Empowered by Innovation

NEC

NEC HPC Strategy and Products

31 October 2006
Toshiyuki Furui
NEC Corporation

U can change.

Contents

NEC's HPC Activity

NEC's HPC Strategy and Products

Toward the Future of HPC

U can change.

Contents

NEC's HPC Activity

NEC's HPC Strategy and Products

Toward the Future of HPC

U can change.

Supercomputer Performance Gains

FLOPS (Peak)

NEC Earth Simulator
2002 40TF

Copyright JAMSTEC/Earth Simulator Center

NEC SX-2
1983 1.3GF

Cray-1
1976

+47%/year

CDC6600

CRAY-1

SX-2

SX-3

SX-4

SX-5

SX-6

Earth Simulator

SX-8/8R

Blue Gene/L

+75%/year

NEC SX-8/SX-8R

ENIAC
1946, 300FLOPS

Peta 10^{15}

10^{14}

10^{13}

Tera 10^{12}

10^{11}

10^{10}

Giga 10^{9}

10^{8}

10^{7}

Mega 10^{6}

1970   '80   '90   2000   '10

U can change.

4
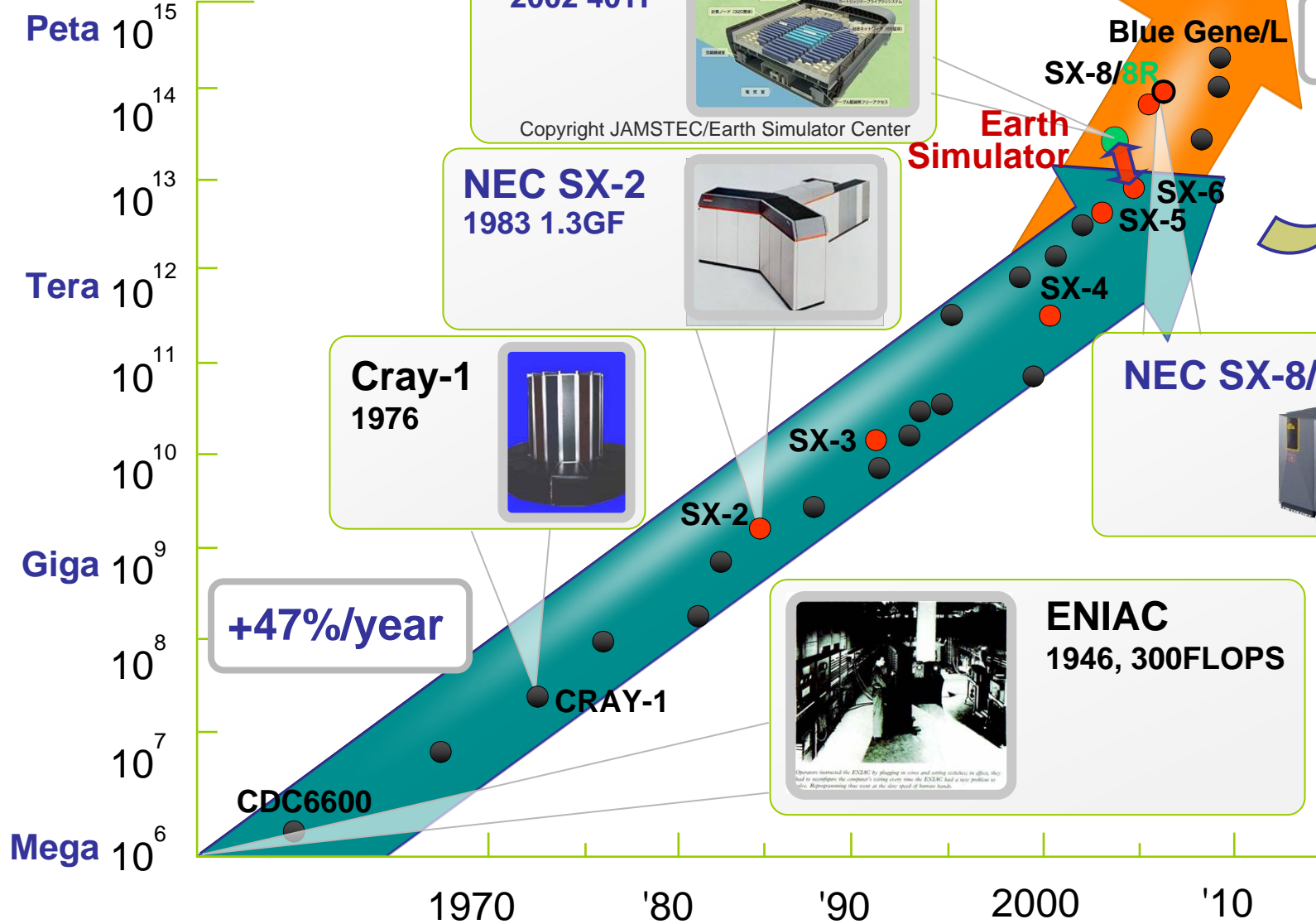
No.1 Vector Supercomputer in the World

Over 1000 SX systems (cumulative orders)

Europe (HPCE)

Asia

Japan

North America

Canada
- Ouranos Consortium
- University of Victoria
- University of Toronto

Oceania (NEC Australia)

South America (NEC do Brasil)

