Chapter 10

SH Microprocessor Leading the Nomadic Era

The microprocessor trial with Motorola was completely settled in October 1990, and Hitachi's microprocessor business secured a new degree of freedom without the constraint of the past circumstances, and new activities started in development, manufacturing and sales.
In other words, the microprocessor independence war ended and the time of reconstruction started. In this situation, the SH microprocessor was promoted strategically as the most important new product. SH is an abbreviation for SuperH, and it is a 32-bit microprocessor with the original architecture.
The development team of SH microprocessor pushed on towards the common goal that, "Let's draw a picture on a pure white canvas based on the most advanced technology. Let's provide our customers with the optimum microprocessors towards the future growth fields!" We also asked the company-wide research laboratories for their greatest support by explaining the strategic importance of this project.
Although I cannot list up all the members who were involved in the development, the core members of design and development from the business division were; Shumpei Kawasaki, Keiichi Kurakazu, Yasushi Akao, Shiro Baba, Toshimasa Kihara, Shinichi Yoshioka, Ikuya Kawasaki, Hideo Inayoshi and others. From HMSI (US design company of Hitachi semiconductor), Jim Slager, Ehsan Racid etc. From the laboratories are Takaki Noguchi and Kunio Uchiyama of the Central Research Laboratories, Masahiro Kainaga and Nobuyoshi Domen of the Systems Research Laboratories, Hideo Maejima of Hitachi Research Laboratories, and others. Of course, in addition to them, a lot of engineers were involved in the areas of customer support systems such as development tools, marketing/public relations, process technology and packaging development, quality assurance etc.
The architecture of Motorola microprocessor was based on CISC (Complex Instruction Set Computer), but based on the fundamental proposition "to develop a completely different architecture", the architecture selected by our development team was RISC (Reduced Instruction Set Computer: a method using a small instruction set).
The RISC architecture was first applied to IBM's 801 computer in the 1970's. Improvement was subsequently added, and in 1985 MIPS Technologies first developed a commercial MPU. Further on, high-performance computer-oriented applications were expanded such as IBM's Power PC, Sun Micro Systems' Sparc, and DEC's Alpha.
A lot of ingenuity has been incorporated by our technical team to minimize power consumption while taking advantage of the high-performance features of RISC. For example, although the address length and the data length are naturally 32 bits, one of it is that the code length of the instruction set is made to the fixed length of 16 bits from ordinary 32 bits. As a result, the required memory capacity and power consumption were greatly reduced.
SH-1 was announced as the first product of the SH series at the Microprocessor Technical Seminar of Hitachi in November 1992. It was introduced as an optimal product for multimedia equipment including PDA, HDD, and mobile phones.

Fig. 10.1 shows a chip photo of SH-1. Using 0.8μm CMOS technology, chip size is about 10 mm □. The number of transistors is about 600,000.

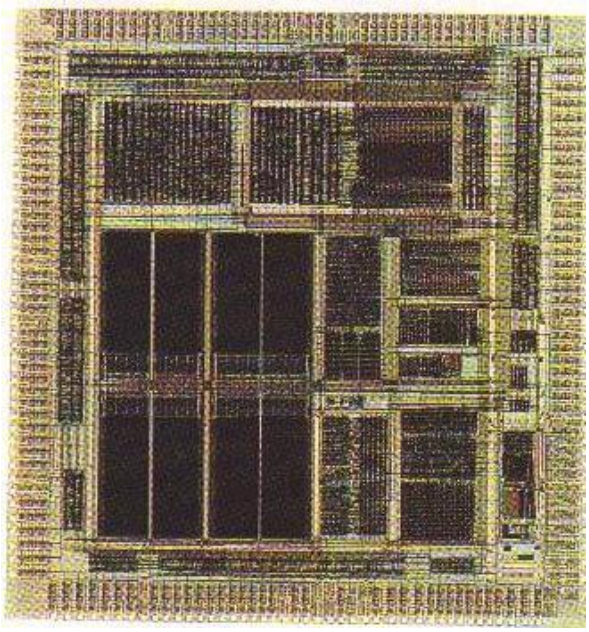

Fig.10.1 Chip photo of SH-1

Chip size approx. 10 mm □, 0.8μm CMOS process, 600 thousand transistors

Sampling of SH-1 started in March 1993. The evaluation in the market was extremely high, and concrete design-ins progressed smoothly. In addition, as a feedback from the market, there were also strong demands for product development with different specifications according to various applications. In response to the request from the market, development of succeeding products following SH-1 was carried out. Fig. 10.2 shows the road map of development of the product series. The SH family steadily increased its family products including SH-2, SH-3, SH-DSP, and SH 4.

