From Margin to Center: Reframing the History of Women in Computing and Information Technology through Oral Histories

An Oral History Interview with Klara Nahrstedt

Conducted by Bethany Anderson on October 11, 2017 in the Coordinated Science Laboratory, University of Illinois at Urbana-Champaign
Transcription by Alicia Hopkins

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Abstract: Born in Bratislava, Czechoslovakia, Klara Nahrstedt received her bachelor of science degree in mathematics from Humboldt University in Berlin in 1984, and her master of science degree a year later from the same university. After working as a research scientist for several years in Berlin, Nahrstedt moved the United States and received her PhD in Computer and Information Science from the University of Pennsylvania in 1995. Nahrstedt is currently the Ralph and Catherine Fisher Professor in the Department of Computer Science and the Director of the Coordinated Science Laboratory at the University of Illinois at Urbana-Champaign. In this this interview, Nahrstedt describes her childhood and education, as well as her professional path that led her to a career computing and as an educator.

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Part 1:

00:00:02
BA: Today is Wednesday, October 11, 2017, and I'm Bethany Anderson from the University of Illinois Archives. I'm here today in the Coordinated Science Laboratory with Klara Nahrstedt, Ralph M. and Catherine V. Fisher Professor of Computer Science and Director of the Coordinated Science Laboratory, to talk with her about her experience as a faculty member in Computer Science at the University of Illinois and her experience working in the computer science field more broadly. This interview is part of the ACM-funded project "From Margin to Center: Reframing the History of Women in Computing and Information Technology through Oral Histories." So, first of all, thank you for talking with me.

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KN: Thank you.

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BA: To start off, I wonder if you could talk a bit about your background and your childhood. Where did you grow up?

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KN: I grew up in Czechoslovakia particularly in Bratislava, where I was born and then went to elementary school as well as high school.

00:01:00
BA: Great. So, growing up in Czechoslovakia were there any hobbies, or interests, or subjects at school that attracted your attention and that might have paved your way toward your decision to pursue a technical career later on?

00:01:13
KN: So, I had very diverse hobbies. I liked math and particularly, I liked sort of various science aspects. And since I grew up in a family surrounded by scientists and engineers, my—both my parents were electrical engineers at that time and my uncle was an electrical engineer. My aunt was in the electrical engineering field. So, a lot of engineering discussions have been around me. But I also very much like history and I liked languages and one of the reasons was that I also grew up in a very multi-lingual type of environment.

00:02:13
KN [cont.]: Since, for example, my grandparents on the father's side spoke Hungarian. You know, Slovakia had been part of the Hungarian Austrian Empire until 1918. And so, the south Slovakia very much spoke Hungarian and my grandparents spoke Hungarian and so my parents spoke to their parents in Hungarian so I would listen to languages and so, I like them. But of course, also being close to Austria, you listen to German so, it has been quite a, sort of, a multilingual aspect. And then when you go to school, at that time, in Czechoslovakia, you start learning Russian when you are ten years old. And so, you again, pick up on other sort of Slavic languages. And um, so yeah, it was definitely very interesting growing up in that area. And so, languages have been something of interest to me as well.

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BA: So, a question related to that, what languages besides Russian did you formally learn?

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KN: Formally, I learned German.

00:03:29
BA: Mm-hmm.

00:03:30
KN: I, after finishing sort of elementary school, the first couple of grades, I continued in that same school in a German track and that particular school then had a very intensive set of German classes. And so, by the time I finished my eighth and ninth grade, I was pretty fluent in German language. And then, when I went to high school, I learned English.

00:04:11
KN [cont.]: Since I wanted both but German was definitely something that was widely spoken in Slovakia and Czechia since as you know, Czechoslovakia—a big part was surrounded by Austria that speaks German as well as then, Germany.

00:04:30
BA: Mm-hmm. Talking more about high school, what was STEM education like in Czechoslovakia? In addition to other courses that you might have taken in history as you mentioned, and so forth? And how do you think that would compare to what you've observed of education in the United States?

00:04:51
KN: STEM education in Czechoslovakia was outstanding. One of the reasons, I believe, is that the curriculum for sciences was given. Everybody had to take, in the high school, four years of mathematics, at least four years of some science, and one thing that one then had the choice is to go either towards even stronger STEM and science education or towards more humanities, depending on what college you have been considering—

00:05:36
BA: [overlapping] Mm-hmm.

00:04:38
KN: When you were at the gymnasium. And I went to a high school that had a very strong STEM education and so, for me, it was not only four years of mathematics and four years of a science class like physics or chemistry or biology, but I actually had all of them four years. So, you truly got a very good overview of not only math but what physics is about, what biology and

chemistry—and we also had a much more extensive education in mathematics, a lot of preparation for math Olympiads—

00:06:21
KN [cont.]: Had been going on. So, there were no computers at that time but between 1972 and 1976, but we definitely had very, very strong mathematics and therefore very strong preparation for either going to engineering fields like a technical university in Czechoslovakia or going to University of Cominsky which was the university that would take physics, chemistry, biology students. So, I felt that if you attended gymnasium, which is equivalent to the high school in the United States, you were very well prepared to go to a college and out of our class, I would say 95% went to college. Very few that didn't go to college.

00:07:21
BA: [overlapping] Mm-hmm.

00:07:25
KN: Of course, in Czechoslovakia, there was also other track when you finish your elementary, eighth grade or ninth grade, you could go to a trade school. And you would get prepared for being an electrician, being a plumber, being sort of any other skilled worker.

00:07:47
BA: Mm-hmm.

00:07:47
KN: Where you could interlace between regular education, again in math and much more in sort of hands on skills and then, actually work in a factory or in a company that would sponsor you. So, this is currently very much the German system—

00:08:05
BA: Mm-hmm.

00:08:06
KN: Where you have these trade schools. And car companies would train, actually, people between fourteen and eighteen years of age to basically come and then work for their companies. But it's a very rigorous trade school training program and whoever wanted to go to university would go to gymnasium.

00:08:26
BA: Mm-hmm.

00:08:26
KN: And as I said, you could train as a humanity researcher or graduate so you would have much languages, much more history, much more art. Or you would go the STEM. But even those students that would go more towards the humanities, there was a lot of rigor in getting mathematics and at least one science overview over the four years.

00:08:53
BA: Mm-hmm.

00:08:53
KN: [overlapping] Which I find here in the United States, having seen it, seen my son that the high schools give just too much selections.

00:09:05
KN: And sometimes if parents don't pay attention then some of the students select too easy courses that then leave them hanging. Because they are just not well prepared for the college—to succeed.

00:09:24
BA: Mm-hmm. Mm-hmm. We had previously spoken about teachers from this time that had an influence on you. And one of whom, Frau—I'm probably going to butcher her name again so I apologize—Masarikova. Did I say that correctly?

00:09:44
KN: Correct.

00:09:45
BA: Great. [laugh] In what ways did she encourage your interests in mathematics or you know, sort of propelled you, in a sense, toward a more technical career?

00:09:54
KN: Right. So, Frau Masarikova was a math teacher in my sixth to ninth grade, in the elementary school. We don't have, didn't have the elementary and junior high; we had elementary school from first grade to ninth grade, at least at the time that I went to school. And she basically was teaching—starting to teach mathematics after you finished the fifth grade. And she really initiated the love for mathematics, for much more rigorous, logical thinking and she was the reason why I went into the mathematical gymnasium. As I mentioned, I attended high school—gymnasium—

00:10:43
KN: Where there was a much more increased amount of mathematics and STEM education and she was the reason.

00:10:54
BA: Mm-hmm.

00:10:55
KN: She would have these really fun exercises. She would walk into the class and first five minutes, she would walk around us and would give examples. Two plus two, and would point at a student, and you had to put four. And then she would do "Times three!" And then you know, twelve and then "Plus five." Seventeen and then so the students had to be all aware what was said before and what sort of are right answers. And that would go for a couple of minutes and we had been very well, sort of awakened.

00:11:34
BA: [laugh]

00:11:35
KN: And so, she started then teaching—

00:11:37
BA: Mm-hmm.

00:11:37
KN: …the various aspects of the mathematics and explaining much more the processes in mathematics than actually memorization. That was something that I also very much appreciated about her. She much more wanted to know how do you get to a particular result than memorize what the result is.

00:11:59
BA: Backtracking a little bit, you had mentioned at the beginning that your mother and your father, and other relatives, were engineers. In particular, your mother and father were electrical engineers. So, can you talk a bit more about their work and how their work in this profession impacted you?

00:12:24
KN: My father was an electrical engineer looking at much more measurement systems and power grid, electrical grid as well. And he—the second direction that he was very interested in was using computing in education of electrical engineering. So, I didn't understand very much what he was doing but as universities started, end of '60s and beginning of '70s in Czechoslovakia, to contemplate computers for education. My father wanted to develop quizzes for students and then have them respond in a lab on these computers.

00:13:30
KN [cont.]: The quiz questions, and then he wanted sort of statistics on how the class is doing. Particularly because these classes have been like here in state schools, very large. So, he felt instead of writing exam questions in these larger lecture halls that they would go to labs which would have a lot of these computers and he would answer questions on these computers. So, he would bring home some of these Russian personal, more smaller types of computers as I mentioned, they, these particular computers would have all kinds of questions.

They would have small displays where it would have one question at a time. You would answer one, two, or yes, no, or numerical or sort of small sort of short text responses.

00:14:24
KN [cont.]: And so, he would learn how to program them and so, he would sort of for fun program for example, "What is the capital of Russia?" Or "What is the capital of" you know, "Germany?" And so on. So, then he would me, you know, "Go and answer those!"

00:14:44
BA: [laugh]

00:14:45
KN: And so that was a lot of fun to see that at home as he was trying to gain understanding of these computers. I was one of the sort of first subjects, probably.

00:14:58
BA: [laugh]

00:14:59
KN: Just for fun, to see how it works. And that actually had an impact on me that I felt this was something that could be very well used. I hadn't at that time thought about maybe developing computers and so on, but much more using computers for other types of tasks. And some of the other tasks that I was interested in, in high school particularly, was not only mathematics but also, physics. So, one of the things—

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BA: [overlapping] Mm-hmm.

00:15:34
KN: I was contemplating, was to study astronomy. And—but—Then, my father

would make comments, "You know astronomy is a very lonely job." [laugh] "And you want to get married." [laugh] "So, you definitely maybe might reconsider to gain a profession that leaves you in society rather than somewhere in an observatory." [laugh] So, it was very interesting. But yeah, the computers have been coming into my life basically through this educational process that my father was engaged. My mom has been in, also, electrical engineering but she actually branched out instead of going towards the hardware and grid, electrical grid and measurements of devices.

00:16:35
KN [cont.]: She went towards the very beginnings of informatic—

00:16:39
BA: Mm-hmm.

00:16:40
KN: And information technology. As we started to program things and sort of look at thing and my mom then was given a scholarship to Stanford as a visiting scholar. And so, she actually then continued studying more artificial intelligence at Stanford and then she worked at the University of Pennsylvania.

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KN: So, she's currently an expert in robotics and computer vision. So, uh—

00:17:21
BA: [overlapping] Okay.

00:17:23
KN: So, I had these examples of more on the hardware, electrical engineering but then, sort of, my mom being electrical engineering but then basically through other directions she got interested in the informatics and computer science and she went more into these AI and robotics. And currently, she's a professor at the University of California-Berkeley, to teach, actually, and explore the combination of robots and computer vision.

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BA: It sounds like these two different approaches or tracks that your parents took toward electrical engineering, you know, your father investigating more the hardware aspect and the role of computers in education, and your mother more looking kind of more theoretically at information technology and robotics and AI research. So, and we'll talk a little more about your individual research a bit later, but these two different aspects, did—do you think that they influenced your approach as an educator and a researcher as well?

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KN: Yes. Definitely. My father was a very, very good educator and I remember you know, as a girl, sitting in the lecture hall.

00:18:57
BA: Mm-hmm.

00:18:58
KN: And watching him, basically, teach. And so—so, I think I have been around them to talk about certain principles and talking about sort of academic research and education goals. You know, why would you be at the academic institutions versus being in the industry or a research lab?

