Andy Hopper

Interviewed by

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At the

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Welcome to the Archives of Information Technology, where we capture the past and inspire the future. It's the 21st of June 2018. And that's a significant date, because 70 years ago today one of the very first stored-program computers ran its first program. It was at Manchester University. We're in the headquarters of the Royal Society in central London. My name is Richard Sharpe, and I've been covering information technology since the early 1970s. And we're in the Royal Society because Treasurer currently of the Royal Society is Professor Dr Andrew Hopper CBE. Dr Andrew Hopper co-founded so many companies that he is one of these very important people who branch between the academic world and the industrial world.

[00:56]
Professor Hopper, you were born in Poland in 1953, on May the 9th. You're Polish.

Yes, I'm fully Polish, both parents Polish. Born and went to school there. But, my parents separated and my mother met and married an English person, William Hopper. So, he adopted me. We came to the UK in 1964 when I was just eleven, thereabouts. And since then I've lived in the UK, but culturally I'm Polish, and, you know, I can eat a sausage faster than most people near to us. So, so, there is some deep Polish culture there, and I'm fully fluent in Polish still to this day.

[01:48]
You have a scientific background. Did your parents have a scientific background, and did your stepfather have a scientific background?

No, no particularly, but, cultures of engineering in the broad do very considerably in my country, in the Polish culture, and I even remember this today, even at that early age, engineering in a broader sense, and at that time it wasn't so much computer engineering, was a high value item so to speak in terms of prestige, esteem, earning power and sort of, societal commentary. So, it was more that sort of thing, rather than some immediate family background.

When you came to the UK, how did you integrate into the UK? You still, you had English as a second language, did you, by then?

No, I had Russian as a second language.

Russian?

I didn't speak a word of English when I came to this country. At the time I thought I had no problems at all, and I was completely happy and so on and so forth. But in retrospect, actually, for a number of reasons it took me a little while to sort of, properly get going. And perhaps the cultural and the language change was part of it, I have no idea.

[03:09]
Did you have to sit the Eleven Plus?

I just came at the time when the Eleven Plus would have been sat, but because I couldn't speak English, I didn't take it, and thereby I was excluded from a whole bunch of schools, because, not taking it was the same as not getting it, and, that was one of the barriers to my education in this country.

So how were you educated in secondary education?

Well, the sort of, bigger schools… My stepfather could afford a private education, but places like Westminster School, Latymer School, said, nothing doing, not interested in you. So all those interviews failed. And eventually he, I'm not quite sure how but, managed to convince a headmaster in a grammar school in St John's Wood called Quintin School to accept me, and that's where I went. This was a little bit of a thing, because we lived in Putney, so I had an hour commute every day to school, each way, to go to this particular school called Quintin School.

Did you enjoy it?

Yes, I mean, you know, I… It was socially very mixed. It became a comprehensive school. When I joined the sixth form there, it merged with the secondary modern school which was adjacent, actually in the same style of buildings, just there was a kind of, artificial partition into the two types of school. That was removed, and it

became one, so the social mix, at all times actually, but even, in particular during the lower sixth and upper sixth, was very good. And I was… London's a great place now, and it was a great place then, so, living in London and enjoying what it has to offer, even at the simple level of a, of a young person at school, was great. So, I don't, I have just great memories. But looking back on it, let me put it this way, my achievements, performance, ability to do stuff, wasn't, I wasn't as effective at that time. I was rather more effective, for whatever reason, but perhaps education, or, language or something has got to do with it, later on.

[05:36]
What were your favourite subjects?

Well I've always liked physical, tangible things, so, you know, the physical sciences did interest me. So on the positive side, certainly physics, electronics in the sense of, within that subject, and doing some hobby stuff at home. The other way, I was excluded from the biological sciences because of my performance, so I didn't really do biology at, at that school. And, my focus was much more on, on the sort of, physical side. On the languages and so on, I was OK, but since English was not my language, it took two or three years to become fluent, or, more fluent, I'm not sure I'm completely fluent today, you know, I didn't really get tremendous traction. I did all right. I have no complaints, everything's fine, but in retrospect I, I was at the bottom of the class. In those days you would be, you know, in the list, and, having been, you know, done very well in the Polish schooling system where I was, all right, in retrospect, I went way down. However, at the time I was completely happy, and I've got no complaints, I wouldn't change anything. So, you know, it's nothing, no, no overtone of any kind. But, I, I think the third year of secondary school, of this grammar school, was my worst; then I sort of slightly picked up for O Levels. And then at A Levels, the lower sixth was probably actually another low point. I remember the sort of, careers people recommending that I am not suitable for university, that I should do what at that time was called a National Diploma, Higher National Diploma, go into that sort of line of work. So, my parents even, you know, went out to some sort of, psychology types or something, I can't quite remember, but anyway, they scored me as well, and also said, 'Mm, not sure about this.' Well that was a load of nonsense, but… I, I kind of picked up towards the upper sixth, but only

got medium grades, so I ended up, as it turns out was fabulous, fantastic, but going to Swansea, because of my grades, didn't quite make Manchester, didn't make the offer there, so Swansea was the place I ended up at.

[08:26]
And what did you read?

Well, it's fantastic. I read computer technology. So imagine, in 1971, this university, Swansea, put on a course which they called Computer Technology, and contained the following two major and one smaller items: the major were computer science and electronics, electrical engineering, but on the lighter side, and the minor thing was economics and accountancy. Fast-forward to 2018, today, that's, you know, computer science is big, and all the enterprise stuff today, well it was in that course, the, what did I day? Accountancy and economics, right. So, so an undergraduate, in your first year getting some underpinnings in how to do a balance sheet, and sort of, some vague idea of marginal cots, marginal revenue, pricing and stuff like that, as a minor part of this computer technology course, was fantastic. So, so it's just because, you know, particularly, I love it. I am Professor of Computer Technology at Cambridge University. The department is called, in Cambridge, Department of Computer Science and Technology. And in 1971 they were bright enough in Swansea, it was a person called David Aspinall, who was from Manchester, and had gone to Swansea for his first chair, he was at UMIST actually, had the foresight, the nous, whatever it was, to put together a course which, as I saw, just, I think was amazing, and, it was right on the money, both intellectually and financially.

[10:17]
Do you think it is important that you are from Poland and that Hermann Hauser is from Austria, and that you both succeeded in this country?

Well it's very important. One doesn't really know the reasons why, and it's, you know, it's a, probably some complex and, subtle in many ways, reason. But it's not, you know, my gut feeling, to answer your question, it's not because we are immigrants and want to succeed; maybe there is a little bit of that. But, we are outside local culture to some extent, so we don't see some of the barriers, we're not quite so

embarrassed. Because if we, you know, say something silly, oh, they are different, it's not, bad of the local culture. Maybe, I don't know. I can be embarrassed plenty, but, do you see what I mean? It's, it's, trying things in a slightly more unrestricted way, is probably more important than the, oh, I'd better make it good because I'm an immigrant, so, you know, I'm going to try harder. Certainly doesn't apply to me, that.

[11:27]

You succeeded at Swansea. What else did you like apart from your studies of being at a British university?

Well, it's a beautiful place, so I spent as much time having fun as working hard. I did work hard. And, that's where I… I mean, the paradox for me is that, I didn't do so well in A Level, but from the first term at Swansea I did very very well. Thereafter it was, you know, everything was, amazing. So, obviously there was a fit, opportunity and whatever. So I did that. But party, party, party, come on, this was the early Seventies, so, beaches, you know, all that sort of stuff. So I really enjoyed that aspect of it. And, even then, as today, it's not that far away on the train, or by car, so, to come back to my… It was provincial, compared to London, so you know, we're in the west… Well, we're, St James's here, the West End of London. I was very familiar with everything round here when I was eighteen years old, seventeen years old, sixteen, I mean very very, used to go to clubs and all that stuff. So Swansea in relation to that was provincial. So I would come back here and meet my school friends, some of whom I have contact with to this day. And, you know, we would be doing the latest, greatest, fun thing, whatever that was. And then I'd go to Swansea, which was a little more provincial, but very, very interesting.

