A. M. Turing Award Oral History Interview with

John E. Hopcroft

by David Gries

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Gries: Hello. I'm David Gries, Professor Emeritus of Computer Science here at Cornell, although I'm still teaching because our courses are so huge. I'm here to interview my friend and colleague of almost 50 years, John Hopcroft, who received the Turing Award in 1986. We have been colleagues for almost 50 years. We share something else – we were both born in 1939. I'm four and a half months older than he is.

John, as you'll see, is one of the most eminent computer scientists ever. He's excelled in and made significant contributions to all three aspects of computer science – that's research, that's teaching, and there's service to the community. His work and service have placed him in the National Academy of Engineering, the National Academy of Science, as a foreign member of the Chinese Academy of Science, and he has the CRA Distinguished Service Award, five honorary degrees, 9 to 10 honorary professorships. The list goes on and on.

John was a co-winner of the ACM Turing Award in 1986, as I said earlier. Here's the citation. I'll read it. "With Robert E. Tarjan, for fundamental achievements in the design and analysis of algorithms and data structures." John and Bob developed a linear algorithm for testing whether a graph was planar, a remarkable achievement. This was back in the early '70s. And they both contributed greatly to the fields of algorithms and data structures for the next… well, he still is doing it.

Let's begin, John. You grew up in Seattle. What was it like then?

Hopcroft: Well, this of course was a long time ago and Seattle was a small city. [laughs] I think the population was only about a half a million and the other side of Lake Washington, where Microsoft and many of the companies are today, simply was woods. It was a city that you could walk and explore. That's what I enjoyed doing as a child.

Gries: What did you do for fun as a kid?

Hopcroft: Well, I searched a lot for other kids to play with, to explore, but didn't find too many. But if there was just a path in the woods, I wanted to see where the path went and I wanted to see where various streets went. I now think I was just kind of curious and was exploring.

Gries: You've done that all your life. About your dad. Tell me about your dad.

Hopcroft: Well, my dad was actually an illegal citizen. He had walked across the border from Canada into the US. I didn't realize it, but he worked for half of minimum wage. We were probably a very poor family, but my parents were quite frugal and I didn't know that we were poor. One of the advantages I think that I had that many people don't is my parents loved one another, and I never heard my father or my mother say anything negative about the other.

The other thing is that neither of them had graduated from high school. Maybe that wasn't that uncommon in those days. But they wanted me to have a better life than they did, and that I think was almost their goal in life. They wanted to make sure that I had a university education, and they spent their time teaching me to swim, teaching me to do things, in a way which I think a lot of other children didn't get this kind of advantage. And I now know, I'm actually reading literature on early childhood development, because many researchers say the first two years of a child's life are critical in how they're going to succeed and having a stable environment has a big impact on how the brain develops. I think my parents gave me that, and I think that my success, a lot of it goes back to that early childhood. And I guess I would like to see everybody today have a level playing field, so that in an inner city where maybe life is rather chaotic, it would be great if we put in place high-quality childcare…

Gries: Maybe near the end, since that is one of the things you're thinking about, we can talk about that later.

Hopcroft: That would be great.

Gries: Early childhood is not something that computer scientists think about too much. And maybe they should.

Hopcroft: No, but they should.

Gries: What were your best and worst subjects?

Hopcroft: Well, I liked math, and that was my best. And I liked the science that we got, but in elementary school, the science wasn't that much taught. Probably where I was not so good was history. What I didn't like about history at that time, it was just a list of who the generals were and what the battles were and the dates. There was very little explanation as to why the world evolved the way it did and so on.

Gries: So basically all through your life, it's been explanations you're looking for and not just facts.

Hopcroft: Right, right.

Gries: In high school, what did you want to do?

Hopcroft: High school, once again what I was good at was math. I wanted to meet other kids and go out and explore. I found a few more there that wanted to explore, that wanted to do things like go skiing or something like that. But high school, I was pretty much focused on getting an education. One of the things in those days, we did have more time, more free time. School would get out a little after three, and then we could pretty much do what we want in the afternoon and evenings.

Gries: That's not the case today.

Hopcroft: Not the case today. I think we should go back to that, because part of your education is learning how to interact with other kids and other things. I think we may have lost some of that.

Gries: I think our use of these cellphones is contributing to that loss tremendously. Was there a particular teacher who inspired you?

Hopcroft: Yeah. I was fortunate to have really good teachers. The one that most was John Goodwin, who taught high school algebra. But he was also the football coach. You may wonder, "How could a football coach be a superb algebra teacher?" But I think what it was, is something which made him good at both was he had a way of conveying to you that he really cared about your success and you didn't want to disappoint him. That's why he was good I think in both roles.

Gries: You went to an elementary school?

Hopcroft: Yeah. I went to an elementary school, a Catholic school that was run by nuns. The interesting thing is that the nuns actually did not have college education. When they graduated from high school, they went into a religious order because they wanted to help other kids. I think one of the most important things in a teacher being good is that they care about the success of their students.

Gries: And that was your football coach also, you could tell…?

Hopcroft: Football coach cared about the success of students.

Gries: And was this a Jesuits' college that you go then?

Hopcroft: Yeah. It was a Jesuit high school, and I also went to a Jesuit college, Seattle University.

Gries: Why did you go to Stanford? How was that and what…?

