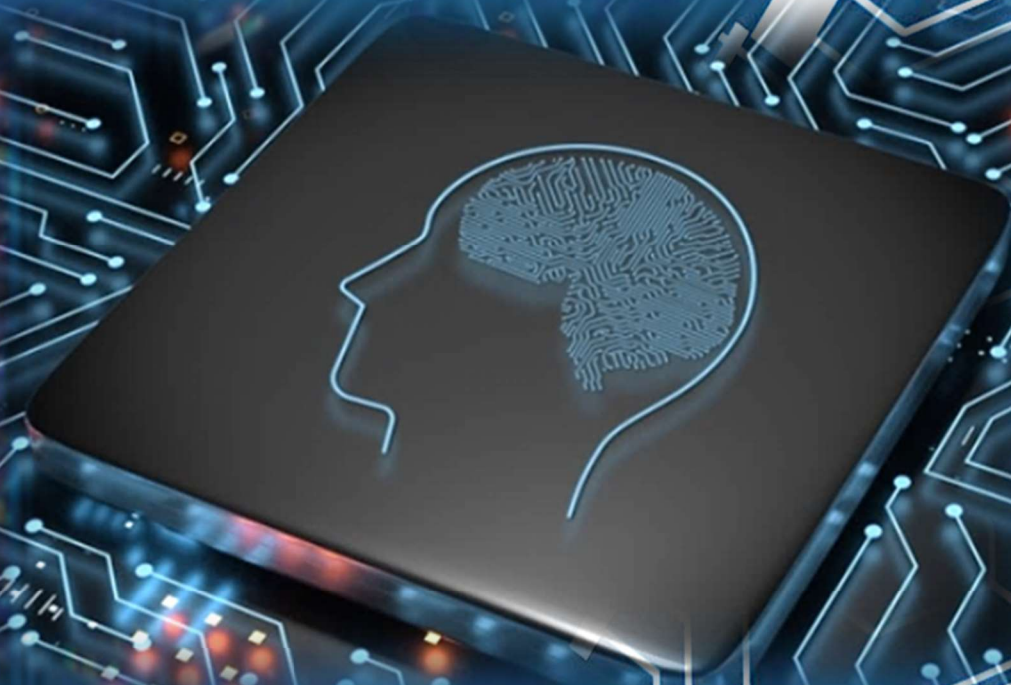




MRAM Application Information

2022 Feb.



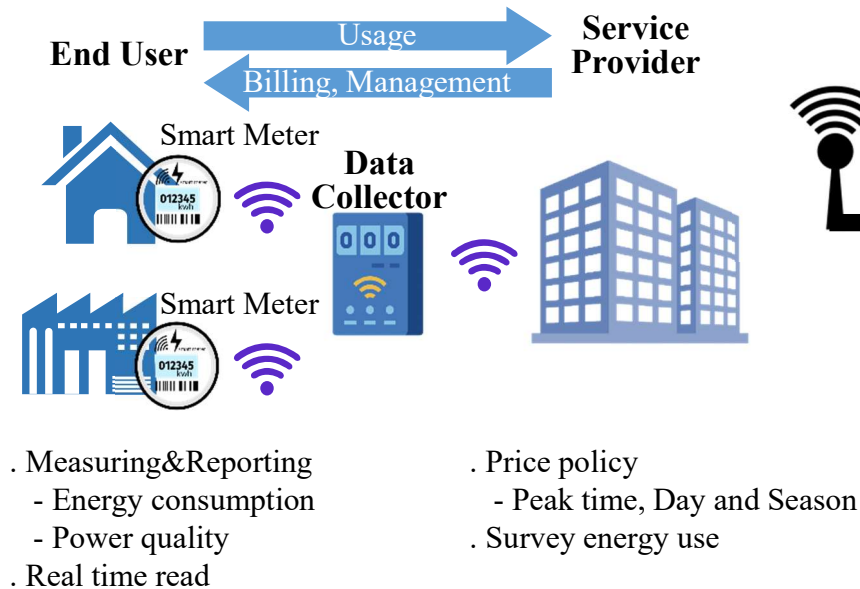
New Evolution of Technology and Solution

Smart Meter

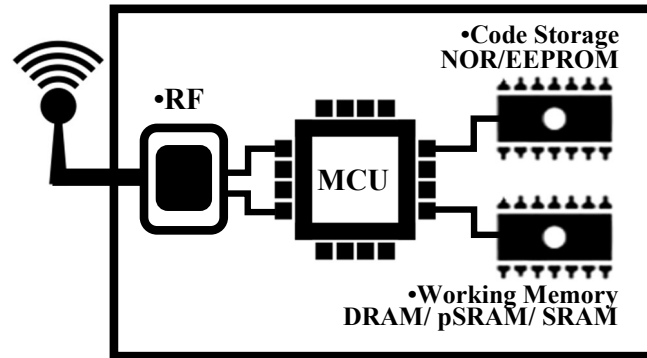
[Smart Meter]



[Smart Grid]



[Traditional]



Code Storage

- 1) NOR
 - . Non-Volatile
 - . Page basis access
 - . Security Feature
 - . Slower speed than RAM
- 2) EEPROM
 - . Non-Volatile
 - . Byte basis access
 - . very slow write speed
 - . Limited write endurance
 - Not adequate for OTA update

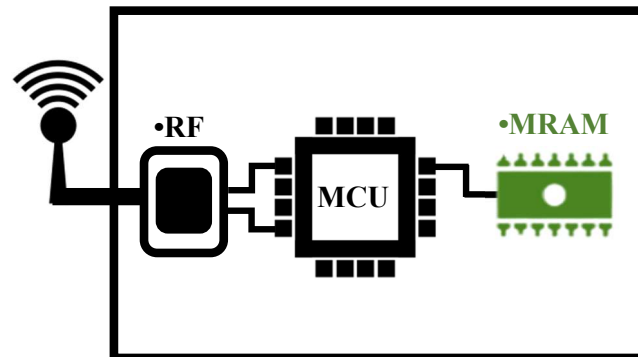
Working Memory

- 1) DRAM/pSRAM
 - . Low cost
 - . Byte basis access
 - . Refresh required
 - . Volatile
- 2) SRAM
 - . Fast speed
 - . No refresh required
 - . Byte basis access
 - . Expensive
 - . Volatile

