Oyo-Buturi International

Interview

Dr Masatoshi Shima was part of a talented group of engineers who in 1971 developed the world's first microprocessor, the 4004. In this interview, Dr Shima sheds light on some of the critical events leading up to the development of the technology that revolutionised the electronics industry and society as a whole.

OBI: You studied chemistry as an undergraduate but then joined a company working on calculating machines. Why did you change fields?

Dr Shima: I studied chemistry at university because I liked it and was interested in the subject. But I graduated in 1967 when the Japanese economy was weak. There was not a lot of demand for chemistry graduates, so I had to consider other fields of employment. It was at just this time that an "electronic computer" was installed at Tokyo University. The machine was supposed to be able to calculate the structure of compounds. It was in stark contrast to the mechanical calculators that I had been using. The idea of an electronic computer was very intriguing, so, after consulting a friend who was working there, I joined Busicom Incorporated. Busicom manufactured calculating machines and other such office equipment.

OBI: What kind of work did you do when you first joined Busicom?

Dr Shima: I first learnt how to write a program. I did not have any previous experience in programming but I managed to pick-up the basics quite quickly. I did that kind of work for about six months but I found that the applications side of the work, such as business applications, did not interest me much.

OBI: So what did you do instead?

Dr Shima: Well, Busicom had a manufacturing subsidiary working on calculators and I asked to be moved there. So, in October 1967 I moved to a place called Ibaraki in Osaka and became involved in work related to the development of calculators.

OBI: What was your approach to this new field of development?

Dr Shima: I decided to begin by reading a few books on to the subject. One was *Denshi-Keisanki* (obi: "Electronic Computer") by Shigeru Takahashi, which outlined the system, architecture, instruction set and microprogramming of computers; almost everything concerning computers. Another book I read was about logic. It was written by Professor Udagawa. I read both of these books avidly and then began to design the circuit boards that go into a calculator. This process involves connecting ics with wires and designing complicated wiring patterns. There is also the inter-board wiring. If there are, say, ten boards then they all have to be physically wired up. There were two main problems to be overcome in this work. The first was how to transfer the signal with a minimum of losses. The second, was how to devise a process whereby the wiring up could be undertaken according to a set of instructions by people who were often not qualified engineers. This work required a lot of new thinking and many aspects of the ideas were original. I believe that no matter what the task may be, it is always important to try to do something creative and original in your work.

OBI: For how long did you do this kind of work?

Dr Shima: I did it for about four months. The next development in my career occurred as a result of my being lucky or as we say in Japanese *unmei* (obi: fate or destiny).

OBI: What do you mean by that?

Dr Shima: Well, although the transistor was invented in 1947, it was not commercialised until 1951. The commercial use of the transistor then led to a new era, namely, the "era of the circuit". That is to say, if you could fabricate a circuit by putting together a transistor, a resistor and a diode, you could construct and develop a "system". Furthermore, in 1961 the first commercial ic was developed. This led to the "era of logic". It was at the beginning of the "era of logic" that I first started working on the development of calculators in industry. So I was lucky that the tools for development were already available when I started work. Incidentally, it's interesting to note that there were periods of exactly 10 years between the commercialisation of the transistor in 1951, the ic in 1961, and the microprocessor in 1971.

In 1968, one year after I graduated from university, my company decided to relocate its R&D to Tokyo. So I, too, returned to Tokyo.

OBI: Did the move affect the nature of your work?

Dr Shima: Yes. In 1968 Japan had won a major share of the world calculator market, mostly based on (oem) agreements. Busicom also carried out oem-related business. Their major concern was that most of the calculators were made using "hard-wired logic" which would be difficult to use in the longer term. Our technical manager wanted an alternative to this technology and, because I had some relevant experience, I was asked to study the introduction of the "programming" approach instead of the "hard-wired" approach. "Stored programming logic" as it was called. So I had the task of defining the instruction set necessary for the development of calculators; the programs and instruction set would then be given to hardware engineers for implementation. Since it was also necessary to connect a printer to the final version of the calculator, I had to take that into account as well. That was in the Spring of 1968.

OBI: How did you approach the new project?

Dr Shima: I succeeded in designing a system based on "stored programming logic" and tested it with a printer. It worked very well. Then, towards the end of 1968, a major Japanese company announced that it had developed a calculator using only four lsi chips; truth to tell, it was actually five. This caused quite a stir in industry because at the time no Japanese companies had the technology to make high performance lsi chips. The result was that almost all the major companies went to the usa to find partners to fabricate ics.

OBI: And what did your company do?

Dr Shima: The company's Osaka branch, which worked on small pocket-sized calculators, chose mostek. Tokyo, which worked not only on calculators but also on business machines such as billing machines, approached Intel.

OBI: How did you choose those two companies?

