Chapter 1

Prologue

On June 13, 2010, the asteroid explorer “Hayabusa” succeeded in returning to the earth, and it brought a great joy to the people all over Japan. In August, an exhibition of “Welcome back, Hayabusa” was held in Oazo facility near the Tokyo station, and a lot of people visited it, surrounding the Oazo building showing its popularity.
A television camera caught a figure of an elderly man with tears after watching the exhibition. Answering to the question of “How is the impression of seeing Hayabusa?”, he said “I was deeply touched. It must have experienced so many obstacles on the way, and it overcame them all and finally came back after 7 years. It overlaps with my own life …”
I could not catch the following words in his tearing voices, but I thought that there must have been many people who shared such feelings in the background of the popularity of “Hayabusa”.

After a while I was surprised at the e-mail delivered from my acquaintance in my Hitachi days. It was the news that SH microprocessors were used for the control computer of “Hayabusa”.
SH microprocessor was developed with its own original architecture by gathering all the power of Hitachi semiconductor group at the time. The CPU used for “Hayabusa” was SH-3 (60 MHz version of SH 7708), and the OS was μITRON. The system was designed as triple redundant system in order to secure high reliability. Why was SH microprocessor selected for such an important mission?
Simply stated, it was because the microprocessor combined features of both low power consumption and high performance.
At that time, the value of MIPS/W of SH-3 was at the highest level in the industry. From the beginning of the development, we set MIPS/W as the most important index aiming for a new era of mobile devices – the nomadic era. We could achieve the highest level by integrating the state-of-the-art knowledge of all engineering fields which we had in Hitachi at the time, including architecture design, software, circuit technology, process and device technologies.
This result was consistent with the demands of space equipment requiring low power and high performance, leading to its adoption to “Hayabusa” and its brilliant achievement of successful return after 7 years of rocky roads in the space travel. “Very well done! You did a great job, SH microprocessor!”

This text describes the twists and turns in the process of the launch of the microprocessor business based on its original architecture in Hitachi’s semiconductor division.
Beginning with the introduction of technology from the United States, overcoming numerous frictions and obstacles that had occurred in the process until we stood on our own, SH microprocessor is based on our original architecture that we finally reached. SH microprocessor/controller has been handed over from Hitachi to Renesas as a microprocessor with Japan’s leading original architecture, and it is now used in wide variety of fields all over the world.
We hereby use a rather broadly defined term of “microprocessor” to include MPU (microprocessors

unit) and MCU (microcontroller unit).
Today, microprocessors are the most important components in all high-tech fields, and there is almost no high-tech product without a microprocessor. What kind of challenges did we overcome in the process of creating the original architecture microprocessor? This is the theme of this series of texts.

I would like to describe the positioning of microprocessor in Hitachi semiconductor by following the transition of the main semiconductor product generations.
The first-generation products were transistors. They were launched in the late 1950’s for the applications to radios and TVs and reached their golden age in the mid 1960’s.
The second-generation products were ICs and LSIs. They started in the mid 1960’s for computer and calculator applications. Especially from the beginning of the 1970’s, custom LSIs for the calculators rapidly increased and reached to their golden age. However, they were hit by the oil shock that began in 1974 and lost their momentum.
The third-generation products were memory. Starting with the commercialization of Intel-compatible 1K DRAM, Hitachi’s 64K DRAM and 16K SRAM which were developed in the latter part of the 1970’s made a big leap to occupy the world’s top position. The golden age came in the first half of 1980’s, but from the middle of 1980’s, we suffered from the great difficulties due to the memory recession starting in 1985 and also due to the Japan-U.S. Semiconductor agreement since 1986.
The fourth-generation products are the microprocessors of the subject of this text. Hitachi’s first product was Intel-compatible 4-bit microprocessor which was commercialized in 1974. Subsequently, an 8-bit microprocessor by the technology introduction from Motorola was commercialized in 1976. And then, the development of unique products made a big success, such as introduction of CMOS microprocessor in 1981, and introduction of ZTAT microprocessor in 1985. However, caused by not having “original architecture”, our advancement was blocked on the way. And the humiliating feel at this time became the secret energy to establish our own original architecture and it was shared among the all microprocessor engineers in Hitachi.
The H8 microprocessor with its original architecture was introduced to the market in 1988, but immediately after that, we were taken into a trial case over patent infringement. SH microprocessor with its new RISC architecture was announced in November 1992 after the close of the regal case. SH microprocessor greatly contributed to the launch of innovative products such as digital cameras, game machines, car navigation systems and electronic musical instruments. In 1996, Windows CE of Microsoft was installed in SH, and it dominated the handheld PC market. These moves led to the golden age of microprocessor for Hitachi.
After DRAM was separated from Hitachi by the establishment of Elpida Memory in 1998, the microprocessor literally became a major pillar of Hitachi semiconductors, and this business formula was passed on to Renesas Electronics through Renesas Technology.

In the course of promotion of Hitachi’s microprocessor business, we can cite three innovative developments that led a trend in the global industry. While the details are given to the main text, the following is an outline thereof.

The first is the application of high-speed CMOS technology to microprocessor. In the 1970’s, NMOS technology was the mainstream of microprocessor, but Hitachi spearheaded the shift to CMOS in 1981. Today, not only all microprocessors are made in CMOS, but the influence has been spread to memory, logic, analogue, etc., and it is the base of today’s semiconductor electronics.