※ OTA (Over The Air)

; Remotely controlled software update

[with MRAM]



MRAM

- . Works for both of Code Storage and Working Memory
- . Fast speed like SRAM, much shorter write time than NOR
- . Byte basis access
- . Security Feature
- . Non-Volatile
- . Good for OTA update

- 2 memory ICs can be replaced by 1 MRAM
- Fast Speed, Security feature
- Byte basis accessibility makes software more efficient. Smaller density required
- Less program update time, Less power consumption
- Safe from sudden power failure, Short recovering time

Multi-Functional Printer

[Multi-Functional Printer]



※ Multi-Functional Printer has SRAM for storing log data such as copy, print, scan and fax history.

Log data is small and frequently written.

To prevent data loss at power failure, **it accommodates a battery** to supply power to SRAM during power outage because SRAM is volatile memory.

Flash memory (NOR/NAND) is too slow to work as a data logging memory.

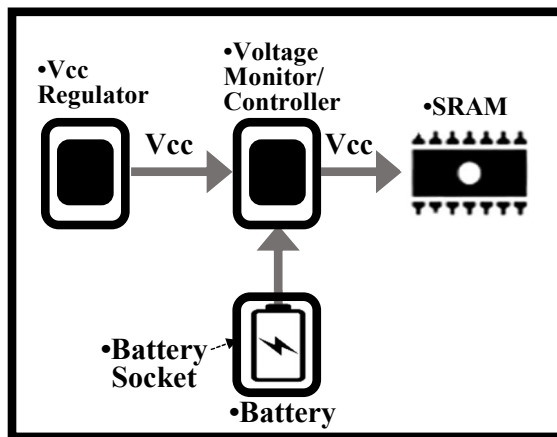
[Example of Battery Backed SRAM]



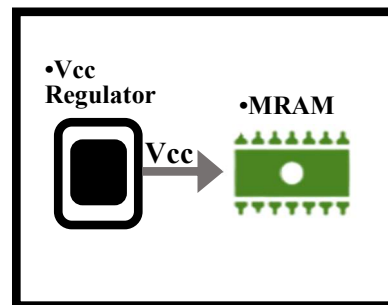
• Disadvantages of Battery backed SRAM system

- 1) Additional 3 components are necessary. Extra cost.
; Voltage monitor/Controller, Battery Socket, Battery
- 2) Battery life is variable, depending much on temperature.
; Nominal life time is 4~7 years depending on SRAM standby current consumption.
- 3) Complexed assemble process due to socket and battery
- 4) Socket connection is vulnerable.
- 5) Battery maintenance is necessary.
- 6) Complicated ROHS regulations compliance due to battery.

[Traditional]



[with MRAM]



※ Some cases use nvSRAM instead of battery backed SRAM.

But they still need a super capacitor to supply power to nvSRAM at power failure

because nvSRAM requires certain time to copy data from SRAM array to non-volatile memory array at power failure.

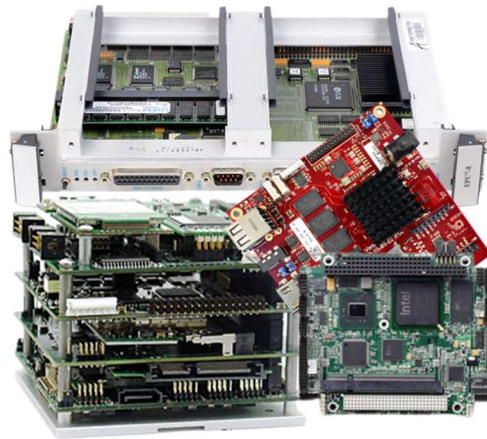
- **Fast speed to work as a data logging memory**
- **Eliminate voltage controller, battery and battery socket**
- **No capacitor needed**
- **Safe from sudden power failure, Short recovering time**
- **Longer retention time (10years vs. 7years)**

Embedded Computer (Industrial PC)

[Embedded Computer]



[Board Example]

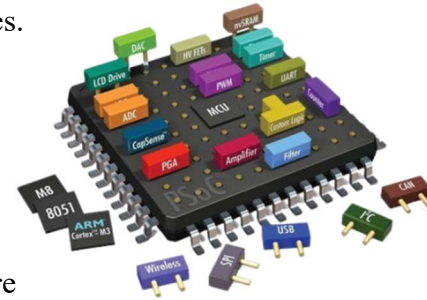


• What is embedded Computer (Industrial PC)?

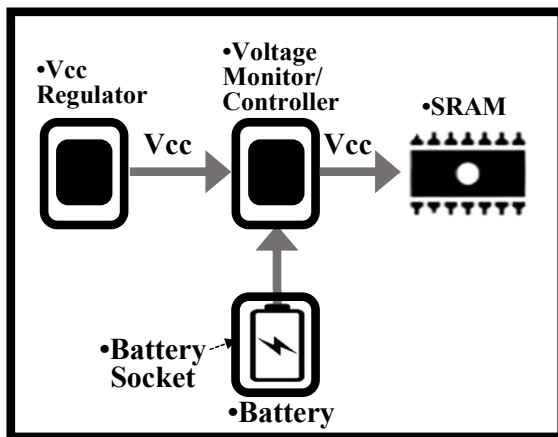
- . Similar with Desktop PC but optimized for special purpose, mainly for industrial system control.
- . Program is embedded in SOC in some cases.
- . **Equipped with Battery backed SRAM.**

• Purpose of Battery Backed SRAM

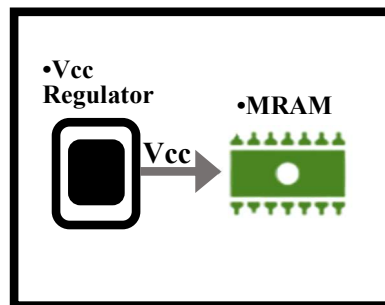
- . Critical data back up
- . Store data-log to recover from power failure
- ✗ Embedded PC also can use nvSRAM.
But super capacitor is still required to supply power to nvSRAM at power failure.



