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My road to Infrastructure

Ole Hanseth
Department of Informatics, University of Oslo, Norway, oleha@ifi.uio.no

Reflection note

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Ole Hanseth
Department of Informatics, University of Oslo
Ole.Hanseth@ifi.uio.no

1 Introduction

More or less all my research has been related to information or digital infrastructures—more specifically: innovations in information infrastructures which has been the theme of a series of workshops Robin Williams established. My approach to this topic, however, was the outcome of a long journey. It all started with, and was most influenced by, Kristen Nygaard who was giving two lectures on his pet topic, "systems development as a technical, organizational, and political process" in the introductory course to informatics during the spring 1977 (where we learned object-oriented programming in Simula). Kristen was at this time just hired as an adjunct professor and developed three courses on systems development—one at the bachelor level (Data processing and society), and two on master level (Large data systems—two cases, and Methods of systems development) which I attended. This convinced me that systems development was a "technical, organizational and political process", which implied that also organizational and political issues had to be considered in the design processes. One way to do so was to organize the development processes so that users actively got involved. Another issue was how social, organizational, and political issues were supported or constrained in a system's specific design (architecture, functionality, whatever). The focus on my education was computer science and software engineering. So as a software designer my primary concern was how to account for social, organizational, and political issues in the design of artifacts.

Kristen has had strong influence on me in addition to his thinking about technology[1]. This included his approach to life and work. He was a political activist, most clearly demonstrated in his role as head of the No-movement in connection with Norway's referendum about EU membership in 1994, but he also had an activist approach to research. Rather than reading, reflecting, and writing in solitude in his office or study,

he gathered people around him, locally and globally, discussing what mattered and how to get things done[2]. This meant that he was connected to a large community of scholars with vastly different backgrounds, a community where lots of interesting ideas and issues emerged and were explored and discussed. This community represented a huge resource for a curious young mind.

NCC/NR, in the wake of Kristen's pioneering project together with the Iron and Metal Workers' Union, hired a group of social scientists to complement their computer science and statistics expertise, making it a very attractive employer for me. And luckily, I was offered a position from 1st of January 1982 after having completed my master (cand. real.) thesis. My intellectual development and research interest was from then on shaped by the issues and challenges I confronted in the projects I engaged with, at the same time as my interpretations of and lessons I drew from these confrontations were strongly influenced by discussions I had with colleagues and people I met (at NCC/NR and in Kristen's wider network), and literature these people made me aware of and which my curiosity led me to read.

2 Projects

When I started, I got involved in two projects: a pilot implementation of the ISO OSI session layer communication protocol, and to extend the Pascal programming language with concepts for concurrent processes need for programming a Norwegian supercomputer designed for processing satellite data (for surveillance of Norwegian sea). The next project was the design of a Simula machine, i.e., a computer especially tailored to the Simula programming language where my task was to micro-code the Simula specific instruction set called Sipofix, including its memory management system. This was followed by a project aiming at implementing and extending Kristen's new pet programming language BETA.

Over the years, my activities became more concentrated on communication technology. And what turned out to become a 'critical juncture' or path creation event in my career was a project we conducted for the Norwegian tele-directorate's research organization. The aim of was to implement a pilot solution where documents could be produced or edited, exchanged between users/computers, stored, and retrieved based on the ISO OSI ODA multimedia document standard. The solution was based on the integration of several modules developed by various organizations (and individuals we did not know). We succeeded in the end, but the integration of all software modules turned out to be far more challenging than expected, bringing the project at one point to the brink of total failure.

While we were working on this project, our client, the Norwegian tele-directorate's research organization, established a centre in Tromsø called *Telemedicine in Northern-Norway* which was given the task to develop solutions for new telecommunication-based services for health care—with a focus on utilizing multi-media technology. Staff at this centre became aware of our project. They though ODA was an appropriate standard for this task, so Gisle Hannemyr and me were engaged (in 1988) to set up a demo solution exchanging medical multi-media information based on ODA on the one hand and to contribute to the development of international standards for exchange of such information on the other. This engagement led me to leave NCC in 1990 and join a software company developing solutions for information exchange in health care, returning to the NCC/NR towards the end of 1992.

The two ODA projects and the two years working for the software company sealed my destiny as a researcher. After the first ODA project led me to conclude that future software development is not just about developing software from scratch, but rather by integrating existing modules developed by others; that doing so is far from trivial; and that this issue needs research. Further, an important conclusion I draw from my work for the software company was that communication technology has a huge potential for enabling information sharing between organization within all industries and that this required and opened a huge space for research. Finally, the ODA project also brought me, by accident I would say, into the health care domain which has been the main empirical domain for all my research.