Hopcroft: Well, that came about by accident, because where I lived in Seattle, I just assumed I would go to the University of Washington. But when I went over to talk to them, one of the faculty members said that they couldn't admit me to a graduate program because I went to an unaccredited university. Now I sort of didn't really believe I wouldn't be admitted, but I went back and talked to my department chair. The department chair said, "Why aren't you applying to Stanford?" So I applied to Stanford and they were happy to take me even though I was from an unaccredited institution.

Gries: You got your degree fairly early, didn't you? How old were you when you got your…?

Hopcroft: I was 24. In those days, you could get a degree much sooner than now.

Gries: You just has to spend three years. That's it. And if you did the work. Now the average is more like five or six. I would like to see that changed.

Hopcroft: Oh, I would like to see it go back, but I don't think it's going to.

Gries: No. What did your parents want you to do when you grew up?

Hopcroft: I don't know. My father worked… once he became a citizen got a job at a power and light company. He was a janitor. But he saw *[0:10:00]* draftsmen sitting at tables in white shirts and drinking coffee and doing what he thought was very little work, and they were paid a lot more than he was. He thought they were electrical engineers, and so he said, "You ought to be an electrical engineer." And didn't put any pressure on me, but I liked science and math, so engineering seemed reasonable. I started in electrical engineering, I enjoyed it, and it was a good choice.

Gries: There weren't any computers at that time. What did you do in electrical engineering?

Hopcroft: Well, we studied linear circuits. So I learned how to solve linear equations and… Well, we also learned a lot of things that aren't necessarily useful today, like about rotating machinery, power lines…

Gries: Vacuum tubes?

Hopcroft: Vacuum tubes, yeah. Because just about the time I understood vacuum tubes, transistors came along.

Gries: [laughs] What was your first exposure to computers?

Hopcroft: Well, one of the faculty members in physics at Seattle U had a computer program that wasn't working, and so he hired me to debug it. This was before FORTRAN. This was written in assembly language. The computer in that day, I think it was a 650, IBM 650. It had a rotating drum, so if you fetched two numbers and added them and you were going to store it, you had to know about how far this drum had rotated if you wanted your program to run fast. So they had applied a program to this program to determine where things were stored. It was kind of hard to debug, but that was my first exposure to computing.

Gries: Who taught you the assembly language?

Hopcroft: Assembly language then was pretty simple.

Gries: Machine language. So they just said, "Here's the manual. Go do this"?

Hopcroft: Oh no, I didn't even have a manual.

Gries: You didn't have anything.

Hopcroft: You just knew that "A" stood for the code for add and… I mean there were only maybe 10 symbols.

Gries: Ten symbols. So you never really had instruction in…?

Hopcroft: That's right.

Gries: Did you ever take a programming course?

Hopcroft: No, no.

Gries: Never? Hmm. I took one. It was on a fake machine and for a fake assembly language, because we didn't have any computers. We would write subroutines to solve sine and cosine. We had no way of knowing whether they were right. The teacher didn't either. The basic idea was try to make it take fewer instructions than the person sitting next to you. That was back in 1969. '59, '59.

Hopcroft: Yeah. Well, see, I started in '63, but there was a computer. University of Washington had one and we could go over and use it for 15 minutes.

Gries: Ah, okay. What did you study? I think we covered this partially. What did you study in electrical engineering? What did you think of the labs you had to do?

Hopcroft: Well, electrical engineering, a lot of it was having to do with physical devices and things of that type. Initially, I was going to go into lasers. But when I took a laboratory course, I realized I was not good at laboratory work and physical devices, and that I really enjoyed the mathematics more. So I switched from that to more systems.

Gries: More theoretical stuff?

Hopcroft: More theoretical stuff.

Gries: Information theory?

Hopcroft: Information theory.

Gries: Who was the person there? Norm Abramson?

Hopcroft: Norm Abramson was there, and he was a world-class teacher. I just ran into many people who were good like that. Whenever I saw that Norm Abramson was teaching a course, I signed up for it, because I just would learn a lot more in a course from him than many of the other faculty.

Gries: Who were the most important influencers in your life at college?

Hopcroft: Well, in Seattle University, there was the chair of the department. It was a priest, Father Wood. He had a big impact on me. Also, there was another faculty member, Byron Gage, who had just gotten his PhD at University of Washington. So he wasn't that much older than I was, and we did things together. He had a motorboat and went waterskiing, and he took me waterskiing and things like that that were fun.

Gries: You graduated from Stanford ECE. Where was your first job? How did you get it?

Hopcroft: Well, this was kind of a stroke of luck, because I was originally planning on going back to Seattle University and getting a faculty position. But when I talked… I was walking past Bernie Widrow's office and his door was open. He was talking on the phone and he motioned, he said, "John, come on in." At the time, he was talking to Ed McCluskey at Princeton, who wanted to know if there were any PhD students graduating who would make good faculty. Bernie handed me the phone and said, "Talk to Ed McCluskey." I talked to him a little and McCluskey invited me back to Princeton for an interview. I had never thought of going back, but I thought I ought to at least go for the interview.

I went for the interview and when they offered me a job, I thought, "It would be good to see what an Ivy League institution is like and go there for three years."

But even then, I still thought maybe of going back to Seattle University. I didn't realize that to get tenure, you had to publish papers.

Gries: That idea wasn't there yet?

Hopcroft: [chuckles] That idea wasn't there yet.

