An Interview with Ubicomp Pioneer Norbert Streitz

INTRODUCTION

Norbert Streitz

Dr. Norbert Streitz, Scientific Director of the Smart Future Initiative (SFI), was one of the early pioneers of ubiquitous computing in Europe. Prior to launching the SFI (www.smart-future.net) in January 2009, Streitz worked for more than 20 years at the Fraunhofer Institute IPSI in Darmstadt, Germany, holding different positions as the Deputy Director and Division Manager of the research division "Ambiente—Smart Environments of the Future." He also taught in the Department of Computer Science at the Technical University Darmstadt for more than 15 years.

His research interests include cognitive science, human-computer interaction, human-centered design, hypermedia, computer-supported cooperative work (CSCW), ambient intelligence, smart environments, cooperative buildings, and smart hybrid cities. Streitz received a PhD in physics and a second PhD in cognitive science. He has published/edited 19 books and authored more than 120 scientific papers. Among other things, he's known for developing Roomware, which integrates hardware and software into the environment.

Here, I interview Streitz about technology's evolution and the significance of Weiser's vision today, his work on the Disappearing Computing Initiative, and his prediction of where we'll be 20 years from now.

—Nigel Davies, editor in chief

Tell us about your first exposure to ubiquitous computing at Xerox PARC [Palo Alto Research Center] and how this shaped some of your research work.

I was at PARC as a visiting scholar in the summer of 1990. The initial motivation was, I have to confess, independent of ubiquitous computing, because at that time I was working in the areas of hypertext, hypermedia HCI, and CSCW. In particular, I was working with my team on a cooperative hypermedia authoring system called SEPIA [Structured Elicitation of Ideas for Authoring] that we developed at IPSI in Darmstadt, Germany. There was a group working on hypertext at PARC, Frank Halasz being one of them, and Frank, one of the hypertext heroes at that time, invited me to PARC.

Frank was also my link to Mark Weiser, because they worked together on the Liveboard, which represented—together with the Pads and Tabs—one of the three categories of ubiquitous computing devices in Mark's vision. Thus, the main influence regarding ubiquitous computing for me was provided by the possibility of witnessing and experiencing the first Liveboard—a wooden cabinet with a large interactive display operated with a pen using scribbles and gestures. It was presented to us in a special room in which only people with the corresponding confidentiality clearance had access. Looking like a large piece of furniture—even having handles on the side to pull it, which were nicknamed "towel racks"—it was a first realization of something that presented itself with a very different form factor as the furthest deviation from a standard PC at that time. Standing in front of this large, vertical display and reaching out with your arms in order to interact with a pen was quite a new experience.

After having the chance to experience it, my idea was, of course, to exploit these new features. In SEPIA, we relied mainly on text input, taking notes and graphical presentations of formal structures—for example, argumentation structures with typed nodes and links—but we didn't have a way to capture brainstorming activities as free-form scribbles. The Liveboard seemed to provide an appropriate interactive surface—especially with the ability to place it in front of a group in a meeting room. So, the plan was to combine the Liveboard with our SEPIA system and then integrate it into a more comprehensive meeting-room scenario and environment. We wanted to support groups working in the same room—to brainstorm, discuss ideas, make decisions, meet formally or informally, and so on—by not only letting them share information on their PCs and laptops but also by providing a large interactive display in front of them.

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After some negotiation with PARC, I was able to get two Liveboards—serial numbers 007 and 008—to IPSI in Darmstadt, Germany, in January 1993. We exploited the fact that this large display wasn't only a projection but also an interactive display that could be operated via a pen and using gestures. We extended the hardware constellation by combining the Liveboard with monitors and keyboards integrated in the meeting-room table and developed the software for enabling multiple-user shared cooperation between all devices and with multiple interaction modes. The result was Dolphin, an integrated meeting support system across Liveboards and local and remote desktop environments. [See the "Further Reading" sidebar for more information.] Having two Liveboards, we extended the Dolphin system by connecting two meeting rooms and, in addition, remote desktops, thus creating virtual meeting-room environments that included also video and audio conferencing.

