
Going Global

As the Web slowly spread around the world, I started to be concerned that people who were putting up servers would not use HTTP, HTML, and URIs in a consistent way. If they didn't, they might unintentionally introduced roadblocks that would render links impotent.

After I returned to CERN from San Antonio, I wrote several more Web pages about the Web's specifications. I would update them when good ideas came back from other users on the www-talk mailing list. While this was a start, I wanted to open the Web technology to wider review. Since everything to date had taken place on the Internet, and much of it involved Internet protocols, I felt that the place to get a process going was the Internet Engineering Task Force (IETF), an international forum of people who chiefly corresponded over e-mailing lists, but who also met physically three times a year. The IETF operates on a great principle of open participation. Anyone who is interested in any working group can contribute.

As a good software engineer, I wanted to standardize separately each of the three specifications central to the Web: the URI addressing scheme, the HTTP protocol by which computers talked to each other, and the HTML format for hypertext documents. The most fundamental of these was the URI spec.

The next meeting of the IETF was in March 1992 in San Diego, and I went to see how things worked, and how to start a working group. The answer came from Joyce Reynolds, who oversaw one area within the IETF. She said I had to first hold a "birds-of-a-feather" session to discuss whether there should be a working group. If there was consensus, people at the session could draw up a charter for a working group to begin at the next IETF meeting. The working group could edit a specification and take it through to a standard. The subsequent meeting would be held in July in Boston.

IETF meetings were characterized by people in T-shirts and jeans, and at times no footwear. They would meet in different small rooms and talk excitedly. The networking, of course, was paramount. Compared to Geneva in March, it was a pleasure for me to sit with folks outdoors in sunny, warm San Diego.

One day over coffee I was seated at a white metal table out in the open air, chatting with Larry Massinter from Xerox PARC and Karen Sollins, who had been a student of Dave Clark, the professor at MIT's Laboratory for Computer Science who was very involved with the design of the TCP protocol that had made possible practical use of the Internet. Karen had stayed on at MIT to pursue a project called the Infomesh, to create ways computers could exchange hints to each other about where to find documents they were both interested in.

Larry and Karen asked me what I was doing next. I told them I was considering going on sabbatical. I had been at CERN seven years, and while there was no concept of a sabbatical at CERN, I felt I needed a break and some new perspective. I needed to think about where to take myself and the Web. After I returned

to CERN, both Larry and Karen called independently with offers to come visit them if I did take leave. I could join Karen as a visiting researcher at MIT, and join Larry as a visitor at Xerox PARC.

Both invitations were appealing, because both institutions were highly respected and either could give me a much-needed view of what was happening in the United States rather than Europe, and in information technology rather than physics.

Encouraged by the enthusiasm of people like Larry and Karen, Robert and I released notes about the Web on more Internet newsgroups. But we were frustrated by the fact that the Web's use within CERN itself was very low. We trod a fine line between dedicating our time to supporting users within CERN at the risk of neglecting the outside world, and pursuing the goal of global interactivity at the risk of being bawled out for not sticking to CERN business.

By now the Web consisted of a small number of servers, with info.cern.ch the most interconnected with the rest. It carried a list of servers, which to a degree could coordinate people who were putting information on the Web. When the list became larger, it needed to be organized, so I arranged it in two lists, by geography and by subject matter. As more servers arrived, it was exciting to see how the subjects filled out. Arthur Secret, another student, joined me for a time and set up the lists into what we called the Virtual Library, with a tree structure that allowed people to find things.

Part of the reason the Web was not being used much within CERN—or spreading faster outside CERN, for that matter—was the lack of point-and-click clients (browsers) for anything other than the NeXT. At conferences on networking, hypertext, and software, Robert and I would point out that for the Web to grow, we really needed clients for the PC, Macintosh, and Unix. At CERN, I was under pressure to make a client for the X Window system used by most Unix workstations, but I had no resources. We were so busy trying to keep the Web going that there was no

way we could develop browsers ourselves, so we energetically suggested to everyone everywhere that the creation of browsers would make useful projects for software students at universities.