[13:01]

But I also did a lot of travel, always liked travel. So, in the holidays, between the first and second year, with one of my school friends, we got a car. Imagine, nineteen years old, and we drove from here to Tehran in Iran, and came back. He was an Iranian fellow. So we spent a month or two, yeah, six weeks or something, with his family there. But, just imagine, nineteen years old, driving all the way down to Istanbul. Actually put the car on a boat across the Black Sea, ship, and then drove the rest of the way, and then to some extent around Iran, and then back. So that was between the first and second year. And, between the second and third year I got myself off to

Brazil for the summer, and, got on a bus, and went up to the Amazon, mouth of the Amazon, a place called Belém, and ship to the jungles, Manaus in central Amazonas. And back down, and so on. So, you know, just by myself. So, it wasn't just Swansea and provincial, but actually, some fairly significant travel. And I continue travelling to this day in, all kinds of weird and wonderful ways, sometimes at the fancy, and sometimes at the, rather more basic end. I like both.

[14:40]
You're also a pilot, aren't you?

Yes. So that's, that's…

Over 6,000 hours.

Yes.

And you have a, your own plane?

My own plane. I've got my own airstrip. And, you know, I'm a flying nut, and the most adventurous thing I've done, which, it isn't meant to be adventurous, but, is round the world. But I've actually done around Africa, around South America, around North America, around the world, around Australia, around New Zealand. All that stuff. So you get in the plane, it's only a small plane, you press the button, and you have a little snooze; wake up fifteen hours later, and you are somewhere else, you know. So it's great. [laughs]

But you have to pilot it.

Oh, yeah, well, you press the button and, there you go.

What do you enjoy flying?

Well it's adventure flying, so, it's a little bit like that business of, to Iran and back in the car, and round Brazil. It wasn't South America, specifically Brazil. On the buses,

on the dirt roads as, as was then. So, it's adventure flying, and when I say adventure flying, here is the executive summary. One, of course you travel from A to B, and even with a smallish plane, you know, you can, you can go reasonably far in a few hours. That's 200 miles an hour, so, you know, if you're doing, five hours, you can do ten hours but say five hours, well that's 1,000 miles, so you know, that's a reasonable distance. So that's one, you travel. And, in my case, it's, flying down the valleys, and, you know, it's going down the beach. Now for example, I went from Angola along the beach to Cape Town at 50 feet all the way. And, that's a big distance. So, you're looking at, watching, following rivers, whatever. So it's adventure in that sense. It's travel and visual. And when you land somewhere, most people speak enough English, they might be, just caretakers of the… Because this plane is small, you can go to small airstrips. You can go to the big ones for the bureaucracy, but you go the small ones. So you end up, and you've got… Basically, they say, 'What the hell are you doing here?' And you say, 'What the hell are *you* doing here?' Because I'm, back of beyond. But they speak enough English that, you can communicate. So… And, and typically these places are quiet, so, it's mutually entertaining. But then you've got an engagement with a local, who says, 'Well, try this, try that. What it's like in Cambridge?' Or, you know, whatever. They're people of the world, so it's not sort of… You know, things like that. So that's the second part of it. You engage with the people. And of course then if you follow on from their advice, about what to do next, you have enough flexibility in what you are doing, it's not a tour you bought and, you know, you are following a schedule; even a fancy tour has a schedule. You keep on adapting to some extent. And so, all kinds of interesting new things come along as a consequence of that. So it's all those things: physical travel; it's the, easy entry to the local scene, because you are dealing with somebody who is talking planes to you; and then, the advice and the broader cultural thing, by that I mean, how is it to live in this place, what do people do, what's the education like? You know, all that sort of, stuff, which I personally enjoy, and you can… You know, and you're right into it. So that's my form of travel. What I don't do is business travel. I don't get in my plane, fly off because I've got a meeting. Forget all that.

[18:40]

Maybe I'm going too far here, but there's an analogy with modern computing networking in the way you like to fly, which is, it's not a predestined route, it's not set out like an old PTT would set out a telephone line and allocate trunk space to it, and allocate the other, the last mile going to the, going whoever you are phoning up. You go from place to place and you see what is the best place to go next. It's, it's rather like a, a ring, or… Isn't it?

Yeah, there is some analogy there. I mean you end up getting somewhere, and it's all engineered, so this isn't an adventure flying, flying in the sense of risk taking, not at all. I do the opposite. It's very, you know, assessed, and, and done in a… In other words, you've got enough experience, way, way, way more experience than is necessary to do the next thing that you are going to do, whether that's high flying, low flying, you know, bad weather, good weather, night, whatever it is. So in that sense, it's, like a network if you like, and things, eventually you get there, and it's reliable enough and so on, but the path you take and how it ends up going, and what, the delay so to speak, and where you might stop so to speak to retransmit or the equivalent of retransmission, at least having a buffer, which fills up, and you say, oh I'm going to hang around here, because, I've just met somebody who's really interesting, and, he or she have invited me for dinner. So you have some similarity there.

[20:05]
When did you meet your first computer?

Well, it was really at Swansea, because, the other… 1971 was when I started, which is when the microprocessor was first essentially available. So Intel 4004, but 8008, and hence, the course I think was partially inspired by the fact that you could give people something to play with. And so, in 1971 when I first arrived, the university had one of the, ICL 1900 or whatever it was. In other words, behind a big cabinet, and you couldn't really get at it, was in the first term. And then, fairly quickly in that first year they said, 'Oh here is a bit of a board we've prototyped. See if you can, you know, make the bleeding light flash,' or whatever. Today it's called Raspberry Pi; at that time it was called, you know, Intel 8008. So that's when I really got the idea of…
[21:05]

Let me tell you a funny story. I mean it's not funny, but it's an anecdote that I remember. So to go for my interview in Manchester in 1971, I was reading the *Computer Journal*, and I was trying to figure out the difference between hardware and software, OK. So, so as a, upper sixth form student age seventeen, I still hadn't had enough education to understand the difference. I remember doing it on the train, like, they might ask me, so I'd better understand a little bit more about this. And that's because I hadn't had any hands-on experience. And, of course as soon as you do, that becomes obvious, and, and all that, and so on. And, and, and…

[21:38]

So that was my first computer. And, and actually, my project in the third year, which was '73/'74, was to reprogram a four processor piece of hardware which had been constructed as a research project by Professor Aspinall and his postdocs. So I got a little bit of exposure to, you know, slightly more complex systems and whatever, parallel processing and, so on. And then how to, it wasn't networking, but how to have them working together into the memory system and all this sort of stuff. So, fantastic. I mean you think about it, fantastic. As soon as the microprocessor comes along, they plonk it front of the students, me and others, and let us get our hands on. We get our hands dirty. Get a good feel for it. Ah, marvellous.

[22:35]

And then you move to Cambridge to do a PhD?

Yeah. And that was an interesting little, you know, how does life turn out? I've no idea. I, I'm not a sort of, person who has everything planned. I grab my opportunities all right, mainly, you know, through enthusiasm. To some extent I learnt, you mentioned Hermann Hauser, you know, he's a, one of my best buddies, business partner, almost kind of, I'm almost… He sometimes calls me his little brother. And his enthusiasm infects me, right, has infected me, you know, from when we were at Cambridge as PhD students. So… So yeah, I ended up in Cambridge. But it wasn't necessarily… So, so I, I'm still to this day, and I certainly was then, sporty. So I like a bit of sporty, sporty. And, the sporty that I had in me, funnily enough, was skiing, OK. I know you can't do skiing in London, so we used to go on ski trips. But I had done some skiing in Poland when I was a kid, because, you could send, you know, as part of the old communist system there were sort of, establishments families could

send their kids to, and I was sent on that sort of thing. I can't remember exactly which establishment. But I, you know, I was an OK skier even when I came to this country. Had some ski trips. And then in Swansea, but in Swansea, no can do. So, a little bit of, going on trips, and then, you know, as a sort of, or was at that time, maybe it carries on to this day, a British universities ski competition in Aviemore. So go up there and do a little bit of racing and all this sort of stuff. But, you know, it's, slightly, underplayed, and, I'm not a great skier, but I'm not bad. So I actually wanted to do my PhD in the Alps, because I thought, oh I could do a bit of skiing, and I get a PhD. So I applied, both to EPFL and to Grenoble University. And both at that time were established in computing, and…

EPNL was…?