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BA: Mm-hmm.

00:19:31
KN: And very often it was discussed that, that academic research and academic institutions provide much more freedom—

00:19:43
BA: Mm-hmm.

00:19:44
KN: To explore ideas. And of course, at that time you don't quite understand, as

a girl, and you don't quite know what's happening but [stammers] when I became faced with, "Do I do a PhD or not?" And would have these discussions with my relatives, this particular aspect was brought forward. If you work in industry, there is much more rigorous development of products.

00:20:23
KN [cont.]: You have to consider what the company's interest are to actually deliver things, where when you go to academia, you might not push every, your idea to a product, but you know, the students are the product, right? You impact a lot of students—

00:20:41
BA: Mm-hmm.

00:20:42
KN: Through education and through advising, with working with students. And I like that. I had some experience with teaching. We, actually during high school, since I did excel in mathematics and physics, and some of the sciences, teachers would ask me if I would help other students in the class. And so, I would run tutoring sections.

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BA: Mm-hmm.

00:21:21
KN: I mean, similar as here currently [stammers] in the college, that is happening. So, I ran these tutoring sessions for several students and I liked that.

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BA: Mm-hmm.

00:21:35
KN: [overlapping] So, that was my first sort of experience. I hadn't done that then in the college. And after college, I did work in the industry; in the computer

systems as a systems administrator in the computer science, in the Computer Center for the Ministry of Agriculture in East Germany but—

00:21:55
BA: Mm-hmm.

00:21:56
KN: So, I know what some of these aspects of getting things on time, getting things, products done and so on.

00:22:05
BA: Mm-hmm.

00:22:06
KN: You know, depend on you and then interest for that company, how important that is. So, when I started to think about PhD—

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BA: Mm-hmm.

00:22:16
KN: These discussions with my parents and their view on academia and my own experiences and actually, very much made the decision for me that I did want to do a PhD for the reason to actually become a professor.

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BA: Mm-hmm. Going back to your mother for a minute, was it unusual at all in Czechoslovakia for women to work in technical professions at all, such as electrical engineering? I wondered if you could speak about that. [laugh]

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KN: [overlapping] Yes. So, my mom was the first woman to get a PhD in electrical engineering.

00:22:57
BA: Oh, wow. [laugh]

00:22:58
KN: At the Technical University of Bratislava.

00:23:00
BA: [overlapping] Wow. Wow. [laugh]

00:23:03
KN: So, you can imagine how many women were there, right? [laugh] So, there—After the Second World War, a lot of women did go to school. And the reason is, many men died.

00:23:21
BA: Mm-hmm.

00:23:22
KN: As you know, there has been a huge amount of human life lost after the Second World War. So, women, particularly, I can talk about the East Bloc, like Czechoslovakia, there was a need for women to take places that men used to occupy. So, a lot of women would go to colleges. So, that was in the college level you would see more women, even in technical fields. But then going the next step of getting PhD and going in these technical fields towards more leadership positions and functions was very unusual. It was very unusual. And so, the glass ceiling has been there as well. But you would see in the technical fields, much more women and that was really driven by lack of men.

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KN [cont.]: And basically, being in those positions. So, [stammers] women would be in Tesla. Tesla was a company that produced acoustic equipment. So, my aunt, for example, was an electrical engineer.

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BA: So, this is Tesla, Nikola Tesla?

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KN: Nikola Tesla, that's right. Yeah.

00:24:56
BA: [overlapping] Okay. Okay. So, the same.

00:54:57
KN: This is currently, as you know, Tesla was—It's a big company, was a big company across Czechoslovakia.

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BA: Mm-hmm.

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KN: They would produce, basically, acoustic equipment for recordings for the whole East Bloc. I mean, export to Russia. There was a lot of things that Czechoslovakia was very good in technical areas. If it's mechanical engineering, electrical engineering, and that would be the product which would be the currency to pay to, for example, Soviet Union for oil.

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BA: [overlapping] Mm-hmm.

00:25:36
KN: And gas, right? And for the [stammers] raw materials because Slovakia and Czechia, sort of Czechoslovakia didn't have raw materials.

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KN: So, the currency to pay for was a lot of the fine electronics, core electronics, and vehicles. We would build large cranes, large car companies. You know, Skoda and so on.

00:26:03
BA: Mm-hmm.

00:26:04
KN: So, there were plants all the Czechoslovakia.

00:26:05
BA: Mm-hmm.

00:26:07
KN: So, this particular education was, and is still very well [stammers] very well developed in the engineering fields. Because, you know, when you have a small country, like Czechoslovakia at that time, and now Slovakia and Czechia, you— if you want to compete you have to have a well-educated population to actually compete—

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BA: Mm-hmm.

00:26:31
KN: Further. And you know, you can see this with other small countries like Denmark, right? And Sweden and Norway and so on, where the population is— Finland basically, would have a very well-educated population to compete with other larger countries. Yeah.

00:26:48
BA: Mm-hmm. Mm-hmm.

00:26:49
KN: So, yeah, so basically, we have seen that in Czechoslovakia, that up to a certain point, women have been in the positions but then of course, has been a great big glass ceiling.

00:27:09
KN: And another sort of major, major issue was the political atmosphere.

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BA: Mm-hmm.

00:27:19
KN: That to move up you had to agree with a lot of the political ideologies and if you disagreed in anyway, again, your technical abilities were squished.

00:27:37
BA: Mm-hmm. Mm-hmm.

00:27:38
KN: If you did not agree with the political ideology of the system.

00:27:43
BA: Mm-hmm. So, you eventually left Czechoslovakia for Germany where you enrolled at Humboldt University in Berlin and received your bachelor's degree in mathematics in 1984 and a master's in numerical analysis in 1985. Could you talk about what drove that decision to move to Germany and to attend Humboldt for your education?

00:28:10
KN: So, the move to East Germany was more driven by personal aspects since I met a young German man and got married to him and so I moved to Germany. I met him during one of the sort of summer exchange programs. And so, I was looking for possibilities. He, at that time, studied in the Berlin area so I was looking for a possibility to join him there. And since I liked mathematics, so I

applied to Humboldt University which was the best and closest place to be there and so, I got accepted.

00:29:14
KN [cont.]: And [stammers] I started to study mathematics and you—During the first couple of years, you have to start to sort of decide what you might do for your diploma. So, in Germany, in East Germany at that time they didn't have like a bachelor's and master's separate. It was all five-year programs which basically would have three years of a very basic education. I would compare it to the bachelor's degree and then basically in the fourth year, you start to think about your diploma, like a master's thesis. And computers started to come up—

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BA: [overlapping] Mm-hmm.

00:29:57
KN: At that time, it was around the '80s, early '80s. And particularly, the IBM 360-like computer, right? I mean, you have to sort of understand that there was an embargo on all of the computing developed in the West, and so, what happened in the East Bloc is that the Warsaw Pact and the east European counties and central European countries, socialist countries, are discussing how to develop their own type of computing platforms and it was distributed. So, East Germany had a major development on central unit, CPUs, right?

00:30:52
KN [cont.]: And they built the mainframe CPUs. Bulgaria, for example, developed disks.

00:30:58
BA: Mm.

00:30:59
KN: Big disk drives, right, and so on. So, you had sort of various countries developing certain and they would be assembled computers all across the Eastern Bloc. So, that was very interesting. And I think some of the computers

also would come from the West through other countries that have been friendly to Eastern Bloc countries.

00:31:26
BA: [overlapping] Mm. Mm-hmm.

00:31:30
KN: Like Iran, at that time. So, we would some sort of IBM 360s, end of '70s, early '80s, show up in these universities where then you know, people would be doing reverse engineering on—

00:31:48
BA: [overlapping] Mm. Oh.

00:31:50
KN: Many of these computers. There was no documentation, right? I mean, they would all be illegally somewhere, imported to the Eastern countries. But basically, you would learn as you go and test what is happening. [stammers] So, when I got to Humboldt University and started to look around what I would like to do—

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BA: [overlapping] Mm-hmm.

00:32:15
KN: For my diplômé, or for my diplômé work, I liked some of the information technology that started to be the PDP-11, you know IBM 360s. Replicas.

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BA: [laugh]

00:32:31
KN: And sort of programming, so I started to learn Fortran.

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BA: [overlapping] Mm-hmm.

00:32:35
KN: And I liked the algorithmic aspect of Fortran and solving some of the mathematical problems. And so, I decided to do the numerical, it was more the scientific computing because I did learn I like more the application of the mathematics rather than the developing only mathematical processes and formulas and proofs for the sake of mathematics.

00:33:15
KN [cont.]: So, I liked the scientific computer, now we call it scientific computing; at that time, it was numerical analysis. Because there always had been a problem that industry, for example, placed. So, one of the interesting problems, my professor, Professor Meritz, she worked with a chemical industry on solving some chemical processes that could be formulated as mixed algebra differential equations. But they were huge, right? I mean you are producing polymer, you are producing any of these chemical materials.

00:33:58
BA: Mm-hmm.

00:33:59
KN: And its thousands of equations that basically have to be solved, so the question is, "How can the computer help solving these very mixed equations between algebraic equations and differential equations?" And so, that actually became then my diplômé work, or master thesis to solve it. And so together with her and another student, we had been working programing the computers. You know, we would have these cards, right?

00:34:34
KN [cont.]: So, that was uh—With my father, when he was working on educational computers, he still had the sort of a strip, right? That you would have these rolls of a lot of data that was on that paper roll.

00:34:47
BA: Mm-hmm.

00:34:48
KN: But when I came to Humboldt University and started to work with the differential equations, algebraic equations, and solving metrices, and you know, sort of, writing programs for it. As I learned—I mentioned I learned Fortran then, it was already the punch cards, right?

00:35:07
BA: Oh. Okay. Yeah.

00:35:07
KN: Right, that basically had. So, learning the job control language and so on. So, it was very, very interesting.

00:35:18
BA: Were there any particular courses that you found to be memorable? For instance, any that you used these replica IBMs in? [laugh] If you could speak about any courses you remember.

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KN: [overlapping] So, the IBM replicas, I hadn't gotten to them until I started working.

00:35:38
BA: Mm.

00:35:38
KN: After the mathematics.

00:35:39
BA: Okay.

00:35:40
KN: When I worked in the University on the computers, the computers were hidden.

00:35:49
BA: Oh. Okay.

00:35:51
KN: So, I don't even know what kind of computers Humboldt University had [laugh]. And the reason is—

00:35:56
BA: [overlapping] But they had some computers, then?

00:35:57
KN: They had computers and the reason is that the interface, to me, was a big box full of punch cards.

00:36:05
BA: Okay.

00:36:06
KN: Okay. So, you would have a terminal that maybe you write your code and then there was a front room that basically produced these punch cards, right? But then, basically you would have this big box you put your punch card and programs and you would come to a delivery room that you gave to a person, and the person would walk to a computer behind the glass door and she would—

00:36:41
BA: Okay.

00:36:42
KN: And you would not even see where she goes, but she would actually then

process those particular data. And then, actually, there was another room, Output Room, where you would have your names and there would be a printout. "This is currently what your program looks like. This is currently what your program did." And of course, when you made a small syntactic error, it was like, "Oh, my God. I forgot the comma!" [laugh] You go back, you print off your page. And so, it was like a single program that now basically you have in two minutes or a minute or a millisecond process on your PC or on your laptop. It took two days, right? [laugh] Because one day and then they would run these jobs overnight and then the next day you would get the printout.

00:37:35
KN [cont.]: And of course, if you have dropped the particular box [laugh] with all of your punch cards, putting them together was just really, really something. [laugh] So yeah, so, my whole master thesis was written with punch cards and…

00:37:55
KN [cont.]: But yeah, so we basically in this particular space.

00:38:03
BA: I see. And so the computer was always sort of this hidden component?

00:38:07
KN: Hidden component.

00:38:08
BA: Okay.

00:38:08
KN: Very much controlled. You know, for security reasons.

00:38:13
BA: Mm-hmm.

00:38:14
KN: We were not allowed to go into the room. I remember maybe once I was allowed—My professor, I had some conference deadline and I needed to do that so basically, we got permission to run the jobs under some supervision of an operation during the night.