Gries: It's interesting. Most people nowadays don't know how the field was at that time. I got my PhD in Munich Institute of Technology in Germany, and I got a job at Stanford without an interview. My thesis advisor wrote to George Forsythe, the chair, said, "Take him," and they took me. This was a time when all of the new departments – first was in 1964, Purdue, and then Stanford, Cornell, and others, '65, '66, and so on – they were all looking for faculty members and couldn't find them. So a totally different ballgame than today.

Hopcroft: Right. But also there wasn't the same emphasis on publications, because I had zero publications when Princeton hired me. I don't know if I had actually submitted my thesis yet or whether I was still writing my first publication. Today, you wouldn't get into a PhD program probably. [laughs]

Gries: You almost have to have an undergraduate research paper.

Hopcroft: Right.

Gries: Yeah, so what a change. Did you continue your PhD work when you went to Princeton?

Hopcroft: No, no. I decided… I was looking around for something else to do. One other thing that has changed. At that time, they wanted someone with a PhD and someone who would do research, because they thought that that would keep them up to date with the field their entire career. But it wasn't that they were hiring somebody because they wanted to increase the research reputation of the institution. I mean the focus was much more on educating the next generation of talent than it is today.

Gries: So you were at Princeton. You left Princeton for Cornell after two and a half, three years.

Hopcroft: Right.

Gries: How did that happen?

Hopcroft: Well, it happened for two reasons. One of them, there was a lot of politics going on in the department. There was a more established area of electrical engineering where whenever there was a faculty spot, they could bring in 10 highly qualified people. And when McCluskey would try to bring in someone in computer science, there basically wasn't anybody. He could bring in somebody, but the person maybe wasn't as good as these 10 people in this other field, and it was hard to make the argument that computer science was growing and they better make an investment in it.

Gries: They hadn't started a department yet. This was still ECE.

Hopcroft: Oh, no, it wasn't a department. It was simply that McCluskey understood that computer science… well, that computing – I shouldn't use the word "computer science" because that didn't exist – the computing was going to be important and he was trying to hire people in that area. But there weren't programs in the area, so it was hard. But he had a vision.

But the other thing is I ran the seminar series, and the budget was only big enough to invite in two external people in the semester. So I invited Juris Hartmanis from Cornell and Fred Hennie from MIT. These were two of the leading scientists I thought. And when I talked to McCluskey… Or, excuse me, when I talked to Hartmanis afterwards, he was telling me how they were trying to hire at Cornell and I happened to ask what they paid. They were paying an assistant professor 50% more than I was earning. So I asked him, *[0:20:00]* "What would you pay me?" and he made me an offer. And I thought then maybe it would be much better to be in a department where they really understood what I was doing than in a department that I was going to have to fight for recognition. That's why I went to Cornell.

Gries: For those of you who don't know, Juris Hartmanis was the founding chair of computer science here at Cornell in 1965 when the department was formed. He was a mathematician-physicist, but he was doing groundbreaking work on complexity. He's thought of as the father of computational complexity. I tell people my field is computational simplicity.

So you came here. What were you doing at Princeton? I know that you had an early significant contribution, a book with Jeff Ullman, *Formal Languages and Their Relation to Automata*. What made you do that? And who was Ullman?

Hopcroft: Right. Ullman was a graduate student there. McCluskey asked me if I would teach a course in computer science. I had to ask him, "What does one teach?" because there were no books, there were no such courses. He gave me four papers and he said, "If you cover these four papers, it will be a good course." So I developed notes for the course and afterwards I looked around, I wanted a co-author, and Ullman and I then took these notes and developed them into a book.

Gries: Did he take your course?

Hopcroft: Yeah, he took my course, and Al Aho also took the course. In fact, I think there were six students in the course. Brian Kernighan was in it. And I don't remember the names of the other three, but all of them were very successful computer scientists.

Gries: Very well-known people, yes. This book has had a tremendous impact on the field I must say. The book was used in just about every single department in computing science, and it set a bar, a standard that was hard for other textbooks in that field to meet. It really was something. I noticed this. Over the two years from March '67 through January '69, you published 11 papers with Jeff Ullman. That's a tremendous amount while you're writing this book. So you were not just taking what was known in the field, you were producing the stuff that had to go into the textbook.

Hopcroft: Yeah. When you write a textbook when a field doesn't exist, you run into all kinds of interesting questions and you sort of have to answer them. But a lot of this came after we wrote the book, but…

Gries: So you come to Cornell in '67 and you kind of begin changing fields. The book came out in '69, you probably finished it in '68, and you changed fields essentially completely. Not just formal languages and automata theory. Now it was algorithms.

Hopcroft: Yeah. I realized that the area of computer science was much broader. See, initially I was thinking of writing a theory book for the theory in computer science. But I realized that the field, a much more important area of it was algorithms, and there ought to be a theoretical book on algorithms. So I developed many of the things, like I had worked on divide and conquer and depth-first search and many of these things.

Then I went of course to Stanford for a sabbatic. I happened to share an office with Bob Tarjan. He was working on trying to determine if a graph was planar.

Gries: He was a PhD student, not a faculty member.

Hopcroft: He was a PhD student. Since I knew how to solve this problem in time $n \log n$, I worked with him to reduce the $\log n$ factor and come up with a linear algorithm.

Gries: So this idea of being in an office with somebody, that really helped in a way. I too when I went to Stanford in '66 just as an assistant professor, I shared an office with Jerry Feldman and we ended up writing an important survey paper together, only because we were sitting there wondering what the other person is doing.