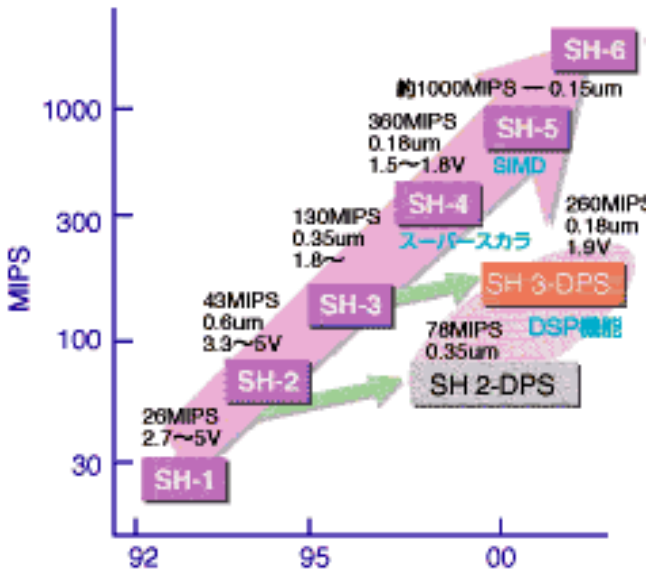

Fig. 10.2 Road Map of SH Microprocessor

SH-1 played a role as a lead-off batter in sufficient manner, and we succeeded in widely spreading the name of SH to the world.

Among many design-ins, here I would like to give a special mention to Casio's digital camera as a representative case. Regarding digital cameras, attempts had been made by many manufacturers to commercialize them in the past, but the level of technology failed to catch up, and the ideas could not be realized. The bottle necks were insufficient performance of microprocessor and its cost. SH-1 realized the performance of 16 MIPS at the cost of 2,000 yen for the first time as a single chip microprocessor, and solved these bottle necks.

In Casio, they succeeded in commercializing it by their devoting efforts with ingenuity, and released it with the type name of QV-10 in 1995.

It was equipped with a 270 thousand-pixel CCD, and it sold extremely well, beyond expectations. 1995 was the year when PC spread in the market sharply, driven by the release of Windows 95 from Microsoft, and QV-10 gained popularity as a handy input device for personal computers.

The following is what I later heard from Mr. Kashio, the President of Casio.

"Prior to the release of QV-10, we had it evaluated by camera experts and photographers, but their opinions were generally negative in that image quality was low, and we actually did not expect much out of the product inside the company. At that point of time we lacked in the viewpoint of a handy input device to PCs. So the production arrangement was not sufficient inside Casio. In that situation we got sudden rush of orders, and we ran into Hitachi and asked for the rapid production increase of SH microprocessors, and asked CCD and LCD manufacturers, too. If we compare it to a golf game, it was more like getting a lucky birdie by an OB ball which hit the green instead, after being kicked back by a tree."

QV-10 spearheaded to create a new digital camera market, and many camera makers and electronics manufacturers followed this move. Digital cameras surpassed the production of film cameras in 2003, and they are the mainstream products of cameras today.

In case of SH-2, Sega's game machine (Sega Saturn) is a good example of its successful design-in.

We had contacts with Mr. Nakayama, the President of SEGA (Now SEGA-SAMMY Group) from around January 1992 when SH microprocessor was still in the development stage, and we kept him informed as to the development situation of SH. In October of that year, before SH's formal announcement, Nakayama told us that they decided to use SH in the next model of SEGA machine. Now, at Hitachi, we could not back down.