Meeting rooms have played an important part in many ubicomp visions, but they still don't feel very smart—usually, they just have a projector that you can connect to a laptop. Do you think that's a technology issue or working-practices issue?

I think it's both. The technology could have evolved much faster, but most of the commercial technology for large interactive displays was more oriented toward learning environments, such as classrooms, leading to different applications. On the other hand, there's certainly a work-practice issue. I think there's an intrinsic problem with using these possibilities for actually capturing the processes in meetings and documenting everything in an electronic format. Not being used or trained to exploit these types of meeting protocols creates problems—not to mention the legal implications this could raise in terms of liability issues. In addition, if you just video tape a meeting, as we also used to do, people rarely look back at these hour-long discussions, and video abstracting hasn't been very promising. There are still technology challenges to be explored, but the main obstacle is a work-practice issue.

It often feels like the technology is there—not necessarily as well integrated as we might like—but we don't know how to capitalize on it. This feels like a general ubicomp issue—the technology seems close but when you read the scenarios and compare them to what we're doing now, we still have a long way to go.

I agree that bits and pieces are there, and integration is a big issue. Another aspect is, of course, whether you can market it at a price to a large enough community or group of people so that it pays off and is also a commercial success.

Nowadays, we see this type of interactive "tables" or "boards" technology in television broadcasts of sport events and in talk shows. But they're only being used as a touch-based interface—for a vertical or horizontal display—for example, to play back certain clips from a soccer game or to show emails sent in by the audience of the TV show.

Technology's role in meetings usually doesn't go beyond the use of laptops—and, more recently, tablets—and a projector for the presentations. Unfortunately, people are taking notes only on their own computer or laptop and don't share them in the group.

FURTHER READING

Overview

Universal Access in the Information Society, upcoming special issue on "The Streitz Perspective: Computation is Ubiquitous, Yet Must Be Designed for Human Use—A Festschrift for Norbert Streitz," D.M. Russell ed., vol. 11, no. 3, Springer 2012.

Dolphin Meeting-Room System

N. Streitz et al., "DOLPHIN: Integrated Meeting Support across LiveBoards, Local and Remote Desktop Environments," *Proc. ACM Conf. Computer Supported Cooperative Work* (CSCW 94), ACM Press, 1994, pp. 345–358.

Disappearing Computer

Comm. ACM, special issue on the disappearing computer, N. Streitz and P. Nixon, eds., Mar. 2005.

The Disappearing Computer: Interaction Design, System Infrastructures and Applications for Smart Environments, LNCS 4500, N. Streitz, A. Kameas, and I. Mavrommati, eds., Springer, 2007.

Early Ubicomp Workshops and Symposia

Proc. First Int'l Workshop Cooperative Buildings—Integrating Information, Organization, and Architecture (CoBuild 98), LNCS 1370, N. Streitz, S. Konomi, and H. Burkhardt, eds., Springer, 1998.

Proc. Int'l Symp. Handheld and Ubiquitous Computing (HUC 99), LNCS 1707, H. Gellersen, ed., Springer, 1999.

Roomware Smart Artifacts

N. Streitz et al., "i-LAND: An Interactive Landscape for Creativity and Innovation," *Proc. ACM Conf. Computer-Human Interaction* (CHI 99), ACM Press 1999, pp. 120–127.

N. Streitz et al., "Roomware: Towards the Next Generation of Human-Computer Interaction Based on an Integrated Design of Real and Virtual Worlds," *Human-Computer Interaction in the New Millennium*, J. Carroll, ed., Addison-Wesley, 2001, pp. 553–578.

Smart Cities InterLink Project

N. Streitz and R. Wichert, "Towards the Humane City: White Paper on a Future Research Agenda for Ambient Computing and Communication Environments," white paper, InterLink project, 2009.

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Furthermore, they're often just reading their email. In this way, the technology usually available in meeting rooms has led to more distractions rather than to more collaboration.