EP… École polytechnique fédérale de Lausanne, EPFL.

Oh, OK.

Lausanne. So one of the two, that's ETH and EPFL in Lausanne, ETH is in Zurich, and then University of Grenoble. So I'm an undergraduate. Exams coming up. I send off my stuff. Nothing happens, no response, no reply. Oh, it's sad, oh dear. So, I get my results, I do well. And, you mention in the introduction about the banter between Manchester and Cambridge about who did the first computer. Well actually both did in their own way. Everybody's claim on the first computer is true, not just ours, those two, but there are others, and they're all true. Because they're all slightly different. But, David Aspinall, Professor Aspinall at Swansea, knew people at Cambridge. Because the banter is, is not competitive in a bad sense; it's, you know, it's, it's good stuff, you know, in its own way. So I said, 'What shall I? I've got a good result, I've applied over there.' He says, 'Go and see David Wheeler in Cambridge.' So, it was very late on, after the exams, so, we're the end of June, so it would have been around this sort of time, maybe even slightly, another week or two forward from, from today, but in 1974. Off I go to Cambridge, saying, 'David Aspinall sent me.' You know, 'I'm interested in a PhD.' So they say, 'Yeah yeah, come along, we'll interview you.' So I, I go up to Cambridge, and I am interviewed,

not particularly by David Wheeler, but by Maurice Wilkes and Roger Needham. And…

Did you know who they were?

No. I just, I… You know, Cambridge, good, great brand. I… David Wheeler was the specific person who ended up being my PhD supervisor, but, no, I, I knew nothing. Cambridge was one of these places where I couldn't have possibly got into, and what am I doing here? And it's flat, there is no skiing, right? I mean… [both laugh] What's going on here, right?
[27:21]
But they gave me an interview, and very quickly they said, 'Yes, you're in, and we've got a studentship.' So I thought, my word, that's really good. And the deadline was very close, so I actually hand carried the… So I drove to Swansea and back to Cambridge, and back to Swansea, back to Cambridge, to get all the paperwork in place so that they could award by the deadline, I guess that must have been end of July, by, by then, so that I could have the grant and the, and the place. So that turned out very well. Subsequently, you know, I, many years later, *I* was the one interviewing and running the admissions programme and all that sort of stuff. And, I twigged that what happened, they had somebody drop out, OK. And I turned up. So of course they said [laughs], 'Well, he's good, he's all right, but, if we don't make an offer right now, we're going to lose the studentship. So you're in.' [both laugh] So…

No no, really, it was because you were so good, oh come on.

Well, I wish it were true, but, you know, it's not completely true.

[28:25]
What did you choose to study in your PhD?

Well, you see, the other… You know, talent is important, but many people have talent. A bit of good fortune. And contribution of the right thing at the right time is important. So, I had come from a course which enabled me to build a bit of hardware

and then put up some firmware, software, then a bit of an application on top. But it's the first bit, I knew how to use a soldering iron, and I knew what the TI catalogue was with, with all the 7400 chips inside it. And, at Cambridge they had just completed building the CAP machine. And when building too much… So Cambridge Ring was only just getting going, and I turned up as a person who says, 'Oh I like a bit of hardware construction, design construction.' So they welcomed me, because, also, you know, from a, not just, [laughs] the grant was going to be lost, but also, what I said I'd like to do was in line with just the lie of the land, as it turned out, at the department. So when I arrived, they, they had, Maurice Wilkes was the head of department then, I was allocated a space, not just in the PhD students' room, shared, shared laboratory, and I shared that room with interesting people, but they gave me some lab space with the, the technicians and engineers who had built the CAP, and had been involved in EDSAC 2, and they gave me a, a bench up there. And I started building little bits of hardware. And they were very happy there was somebody up there. And equally, it was a little unusual for a PhD student to be sitting with that engineering group and support group, but that meant I got to know them quite well. So later on when I helped out with the Cambridge Ring design, where those people were building it, and, David Wheeler had designed a lot of it, Maurice Wilkes had the conceptual thoughts about it, Roger Needham did the distributed system around it, I wore short trousers and helped out with little bits and pieces, but nevertheless, those little bits and pieces did help with the construction. It was in the bosom of the engineering and technology, technical team, and then I could also do my PhD as a, which was to design a VLSI version of the Cambridge Ring, and other local area networks.

Great.

[31:04]
But you see how it all fitted nicely. I, I fell into a, very embracing situation from a support point of view. I fell into a situation where strategically they were looking for the next thing to do, which turned out to be the Cambridge Ring, or had just started it. And my background was such that I was, you know, a, a good fit. So, I didn't decide to do subject X, Y or Z; that was my background, and it became, local area networks for my PhD, and chip implementations of those.

[31:40]

So from the early Seventies we've got microprocessors, we've got a proliferation of what would be called microcomputers. They also have peripherals hanging off them. And people are now, in the early Seventies, thinking of, how do we begin to link these things together in a cheap and practical way, not having to go through the local PTT, the telephone company, and telephone wires and so on. So, in Xerox for instance, in Palo Alto, they're working on what became the Ethernet, and in Cambridge they're working on the Cambridge Ring. And there's a significant technical difference between the two of them, to say the least. The Cambridge Ring is not the group of people who, who were recruited by the Soviets of the 1930s, although if you google Cambridge Ring, you will find that as well. It was a very early local area network. And one of the characteristics that I'm struck by in terms of the architecture of the Cambridge Ring, and perhaps you can explain to me the background to this, is at how robust it really was from the word go.

Yeah. Well, because the department had built, EDSAC 1, EDSAC 2, the CAP machine, it had a tradition of building things that stood the test of time, in other words, were useful to others, and, and provided a platform, computing platform of some kind, so that was behind it, there had been a, a visit by Maurice Wilkes to a company called Hasler in Switzerland who had, I think some telecoms background, but had also built a ring, a register-insertion ring as it was called, as it's called. So there was, some aspect of that. But, there was innovation in the way the protocols worked, so it wasn't robust in the PTT sense, that it all had to really really work and, and you know, no retransmissions were essentially envisaged, was more of a collapse objective to retransmit. So the idea of packets and being able to retransmit, and is sufficiently reliable that you only retransmit occasionally and that's fine, and you don't have to have any acknowledgments and all that sort of, thing, which is part of the architecture, was also what contributed to the robustness. But, you mentioned Xerox. Again, on a lighter note, as with Manchester and Cambridge and others on, on the initial computers, on local area networks we knew each other. So I remember going to Xerox PARC, must have been second or third year of my PhD, in other words, 1976, and they were very hospitable to me, but what they remember me for in America of the Seventies as now, land of cars, I cycled. So, so I turn up, slightly