Hopcroft: Yeah. No, it's very important to talk to other people. Just by yourself, when you're in an office by yourself, you're kind of isolated in a way. And just talking to people, you have an idea and they see it slightly differently, and they describe it to you differently, and gradually you have a much clearer view of it.

Gries: You ended up writing five papers with Bob Tarjan, and he actually came here as a faculty member.

Hopcroft: Yeah. He was here for I think about a year.

Gries: One year. He couldn't take the Ithaca weather.

Hopcroft: Right.

Gries: And it's interesting that he went to Princeton. So there has been this triad, three universities, Stanford, Princeton, and Cornell, which have been very important in your life and his life and so on.

Hopcroft: Right, right.

Gries: Interesting. Out of this work on algorithms came a book with Aho and Ullman. This I think was even more important setting the standard than the formal languages and theory, formal languages, and that book was talking about material that people really didn't have to do much research in after that, but the algorithms are still working, still going on. Tell us about that book.

Hopcroft: Well, Aho and Ullman were very influential. It's a little bit unfortunate that, for the Turing Award, they didn't get included, because they made significant contributions to the algorithms area. I get a lot of credit, but there are a lot of other people. It's just one person tends to get singled out. Maybe it's not totally fair, but that's what happens.

Gries: Well, you were the senior people of all these three.

Hopcroft: That's true. I was a little older and both Ullman and Aho took courses from me and so on. But their contributions were incredible.

Gries: This is algorithms in general, a lot of work on graph theory, all over the place. These first 10 years of yours as a faculty member, '64 to '74, were tremendously influential. I think that it turns out that most people do their most significant work in their first 10 years. Do you agree with that, that it's…?

Hopcroft: I tend to think so too. Partly you seem to have more time. Also, the relationship with graduate students, you're both building your careers, and so you work together in sort of a fundamental way. When I'm older and work with a graduate student, it's not the same thing. In fact, I tell graduate students now who ask me to be their advisor, I say, “You ought to first consider if there’s an assistant professor, because the relationship you will have will be different. You will both… You’ll be working together trying to build your careers. Whereas if you work with me, I’ll give you advice and so forth, but the relationship will be different.”

Gries: John, let’s change topic a little bit and talk a bit about administration, about service to the field. You were chair of CS from ’87 to ’92. You took over from me. I was the chair before that. And you immediately became *[associate – ed.]* dean of engineering, and then dean of engineering. How did this switch happen? What led you to become an associate dean?

Hopcroft: Well, one of the things, before I became chair, I didn’t think I would like administration. [chuckles] But I think our department ran out of senior faculty who could be chair, so I sort of had to become department chair. But when I became department chair, I really enjoyed it. I discovered that I could make things happen. So I thought if I enjoyed doing things for the department, maybe I could have an impact on the college. So I talked to Dean Streett and became associate dean for a year, and then he retired and I became dean.

Gries: What did you do differently? What was your vision?

Hopcroft: Well, one of the things is that it’s really the departments that make up a university, so I gave a lot more authority to chairs of departments. I mean one of the things that happened to me is a department chair came in and asked for an additional secretary line. I didn’t know how as dean I would ever find out if this was really something he needed or whether this was something he thought he could get his budget increased by. So I changed the budgeting. I gave departments a budget and told them it was up to them to decide how many faculty they wanted, how much they wanted to pay them, *[0:30:00]* and how much they wanted to support them. It’s just they had to stay within their budget.

So I moved all of those decisions out of the college down to department chairs. I think it had a major impact on the college because, if you notice, a few years later, most of the departments had department chairs who were members of the National Academy.

Gries: How did you try to decide who needed more money, what department was better?

Hopcroft: This is where I thought the question should be. It should be not “What should they do with their money?” but “What slice of the pie should they get?” Some of the principles I had is I felt some department chairs were simply better than others. I sort of felt, if some department chair is really good and is going to hire good faculty, I ought to give them a little bit more money so they can increase the size and not give so much to someone who’s a little weaker. You have to keep the actual funding within close to something depending on their workload, but…

Gries: What about metrics? How did you judge?

Hopcroft: Well, one of the things I did is I made a list of the course every faculty member taught and how many students were in it. Then I ranked this and looked at what was the median number of students that people were teaching. And part of it was because of computer science. Computer science was teaching a course with a thousand students or something in it, but they only had one faculty member associated to it, so I didn't think I should add several faculty for their average teaching load. That's not what the faculty were doing. And actually what I did is I took the middle third, the teaching load of the middle third and averaged them and used that as…

Gries: So a lot has to do with using the right metrics in order to…?

Hopcroft: Oh, the right metrics are terribly important in everything.

Gries: But they're often hard to measure.

Hopcroft: Oh, they're hard to measure, yes.

Gries: Duffield Hall was built under your administration. Duffield connects… It took away a large part of the Engineering Quad. It connects three other buildings. Well, it connects with Upson Hall and Phillips Hall. There was a lot of controversy over that.

Hopcroft: Right. But one of the reasons we built that particular building is I realized that, in the areas, certain areas, we needed vibration-free clean room space, and it simply wasn't possible to renovate existing buildings to do that. Another thing, one of the big costs in engineering is whenever you renovated a lab, if you made significant changes to the building, you had to bring the whole building up to the current code. So we needed a building where you could make reservation-… you could work on labs without having to bring the whole building up to code. So we built a building that had labs parallel but a six-foot-wide space in between where there was no floor, and we didn't have to renovate the building if you wanted to bring a pipe up or something like that. So there are a number of things like that. But it was very expensive space, so I didn't put offices in. Asked to renovate existing buildings for that.