[Traditional]



[with MRAM]



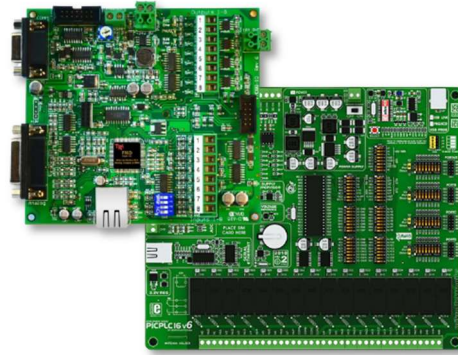
- **Eliminate voltage controller, battery and battery socket**
- **No capacitor needed**
- **Safe from sudden power failure, Short recovering time**
- **Longer retention time (10years vs. 7years)**
- **Security Features**

PLC (Programmable Logic Controller)

[PLC]



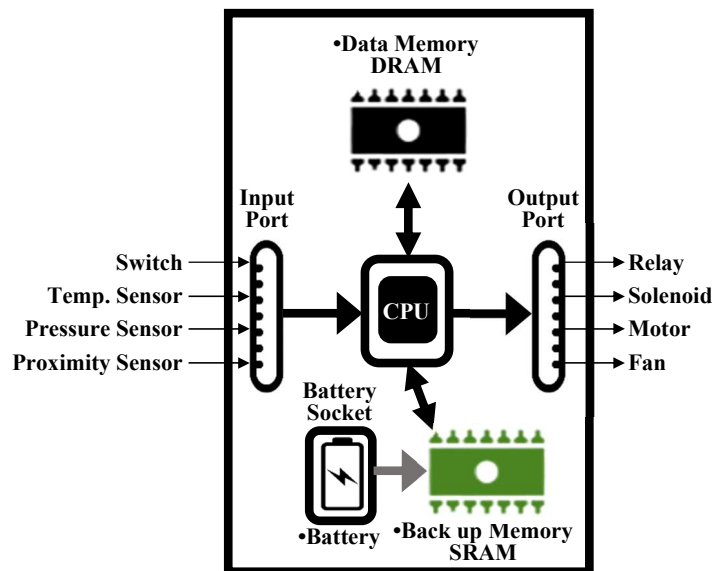
[PLC Board Example]



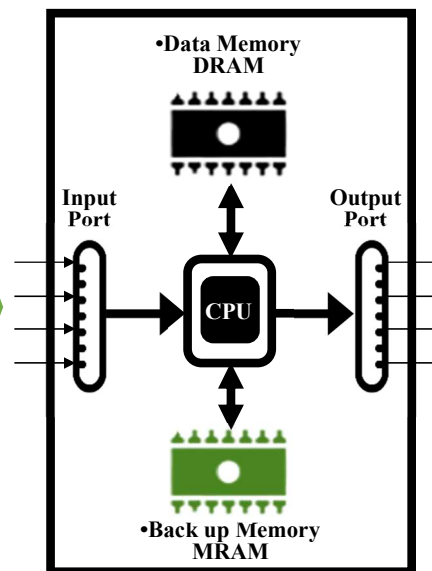
• What is PLC?

- . An industrial computer control system that monitors the state of input devices and control the state of output devices based on a customized program in real time.
- . It has many of input ports to receive various input devices' signals as well as many of output ports to send signals to control machines.→ Factory Automation
- . It is **equipped with Battery backed SRAM** for quick data backup at power failure.
- . Modern PLC uses **super capacitor** with non-volatile RAM to back up critical data along with PLC program because battery requires maintenance and it has ROHS issues.
- . Usually Super Capacitor can supply power for 100ms, so Flash (NOR/NAND) is not considered for back up memory due to long write time.

[Traditional]



[with MRAM]



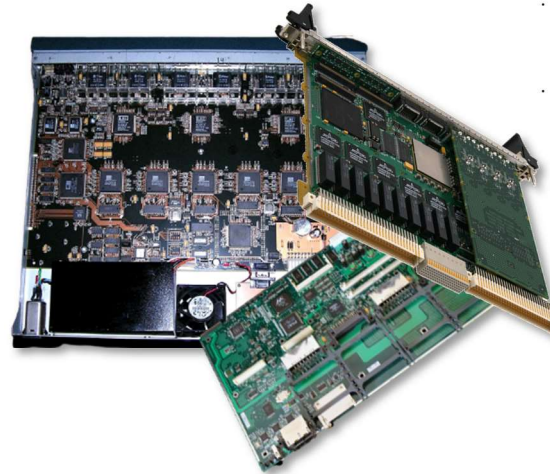
- **Eliminate battery and battery socket**
- **No capacitor needed**
- **Safe from sudden power failure**
- **Short recovering time**
- **Longer retention time (10years vs. 7years)**

Network Router/ Switch

[Network Router/ Switch]

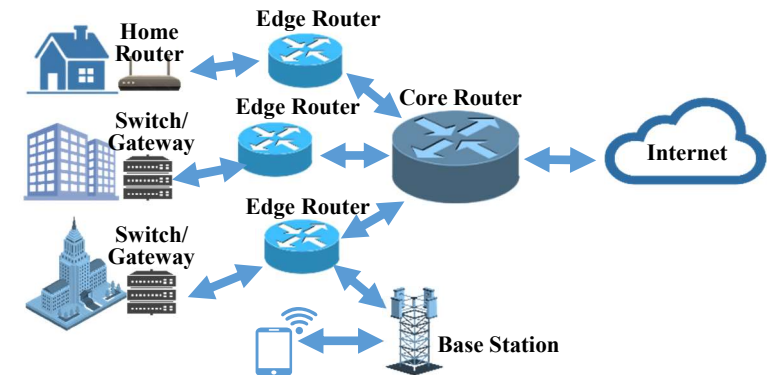


[Router/Switch B'd]