Sales (units) by region

Japan 50%	Europe 36%	Others 14%
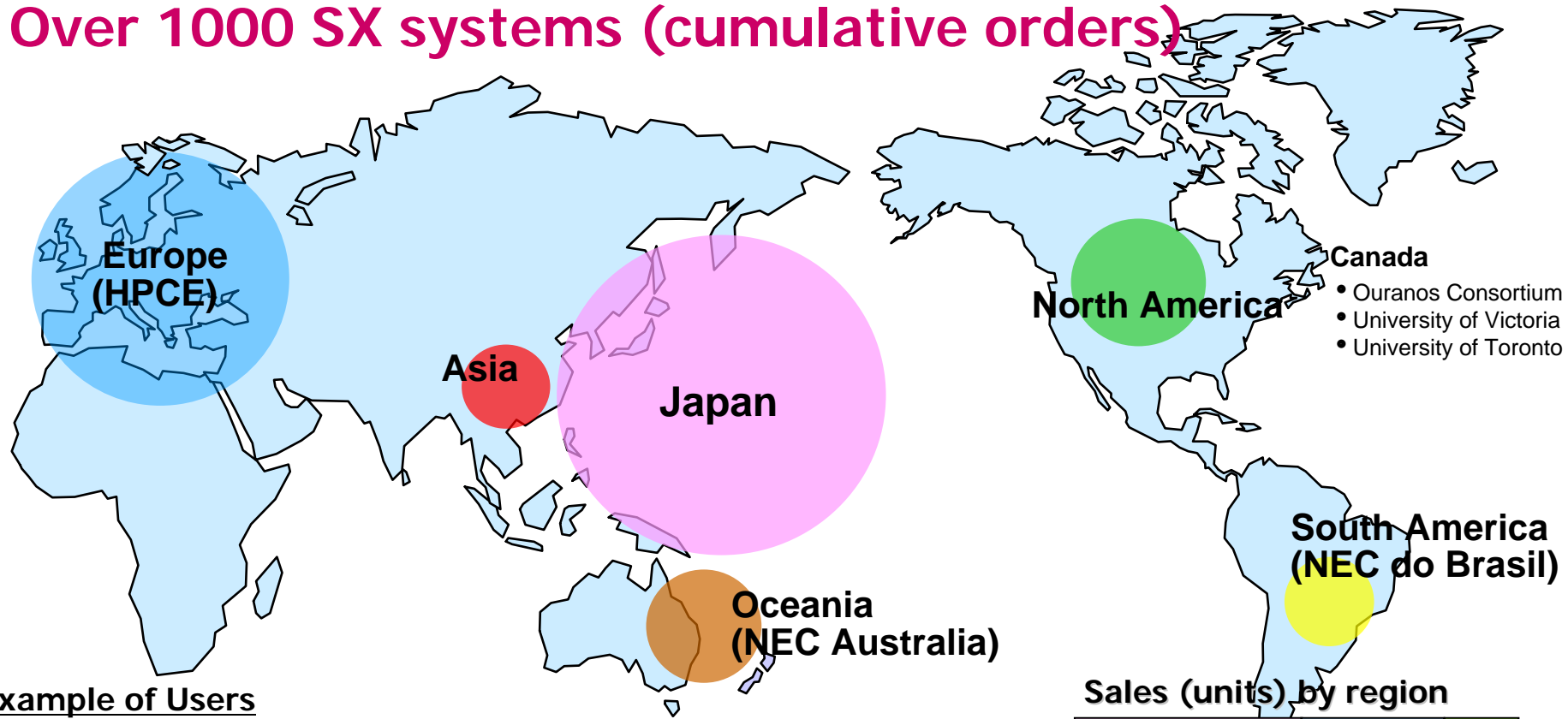
Example of Users

Europe
- The Met Office (United Kingdom)
- Meteo France (France)
- Danish Meteorological Institute (Denmark)
- German Climate Computing Center (Germany)
- CHMI (Czech)
- University of Stuttgart/HLRS (Germany)
- CNRS/IDRIS (France)
- Swiss Center for Scientific Computing (Switzerland)
- Aerospace Laboratories
  (Netherlands, Germany, France, Italy)

Japan
- Tohoku University Information Synergy Center
- Osaka University Cyber Media Center
- National Institute for Environmental Studies
- National Institute for Fusion Science
- Meteorological Research Institute - JMA
- Central Research Institute of
  Electric Power Industry
- Japan Aerospace Exploration Agency
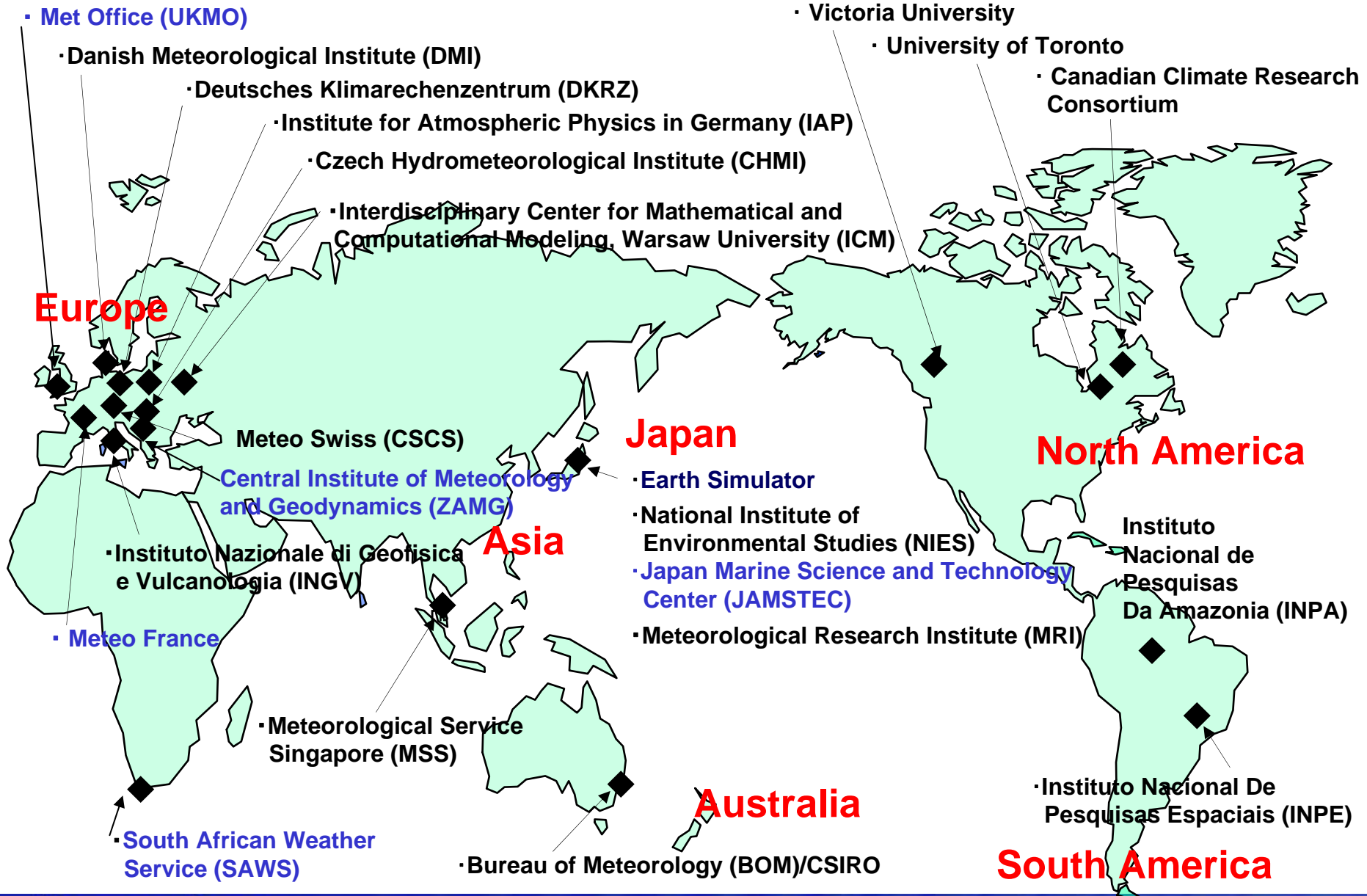- Toyota Central R&D Labs,. Inc.
- Nissan Motors

Asia Pacific/South America
- Bureau of Meteorology / CSIRO (Australia)
- Korea Institute of Science, Technology and Information (Korea)
- Meteorological Services of Singapore (Singapore)
- National Institute for Space Research (Brazil)

U can change.