But I should point out one of the things. I gave the architects 12 locations they might build a building in, and then I gave them a list of things that we wanted to achieve. They came back a few days later and said, "John, none of the 12 sites that you've given us really are the sites which are going to achieve what you want. Here's where you should build the building." And I didn't even think you could build a building there to be honest with you, but they convinced me that it was the right place to build it. And it has integrated several of the buildings together and…

Gries: Well, the important thing that eliminated a lot of the controversy was this notion of the atrium. Was that your idea?

Hopcroft: No, that was the architects'. Having a good architect is really important. And I wondered if that atrium was going to work, because it's relatively narrow and high, and I thought the acoustics were going to be terrible. So I told the architects every time I saw them that we weren't going to pay them unless they got the acoustics right. And they did. It's really successful.

Gries: That's about the most successful place on campus as a meeting place for students. People are there all hours of the night in the little nooks and so on.

Hopcroft: Well, that was the other thing. The architects pointed out that if we didn't put locks on the outside doors, then the building could be used a whole lot more. They said, "Look, if someone wants to secure it, they'll have to pay to put the locks on, so they probably won't do it." [laughs] So it's one of the few buildings on campus which is not locked today 35:06.

Gries: Again, it was the architect's idea?

Hopcroft: It was the architects'. We had really high-quality architects for that building.

Gries: A beautiful job. In 1992, you were appointed by Bush, President Bush to the National Science Board, which oversees the National Science Foundation. What was it like being on that board?

Hopcroft: Well, for me, this was a real opportunity because I was quite young. One of the things I point out, that this is an advantage of being first in a community, because just by luck, not by anything else, I taught one of the first computer science courses, and that made me one of the senior computer scientists even though I was young. And when our government was looking for a senior computer scientist, there weren't people ahead of me. I mean if I had been in high-energy particle physics, I'd still be waiting today for the senior faculty ahead of me to retire. So I just mention computer science is changing, and rather than stick in the old field, a young person ought to move into the new directions, because then they will be the senior people.

Gries: I'm going to ask you later what those new directions are. [laughs]

Hopcroft: Okay, we can come to it. But it was a very important experience for me because, after two years, I became chair of the committee that brought any expenditure to the board. The board has to have a process by which expenditures can be brought to it and voted on, and so every expenditure that came through I brought to the board. So I sort of was spending seven and a half billion dollars a year for the last four years I was there.

One of the things I did is Bush wanted to reduce the size of our government, so he set line counts on each division. The Navy used to provide all the logistics for US personnel in the Antarctic, and we simply paid them and they were happy to do it. But with their line count, they didn't want to use up their line count, so one of the things they did is they said, "You'll have to find private contractors to do it." So I became responsible for all US personnel in the Antarctic.

Gries: Hah. And is that why you went down there?

Hopcroft: That's why I went down there. We were rebuilding the South Pole Station, and…

Gries: How was it down there?

Hopcroft: Well, it was minus-30 at the South Pole, but it actually felt warm because the sun was shining and there was no wind. But that was a good experience.

The other one was the Internet, because Jack Schwartz was at ARPA, which is now DARPA, and he realized that the Internet was being used by scientists to collaborate. It was no longer a research project. And he didn't want to use his research money for that. So he called me and said could we transfer it to NSF? Then I sort of became responsible. It was NSFNET. Then I realized there was a lot of pornography on it, and I became nervous that someone was going to challenge NSF and say, "Why are you supporting pornography?" So I talked to staff and said, "You've got to privatize NSFNET," and that's what happened.

One of the interesting things, I realized that there would be a lot more domain names sold than what people were planning and some company was going to make a fortune. So what we did is staff said, "Well, look. Why don't we in the contract say if they sell more than certain names, they will give the money to NSF, which we could use to fund science?" I thought it was a good idea. I asked my attorney who always was with me, and fine. But what I didn't realize is someone was going to sue us. Someone who bought a hundred thousand domain names filed a suit claiming it was unconstitutional because an agency cannot sell something for more than it costs. That's not a profit, it's a tax, and agencies don't have the authority to tax. So we got sued and we lost the suit. But fortunately the judge said, "However, Congress can pass a tax retroactively," which we asked them to do. I don't know how it eventually happened because I went off the board about that time.

Gries: Then you saw a lot more *[0:40:00]* than most computer scientists saw about this.

Hopcroft: Oh, you get a lot of experience.

Gries: Yes, neat. You left the deanship and became a faculty member. You hadn't done research full-time for…

Hopcroft: Eight years.

Gries: …eight years. How did you get back in? What did you do?

Hopcroft: Well, one thing, the university gave me a year at full pay where I could just focus on research, and that got me back. By this time, computer science had moved into social networks, so I started there for a while. Then I moved into machine learning, because I realized that was such a big area. That's where I'm working now.

Gries: That's basically AI, and our department looked down on AI back in the '70s.

Hopcroft: Right. Well, there was a lot of hype and not too much contribution. But actually one of the things that changed it was this ImageNet competition and AlexNet, because it really worked. And a number of companies tried this technology in a wide range of areas and it worked. This has made it a big, big area.

Gries: That's machine learning?

Hopcroft: Machine learning.

Gries: Machine learning. A lot of it is statistics.

Hopcroft: A lot. Right. And a lot has to do with information. One of the things, robotics, I was in robotics for a little while. But I was looking a little bit at it as mechanical things, having a mechanical robot which would move things. But that's not really where robotics is. Because you would think robotics is in mechanical engineering.