We were told by President Nakayama and Vice President Irimajiri that they decided the release date of September 1994, and they wanted us to firmly support them with the microprocessor product. Hitachi made an even more secure and well-prepared system for the development and production of SH-2. Sega Saturn debuted at the Toy Show in June 1994, gaining good popularity. Two SH microprocessors per machine were used. The actual sales started in November of this year, and 170,000 units were sold on the first day alone. Hitachi also accelerated the production of SH microprocessors.

See Fig. A to C below.

Fig. A　Sega Saturn game machine

Fig. B　Main board of Sega Saturn

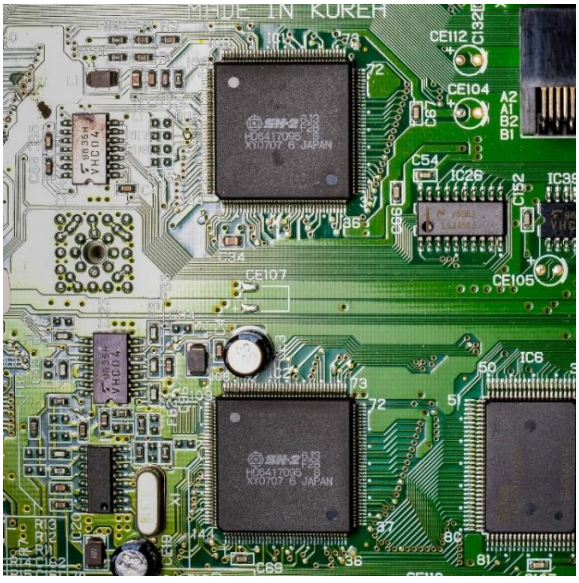

Fig. C　Two SH-2 used in the Sega Saturn main board

I introduced only two cases as above, but of course, there were also many other design-ins in the applications such as electronic musical instruments, car navigation systems, digital movies, VCRs, etc. The SH microprocessor opened up a big new field called “digital consumer products”.
In the beginning of 1995, unexpected good news came to us. An American computer-related magazine announced the ranking of RISC microprocessors, and SH ranked second in the position after Intel’s i960, surpassing IBM’s Power PC.
Sega Saturn was a big factor that put SH in such a high ranking. As a background that SH microprocessor gained popularity in the market, we can list the following features achieved by the new architecture.

- Performance per power consumption, or MIPS/W, was the world’s best: 100 MIPS/W for SH-3, more than an order of magnitude higher performance compared with others.
- World’s smallest core size high-performance RISC · · · Core size: 6.58 mm²
- Significant reduction in cost per MIPS · · · $1/MIPS was achieved
- Ideal as a processor for multimedia · · Synergistic effect of RISC + DSP function

I introduced in the opening chapter “Prologue” that SH microprocessor was used as the main processor of the asteroid explorer “Hayabusa”. The reason why SH was chosen for such a difficult mission can also be found in the above features. In particular, it was highly valued that MIPS/W was at the world’s highest level.

Well, going back in time a little, I was appointed to the GM of Semiconductor Division in 1992, and I took over the responsibility for the total semiconductor business. My main focus above all things was on the microprocessor business, and I committed myself deeply to the launching of SH microprocessors. In retrospect, I had been engaged in the microprocessor business of Hitachi from the time when we started a technical alliance with Motorola, going through the conflict with them following a period like honey-moon, the wind-down of ZTAT microprocessor, and furthermore, the trial case of H8 microprocessor, and all the way down to the settlement negotiations with Motorola. In such a process, it was the earnest wish in those ten years that “By all means, we must develop an architecture that we can completely control by ourselves”. Therefore, in the process from the development to the commercialization of the SH microprocessor, I worked all the way, persuading myself to take the lead, to achieve the final success. And the development team succeeded in developing an outstanding microprocessor.
How can we successfully introduce this to the market, acquire customers and put production and sales on the road? It was my duty to synchronize these series of processes without delay and to lead us to a winning battle. When the sample activities of SH-1 began in 1993, a promotion plan was proposed from the marketing group, and it was decided to put large advertisements on various domestic media. The advertisement of “The single chip of determination” shown in Fig. 10.3 is the one which was published in Nikkei Electronics dated August 30, 1993. It was an extremely unusual advertisement, in a way, and expressed our firm will of the new start in our microprocessor business, by showing that SH microprocessor was “the microprocessor with firm determination” for Hitachi and for me.