00:38:39
KN [cont.]: But normally, it was there was an input room and there was an output room.

00:38:44
BA: Mm. Mm-hmm.

00:38:44
KN: Right? And you just delivered your cards, or you got your printouts.

00:38:48
BA: Hmm. So, how many—Did you have a sense of how many computers were available on campus at all or was this the only—

00:38:54
KN: [overlapping] Oh, there was just one.

00:38:56
BA: [overlapping] There was just one. Okay.

00:38:56
KN: There was just one computer center and everybody would go there.

00:39:01
BA: Mm-hmm.

00:39:02
KN: Yeah.

00:39:03
BA: Did you sometimes have to wait a long time because there was a line in front of you? Waiting with their punch cards? [laugh]

00:39:10
KN: Yeah, I mean. Yeah. That's—you would have a queue, right?

00:39:15
BA: Yeah. Right.

00:39:16
KN: Of punch cards.

00:39:16
BA: Mm-hmm.

00:39:17
KN: People particularly for the receptionist to sort of make the entry that you made it. But at some point, they did optimize it that you would have, actually, a, like a big cabinet where you would have names of the professor [stammers] and you know, or a student and then you could just put the punch cards in there and—

00:39:40
BA: [overlapping] Mm-hmm.

00:39:41
KN: And then they would take it out. Now, the problem was if you had more jobs, right? That you wanted to get processed, right?

00:39:46
BA: Yeah.

00:39:48
KN: So, there was also sort of a limit to how many jobs you could actually run per day, for example. Right.

00:39:56
BA: [overlapping] Mm-hmm. So, you had mentioned Professor Meritz that you had worked with. Could you talk a bit more about this faculty member who you interacted with?

00:40:05
KN: [overlapping] Mm-hmm. Mm-hmm. So, Professor Meritz, she was one of the really very early professors, the female professors, at the math department. And she was very supportive of female students, I really acknowledge she was very encouraging and was very supportive. Also, she would very much guide us towards research. So, a lot of the research principles, how do you go about finding related work? How do you organize the related work? How do go about some of the sort of logical processes?

00:41:03
KN [cont.]: She would spend time with me and I mentioned there was another student that we were sort of working jointly. There were, sort of two different types of approaches for solving this algebra differential equations and so she sort of let us work together on these problems. And you know, one of the so interesting things is that both of us had children at the end when we were doing—you know, sort of small children, and so she was very understanding of how you know, we organized our time and [stammers] so I really felt in particular, with respect to me, I had a small boy, so it was really, very, very understanding.

00:41:58
KN [cont.]: But yeah, overall, she was a definitely a role model to how a woman basically can be treated in academia. I never remember that the colleagues would sort of would be disrespectful. I don't know, as an undergraduate student, you

don't have these kinds of conversations. Was there a certain discrimination? Did she feel that she couldn't move up or be in leadership positions because she was woman? But overall, I felt she was very supportive towards us, very understanding. Especially because I had a small child. But she was truly also a mentor and a teacher. You have to understand that class, in mathematics, at that time, we started at 40. By the third, fourth year we were at 20.

00:43:03
KN [cont.]: And so, these—the diploma, she would have a very small group. She would have a couple of the PhD students and postdocs, but the master thesis, she basically had just the two of us. And I was really appreciative that she would spend time—she also had a PhD student that would work with us to sort of train us in some of the aspects and help us. So, overall, I had a very good experience in her group.

00:43:37
BA: Were there many other women faculty members in mathematics?

00:43:41
KN: No.

00:43:42
BA: No, okay. So, was she one of the only ones at that time?

00:43:45
KN: That's what I remember, yeah.

00:43:47
BA: Mm-hmm.

00:43:48
KN: She was really unique. And most, all the other faculty that I remember that worked with us and taught classes, you have to remember that the first couple of

years you have classes but then the third, the fourth, in particular the fifth year, you really only work with your advisor. So, you don't—

00:44:14
KN [cont.]: Interact as much with other—And you take classes in the fourth year and even in the fifth year with your advisor or with the PhD students but they're not really students. They are employees. They just—they are employees that are doing PhD on the side, right? That's a difference to United States where PhDs are student, right? That they are taking classes. That didn't exist, or doesn't even exist now. When you go into a PhD program, you don't take classes.

00:44:51
BA: Mm-hmm.

00:44:52
KN: There is understanding is that your educational development finishes with diplômé or with a master thesis, or with a master degree. And then, when you do PhD you will teach. You would do research but work on your thesis, but you don't take classes.

00:45:15
KN [cont.]: So, we would work with the PhD employees or the postdocs in her group. But the professors that I remember were, you know, there was a Professor Starker and he was very well known, and is very well known, in the petri nets. Petri nets is a computer logic type of tool and concept to model computer systems.

00:45:51
BA: Mm-hmm.

00:45:53
KN: If you want to model certain behaviors of systems then petri nets are one methodology how to model processes in computer systems.

00:46:08
BA: Mm.

00:46:09
KN: And he was very instrumental, very early. You have to think about this is early '80s when he started to talk about these petri nets, develop programming languages, how you can model these computer systems' behaviors.

00:46:27
KN [cont.]: And then validate them, derive various properties, if particular, the system, which moves from one state to another has a loop or has deadlock or— You know, and so on. So, sort of timing behaviors that are—can be represented in the systems, so—

00:46:47
BA: Mm-hmm. Speaking more broadly about your time as a student at Humboldt, what was it like to be a student there? How would you compare it to an American university?

00:46:59
KN: So, you know, I wasn't an unusual student in the sense that I had a child. And so, for me it was you know, going to classes, trying to understand whatever free time I had between the daycare, when my son would go in and I would pick him up, I would sit in the library and do homework.

00:47:31
KN [cont.]: Because I, you know, at 3:00 or 4:00 you pick up your son and then spend time with your son either at the playground, and you know, in the evening, maybe even the son sleeps and you know, you have husband, right? That also wants attention.

00:47:50
BA: Mm-hmm.

00:47:51
KN: We would chat and sort of talk. So, I think I have had much more focused time as a student.

00:48:03
KN [cont.]: Much less participation in any clubs or any extracurricular activities. My extracurricular activity was being a mom. [laugh] And now, there were many students that had children. And so, I want to sort of comment this is something that is very unusual for United States. In East Germany, the social programs were incredible. So, one of the major goals for the East German government was for young women to have children before the age of 21. They did understand that the older you get, the harder it gets. And so, they basically created all kinds of programs in colleges so that young girls and boys—men and women—would have children during their college time.

00:49:09
KN [cont.]: You would have, I would have classes or one on one tutoring with a professor to accommodate me.

00:49:17
BA: Wow. Hm.

00:49:19
KN: When Peter would be sick, my son.

00:49:20
BA: Mm-hmm.

00:49:21
KN: Or when I couldn't go to class. Or when the daycare would close. There were some classes that were, you know, 5:00 or 6:00 p.m. I said, "I cannot attend it." So, I would have a special tutor session.

00:49:34
BA: Mm-hmm.

00:49:36
KN: So, the daycare that my son would go in was free. I would get money, stipend, to have a child. So, I could live on this. I mean, both my husband at the time and I, were students. We would get stipends because we had a child.

00:50:00
KN [cont.]: So, it's unusual.

00:50:02
BA: Mm-hmm.

00:50:03
KN: But we lived in a dormitory— where basically I lived where other students had children. And so, there was another classmate of mine who also had a daughter and so we would babysit each other, right? If one had to sort of work on something, then the other would babysit and so on. And that was really something that the whole dormitory was apartments with students who had families.

00:50:36
BA: Mm-hmm.

00:50:37
KN: And so, in that sense, being a student at Humboldt University, for me, it was truly developing these relationships with students who were mature.

00:50:53
KN [cont.]: Because when you started to have a family, right? And you know, some people moved in when they were in their third year, fourth year, because that's basically when got their babies and so. The day care was very close to that particular dormitory so we could actually drop off the children and then take the

subway or Stadtbahn to Humboldt University and then come back and then get those. So yeah, so it was for me, being a student was developing a discipline. We actually started with quite a large number of women but it did require discipline.

00:51:34
KN [cont.]: A lot of the women didn't finish. Out of, I think it was like ten women—um, only four finished.

00:51:45
BA: Hmm.

00:51:45
KN: So, being a student for me, at that time, it was really, very being rigorously disciplined.

00:51:52
BA: Mm-hmm.

00:51:53
KN: That whatever free time I had was being concentrated on doing homework. For example, when I started, Peter had a lot of ear infections. So, it was like three weeks being at home, one week being at school.

00:52:10
BA: Mm-hmm.

00:52:11
KN: Three weeks in home, or in this apartment, dormitory apartments. And you know, my husband at the time, he was going to school, now the school wasn't directly at Humboldt. It was another sort of school, but so, so, during the week he was in the dormitory because it was a larger distance.

00:52:28
BA: Mm-hmm.

00:52:29
KN: But so, these other friends [stammers] or classmates would take notes for me and then I would sort of have to make up. So, that the experience that--

00:52:40
BA: Yeah. Wow.

00:52:41
KN: Actually, then served me very well when I would be a PhD student because the level of understanding that you have an hour—

00:52:52
KN [cont.]: Or two hours. You have to get concentrated. You can't sort of start to do something else because you know by that time somebody else needs you.

00:53:01
BA: Mm-hmm. Yeah. So, the support for families and for women pursuing education at a university, was this typical of a lot of East German universities or was it more so at Humboldt that way?

00:53:18
KN: [overlapping] No. It was across East Germany.

00:53:20
BA: [overlapping] It was across, okay.

00:53:22
KN: The social programs, overall, so for example, when I started to work—

00:53:28
BA: Uh-huh.

00:53:30
KN: In East Germany they would have one day, I think a month, and it was called Household Day.

00:53:39
BA: [overlapping] Mm-hmm.

00:53:41
KN: And that was the day where you could stay at home and clean up your apartment. [laugh] And—Or do other things. So, the child would be in the daycare.

00:53:53
KN [cont.]: Or in the school. But you would have a time for yourself.

00:53:55
BA: Okay.

00:53:57
KN: So, that was usually the time you wash your windows, or [laugh] you do something else, basically, that you know you just don't have time when you have a family around.

00:54:08
BA: Mm-hmm. To talk a bit about your master's degree, so you ended up studying numerical analysis, could you talk about your path toward that subject more specifically?

00:54:26
KN: So, I, quite early when I started mathematics, you—In the first and second year you get very good understanding of what's algebra.

00:54:41
BA: Mm-hmm.

00:54:42
KN: What differential equations are. What some of the logic, some of the sort of directions of mathematics and you get some of the matrices, calculus, and so on. And I also started to take Fortran and other programming languages. And so, there was [stammers] the discussion in my mind, in the second and third year, what would I really enjoy? And you know, you sort of get to know yourself, right? Do I enjoy, you know, proving—and I sort of exaggerate, but there were students who basically said, "Can I prove a theorem?" Right? There are some outstanding challenges that, you know, you basically, in algebra or in calculus and so on. And I felt I wasn't—not quite good enough. But there was a—I maybe didn't have as much deep understanding.

00:56:05
KN [cont.] Maybe didn't have as good visual representation of some of the large spaces that you need to have. You know, we have all different talents. But I took a class in Fortran and in programming and in formulating, algorithmically, these various problems to automate some of the mathematical processes. And I just loved it. I uh, you know—

00:56:40
BA: [overlapping] Mm-hmm.

00:56:40
KN: It's the—What I'm saying is some of these others I'd think, "Well, okay." But I just didn't enjoy them. I didn't have the same intuition as other students had, right? Some of the students would see, "Okay, I proved this and then I can prove that and I can branch off." I didn't see that but I saw much more, I get a problem, maybe there's a part of the engineering, you know, if I developed these algorithms, and how do I optimize these algorithms? How do I do get better

solutions? And so that's basically where the numerical analysis actually then really fit very well in the math department.

00:57:24
BA: [overlapping] Mm-hmm.

00:57:27
KN: This whole sort of the much more applied, but the algorithmic, the informatic, like type. Remember, informatic and computer science didn't exist at that time.