Our strategy paid off when Robert visited Helsinki University of Technology. Several students there decided to make their combined master's project a Web browser. Because the department was "OTH," they decided to call the browser Erwise (OTH + Erwise = "Otherwise").

By the time it was finished in April 1992, Erwise was quite advanced. It was written for use on a Unix machine running X-Windows. I went to Finland to encourage the students to continue the project after they finished their degrees, and to extend the browser to an editor, but they had remarkably little ongoing enthusiasm for the Web; they had already decided that when they graduated they were going to go on to what they saw as more tantalizing or lucrative software projects. No one else around the institute wanted to pick up the project, either. Certainly I couldn't continue it; all the code was documented in Finnish!

Another graphical point-and-click browser came at almost the same time, however. Pei Wei, a very inventive student at U.C. Berkeley, had created an interpretive computer language called Viola, for Unix computers. He had been working on it a long time, and it had powerful functionality for displaying things on the screen. To demonstrate the power of Viola, Pei decided to write a Web browser, ViolaWWW. It was quite advanced: It could display HTML with graphics, do animations, and download small, embedded applications (later known as *applets*) off the Internet. It was ahead of its time, and though Pei would be given little credit, ViolaWWW set an early standard, and also had many of the attributes that would come out several years later in the much-hyped program HotJava, which would take the Web community by storm.

Pei released a test version of his browser on the Web in May 1992. The only detracting feature was that it was hard for a user to install on his computer. One had to first install Viola, and then

ViolaWWW as a Viola application. This took time and was complicated. But finally, people working on Unix machines—and there were lots of them at corporations and universities around the world—could access the Web.

Although browsers were starting to spread, no one working on them tried to include writing and editing functions. There seemed to be a perception that creating a browser had a strong potential for payback, since it would make information from around the world available to anyone who used it. Putting as much effort into the collaborative side of the Web didn't seem to promise that millionfold multiplier. As soon as developers got their client working as a browser and released it to the world, very few bothered to continue to develop it as an editor.

Without a hypertext editor, people would not have the tools to really use the Web as an intimate collaborative medium. Browsers would let them find and share information, but they could not work together intuitively. Part of the reason, I guessed, was that collaboration required much more of a social change in how people worked. And part of it was that editors were more difficult to write.

For these reasons, the Web, which I designed to be a medium for all sorts of information, from the very local to the very global, grew decidedly in the direction of the very global, and as a publication medium but less of a collaboration medium.

There were some pockets of strong internal use. CERN, eventually, was one. Within Digital Equipment there were a hundred Web servers early on that were not available from the outside. These internal servers were not well publicized, so journalists could not see them. Years later the media would suddenly "discover" the "rise" of these internal Web networks and invent the term *intranet*, with the notion that they were used largely for internal corporate communications. It seemed somewhat ironic to me, since this had been happening all along, and was a principle driving the need for the Web in the first place.

With Erwise and Viola on board, Robert set out to design a browser for his favorite computer, the Macintosh. Robert was a purist, rather than a pragmatist like me. In the Mac he found the realization of his highest ideals of how computers should be: simple and intuitive to use. But Robert's idealism was sometimes a tough match for the practical need to get a project done. As mentioned earlier, I had found a little extra space in the text-editor code on the NeXT machine, where I could store the URI addressing information defining each hypertext link. This proved essential to being able to make the Web server in a simple way.

The designers of the Macintosh text editor had a similar structure, but without the extra space. However, they had set aside thirty-two bits for storing the text color, and used only twenty-four of them. I suggested we use the spare eight bits, and steal a few more from those used for color, which would not cause any change in the colors that would be noticeable to users.