SX Series in Weather/Climate Community

· Met Office (UKMO)

·Danish Meteorological Institute (DMI)

·Deutsches Klimarechenzentrum (DKRZ)

·Institute for Atmospheric Physics in Germany (IAP)

·Czech Hydrometeorological Institute (CHMI)

·Interdisciplinary Center for Mathematical and Computational Modeling, Warsaw University (ICM)

· Victoria University

· University of Toronto

· Canadian Climate Research Consortium

Europe

North America

Meteo Swiss (CSCS)

Central Institute of Meteorology and Geodynamics (ZAMG)

Japan

Asia

·Instituto Nazionale di Geofisica e Vulcanologia (INGV)

· Meteo France

·Earth Simulator

·National Institute of Environmental Studies (NIES)

·Japan Marine Science and Technology Center (JAMSTEC)

·Meteorological Research Institute (MRI)

Instituto Nacional de Pesquisas Da Amazonia (INPA)

·Meteorological Service Singapore (MSS)

Australia

·South African Weather Service (SAWS)

·Bureau of Meteorology (BOM)/CSIRO

·Instituto Nacional De Pesquisas Espaciais (INPE)

South America

U can change.

Contents

| |
|---|
| **NEC's HPC Activity** |
| **NEC's HPC Strategy and Products** |
| **Toward the Future of HPC** |

NEC's Computer Product Strategy

Leveraging two key technologies:
High performance technology and Highly reliability technology

High Performance Technology

◎ **Most advanced technology**
- **High-speed/high-density VLSI**
- **High-density packaging**
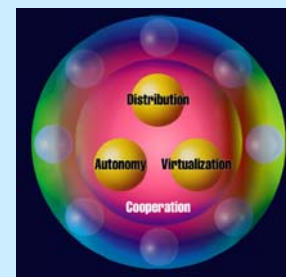- **High-efficiency cooling**
- **High-speed interconnect**
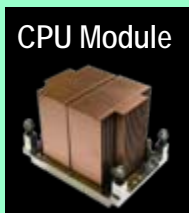
◎ **Parallel processing technology**
◎ **Cluster control technology**

CPU Module

High Reliability Technology

◎ **VALUMO**
(Platform Technology)

- **Autonomy/Virtualization**
- **Fault-tolerance**
- **Continuous operation**

VALUMO

Technology leader products

Super-computer   **ACOS Mainframe**   **IPF Server/ Blade Server**   **Express PC Server**   **IA ft/Blade Server**   **iExpress Network Server**   **iStorage**   **DVD**

U can change.

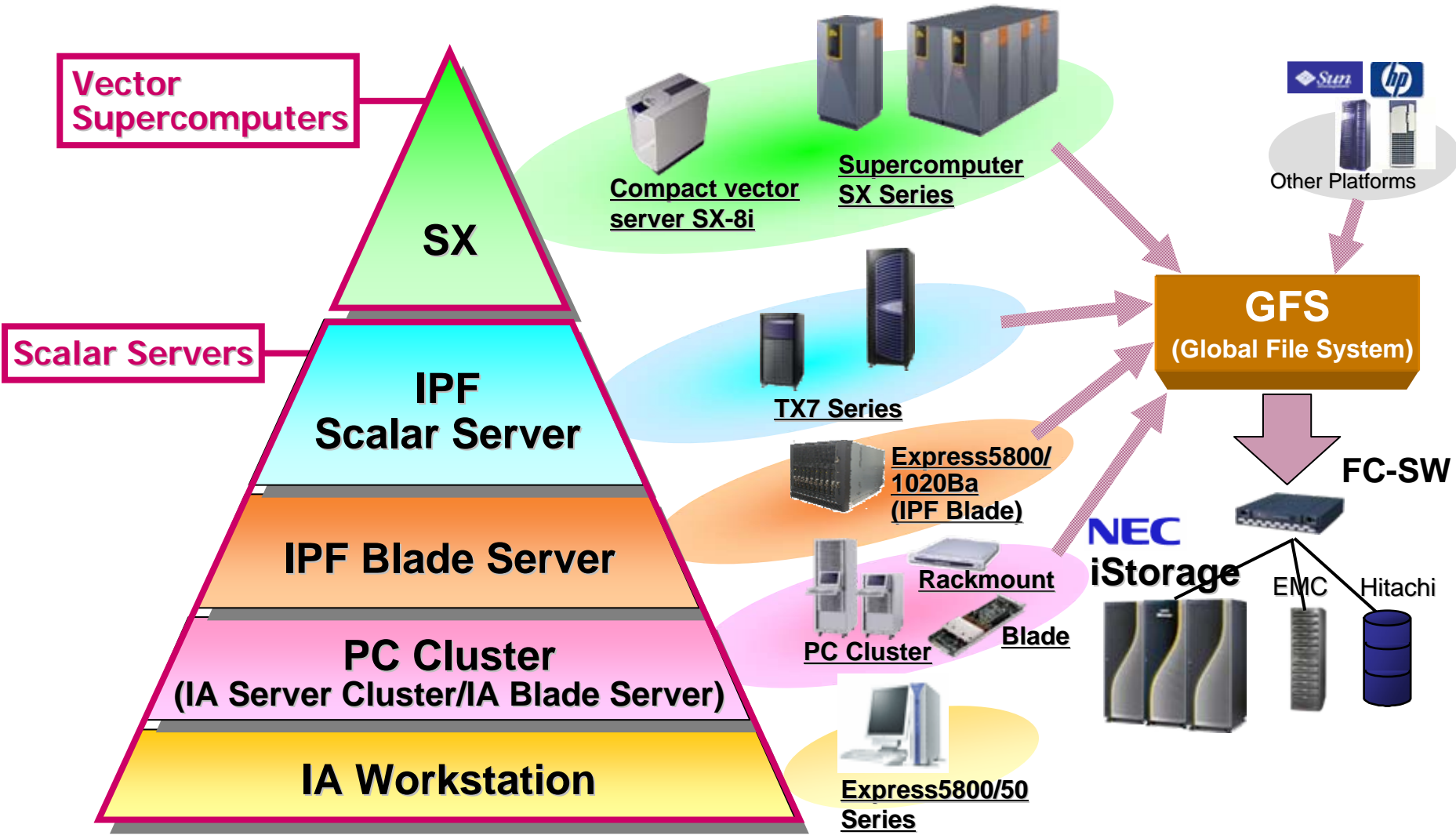# NEC's Strategy on HPC

SX: Vector supercomputer based HPC system
- Overwhelming sustained performance and high reliability with NEC original cutting edge technologies
- Ever-increasing per Core(CPU) performance
- Seamless connection with other servers