00:57:37
BA: Mm-hmm.

00:57:38
KN: Right? Between 1980 and 1985. So, that was truly an issue, right? What do you do? We had a computer but math, actually computer science, really then developed out of the mathematics that Professor Starker, you know, Professor Meritz, actually after I finished, then they started to talk about developing an informatic department and so on.

00:58:07
BA: Mm-hmm.

00:58:08
KN: So, I think I truly then like that particular area.

00:58:13
BA: Mm-hmm. Mm-hmm.

00:58:14
KN: And that was actually also the reason why, because I had Fortran, I had a

certain algorithmic understanding how to solve these large scale mathematical problems. How to organize them in the computer, right?

00:58:30
KN [cont.]: I had a much better understanding of the memory, and the processor, and these algorithmic aspects that my job then, basically after I finished the diploma was in a computer center.

00:58:44
BA: Mm-hmm. Mm-hmm. [non-interview dialogue]

End of part 1

Part 2:

00:00:01
BA: Okay. After you graduated with your master's degree, what was your first job and where did you work?

00:00:10
KN: So, my first job was in the computer center of the Ministry of Agriculture.

00:00:20
BA: Mm-hmm.

00:00:21
KN: And the reason was that, there were a couple of reasons, but one of the reasons was that working in mathematics and numerical analysis was very difficult. It—you either had to wait until somebody died or retired. [laugh] Some positions in academia or some institutes that have been employing numerical analyst. And also, I wanted to stay in Berlin. I didn't want to go to some outskirt places, particularly chemical industry. The air pollution had problems.

00:01:24
KN [cont.]: You know, I had a small boy. By that my marriage didn't work, so I basically wanted to stay in Berlin where the job had been broader. The air has been cleaner. And therefore, I tried to utilize the knowledge that I had in Fortran, in programming, and interest in informatic. So, this first job in the computer for Ministry of Agriculture was very interesting because I worked for basically two years as a system administrator. And that has been a very valuable experience on multiple levels.

00:02:26
KN [cont.]: One was that I did get to work with customers so I would write programs for customers. We would get requests from various agriculture corporations to retrieve data. They would want to have certain overviews. Remember at that time networks, digital networks, did not exist.

00:02:52
BA: Mm-hmm.

00:02:53
KN: Right? It's 1985 and there are just these [stammers] mainframes. So, you would have personal computers but they would not be connected to the mainframe. Many of these agriculture co-operatives around Berlin would have their own PC but they would have the floppy disks. They would put data into the computer, store on the floppy disks, and then I would usually travel [unintelligible] sort of to get there, pick up the floppy disks and then enter them into the mainframe and do analysis on the data. And then, you usually would either call them you know, "This is currently what some of the yields are. What is currently compared between your yields and other cooperative yields and so on."

00:03:54
KN [cont.]: I got to really see working with these customers, working with people who are dependent data and need the analysis and how to program you know, in some way but also debug.

00:04:12
BA: Mm-hmm.

00:04:13
KN: Very often, you know, some of the systems that we got we wanted to do certain operations, it—you didn't have a manual to actually see how to do that. So, one had to do a lot of reverse engineering, right? One would get the core done and then goes through the hexa.

00:04:37
BA: Mm-hmm.

00:04:38
KN: And sort of trying to figure out where are, currently, some of the errors. Or how can you speed up certain operations? Because there was a lot of data and things took time and you have deadlines by when you have to provide, either to the Ministry, various results, or to the cooperatives because their harvest wouldn't wait, right? And so on. So—so that was really valuable lessons and the patience, the pressures on system administrators, to deliver certain things towards customer satisfaction. The second thing that I really felt was very interesting in this job was that it really got me to think about more efficient IT and computing.

00:05:33
KN [cont.]: I, maybe because of the mathematical background and algorithmic background, that you want to optimize processes.

00:05:42
BA: Mm-hmm.

00:05:43
KN: So, you would ask questions, right? You would want to develop various procedures, routines in the computer, and outside of the computer, that speed up things.

00:05:54
KN [cont.]: You know, "Why are we doing things as we are doing them?" My boss would go, "Well, because this is how we are doing for the last X years." [laugh] So, you know, you could sort of question the status quo.

00:06:02
BA: [overlapping] Mm-hmm.

00:06:04
KN: So, one of the things that at the time started to pop up was digital networks. So, one of my colleagues, who was more senior to me, and I basically started to talk about, "How about if we connect the agricultural PCs to the mainframe? Then I don't have to travel but you know, it might be basically faster as we get the data; then we can process them more efficiently." So, during the, I would say, second half of my time at Computer Center I worked very hard on internetworking the agricultural cooperatives in those villages with— basically working with the Ministry to lay copper networks, wired networks, and then develop and install the software for X25; which was the network that the European countries actually went to do digital networks.

00:07:17
KN [cont.]: You know, in United States at the time, it was the Arpanet, right?

00:07:21
BA: [overlapping] Mm-hmm. Mm-hmm.

00:07:22
KN: And then it was the NSFnet, right? And so on. In Germany, East Germany particularly, it was the X25 standard—

00:07:30
BA: Mm-hmm.

00:07:31
KN: [overlapping] That they basically are—were—pushing. And so, yeah, I was there when basically, we had been starting to see first bits [laugh] coming from those computers. And as I said another thing that we have been pushing and I have been part of the team to put the terminals, time sharing terminals, connected directly to that particular mainframe so that you could upload the programs directly without sort of these punch cards. That was actually really major achievement because of—there were just so many errors through the punch cards and the process was just so much slower. But I still remember the punch cards, basically.

00:08:12
BA: Mm-hmm.

00:08:13
KN: The first year we had them. But then the [unintelligible] or the time-sharing terminals and the X25 networking really started to come up '86, as I basically had been there. But then, an opportunity opened up at Academy of Science, particularly the Institute of Informatic where I could get a position and I wanted a more research position.

00:08:47
KN [cont.]: I started to see myself you know, any idea, as I said there was a lot of boom. I would through some of the magazines. So, I read quite well English. Russian and English both. And so, you would see a lot of development and you would come to your boss and they would say, "No, no, no! We are not doing this way!"

00:09:10
BA: Hmm. [laugh]

00:09:11
KN: You know, so I felt a lot of sort of the [unintelligible] on this level. And so, it started to get a little bit stifling. So, I hoped that in the Institute of Informatic, because it was a research institute, the Academy of Science had the general means with more freedom. And so, I switched to Institute of Informatic as a

research programmer at that time. And so, I started to learn new programming languages and so, in the Center for Computing, I would program Fortran and I would program some assembly languages when I came to the [stammers] Insitute of Informatic. Again, Fortran was, Assembly was basically, Pascal was the language that we had been starting to sort of develop.

00:10:05
BA: [overlapping] Mm-hmm.

00:10:09
KN: And some sort of interesting new applications started to come so that the digital network, the X25 network started to become more ubiquitous.

00:10:20
BA: Mm-hmm.

00:10:21
KN: [overlapping] Within the East Bloc by '87. And so, new applications started to come and one of the was Mailing System X400 and also Directory Service X500.

00:10:39
KN [cont.]: And you know, you have to understand that basically [stammers] the East German government would [stammers] give directives. You know, we basically want to get these particular standards implemented. To give credit, actually, they wanted the standards so that basically different countries can interface. So, this overall aspect of interconnectivity because the central and eastern countries depending on each other, as I mentioned, they produced different pieces in different countries, so this interoperability was very important.

00:11:18
BA: Mm.

00:11:19
KN: And that sort of manifested itself also in the informatic so that then, I felt this push towards going towards these standards that started to come from the West. The ISO Standard, right? The International Standard Organization that put out the x-frame. The institutes in East Germany, and across the countries in Eastern Bloc, they wanted to implement so that they can interface and at some point, probably hoped interfacing to other software. So, in the software race, that was the goal. And so, I actually had been working the X 400 mailing systems.

00:11:58
BA: Mm-hmm.

00:11:59
KN: And what was really very interesting was sort of '88, '89, some of the new standard—You know, the standards get proposed then basically some organizations, groups start to implement some of the standards. They come back and they say, "This doesn't work. This works." And so on.

00:12:22
BA: Mm-hmm.

00:12:22
KN: And then sort of new versions of the standard comes. And so, one of the versions that came about was that, "How about if in the mail system, e-mail systems, we also would send images or voice?" And I got fascinated by that.

00:12:41
KN [cont.]: Basically, since you know, as we know, a picture can represent a thousand words. [laugh] You know so, I wanted to understand how to represent the images in the email messages and so on. So, that was some of the work that I had been doing and also interfacing, another one of my colleagues was doing the Directory Service X 500. Which was also important because you need to index certain messages. You have to record databases, right? [stammers] And so, we were working how these sort of email systems—the front and the back end and so on.

00:13:25
BA: Mm-hmm. So, did your interest in multimedia systems emerge from this context?

00:13:30
KN: That's correct.

00:13:31
BA: Yeah.

00:13:32
KN: That actually was really the first time that I basically got to think about and solve some of the software with respect to images, with respect to voice possibilities. Remember at that time, actually there wasn't some of the voice digitized yet. That started to come '87, '88. Images were much earlier than the digital voice and the reason was that you need, for digital voice, very good quality, very fast digitization, analog to digital translation has to happen because many of the microphones, basically, are analog.

00:14:15
BA: Mm-hmm.

00:14:15
KN: And you need to sort of translate it into a digital space, and so on. So, but in the eighties a lot of the multimedia images and images actually started much earlier, in the beginning of the '80s, to be digitized. But audio came a little bit later, which was Xerox's part.

00:14:34
KN [cont.]: They have been very instrumental. So, we had read the standards but we didn't have the technology for sounds. But we did have technologies to visualize all the imaging.

00:14:48
BA: Mm-hmm.

00:14:49
KN: So, that's actually what could have been involved and into the email systems.

00:14:52
BA: Did you have many female coworkers at either the Computer Center of the Ministry of Agriculture and at the Institute for Informatic, respectively? So, could you talk a bit about how many women you were working with in each place and what the sort of general environment was, in terms of gender, in a sense?

00:15:19
KN: So, the number was zero.

00:15:21
BA: Mm-hmm.

00:15:22
KN: So, I was the only woman and definitely in the Center of Computing, there—the group that I was, with respect to the email systems and the network systems, there wasn't a woman. But there were other women in other groups of the more sort of—in some of the AI.

00:15:46
BA: Mm-hmm.

00:15:46
KN: [overlapping] Or maybe some of the other sort of areas. So, that was actually a big surprise to me why the computing area didn't have more women because when I was in the mathematics, I would see more women, right? Of course, my advisor was a female professor. So, I wasn't quite sure what was it that the networks or the hardware or that there was my boss then in the Center of

Computing was a man. All of my sort of collaborators that I worked with were men. The women that I would see were much more into agricultural cooperatives that would enter the data.

00:16:33
KN [cont.]: That was—but having somebody who would code and work on the software and hardware, now some of the men would say it was hard work. And it's true that the old mainframes would have these hard, large disks, big cylinders that you would actually have to move from one place to another.

00:16:57
BA: Mm.

00:16:58
KN: And that has sort of a decent weight, right?

00:17:00
BA: Mm-hmm.

00:17:01
KN: So [stammers] so I definitely encountered much, much more women at the Humboldt University in the math department. As I mentioned, my collaborator on diplômé or the master thesis was a female. It was Margaret Brown but—my female advisor was there, but I sort of moved to the workforce, in my immediate neighborhood there were no women.

00:17:34
BA: Mm-hmm. So, what year did you move to the United States?

00:17:41
KN: I moved to the United States in 1990.

00:17:44
BA: 1990, okay.

00:17:45
KN: Mm-hmm.

00:17:46
BA: And five years later, you received your PhD from the Department of Computer and Information Science at the University of Pennsylvania. First of all, could you talk about why you decided to move to the United States to pursue your doctoral degree? And then secondly, why you chose the University of Pennsylvania?

00:18:07
KN: I decided to move to United States, again for multiple reasons.

00:18:16
BA: Mm-hmm.