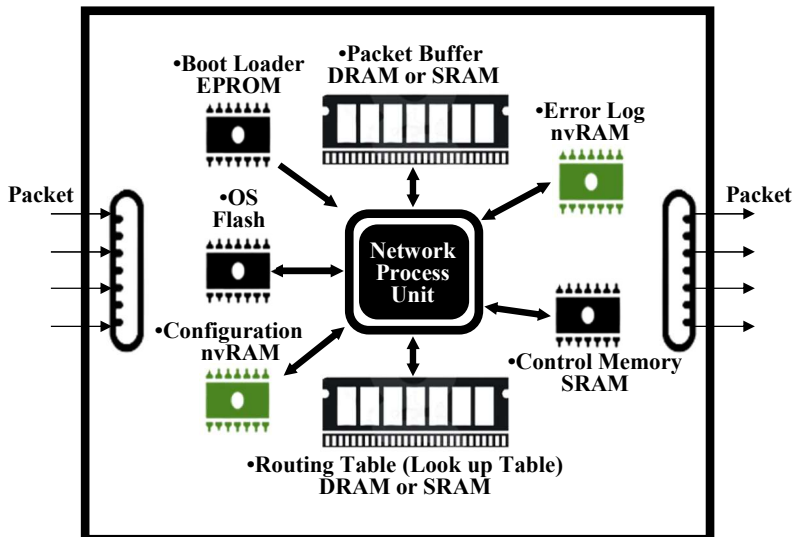


• What is Network Router/ Switch?

- Switch is a hardware that connects devices on a network by using packet switching to receive and forward data to the destination device.
- Router is a hardware that finds fastest way to transfer packets to the destination and processes packets on various purposes.



[Memory Subsystem example]

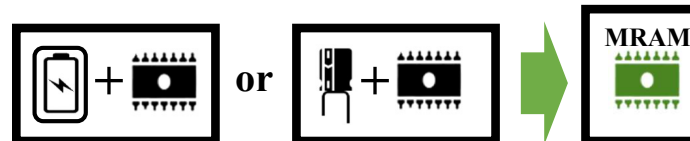


- **Boot Loader** : EPROM, Stores Boot Loader (initialize hardware, find kernel and execute)
- **OS Memory** : Flash, Stores Operating System in compressed image form
- **Configuration Memory** : nvRAM, Stores Configuration Information (Hardware/Software arrangement for each functional block, exact information of what the system is made up of)
- **Packet Buffer** : DRAM or SRAM, Stores packet during packet throughput time.
- **Routing Table** : DRAM or SRAM, Stores information of external network environment and various path to destination.
- **Control Memory** : SRAM, Stores packet header for processing based on policy (Queuing, Prioritizing, Statistics...)
- **Error Log memory** : nvRAM, Stores error logs

※nvRAM

nvRAM can be either one of Battery backed SRAM or nvSRAM with Supercapacitor.

Both of them can be replaced with MRAM



- Simple architecture, easy maintenance
- No battery, no capacitor needed
- Longer retention time (10years vs. 7years)
- Immediate data back up at power failure
- Short recovering time

Portable Ultrasound Scanner

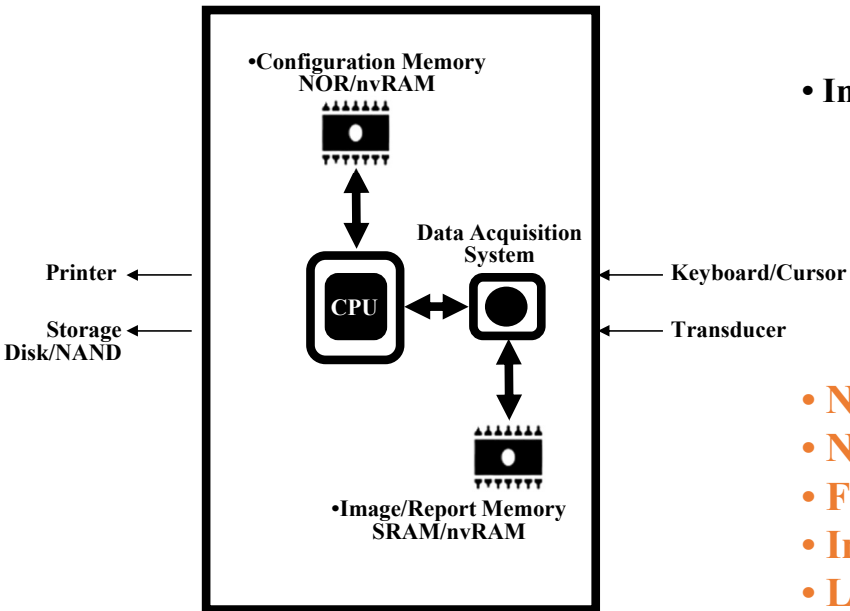
[Portable Ultrasound Scanner]



• What is Ultrasound Scanner?

- Ultrasound-based diagnostic medical device that is used to visualize muscles, tendons, and other internal organs for their size, structure, and any pathological lesions.
- Sending pulses of sound into a material and detecting reflected sound wave, then measuring and calculating the waves and turn them into a real time images.

[Block Diagram]



• Configuration Memory : NOR or nvRAM

Stores Identification and Configuration Information of outer hardware.
Non-Volatility is a must to prevent data lost at power failure.

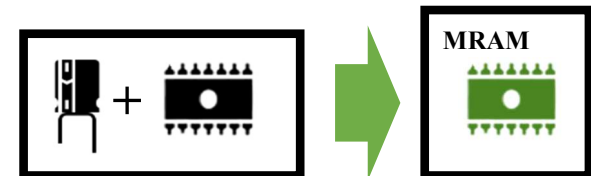
• Image/Report Memory : SRAM or nvRAM

Stores images and corresponding report data.
Non-Volatility is good to have to save data from flat battery.