There was actually a project called "Feel" in our Disappearing Computer [DC] initiative addressing this problem. It developed a system that let users control and moderate the type and number of intrusions coming into a meeting room, and then reduce or even block them completely. The interaction mechanism for controlling it was realized by a knob in the middle of the table. So, you could turn down the level of calls, for example, of mobile phones. You could allow emergency calls from your family to come in but could block other calls—or emails and other intrusions. It would apply to all kinds of incoming and outgoing streams of information. I think it was a great idea to control the level of meeting intrusions, depending on the meeting's importance, and handle the interaction via a simple tangible device—a knob.

Through your work on the Disappearing Computing initiative, you've helped shape European research in this area. For readers not familiar with the program, can you give a brief overview of the initiative?

The DC initiative was launched by the European Commission—in particular, initiated by Jakub Wejchert from FET-IST—and I had the honor of participating in its early planning stages and was later the elected chair of the DC Steering Group. When we prepared the call for proposals, we used as a guide Mark Weiser's opening statement in his famous *Scientific American* article ["The Computer for the 21st Century," Sept. 1991]: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." The DC initiative's mission was to see how information technology can be diffused into everyday objects and settings and how this could lead to new ways of supporting and enhancing people's lives, going above and beyond what's possible with the computer today.

Specifically, the initiative focused on three interlinked objectives:

- create information artifacts based on new software and hardware architectures integrated into everyday objects;
- look at how collections of artifacts can act together, so as to produce new behavior and new functionality; and
- investigate new approaches for designing for collections of artifacts in everyday settings and for ensuring a coherent and engaging experience for people in these new environments.

The call resulted in 17 accepted projects. They started in the beginning of 2001 and lasted for around three years

The Disappearing Computer initiative's mission was to see how information technology can be diffused into everyday objects and settings.

[for details, see www.disapearing-computer.net]. A wide range of topics was covered. There were basic hardware-, sensor-, and network-oriented projects that, for example, integrated computing into different materials; combined multiple devices in an ad hoc way; used architectures and infrastructures to help gadgets communicate; developed small-scale embedded devices that could be attached to everyday objects to augment them with sensing, perception, computation, and communication, for example, resulting in augmented paper. There were also more application-oriented projects addressing different scenarios at home, at work, in museums, for e-commerce, or for traveling. Some of them addressed larger domains either in office buildings or in open public spaces, making the implications of built architecture a key aspect of the work. Different methodologies were used from rapid prototyping and proof of concept to psychological experiments and ethnographic studies.

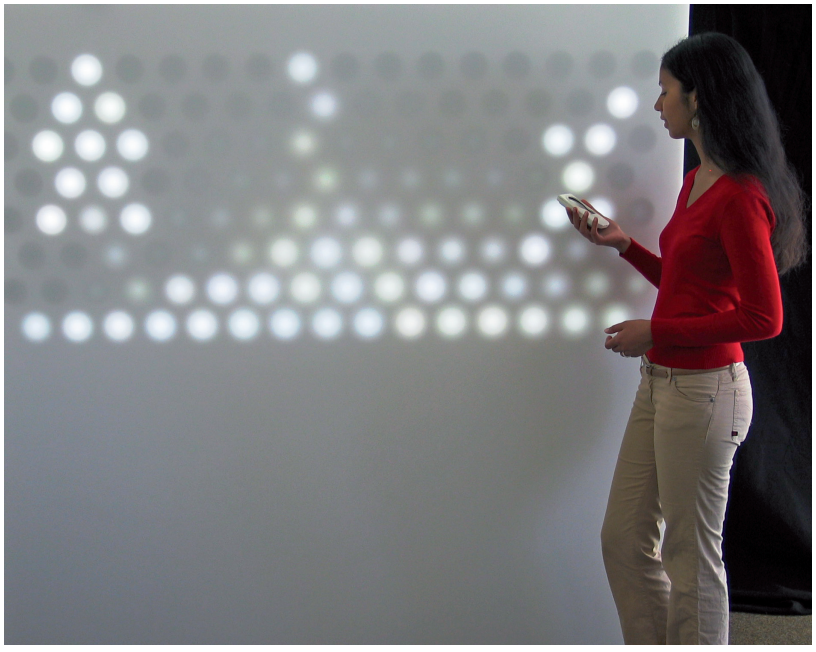
Work on the different projects was complemented by a number of additional activities with the purpose of establishing a DC community, encouraging cross-project collaboration and challenging project boundaries. This was achieved by the fact that each project had to pay a given amount of its project funds into a pool administrated by the DC Steering Group—at that time a unique policy for EC projects. Individuals and groups from the DC community could apply for different activities being funded—for example, Disappearing Days, which were thematic workshops; Troubadour Grants, which were for researchers traveling to visit partners of different projects studying a cross-project-relevant theme, such as privacy; Research Ateliers, which were small-budget and short-timescale mini-projects, lasting only a few weeks or a couple of months, that merged ideas from different projects; and, finally, the Jamborees, which were the annual round-ups of all projects in one location, where researchers could demonstrate their work, exchange ideas, and have their work reviewed by the EC.