00:18:17
KN: The first one, the same way as I moved to Germany, for personal reasons, also, I moved to United States for personal reasons.

00:18:27
BA: Mm-hmm.

00:18:28
KN: My mom was then here. And she was a professor at the University of Pennsylvania. So, I wanted to join her with my son. And the second reason was that I wanted to be part of much more, speed up of the computing revolution—

00:18:57
BA: [overlapping] Mm-hmm.

00:18:58
KN: That has been happening. That's the second reason. And then the third reason was, remember 1989, 1990? When the wall came down?

00:19:07
BA: Mm-hmm.

00:19:09
KN: The environment in Germany, but also in Czechoslovakia, right? There was this progress spring. There were a lot, a lot of uncertainties and I felt that this was not a good time to be a single mom. [stammers] There were all kinds of rumors about certain organizations being closed.

00:19:41
KN [cont.]: Basically, you know, you just didn't know, right? With the opening of the Wall, it just gave the opportunity, "Let's get out of here!" And it was the best decision I have ever made.

00:19:56
BA: Mm-hmm.

00:19:57
KN: Because, true enough, in the East part of Germany, 1990, 1991, 1992, had been tremendously uncertain.

00:20:08
BA: Mm-hmm.

00:20:09
KN: Environments. Many groups got closed. Of course, centers got closed. People migrated back and forth. And so, doing science in that environment, many of my East German friends and colleagues would say, "It was impossible. You have been worried about your everyday life, bread and butter, basically."

00:20:40
KN [cont.]: But not about science. So, because of my mom being here in the United States, she provided me with a green card and for my son. And provided the peaceful environment for me to go back to school.

00:21:01
BA: Mm-hmm.

00:21:02
KN: As I mentioned, I did feel certain constraints when you are in the industry that actually also manifest itself in the Institute of Informatic. That as a diplômé person, a master's [unintelligible] student and employee, there was only so much you could do.

00:21:24
BA: Mm-hmm.

00:21:25
KN: The—Many of the fun decisions and research would be given to people who have PhDs. So, when I came to United States, as a reunification person, then I wanted to go back to school so that I have A) a better chance to find a job here in the United States and B) I wanted much more the scientific freedom and do much more research then, then what I had done—

00:22:03
BA: Mm-hmm.

00:22:04
KN: In industry in East Germany. And you know, I wanted to see if I could get the education to teach in the future.

00:22:16
BA: Mm-hmm. So, what was it like to be a computer science student at Penn? How would you describe that?

00:22:23
KN: So—So, it was, again, very interesting because even though I um, in East Germany, in my neighborhood, as I worked, there were no women. I never felt discrimination, any changes that I was woman or not. There was just not enough women.

00:22:58
BA: Mm-hmm.

00:22:59
KN: And you know my friend, for example, Margaret, with whom I did the master thesis. She went to other type of organization in the computing. We graduated twenty people from the math.

00:23:15
KN [cont.]: From those maybe four or five had taken some programming. So, it was so in the infancy where the industry really started to pick up on, so there was just not enough people. So, but when I came to UPenn, very few women but the other interesting thing that I would start to hear was, "You know, there are enough women but they don't want to go to IT fields."

00:23:41
BA: [overlapping] Mm-hmm.

00:23:42
KN: "To computer science field." And so that was a big difference, that suddenly you—you would face these other issues in a different culture where women had the opportunity, have the option, but are not going into those fields.

00:24:15
BA: Mm-hmm.

00:24:16
KN: So, in the Systems and Networking Group, where I was, Professor Jonathon Smith was my advisor, there were no women.

00:24:24
BA: Mm-hmm.

00:24:25
KN: So, he was fantastic. He was very understanding. Again, I had a son. And so, but other groups, would have female students.

00:24:40
BA: Okay. Yeah.

00:24:41
KN: But now, in comparison to the Humboldt University none of them had children.

00:24:47
BA: Mm.

00:24:48
KN: Right?

00:24:48
BA: Mm-hmm.

00:24:49
KN: I mean, I would be the odd man in that—or odd woman—in that particular group.

00:24:55
BA: Mm-hmm.

00:24:56
KN: So, again, for me to be a PhD student I probably was much more [stammers] a very different student because I would get to the lab at eight, when Peter would go to school, and then I would study. I would go to classes. Whatever free time I would basically say, "Guys, I cannot talk. I need to code." [laugh] Or "I need to do something. I need to do my own work." Or I would disappear in the library. And by 4:00 or 4:30, I would leave to pick up Peter from the after-school program; where my lab mates would go for a beer, you know? Socialize, right? And then in the evening they would come to the lab.

00:25:44
KN [cont.]: So, so I think it has been a little bit different than for other American or other international students who don't have those obligations.

00:26:00
BA: Mm-hmm.

00:26:01
KN: But it has been a fun time. It has been fantastic that there was a lot of new courses. I had to learn a lot. I mean, the industrial experience, being a system administrator, being a [stammers] then in the Information Institute of Informatic helped me tremendously to focus, to understand certain behaviors, some of the certain things I had to basically learn. So, it was a tremendous learning curve.

00:26:41
BA: Mm-hmm.

00:26:42
KN: And I enjoyed many of the classes. And again, I—because of the work that I had in [stammers] on the mailing systems, on the networks, I wanted to go into that area.

00:26:55
BA: Mm-hmm.

00:26:56
KN: And as I said, that's an area still quite low in terms of number of women in computing. Even now, which is very surprising. But I also made a lot of friends since I was in the robotics labs working on tele-robotics there were more women; and I made a lot of friends.

00:27:19
KN [cont.]: There were also female faculty but also much more female [stammers] woman students.

00:27:27
BA: Mm-hmm. So, going back to your advisor, who you just mentioned, Jonathon Smith. Could you talk about your relationship with him and the one question I have is, did he help steer more toward this direction with networking?

00:27:44
KN: Yes. So, Jonathon was tremendous advisor in the sense of giving you freedom. You know, there are sometimes advisors that basically say, "You know, this, this, this, this." And we have to do it. So, at the time when I came, I joined a project called "Aurora." It was a joint project to develop high speed networking between the University of Pennsylvania, IBM, MIT, and some other sort of organizations. But Jonathon was much more a low-level hardware operating system person, some sort of networking interests. And I came from Germany and I explained to him what I do.

00:28:43
KN [cont.]: I said, "You know, I'm much more in application level networks."

00:28:44
BA: Mm-hmm.

00:28:45
KN: You know, I understand the network but I basically built the more distributed systems software and so on. So, I think he embraced that, even if he was sort of lower in the protocol stack.

00:28:59
KN [cont.]: And worked with me on various aspects of applications. He created this connection to the robotics and he says, "You know, there are people who need some of these more distributed systems, software and networking that sits on high speed networking. You know, why don't you take over that kind of project?" And that was fantastic because I started then to work with robotics people and started to understand some of the requirements they had as applications, they need real time. That they need very high-speed control of remote robotic hands. And that actually then got me to think about how do we map their robotics control software down to the network?

00:30:00
BA: Mm-hmm.

00:30:01
KN: And so, my whole thesis then really became to think about quality of service because the interesting thing was the robotics remote notes would be robotic arms that would grab something.

00:30:18
KN [cont.]: But would be also be computer vision camera, to actually see what the hand is doing. And when you look at what kind of information the hand or the camera provide, they differ quite a bit.

00:30:32
BA: Hmm.

00:30:33
KN: And so, how do you map and what kind of real time guarantees the

network has to provide both to get to the remote operator information from the camera or from the hand in order for the operator to manipulate it is different.

00:30:54
KN [cont.]: And so, I started then to develop these quality of service concepts for the tele-robotics, developed brokerage capabilities. Sort of the broker and mapping actually from the application level parameters that the operators understood. "Move this particular hand five centimeters to the right, to the left." Right? In [stammers] You know, and this particular delay, that had to then be translated into, "Open that particular connection. Put a bound on ten millisecond delays." And so on.

00:31:34
BA: [overlapping] Mm-hmm.

00:31:37
KN: So, so yeah. That was it. And then we basically modeled the protocols, the translation capabilities and Jonathon has been very supportive.

00:31:47
BA: Mm-hmm.

00:31:48
KN: I remember he would take me out for afternoon coffee or beer, whatever, sort of. And on the napkin, he would just sort of [laugh] draw pictures and we would sort of brainstorm you know what has to be done and if I would hit a roadblock, "Well, let's talk it out." Right?

00:32:10
KN [cont.]: And so on. So, incredibly supportive to give me this freedom and also helping me formulate some of the ideas. As a PhD student, sometimes you are so embedded in the details that you just don't see where actually your contribution is, right? And Jonathan took the time through our coffee breaks or through our meetings to listen, "What am I doing?" You know, "How am I?" And

basically, then really much more generalize it and put sort of abstract spins on that.

00:32:49
BA: Mm-hmm.

00:32:50
KN: What the community actually then understood as a quality of service broker, brokerage. And there has a big flurry of brokerage services because people understood that this is currently important that the applications and users, now currently we have talk about quality of experience. At that time, with Jonathon, we talked about quality of user.

00:33:15
BA: Mm-hmm.

00:33:16
KN: Right? Sort of what's the user's quality, right? The user, what would you see on your video display is very different from what the networks see, right? And that kind of translations and services that need to actually be between the application and the user and the network are very important.

00:33:33
BA: Mm-hmm.

00:33:34
KN: So, I give credit Jonathon really helping me.

00:33:37
BA: Yeah.

00:33:37
KN: Formulate a thesis this way.

00:33:38
BA: Mm-hmm. So, how did your interaction with early precursors to the internet, in Germany, and thinking about you know, sort of networking protocols, sort of inform this work that you ended up pursuing as a doctoral student?

00:33:56
KN: So, in Germany, the—I mentioned in the center of the Ministry of Agriculture—

00:34:04
BA: Mm-hmm.

00:34:05
KN: They started to look at the X25.

00:34:07
BA: Mm-hmm.

00:34:08
KN: Now, the interesting thing was that the philosophy at that time was, there is going to be full circuits. That, you know, the center and the receiver would be constantly in communication. And so, setting up these circuits was—took some knowledge. And I always sort of though, "My God. You know, how do we—how are we going to built these systems?" You know, in the agriculture cooperatives, they did not know how to all set up these circiuts and how we are sort of going to be working on these application setting. And so that actually sort of got me thinking about—

00:34:56
BA: Mm-hmm.

00:34:57
KN: Sort of how—that's why I started to work on the mail over X25, how these applications start to sort of work with the networks.

00:35:04
BA: [overlapping] Mm-hmm.

00:35:05
KN: When I came to the United States, I got exposed to internet. Packets. No circuits.

00:35:16
BA: Mm-hmm.

00:35:17
KN: Right? And so that was sort of eye opening, that there is just much more freedom. But there was also another set of networks and that was the ATN networks. And the ATN networks were interesting because they had circuits but it was virtual circuits.

00:35:41
BA: Mm-hmm.

00:35:42
KN: And for this real-time traffic, I needed some kind virtual circuit to send real time traffic between the robot operator and the remote hand, or the command. So, all of this information of the X25, very fixed circuit type of networks and the application, like the email system, that was in real time, right? So, at that time I was actually wondering, "Why do I need, for email, this kind of really fixed set up networks?" Then, coming to US, I thought, "Oh! The email could use the internet." Because it doesn't need, in real time, everything.

00:36:29
BA: Mm-hmm.

00:36:30
KN: But then when we started to work with robotics groups, and on the tele-robotics, I thought, "Let's go back to the circuits." But the virtual circuits were much more flexible. You set up the circuit, if you don't need it you close it and

then you open another circuit. So, you don't—you didn't sort of have to build something fixed and constantly use it.

00:36:48
BA: Mm-hmm.

00:36:49
KN: So, I think all of these pieces of information actually really helped me to acquire certain pieces of the concepts and understanding why they are good for somethings but not good for something else.

00:37:06
BA: Mm-hmm. Mm-hmm.

00:37:07
KN: And this trade off analysis, you start to learn, right? As a PhD student, and also as a professor, and I try push this kind of questioning and knowledge also in my students that you know, there is not solution for everything, right? There is always trade-offs and the big success, I think, to find the right sort of solution for the right problem.