Robert was appalled—appalled at the idea of using a field intended for the color for another purpose, appalled at stuffing the hypertext data into the cracks of the color data. The program was held up for some time while I tried to persuade Robert that taking this admittedly less elegant but simple route would allow him to get on with the rest of the project and actually get the Web browser running. In the end, he accepted my kludge, but in fact had little time to pursue the program. Later on one summer, Nicola Pellow returned for a few weeks and picked it up, and at one point it was basically working. We named it Samba.

Every team benefits from a variety of styles, and my collaboration with Robert was no exception. Robert's insistence on quality of presentation would carry us through many papers, demonstrations, and presentations. All along, Robert tirelessly trawled for more resources. He ended up getting the students Henrik Frystyk Nielsen and Ari Luotonen to join the team. Henrik, an affable blond Dane, took responsibility for the code library and the line-

mode browser. Ari, a wild dark Finn took on the server. Each made his mark and put more time and energy into the products than I could have, in some cases turning them upside down to rewrite them into something better. This effort supported a dramatically growing number of Web sites, and "productized" our work so users would find it easy to install and use.

As the browsers appeared, so did new servers, with ever-increasing frequency. Occasionally, one new server would demonstrate to the community what could be done in a whole new way, and pour fresh energy into the young field. One that impressed me was a server of information about Rome during the Renaissance. The Vatican had lent a (physical) exhibit to America's Library of Congress. Some of the material in it had been photographed, scanned into a computer, and made available in the form of image files on an FTP Internet server. Then in Europe, Frans van Hoesl, who was aware of the Web, created a hypertext world of this material on a Web site. The site took the form of a virtual museum; a browser chose a wing to visit, then a corridor, then a room.

On my first visit, I wandered to a music room. There were a number of thumbnail pictures, and under one was an explanation of the events that caused the composer Carpentras to present a decorated manuscript of his *Lamentations of Jeremiah* to Pope Clement VII. I clicked, and was glad I had a twenty-one-inch color screen: Suddenly it was filled with a beautifully illuminated score, which I could gaze at probably more easily and in more detail than I could have done had I gone to the original exhibit at the Library of Congress. This use of the Web to bring distant people to great resources, and the navigational idiom used to make the virtual museum, both caught on and inspired many excellent Web sites. It was also a great example of how a combination of effort from around the world could lead to fantastic things.

Another classic of its time was a server by Steve Putz at Xerox PARC. He had a database of geographical information that

would generate a virtual map on the fly in response to a user's clicks to zoom and pan. It would prove to be the first of many map Web servers to come.

Seeing such sites, scientists and government groups, who had an obligation to make their data available, were realizing it would be easier to put the information up on the Web than to answer repeated requests for it. Typically, when another scientist requested their data, they had had to write a custom program to translate their information into a format that the person could use. Now they could just put it on the Web and ask anyone who wanted it to go get a browser. And people did. The acceptability of the Web was increasing. The excuses for not having a browser were wearing thinner. The bobsled was starting to glide.

As June 1992 approached, I increasingly felt the need for a sabbatical. David Williams, head of my division at CERN, had seen this coming and was ready with an offer I couldn't refuse. He explained that I could go away for a year and have my job when I returned. However, during that year I would lose my CERN salary and benefits, which were quite good, and I would have to pay all my travel expenses. As an alternative, David said I could go away for an extended business trip for three months and he would pay me a per diem rate for this "extended duty travel," on top of my ongoing salary and benefits. Not surprisingly, I chose the second option. My wife and I planned a three-month mixture of work and vacation. I would visit MIT's Laboratory for Computer Science (LCS) in Cambridge, Massachusetts, and also attend the IETF meeting in neighboring Boston. Then we would vacation in New Hampshire, and end up in the San Francisco area where I would visit Xerox PARC.

The summer turned out to be a great opportunity for me to take a snapshot of the state of the Web's penetration and acceptance in the States.