Right platform for right application, which best fits the customers' needs
- SX
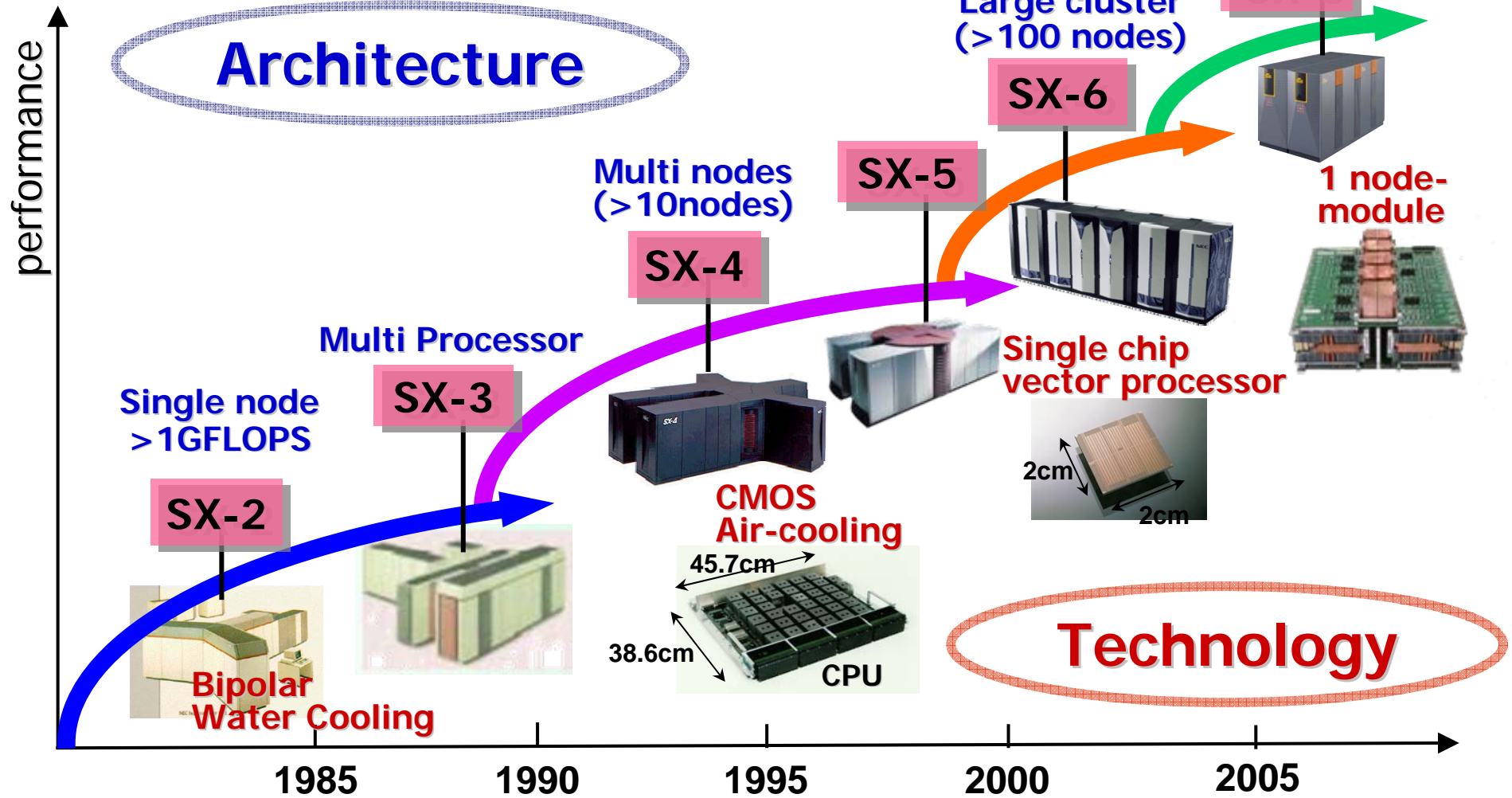- SX+Scalar
- Scalar
  - IPF scalar server
  - PC cluster

Integrated NEC HPC solution

NEC's HPC Products Lineup

Vector Supercomputers

Scalar Servers

Pyramid levels (top to bottom):
- SX
- IPF Scalar Server
- IPF Blade Server
- PC Cluster (IA Server Cluster/IA Blade Server)
- IA Workstation

Compact vector server SX-8i

Supercomputer SX Series

Other Platforms

GFS (Global File System)

TX7 Series

Express5800/1020Ba (IPF Blade)

Rackmount

Blade

PC Cluster

Express5800/50 Series

FC-SW

NEC iStorage

EMC   Hitachi

SX Innovation

Continual Break-Through Achieved in both Technology and Architecture

performance

Architecture

Technology

Super large cluster (>500 nodes)

SX-8R

SX-8

Large cluster (>100 nodes)

SX-6

1 node-module

Multi nodes (>10nodes)

SX-5

SX-4

Single chip vector processor

Multi Processor

SX-3

2cm

2cm

Single node >1GFLOPS

SX-2

CMOS Air-cooling

45.7cm

38.6cm

CPU

Bipolar Water Cooling

1985 1990 1995 2000 2005

SX-8R Product Highlights

**1. World's fastest vector supercomputer
                        with maximum performance of 144 TFLOPS**

- Very large scale : Up to 512 nodes, 4,096 CPUs
- Very large memory / memory bandwidth: 256TB / 288TB/s
- High speed data transfer between nodes : 8TB/s in total

2. High-density packaging with state-of-the-art technology

- Single-chip vector processor with 35.2GFLOPS performance
- Leading-edge CMOS technology with 90-nanometer process /copper interconnects
- Single-module node with 281.6GFLOPS performance

3. Enhanced SUPER-UX / Tuned applications

- Proven operating system for SX series enhanced to expand scalability
- A lot of ISV application programs tuned for SX series available

SX-8R Enhancement

- **Vector adder and multiplier doubled**
    - SX-8 : (Multiply + Add) x 4pipes x 2GHz = 16GF
    - SX-8R: (Multiply + Add) x **2sets** x 4pipes x 2.2GHz = 35.2GF

- **Memory capacity is doubled**

    SX-8   SX-8R
    - 128GB ➡ 256GB/node (DDR2 RAM)
    - 64GB ➡ 128GB/node (FCRAM)

- **Clock-up**
    - 2.2GHz (10% up)
              note: ONLY FOR DDR2 models
   FCRAM model's clock cycle remains with 2GHz.

U can change.

Comparison of CPUs (SX-8, SX-8R)

SX-8

4 Vector pipelines

Mask Reg.

Mask

logical

Multiply

Add

Div./Sqrt

Load or Store

Vector Reg.

Scalar Unit

Cache

Scalar Reg.

Scalar Exec.

$2(M+A) \times 4vpp \times 2GHz = 16GFLOPS$

SX-8R

4 Vector pipelines

Mask Reg.

Mask

Mult./Log

Multiply

Add

Add./Div./Sqrt

Load or Store

Vector Reg.

Scalar Unit

Cache

Scalar Reg.

Scalar Exec.