Gries: Mechanical engineering, yes.

Hopcroft: But it's not. Think of driverless cars as an area of robotics. The big players are Baidu and Google. They're not in manufacturing cars. They're simply going to buy the car and put the information into it.

Gries: It's the computing.

Hopcroft: Yeah. And the important things in driverless vehicles are the sensors and the maps. These have nothing to do, at least I think, with mechanical engineering. It's computer science.

Gries: I'm going to get back to where you think the field is going later, but right now I would like to talk to you about your… or have you tell us about your service to other countries. One thing stands out on your résumé that's different from just about every other one I've seen, is this continual service I say starting about 2002 or '03 to various companies. You were on an engineering school advisory board in Hong Kong in '94, but all the rest started about 2003-04 – Kuwait, India, Australia, Vietnam, Brazil, Korea, Russia, and of course China. Let's start with Vietnam. How did you get involved?

Hopcroft: Well, the National Academy asked me if I would go over and help them with a project. They had started the year before, so I only came in the second year. Unfortunately, they had brought a number of world-class researchers over to set up a program for Vietnam. What they had told them, told Vietnam is to send undergraduates to the United States to get PhDs and then go back and improve the educational system in Vietnam.

Well, this would have been excellent advice if it was the United States. But at that time in Vietnam, the top universities were hiring people who just got bachelor's degrees to teach. Basically, there wasn't the research infrastructure where these PhDs would go back. So when I went over there, I realized it was the wrong program. They should have sent people for master's degrees. They could have sent five times as many because they'd only be there one year rather than five, and secondly, they would have to go back to Vietnam because they wouldn't be competitive on the world market, where the PhDs would. By the way, none of them went back to teach. [laughs] And they could have upgraded teaching much faster. They could have upgraded it after one year. But the prime minister said, "Look…" He immediately recognized it, that it was the wrong program. He said, "I can't back off the program now, but I'll add the master's component to it."

But I guess one of the things is when you're young, your goals are to build your professional reputation, and that's what you want to do. But when you get older, you want to have an impact on the world and make the world a better place for other people. So I worked in a number of countries.

But all of these countries, there's a problem – that unless at the very top there's support for education, there's not much you can do. In one place, I was talking to a university and I said, "Why don't you just increase the quality of the computer science department up to the equivalent of Stanford, Berkeley, or Cornell?" And the president said, "Well, what will it cost?" I said, "The only cost would be you would have to reduce the teaching load of three faculty members." And he said, “That’s too expensive.” [laughs] And you can see, you can’t, you can’t have an impact if that’s the…

But when I got to China, China is different. China knows that they have to improve education. The premier told me, he said, “Look, one of our top priorities is stability of the country. To do that, we’ve got to raise the gross national product so we can raise the standard of living people faster than their expectations go up. And we can’t do that unless we improve undergraduate education.” So in China there was a real opportunity.

Gries: You started there with Shanghai I think, right?

Hopcroft: No, actually I started in a project… Before that, the ministry of education asked me if I would help them upgrade a thousand second- and third-tier universities. So I spent time working with 50 faculty at a time to upgrade things, but I realized it wasn’t going to work. So I went back to the ministry of education and said, “You’re wasting your money. Let’s drop the project.” Then the president of Shanghai Jiao Tong University said a better strategy would be if I would become a counsellor to them, to him, and help him improve the university, and they could produce high-quality PhDs which would go out to local universities and move up. It sounded like a good idea, but you can see that the time that that was going to take to do something would be too small.

Then I got an opportunity. I sort of became an unofficial advisor to the premier. I got invited, my wife and I, over four times to advise him and have dinner with him. This changed my ability in China. I mean one of the meetings, the premier just wanted to have televised us shaking hands and broadcast nationally. And that gave me… I now have access to high-level officials. If I want a meeting, I get it, and they will fund literally anything that I ask for.

Gries: What are you asking for now? How are you think you’re going to change?

Hopcroft: Well, one of the things, I chaired an international committee on how to improve education in China for the premier. We were told that our report should be only one page. [laughs] May sound kind of silly, but it does focus you. When you have to write it in one page, you ask, really, what are you going to say, and realize if you told the premier to do 10 things, probably nothing would happen, but if you tell him just one thing, it’s likely to happen. We told him to change the metrics by which university presidents are evaluated.

Gries: So this gets back to metrics again.

Hopcroft: It gets back to metrics. University presidents have five-year terms. They’re government employees and they’ll get another job afterwards, and they want a better job. So what they do is they increase the research funding at the institution and the number of papers published, and they can say, "Look, I increased the research funding at the university by 20%." The difficulty with that is they put so much pressure on junior faculty to raise money that the junior faculty have to work for senior faculty to do it, and there's no emphasis on teaching. In fact, I offered to work with some junior faculty to help them improve their teaching, and they told me they would first have to check with their senior faculty, and they came back the next day and said senior faculty said, "Don't waste your time on teaching."

So what we're trying to do is change the metrics and make them two metrics. One is "What is the quality of undergraduate teaching?" and secondly "What is the professional reputation of junior faculty as measured by international experts?" And to evaluate them, I'm proposing we don't even send their vitae, because if we send the vitae, the international experts will start to count publications. Instead, we'll just ask a few questions – "Do you know this person?" just one sentence, yes or no; "If yes, how do you know them?"; and then "Do you know, in one sentence, something that they've done that's important and, one more sentence, why is it important?" If we can write five senior people and two or three of them say, "Yeah, I know him and he's done this. It's sort of interesting," that sufficient.