Dr Shima: The decision was based partly on information provided by consultants but, more important, the Busicom president of the day had a very good "eye" when it came to judging potential business partners. He said that the key requirements for a successful project would be reliable top management and expertise in silicon gate technology, instead of metal gate technology, for lsi fabrication. mostek and Intel were considered to satisfy both of those requirements and so were chosen as partners. However, we did not think so deeply about the kind of engineers working for either of these companies.

OBI: Why was that?

Dr Shima: That was because the plan was to take our logic circuit design to the partner company and ask them to transfer it to transistors. The Osaka company managed to do this successfully and fabricated a single LSI chip for their small calculators.

But, in June 1969, when Busicom approached Intel we found that Intel was really a company dedicated to making semiconductor memory. Their most important, and only, technology, was related to the fabrication and processing of semiconductors. So there were many chemists and physicists, but hardly any people with experience of logic circuit design there were around 200 staff of whom about five had doctorates. The applications manager at the time was Ted Hoff, whose expertise was in computers.

OBI: What was his reaction to your logic circuit designs?

Dr Shima: He did not understand the designs when I first showed them to him and said that they were far too complicated. I thought that my explanation might have been incomplete or that maybe there was a real problem with the designs.

OBI: So what did you do?

Dr Shima: I continued to try to explain the designs to him for a few months but still without making any progress. So I then decided to talk about the programming of desk top calculators, instruction sets, such as the binary instruction sets and the decimal instruction sets, flow charts and so on. Thankfully, Ted Hoff understood all this and he agreed with some of the new ideas and approaches that I had proposed. He pointed out, though, that computers based on the decimal instruction sets are more complicated than those based on the binary instruction sets.

It was towards the end of August 1969, that Ted came into the room with several pieces of paper in his hands. He looked quite excited about something. He said that he "had come up with an idea".

OBI: What was his idea?

Dr Shima: There were "three boxes". One of the boxes was a 4-bit alu for "making micro-commands out of macro commands". The other two boxes were the "stacks" and "registers" which could be used as "address pointers"... So the 4-bit alu would use "micro commands" for producing "macro-commands by program, using micro-commands". That was the idea. I think that this could be considered to being the "birth of the microprocessor".

OBI: This was in August 1969?

Dr Shima: Yes. But there were many problems still to be overcome, one of them being how to implement commands in decimal instruction sets. The solution to this problem showed the differences in approach between America and Japan at the time. The American solution was to use lots of memory, which was expensive. In Japan the preferred solution was to use as little memory as possible. The second problem was how the system could be constructed using only lsi, that is, without using ttl at all. The third major problem was that a programme language had to be used and any new language employs an interpreter and not a compiler. The fourth, and most difficult problem of all was how to control the many peripherals connected to the calculator in real time using software. It had never been attempted before with such a slow processor.

So, although there was a proposal based on the "three boxes" there were no proposals for solving these four related problems.

OBI: How did you resolve these problems?

Dr Shima: I spent about 4 months trying to find solutions to these problems. I made a manual by myself that contained many examples, and in December 1969 I came back to Japan for a while. Then, in March 1970, I went to America for an update on development activities. When I got to America I met Ted Hoff. He said he going off on his vacation- a big surprise for me. I then met Federico Faggin, who had started at Intel only about a week before. He said he had not been told anything about the project and asked me to explain it to him. Another surprise. When I asked why they had not hired more people for the project and I was told that they had not been able find any suitable people. So I decided to participate in the development myself once again.

There were four chips and I decided to develop the 4004 microprocessor by myself. The others parts were to be developed by Federico Faggin.

OBI: How long did this stage take?

Dr Shima: There was already a working processor in December 1970 when I left for Japan via Europe; we then entered the last phase of designing the calculator. The final product was ready in March 1971.

OBI: How did you feel after this achievement?

Dr Shima: I was more deeply moved by the completion of the calculator development project than by the microprocessor. I think it's because the original goal was to develop the calculator. The microprocessor was merely a means to that end. So, if you were to ask me why the microprocessor was born, I would say it's because we had an application in mind- and the microprocessor was a necessary part of the application.

OBI: Why do you think the development of the microprocessor was successful?

Dr Shima: I think one reason is that the development group all came from different technical backgrounds. We all had differing opinions, differing ideas, and this varied mixture was an important feature in the successful completion of the project.

OBI: Can we change the subject slightly by asking you why you think young people seem to be losing interest in studying science and technology?

Dr Shima: It may be because Japanese society does not regard engineers as highly as they should, so young people do not find engineering interesting enough. Another problem may be that the salaries of engineers are not high enough to encourage young people to take up engineering as a career. I think that young people should be taught that science and technology is really a form of art.

OBI: What idea or invention do you think has had the most effect on our lives in the 20th century?

Dr Shima: Quite honestly, microprocessor. It is used in such a wide range of equipment, all the way from computers to consumer electronics, that it would be difficult to imagine a modern society without it.

