Transition of LSI Design

I started LSI design work just after joining NEC in 1971 and obtained LSI design expertise that expands almost all LSI design fields in both Japan and USA.

I am one of a few people who experienced the broad LSI related technical fields including both hardware and software design as well as customer visits. Let me introduce the historical design methodology advancement below.

(A) Emerging Hardware Description Language and Synthesis

Transistor or gate level logic description by primitive handwritten schematic, direct netlist editing, or schematic entry system was replaced with hardware description language utilizing behavioral modeling (Verilog HDL and VHDL).

The Hardware Description Language (HDL) evolved the logic design methodology drastically.

Software engineers who do not know semiconductor device physics and transistor level design became possible to design digital logic circuits as if writing software applications. But, the gate timing consideration as well as signal delay time must be thoroughly examined through the logic synthesis referring to the device and cell design library furthermore.

(B) Mainframe to Workstations

Private use workstations replaced common use mainframe accessed by common use terminals located at design center and private use PCs networked through Ethernet.

Mainframe was the fastest processing computer which can govern and run various LSI design tools such as logic and device simulation (Spice), and photo mask data base generation. Because the mainframe was a commonly used shared computer that many people access at the same time, the processing speed was not so fast especially in crowded time.

A private use workstation is handled by one person running various design tools in parallel dependently as well as it can handle plural common use workstations (servers) which are connected through the network to accelerate the processing or run multiple jobs at the same time.

(C) Display Device

Company	**NEC**			**Chips and Technologies**
Year	1971 ~ 1987			1988 ~ 1991
Country	Japan			USA
LSI Products I designed	μPD282, 940, μPD1201, etc.	μPD777, etc.	μPD7220, 7220A, 72120	82C455/456/457
Function	Desk-top calculator	Single-chip Television Game Processor	Graphics Display Processor	VGA flat panel controller
Display Device	Fluorescent/LED 7/8 segments tubes	Analog CRT NTSC television	Analog CRT monitor television	Digital flat panel (LCD, TFT, EL, Plasma,,)

(D) Breadboard

LSI Product	Year	Random Logic	ROM Emulation	System Controller
NEC µPD281/282 chipset	1972	MOS SSIs	Soldering/desoldering diodes directly on board	None (Unnecessary)
NEC µPD940	1974		UVEPROM → Diode short pin matrix board	
NEC µPD1201	1975		Wire memory (Nonvolatile)	NEAC M4 mini computer
NEC µPD1205	1976		Slow speed paper tape reader and puncher installed on Teletype Model 33 to dump ROM code for computer simulation and for preparing photo mask data base	
NEC µPD777	1977	Bipolar TTLs	SRAM	NEC TK-80 High speed paper tape reader and puncher to dump ROM code at the end of daily debug work
NEC µPD7220/7220A	1980			TRS80 Z80 1.774MHz 8 bit personal computer (TRSDOS console) 5.25” Floppy Disk Drive to store ROM code at the end of daily debug work
NEC µPD72120	1985			NEC PC-9801XA 8086 8MHz 16 bit personal computer (MSDOS console) 20MB Hard Disk Drive to store ROM code at the end of daily debug work
Chips and Technologies 82C455/456/457	1988	Computer Simulation	None (Unnecessary) Verify by so-called “Full screen simulation” limited to a portion of quarter screen ((160 out of 640) x (120 out of 480) from top-left most screen)	
ASCII of America DA7290/HD814102	1993		None (Unnecessary) Analyze and replay PCM audio sound data output by computer simulation, Encode the sound data and compare to the original MPEG compressed audio data	
Auctor Corporation Flash memory Controller	1995	Altera FPGA	SRAM	IBM PC Pentium 120MHz 64 bit personal computer (MS Windows 95/MSDOS console)
SanDisk USB to Flash memory Bridge	2000			IBM PC Pentium III 550MHz 64 bit personal computer (MS Windows NT/MSDOS console)

See “Breadboard Design History” more in details.

(E) Personal Computer & Work Station

Company	NEC				Chips and Technologies	Graphics Communications America	ACC Micro / Auctor Corp	SanDisk
Year	1977 ~	1978 ~	1981 ~	1985 ~	1988 ~1991	1992 ~ 1994	1995 ~ 1996	1996 ~ 2001
Country	Japan				USA			
Personal Computer, Work station	NEC TK-80	Tandy TRS80	NEC N5200 (APC)	NEC PC9801	IBM PC	IBM PC, Unix work station, Macintosh	IBM PC, Unix work station	
PC OS	--	TRSDOS	NEC ITOS	MSDOS		Windows 3.0, MSDOS	Windows 95, MSDOS	Windows NT, MSDOS
Work station OS	--					Solaris		
Macintosh OS	--					Mac OS	--	
PC CPU	NEC 8080	Zilog Z80	NEC 8086		Intel 8086	Intel 80486	Intel Pentium 120MHz	Intel Pentium 550MHz
Macintosh CPU	--					Motorola 68000	--	
Software	--	BASIC, Z80 Assembler	BASIC, 8086 Assembler, Word Processor, Spreadsheet		8086 Assembler, Microsoft C, Word Processor, Editor	Microsoft C, Word Processor, Editor	Microsoft C, Word Processor, Editor Visio	Microsoft C, gcc, Word Processor, Editor Visio
Network	--				Ethernet			
Email	--					Yes	--	Yes