Fig. 10.3 Advertisement on Nikkei Electronics magazine (August 1993)

Since the market introduction of the SH microprocessor, I was thinking over a secret strategy for pushing it up to the mainstream position not only domestically but also in the world. At that time PDA (Personal Digital Assistants) appeared on the market. I was greatly inspired by the emergence of high performance portable digital terminals such as Apple's "Newton" and Sharp's "Zaurus". Especially Newton's debut was sensational, and it made us feel that that the age of "nomadic computing" came at last.

"Nomadic" means the situation where people are freed from constraints of time and place by using mobile terminals. This word was first used by George Heilmeier of Bellcore at ISSCC in 1992 as an adjective to digital cellular, but with the advent of PDA in 1993, the image of nomadic computing became more concrete from a somewhat abstract concept. I caught such a series of movements as a start of the shift from "the downsizing trend" led by PCs in the 1980's, to "the nomadic trend" led by mobile terminals in the 1990's. And I positioned low-power and high-performance SH microprocessor as the product to play a core role in this new trend. In other words, it would be "the main engine in the nomadic age."

As the total operation of Hitachi's semiconductor division, we could provide customers with "all CMOS" portable systems consisting of low-power memory, low power logic, RF devices, etc., with SH microprocessors as its core. It was a forerunner in the "system proposal business in the nomadic age."

In order to get thorough understanding of this concept within all the sectors of Hitachi semiconductor, I presented it at the Sales and Manufacturing Meeting within the semiconductor

division in June 1993 as the first move. This meeting was held once every month for the top managers (generally above directors) related to semiconductor business, including sales, business operations and factories, to review and exchange information. Policies made at this conference set the basis of business execution. Starting with the speech at this time, I repeatedly appealed the concept of nomadic age in various meetings in the company, and also outside of the company such as customer presentations, conferences, and in the case of interviews with domestic and overseas presses. In this way, I made the positioning of SH microprocessor clearer as the “main engine in the nomadic age.” Gradually, SH microprocessor came to be known better in domestic and global market through these activities, and advanced to the global product.

In 1994, I got an invitation to give a key note speech at an international conference held in May by the semiconductor industry research company, InStat. The president of InStat, Jack Beadle, was “a lion” who was formerly at Motorola and the place was Phoenix which could be called the home base of Motorola.
I took it as a good opportunity to get SH known more widely, and accepted the offer. I set the title of “Megatrends in the Nomadic Age”. Fig. 10.4 is a page from the presentation slides I used at this time.

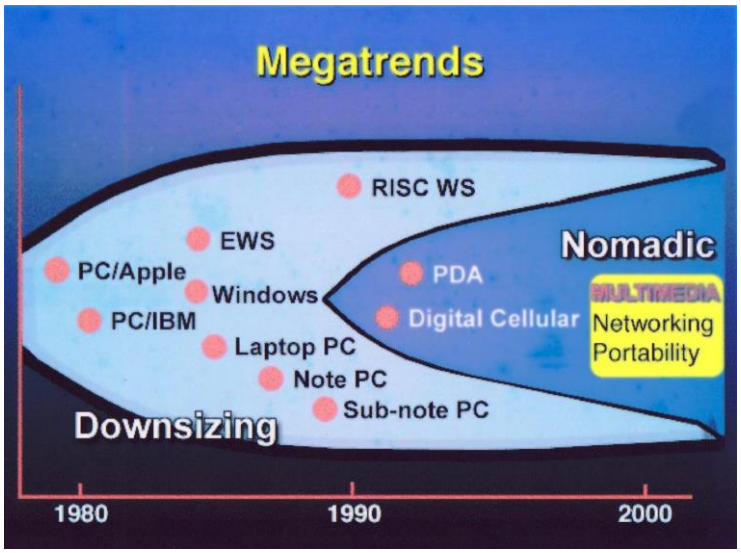

Fig. 10.4　A slide used in the presentation, “Megatrends in the Nomadic Age” (May 1994), showing the trend of shift from “down-sizing” in PC age to “nomadic” age.