※ nvRAM

nvRAM can be nvSRAM with Supercapacitor.
It can be replaced with MRAM

- No battery, no capacitor needed
- No limit on endurance, No wear-out life time
- Fast speed for image buffer
- Immediate data back up at power failure
- Long data retention time (10years)



Pachinko/ Gaming Machine

[Pachinko/ Slot Machine]



[Pachinko Board]

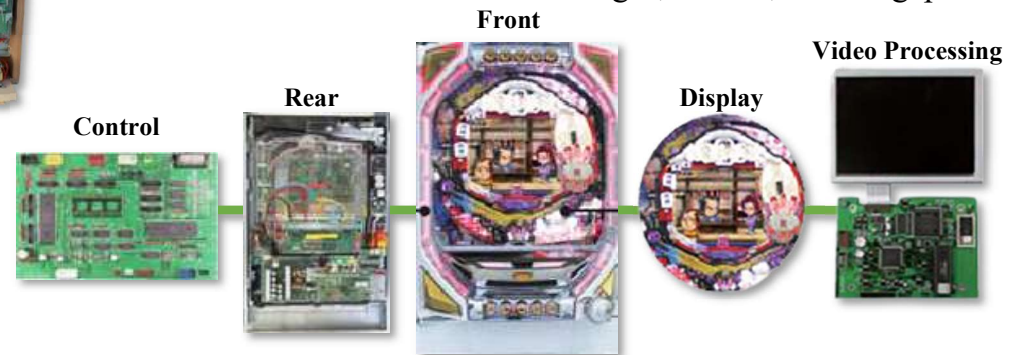
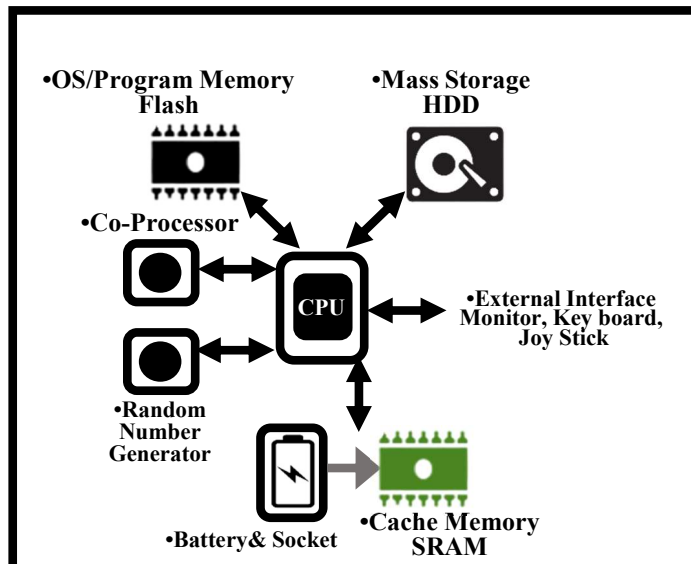


• What is Pachinko?

It is a type of mechanical-electronical game, originated in Japan. It is a mixture of slot machine and pinball, which is regarded as recreational arcade game but is actually a gambling.

As of 2015, Japan's pachinko market revenue is more than that of combined revenue of Las Vegas, Macau, and Singapore.

[Block Diagram]



• Cache Memory : Battery backed SRAM

- . Stores critical data, runtime processing data, machine states, and configuration data.
- . Critical data : number of winning outcome, payout, coin-in amounts, player's game record, timer
- . Data should be kept even at power failure. Battery backed SRAM is used.

→ Replaced with MRAM

- Eliminate battery and battery socket
- Easy maintenance
- Immediate back up at power failure

RAID System/ Data Storage/ Data Center

[Raid System/ Data Center]



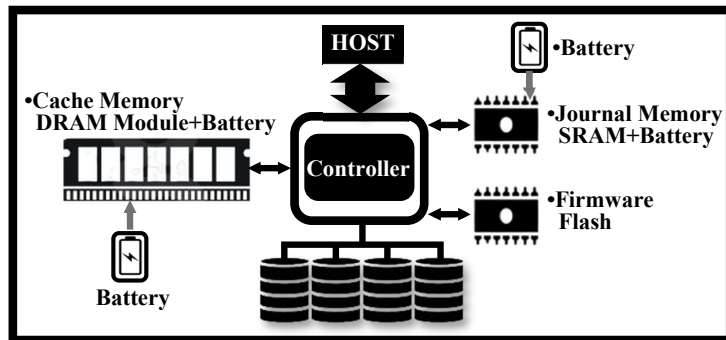
[RAID Controller B'd]



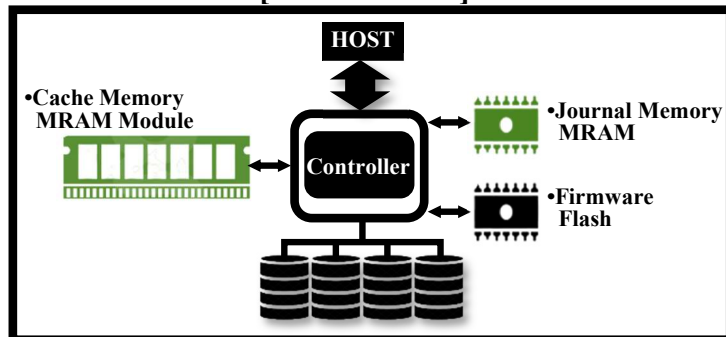
• What is RAID system?