Now that time has passed, which of the Disappearing Computer projects do you feel has had the greatest impact in the field?

The DC initiative as a whole had a significant impact due to its comprehensive vision, combined with a versatility of approaches and an innovative collaboration structure extending beyond individual projects. This was initially the case at the European level, but later on at the international level as well by having papers accepted at all major conferences relevant to this area. International visibility was also achieved with the second DC Jamboree and public DC Exhibition, organized jointly with the International Conference on Ubiquitous Computing, UbiComp 2002,

held in Göteborg, Sweden. After the closure of DC, two major publications in particular presented the DC initiative to the scientific community. One was a special issue on "The Disappearing Computer," published in the March 2005 issue of *Communications of the ACM*. This was based on an EU-NSF joint advanced research workshop, bringing together ubicomp researchers from Europe and the US in Vienna in 2004. The other is the comprehensive book, *The Disappearing Computer—Interaction Design, System Infrastructures and Applications for Smart Environments*. Mentioning individual projects is certainly biased by my personal perspective, but I would name Smart-Its, Accord, Shape, WorkSpace, Feel, and our Ambient Agoras project. Other people taking another perspective—rooted in another community—might mention other projects.

The second generation of the IPSI Roomware components (DynaWall, InteracTable, CommChair, ConnecTables), developed in 1999.



The HelloWall—an ambient public display showing dynamic aesthetic light patterns communicating awareness parameters—used in combination with the personal device ViewPort, developed in the Ambient Agoras project in 2003.

Since Weiser's article, many things have changed—the arrival of the Web and of smartphones being obvious examples. In light of these changes, do you think the original vision is still relevant to researchers today?

Let's first have a short look back. After Mark's publication of his seminal article in 1991, the individual components—for example, the Liveboard—received quite some attention in the scientific community, but it wasn't so much the case for the overall paradigm of ubiquitous computing. My observation is that the post-PC or post-desktop model of HCI was more in the foreground. This was in line with the trend at that time to include the real world into the design perspective—for example, 3D visualization and interfaces, augmented or mixed reality, and then later tangible interfaces. There was about a six- to eight-year delay before Mark's ubiquitous computing paradigm was really appreciated and then referenced in almost every article published at that time. The corresponding series of workshops and symposia started in 1998 (CoBuild 98) and 1999 (HUC 99), which were preparations for the following UbiComp Conference series. This was also the time when we realized our approach to ubiquitous computing and the disappearing computer, resulting in our Roomware components (interactive tables, walls, chairs, and so on). Thus, it took about 10 years to establish a full-fledged research community in the area Mark initiated. Too bad he couldn't experience the full breakthrough and adoption of his ideas, as he died much too early and too young in April 1999. In retrospective, I'm very glad that Mark Weiser could experience the appreciation of his work also in Europe because I invited him as a keynote speaker to our

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CoBuild 98 event, which was among his last international presentations.

Now, another 10 years later and thus 20 years after Mark's seminal article, we can state that the vision is still relevant as an inspiration, although it's being less referenced now compared to the early days. Once in a while, I'm going back to look at this and other papers he wrote, and I'm still impressed by the creativity and comprehensiveness of his perspective.