This figure is the first version of the concept to show the shift from “down-sizing trend” of PC to “nomadic trend” created by high performance mobile terminals. Three elements of “multimedia, network, and portability” are cited as the technology base to drive the new trend. As shown in the figure, there were only digital cellular and PDA as the product at the time, and it was still a rather scanty content. But later, new products were introduced to the market one after another in this category of market. They were, for example, MP-3 player, HPC (handheld PC), portable game machine and the like. And as the extension of this move, there are various electronic equipment today such as netbook, tablet PC, smartphone, e-book, etc. The Fig. 10.4 has also been updated along with these moves.

In June 1996 I gave a lecture entitled “Market and Technology Trends in the Nomadic Age” with the request of keynote speech at “VLSI Symposium” held in Hawaii. The theme of the speech was a new paradigm in the post PC era that high performance low power devices would bring about. I set SH microprocessor as the center of the talk and described the impact of its technological innovation. Let me introduce three slides which I used at this time.

Fig.10.5 shows the transition of various architectures since Intel 4004 market introduction. Although the CISC type has been the main stream, the RISC type appeared in the mid 1980’s, and it was applied to high performance computers. In the 1990’s, a new type of RISC such as ARM and SH was introduced in the market, with the performance being rapidly enhanced, and I mentioned that it was already in line with the CISC type.

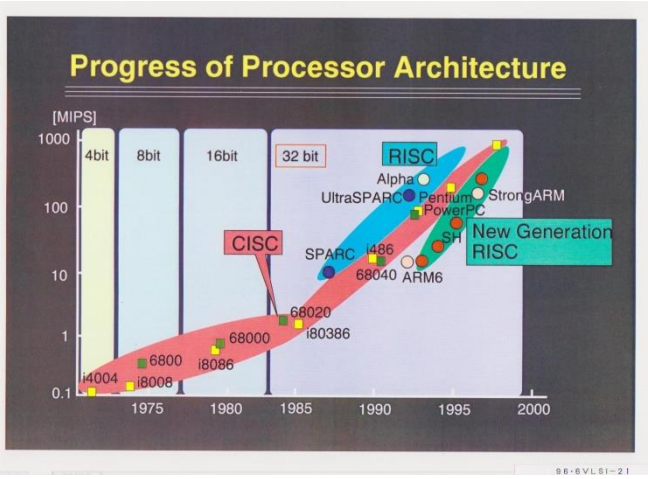

Fig.10.5 Trends of various microprocessor architectures. It shows that the new RISC is progressing rapidly. (From 1996 VLSI Symposium Keynote Speech)

Next slide shows the distribution of performance (MIPS) and power consumption (Watt) of various microprocessors. Compared to microprocessors for PCs and worksations, the new RISC microprocessors are overwhelmingly superior in terms of MIPS/Watt. I emphasized that this difference was the driving force behind the new paradigm of the post PC era.

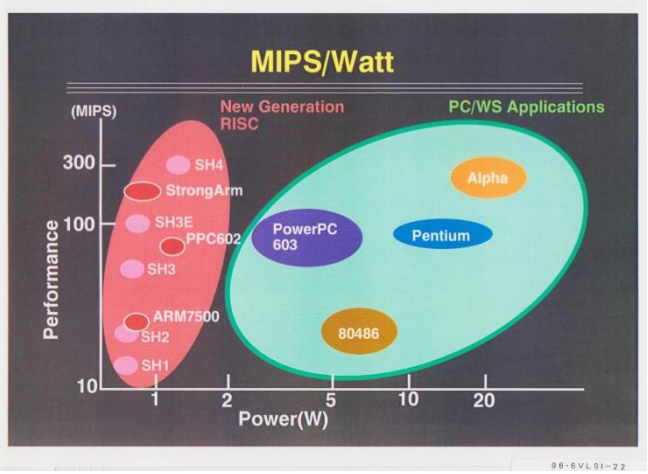

Fig.10.6　Performance and power distribution of various microprocessors. It shows that the new RISC is overwhelmingly superior in terms of MIPS/Watt. (From the 1996 VLSI Symposium keynote speech)

Next slide shows the distribution of performance and cost for various microprocessors. When looking at MIPS/cost, it showed that there is almost one order of magnitude difference between CISC type and new RISC type. And I talked that that the new RISC would break the wall of 10 MIPS/$ in near future, and it was already realized in the next year after this lecture.