sweating, because it's up a hill, on a bicycle, saying, 'Where do I put it?' And, you know, 'I'm from Cambridge, and I'm Andy.' And I remember to this day the sort of, very positive but slightly bemused, you know, they remember me for that, [laughs] not whatever I talked to them about at the, at the time. No, it was a fantastic project, but again, looking back on it, the Cambridge Ring was nicely resourced at the university level because of the capacity of the computer lab. In other words, those engineers and technicians who could build things, and weren't trying to publish, having picked up experience on EDSAC 2, and some of them on EDSAC 1, that there was enough flexibility in the way the academic system worked that you could essentially trade publication for construction, as the principal person, because the principal person published less in comparison to others. So it was well resourced, but still, as compared to Xerox and an industrial position though, it was smaller.
[35:58]
And then my PhD, I made one or two minor, well, you know, whatever, not major contributions to the design of the Cambridge Ring, but I did spend a lot of time on a VLSI version, or a chip version of the VLSI: that's slightly generous, but anyway. And, when I look back on it, there was a funded project, Government funded here, for doing a chip version of the Cambridge Ring, because it seemed, you know, that this was in every way going to, faster networks, good local area networks, good intellectual impact, financial, commercial impact, you know, all that sort of stuff, technology, lovely, lovely. But, it paid for one person, me. Literally one person. So, the chip version of the Cambridge Ring was one person, and, while the chip version of the Ethernet was Intel, Xerox and DEC. So this, now looking back, is barking mad. Because, we did OK, but you know, it was, not resourced properly. The Ring, not, not the chip version, the Ring itself was in its own way resourced OK. The chip version, it's ridiculous. [laughs] Now I don't blame anybody for that; I just look back on it, and I think, you know, I, I was, we were all enthusiastic, ambitious, keen on it, and naïve as well. I speak for myself.

There was a fundamental difference…

I wouldn't like to comment on my colleagues, but I was naïve, taking this on.

OK.

But there were all sorts of corollaries which I can take you through which are extremely positive, which essentially, this is the precursor to why ARM exists, why the chip line in Cambridge exists in many different ways, but the precursor, and I mean, the real precursor of why, you know, there was expertise, starts with this particular project, even though the later things are of a different kind.

[38:04]
Your fundamental architectural differences between the Cambridge Ring, which is called a token ring network, and Ethernet…

That's a slot ring. It's a slot ring. IBM's the token ring.

Right.

Cambridge Ring was a slot ring. And, they're different to the Ethernet of course.

You had something like 255 nodes on the Cambridge Ring, and each node could generate a packet. And that packet would be sent around the Ring to a recipient; the recipient would unload the packet, and then own that token, and be able to put the packet back on loaded.

Yes.

So, it really had very consistent performance.

Yeah. It was pretty good, from that point of view. So it was a little bit towards the sort of, synchronous behaviour that you will have in PTT style networks which existed at that time and continued to exist later. And it had a certain fairness of access, so that the, the slots, I tell you, if you want to think of them as tokens, but they were multiple slots, like it's a multiple token system rather than a single token system, allowed arbitration prioritisation and fair sharing, and allocation of bandwidth. Yeah, so was, yeah, it was a great design, and, Maurice conceived it, and David Wheeler designed it.

[39:25]
But Ethernet was a device, would look at the, look at the LAN, and say, yup, I've got a chance. I'll go in.

Yes.

And that's the fundamental difference between them. And the Ethernet could collapse disgracefully as it's called. Disgraceful degradation. It could just, throw its arms up and say, 'Look, I can't do anything else.'

Yeah. Yeah. So… And looking back on it, these weren't sort of, such constructive thoughts. At the time we thought we thought we had a great design, it worked, and so on. And the maintenance was, a little, my contribution was in the way the maintenance was done, and some packets, well all packets were marked with some parity bits for maintenance purposes. So it was more robust, and, and things like that. And the degradation was bounded, in other words, the performance was a little bit closer to the synchronous behaviour than in Ethernet in comparison.

Yes.

Now it turns out, that bounding was appropriate, but not necessary, right? Because today we use Skype or whatever, which is, you know, working with very unbounded network delays across the planet, and we still somehow put up with it. Worldwide we put up with it in the positive sense, compensate for it using technology buffering and all the rest of it, and put up for it, somehow socially we accept that, it's gone, and you can't hear what's going on. Which a Bell head, in other words a person from the PTT world, would never, never, never allow, say, that's impossible, that's a sin.

[40:55]
So the idea of, of token passing was picked up by IBM, IBM Zurich laboratory. IBM eventually, in 1985, actually launched a product, ten years after the Xerox patent. It looked as if, with IBM then behind it, and it being more robust, token ring would be it. But actually, Ethernet was it.

Yeah, Ethernet was it.

What do you learn from that?

Well, I learnt from that that no matter what it is, given a good brand, because, call it Ethernet, even if it is an ethernet, [laughs], because, what we have today as Ethernet is miles away from all that, and sort of, the standardisation on the one hand, and the power of the marketing, and I don't mean in a cheapskate sense, I mean the assertion of an industrial position, win.

And that was because Xerox and Digital Equipment and Intel were behind this?

Assert the industrial position in every way. How? Cmmercially, pricing, marketing, position papers, academic papers. Assert. Win.

Have you applied that lesson?

You bet. But, not… And I learnt from that one. [laughs] So…

[42:18]
So you get your PhD. You are now a Doctor. You're in Cambridge. You know all the crew at Cambridge. You've met Hermann Hauser by now, and you've met Chris Curry by now, and you've seen interesting things going on in various places. What do you decide to do next?

Well, I think I'm still right in saying that I met Hermann in a disco in Darwin College. We started chatting because there wasn't much disco going on or whatever. By then the Cambridge Ring was being sold by three companies, or, about to be sold by three companies. Maurice would hand out the drawings, I think it was for £10,000, as seen, drawings as seen, non-exclusive, they are copies, get on with it. That's what I call technology transfer. Cash in hand, good luck, non-exclusivity. Next. I love it. I wish it was like that today. So Hermann says to me, 'Hey, why don't *we* start a

company, and be another one selling the Cambridge Ring?' So I said, 'All right, let's do it.' So we started a company, called Orbis.

This was 1978, the time you got your PhD.

'77, '78, yes, that's right.

Yup.

I can't… You know, it was precisely that, yes. And, and working on the VLSI version, but this is selling the board version.

Right.

Which Logica are also selling, Topexpress is also selling, and one other which I've forgotten. So we indeed, also pay our £10,000 [laughs], or whatever, I can't remember, was, a reasonable amount of moony. But it was as, you know, it's like selling a car as seen, there we go. We have our first employee, who is Mike Muller, who is the CTO of ARM to this day, and the only employment that man has had is, Orbis, which was absorbed into Acorn, which span out ARM, so he's never, [laughs] applied for a job after that first… Well he didn't apply; we met in the Eagle in Cambridge, the Eagle pub, on his, after his last exam, and I offered him a job. He said, 'All right,' and that was it, he never applied for another job, and look what happened to him. A fantastic man. Great, a great person. Anyway. So I, we start Orbis, and we find a customer, namely what was then called ICI in Runcorn in Cheshire. I still remember to this day the mark-up on the hardware was seventeen times. We had an early adopter who wanted to, you know, show ICI how higher speed networks, local area networks, at ten megabits per second could be used in their business. The order was with us. Worked our guts out constructing this and delivering it and all the rest of it. But of course there was a story that, as best as we could, that there was a chip version coming, so there was a pathway into the future. And it, and it worked well in the sense that there was enough money in the company then to, to operate, right, and it was that first order was good enough to, to…

Because, we funded it ourselves, but with modest money, we just got that order, and, and off we went. And we said, manna from heaven, the company has got going, right. [45:53]

So that was how… So meeting Hermann by chance, getting on very well, and him nudging me into starting a company, because, it was, it came from his side, it wasn't me that I was being entrepreneurial; I was running around trying to make this chip work, right, or design it and so on. I can take you through those scars afterwards. It was a challenge to say the least, but a good, you know, it in many ways turned out very well. And we started this company. And at the same time, CPU, Cambridge Processor Unit, is, has also just got going, I can't remember, a few months earlier, which had been started by Hermann and Chris Curry. And then, not too long after, CPU stops being a consultancy doing fruit machine, digital replacements and upgrades; starts getting into home computing. The Atom. Well actually, there's a Series One before that, a little board thing. And it becomes obvious that this networking business is important, in general, because we, you know, file server, you know, all the sort of networking distributor systems stuff is happening there, and I'm doing a particular bit, but many others are doing many other bits. So we decide that, it's probably better to discontinue – to absorb Orbis into CPU. Acorn was always the sort of trading brand name, so CPU was an underlying company. I become the third director and shareholder of CPU, in return for my shareholding in Orbis. So, Hermann and Chris are directors; I become the third director. So I wasn't there right at the beginning, but I was, you know, fairly quickly afterwards, albeit Orbis, was there more or less right at the beginning. Meaning, when CPU started , round about that sort of time. And we discontinue being… We deliver our Cambridge Ring thing, and we start those activities in CPU, in other words Acorn, which became the Econet ultimately. So we decided to do a networking system for the low end computers, and, and that was one of my contributions to CPU/Acorn, to provide a networking system, which was actually more of an Ethernet type as it, as it happened.