But to do this, to put pressure on university presidents, we have to rank universities on the quality of undergraduate teaching. That proposed a lot of difficulty, *[0:50:00]* because the ministry of education is a little I think uncomfortable doing it, having a ranking which is a government ranking. So we changed it. This January we changed it. Instead, what we're going to do is we're going to give teaching awards. Actually, next week I'm going over to help instruct the people who are going to evaluate the teaching to give these teaching awards. And they're major awards. We're going to give 50 awards of $10,000 each to faculty at the top nine institutions. On average, an institution will get six awards, but some will only get four and some will get eight, and there will be an official ranking. We're only going to rank one department in the spring to test, but in the fall, we'll rank five departments. Then next spring, we're going to work with 42 universities. And it's not so much doing the ranking as sending the message to the university presidents.

Gries: So you're going to send people over there to teach people how to evaluate teaching.

Hopcroft: A lot of it will be done by people who are there.

Gries: Yes. But you have to teach them how to…

Hopcroft: Right.

Gries: Have you found people who understand…?

Hopcroft: I've tested the methodology last year at Shanghai Jiao Tong University. We had Asian faculty come in and evaluate courses, but I also sat in on many of the courses and evaluated them and got the same evaluation. But what's interesting, is realize the courses are taught in Mandarin, and even though I know no Mandarin, I came up with the same evaluations. Because what we're doing them is we're scoring them, is how well does the faculty member… how comfortable is the faculty member with the material, how well they are engaging the students, what fraction of the students are listening and what fraction are on their iPhone. Things like this. And what's interesting, I could even afterwards tell some of the faculty how to improve their lecture, even though I didn't know what they were lecturing on.

Gries: That's neat. That's good. So you'll be going there in April. That's next week?

Hopcroft: That's next week.

Gries: That's good. Have a good time there.

Hopcroft: Right.

Gries: We're the same age. I retired five years ago, although I'm still teaching because our courses are so huge. How long are you going to continue with this whirlwind pace?

Hopcroft: I think I can only another couple years. But also, just as you, as long as the department has such a pressing need for faculty, I'll help them.

Gries: What should the department be doing with its problems?

Hopcroft: Well, I think people have to realize that we're entering the information age, and this is going to have a tremendous impact. And you'll notice that many of the students already realize this, that I believe one-tenth of the majors at Cornell are in computer science and we're doing one-tenth of the teaching with 2% of the faculty. I think Cornell's got to make a decision to really create, make the department into a college with maybe four or five departments, and it's going to have 100 to 200 faculty. It'll be the equivalent of Engineering or Arts and Science.

Gries: We already have the college, CIS. Should it become a real college?

Hopcroft: Well, to make it a real college, it would have to do admission of undergraduates. But I would just change the definition of a "college." I'd make it a real college, but not have it admit undergraduates.

Gries: I agree. I don't see why we should do that.

Hopcroft: We're getting high-quality students from Arts and Science and from Engineering, and I don't think we would get as high if we did it ourselves.

Gries: How do you see this CIS changing? Should computer science get a hundred faculty members? How would you do it?

Hopcroft: Well, one of the things. People who look at size of departments and cohesiveness understand that as soon as you get above 25, you're not longer a cohesive department. So I would break the department up into units. I mean right now, I think we're about 40 faculty, and I would add IS to it, which maybe would be 60, and break us up into four departments of size 15. Then each of these could add three per year, so we'd be adding 12 faculty a year and we could reduce the teaching load.

Gries: What else for faculty? What would you tell the junior faculty? How should the department help its junior faculty? They're teaching a lot.

Hopcroft: The junior faculty are the future of the department, and we've got to invest in their professional development. And I think a number of things. One is reduce their teaching load. When you become a senior faculty member, you can teach some of the bigger courses, but have the junior faculty just teach smaller courses in their area, with one exception. I think one semester, you should have them teach a bigger course just to make sure they can be a good teacher.

And secondly, we should focus on getting them high-quality PhD students. I mean my career was built on my PhD students. They were every bit as bright as I was, and working together, we did great things.

Gries: You've had PhD students who were president of a university, deans of universities, chairs, all over the place.

Hopcroft: Right. And one heads the CI-… AI lab at MIT, places like that. One is…

Gries: They've won MacArthur awards.

Hopcroft: Yeah, and one is deputy director of NSF China. Or not NSF. Microsoft Research Asia. These were just incredibly bright and dedicated students, and when you work with people like that, it builds your career. So I think we've got to help the junior faculty have much better, the best PhD students in the world.

Gries: You've been here a long time. Tell me what you think about our whole environment, perhaps compared to other places.

Hopcroft: Well, the environment, there's a lot of things that are good. But let me, for one thing, talk about the physical area. A lot of people have to live in big cities. If so, we're not going to attract them to Cornell. But there are others who want to live in a rural environment. I don't know what the percentages are. Maybe 20% of the people. A lot fewer. But we are the only university, only really major university that's in a rural environment. So the competition for us for high-quality faculty, we have a better chance than others.

And coming here, there are things you can do. You can go skiing. There's a ski area, a number of ski areas 20 minutes from here. California, you can argue the skiing is better, but you'll never do it because it's four hours away. There's a lake for sailing, there's a lot of Finger Lakes trails, and just people who come here like the outdoors, they like athletics and sports and things. So the environment is actually a very good environment, unless you in some sense have to be in a big city.