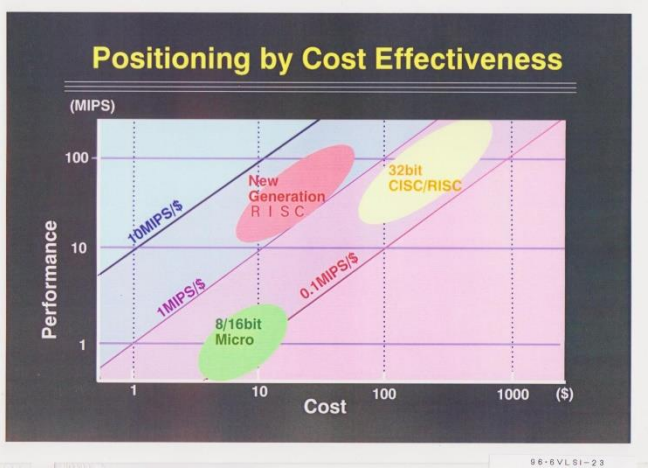

Fig.10.7　Distribution of performance and cost of various microprocessors. It shows that the new RISC is overwhelmingly superior in terms of MIPS/$. (From the 1996 VLSI Symposium keynote speech)

After my lecture, I had an opportunity to talk with a technical executive of Intel.　He was one of the regular persons who used to be at various semiconductor conferences.
He said, “Dr. Makimoto, in your speeches, I have been surprised twice so far”.
“The first time was when you talked about CMOS memory at the Dataquest Conference in 1981. I was surprised at the data comparing Intel’s 2147 (NMOS) and Hitachi’s 6147 (CMOS). It gave a strong impact on the technical staff of Intel that a tremendous device came out.”
“And the second time is these data on the difference between the new RISC and the CISC.　Both MIPS/Watt and MIPS/$ have an order of magnitude differences. I have been greatly stimulated.”
It seems that the SH microprocessor at this point had a brightness like a flag-bearer of “Nouvelle Berg” so to speak.

In November 1996, a memorable time came when SH microprocessor made a big leap in the world market. At the Comdex exhibition, which was held in this timing every year in US, SH showed a strong presence as a processor for HPC (handheld PC) announced by different companies.
HPC is a handheld PC based on the newly developed OS, Windows CE, of Microsoft. Products were announced from 7 companies, and five of them, namely HP, Compaq, Casio, Hitachi, and LG, all used SH microprocessors. MIPS processors were used by remaining two companies, NEC and Phillips. By this sweeping victory in the HPC field, the name of the SH microprocessor became increasingly known, and it was established as a global brand leading the nomadic era. Let me revisit another chapter about the cooperative project with Microsoft concerning Windows CE which became the trigger of this event.

Now, changing the subject, I got acquainted with David Manners, a reporter of Electronics Weekly (UK) in the latter half of the 1980's. Since then, I met him from time to time on various occasions, and we exchanged lively talks every time. He had deep insights in the field of semiconductor and electronics, and I was often very much enlightened by him. Incidentally, he was also the one who gave the name of "Makimoto's Wave" to the cyclical phenomenon of customization and standardization in the semiconductor industry.

We firmly shared between us the concept of nomadic trend in which SH microprocessor took the lead, and we agreed to jointly publish a book on this theme. I handed all my presentation materials over to him and he was to do the actual writing.

The title is "Digital Nomad" in English, and the Japanese version was the direct translation of "Digital Nomad". We decided to publish the English version first, because "Too new a concept" is hard to be accepted in Japan. The English version published in 1997 got better popularity than expected, but we had hard time in finding a publisher in Japan.