[48:35]

And here you are, twenty-five.

Yeah. Yeah. And so, I was a research assistant for two years doing the, the chip project. Got my PhD. Two years postdoc, with money I had found actually, so the

money for the chip, I had found. Well I couldn't be my own principal investigator, to use sort of, university speak, so Maurice was the principal investigator. The money came from the Rutherford Labs, a man called David Thomas, who was head of that particular division of Rutherford Labs. Took a shine to this stuff, and decided, core, the UK needs to self-fund this particular thing. So that's where the money came from. So for two years I was doing that. Orbis became Acorn, or, was absorbed into CPU/Acorn. And, I am, twenty-five, twenty-six. And after two years of the postdoc I become an assistant lecturer. In other words, at that time there was a five-year fixed term lecturing post called Assistant Lecturer. So I joined the Computer Lab faculty as an assistant lecturer in the normal sort of way.

[49:55]
So we're in the late Seventies now. You're, now you're part of this Acorn operation. Acorn goes and gets the BBC Micro, and, things are looking quite amazing. And inside, there's a little project deep inside Acorn by some of the engineers who are looking, what's beyond the BBC Micro? 'Oh, we don't like the processors that are on offer. Oh, could we do our own? Oh, yes, we do.' And they therefore build a small RISC processor, Stephen Furber and others, and therefore, we have the beginnings of ARM. And things fall apart for poor old Acorn. And Olivetti, Italian company, then, having made millions and millions through its IBM compatible PCs, biggest European PC maker, decides to scoop up Acorn and buy it, and therefore scoops up your talent and the talent of Hermann Hauser and the talent of Chris Curry. Then they decided that, here is a man in Hermann Hauser who can really lead some research. He's good at this. He's good at putting these themes together. And he sets up a lab. And he appoints you as the head of it. How old are you when that happened?

Thirty or something like that. But let me just give you a little more subtlety to what you have just, the sequence you have just said.

Yup.

So first of all, at that time, when it was still the BBC Micro, the interface between the university department and the company is fantastic. There's flow both ways, there

isn't… There aren't any barriers. So, the whole notion, not just in terms of people but the notion of doing a, a networking system for the BBC Micro, is very much inspired by the work in the university, personnel change, and perhaps in retrospect more importantly, the idea of doing chips for a small company like Acorn is in this earlier Ring work, so we had a whole… and the university CAD system, a whole project for doing the chips and so on and so forth. And that becomes available, again, cash, as a platform to this, not so small but a smaller company. So, the whole ability, the capability to design chips, which were crucial to the BBC Micro, came from that pathway. And actually also infected Sinclair, because they did the Ferranti gate arrays independently, but the reason they were doing it wasn't just pure magic, you know, it was the momentum, in this case competitive, in our case, symbiotic with the university. It doesn't matter, there's a reason for this, it's not magic. So we had learnt on the Cambridge Ring chips how to do VLSI on chips, and those, to use a slightly awkward modern word, those learnings, and experience, that confidence, that toolkit, those people with the ability to, to do it, became available, where? within Acorn. The BBC Micro chips, still using some consultants at the university, and then went on to the RISC processor. But again, the RISC processor, here is my recollection. I hope I've got this right. Why is it that this small company, you know, was contemplating doing RISC? Well I remember the following fairly well. Through the university connection I spotted, and was interested, and spotted, being in a more heavyweight way, people I heard of in the RISC project at Berkeley. And through my academic connections, I was a lecturer, assistant lecturer, I investigated, got some people to send me the papers, and decided that this was actually something we could contemplate. So again, the feed in to the company wasn't a sort of eureka moment; there were reasons. There was ability to see the details of that project in Berkeley, California; the ability to talk in effect to PhD students of mine and others to say, 'Is this any good?', to get an assessment from them, from the US , not, PhD students, ex-PhD students, you know, people over there. A man called Carl Deller I'm thinking of in particular. Bringing those papers to the attention of Hermann, who is of course a sucker for this sort of stuff, so he said, 'Yeah, no, let's do it.' Right? Bringing that to the attention, and I mean in the heavyweight sense, in the, in the provocative sense, not that they would have been aware of them, but you know, could we do this, to Steve Furber and others. And, and then getting on the hook. So now you see the combination?

Yes.

The CAD and so on, so forth. So then, Acorn does… Now you say, Acorn sort of… I don't… You know, of course, I'm one of those who doesn't think of Acorn as failing, because I think Acorn became ARM, so that's a success. I manage, you know, somehow by magic, to get myself an aeroplane and that stuff, and get a runway at home and so on. So you know… And many others did very well, you know, out of that stuff. So I don't know how I measure success, but I don't measure it that it has to be perfect at all times into the future, and any down is, is, you know, oh it's failed. No no, I, I think that's nonsense. It did very well. It changed the country because it, you know… It hasn't been… Maybe Raspberry Pi's replacing that today. Infected the careers, the perception of the whole country through the BBC Micro, changed direction of this country. Fantastic. Made a pile of money for a pile of people, not just me and Hermann and Curry, but, you know, Chris, but, you know, some others as well. And then, yeah, we, we built too many and we ran out of cash. Elementary mistake, but, you know, we're not perfect. So, you know, I'm not defensive; I'm saying, hey, that's pretty good. And, Hermann tried to sell the ARM project when it was in Acorn to all sorts of companies, Siemens and others, and nobody was interested, right? So, you know… [laughs] Anyway. So..

Fool them, eh? Fool; them.

[laughs] Fool them. I mean, all I'm saying is that… So then, the spinout happens of ARM, but before that, you know, Olivetti took the majority shareholding, 76 per cent initially and then a little bit more, because we ran out of cash, so, you know, no cash, no good, right? And, Hermann becomes Vice-President of Research in Olivetti, and turns to me, you know, his colleague, buddy and partner, saying, 'Let's do it' I said, 'Manna from heaven. Bring it on Herman,' right. Love it. OK.

[57:04]
So, on the 1st of... I'm sorry. April the 26th indeed, 1985, the first ARM chips came back, and were running beautifully, and found out something amazing, that they actually ran with almost no power at all. So they were just, just in the right space for

mobility to come along. And that's the year that your second co-founding company emerges in the world. 1985, Qudos, the CAD company, computer-aided design. What's this about?

Qudos, Quick Design on Silicon. Qudos.

Ah.

Quick Design on Silicon. Well, so, the executive summary is, we… The company which did software for chip design and hardware prototype beam, using electron beam direct-write, on the Ferranti gate arrays that we had used in the BBC Micro and earlier in the Cambridge Ring. We should have concentrated on the CAD, and we would have been called Cadence. But we didn't. We concentrated on the CAD and the hardware too much. And the prototyping was important, because one got chips wrong, and so the prototyping was important, but the hardware effort, we built our own electron beam machines. And there was a third partner in that business. There was me, Hermann and Haroon Ahmed, Professor Haroon Ahmed, Professor of Microelectronics as Cambridge, who is the e-beam person. Well, the e-beams were fantastic, but, the bespoke, one at a time, manufacturing, what today is called 3D printing, but you know, those were different days, you can only cover the prototyping stage of chips, was, not enough of a business, but, but more important was the dominant part of what was happening and we should have dropped it, and we didn't. But we had the CAD position, because of all the, again, precursors that there was at that time, the major CAD companies were establishing themselves, and, you know, that's a miss for us. Had we started that as a, or, stopped the hardware side, just concentrate on the CAD, we would have been tremendous.