00:37:35
BA: Mm-hmm. So, could you talk about your dissertation and how did this, all of this work, lead up to what you decided to work on for your dissertation ultimately?

00:37:47
KN: So, the—My dissertation started through this research assistant project that I became part of it and that's Aurora. So, I would take networks with Jonathon Smith, and there was also another professor, David Farber.

00:38:11
BA: Mm-hmm.

00:38:12
KN: He was then on my PhD committee. And they taught courses where they talked about some of the X25 through the network that the Europeans went to that was really very fixed and not— very static. And then they started to talk about internet, right? So, packet based networks and very flexible, you know, every router decides where to go. And then they talked about ATN networks and those were basically new networks that the Aurora project actually had as a goal to investigate for real time communication.

00:38:52
BA: Mm-hmm.

00:38:52
KN: [overlapping] But also for just very high sort of output, high bandwidth networks. So that was really the background that I got to see these different types of networks, different types of protocols. I was, first time, at the University of Pennsylvania, introduced to TCP, IP Protocol Stack, right?

00:39:11
BA: [overlapping] Mm-hmm.

00:39:14
KN: I didn't know about that, right? In Germany the X25 basically was protocol stack, on top of it you had the application. But as I said, it was very static because at that time basically there was just very few applications and there was, you know, not an anticipation that there will be millions of notes, right? Until there was just, "Okay. Ministry's going to talk to very, very strategic set of notes that was about it."

00:39:40
KN [cont.]: So—so that was the, really, precursor that I got interested in these networks. I also was a teaching assistant to Jonathon. And he was teaching he was teaching more like a systems programming, operating system and I got to learn much, much more about the complexity of the system, moving the data between the networks and the applications and really formulate that and so on.

00:40:11
BA: Mm-hmm.

00:40:12
KN: And then came my qualifying exam. So, in the qualifying exam, the qualifying exam consists of written exam and then an oral exam. And in the oral exam, I came during my networking class we had a book from Tanenbaum and—

00:40:39
BA: I'm sorry, from whom?

00:40:41
KN: Tanenbaum.

00:40:42
BA: [overlapping] Tanenbaum.

00:40:43
KN: Professor Tanenbaum.

00:40:43
BA: Okay.

00:40:44
KN: He is a professor in the Netherlands.

00:40:45
BA: Okay.

00:40:46
KN: And he wrote this really famous—

00:40:49
BA: [overlapping] Mm-hmm.

00:40:49
KN: Network books. I actually knew his network book when I was studying X25 in East Germany, so that particular book was already well known.

00:40:59
BA: Mm-hmm.

00:41:00
KN: And when I came to University of Pennsylvania, I think we had like a second version, learning networking from his textbook. And one thing that caught my attention was that he started to talk about quality of service, what kind of connection you might set up between sender and the receiver in your networks.

00:41:23
BA: Mm-hmm.

00:41:24
KN: So, in particular at that time, this was in 1988 or '89 type of textbook, very early version that he basically said, "You know, as we sort of start to think TCIP, there could be in the IP Protocol, metadata header could be a type of service bit, or bits, to actually specify how long should you actually take to set up a connection between the sender—

00:41:52
BA: Hmm.

00:41:54
KN: And that could actually quality. If something is set up slow or something is set up fast."

00:41:59
KN: Right?

00:42:00
BA: [overlapping] Mm-hmm.

00:42:01
KN: So, it caught it my attention. And so, when I was asked for the oral part of the qualifying exam, what would I like to sort of research, I said, "You know, I would like to sort of just see some papers about quality of service." And so, the committee told me, "Well, you know, find papers on quality of service and write a short survey paper and then we will come together and you will present." That was the part of the oral exam as a PhD student.

00:42:46
KN [cont.]: And that got me really started because then I basically started to study in the networks, what's quality of service? The new ATN networks started to talk about quality of service, how fast you set up but also how you send the data; how you shape the traffic. Multimedia started to come.

00:43:08
BA: Mm-hmm.

00:43:09
KN: Digital video. Digital audio started. You know, there was the various— Apple actually started to come up with various machines. So, because I was looking at applications for these new networks, the ATN Networks, and how do I preserve, basically, their quality. So, it all started to come together.

00:43:31
BA: Mm-hmm.

00:43:31
KN: [overlapping] In this survey paper as I was looking for what do the

networks do in terms of quality of service. I find the whole community that one of the centers was at University of California, Berkeley. And there was Professor Ferrari, who was leading in real time communication and starting to control the networks where they actually support digital video, digital audio in real time. So, part of that survey was actually looking at ATN networks, real time communication, digital audio, digital video.

00:44:08
BA: Mm-hmm.

00:44:09
KN: And I wrote the survey paper and then gave a presentation to the committee. I passed and then, of course, as part of the Aurora Project we started working on tele-robotics.

00:44:23
BA: Mm-hmm.

00:44:24
KN: As applications of the new protocols. What Jonathon Smith and another student, my colleague Brendon Traw, who is currently an Intel Fellow at Intel. He worked on device trial. There was another student that worked on some operating systems support for these high-speed networks and then I was building these tele-robotics protocols. Sort of application level protocols to control the remote arms using the results of the other two students, right?

00:44:55
BA: [overlapping] Mm. Mm-hmm.

00:44:57
KN: As part of this, so we really worked as a whole protocol stack and Jonathon, of course, was supervising and working with us on this whole stack for ATN networks. So, it was a lot of stuff.

00:45:09
BA: Mm-hmm.

00:45:10
KN: A lot of—and that actually then got me to really think about, "Wow. I cannot talk to the—" Because that actually got me introduced to very different domains.

00:45:21
BA: Mm-hmm.

00:45:22
KN: And those were the computer vision people, those were the robotics people. Where, you know, they could care less about quality of service, right? [laugh] They could care less about packets. And—

00:45:32
BA: Mm-hmm.

00:45:33
KN: Delays and jitter and end to end delay, right? They cared about you know, their pixels.

00:45:41
BA: Mm-hmm.

00:45:41
KN: [overlapping] They cared about how many pixels did I use, what's my temporal resolution of the pixels, right? Is my command getting there by so much and so much, deadlines, right?

00:45:50
BA: Mm-hmm.

00:45:51
KN: And so on. So, it was very interesting that that actually got me onto the path bringing these two communities together.

00:45:56
BA: Hmm. Alright. So, now I'm going to transition to talking about your time here at the University of Illinois. So, could you talk about how you first came to—with the Department of Computer Science, at the University of Illinois, and what year was it that, that you came here?

00:46:13
KN: So, when I graduated in 1995—First of all, when, 1994, I would have my discussion with Jonathon, what do you want to do? You know, I had publications. I said, "You know, I really would like to try a research lab or a university because I [stammers] was going to the PhD so that I could teach or I could—

00:46:41
BA: [overlapping] Mm-hmm.

00:46:42
KN: Sort of do research. At that time, I had started and worked very closely with Professor Ralf Steinmetz. So, that's a very interesting relationship.

00:46:55
BA: Mm.

00:46:56
KN: Because that actually is now over twenty years.

00:46:58
BA: Hmm.

00:46:59
KN: Relationship. Professional relationship.

00:47:01
BA: Mm-hmm.

00:47:02
KN: With a professor in Germany. So, 1993, Professor Farber, who was on my PhD committee, was at some professional meeting and he met this researcher from IBM Heidelberg.

00:47:21
BA: Mm-hmm.

00:47:21
KN: Professor Steinmetz. Professor Steinmetz said, "You know, I am very interested multimedia technologies. It's coming. It's big." He was in West Germany. And he said, "You know, I wrote this book in Germany but it's in German and I need somebody who knows German and English to translate it and expand on the network part."

00:47:49
KN [cont.]: "And on some of the real-time aspects." And Professor Farber says, "Oh! In my lab!" [laugh] "Professor Jonathon Smith's student, Klara Nahrstedt, has that capability to A) translate your book, German book but also expands it because she works exactly on some of these parts that you are—"

00:48:12
BA: Mm-hmm.

00:48:13
KN: "Missing and you want to sort of include." So, starting in 1993, I was working on my PhD thesis, the Aurora Project, but also slowly, I basically started to translate.

00:48:25
BA: Mm. Mm-hmm.

00:48:27
KN: And put into the book, my PhD thesis.

00:48:30
BA: Hm. Mm-hmm.

00:48:32
KN: The book was then published in 1995 by Prentice Hall.

00:48:36
BA: Mm. Mm-hmm.

00:48:37
KN: And became the textbook for many years.

00:48:40
BA: Wow.

00:48:41
KN: For many, many students to learn.

00:48:44
BA: Mm-hmm.

00:48:45
KN: About multimedia technology and multimedia systems and multimedia networks.

00:48:48
BA: Mm-hmm.

00:48:49
KN: So, when I—1994, when I talked to Jonathon, you know, "What do you want to do?" I said, "You know, I would like to go to university." Jonathon said, "You know, one of the things that you should maybe try is, take your textbook … " At that time, it wasn't published but it was all written.

00:49:09
BA: So, did you get—were you also a coauthor then, on this textbook?

00:49:12
KN: Oh, yes. Oh, yeah.

00:49:12
BA: Okay. Okay. Just wanted—Yeah.

00:49:13
KN: [overlapping] I was the second author.

00:49:14
BA: Okay.

00:49:15
KN: Because there was also other material that I put in.

00:49:17
BA: Okay. Great. Yeah.

00:49:18
KN: And so, basically, Jonathan said, "Well, take your textbook and teach."

00:49:25
BA: Mm-hmm.

00:49:27
KN: "At UPenn. You know, I will start the seminar but then you will teach using your material and you will see if you like it." So, I actually taught a seminar, a smaller, limited number of students, on multimedia systems, multimedia technology and it gave me a first blueprint actually.

00:49:46
BA: Mm-hmm.

00:49:47
KN: [overlapping] For class that I brought here in 1995.

00:49:50
BA: Mm. Mm-hmm.

00:49:51
KN: I liked it, so I applied to various universities. Mostly in the East up to the Midwest because I wanted to stay close to my family, right? My mom and you know, sort of were all in the East Coast.

00:50:06
BA: [overlapping] Mm-hmm.

00:50:08
KN: And her partner. So, then basically I got offer and I selected University of Illinois, Urbana-Champaign for multiple reasons. One thing is it had a tremendous reputation in systems and networks. There are universities that, you know, would not have many systems and networking faculty. And therefore, the appreciation of the contribution with systems and networks researchers do is not there. So, it was important for me to get into a group or in the department where there is a strong appreciation.

00:51:01
BA: Mm-hmm.

00:51:02
KN: And because of the ILLIAC I, II, III, IV and then many others, CEDAR, and so on, others, PLATO.

00:51:08
BA: [overlapping] Mm-hmm.

00:51:09
KN: And so, there was tremendous appreciation in the department for building systems and I was a builder. From the time that I have been in the Ministry of Agriculture computer center, I built the email system. I wanted to build.

00:51:26
BA: Mm-hmm.

00:51:27
KN: To building the tele-robotics application and tele-robotics systems, which is important for me. So, Illinois was definitely a clear choice.

00:51:35
BA: Mm-hmm.

00:51:36
KN: The second thing is that the department had female faculty.

00:51:41
BA: Hmm. Mm-hmm.

00:51:44
KN: You know, I interviewed and I met Jane Liu and she was just amazing, right?

00:51:52
BA: Mm-hmm.

00:51:53
KN: And there was, there were other faculty that I didn't, don't remember meeting them. I definitely remember Professor Jane Liu. And we basically, at home, sort of debated it and my mom says, "Oh, that's a fantastic university and go for it!"

00:52:13
BA: [overlapping] Mm-hmm. Hm.

00:52:16
KN: And I actually, I had a very, very good experience doing the interview. And so, I felt this is the place where I want start my career. And they made an offer, I accepted it.

00:52:32
BA: So, Illinois had more women faculty in computer science than a lot of other universities at the time?

00:52:39
KN: Yes.

00:52:40
BA: Wow.

00:52:41
KN: So, there was another university and you know, there was one female professor.

00:52:46
BA: [overlapping] Uh-huh. Right, yeah.