People at LCS had installed Viola, and MIT was well into the Web. The name "www.mit.edu" was taken very early on by a student computing club, so "web.mit.edu" would become and remain the name of MIT's main server. At LCS, I described the ideas behind the Web to a select group of individuals in the fifth-floor auditorium. Some of the researchers and administrators wondered a bit why I was there. I was trying to see how this creation, which was really a matter of engineering, fit in from the point of view of the research community, what the Web could learn from researchers in the field, and why it hadn't happened before.

At the IETF meeting I held my birds-of-a-feather session to investigate forming a working group to standardize the URI spec, as Joyce Reynolds had suggested. We met in a small room at the Hyatt Hotel. I presented the idea of a *universal document identifier*—my initial name for it—and said I was interested in it being adopted as an Internet standard. A number of things went less than smoothly. The open discussion was great. I felt very much in the minority. There was another minority who seemed to resent me as an intruding newcomer.

Even though I was asking for only a piece of the Web to be standardized, there was a strong reaction against the "arrogance" of calling something a universal document identifier. How could I be so presumptuous as to define my creation as "universal"? If I wanted the UDI addresses to be standardized, then the name "*uniform document identifiers*" would certainly suffice. I sensed an immediate and strong force among the people there. They were trying to confine the Web to some kind of tidy box: Nothing could be universal. Others viewed the IETF as a place where something universal might be created, but that something was not going to be the Web. Those tensions would continue through that IETF meeting and subsequent ones. Some people wanted to integrate the Web with other information systems, which directly begged the point, because the Web was defined to be the integration of all information systems.

I tried to explain at the session how important it was that the Web be seen as universal, but there was only so much time, and I decided not to waste my breath. I thought, *What's in a name?* If it went through the standards process and these people agreed, and all I needed was to call it *uniform*, as long as I got the right spec that was fine by me. I was willing to compromise so I could get to the technical details. So *universal* became *uniform*, and *document* became *resource*.

As it turns out, it had been important to nail down the name, because behind the name was the fundamental philosophical underpinnings of what the Web was trying to be. Ultimately, the group did decide to form a uniform resource identifier working group. However, they decided that *identifier* wasn't a good label for what the Web used. They wanted to emphasize that people could change the URIs when moving documents, and so they should be treated as some sort of transitive address. *Locator* was chosen instead, like a branding, a warning mark on the technology. I wanted to stick with *identifier*, because though in practice many URIs did change, the object was to make them as persistent as possible. We argued, but at the IETF the universal resource identifier became URL, the *uniform resource locator*. In years ahead the IETF community would use the URL acronym, allowing the use of the term *URI* for what was either a URL or something more persistent. I use the general term *URI* to emphasize the importance of universality, and of the persistence of information.

Progress in the URI working group was slow, partly due to the number of endless philosophical rat holes down which technical conversations would disappear. When years later the URI working group had to meet twelve times and still failed to agree on a nine-page document, John Klensin, the then IETF Applications Area director, was to angrily disband it. Sometimes there was a core philosophy being argued, and from my point of view that was not up for compromise. Sometimes there was a basically

arbitrary decision (like which punctuation characters to use) that I had already made, and changing it would only mean that millions of Web browsers and existing links would have to be changed. After months of rather uncontrolled arguing in the IETF, it seemed that they had to take either all of the Web, or none of it. In the end I wrote a specification on how URIs were used on the Web, and issued it to the IETF community as an informational "Request for Comment 1630." While hurried and with a few mistakes, it was a foothold for future progress. The whole affair would also have gone more smoothly had I been more forceful about the points on which I was prepared to negotiate and those on which I was not.

My stay at LCS had been more inspiring, and the same was true when I went to Xerox PARC. Being security conscious, PARC had many experimental servers available internally, protected behind a firewall built into their system that prevented outsiders from illegally gaining electronic access. There was a special way of getting a connection from inside to outside. They were not using Viola because it had to be compiled with special code to make this connection, so the first thing I did on arrival was to do that.