- . Redundant Array of Inexpensive Disks
- . Increasing reliability of storage system by data mirroring. Prevent system failure
- . Reducing disk access time by data striping. Increase overall speed

[Traditional]



[with MRAM]



• Journal Memory

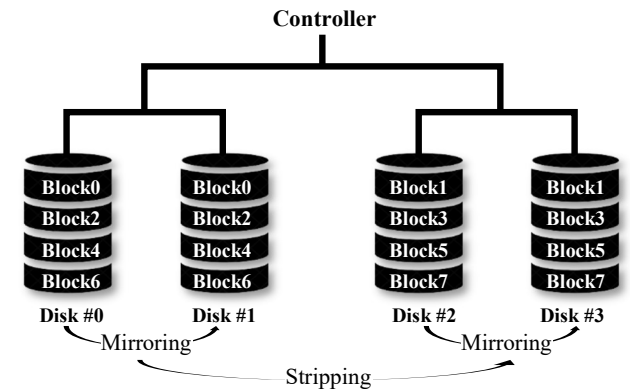
- . Storing log and critical data such as completion of data write, parity write, fail log, Etc.
- . Non-volatility is a must.
- . At power failure, controller refers to Journal memory and figure out where to start to recover.
- . For efficiency and reliability, dedicated memory is required.
- . Small size of data, frequent write operation
- . Battery backed SRAM or nvSRAM with super capacitor → **replaced with MRAM**

• Cache Memory

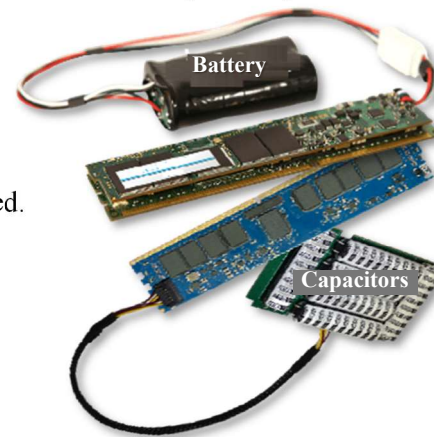
- . Temporarily stores data for quicker processing.
- . Data is written to cache memory first then written to HDD when controller is not busy.
- . Host and controller can work on other task due to cache memory. Significant performance increase.
- . To prevent data lost at power failure, battery backed memory module (nvDIMM) is used.
- . vice versa at restart. Long recovering time → **replaced with MRAM**

• Eliminate battery backed nvDIMM and battery backed SRAM

- **No capacitor needed**
- **Simple maintenance**
- **Longer retention time (10years)**
- **Immediate data back up at power failure**



[nvDIMM]



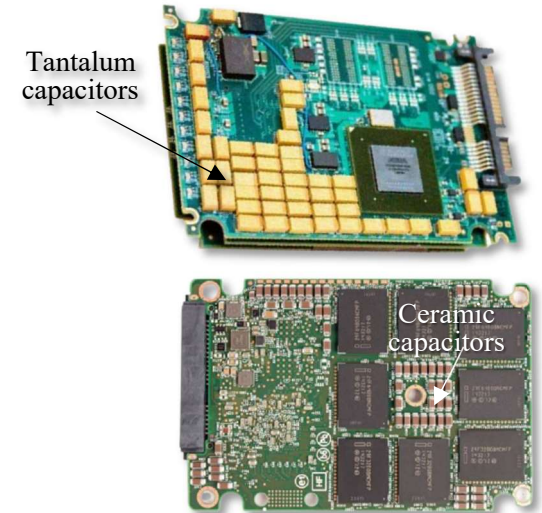
Enterprise SSD

[Enterprise SSD]

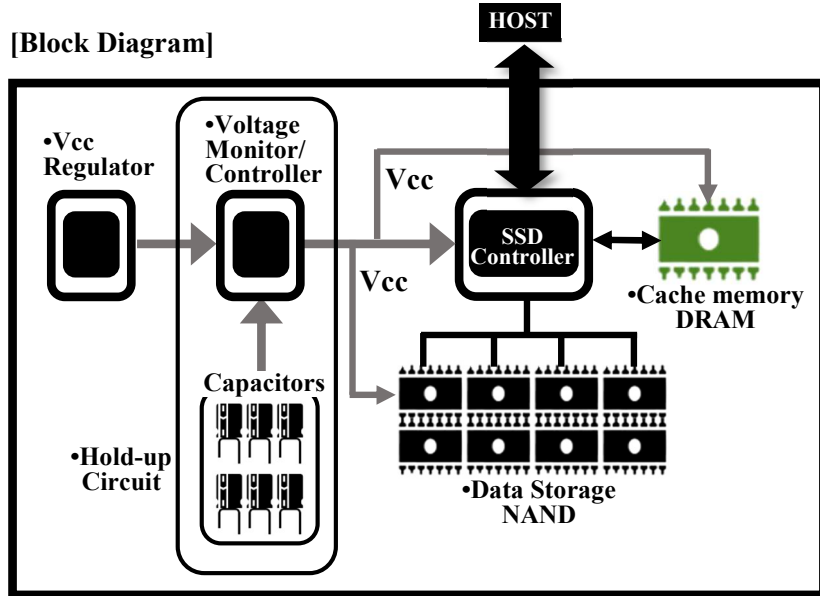


• What is Enterprise SSD?

- . Enterprise SSD provides better speed, reliability and life time than consumer SSD so that it can be used in server, data center and other mission critical applications.
- . At sudden power failure, all data that is in process (in-flight data), not being written to NAND, will be lost which will result in data-corruption. In order to prevent this situation, Enterprise SSD is equipped with power hold up circuit which supplies power during back up in-flight data to NAND.
- . Hold up circuit consists of Voltage monitor/controller and bunch of capacitors for energy storage.



[Block Diagram]



• Cache Memory : DRAM

- . Stores FTL table (Flash Translation Table) and meta data (data that describe stored data). ; FTL and meta data are periodically backed up to NAND.
- . Temporarily stores data for quicker processing

• MRAM replaces DRAM

- . No need to periodically back up FTL table and meta data to NAND → Improving system speed and NAND life time.
- . No-need to back up data in cache memory at power failure → Decrease the amount of energy storage for back up.

- Reducing required amount of capacitors
- Increasing NAND life time
- Short recovering time

Etc. - Data Logging Purpose

● Data Logging

Data Logging is a process of collecting and storing critical data over time.

The data is regarding;

- events for tracking
- environmental parameters
- other data for analyzing purpose
- history of usage
- status of machine

Fast write speed and high rewrite endurance are required for data logging memory.