00:52:48
KN: Yeah, so, or there were none.

00:52:51
BA: Mm-hmm. Mm-hmm.

00:52:53
KN: And here, it was Professor [stammers] Jane Liu and Professor Belford, all in systems. Professor Belford was, Geneva Belford, was in distributed systems. Professor Jane Liu was in real time systems. There was sort of other sort of professors and they have been all partially in systems or—

00:53:25
BA: Mm-hmm.

00:53:26
KN: Or some sort of theoretical databases and so on but, yeah.

00:53:30
BA: Mm-hmm. So, could we talk a bit about Jane Liu and Geneva Belford? And then also, we had previously talked about Marianne Winslett so—

00:53:42
KN: [stammers] That's right.

00:53:43
BA: So, if we could talk just more about your relationship with, with Jane Liu first and then go on and talk about the others, that would be great.

00:53:49
KN: Professor Jane Liu was my mentor. From the moment that I came she was my research mentor. At that time, first Dr. Lawrie but then especially Dan Reed was the department head. They paid attention to mentoring, at least from my perspective. And I would have two mentors; one was on the research side, it was Jane Liu and on the teaching side, it was Marianne Winslett.

00:54:29
BA: Mm-hmm.

00:54:29
KN: And you know, I was told, "If you have any issues, you go and talk to them. They probably are busy, you know, so you need to sort of start initiating." So, I would have you know, discussions with Jane Liu. The other thing that Jane has done is, as a mentor and as a researcher, she put me on grants that she had. She brought in some NASA grants and she invited me to join. Then there was a call in DARPA on quality of service and she says, "Klara, we are going after it."

00:55:06
BA: Mm-hmm. [laugh]

00:55:07
KN: "You have that particular expertise." [laugh] "I am in real time systems."

00:55:11
BA: Mm-hmm.

00:55:12
KN: "Let's go for it." So, she and I had this joint quality of service grant.

00:55:17
BA: And what year was this?

00:55:20
KN: This was 1996 to 1998.

00:55:21
BA: [overlapping] Okay.

00:55:22
KN: Or 1999, actually and 2000.

00:55:27
BA: Mm-hmm.

00:55:28
KN: So, it was four, five years grant.

00:55:29
BA: Mm-hmm.

00:55:30
KN: But when I came here, immediately basically, she started to involve me and bring me into these grants. So, that actually gave us an opportunity to collaborate together and be much more in contact. And I was on PhD committees of her students, she was on a PhD committee of my student's, that had been—So, my two students actually, Shigang Chen and Baochun Li had been on the DARPA quality of service grant with her.

00:56:04
BA: Mm-hmm.

00:56:05
KN: So, so, yeah. So, and even then after this grant expired she then left for Microsoft and then later on to Academica Sinica. We have been in touch and so she has been a fantastic mentor, particularly through the assistant professor years

on the research side, and very, very supportive. On the other side was Marianna. Marianne Winslett, who has been supportive in a different dimension and that's the teaching.

00:56:40
BA: Mm-hmm.

00:56:41
KN: As you know, as a faculty, you come here you don't have a pedagogy degree so a lot of issues that come in the class with the students, you do want help, right? How do you resolve conflicts? What happens if one student cheats, another student accuses other students and so on? So, a lot of these situations I would have meetings with Marianna.

00:57:11
BA: Mm-hmm.

00:57:12
KN: Either we would go for lunch, coffee break, or just in the office and chat about you know, advising. You know, how do you get students to do what you would like to do? How do you leave them freedom so that they can explore new areas so that they explore areas and so on? So, she was very helpful in that space. And then just generally guiding me through the department. You know, how you navigate through committees and so on.

00:57:38
BA: Mm-hmm.

00:57:39
KN: So, I found that those two dimensions of mentoring was just really, really important.

00:57:46
BA: Mm-hmm. Mm-hmm.

00:57:47
KN: For my development, professional development.

00:57:51
BA: So, your interaction with Geneva Belford, as you had mentioned, she worked in this area of distributed systems. How did your time here intersect with her?

00:58:05
KN: So, when I came, Geneva wasn't as active research wise. Definitely Jane was very active.

00:58:16
BA: Mm-hmm.

00:58:18
KN: And Geneva was more active on the theoretical aspects of distributed systems.

00:58:26
BA: Mm-hmm.

00:58:27
KN: So, interface a little bit less with me than Jane, for example.

00:58:31
BA: [overlapping] Mm-hmm.

00:58:34
KN: But Geneva was very active in the academic office.

00:58:40
BA: Mm-hmm.

00:58:41
KN: She was very much cared about the graduate students and so, we would work together on some committees. Some students that had some issues and she would be very understanding towards those students, work with the advisors how to solve conflicts, graduate students, graduate advisors. And she would aim to shape the graduate education in our department.

00:59:25
KN [cont.]: How do you conduct qualifying exams? How do you conduct preliminary exams, final exams, and so on? So, I would interface with her much more on the level of the service provisioning in terms of the graduate education.

00:59:45
BA: Mm-hmm. Mm-hmm.

00:59:47
KN: But also as a colleague you know, you could come to her with any question. If it is about committee work, she was also very much engaged at the campus level and the college level in terms of services and so you could ask any questions. For example, when we would be serving on committees to approve courses, right? She would provide much more feedback.

01:00:17
BA: Mm-hmm.

01:00:18
KN: [overlapping] About what these committees are about, and so on. So, in some way having her as a female faculty, you know, for some of the female faculty, it's just easier to approach and get that particular information. Since we'd, you know, you would have some colleague – male colleagues that would feel that women don't belong in computing.

01:00:41
BA: Mm-hmm. How has the department and also more broadly the field of

computer science, if you could speak about that, changed since you began working here in 1995?

01:00:56
KN: So, the field of computing changed in the sense that computing is not anymore just a matter of computer science.

01:01:13
BA: Mm-hmm.

01:01:14
KN: And computer engineering.

01:01:15
BA: Mm-hmm.

01:01:16
KN: The computer science needs to, I think, really reach out to many, many other fields.

01:01:26
BA: Mm. Mm-hmm.

01:01:28
KN: Because computing became a ubiquitous fabric for all of the sciences.

01:01:34
BA: Mm-hmm.

01:01:35
KN: All of the humanities. All of the fields. And so, what has to happen is, I think, two things. And they are happening, actually. One is how do we educate

other parts of the campus of the college to get strong computing education? And then the second thing is how do we engage—

01:02:15
BA: Mm-hmm.

01:02:17
KN: With other fields to do—solve research problems that come into the computer science through these other fields? And you see this particular development now on both levels. In the educational space, it's the CS+X Program, it's the various MOOCs, it's the various programs that go across colleges where computer science and other colleges are partnering to deliver joint courses. Or you start to see that other colleges are building up their information science.

01:03:06
BA: Mm-hmm.

01:06:07
KN: Their computer science type of courses. Although, we currently definitely, at least here at Illinois, are aiming for synchronizing these courses. And of course, Illinois has also some advantages in the sense we have an iSchool and we have a computer science. We have computer engineering. I mean many other universities have similar, but the iSchools basically then can help also in terms of bringing some education in the information sciences.

01:03:38
BA: Mm-hmm. Mm-hmm.

01:03:39
KN: So, it's not all computer science. But at the educational level, this is a major change that computer science has been going through, and is going through. It actually also started with Professor Marc Snir.

01:03:59
BA: Mm-hmm.

01:04:00
KN: When the iCube started.

01:04:01
BA: Hmm.

01:04:02
KN: The Information—Illinois Information Informatic Institute.

01:04:07
BA: Mm-hmm.

01:04:08
KN: And that was actually between iSchool, CS to really bring other fields and allow people to get educated in informatic.

01:04:21
BA: Mm-hmm.

01:04:22
KN: That are not core computer scientists.

01:04:26
BA: Mm-hmm.

01:04:27
KN: So—so, I feel that this is currently very important direction. The second direction is that you are starting to see new fields.

01:04:38
BA: Mm.

01:04:39
LN: Bioinformatics, right? It's really bringing computer scientists who are interested in biology and then looking at the computational biology or biological problems where computer science can contribute deep research to solve some of the large-scale problems that we are facing in biology. You are seeing computational sciences, computational chemistry, computational physics, right? Computational mechanics. Where people are using large scale computer simulations to run new, novel materials.

01:05:25
BA: Mm-hmm.

01:05:25
LN: [overlapping] New, novel devices and so on. You are seeing other fields that are partnering with computer science in research. If it is civil engineering, right?

01:05:41
BA: Mm-hmm.

01:05:42
KN: I mean, many of these civil infrastructures will be cyber physical systems.

01:05:48
BA: Mm-hmm.

01:05:49
KN: Where every physical infrastructure, like the smart grid, like buildings, will have censors. And so, many of these [stammers] areas now must have computing as integral part of their education and of their research. And that's a huge change.

01:06:13
BA: Mm-hmm. Mm-hmm.

01:06:14
KN: Across the country, across the world, that's actually definitely, is happening here at Illinois.

01:06:22
BA: I wonder if you could talk a bit about the specific environment of the University of Illinois and how that's affected computing and computer science. One of the things that I've heard, maybe formally and informally, is that, you know, Illinois is known for a lot of interdisciplinarity and exchange that happened. And I jokingly heard somebody say it's because we're sort of in the middle [stammers] of nowhere [laugh] but I don't know if that's just a joke, of course but a lot of people like to talk about how this environment sort of facilitated and this sort of interdisciplinarity. So, do you think that, from your perspective, is that something that you've observed at all and if so, do you think that that has an impact on the direction of this department has grown? And maybe other units in the College of Engineering?

01:07:17
KN: So, one unique thing in Illinois, which I don't see as much in other universities, it's coming but it's, I think, the roots and deep tradition are here, are the interdisciplinary research units. If you think about CSL—

01:07:46
BA: Mm-hmm.

01:07:47
KN: It's now over 65 years old.

01:07:51
BA: Mm-hmm.

01:07:53
KN: The ILLIAC, right? Many of these large projects.

01:07:58
BA: Mm-hmm.

01:07:59
KN: Have been very interdisciplinary, right? When you talk about ILLIAC, it brought physicists, computer scientists, right? Electrical engineers, all together. So, Illinois has these IRUs like CSL, MRL, Material Research Lab, Micro Nanotechnology Lab, Beckman Institute, Institute of Genomic Biology, right? And others.

01:08:31
BA: Mm-hmm.

01:08:32
KN: And CSA, of course, that bring together these different researchers from different departments to share lab spaces, microscopes, right? Large laboratories. Micro Nano has these clean rooms. And us, here in CSL, you have researchers that care about control, care about signal processing, many, many different people care about that from not only electrical engineering or computer science but also from bioengineering.

01:09:12
BA: Mm-hmm.

01:09:13
KN: From mechanical engineering, from industry of engineering, and so on. So, people come together so that they, besides working in their own department, they want in the research, work on certain scientific or societal problems.

01:09:33
BA: Mm-hmm.

01:09:34
KN: Where they need multiple people. And our alumni's have acknowledged that.

01:09:46
BA: Mm-hmm.

01:09:47
KN: Just think about Beckman, right? I mean, the Beckman Institute—

01:09:52
BA: Mm-hmm.

01:09:53
KN: Came because of an alumni putting foot down and saying, "That's a building where only interdisciplinary research can live." CSL started with ILLIAC.

01:10:06
BA: Mm-hmm.

01:10:08
KN: With PLATO, with CESAR—CEDAR—and so on. And these different building computers where again, you need so many different experiences. So, I feel that culture.

01:10:26
BA: Mm-hmm.

01:10:27
KN: And these kind of IRUs having these test beds, having these interdisciplinary things where you have to listen to others and then validate under very different conditions. Biologists talk a very different language than the psychologists than the computer scientists. You need to learn your—the

language of the others and you when you build, you validate in the middle somewhere, when you validate these systems.

01:10:59
BA: Mm-hmm.

01:11:00
KN: And I think that's also where the appreciation of systems is here.

01:11:04
BA: Mm.

01:11:05
KN: Because these interdisciplinary research efforts require that you build large scale systems and have appreciation of these different contributions.