3 Issues, people, readings

Some issues I repeatedly discussed with colleagues were also discussed widely in IS communities. This included approaches to software development: top-down (waterfall) vs. bottom-up and iterative or evolutionary approaches. In these discussions, Kari Thoresen insisted that software development was fundamentally a learning process and had to be conducted and organized as such, a view I came to share, and which became fundamental to my thinking about infrastructures.

During the 1980s and -90s there was also a heated debate about fundamental principles for the establishment of communication standards—often referred to as a religious standards war between the proponents of the ISO OSI protocol suite and the Internet community, a war where my colleagues at NCC/NR were all on the ISO OSI side—with one exception: 'Internet evangelist' Gisle Hannemyr. Discussions with Gisle was important for understating what was going on in the Internet community and

contrasts between OSI and Internet at technological (architectural), methodological, organizational, as well as political levels.

My discussion with Gisle combined with my experiences in the ODA projects and in particular in the software company had for me two important implications. First, over time I came to see that the discussions between waterfall and evolutionary software development approaches could be seem as analogue to the religious war about standards, and accordingly standardization should also be seen as, for instance, a learning process. Second, Gisle forwarded to me an email sent by Einar Stefferud to Eva Kuiper with copy to IETF's mailing list (on 12th of May 1992) where he argued that the problem with the OSI protocols was that they were "installed base hostile," i.e., they were specified to communicate only with instances of the same protocol and, accordingly, an OSI networks could not communicate with or connect to any existing network. This notion of the installed base and installed base hostility was and eye opener: it pointed to key differences between both ordinary software solutions and solutions integrated across computers and organizational borders and between OSI and Internet approaches to standards development.

I was constantly feeling a need for a deeper understanding of the issues I have mentioned. And the community I was a part of or had links to make me aware of rich sources of literature that I thought would help. I will here mention some important ones.

Lars Matthiessen did his PhD in Oslo. The Swedish sociologist Joachim Israel was his second supervisor (Kristen was the first). This brought Israel to Oslo, giving a lecture at NCC/NR in 1981 presenting his recent book "The Dialectics of Language and the Language of Dialectics," which I attended (while a master student). Israel talked about ontology and epistemology in addition to dialectics—words I had never heard before. I didn't understand a word but bought the book and read it—still without understanding anything. But a second careful reading helped a lot.

During 1982 Kristen established together with other Scandinavians a research program called "Systems Development and Profession-oriented Languages" (Sydpol). Stanford Professor Terry Winograd was invited to the kick-off seminar in early 1983 where I also participated. Winograd brought with him a draft of the book he co-authored with Fernando Flores, "Understanding Computers and Cognition. A New Foundation for Design," (1997) which he shared with us. The book included a chapter on Gadamer's hermeneutics (another very strange new word) and presented a 'teaser' of Heidegger. The latter hit my curiosity leading to many evenings struggling with Being and Time.

Sociologist and colleague Tom Pape was closely affiliated with Scandinavian action research community, and one day he gave me a copy of the draft of a book with the title "Sociology as Action," written by Bjørn Gustavsen—one of the community's most

experienced members[3]. Here Gustavsen summarized the experiences of three decades of action research and three major working life reforms in Norway and outlined a methodology he called "democratic dialogue," drawing extensively upon Habermas, (the late) Wittgenstein, and Foucault. While spending some time reading Habermas, the latter two got much more of my attention over a few years. I found in particular Foucault's "Discipline and Punish" and Wittgenstein's analysis of following a rule (and its difference to acting in accordance with a rule) helpful in getting deeper into issues related to software and standards development approaches.

Lucy Suchman engaged with the Scandinavian technology-oriented research following Kristen's Iron and Metal Workers project and visited Scandinavia presenting her work, first her early paper on "Problems and Procedures in the Office Workspace" (which she later elaborated and published as her hugely influential "Plans and Situated Action.") I found Lucy's analysis as closely related to my understanding of and interest in Foucault and Wittgenstein. She used however, yet another strange word—ethnomethodology. This triggered my curiosity again. There was not much literature to find—just Harold Garfinkel's thin book "Studies in Ethnomethodology" and Michael Lynch's "Art and Artefact in Laboratory Science." Lynch's book turned out to be my first meeting with the at that time emerging STS field. This brought me further to Latour and Woolgar's "Laboratory Life" and to Knorr-Cetina's "The Manufacture of Knowledge," followed by a broad stream of STS literature of which ANT and Thomas Hughes' "Network of Power" and his theory of Large Technological Systems became most important.