- No battery, no capacitor needed
- Fast write time
- No limit on endurance
- Immediate data back up at power failure

EDR (Event Data Recorder)
; Vehicle status at accident



TPMS (Tire Pressure Monitoring System)
; Tire pressure



Smart Watch
; GPS position



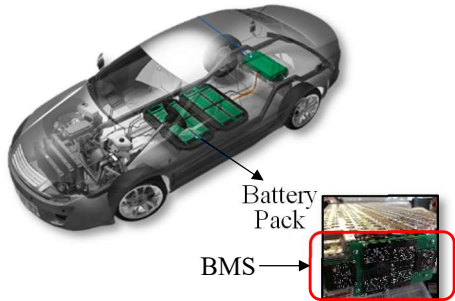
Elevator
; Precise position data



Drone
; Flight data



BMS (Battery Management System)
; Battery condition



Navigation
; GPS position



Vending Machine
; Sales history















ATM
; Money bill history



Solar Power Unit
; Weather, power related data





Industrial/ Commercial

Application	Detail Application	Example	Customers	
Industrial & Commercial	Automation <ul style="list-style-type: none"> Factory/ Industrial (CNC, ServoMotor) PLC Embroidery Machine 	 	Japan	FANUC, Muratec, SHIMASEIKI, Mitsubishi
		 	EMEA	B&R Automation, Siemens, Danfoss, ABB, Scheider Electric, ZOLLNER
			China	Xiamen Haiwell technology, Vmmore ctrl&tech, Shenzhen UniMAT Automation Technology, Hengqiang, Zhejiang Mind Robotization&Quipment
	Broadcast <ul style="list-style-type: none"> Digital Broadcast Infrastructure 3D camera 	 	Japan	Sony
		 	US	Harmonic, CASA SYSTEMS
			China	3D World
			Korea	AddPac, K2E
	Commercial <ul style="list-style-type: none"> FingerPrint Reader(Scanner) 	 	US	HID(Lumidigm), ZVETCO, ib Biometrics, Secugen, ZKTECO
		 	EMEA	Smurf Bio, Fingerprints, IDEX
			Korea	Suprema, Nitgen, K&J, PJ Electronics




Industrial/ Commercial

Application	Detail Application	Example	Customers	
Industrial & Commercial	Commercial <ul style="list-style-type: none"> • ATM/Cash Machine • Cash Counter • Counterfeit Detector 		EMEA	WINCOR NIXDORF
			China	GrgBanking, Feng Hui Jia, Saint Fluence, Kangyi
	Commercial <ul style="list-style-type: none"> • POS(Point Of Sale) • Credit Card Reader/Printer • Contactless Smart Card (Transportation, Identification) 		Japan	NEC Abiko
			US	Verifon, Dejavoo, Equinox, Exadigm
			EMEA	Ingenico
			China	Itwell, Ronga, Prochip, Rongda, PAX, XGD, LANDI, Lakala
			Korea	E2S, PosBank, Hanasis
	Commercial <ul style="list-style-type: none"> • Calculator • Laser stage lighting • Audio products&systems • Video Recorder 		Japan	Casio, Canon, YAMAHA
			US	HARMON KARDON, BOGEN COMMUNICATIONS
			China	GD Han's Yueming, Shenzhen Ray Photonics
			Taiwan	USOUND




Industrial/ Commercial

Application	Detail Application	Example	Customers	
Industrial & Commercial	Display <ul style="list-style-type: none"> HMI/LCD Module DID(Digital Information Display) LED Artwork 		Japan	NEC
			US	Planar
			EMEA	Philips
			China	DWIN, Boruan, Topway, Wincomtech, Huibang, Wuxi TIANREN ELECTRONIC, eView, Kinco, Liliput, CORE TECHNOLOGY ON THE HAILANG, Equal, Laisee, Apexls, Bako, MR LED, On-Bone software, Absen LED, Sage LED
			Taiwan	Winstar, Sunlike, Microtips, Raystar, Nexcom, Lanner, WEINVIEW
			Korea	LG, warecube, Galaxia electronics, Basic Tech, Media INT
	Energy <ul style="list-style-type: none"> SmartGrid (Smart Meter, Power Meter) Solar Inverter 		US	Honeywell, Silverspring, Itron, Mueller systems, Master Meter, Night Hawk, Advanced Energy, Morningstar
			EMEA	Landis&Gear (merged in Toshiba), TQ SYSTEMS, SMA Solar, Solar Edge, Schneider Electric
			China	Sunrise, Kaifa, Wasion, Onbone, Chint, Orient, Shijiazhuang KE Group, Guangdong Hao Di Innovation&Technology, ZhengZhou Micsin Electron Technology, Samil Power, Omnik New Energy, SUNGROW
			Korea	I&C technology, PSTEC, LS IS



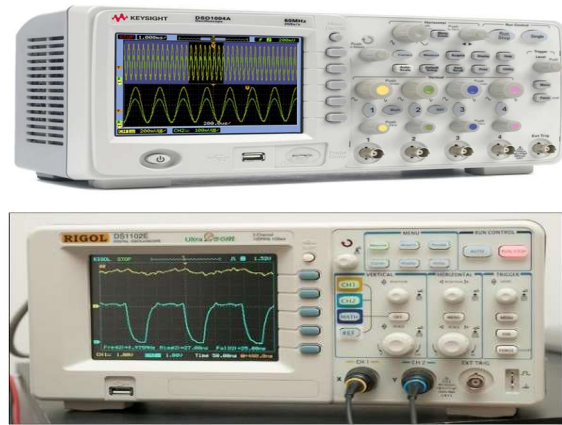
Industrial/ Commercial

Application	Detail Application	Example	Customers	
Industrial & Commercial	Industrial • Motor Control • Servo Motor		EMEA	SEW Euro Drive, Moog, Elmo, ABB, B&R automation
			Japan	Fanuc,
	Industrial • Infrared Detector • Infrared Camera		US	Flir, Fluke, Raytek, LumaSense, ICI
			EMEA	Infratec, Xenics, KIMO, Jenoptik
			China	Guide Infrared, Sate Infrared, Dali, ULIRvision
			Korea	I3systems
	Industrial • Down the hole drilling		US	Schlumberger, Honeywell
			EMEA	Bauer, Siemens