The second is application of ZTAT (Zero Turn-Around-Time) and F-ZTAT technology to microprocessor. It is the concept to make TAT to be zero from user’s point of view by making on-chip ROM of microprocessor to field programmable. Currently, F-ZTAT (flash on chip) technology is used for most microprocessor, and it is a mainstream of microprocessor technology.

The third is realizing the world’s highest-level MIPS/W (or performance /power) by SH microprocessor by adopting the new RISC architecture. This drove a group of new product markets called “digital consumers”, causing a paradigm shift from analog to digital. In addition, it is also an important factor in creating a new lifestyle that is expressed by the term “nomadic age”.

In the process of these innovative technology developments, we had been painfully taught how important the independent originality of MPU architecture was. I would like to roughly describe its move, while I will describe the details in the main text.
The substantial launch of Hitachi microprocessor business started after the technical agreement with Motorola. It was a technology exchange in which Hitachi introduced the 6800-series microprocessor technology from Motorola and provided them with the world best automatic bonding machine technology at that time. It started as a so-called Win-Win relationship. Hitachi became a powerful second source for Motorola, and the two companies tied up to pursue the campaign of the Intel camp. For the first five or six years from the start, the relationship between the two companies continued to be like a honeymoon, and we also learned a lot from Motorola who was our senior in this field. However, the relationship became progressively more difficult. As the competition in the market became more intensified, the issues related to “architecture” became more critical. As a result, the honeymoon state gradually changed into a competitive relationship.

The process is divided into the following three steps:

(1) Conflict in the strategy of shift to CMOS

Motorola took a negative position to the CMOS microprocessor led by Hitachi all the way. The progress of CMOS shift was blocked, because the “architecture” was owned by them.

(2) Wind down of ZTAT microprocessor

The ZTAT microprocessor developed by Hitachi was also forced to withdraw after market introduction, because the “architecture” was not the one of its own, and Motorola did not give license to the ZTAT products.

(3) Trials over H8 microprocessor

Although the H8 microprocessor was developed based on Hitachi’s own architecture, they filed a patent infringement petition on the ground that “architecture is similar” and went into a judicial proceeding.

The relationship between the two companies followed the path of rigidity through the above steps, and eventually it was brought into the form of “trial”, which was also unprecedented in Hitachi’s long history. The above three cases were unbearable humiliation for Hitachi’s microprocessor camp, and thus the secret energy became the force to push the way to “MPU architecture independence”.

The SH microprocessor was developed with this historical background. The basic aim is to develop a highly energy efficient microprocessor to prepare for the upcoming nomadic age, based on “completely new original architecture”.
Not only the Semiconductor Division but also all of the Hitachi’s microprocessor related engineers, including the laboratories and the user divisions, were inspired by the independence of the MPU architecture and gathered together for the development of the world’s top-level product.

Today, microprocessor plays a core role in almost every electronic system, and it represents the essence of semiconductor business. In order to protect this essence and make it alive, we must have an original architecture over which we have the complete control.
It takes time counted in decades to send out a new architecture to the market, to nurture it and to get the rich fruit of it. Both the H8 and the SH microprocessors have become the big fruits now, but the journey was never smooth.
I think that it is meaningful enough to keep track of our challenges to establish an independent MPU architecture, and to leave it to future generations.

In May 2010, Apple surpassed Microsoft in stock market capitalization, which surprised the world. This can be regarded as a symbolic matter representing an important turning point. The message can be summarized as “the age of Wintel, that is, the age of personal computers, has come to an end and the age of mobile devices, namely the nomadic age, has arrived.”
In the era of personal computers, MIPS values themselves were important, but MIPS/W is the important index, instead, in the nomadic age.
Of course, MIPS/W is a symbolic expression, and it is more generally “performance versus power consumption”, or energy efficiency in a broader sense. Thus, depending on the device, there may be indices such as MOPS/W, FLOPS/W etc. In the case of mobile memory, Speed/W is an important index.

I want to send a message as follows to the people who are involved in the electronics field or the IT industry as well as the semiconductor field at this turning point.
That is, it is a big opportunity for Japan that the nomadic age centering on the mobile devices is opened to us from the age of PC. The traditional strength of electronics in Japan has been the strength of “energy efficiency”. That is, it is the strength of MIPS/W in a broader sense.
All the world-leading products such as portable radio, portable TV, Walkman, calculator, etc. had overwhelming strengths in energy efficiency.
Right now, I want you to build a global strategy from the perspective that “the era of the new MIPS/W has arrived!”

It was in 1969 when I was appointed Department Manager of Product Development at Hitachi Semiconductor Division. Two years later, in 1971, Intel introduced the world first microprocessor (4004), and gave great impact to both the semiconductor industry and the system industry.

Amidst of the era when custom LSIs were playing the major role, an entirely new system configuration method appeared, which brought paradigm shift.

This year is a memorable year of the 40th anniversary from introduction of the microprocessor. I was deeply involved in Hitachi’s microprocessor business in this period, and if I express this process in a word, I would call it “an independence war for establishing an original MPU architecture”.

After leaving the active duty and being over 70 years old, I think that I am now allowed to write down such a history. Rather, it may be a duty given to me. I hope this text will contribute to the reference as “an attempt to discover new things by studying the past”- “Onko-Chishin” in Japanese - to everyone involved in the semiconductor, electronics and IT industries, not just reading as “memory talks”.

It is a long time since Japanese semiconductor weakness has been talked about, but now is the time to leap forward, grasping this opportunity, when new waves are flowing in the electronics field and IT field.

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