$2(M+A) \times 2set \times 4vpp \times 2.2GHz = 35.2GFLOPS$

M/A V Pipe doubled
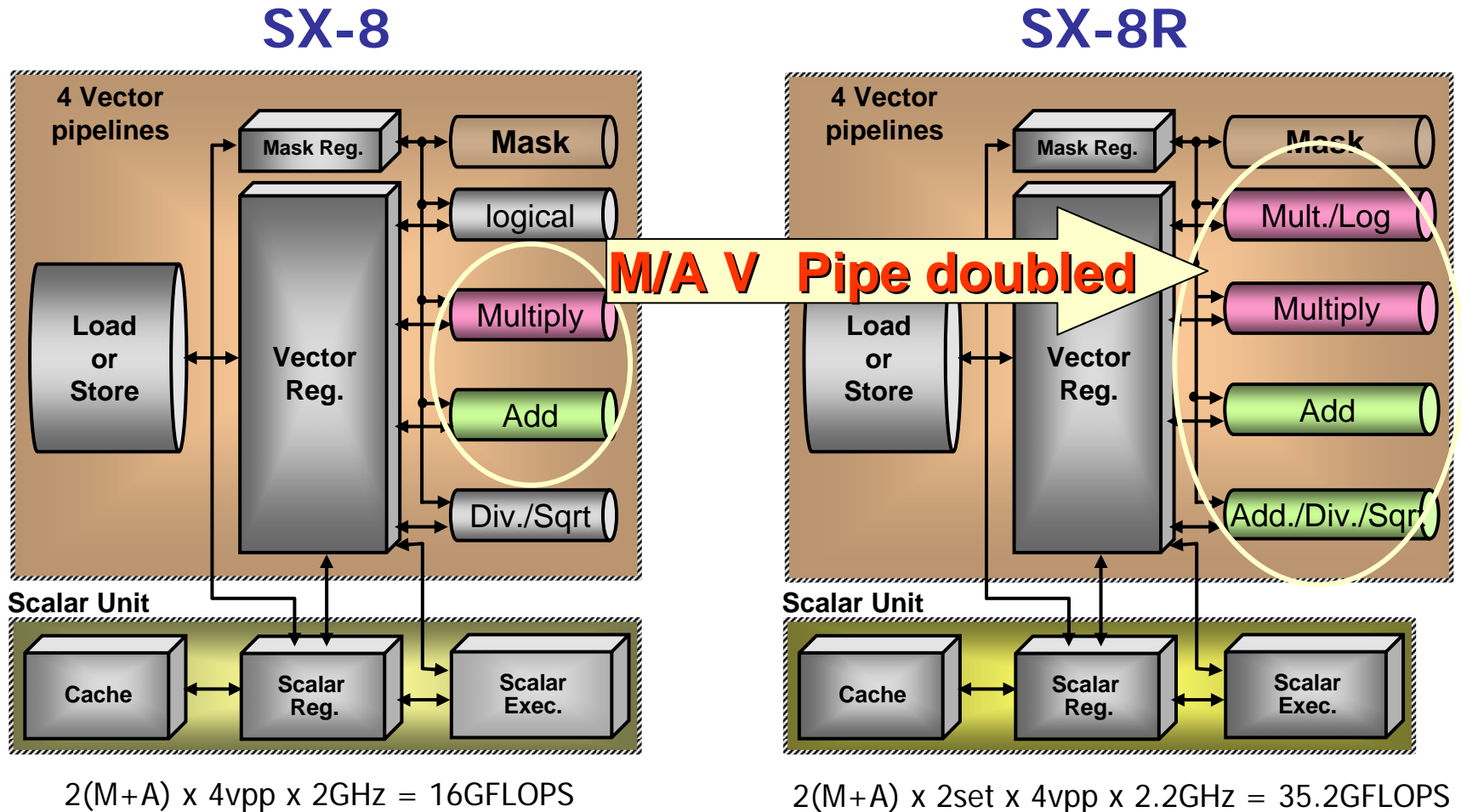
Note: One vector instruction occupies one vector pipeline on SX-8R.
e.g.) The peak performance of one VFAD (vector FP add) Op. is 8.8GFLOPS

U can change.

SX-8R Single Node Module   (DDR2 model)

- ## Up to 8 CPUs/node
  - **Peak Vector Performance(PVP):**
    35.2 GFLOPS/CPU
    281.6 GFLOPS/node

- ## Symmetric multiprocessing (SMP)

- ## Large Capacity Memory
  - **Up to 256GB**

- ## Ultra-high memory bandwidth
  - 70.4GB/s per CPU
  - Total 563.2GB/s per node

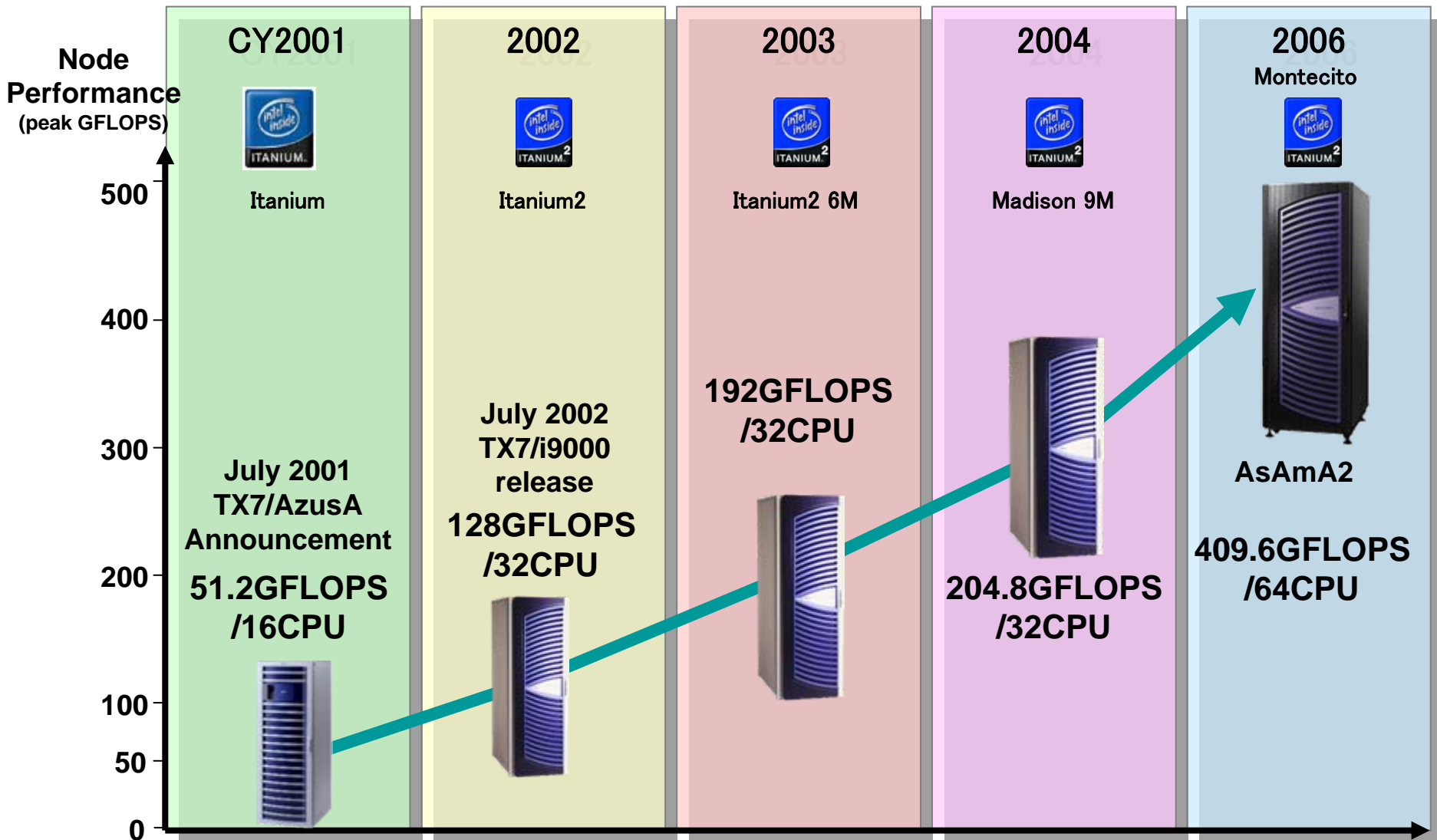- ## Large I/O throughput
  - 12.8GB/s per node