Gries: Right. There are people who want the city. What about the computer science department?

Hopcroft: Well, it's one of the top computer science departments in the world. Right now, there is this issue with size, but if we can get the teaching… The number of students just increased so rapidly, but if we can grow the faculty fast enough and get the teaching load back… But this has happened to every university in the country, so everyone is in this. And we'll resolve it in a year or two and it'll be a fantastic place for faculty.

Gries: Sort of a last question. You've been able to anticipate the direction of the field several times. You've given something like 38 talks talking about the future of computer science. What would you tell our young PhD students what they should be learning and studying, what they should be doing, and even our undergraduates?

Hopcroft: Well, I think our undergraduates know pretty well where the world is going. They probably watch television or read *Time* magazine or something. I don't know just how they get their information, but they seem to get it. That's why the number of students has increased long before faculty realized that there was a change. I would just tell faculty, being the first in a new direction really enhances your career. And simply because you've taught a course for 10 years doesn't mean you should continue to teach it. You should explore where things are going and start moving forward.

Gries: And what are those new directions in your opinion?

Hopcroft: Oh, in my opinion, there's an information revolution, and it's going to be as big as the Agricultural Revolution or the Industrial Revolution. And people should start thinking about things. For example, what percentage of the population is going to be needed to produce all the goods and services we need? So one of the things where I work in other countries, I listen to them as they're planning. China for example believes it's only going to be a small fraction of the population, like 25%. And some other countries *[1:00:00]* are thinking about guaranteed financial income whether you work or not. That doesn't mean that you're going to write someone a check. What you might do in the United States to give someone an income is give free medical, have the federal government pay all the doctor bills.

One of the things that could do is it could improve medicine here. I believe in Germany, when they contract for someone to build a road, the contract is not only to build the road but to maintain it for 20 years. So they figure out what materials should they use and so forth to reduce their total cost. With medicine, if a medical organization had to treat someone for life and they got so much per year independent of how well that person was, they would invest in wellness to reduce their costs later on.

So the world is changing in lots of ways, and I would start… That's why, when you're getting an education, you shouldn't just focus on computer science. You should take a few courses in other areas. I mean if you're interested in building a company, maybe you ought to take a course or two in business.

Gries: Entrepreneurship.

Hopcroft: Yeah. Or if you're thinking of going to just work for a company, maybe take a course in human resources to see what motivates people. Or you want an impact on the world, take courses in sociology and things like that, a broader education.

Gries: Yes. In this sense, IS is a very good major.

Hopcroft: Right, right.

Gries: You're branching out, more looking at other fields, law, history, just about everything.

Hopcroft: Oh, all of these areas are important. Now you can't take a course in all of them, but at least explore a little.

Gries: Does this say something about our undergraduate requirements?

Hopcroft: Oh, I would change the requirements drastically. I wouldn't have so much course requirements. I would say you've got to take a certain number of courses, credit hours in humanities, a certain number in social sciences, and so on. But let the faculty advisor and the student figure out just which courses. And I think a lot of…

Gries: We've tried to do that a little bit with our vectors and so on, but I don't think… the field is so large, there's a limit to how many core courses you can ask students to take.

Hopcroft: Well, I think the number of requirements in computer science is at a limit, the maximum that the arts college will let us take. I think we should reduce it. Because part of your education is not just what you learn in courses, but it's interacting with other students, being engaged in social activities. There's a lot to a college education which is more than just focusing…

Gries: In a sense, we shouldn't be educating for living, making a living, we should be educating for life.

Hopcroft: That's right, that's right.

Gries: That used to be the way it was, and I think that has changed too much.

Hopcroft: Right.

Gries: John, this has been wonderful. I've learned a lot in talking to you. Is there anything, a final word you would like to say?

Hopcroft: No. It's just that the world is changing and I would hope that Cornell as a university would play a major role. We have people in all kinds of disciplines who could help make the world a better place for people. Almost if you ask, "Why are there so many social problems in the world today?" well, in sociology and in many of the other departments, there are experts, and I think we should think not just as a university but put together teams from major universities to try to solve some of the world's problems.

Let me mention one thing that helped computer science when it… This is back in '67. When we were trying to attract high-quality PhD students, we had a tremendous reputation in Asia. The reason for that reputation was the agricultural school. There was someone I think in 1920 who went to China and developed new strains of rice and wheat. This had such an impact in Asia that it built Cornell's reputation. And that helped not just the agricultural school, it helped the whole university. We should be engaged at things of that level now as a university to really be world class.

Gries: Well, I think that's precisely what you're doing in going over to China so often and helping them with their education. That's the same thing what those people did in the 1900s with agriculture.

Hopcroft: Right. But it would be better I think if the university would take this act on rather than me.

Gries: Right. Maybe that's your next job, to get them to take it on.

Hopcroft: Well, that's what I'm trying to do. I mean China gave me this award, which is the highest award they'll give to a foreigner, but instead of giving it to me, it could have gone to Cornell.

Gries: Well, thank you, John. This has been wonderful. I really enjoyed it. It's been a nice 50 years I must say.

Hopcroft: Right. No, and thank you for volunteering to do this. You've done an excellent job. And also, the job, we didn't get to talk about the impact that you had on compilers. You wrote one of the first books there and had a tremendous impact. But thank you.

Gries: Yes. Okay. Thanks very much.

[end of recording]