The theory of science and philosophy I had been reading—Israel, Heidegger, Wittgenstein, Foucault—was certainly not easy for me to operationalize in the projects I worked on but turned out to be very helpful in getting a better grasp of the STS literature.

In January 1987, Eric Monteiro started at NCC/NR. (Actually, I hired him, being the head of the programming languages and environment group, but when he arrived, he decided he did not want to work in my group.) Eric was trained as a traditional civil engineer in computing and found what the social scientists were talking about rather odd, but having an open and curious intellectual mind, he wanted to understand them. Eric and me also started to discuss what he found strange or odd—discussions that have continued on a more or less daily basis ever since, drifting into STS and over time more or less any topic. These discussions have been very important in the sense of having had a huge impact on my intellectual development, but also in the sense of cultivation a close friendship.

Soon after he started at NCC/NR, Eric got a scholarship and started on a PhD (on intuitionistic logic as a foundation for programming languages). After finishing in his PhD in 1992 he got a position at the university in Trondheim at the same time as I returned from industry to the Norwegian Computing Center. And around that time, our discussions also turned towards the writing of joint papers, the first on participatory standardization presented at IRIS in 1992.

4 Crystallization of a research agenda

The Norwegian Computing Centre was a lively and inspirational place. All employees were entitled researchers, but there was absolutely no culture for proper academic publishing. Personally, I wrote a few working papers (or internal research reports) from the programming language projects I was involved in. Based on the ODA projects I wrote a couple of papers on integration challenges and a more theoretical one the standardization approach taken for informal conferences and workshops (criticizing the naïve realist assumptions of its focus on a data modelling approach and its shortcomings).

While the ODA projects provided me with some 'food' for research, it was my work in the software company that really gave me access to (or rather dumped on me) an inexhaustible source of valuable data. I saw that using communication technology supporting collaboration and information sharing, i.e., integration of information systems, in particular across organizational borders, held a great potential for beneficial use of IT—in the health sector as well as all others. And I also saw that this generated many practical challenges as well as research questions—none of which addressed by the Scandinavian Participatory Design (PD) dominated Scandinavian IS community, the research community closest to me. Helpful in this regard was Bo Dahlbom. He argued that the research of the PD community, with its narrow focus on only user involvement in in-house projects developing moderately complex solutions from scratch, was outdated. Software was now (1990), he argued, all about off-the-shelf products developed by software companies, and, accordingly, research should focus on *use,* not development, of such products. Bo's argument helped me sharpen my view. I agreed that the PD community was to some extent outdated, but there was also a need for integrating software products, in particular into what I at that time called inter-organizational information systems. In my view, and based on my experience, such integration tasks, and the development of interorganizational systems raised several new challenges and required extensive research. And so did the development of the standards such solutions required.

The development of inter-organizational information systems also differed substantially from the assumptions the PD (and actually more or less all IS) research were based on: the development as well as adoption and use of such systems involved many autonomous but interdependent organizational—what today most would call ecosystems—which made the organizing and 'management' of the development process radically different.

In 1993 I dropped the term inter-organisation systems and replaced it with information infrastructures which was popularized by the Clinton/Gore National Information Infrastructure (often called electronic superhighways) strategy. I liked this term for mainly two reasons: first, it was helpful in conveying that what we were dealing with was fundamentally different from information system—that the difference was more fundamental than what would be communicated by just adding inter-organizational, or complex for that matter, in front of information systems. Second, traditional infrastructures are complex, big and heavy, build on standards and evolves slowly over long time—aspects that it was important to highlight and focus on.

While information infrastructures were different from information systems in important respects as pointed out, they were also *equal* in equally important ways. Infrastructures as well as their standards are technological artifacts, and as such they are of course also socio-technical systems—although more complex ones. And as technological artifacts, they can only be developed through an innovation process based on elements of trial and error, i.e., a learning process, and they have to be adapted to changing user requirements. However, standards and infrastructures become increasingly resistant to change as their installed bases grow. In addition, the availability of *stable* standards is a precondition for scaling infrastructures. I identified this dilemma—i.e., the need for stable standards at the same time as infrastructures, including their standards, need to evolve as we learn how to design them and as users' requirements change—as fundamental to successful infrastructure development.