[59:30]

But that company is, you know… None of my companies have disappeared, so, so we, we've got, Orbis, my role in Acorn, and now Qudos, in their own way they still continue, but that one joined, plateaued, and perhaps slightly unkindly I might call it, joined the living dead, but by that I mean, it wasn't doing high tech, but it became actually part of Rutherford Labs and an e-beam side prototyping facility. And, and it continued until just a few years ago as a, as a, engineering centre under the label Qudos.

[1:00:10]
Would you describe Olivetti research labs based in Cambridge, which eventually was taken over by AT&T, as a, as a success?

Yeah. Because, for three reasons. One, it made money, and it made money for the sponsors and it made money for the, what became spinouts for the teams that made spinouts, and, you know, reasonably big money. It was a fantastic environment which permitted innovation in a way that's not possible in a university situation for all kinds of reasons, and, so many reasons, got worse today. And, it succeeded because, Olivetti understood very well how to leave the local culture, in other words, do things in Cambridge the Cambridge way, not the Italian way, in Italy, the Italian way. So they provided the, the framework which enabled it to happen. So let's work backwards. So, I wasn't, and never have been so to speak, company, a big company man, so, when Hermann and I were starting the Olivetti Lab, we said, right, let's have an independent company. I'll be, Andy will be the managing director. We'll have a board. The company will be 100 per cent owned by Olivetti, but all operational aspects are at the company level, not at the division or the business unit or the headquarters level. So that separation was very important. Olivetti said, 'Great. Get on with it.' So that means that operationally, was total freedom, I mean complete freedom, right? What you pay, how you recruit, what the project are. Do you pay money, do you pay in Chelsea buns? What's the situation about simultaneous engagement with the university by individuals? So on, so forth. The closest we have today to that is Google DeepMind, OK, where there's enough autonomy, they're a big company, but even they, they have more money, and, you know, it's a bigger situation, but it's sort of, similar. I am a director of it, it's, I'm not an academic just having some academic projects. There's a command line, there's money, there's power, there's, you know, so on, so forth. So, so Olivetti agreeing to all that, and then being on the board as the control mechanism, operationally we jump and we serve as much as we can, but, but control-wise, you know, there is, so on. So that led, the freedom to, to innovate by using local talent, and using the local power, which was the very thing that was the reason for ARM starting in Acorn, right? And actually the BBC Micro and all that sort of stuff. So that's… So it was a step and repeat.

Although there were all new people, only one person, Chris Turner, transferred. So the recruitment was fresh. And, it went up to about 50, 60 people, 60…

But the philosophy was the same, you are saying?

Totally the same.

Right.

Totally the same. And, and it was the smartness of Olivetti to leave it alone so to speak, or not to muck it up, or, you know, whichever version you want to call it. They wanted money. This is not Boy Scout stuff. But they said, 'Listen, you know, we understand.' So, so that's one.
[1:03:23]
And then secondly, it's therefore hardly a surprise that, you know, all sorts of interesting things came along, and, you know, those times we, there wasn't too much multimedia streaming, video streaming on networks, so we did all that. A whole bunch of stuff, well became webcams, direct peripherals as we call them, on the Internet. The Internet, World Wide Web anyway, came along around that, and so on and so forth. So we innovated in all kinds of, many many, many ways. But here is the second part, which was crucial in order, for my first comment, made lots of money to actually be true. So the normal problem for a research lab is that you do something and the business unit can't handle it because, it's too innovative. And it might be too innovative for technical reasons, and it might be too innovative for business method reasons. It's a different business plan that's required to exploit the new thing than what, whatever the business plan, the business method, business model of the business unit in the large companies.
[1:04:35]
So we ended up with the following model, business model, for how to do something about this innovation. And wherever the innovation is command line innovation, it's whacky at the top. We'll try something crazy, something different, the unbelievable truth will happen. My God, it's a miracle if this turns out. But then we execute on it. We don't mess about, right? So we build prototypes. People are told what to do, in a, in an appropriate way, but we're on a mission, right, we're not on random writing

papers. That's with your university hat on. If you want to your university hat on, by all means. So I wear my university hat when I'm writing papers, and I wear my, we're going to build a new wonderful thing, using the power we've got, like teams, and command lines, and money, and contractors, and subcontractors, in order to do this. So you end up nevertheless… So you end up with something very practical. Here it is, my faster, better, cheaper, more, new, whatever it is. And you actually show it to customers, meaning visitors, but actually customers for something else, and you look at them, and they say, 'Yeah, I'd like some of that.' So you've got to feel that, not only your gut feeling, but there's some external person. You're not trying to sell them, they're visitors, but they're customers of the company coming for a bit of a, you know, show business so to speak in a research lab. But you look them in the eye, and, and you listen to them, and you see, they've got a tickle. It's like that earlier doctor of that ring network in ICI. He had a little, little sparkle in his eye you get down on, right? He was, he was keen on it, he could see the business purpose in that company. So you… And then you think, OK, we prioritise, change something, but then you know you've got something interesting to work on. So you go to the business unit, and almost always they say, 'Very nice but we can't handle it. It's great, we love it, we believe it will work. Andy, you're great. Perfect,' br-br-br-br. 'But, sorry, I'm busy firefighting and so on.' So occasionally you manage to transfer. And, most of the time you don't. And if you then try and do stuff for them, then you don't do the innovation. It's a catch-22. So this is what Olivetti said, 'Hey, listen…' And this is remarkable, this bit is remarkable. And it was driven actually by me and Hermann. So they didn't say… We proposed it to them, and, they said yes. We said, 'Listen, unless we do something, things will end up in the rubbish bin. So let's spin out companies.' Olivetti gets 20 per cent of the span-out company. We, but it's actually me, Andy, in my private capacity, not as Olivetti man, but as Andy, becomes a founder, and finds the money, venture money, for this company. The team moves, they go from being research engineers to being God [laughs], and we see what happens. And you can, you, Olivetti, can have representation on the board because you've got your, actually 19.9 per cent, so you don't have to consolidate it. So it's not visible to your, you know, public shareholder base, because who knows what'll happen? And off we go.

[1:07:35]

So. And then actually, there's a third bit… And even then you have too many interesting things. So then you open source. So the third bit is, and beyond spinning out companies, if you've still got live stuff, which you always do, and it's timely, you open source it to keep it alive, first… You know, because you're not, you're not… Business Unit is not interested, you put it in companies. You've still got something. It'll go in the bin, be forgotten. So you open source it, just, just to keep it in some race or other, right? So that was, that's it.

[1:08:03]

So we transferred a few things. But we span out companies. ATML, which became Virata, was one of them; Telemedia Systems Limited was another one. Cambridge Adaptive Broadband, which then became Cambridge Broadband Systems. And… But the role of the individuals is, in their own capacity. So I am chairman normally, but there's Andy, and there's another person representing the Olivetti shareholding.

Right. Right.

So it's a remarkable thing. Just think back what I've just said. It's, it's… I'm being paid a salary as director of research of, of this lab, managing director, and yet I'm spinning out and becoming a founder and doing my bit for these companies. So, the biggest success was, when we designed that ATM network, it was actually rooted in the Cambridge Ring originally, the design. We span out a company. The business unit wasn't interested, they wanted Ethernet. We span out a company to commercialise ATM networks. That was a modest success, funded by American venture capital, we did a pivot as it's called today. Turned it into a DSL chip company, Virata, with a market cap at its peak on Nasdaq to five billion. And not too much dilution in the meantime, so the Olivetti 20 per cent, I can't remember what it was, maybe half that, you know, they, I don't know, they sold, I presume they did, but you know, it or all the research funding for years, blah blah blah, right? So, so that was the…

[1:09:43]

That was your number three. Your number four was IPV, two years later.