CPU ... CPU CPU CPU

MM

to IXS

I/O I/O ... I/O

Memory

CPU

Node Module

U can change.
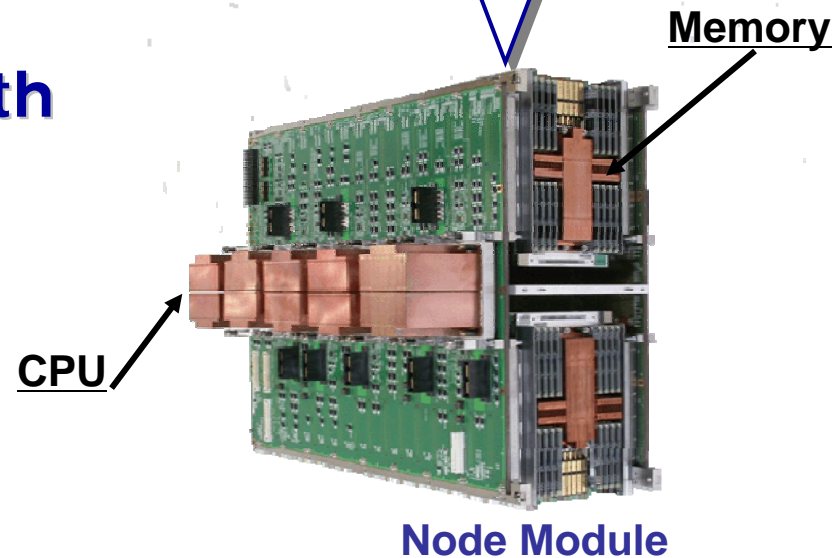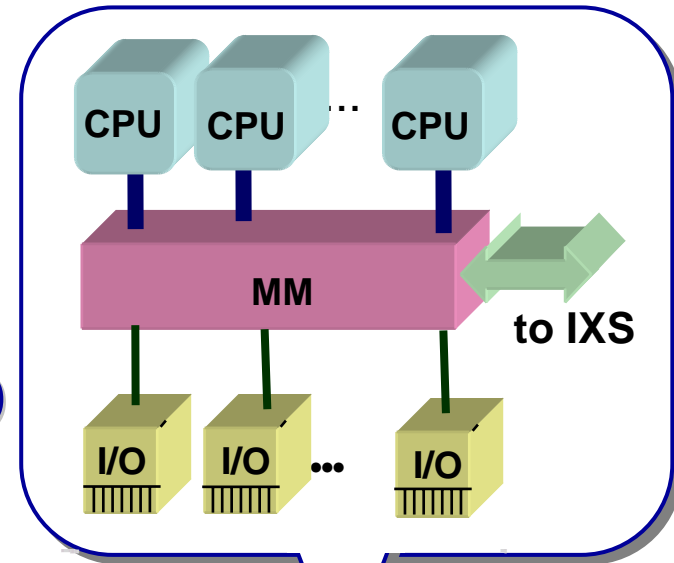
Large Scale Multi Node System

High speed processing of large data with high performance single node, large number of nodes, and high speed interconnects among nodes

Key points for high performance

1. **Single node performance** — **Max 281.6GFLOPS**

2. **Maximum number of node** — **Max 512 nodes**

3. **Data transfer rate among nodes** — **Max 8TB/s** （Peak data transfer rate）

Very efficient non-blocking switch

High speed inter-node switch (IXS)

16GB/s x 2 / nodes

Max 8CPU 281.6GFLOPS

CPU CPU ···· CPU

Optical Interconnection

MMU

IOF IOF IOF IOF

Node#0 #1 #2 #3 #4 #5 **Max 512 nodes**

Max 8CPU 281.6GFLOPS

CPU CPU ···· CPU

MMU

IOF IOF IOF IOF

Node#511

IPF Server Roadmap

Node Performance
(peak GFLOPS)

	CY2001	2002	2003	2004	2006

- CY2001 — Itanium
- 2002 — Itanium2
- 2003 — Itanium2 6M
- 2004 — Madison 9M
- 2006 — Montecito — Itanium2

500

400

300

200

100

50

0

July 2001 TX7/AzusA Announcement

51.2GFLOPS /16CPU

July 2002 TX7/i9000 release

128GFLOPS /32CPU

192GFLOPS /32CPU

204.8GFLOPS /32CPU

AsAmA2

409.6GFLOPS /64CPU

Platform for PC Cluster

Enable to choose Optimized server
depending on usage and budget

Opteron/Xeon Rack

Express5800/T220Rc-1(Opteron)
Express5800/T120Rb-1（Xeon）

Express5800/100 series, Opteron server

Cost performance Opteron/Xeon server

Good price/performance ratio.
More memory slots achieve
system cost reduction.

Xeon Blade
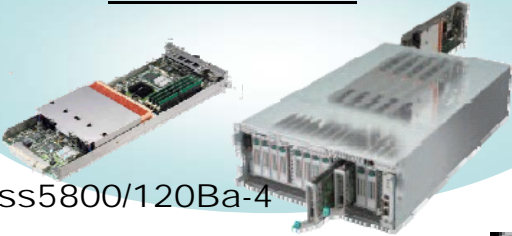
Express5800/120Ba-4

Express5800/BladeServer

High density & Cost performance Xeon blade

Higher density than competitors.
PCI slots achieve expandability.
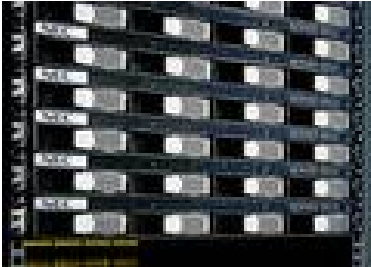
Contents

NEC's HPC Activity

NEC's HPC Strategy and Products

Toward the Future of HPC

U can change.

