surface a landscape on which or in which these gestures can be interpreted. In an extreme case, one can project what looks like a telephone dialing pad on one hand and "dial" a telephone number with the other hand. The microphone and speaker of the head-mounted device serve as the medium for making a telephone call and, of course, it could use voice over IP as well as conventional telephony technology.

Successful speech recognition is bringing us closer to the fanciful Star Trek dialogs with the space ship's computer. Successful gesture recognition can be even more dramatic. In the TED presentation, the speaker showed how using his hands to "frame" an image, his head-mounted computer was able to react by capturing the image that was seen through his fingers. One can go further towards what is now being called "augmented reality." In this environment, information about places, things, scenes, people is overlaid on their images. One could imagine capturing an image of an antique (using the finger-frame method), sending this image to the recently announced Google Goggles image look-up system, and then projecting information about the object onto the object itself or on a handy blank sheet of paper. Any surface becomes a display.

The blending of real and virtual information spaces using portable equipment and the embedding of computing and communication in virtually anything is creating an information environment unlike anything ever experienced before in history. It is the interactive nature of this environment and the ability to search, correlate, associate and commingle information from many sources that makes for an organic substrate in which innovation is almost inescapable.

[1] http://www.ted.com/talks/view/id/685

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Our portable devices can know where they are through the use of the precision Global Positioning System or even estimates derived from radio location in the wireless telephone network. This information can be used to provide access to information that is relevant to location. Indeed, the value of geographically-indexed information is enhanced by making it so useful. We are carrying our "information windows" around on our hips or in our purses.

Fixed sensor devices are also creating new information spaces. The so-called Smart Grid initiative[2] in the United States is aimed at providing consumers with more precise information about their use of energy, businesses with better tools to manage their energy consumption, and the power generation and distribution system operators to manage demand as well as supply. For the first time in the history of electrical power generation it may be possible to make smart appliances conform to a consumer-selected regimen to moderate demand during peak loads in exchange for beneficial discounts.

The notion of information feedback to consumers applies in other areas as well. One can readily imagine that barcoded products could be "looked up" using a mobile whose camera can read one- or two-dimensional "bar codes" and useful information provided as to dietary and health facts or product origin. Our ability to associate information with the things, people and places we interact with daily is rapidly evolving.

Of course, these capabilities can have downsides worth contemplating. Privacy may erode in consequence of the nature and amount of data that is accumulated through these applications. Safety can become a concern. For example, if information about fine-grained power usage is available to an unauthorized party, it may be possible to determine whether a home is occupied or not. One can easily develop other scenarios in which information can be used to annoy, harass or in the worst case, harm, an individual, family or business. It is my hope that this new journal will address not only the technology of information systems and applications but their social, economic, political and policy implications.

It is also becoming clear that national laws are not necessarily sufficient or even compatible at national borders. To imbue digital signatures with equal legal weight around the world, standards for the issuance of certificates and the strength of the associated cryptography need to be established. There is need to assure that information that has been placed in the network is maintained with regard to integrity. This does not mean that the information is correct but only that it is unaltered when retrieved or at least that alteration can be detected with high probability. Because the Internet is global in scope and because abuses may take place in which the perpetrator is in one country and the victim in another, attention needs to be paid to the question of jurisdiction, multilateral agreements, international enforcement of contracts and a plethora of other complex policy matters.

Among these matters will be intellectual property treatment in an environment where the duplication and distribution of digital content is nearly trivial. For many years, the notion of copyright has been strongly bound up with the fixing of a work in a physical form. The rights protected relate generally to the reproduction of the physical form(s). Over the years, other rights have evolved such as the movie rights to a novel, the performance rights to a musical work, and so on. The Internet and the World Wide Web cast many of these concepts into doubt. Consider how a web browser works: it copies a file from a computer on the Internet and then interprets (renders) its contents for a user. It's a giant copying machine! I hope that some of the articles that will eventually appear in this journal will bring new ideas to the table that will enable the creators of digital works to benefit from their efforts without necessarily having to use the "right to copy" as the sole means by which remuneration is accomplished. It is going to require some very creative thinking by legal authorities and technologists to invent new alternatives. Among these is the Creative Commons[3] idea that provides a broader range of rightsholder options for granting rights of access or reproduction of works than is typically found in traditional copyright contracts.