OBI: What developments in this field would you like to see in the 21st century?

Dr Shima: That is a difficult question. I think a more user-friendly computer would useful. For example, a "keyboard-less" computer where just looking at the screen would move the cursor!

OBI: Do you have time for a hobby?

Dr Shima: My hobby is my work! Microprocessor development is the most interesting thing I can find to do at the moment. It requires a lot of self-motivation, but it is very satisfying. I try not to do what others are doing and I develop my own ideas. Although I am not an electronic engineer or physicist by training but I have been motivated enough to accomplish almost all of my goals.

OBI: A final, rather strange question. What would you most like to have with you if you were stranded on a desert island? That is to say, assuming you have sufficient food and water.

Dr Shima: Yes, that is another difficult question. My immediate response would be a sports car and a few books. But I think what I would really want to take would be a "problem" to keep me thinking. I have been solving problems all my life. Problems are sources of great treasure. Where there is a problem there is treasure!

Resume

- 1943: Born in Shizuoka City, Japan
- 1967: Joined Busicom Inc. after graduating from the Department of Chemistry of Tohoku University.
- 1969: Worked in the usa with Intel Corp. on the development of a microprocessor for use in electronic calculators
- 1971: Ricoh Corp.
- 1972: Intel Corp.
- 1975: Zilog Inc.
- 1980: Director of the Design Centre of Intel Japan, Corp.
- 1986: Vice Chairman, later Chairman, of vm Technology
- 1991: President of Shima Co. Ltd.
- 1992: Doctorate in Engineering from Tsukuba University
- 1997: Kyoto Prize (Advanced Technology)
- 1998: President of tops Corporation
- 1998: Honoured as "The inventor of mpu"

Interviewed by Adarsh Sandhu

Review

Development of International Patent Systems

The second and final part of a series of articles reviewing the history of the modern international patent system based on a review by Mr. Fumio Sato, an international patent attorney.

The original Japanese text was translated into English by Dr F.M. Saba, Toshiba R&D Centre.

The Establishment of Socialist Nations and Awards for Inventors

The First World War led to the Russian Revolution and the birth of a socialist nation.The patents system is basically a way of preventing the appearance of a competitor in the market. However, in a planned economy it is difficult to think about the appearance of a market competitor when such a market does not exist in the first place. Moreover, it is not permitted to obstruct the flow of products which have been manufactured according to the national economic plan.

For these reasons, the socialist nations brought in a system of awards for inventors. In this system, the right of use of the invention belongs to the state and the inventor is rewarded financially and accorded various benefits. On the other hand, the inventor is obliged to impart the know-how behind the invention and to give technical assistance to any factory which wishes to use the invention. During the preparations for amending the Paris agreement, the East European side declared that the patents system was a system for protecting an invention, whereas the system of awards for inventors protected the inventor.

The Birth of Multinational Companies and the Move towards Internationalisation

The advance of industrialisation saw, along with the emergence of multinational companies, such as I.G. Farben (Germany) in the chemical industry, G.E. (usa) in the electrical industry, and G.M. (usa) in the automobile industry, the establishment of international cartels in several spheres. This was viewed as a good method of avoiding the effects of cyclical economic downturns. However, the usa proposed the establishment of anti-monopoly laws throughout the world and an amendment of patent laws.

The proposals were:

1. Anyone wishing to use a patent would be permitted to do so on payment of the appropriate licence fee.
2. A judicial or governmental body should be set up to determine whether the licence fee demanded by a patent holder was appropriate or was prohibitive.
3. Licences should not include restrictive conditions.
4. The processing of such activities as the selling of patents, the setting of licences, and the transferring of rights should be carried out with certificates, and a copy of the certificate should be deposited with the Federal Trade Commission within 30 days.
5. Unless a lawsuit against the encroachment of patent rights is successful, damages, prohibition of use, and other such measures of reparation would not be recognised.
6. If the above terms (1) and (2) are violated, the patent rights and monetary gains would be confiscated and returned to the public domain.
7. A unitary patents adjudication court should be established.
8. The validity of a patent should be limited to 20 years from the date of applying for the patent.