01:11:17
BA: Mm-hmm.

01:11:17
KN: From different disciplines. So, I think that is why people see value, people appreciate value in the interdisciplinary research. And new people who come, come because they subscribe to the idea of an interdisciplinary research. Because they know that if they work on the interdisciplinary research, they get acknowledged in their department. They get rewarded for interdisciplinary research.

01:11:54
BA: Mm-hmm.

01:11:55
KN: In other schools, if you don't have culture of interdisciplinary research, your

departments will not acknowledge interdisciplinary research. Your tenure case, your students don't get acknowledged.

01:12:09
BA: [overlapping] Mm-hmm.

01:12:11
KN: In the interdisciplinary research.

01:12:12
BA: Mm-hmm. Mm-hmm.

01:12:13
KN: So, I think that's what's unique.

01:12:15
BA: Mm-hmm.

01:12:16
KN: I think these IRUs, these understanding what is interdisciplinary research is and then you start attracting in every cycle, people who subscribe to that.

01:12:28
BA: Could you also speak a bit about the content of your research projects from the time when you started here through the present? And how this particular environment that we've just kind of talked about, has influenced it, or not? But more generally speaking—

01:12:49
KN: Mm-hmm. So, when I came here, one thing that I really realized was that my PhD thesis was just a really little, little bump in the science.

01:13:02
BA: Mm-hmm.

01:13:03
KN: Of quality of service. So, I read more and more about that and I felt that I wanted to really understand much more the big picture of the quality of service, I knew that there wasn't a tele-robotics—There wasn't a robotics lab so I might take the multimedia and maybe work on other real-time systems like teleconferencing, right? Or you know, some sort of on-demand type of systems. But they all needed the quality service, [stammers] if I work—still continue working with digital media or digital audio. And so, that actually got me in the direction of not so much application to network quality of service translations and coordination but what happens with the quality of service inside of the networks.

01:14:08
BA: Mm-hmm.

01:14:09
KN: And so, I got very interested in quality of service routing. And so, there's one major line of my research is on quality of service routing. That when you looked at internet at that time, the routing in internet was very much best effort.

01:14:36
BA: Mm-hmm.

01:14:38
KN: But the question came from particularly from the ATN networks, how does one also put certain real time and quality of service routing capabilities on the internet? And so, that actually established a lot of really interesting research in terms of graph theory to be used, established a lot of research in terms of scheduling. How do I schedule the packets so that they basically understand what time is and I can actually move the packets in a timely fashion and so on? It brought in actually, a lot of research in how do I distribute data in multicast space? How do I distribute packets and route the packets when I start to have wireless? Wireless networks started to come up.

01:15:31
BA: Mm-hmm.

01:15:32
KN: WIFI started to come up. And so, this quality of service sort of, really, there is a streak of sort of whole research, body of my research where I just was curious, "How do you work with the routers? How do you work with access points? And how do you work with end points?" So that at the end the user, ultimately doesn't care what happens there but I want a strong quality of service. At the end. I want to watch video that doesn't freeze, that has synchronized audio and video and it's pleasant to look at.

01:16:05
BA: Mm-hmm. Mm-hmm.

01:16:07
KN: So that was sort of the really big body of work on quality of service routing, on quality of service scheduling, in wired, in wireless coordination of quality of service.

01:16:24
KN [cont.]: I also looked at what should some of the application middle ware systems, right? By that time, it was not only just applications sitting on top of networks, but people started to recognize that there should be some kind of mid-layer between the applications and the networks to help coordinate. So, in some way these translations, these admission controls, negotiation should be somewhere in the middle layer.

01:17:00
BA: Mm-hmm.

01:17:00
KN: [overlapping] Between the applications and the networks. And so I did quite a bit of body of work on middleware that would to some degree take on providing services to the applications, give them delays, to some degree fool the

applications that they are getting quality of service even though if you are sitting on networks that don't understand quality.

01:17:29
BA: Mm-hmm.

01:17:30
KN: Where you—because I actually moved to the middleware after realizing that even though we proposed a lot of quality of service mechanisms, policies, algorithms in the network, it just would take very long time.

01:17:51
KN [cont.]: For the network companies to build it. And so, the [stammers] the question then became, "If we assume that we cannot change the networks because the networks are in control of ISBs of companies that we cannot influence, can we, at the edges of the network, build these middle wares where we can put the quality of service and adapt?"

01:18:22
BA: Mm-hmm.

01:18:23
KN: And so, one of the major research results then became, for me, was can I apply control theory to do quality of service adaptation for video and audio? Can I develop various coordination algorithms to synchronization algorithms at the mid-layer?

01:18:44
BA: Mm-hmm.

01:18:45
KN: To give the multimedia applications the perception that they have a really strong quality. Particularly, this applied itself to applications that were not as strict in real time as for example, the tele-robotics, where you had to respond in 20 milliseconds or 40 milliseconds. So, in teleconferencing, it was much more

acceptable of having 80 to 100, 200 millisecond end to end delay so you could basically say, "Okay, the internet cannot understand quality of service but maybe if I understand what the content is and the mid-layer could actually do up packets, can schedule packets properly."

01:19:37
BA: [overlapping] Mm-hmm.

01:19:38
KN: It could understand what is currently important packets, and so on. So, the middle ware actually gave us the buffer.

01:19:47
BA: Mm-hmm.

01:19:48
KN: And so, a lot of techniques was developed in that space.

01:19:52
BA: Mm-hmm. Mm-hmm.

01:19:54
KN: So, we also had been—started to investigate another sort of line of work because what happened was cameras became cheaper.

01:20:11
BA: Mm-hmm.

01:20:12
KN: And 3-D cameras started to become possible. So, I was, 2004, on sabbatical in Berkeley and I saw some of the 3-D cameras, very crude. But I saw them and so I started to get interested in what would the middle ware or the network look like? Or the operating system look like?

01:20:47
BA: Mm-hmm.

01:20:48
KN: If I start to have more cameras or 3-D cameras?

01:20:53
BA: Mm-hmm.

01:20:54
KN: So that really became a major question.

01:20:58
BA: Mm-hmm.

01:20:59
KN: So that was one sort of interesting direction. And the second direction became laptops became available.

01:21:07
BA: Mm-hmm.

01:21:08
KN: Cameras on laptops and the question then was, "How would the layers, network and the distributed middle ware layers look like to support mobile video?"

01:21:23
BA: Mm-hmm.

01:21:24
KN: So, those were the questions that we moved from the single cameras, fixed

environments, PCs, right? To start to explore the richness of what's happening around these devices, multiple cameras, 3-D cameras, mobile cameras.

01:21:50
BA: Mm-hmm. Mm-hmm.

01:21:52
KN: And since we have been a systems group, a networking group, right? It's multimedia operating and networking systems group. We really were curious what are then the algorithms, policies, mechanisms, in the distributed layer and in the network layer to—

01:22:09
BA: [overlapping] Mm-hmm.

01:22:10
KN: Support these new developments and that's actually what we are doing. So, a couple sort of very important aspects came out. In the mobile media, video is very, very expensive in terms of energy. Well, you know. When you start on your mobile phone and play a video.

01:22:33
KN [cont.]: It's really, really an issue. So, we partnered with the computer architecture group, Professor Sarita Adve then Professor Doug Jones, who is in signal processing, and Professor Robin Kravets who was the [unintelligible] communication person and I, myself as an operating and networking sort of systems group and had a project called Grace. [non-interview dialogue]

01:23:06
KN [cont.]: So, and that was basically where we developed—

01:23:11
BA: Mm-hmm.

01:23:11
KN: [overlapping] Algorithms. In particular for my group, developed operating system for energy efficient processing of video.

01:23:17
BA: [overlapping] Mm-hmm.

01:23:21
KN: And then came the tele-immersion. That was the multi-camera, 3-D camera tele-conferencing environments. Again, real-time to actually then develop the middle ware, develop the network protocols, algorithms, scheduling to actually allow for immersive distributed, geographically distributed environments.

01:23:46
BA: Mm-hmm. Mm-hmm.

01:23:47
KN: So that's basically where sort of the trajectory goes.

01:23:51
BA: Mm-hmm.

01:23:51
KN: And now of course, I have very different types of trajectories. Sort of, again, systems, networks, but for microscopes.

01:24:01
BA: Mm-hmm. Mm-hmm.

01:24:02
KN: And for various mobile phone ubiquitous type of applications.

01:24:07
BA: Okay. Great. So, I know we're nearing the end of our time but I have two more questions I would really love to ask you, if we could just spare just a few more minutes here. So, in the time that you've been here at Illinois, you've moved up and you're now Director of the Coordinated Science Laboratory as well as the Ralph M. and Catherine V. Fisher Professor of Computer Science. So, could you talk a bit about opportunities for advancement and what that was like for you?

01:24:36
KN: So, because I do like interdisciplinary research, especially in the computing; as you can see, I moved within the layers.

01:24:47
BA: Mm-hmm.

01:24:48
KN: Networking, distributed systems, studied various types of applications, I thought I had been working with the Coordinated Science Lab, in particular, the Information Trust Institute on aspects like critical infrastructures, smart grids.

01:25:07
KN [cont.]: And then basically one of the areas that started to come around 2005, 2006 was security, into my research. So, not only the quality of service and the delays and so on but also, security. And that actually then very much maps to the critical infrastructures so I knew a lot of the research and the interdisciplinary field, this particular area. So, I thought this is actually a great opportunity, is I have been now, full professor to actually also take on leadership positions and work in the broader sense with large community to shape the interdisciplinary research in computing, communication.

01:25:57
BA: [overlapping] Mm-hmm.

01:25:58
KN: Control signal processing and circuits.

01:26:02
BA: Mm-hmm. Great. So, you are the first woman Director of the Coordinated Science Laboratory in its roughly 65-year history. Why do you think it took so long for the CSL to have a woman director? If you could speculate about that or what [stammers].

01:26:22
KN: I think the reason was that CSL as it started, and for many years, was much more concentrating on hardware. On physics. If you think about some of the first directors and ILLIAC people had been physicists.

01:26:50
BA: Mm-hmm.

01:26:51
KN: And then it really basically grew in terms of circuits and signal processing, very hardware, low level software where you don't see many women in that area.

01:27:05
BA: Mm-hmm.

01:27:07
KN: So, I anticipate that with the boom of computer science and software, where the hardware is now playing less a role than—it's not that it's a minor role, but I think that the software and the computing applications and that richness of environments, I think enabled broader audience of CSL, broader projects where women are part of it.

01:27:52
BA: Mm-hmm.

01:27:54
KN: So, you would see since 2005, 2004 I think, more female faculty coming into CSL, part of ITI, part of CSL. There was just more critical mass coming through ECE, coming through CS, coming through MechSe, coming through [unintelligible]

01:28:15
KN [cont.]: And then when you start to have a certain critical mass of women that start participating in various larger projects of CS life and research, you start to basically have larger possibilities. First, the women that actually now become part of that, like myself, you start to watch what's happening around you. You might get invited to be an associate director, so I actually worked under Bill Sanders.

01:28:46
BA: Mm-hmm.

01:28:47
KN: When he was the director of ITI. So, I was a trust leader, then you know, I was invited to actually, or selected to be on the planning and policy committee. So, and other women as well are becoming, and have been becoming, part of the CSL make up that I believe then that you have more candidates, selections to take on leadership positions and I think that's why it was time then basically, to have a female director.

01:29:25
BA: Mm-hmm. Mm-hmm.

01:29:26
KN: And this is currently, I think, very important, that I feel to give female faculty opportunities to be in leadership positions and they don't have to be immediately the directors. They can be associate directors, they can be trust leaders. They can be in multiple leadership positions of an organizations because they then much more get an understanding what's happening around.

01:29:54
BA: Mm-hmm. Mm-hmm.

01:29:55
KN: To actually then really grow and be confident to take on that kind of leadership position.

01:30:01
BA: Well, great. Well, thank you so much Klara. Are there any other questions that I could have asked you about?

01:30:09
KN: No.

01:20:10
BA: Okay, well, thank you so much for your time and for sharing your story and this concludes our oral history interview.

End of interview