Practically all my research has been related to this tension between standardization and flexibility, or, alternatively, the stability/change duality. And this issue has been explored through empirical inquiries drawing upon various theories and through discussions and collaborations with many colleagues.

In terms of theory, I have drawn upon STS as mentioned above, but also Complexity Science, Ulrich Beck and Anthony Giddens' theory of Reflexive Modernization, and more recently Gilles Deleuze's Assemblage Theory (as interpreted and presented by Manuel DeLanda). While much of my research may appear theory driven, I still believe I am a computer scientist at the core. So, the use of theories has been guided by what I believe could help me develop 'better' technologies.

My most formative exploration of the standardization/flexibility tension took place in the first half of the 1990s in collaboration and discussions with Eric Monteiro, Bo Dahlbom and Langdon Winner (who visited the TMV centre (that later became part of the TIK Centre) at the University of Oslo during 1991-92). In this period, Eric and I were reading and discussing lots of STS literature. At this time, Social Constructivism had a strong position (among the members of the STS centre in Trondheim which Eric had close contact with), and its claim about 'everything' having endless (interpretive) flexibility seemed to be in contradiction with the stability and rigidity of standards and infrastructures. This contradiction was also illuminated by Langdon Winner's criticism of Social Constructivist (and STS more broadly) for neglecting the materiality and politics of technology. Further, Bo Dahlbom, a philosopher that became professor of Information System, was fascinated with information technology's flexibility, and what we later would have called generativity. In our discussions, I often found it appropriate to take the opposite position.

In 1991 Lucy Suchman initiated an annual 5-day workshop at the Oksnøen summer camp for youths and schoolchildren south of Oslo called the Osknøen Symposium. Lucy brought with her her group of anthropologists from Xerox PARC and invited about 20 others to this event. I was very lucky to be invited in 1992 (for reasons that are hard to understand) and participated the next 5-6 years. This gave me the opportunity to meet and learn to know some absolutely brilliant scholars. In addition to Lucy, most notably was Susan Leigh Star, Geof Bowker and Marc Berg who was also doing research on standards and infrastructures. Of course, I learned a lot from discussing—also my own ideas—with these scholars for 5 days. But just as important, it boosted my interest in pursuing a research agenda related to standards and infrastructures.

At this time (early—mid 1990s), I had no plans for obtaining an ordinary position at a university. However, in early 1996, Tone Bratteteig asked me if I was interested in a position in the IS group (called the systems work group at that time—systemarbeid in Norwegian) at the Department of Informatics which they would announce soon. That sounded like an interesting idea. But then I needed a PhD. With the support of Bo Dahlbom, I put together the relevant papers I had published (3 out of 4 together with Eric Monteiro), wrote a few more[4], and submitted a thesis to the University of Gothenburg (the same day as the deadline for the position). I defended it in mid-December 1996 with Giovan Francesco Lanzara as opponent and Claudio Ciborra and Kalle Lyytinen on the grading committee—leading to close and for me very fruitful collaboration with all three.

I got the position and started at the University in April 1997. I continued doing infrastructure research together with friends and colleagues mentioned above as well as

new ones. Most important was the collaboration with Claudio Ciborra until he unfortunately passed away all too early in February 2005. Through Claudio I also established broader contact and tighter relations with people at London School of Economics, in particular Jannis Kallinikos who I first meet in 2001 and established close relations to during my stay there in 2003-2004. Even though we have not published any joint papers, we have had frequent contacts and discussion about issues of shared interest from which I have learned a lot. At the University of Oslo, I have worked together with inspiring colleagues and PhD students I have supervised. Some in the latter group have stayed on at the university after their PhDs and become colleagues: Margunn Aanestad, Miria Grisot, Petter Nielsen and Egil Øvrelid. Margunn was the first PhD student I supervised from beginning to end—26 years of fruitful and stimulating collaboration at the University of Oslo. And I have also had a very close, long and fruitful collaboration with Bendik Bygstad for at least 15 years after we first met around 2005 when he was taking my course on information infrastructures as a PhD student (at the University of Agder) after he got tired of a 20-year career as IT manager and consultant.

To summarize, my research career has been shaped by luck and accidents. I was certainly lucky in finding a place to work which provided me a very fertile environment. NCC/NR, and the larger community it was a part of, was extremely heterogeneous in terms of interests and disciplinary background. NCC/NR, as an applied research centre, was not defined by belonging to a specific discipline. So, there was no constrains on reading and thinking outside the box—actually, there was no box! Lack of structure may be a double-edged sword of course. It stimulates creativity, but one may also just get confused and lost. For me, the positive clearly outweighed the negative.