Yeah, that still exists.

Number five was ABL…

Adaptive Broadband.

…two years later.

Yeah, that was bought by the customer at the get-go, so in other words, I was finding the money, and getting the venture, and talking to potential customers, and the customer, like the man with the razor, he bought the company right there and then.

CVL, 2000.

That was a spinout. Because having bought it right there and then, we did our service for him, it was California Microwave, the company, and so the whole team walked, and, well, walked in a positive. Finished that, moved on to the next one, which was Cambridge Broadband Systems. That was my…..

And then, you have a remarkable year in 2003, three spinouts. RealVNC, Level 5, and Ubisense?

Yup. So… So here is the story. So AT&T bought Olivetti. So Olivetti, I have fantastic time for, sympathies, but Olivetti were having their own troubles, couldn't fund the Lab any more. So said to me, 'Find a good home, try and sell it, but we'll keep on funding until you do.' So I found AT&T, and AT&T bought it. And as it happens, the budget for that nine months of funding while I found the purchaser was less than the purchase price. In other words, they even made money on that. But do you see what I mean? It's, it's… But more important, that they left it in good heart, right? AT&T takes over. And we, we are left alone in some appropriate way, and we decide to design a better telephone, being cheeky little buggers, right?

A better…?

Telephone. So, this is my biggest miss ever, ever, ever, but we can come back to that. So we, we do the projects, but now we are in a, the opposite culture of Olivetti. So AT&T, I go every other Friday to head office in New Jersey, just to have some presence and try and deal with this much larger company. And about how to commercialise, how to get impact, and all this sort of stuff. And in a way they had bought us for that reason. But the culture was the opposite of Olivetti, was monolithic, was difficult. But for many, for three years they gave us fantastic support. But then sadly one day I get a call, and they say, 'We're going to shut you.' Just like that. Which I think… 'In fact we've already written you off. You will now make yourselves and everybody redundant.' So… Because they bought the company and the CEO of the company, and that, you know. So I go, 'Oh dear, that's not very good.' And it was just around 9/11, so I couldn't get on a plane, there were no aeroplanes, so I couldn't go to the office and headbutt or whatever. And normally you would go to your board, but as part of the restructuring, and on my board I had the COO of AT&T, I had the chief scientist of AT&T, all these grandees, they were all made redundant as well. I mean there was a real clean-out, American clean-out. [1:12:56]

So what do I do? I, I get on the warpath. So, I, there's a war going on, one of, you know, cause war going on. So I phone up the Ambassador, who I knew, US Ambassador, saying things like, 'Why is America trashing a jewel in the UK when we're…?' You know, so I, I started doing professor things. Potentially dismissible things from it, because I'm still an employee, supposed to be taking redundancy, and I'm, I'm going to war here. I'm going to the House of, MP, going to line up to the House of Lords, saying, 'Why don't you do some political thing?' and so on. So, House of Lords, the, the, not Secretary of State, but it was, you know, one of the ministers, you know, saying… But, but basically, nothing can be done. So I find two people to buy the Lab, even though they said, 'You are shutting down,' namely BT and Intel. They said, 'No. You are shutting, right? You are dead. Go to hell. We are not interested.' I know you've got two customers, and I don't want to…' You know. So, so a terrible situation, right? Worst moments of my life, I tell you. Because, the Lab is going great guns, in fact it's actually just about to miss the iPhone, because we did the iPhone before the iPhone, which is the world's most profitable product ever, and, you know, they're shutting the frigging Lab, right? I mean it's nuts. We didn't know it was going it was going to be, but you know, there

was, there was stuff available. You know, a bit of jinking and funking around, and there would have been value there big time. Because, you know, we're pretty experienced about this, how to do all this stuff by then, and the chances are, you know, if you're experienced, you've got the talent, you've got the business method, you know, things do happen. It's not magic, it's, it's, you know…
[1:14:42]
So, these companies are the start-ups as a consequence of the Lab being trashed. Because the teams were strong, there was no IP exchange, everybody… Because they wanted, again, to license IP at a, some future, price to be negotiated in the future. Well you can't have your cake and eat it, and mug and everything else. So we said, 'Go to hell.' We're going to start independently.' So, in my case, RealVNC, Unisens, and Solarflare, now called Solarflare, at the time was called Level 5 Networks, are the ones I co-found with the teams that were the actual teams in the Lab.

Yeah.

What I did manage to do is, and in some sense this, you know, a positive thing about AT&T, I beat them up enough that they gave very generous redundancy packages, so that everybody was set up for six months, nine months, twelve months of redundancy pay to, to be able to do this, right? And equipment. So, basically, we could, literally, I kid you not, because, technically, you know, the, the computers and all that were written off, had to go in a skip. Well they went into the skip, and five minutes later somebody got in the skip and took it out. [both laugh] I mean literally that's what happened, right? But it was understood, it wasn't, it wasn't… You know. So, so the equipment was available, and the normal redundancy packages which were, well, I made them feel so bad ultimately that even though they, you know, they ended up paying in the redundancy a modest amount of money more than they might have done, rather than the normal sort of brutal American thing.
[1:16:20]
So we were set up with enough money to get the prototypes going. No IP, so we had to start from scratch in all these companies, and there are others as well. So, you'd got to be prudent in the sense of establishing your new IP and, logging, that it's not the old stuff and so on, so forth. But yeah, those companies started because there was

tremendous value on the table, right? And so, what, what's the big surprise? There was innovation culture in that lab, because of the business method I described. And so these things… Well, well carry on. And they are together to this day, right?

[1:16:56]
So you decided to go back into academia.

I left.

You never really left?

I was always simultaneously doing academia.

Right.

I went up in… So we haven't talked about that, but I, you know, I have always had a normal academic job, with normal load, normal everything. So this is all… So one of the things to understand, and I promulgate round the Royal Society and elsewhere, that, the best technology transfer is when somebody does simultaneous career and then they just talk to themselves, right? So I had the good fortune of simultaneously having an industrial career, and, you know, I used to have PhD students with my academic hat, give lectures and all that sort of stuff, but again, the industrial side, whether that is Research Lab or my companies, understood that as actually value added. So gave space for that.

[1:17:45]
What's the biggest mistakes you've ever made?

Mistakes? The biggest miss is the iPhone. So we prototyped… AT&T bought us. We thought, let's design a better telephone. That's a slightly satirical way of saying, we are networking systems people, not Bell heads but Net heads, IP protocol, you know, all this sort of stuff. And we designed something that was based on an iPAQ, which was a little HP hand-held with a Wi-Fi network, but with a touch screen, or a pen screen, where we prototyped, what today are called apps, and they literally look

exactly the same, the layout's the same, and so on, so forth, which were triggered by, you know, by tapping, which then, we called them snacks, web snacks, now they call that. So the… And I, I remember trying to say to AT&T, 'Look, we ought to set up a development unit in Cambridge, we ought to do this, we've got something interesting here, not quite sure what it is,' and so on. But fell on deaf, fell on deaf ears. So that was a miss, because the iPhone and the cico system is the world's most profitable product ever. So, you know, having missed that, I'm quite pleased that I had the miss, but it would have been better to have had a hit [laughs], right? So that was… [1:19:13]