Industrial/ Commercial




Application	Detail Application	Example	Customers	
Industrial & Commercial	IT • Storage/Data center • RAID		US	EMC, IBM, HP, NetApp, Dot Hill, DELL, Seagate(Xyratex)
			China	Inspur, Sugon, Hangzhou Lihong, Zhejiang uniview technologies
	IT • Embedded computer/System		US	Emerson, Kontron, KRTKL
			EMEA	TQ SYSTEMS, KONTRON
			China	SBS Science&technology
			Korea	LK 11
	IT • Graphic Image processor		US	Matrox
			China	Beijing bird technology development, RGB Link

Industrial/ Commercial






Application	Detail Application	Example	Customers	
Industrial & Commercial	IT <ul style="list-style-type: none"> MCU(Micro Controller Unit) FPGA Ref. Board 		US	Xilinx, Altera
			China	FreeFPGA, Terasic
			Taiwan	Nuvoton
	Office Appliance <ul style="list-style-type: none"> IP Phone/VoIP Phone Fax / Copy machine / Multi-Functional Printer 		Japan	Panasonic, Xerox, RICOH, Toshiba
			US	Avaya, Polycom, HP
			EMEA	Unify(Old Siemens Enterprise), Audio Codes
			China	Varicut
			Korea	Intsane
	Test Equipment <ul style="list-style-type: none"> Oscilloscope / Measuring Equipment 		Japan	Shimadzu
			US	Tektronics, Keysight, Teledyne LeCroy, DRANETZ
			China	Rigol, Siglentech, Uni-Trend, Jiangsu Lvyang electronics, micsig, NANJING SAMPLE INSTRUMENT, The 41st Institute of CETC
			Taiwan	Acute, Gwinstek

Industrial/ Commercial







Application	Detail Application	Example	Customers	
Industrial & Commercial	Test Equipment • Semiconductor Tester		Japan	ADVANTEST
			US	Fluke, Teradyne, NexTest, LTX Credence
			EMEA	BST International
			China	BEIJING JICHENG TEST TECHNOLOGY, Top Electrical Technology, Elitech, SUER ELECTRIC
	Test Equipment • Spectrum Analyzer • Electronic Scale		Japan	Canon
			US	XIA
			China	Gratten
	Test Equipment • Factory Test Equipment • Network Test		US	Fluke, Viavi, NI
			Japan	Anritsu
			EMEA	BST International, Anite
			China	BEIJING JICHENG TEST TECHNOLOGY

Application	Detail Application	Example	Customers	
Medical	<ul style="list-style-type: none"> • Medical Monitor • Eye Examination Machine 		Japan	TOSHIBA
			EMEA	PHILIPS
			China	Mindray
			Korea	SAMSUNG MEDISON, Hubitz
	<ul style="list-style-type: none"> • Ultra Sound Scanner • CT/MRI • X-ray Image 		US	GE Healthcare, Carestream
			EMEA	Esaote, SIEMENS, Zeihm Imaging
			China	Mindray
			Korea	I3systems
	<ul style="list-style-type: none"> • Molecular/Generic analyzer 		US	Cepheid, HOLOGIC
			EMEA	Roche Diagnostics
			Korea	Optolane, Nanoentek, Nanobiosys, Bioneer

Network/ Communication

Application	Detail Application	Example	Customers	
Network System	<ul style="list-style-type: none"> • Switch • Router • Network-Security • Base Station 	    	Japan	NEC, HITACHI, Fujitsu, Kyocera, Alaxala, AVAL data
			US	Cisco, Palo Alto NW, ALU, Juniper, cPacket, F5 Networks, Ciena, IXIA, Avaya, Zhone, Fortinet, Benu, JDSU, Keymile, Extreme, Dragonwave, MRV, Fujitsu NW, Arista, Blue Coat, Cyberoam, Tellab, Calix, Netgear, D-Link, NSFOCUS, BB ELECTRONICS, DIALOGIC, DATACOMM
			EMEA	ECI-Telecom, Rad, Radware, Actelis, Telrad, NSN, Ericsson, SPIRENT
			China	Huawei, ZTE, FiberHome, H3C, Routon, TwoWing, New Greennet Tech, Comba, Guangzhou Gaoke, DP tech, SANGFOR, RUIJIE, DCN, MAIPU, WAYOS, TG-NET, D-Link, netcore, Tenda, UTT Technologies, ZBT, LB-LINK, Venustech, Hillstone Networks, Netpower, Uniview, Telepower comm.
			Taiwan	Edge-Core Networks
			Korea	Dasan Networks, ubiQuoss, COWEAVER, Samsung

Military/ Aerospace/ Automotive

Application	Detail Application	Example	Customers	
Military & AeroSpace / Automotive	• Military&AeroSpace		US	Lockeeh Martin, Raytheon, Boeing, GE, Northrop Grunman, Aeroflex, General Dynamics, Minco, Micros, Honeywell, BAE systems, DRS TECHNOLOGIES, NORTHROP GRUMMAN
				
				
				
	• Automotive - Infotainment - GPS - Driver Information - Drive train		EMEA	3DPlus, Elbit, Safran
			China	Wuhan Guide Infrared, Guangzhou Haige Communications
			Korea	SAMSUNG Thales, LIG Nex1, DOOSAN DST, Hyundai Heavy Idustrial
			Japan	Clarion, Pioneer, Denso, Asin AW, Hitachi 金属
			US	Honeywell
			EMEA	Continental, Bosch, Delphi, Magneti Marelli, Hella
			China	Wuhan Guide Infrared
			Korea	Hyundai Mobis, Mando, Mando Hella, Fine Digital
				



THANK YOU