I also visited other important actors in the Web world while in the San Francisco area. When going to PARC I would bike in every day past SLAC. I stopped in to see Paul Kunz and Louise Addis, early promoters and implementers of the Web. I also got together with Pei Wei, who was still at U.C. Berkeley. Although Viola was attracting some attention, the difficulty in installing it limited its appeal. I met Pei at a café outside San Francisco to try to persuade him to make installation easier, and to give editing power to his browser as well—still my ideal. But Pei's interest was always in Viola as a computer language; he saw the Web as just one application of it. I tried to encourage but not push. After all, Viola was broadening the Web's reach tremendously. Part of my reason to meet him was simply to say, in person, "Thank you, well done."

Pei's unassuming demeanor and lack of arrogance about his ideas were remarkable given his product, which was great. When I congratulated him and told him that further development would make Viola the flagship of Web browsers, Pei smiled, but he would reserve his program as his own research tool. He would go on to join the Digital Media group at O'Reilly Associates in Sebastopol, California, run by Dale Dougherty, one of the early Web champions, which was creating various Internet products. He used Viola to demonstrate what online products could look like using different styles.

Because the installation process was a little too complex, Viola was destined to be eclipsed by other browsers to come. Indeed, there was already competition between Web browsers. While Erwise and ViolaWWW competed as browsers for the X Window system on Unix, Tony Johnson at SLAC entered the fray. A physicist, he had developed another browser for X called Midas, partly because he liked to see a program written well, and partly because in his project he wanted to use the Web to disseminate his information, and wanted a browser he could control. He used a nice conceptual model, the programming was very clean, and it allowed him, for example, to import images in a very flexible way.

I met Tony in his office at SLAC. Although he gave presentations around SLAC about Midas, and used it himself, he was as reluctant as Pei or the Erwise group to join in my effort at CERN, even though it would probably provide extra resources. Tony was and is first and foremost a physicist, and he didn't like the idea of supporting Midas for a group any wider than that of his colleagues.

The month I was spending in California was coming to a close, and soon my family and I would have to return to Geneva. But I could not go back without making one more stop, which I knew would be perhaps the greatest treat of the summer. Ted Nelson, who had conceived Xanadu twenty-five years earlier, lived close by, and I had to meet him.

Different people had tackled different aspects of the social implications of hypertext. For Ted, hypertext was the opposite of copyright. The whole idea of Xanadu was driven by his feeling that anybody should be able to publish information, and if someone wanted to use that information, the creator ought to be automatically recompensed. One of the reasons Xanadu never took off was Ted's insistence on a pricing mechanism, and the difficulty of creating one that was consistent across the whole world. In theory this would be possible on the Web with certain extensions, and a system of "micropayments"—small debentures against a person's bank account—would allow automatic payments in very small quantities. I was not keen on the idea of having only one business model for paying for information. But I was keen on meeting Ted.

We had corresponded only a few times via e-mail, and the fledgling relationship we had was a strange one for me at least, because for a long time I owed Ted money. I had first heard of Ted in 1988 when reading about hypertext. His main book at the time was *Literary Machines*, published by the Mindful Press, which Ted operated as a one-man publishing house. Some time later I got around to sending him an order for the book with a check written out in U.S. dollars drawn on my Swiss bank account. Swiss checks were very international, with a space for the amount and a space for the currency type, but I didn't realize American banks didn't accept them. He sent the book, but I didn't succeed in paying, since he didn't take credit cards and I didn't have U.S. checks.

And so it had stayed. I called him up from PARC and found that he lived on a houseboat in Sausalito, across the Golden Gate Bridge from San Francisco. It was the place closest to where things were happening that was sufficiently eccentric for him to live. Xanadu had been picked up by Autodesk, and Ted had some dignitary position with the company. But the day I was scheduled to meet him for lunch was a sad one. That very morning