I don't think I made any mistakes, but, again, people, I don't know if this will be interesting to whoever listens to this piece, but you can't have your cake and eat it. So, by combining academia with industry, you can't have the top position on both sides, it just doesn't work like that. Because on the industrial side, unless you go with a company, you're going to lose your shirt at some point, as an academic. So I've lost my shirt more often than I would have done if I had gone with any of these companies, I would have been in a principal position in them. So whether it's original Acorn position, I was the third schmuck doing the university as well. Had a lot of benefits, I'm not regretting, but there's a price… My point is, there is a price to be paid. Or, as a founder of these companies, when you have some kind of hiccup three years in, as an academic doing it part-time, you don't have a negotiating position. So you lose your shirt. Whereas the people who are in the company don't lose their shirts. And, you know, the principals are still there. With some of these things I get on; with others I lost my shirt, and, we don't get on, because, not with the team, we all, we still have reunions, right, to this day, in the Castle pub in Cambridge, of the people in these different companies getting together, doing sort of, nostalgia. It's the shareholders, the new shareholders that you, you have a, a problem with, you lose your shirt with, and sometimes it's OK. So in the case of Solarflare, which was Level 5 Networks, well they've put $300 million into that company by now, so I don't feel too upset to lose my shirt. And so, I still go, and they invite me to their board dinners occasionally and stuff like that. That's OK. And I was Chairman for many many years. In other situations, Ubisense, which is a fantastic company, I, I am not quite sure I'm in the same place as the new shareholders, and therefore that's more distant, even though the team and the board in that particular company, who is, the CTO, my

former PhD student, elected to the Royal Academy of Engineering just recently, so, you know, we get on. So…

[1:21:14]
Are you slowing down?

[pause] In some ways, yes; in some ways, no. What I must tell you is that this Royal Society lark is a very enjoyable, good one, so I'm not at all slowing down on that one. And the reason is because, this is a very traditional entity, a fine entity, and, even ten years ago, I became a Fellow in 2006, that was a little bit of a surprise. My PhD supervisor, David Wheeler, hardly published at all, he only had six PhD students, the man's brilliant, a genius, looked after me, mentored me. Fantastic. I owe him a tremendous debt of gratitude. He became a Fellow of the Society in the early Eighties. That was most extraordinary. I became a Fellow in 2006; you mentioned Steve Furber, he became a Fellow in 2005, 2004. That was a little less extraordinary, but, still a bit on the extraordinary side. In other words, we don't fit the template of the kind of person you would expect here. Today, they can't have enough of us. So I'm finding that the door is so wide open, being Treasurer of course is very interesting in its own right, but being able to be effective, not having electric fences around me or barriers or whatever, is very appealing. So I'm not slowing down, because I found a situation where I can be effective in my own way, without having to do politics or, you know, all that sort of stuff.

[1:22:50]
And what of this work done by Steve Furber on the Royal Society's 'Shut down or restart?' report? Was that a success?

Yeah. No, the, the… There are various reports that the Society is doing on the digital stuff, whether it's on, teaching computer science, whether it's on machine intelligence, whether it's on cyber security, the bosom here allows it all. I mean it's gone from… I said David Wheeler, and Maurice Wilkes in his own way, but he was head of a unit, and, you know, part of the, you might say, the Establishment in his own way, slightly more traditional man. I can see that. And published and so on. Wheeler was very unusual. Furber and myself were less unusual. And then all these

reports, all this stuff, is, is all being, almost too well received. I mean you know, it's, it's almost too fashionable to be able to do that. Anyway, these reports have their, their effect, and… So I'm not slowing down, because I've got something to do, as my wife tells me.

[1:23:55]
More co-founding?

Possibly. I mean, the thing that you might be interested in is, is the following. When I became a head of department in 2004, of the Computer Lab, now called the Department of Computer Science and Technology, I decided not to participate in any company that was going to spin out of the department. Because I felt, there's a conflict between being head of an institution, it's not like being CEO in a company, that's different, head of an institution which is an academic institution, and participating, and, you know, mentoring, linear promotions, choosing what direction the next lecture will be, doing merit payments, doing my own research, and all that stuff, and participating in companies that are the fruits of that. So I decided not to do it. Hence it all stopped at 2004, for that reason. I… There was one that was started, but it was completely – Text Easy - that was completely independent of, of the university situation, so that was OK. And we shut that one down. That was a company in Kenya, and it was too difficult operating a company in Kenya, so we shut it down. Maybe its time will come. That was a messaging company.

Was that TText?

Text Easy.

Yes. 2013.

Yes. So, but that was not to do with the university.

Yes. Yup.

But I did go for a volume strategy, very unusually in a university system, a volume, get as many companies started as possible, and wish them well and support them in every possible way. Don't take any financial participation, and, and so on, but get them up. And in order to do that, set up a business club around the department. So this is different to the technology transfer offices; this is, this is our own thing. It's called the Computer Lab Ring, you will be pleased to know. Maurice Wilkes suggested that name. But this Ring refers to the networking group, but it's a business club, so there are mentors, there are people with huge amounts of money as investors, there are companies who have done well, less well, and so on. And you join that, well you have to have been through the Computer Lab, otherwise, you're outside. So people will return your call, is what it boils down to, if you are part of that. So get as many out as possible, by minimising barriers, but not by pushing them out, by just saying, you know, if you're starting a company in the department, you can do it, you can have an office, no charge, just get on with it. Here is some free mentoring from me. I don't participate. So, I can give you a reading on, this money or that money or this IP position or whatever it is, but, you know, I'm not involved. Most technology transfer officers are involved in the sense that they have to make money for themselves, so that they are conflicted and so on. And I must say, I'm very proud and pleased that this has worked extraordinarily well, because, there are now… And, and we keep a list, and we keep this up to date as best as we can. There are just over 260 companies, 260, right? So this is the biggest thing in Cambridge, as a house of innovation, of all. Half of them are still going, OK? If you include ARM, which, you know, backdates to that. But there are many others, like Improbable, whatever. You know, the volume of, about eighteen per cent have been sold for a total of just over $40 billion, right? The turnover is a billion, right? So this is heavy duty, heavy duty. Most people don't even realise it, because, it's not the, you know, stereotype, oh somebody did some research, who went through a technology transfer office. You know, some company was formed; apparently that's success. Well it is in its own way, but it underplays. It's not what really happens. The most important thing walks out on its own two feet, starts something, and you can't, in my experience, and I'm not exactly, or Hermann's, not exactly naïve on this, we can't predict which one's going to be successful. So it's no good picking winners. Get them out, right? So that's what I've been doing. But that's the reason that only one has been started. I've had plenty of opportunities, but as a matter of decision, I've decided to do something

else. And it's worked. But of course, and I had the opposite, if you take, participate in some, the volume would have been smaller, but I would have had a participation or whatever in some of them. And I don't even join advisory boards, right? So I don't do advisory boards, and I don't do, you know, shareholding, chairman, director or founder out of that. I've left it alone. So, it's slightly bizarre. It's sort of, back-to-front. But there it is.

[1:28:34]
And people have criticised Cambridge because it's only produced two billion-dollar companies, ARM and Autonomy, and in fact, if they look a bit below the surface, they'll find a lot more activity.

You bet. You bet. It's a very superficial view, and, that's a separate conversation. Anyway. But on the founding, that's, that's the reason. You ask now, I might do it, I might not do it. I'm 65. I can see plenty of opportunities in my research, because I, my academic research has always been of the kind that, there is some story you can always tell about how this could be used in practice, commercially or not commercially, but you know, it has, you know… It's the original Maurice Wilkes thing right, I just, I just step and repeat exactly that, and have done it to this day. And so… So, but opportunities of the research I am doing, but, it's to do with blockchain, to do with audit trails in big data, it's that sort of stuff at systems level, prototype stuff like that. But in my own research and beyond that, I've concentrated on sustainability of the planet and how computer technologies can be used to help. So it's been a little more distant from the, the immediate start-up, although as I say, actually, even with that perspective, there are things that come along. So I don't know, maybe. I'm concentrating on the Royal Society at the moment.

Thank you for your, for your contribution to the Archives, Dr Professor Andy Hopper, CBE.

[End of Interview]