The Web is only a reduced imitation of the original hypertext ideas, which exploited complex structuring opportunities (such as via typed nodes and links) and supported, even in the early days, collaborative work and information sharing. Weiser's vision was independent of the Web or hypertext as a structuring mechanism. Ubiquity and accessibility of information was important for him and the combination of different devices for different purposes supported by their connectivity. We can view smartphones as a reinstantiation of Weiser's original idea of Tabs, although they're primarily a derivative and extension of mobile phones. Weiser's Pads are reincarnated as Apple's iPad—and similar products by Samsung and Amazon—although there were many attempts in between in terms of tablet PCs by Xerox, Microsoft, and so on, and then the e-book readers by Amazon and Sony.

Where do you see the field going in the next 20 years—both in Europe and internationally?

European researchers were very much interested in the ubicomp ideas but considered the approach in the US too much computing and device driven. You could argue that this is even reflected in the terms originating there—for example, "ubiquitous computing," "pervasive computing," and "proactive computing." All have "computing" as a major term. Europe had to find its own approach and emphasized a more human-centered perspective.

This was also reflected in the term "ambient intelligence" [AmI] created at Philips and promoted by Emile Aarts, and then adopted by the European Commission, especially in its stimulating and often referenced ISTAG report, "Scenarios for Ambient Intelligence in 2010"—published in 2001—which was a combined description of a vision and a research agenda for Europe in this arena. The AmI vision has been described as the result of the equation "ubiquitous and pervasive computing + social interfaces + collaboration" and is still a dominant approach in Europe.

In parallel, the DC initiative emphasized a similar approach. Based on these activities and similar follow-up projects and programs, such as the influential Equator-program in the UK, the R&D activities have very much diversified and dispersed the original ideas in many areas of information and communication technology. This is also reflected in the topics dealt with at the prominent conferences in the field. One example is the area of Ambient Assisted Living; others are in the area of gaming and learning. In a way, ubiquitous computing shares this fate with hypertext and the Web. These ideas and technologies are becoming more and more integral and embedded parts of a wide range of infrastructures and platforms, software technologies, and applications.

The trends that I foresee have been informed by my work chairing the Working Group "Ambient Computing and Communication Environments," one of three groups of the more comprehensive EU-funded InterLink project, managed by Constantine Stephanidis [see http://interlink.ics.forth.gr]. We identified two major challenges and 12 research lines. [See the Interlink white paper, listed in the sidebar.] They were developed in the context of an umbrella scenario envisioning so-called "smart, hybrid cities," which are still "humane" cities—that is, cities where people enjoy everyday life and work, have multiple opportunities to exploit their human potential, and lead creative and high-quality lives. The challenges are "socially aware ambient intelligence" and "privacy, trust, and identity." Examples of the research lines include

- hybrid symmetric interaction—that is, symmetrical, bidirectional action/interaction between real and multiple virtual worlds;
- space-time dispersed interfaces enabling dynamic allocation of resources following trajectories in space and time;
- crowd and swarm-based interaction;
- spatial and embodied smartness creating smart spaces as distributed cognitive systems and viewing them as outside-in robots;
- emotion processing or affective computing;
- self-organization in socially aware ambient systems;
- realization and user experience of privacy and trust; and
- scaling, which is quite challenging, not only because it's a horizontal issue but also because it addresses much more than just the increasing numbers of sensors, actuators and devices—it involves investigating fuzzy boundaries of smart spaces, the conflict of interest between different AmI spaces, and the availability and ownership of public and private resources for AmI environments.

In closing, I'd like to emphasize again that privacy and trust are the essential ingredients of establishing human-oriented AmI environments; otherwise, they won't be accepted by the users—the citizens of our smart cities. This includes careful handling of and appropriate policies for location-based services. These policies should be based on free decisions of users regarding what can and should be tracked, with no unauthorized trajectories of people's lives in real and virtual spaces. Social networks can play a role for creating a hybrid smart Web including augmented-reality features, but they'll only have a place if they can operate without privacy infringements. We can only hope that more and more people learn to appreciate and then defend their privacy. Nevertheless, in parallel, rules and legislation have to secure privacy and trust.

The large-scale smart, hybrid, and ubiquitous cities we envision for the urban age are humane cities reconciling humans and technology. P