Actual Design Methodology and Tools I Used

<table>
<tr><th>Company</th><th>NEC</th><th>Chips and Technologies</th><th>Graphics Communications America</th><th>ACC Micro / Auctor Corp</th><th>SanDisk</th></tr>
<tr><td>Year</td><td>1971 ~ 1987</td><td>1988 ~ 1991</td><td>1992 ~ 1994</td><td>1995 ~ 1996</td><td>1996 ~ 2001</td></tr>
<tr><td>Country</td><td>Japan</td><td colspan="4">USA</td></tr>
<tr><td>LSI products I designed</td><td>Desktop calculator
TV game
CRT graphics</td><td>Flat panel graphics</td><td>MPEG audio decoder</td><td>Flash memory controller</td><td>USB to flash memory bridge</td></tr>
<tr><td rowspan="2">Logic Design</td><td colspan="3">Gate level</td><td colspan="2">Behavioral modeling</td></tr>
<tr><td>Schematic handwritten</td><td>Net list editing</td><td>Schematic entry</td><td>VHDL</td><td>Verilog HDL</td></tr>
<tr><td colspan="6">Computer simulation before sign-off</td></tr>
<tr><td rowspan="2">Logic Simulator</td><td colspan="2">Design company proprietary</td><td>Silicon foundry proprietary</td><td colspan="2">Commonly accepted HDL</td></tr>
<tr><td>NEC</td><td>Chip Sim</td><td>VLSI Technology Compass</td><td>VHDL</td><td>Cadence Verilog HDL</td></tr>
<tr><td>Machine</td><td>NEC Mainframe</td><td>IBM Mainframe 3090 x 2</td><td colspan="3" rowspan="2">Private use
Unix workstation (Solaris OS)
System administrator (superuser privilege) at GCA</td></tr>
<tr><td>Terminal</td><td>Common use at Terminal room</td><td>Private use IBM PC</td></tr>
<tr><td>Network</td><td>Not available</td><td colspan="4">Ethernet</td></tr>
<tr><td>Editor</td><td>Proprietary</td><td>K editor running on PC</td><td colspan="3">vim running on PC & workstation</td></tr>
<tr><td colspan="6">Computer simulation when sign-off</td></tr>
<tr><td rowspan="2">Logic Simulator</td><td colspan="3">Silicon foundry proprietary</td><td rowspan="2">VHDL</td><td rowspan="2">Cadence Verilog HDL + Synopsys Logic synthesis</td></tr>
<tr><td>NEC</td><td>Toshiba / LSI Logic</td><td>VLSI Technology</td></tr>
<tr><td>Machine</td><td>NEC Mainframe</td><td>Toshiba Mainframe</td><td colspan="3" rowspan="2">Private use
Unix workstation (Solaris OS)
System administrator (superuser privilege) at GCA</td></tr>
<tr><td>Terminal</td><td>Common use at Terminal room</td><td>Common use at Design center</td></tr>
<tr><td>Network</td><td>Token Ring</td><td>T3 (45 Mbps) between USA and Japan</td><td colspan="3">Ethernet</td></tr>
<tr><td>Editor</td><td>IBM card puncher (Word processor)</td><td>IBM X editor running on mainframe</td><td colspan="3">vim running on PC & workstation</td></tr>
<tr><td>Mask layout</td><td>Applicon, Calcomp, FEDIS for Custom LSIs</td><td>Silicon foundry for Gate array, Calcomp for Custom LSIs</td><td colspan="2">Silicon foundry Standard cell (Mask database tape)</td><td>Cadence Layout tool linking own cells (Mask database tape)</td></tr>
<tr><td>Email & Internet</td><td colspan="2">Not available</td><td>Available (*1) (19.6kbps Modem)</td><td>N.A.</td><td>Available</td></tr>
</table>

Extensive LSI design methodology transition occurred in 1990's.

Silicon foundries as well as design companies who failed catching up the enormous transition such as NEC, Chips and Technologies, Graphics Communications America, and ACC Micro / Auctor Corp were all expelled from the market.

As a design company, only SanDisk survived although Western Digital acquired it in 2016.

(*1); I also worked as an UNIX workstation system administrator handling superuser privilege and obtained a precious three letters domain name of “aoa.com” (ASCII Of America) in 1993 which is similar to a world-famous “aol.com” (America OnLine).