Processor Architecture

Scalar ALU

S SR

Scalar Processor

Scalar ALU
Vector ALU
(SIMD)

S SR

V VR
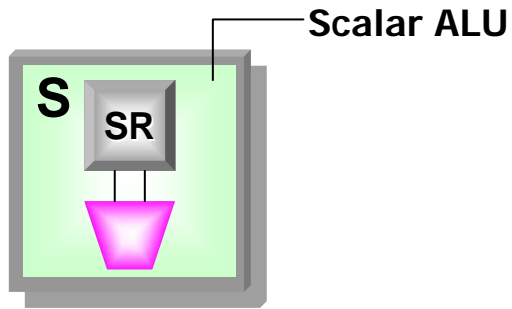
ADD High
Speed Engine
(Vector)
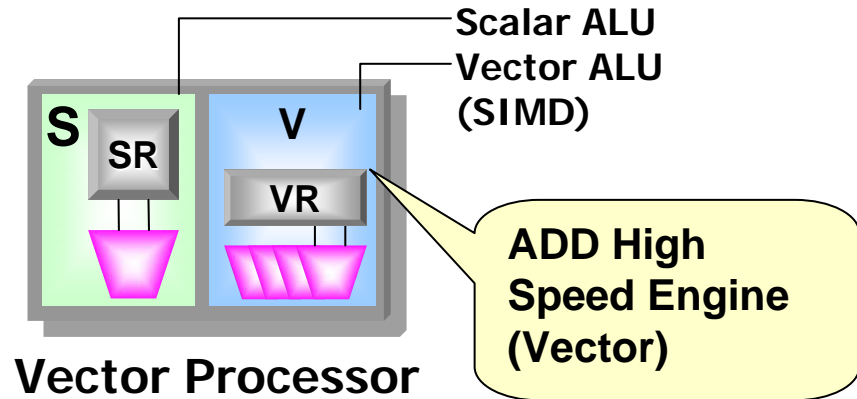
Vector Processor

Pentium 4

Rambus XDR DRAM interface
Memory controller
Power core
Scalar
L2 0.5 MB
Test and debug logic
Vector SPE Vector SPE
Vector SPE Vector SPE
Vector SPE Vector SPE
Vector SPE Vector SPE
I/O controller
Rambus RRAC

Cell

V V
V V S
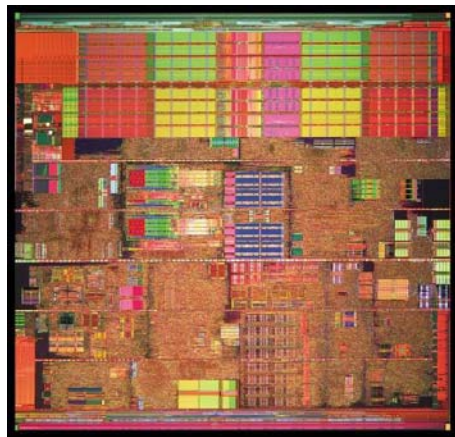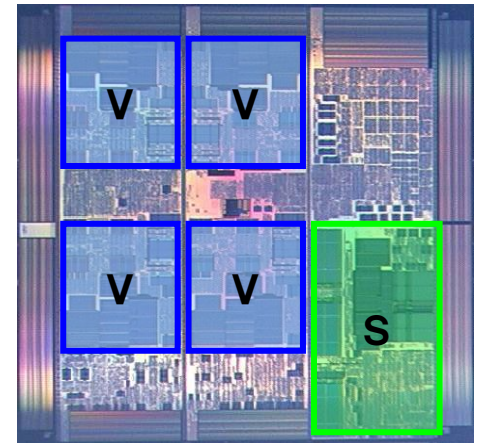
SX-8

Performance acceleration trend

Processor core architecture

①Expand SIMD units　　**②Add-on Co-Processor**　　**③Heterogeneous multi-core**

Next x86

Add-on accelerator card
→One-chip Co-processor

Cell（SCE/Toshiba/IBM）
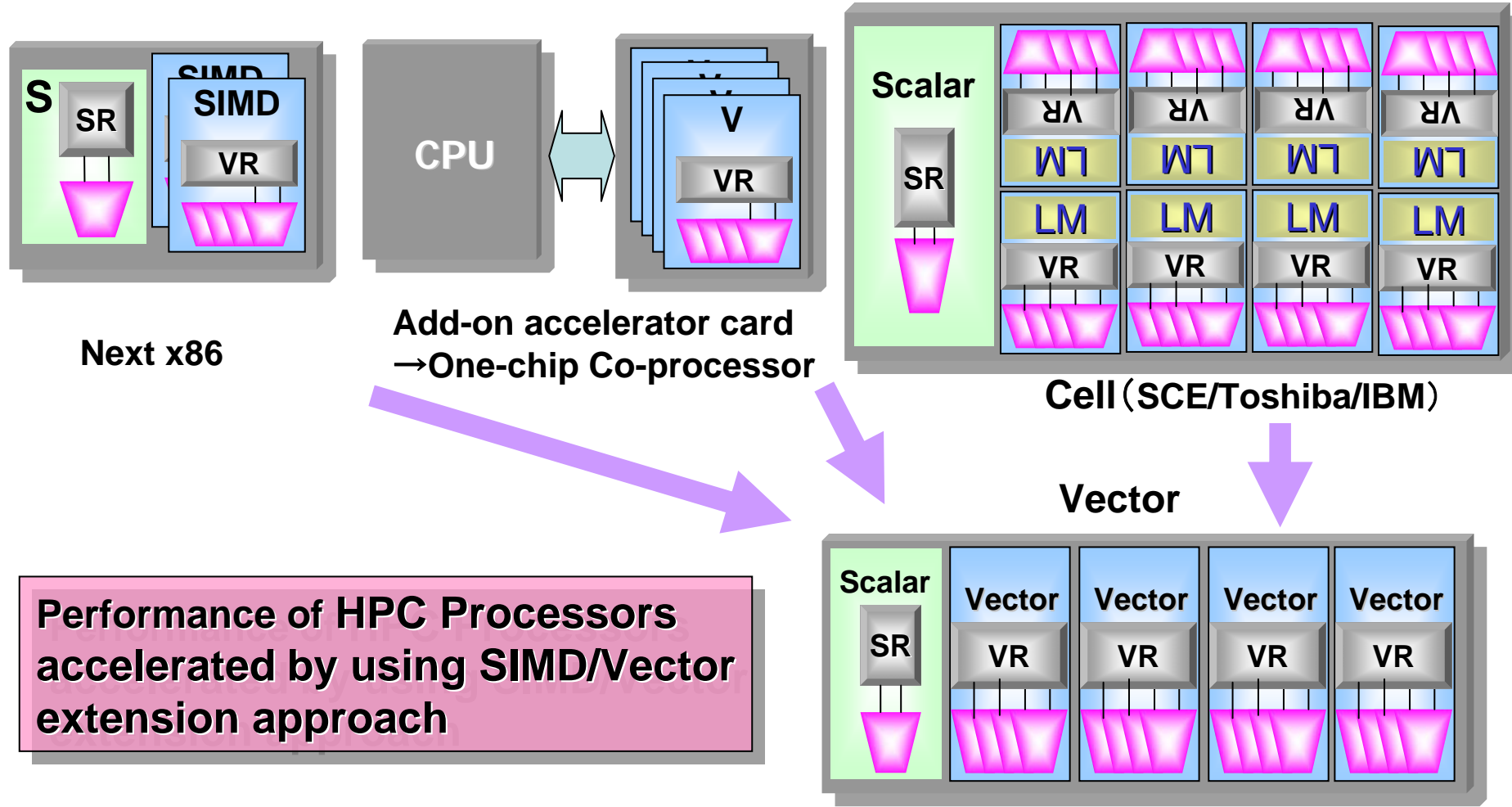
Vector

Performance of HPC Processors accelerated by using SIMD/Vector extension approach

U can change.