Meanwhile, a Taiwanese publisher found this book and wanted to translate it into Chinese, and as a result, the Chinese version translated as "Nomadic Company Workers" became the second. After a while, I had the opportunity to meet and asked President Shimura of the Kogyo-Chosa-Kai publishing company for its publication, and he accepted it on the spot. In this way, the books in three different languages were published. Fig. 10.8 shows a picture of the book and the co-authors, Manners (left) and the author (right).

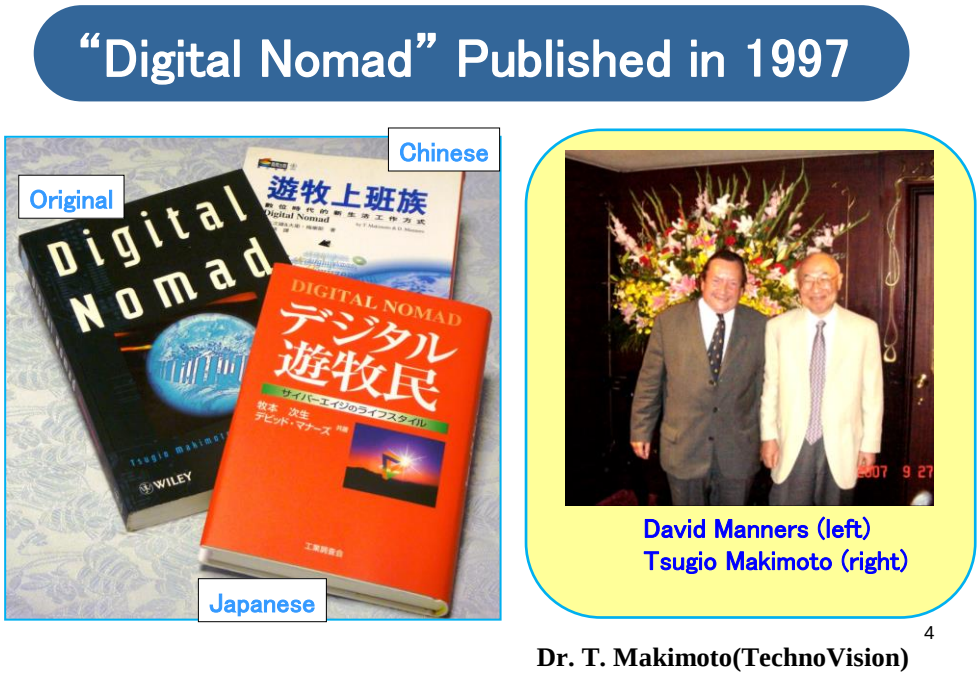

Fig. 10.8 "Digital Nomad" Published in 1997, and the co-author, David Manners at left

When this book was published, it was still around the time when mobile phones just started to become popular, and it seemed the expression of "Digital Nomad" did not come straight to people's mind. However, after more than 10 years, the situation has changed completely, and the lifestyle without mobile devices can no longer be considered. In December 2010, Wataru Ueda published a nice guidance book for businessmen entitled "Nomad Business Trip" (Jitsugyou-no Nihon

Publishing Co.). It may be said that “digital nomads” style is the most advanced business style today.

The arrival of the digital nomadic era means the end of the PC era. Events that symbolized such a paradigm shift took place in May 2010.
The market capitalization of Apple, which made a breakthrough in mobile devices such as iPhone and iPad, reversed that of Microsoft, which should be referred to as the leader in the PC field. Until then, since the performance of these two companies had overwhelming differences over the years, a lot of people might have had both feelings of “No way!” and at the same time “the time has changed!”.
With such a paradigm shift, the so-called WINTEL regime (Microsoft and Intel’s control system) is undergoing a big change, too.
Intel is working on collaboration with Google which developed the Android OS, with the “MIPS/Watt oriented” Atom processor as the core, and Microsoft has developed a newly developed Windows 8 as the one which runs on the processors with ARM core by Nvidia, Qualcom, and TI, as well as on the Intel processors.
The new competitive framework is now starting. Such a series of movements is a proof that the era of post PC, that is, the nomadic era in which SH took the lead had now reached the full blooming time.

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