Gary Zombolas, Chips and Technologies Computer Aided Engineering, designed company private simulator called Chip Sim which frequently misbehaved compared to an official Toshiba simulator working at Toshiba design center.

Because Chips and Technologies was a first fabless (no fabrication; no semiconductor factory) design company who designed LSI chipset exhaustively covering systems logic, communications, and graphics chips for IBM PC. HP, NEC, and other IBM PC manufacturers implemented the Chips and Technologies' chipset together with Intel CPU, BIOS ROM, main memory DRAMs on their motherboard (MOBO) and manufactured IBM PC clones.

An IBM PC clone made by Chips and Technologies resided on all employees' desktop at Chips and Technologies and connected to IBM main frame 3090 through Ethernet with star topology, not ring topology like obsolete Apple net.

This design environments at Chips and Technologies was a big surprise for me because NEC did not have even Ethernet network connection in 1987 when I resigned NEC.

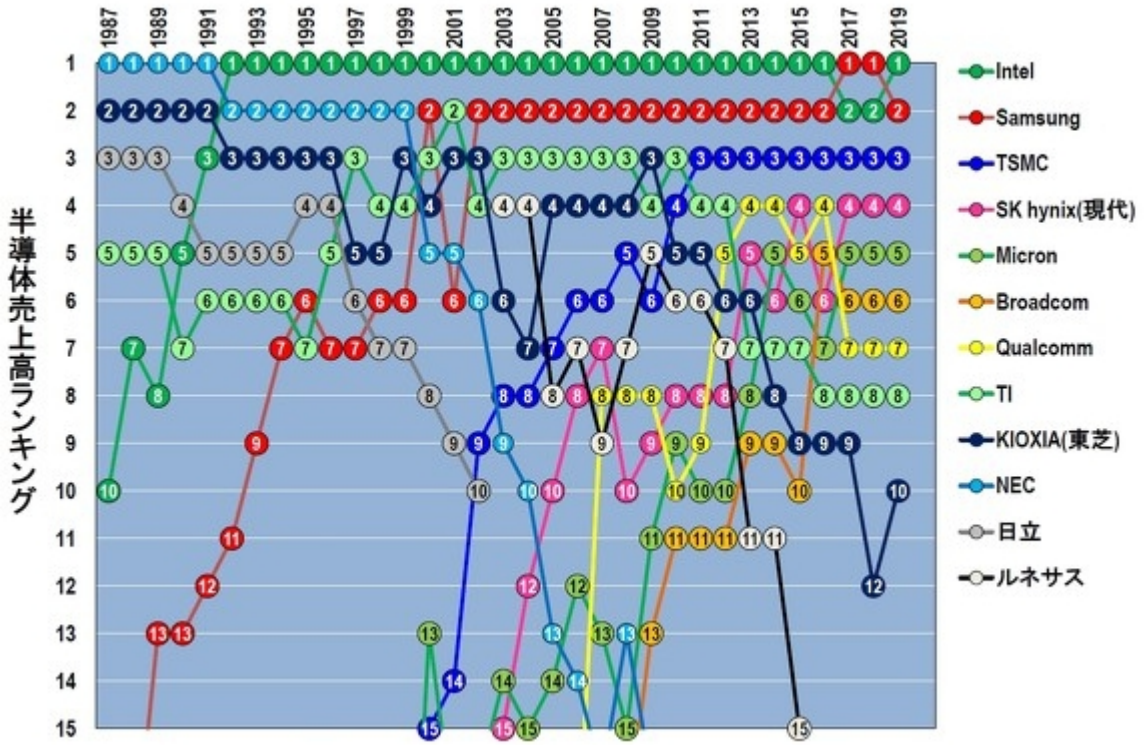
NEC finally caught up with such network system in around 1995, over 7 years later. This is one of the reasons why NEC including other Japanese LSI manufactures such as Hitachi and Toshiba declined sharply. NEC was conceited without knowing such technology trend as well as the design methodology advancement.

"Do-nothings are know-nothings"

Chips and Technologies was able to handle mask layout tool such as Calcomp to make their custom LSIs that combined several ICs assembled on motherboard into one.

LSI design environment at NEC was amazingly obsolete as of I resigned NEC in August, 1987 and afterwards because less knowledgeable antiquated people were leading NEC LSI development although the design skill and creativeness had already deteriorated a lot. It was too late getting noticed the big change which was on-going rapidly in the rest of the world. NEC seems to be too much arrogant right before and after economic bubble burst (1985 ~ 1995) and did not know who they were actually.

What happened afterwards is of no concern to me because I was already away from Japan (1988).



Ranking of semiconductor sales volume (NEC; **Blue**, Samsung; **Red**, Intel; **Green**)

The amount of sales normally reflects so big inertia. But, the rapid sales decline of NEC is remarkable and seems to going to hell down.

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Most Japanese never perceive themselves as mysterious and unusual. "You are so special as well as outdated."