Trend of Processor Multi core Chip
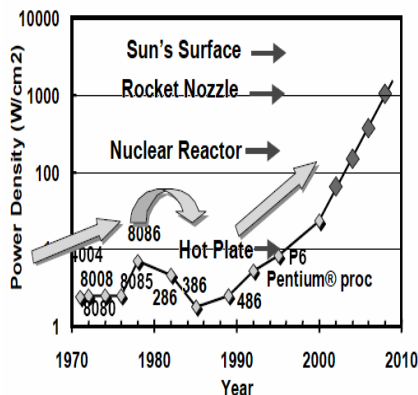
HPC Processors will take in Vector units on the CPU die.

Scalar Machine ..... **Add Vector (SIMD) Function** **Future**

X86 — intel, AMD

S → S S (Multi core) → S+V Multi core

Cell — SONY, IBM, TOSHIBA

S+ Multi Vector → S+V Multi core

Vector Machine

SX — NEC

S+V Single core → Multi core → (S+V) Multi core
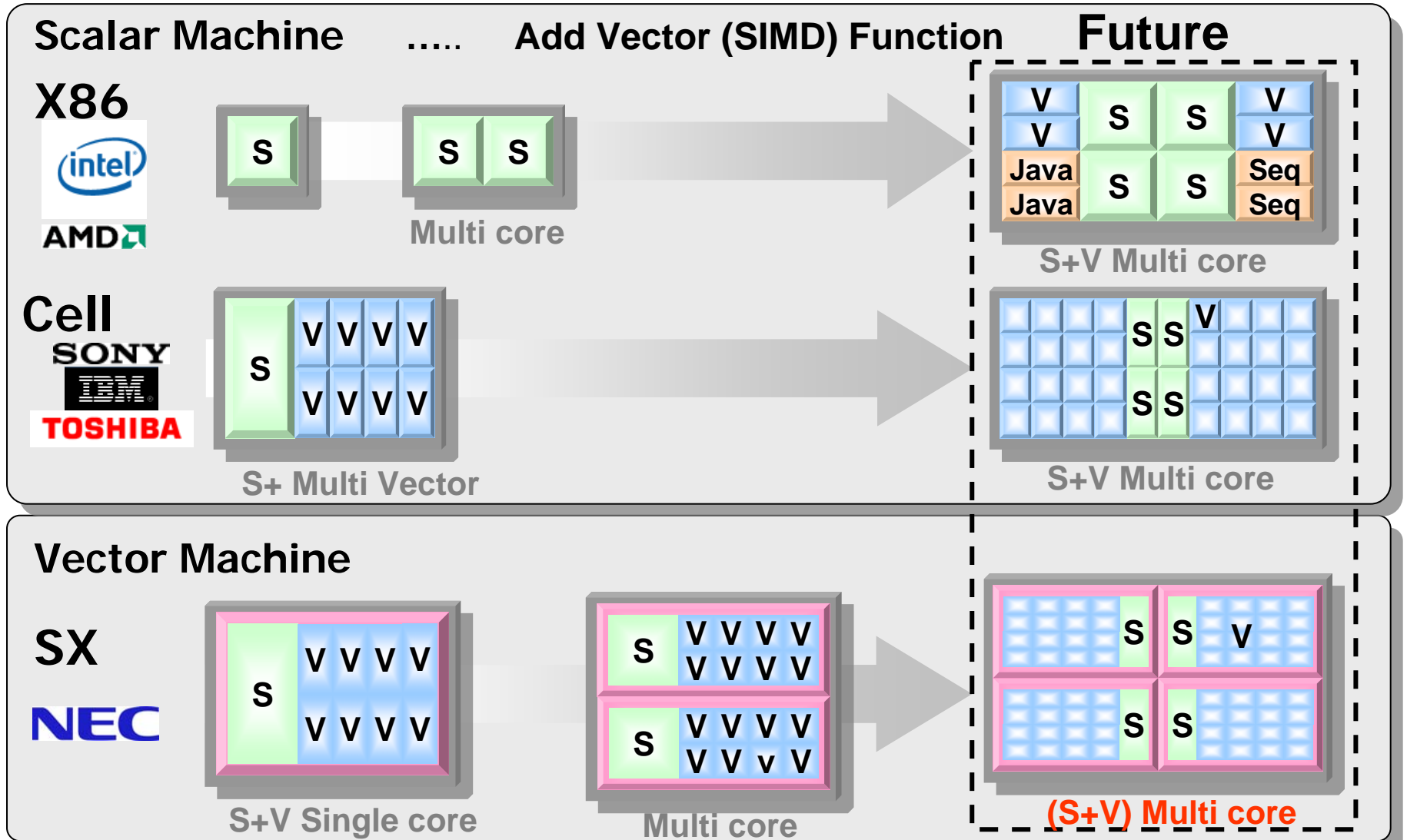
U can change.

Core Technologies for Future Supercomputer

Hybrid System

Vector | Scalar | Special
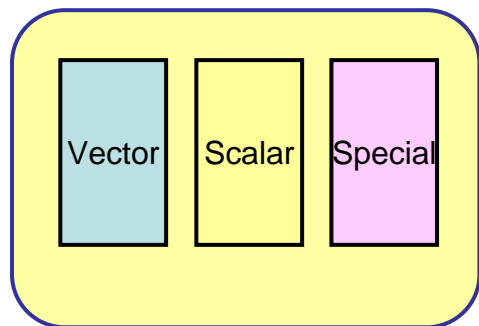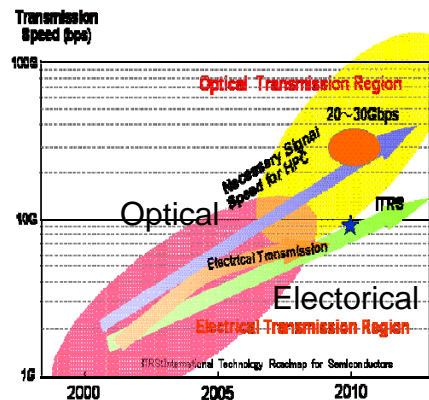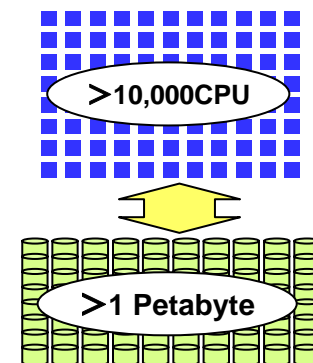
Selection of the suitable platform by applications

⬇

Realize high sustained performance for various applications

Low Power Consumption

Power density will go up like Nuclear Reactor.

⬇

Low Power consumption and cooling technology will be required.

Interconnect

Transfer speed between LSIs will influence the sustained performance

⬇

Optical Transmission Technology between LSIs will be required.

Software

>10,000CPU

>1 Petabyte

- **Super Parallel Software**
- **Super large data handling**

**NEC continues to supply
best product to customers
through
the ceaseless quest for technology
and by
Being a quality leader in the world**

Thank you !!

Empowered by Innovation   **NEC**