Further, the software development projects I worked on were without doubt a most valuable resource. And it was indeed lucky for me that I was engaged on the ODA project and by the software company. I think the projects, in particular the ODA projects, was the factor that has shaped my career the most.

Finally, the fact that NCC/NR lacked focus on and a culture for academic publishing was also an advantage for me. That meant that I did not work all night to reach a deadline for a conference, but rather spent afternoons and evenings on reading. I think that has been beneficial for me (even though Eric and I had to learn how to write a paper on our own when we started collaborating).

5 The infrastructuring of computing

Having examined the past, I will end this piece with a brief comment on the present and the future. In recent years, there has been a discussion about the unique charac-

teristics of the digital realm and how digital innovation differs from other innovation processes. One important characteristic that in my view has been overlooked in this discussion is the essential infrastructural nature of the digital. Theoretically, one could argue that this stems from the generative nature of the digital technology. Additionally, data itself is inherently infrastructural, as evidenced by the fact that integration, or data sharing, has always been considered the holy grail of IS.

But we need to go beyond the theoretical. Just as Marxists distinguish between the idea of capitalism and what they call "the real existing capitalism," we also need to distinguish between the properties of digital material as such and the "real existing digital material." The "real existing digital material" has become increasingly infrastructural throughout its history. Looking at the computer first. In the beginning, one computer could run only one application at the time. Then virtualization technology started to evolve, enabling a single computer to appear as multiple machines. This allowed it to run several applications simultaneously and serve a larger number of users in parallel, effectively becoming a shared physical infrastructure for these users. Todays' virtualization technology, i.e., cloud computing, integrates hundreds of thousands of computers within a data centre, making them operate as if they were a single machine. In 2022, Google had approximately 2,5 million computers integrated, operating as a computing infrastructure for millions, if not billions, of users. So, while we often may think of our laptop as our primary computer, it is only a thin layer ¾the 'icing on the cake'¾ on top the global infrastructure where the applications or services we use are running. The infrastructural character of computing is also illustrated by the European Gaia-X initiative, which aims to facilitate the establishment of 'sovereign data centres'.

Research on information (or digital) infrastructures has focused on the growing number of information systems in use in organizations and their increasingly tighter integration within and across organizational boundaries. This growth in the number and degree of integration of information systems is clearly an ongoing trend, resulting in increasingly complex infrastructures that are shared among a continually expanding user base. While more complex infrastructures will have many features in common with existing ones, they will also develop new characteristics that require further research. Here, I will highlight a few examples, focusing on how the scope of these infrastructures is expanding.

Healthcare has been an important domain for me, as well as for infrastructure research more broadly. This domain exemplifies the importance and challenges of information sharing. It also illustrates the growing complexity of the domain, driven by new technologies that generate more information and by increased specialization and organizational diversity. These factors necessitate information sharing among a larger

number of actors. The complexity of infrastructures will continue to grow with the introduction of sensors, specialized solutions for monitoring and communicating with patients at home, AI and ML. A general trend, evident in healthcare and other sectors, is the integration of infrastructures across increasingly larger geographical and sectoral spaces. This is exemplified by EU's European Health Data Space Health Union (called EU4Health) initiatives.

Another domain in the public sector is the European level, for instance, through EU's Pan-European eGovernment Infrastructures initiative. One example is the establishment of EU-LISA in 2011—the "European Union Agency for the Operational Management of Large-Scale IT Systems in the Area of Freedom, Security and Justice." Eu-LISA develops and operates several platforms supporting the control and management of immigration and asylum seekers within the Schengen are including the Schengen Information System (SIS), Eurodac (asylum seekers' fingerprints), SIS and VIS systems, as well as systems currently under development, such as ECRIS-TCN, EES and ETIAS. While each of these systems represent complex infrastructures in themselves, their integration with each other as well as systems used by police and immigration authorities in the member states constitutes an infrastructure of considerable complexity.

Similar developments are occurring in the private sector, as illustrated by the banking sector. Banks started adopting IT solutions to manage their accounts and customers in the 1960s. Today, large banks have several thousand different solutions, integrated in various ways. In a cash-based economy, we interact with banks only directly to deposit and withdraw cash. Today, however, our interaction with banks primarily involves interbank payment services, such as paying bills, shopping in stores and restaurants, and making on-line purchases. In Norway, the implementation of these services started in 1972 when banks established a new organization, BBS (The Banks Payment Central). BBS developed a solution for interbank payments that banks could integrate with their back-office systems, one year before SWIFT was established to develop a solution for international interbank transfers. The first SWIFT-based money transfer took place in 1977. One core element in the payment service was a clearing system called NICS. In parallel, the national bank, Norges Bank, developed a settlement system, NBO.