If looking back a half-century provides us with significant perspective on the degree of change wrought by the passage of fifty years then looking forward may prove even more challenging. Our ability to have envisioned the present day from the standpoint of 1960 illustrates how difficult it may be to imagine a world fifty years hence. Among the books I most treasure for insight is Jules Verne's *Paris in the Twentieth Century*. A remarkable author by any measure, Verne's limning of a Paris 100 years in his future is nothing short of astonishing. Written in 1863 and rediscovered, translated into English and republished in 1994, this book describes a Paris that we would have recognized fifty years ago. In his review of the English version, Brian Taves observes:

> "Verne's prophecies of the world to come in *Paris in the Twentieth Century*, both in technical and cultural terms, are breathtaking in their extent and nearly unerring accuracy. Virtually every page is crowded with evidence of Verne's ability to forecast the science and life of the future, from feminism to the rise of illegitimate births, from email to burglar alarms, from the growth of suburbs to mass-produced higher education, including the dissolution of humanities departments. The accuracy of the prophecies cannot be overstated,

[2] http://www.oe.energy.gov/smartgrid.htm

[3] http://creativecommons.org/

> and I would estimate that nearly 90% have come to pass. Perhaps Verne's most amusing error was in anticipating that the government would conduct itself in such a businesslike way as to show a dividend."[4]

As we try to peer fifty years into our own future, we may well wonder where is a modern day Jules Verne when we need him?

Returning to the question of vulnerability in the Internet and World Wide Web, we must hope that contributors to this journal will give thought to the questions of reliability, information integrity, resistance to denial of service attacks, resistance to viruses, worms and Trojan horses, various forms of spoofing, Domain Name System and Internet address space hijacking, spam and a variety of other ills that have emerged since the Internet was officially launched in January 1983. There is much work to be done to secure the Internet and the World Wide Web and considerable latitude for serious research and experimentation.

In addition to these issues, we must also confront the difficult problem of identifying the semantics of information held in the World Wide Web. The need to invent and invoke metadata that describes the data held in databases is acute. These repositories of information do not manifest themselves in forms easily indexed by conventional World Wide Web "crawlers" that generally see only web page content encoded in Hypertext Markup Language (HTML) or the newer eXtensible Markup Language (XML). The databases are largely invisible to the indexing programs. Suitable metadata are needed that both disambiguate common references to concepts such as "red" (a color, a political persuasion) and also describe the nature of information contained in the databases.

Finally, I would like to draw attention to two kinds of frailty that we will need to seek to overcome in today's Internet environment. The first of these is the lack of long-term stable identifiers for information found in the Internet. The problem is that the identification of information by way of Domain Names contained in Uniform Resource Locators (URLs) has the potential hazard that the demise of the domain name registration may lead to the invalidation of all pointers to the data. One is left with the thought that some more permanent form of identifier is needed, such as the Digital Object Identifier (DOI) of the Digital Object Architecture[5] along with its repositories of information and directory of DOIs.

The second problem is the potential loss of ability to interpret the bits of files that are accumulated in the WWW, in databases and in repositories of information in servers, laptops, desktops and other data storage media. Even if we can preserve the bits of information over long periods of time (hundreds of years), we may not be able to interpret them, for lack of the software that allows us to correctly interpret and render the bits. We may even need to preserve not only the application software but the operating system(s) and the physical computers (or virtual replicas thereof) so as to allow continued successful manipulation of the data.

There is little doubt that the future will hold a rich collection of hard problems, surprising applications and new opportunities. It is my hope that this new Journal will bring us collectively closer to understanding the nature of our challenges and the paths that will lead towards overcoming them.

[4] http://www.depauw.edu/SFs/review_essays/taves71.htm

[5] http://www.cnri.reston.va.us/doa.html