The Internationalisation of Economic Activities and the Harmonisation of Patent Laws

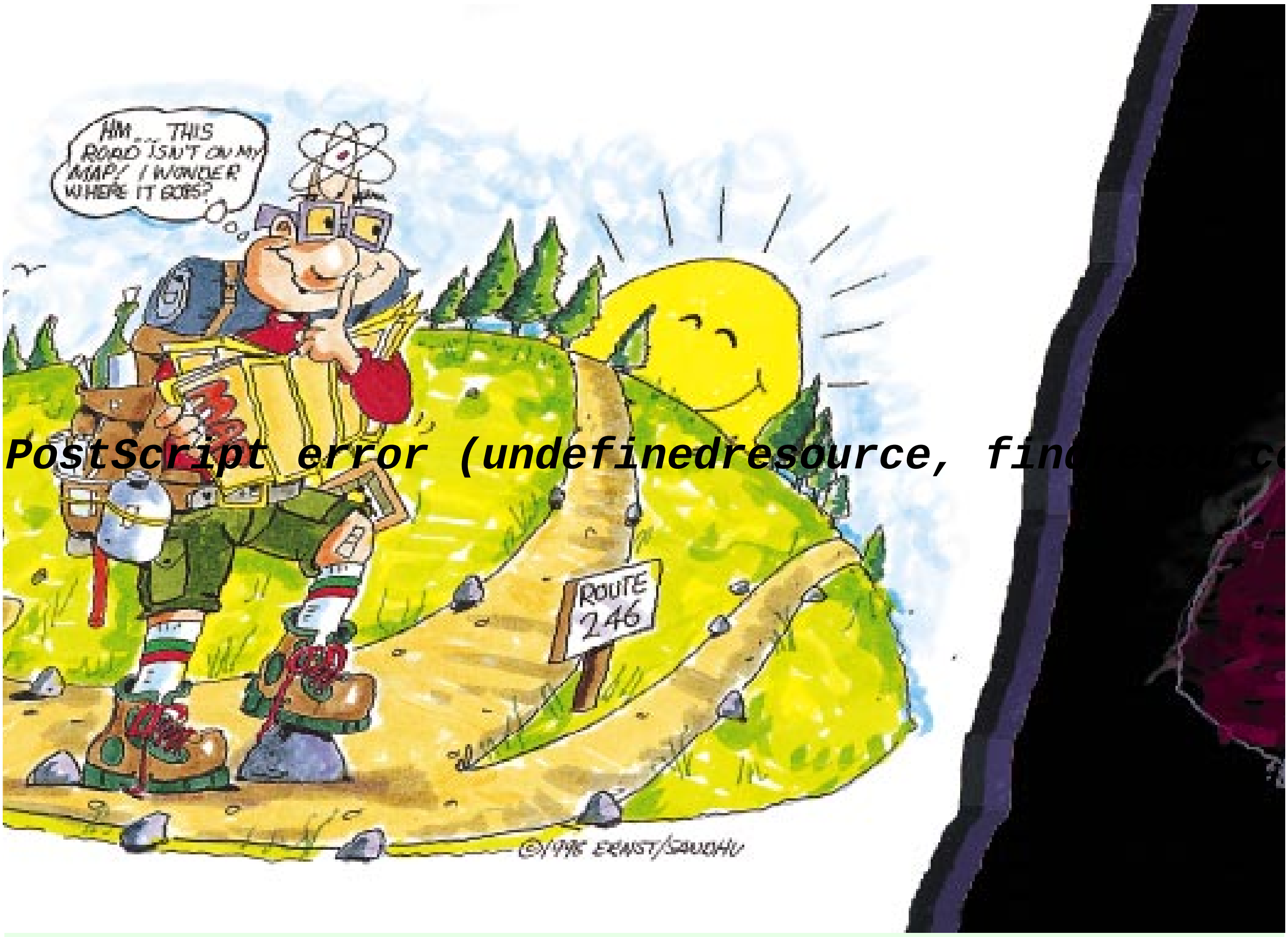
After 1945, the activities of corporations across national boundaries led to demands for the internationalisation of patent laws. The internationalisation of economies brought calls, led by multinational companies, for free trade and the standardisation of patent laws, and across this can be seen the approaching clouds of the north-south confrontation.

Corporate activities across borders led to an oecd dispute over the technology gap in the 1960's. The dispute concerned multinational companies, which were beyond the control of individual nations, and the scale of their activities, which was creating a technology gap between nations and causing such problems as "brain drains" away from less-developed nations.

Considering the costs, the smaller the market, the greater the cost of a patent borne per product unit becomes. For example, in a market which can only support 10,000 units per year, the cost of the patent per unit will be 100 times greater than for a market of 1 million units per year.

At present, patent laws are themselves of international significance. However, with the emergence of global corporations, the movement to formulate a standard global set of patent laws has strengthened.

At the moment, there is a move to revise the patents law treaty which is referred to as "harmonisation". In reality, it appears to be directed towards unification. This, it goes without saying, would be advantageous for global corporations seeking to take out patents in several countries. However, since legal traditions differ between nations, is it really possible to obtain a unified set of patent laws?



Summary

The history of patent systems has been outlined. The development of these systems has reflected the growth of economies, and in a sense have followed paths most favourable to the predominant economic powers of the age. One is reminded of the claim of the Sophists that the law was “the right of the mighty”. However, for patent systems to become truly global, there remains the significant problem of how “the rights of the weak” are to be protected.

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Epilogue

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