In the BBS' development of the interbank payment solution, several additional services were introduced. These included ATMs connected to a network allowing any bank customer to withdraw cash from any bank's ATM, BankAxept for card payments in shops and restaurants, which later expanded with BankAccess for card payments on on-line shopping platforms, an e-invoicing solution, BankID (a common identification and authentication service), and a solution for instant interbank payments. These services were developed and operated by a handful of organizations, all collectively owned

by the Norwegian banks. In addition, the largest Norwegian bank, DNB, developed a peer-to-peer payment service for mobiles called Vipps. Other banks also started planning similar services. However, these banks soon realized they could not compete with Vipps, which had already achieved substantial adoption. DNB, fearing competition from Apple and Google, offered to turn Vipps into an independent company collectively owned by all the banks, similar to other service providers. This transition was successfully implemented.

This illustrates that the variety of payment services and the banks' back-office systems together constitute a vast and complex information infrastructure, which has continuously evolved and grown over the years, accompanied by the virtual disappearance of cash and an explosion in electronic transaction. More recently, however, a new trend has emerged. In 2010, BBS merged with its Danish sister organization, PBS, establishing Nets, collectively owned by Danish and Norwegian banks. In 2014, the banks sold Nets to a consortium consisting of the three equity funds Advent International, ATP og Bain Capital. In 2021, the clearing platform NICS were sold to Mastercard while the rest merged with the Italian based payment service company Nexi which is providing payment service in many European countries. The same year Vipps merged with the Danish MobiPay company (where the Norwegian banks own about 72% and the Danish DanskeBank the rest. Vipps and MobiPay also wanted to merge with the Finnish service but was denied doing so by EU. The Norwegian national bank, is also considering replacing the NGO settlement platform with the Eurozone's TARGET2 which is developed and operated in a collaboration by The Banque de France, Deutsche Bundesbank and Banca d'Italia—known as the 3CB

These examples aim to illustrate the ever-growing complexity and expanding scope of information infrastructures in both public and private sectors. However, they also highlight several significant trends. The evolving infrastructures are not just about adding more solutions and connections; we observe that key components of the infrastructures are emerging as platforms and institutions that mediate between traditional entities like banks or national immigration authorities. These institutions and platforms, such as BBS, BankID, BankAxept, and Nexi, are increasing in number and becoming more independent over time. This trend is exemplified by the evolution of BBS, originally owned by Norwegian banks, which became part of Nets, and subsequently part of Nexi and Mastercard. Additionally, the technological and institutional complexity is compounded by the fact that all mentioned platforms, as well as the internal systems of banks and other private companies and public agencies, operate in independent data centres and communicate via services provided by independent network providers.

The infrastructures discussed here represent important examples of digital innovation, contributing to digitalization and digital transformation. In my view, banks have been radically transformed over the years. In a cash-based economy, banks operated as almost entirely independent organizations. However, with the digitalization of payments, banks have become part of an industry that provides payment services collectively. Further, the bank industry now includes numerous non-bank institutions responsible for core banking (payment) services which all banks depend on. This means that this industry can only undergo digital transformation as a whole. This trend is evident in most industries. Thus, one overall one key issue for future research is the tight coupling between the evolution and transformation of industry-wide infrastructures and the digital transformation of an industry as a whole.

In conclusion, I have attempted to argue that information technology—"the real existing"—is continuously becoming more infrastructural, making infrastructure research more important than ever before.

Notes

1. This also includes my passion for wine—he gave his first "lesson" in 1992 when he guided us through Chas.E's wine cellar in Aarhus followed by a wine tasting in the evening and many more wine tastings over the years at his home.
2. Most of Kristen's discussion partners were non-Norwegians, many of them Americans, causing his telephone bills to create major concern for his employers (Norwegian Computing Center (NCC or, in Norwegian, NR) until 1984, University of Oslo from then on).
3. The manuscript was published in a substantially revised version with the title "Dialogue and development—"Theory of communication, action research and the restructuring of working."
4. One of them with the title "Information Infrastructure Development: Cultivating the Installed Base" was published with Kalle Lyytinen as co-author in 2010, with the title "Design theory for information infrastructures: The case of building the Internet."