NVRAM

REPORT

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INTRO:

NVRAM (non-volatile random-access memory):

refers to computer memory that can hold data even when power to the memory chips has been turned off. **NVRAM** is a subset of the larger category of non-volatile memory (NVM), which includes storage-class memory based on NAND flash. Flash memory chips are slower to read to and write from than RAM chips, making them less well suited for active computational memory.

Computer manufacturers mainly use NVRAM to hold information about the state of the computer for faster boot times. This allows information about the components and devices in the computer to be stored from one use to the next while the system power is turned off. Standard computer memory uses dynamic random access memory (DRAM) which requires constant power to retain data.

NVRAM types:

1. Battery-Backed RAM (BBRAM): BBRAM uses a small battery to provide power to the memory module when the main power source is removed.
2. Ferroelectric RAM (FeRAM): FeRAM uses a ferroelectric material to store data. It combines the benefits of non-volatility with fast read and write speeds.
3. Magneto-Resistive RAM (MRAM): MRAM stores data using magnetic properties. It offers high speed, endurance, and data retention, making it suitable for various applications, including cache memory, storage-class memory, and automotive electronics.
4. Phase-Change RAM (PCRAM): PCRAM uses the different electrical resistances of phases of matter (amorphous and crystalline) to store

data. It offers good read and write speeds, endurance, and data retention. PCRAM has potential applications in storage and memory hierarchies.

5. Sonos (Silicon Oxide Nitride Oxide Silicon) Memory: Sonos memory uses a layered structure of silicon oxide, silicon nitride, and silicon oxide to store charge. It is used in some embedded systems and microcontrollers.
6. Hybrid Memory Cube (HMC): HMC is a high-performance memory technology that combines DRAM (Dynamic Random-Access Memory) with a non-volatile memory layer. It offers high bandwidth and power efficiency and is used in applications like supercomputing and networking.
7. 3D XPoint: This is a type of non-volatile memory developed by Intel and Micron. It offers high performance, endurance, and density, making it suitable for various applications including storage and memory acceleration.
8. Organic RAM (ORAM): ORAM is an emerging type of NVRAM that uses organic materials. It has the potential for low-cost manufacturing and could be used in various applications including RFID tags and wearable devices.

SRAM is the predecessor to DRAM, and is much faster to read from. It allows byte-level data reads, whereas DRAM requires page-level reads, consisting of multiple bytes at a time. SRAM cannot hold data without an electrical charge, however, so it becomes non-volatile by using a battery to keep a constant trickle charge. SRAM is considerably more expensive to manufacture than DRAM, making it best suited for small data storage applications such as storing computer startup data -- BIOS data on Windows PCs and parameter RAM (PRAM) data on Apple computers.

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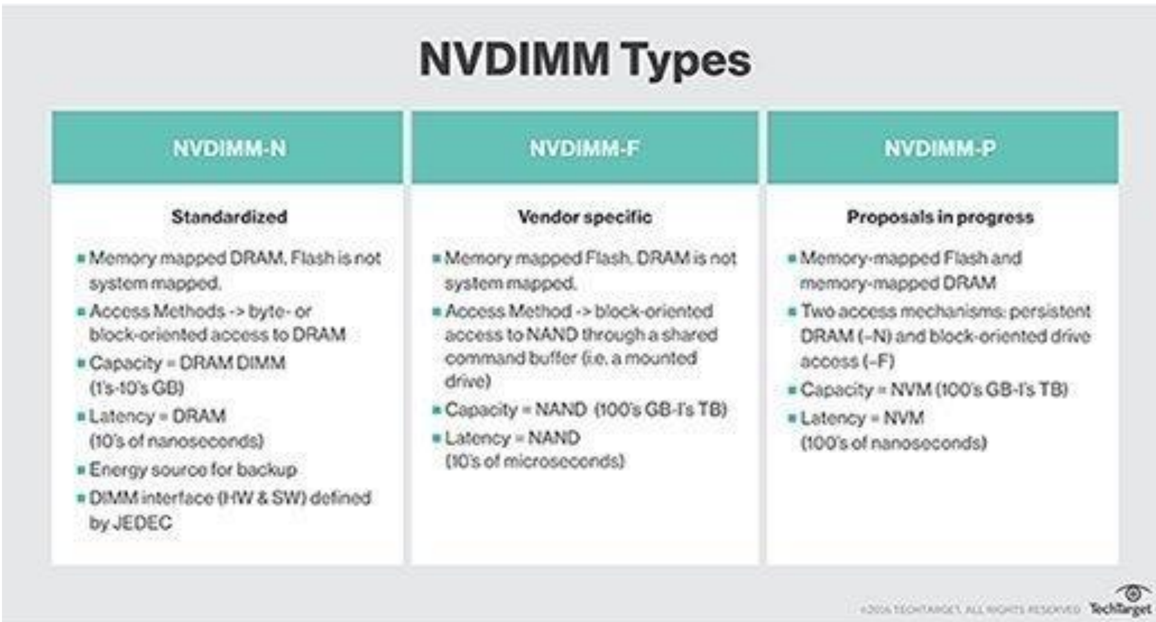
A NVRAM (non-volatile random-access memory) chip made by Dallas semiconductor.

The floating gate transistor, which employs a highly insulating substance for the gate terminal, or switch, that turns a transistor from a binary 1 or 0 digit, is the foundation of EEPROM. Unless a high enough voltage is provided to open the gate, the transistor remains in the previous state it had, and the entire chip retains the data represented by those binary digits.

NVRAM and flash memory:

NAND flash, like EEPROM chips, is based on floating gate transistors, but was built with cheaper production costs in mind, hence the internal structure differs from EEPROM. Instead of DRAM pages or SRAM bytes, data is stored in blocks. This makes the internal wiring structure of NAND flash memory simpler than other types of memory, and allows for greater storage density, driving down the overall cost per byte stored. It also makes flash memory slower than other types of chip-based memory, but faster than magnetic disk-based memory, such as hard disk drives (HDDs).

NVRAM and flash memory come together in a product called a non-volatile dual in-line memory module (NVDIMM), which is designed to fit in the dual in-line memory module (DIMM) slots on a computer's motherboard. The NVDIMM-F variety uses all-flash memory in a form factor that fits into a DIMM socket, but needs to be paired with a DRAM DIMM module designed to work with the NVDIMM-F module.



NVDIMM-N makes standard DRAM non-volatile by adding flash memory to the module itself.

Because the motherboard's BIOS won’t recognize flash memory as usable for active computational memory, NVDIMM's require updating the BIOS on most computers.

Design parameter level	Retention	Endurance	Speed	Power
High write current	+	− (breakdown)	+	−
Low write current	−	− (read disturb)	−	+
High Δ	+	− (breakdown)	−	− (higher current)
Low Δ	−	− (read disturb)	+	+ (lower current)

Advantages of NVRAM:

1. **Data Persistence:** The primary advantage of NVRAM is its ability to retain stored data even when power is turned off. This ensures that critical information, configuration settings, and system state are preserved across power cycles, reducing the risk of data loss and enhancing system reliability.
2. **Fast Boot Times:** NVRAM enables faster boot times for computers and embedded systems. Since essential boot-up data can be stored in non-volatile memory, the system can quickly access this information during startup, resulting in reduced initialization times.
3. **Energy Efficiency:** NVRAM consumes lower power compared to traditional volatile memory like DRAM. This energy efficiency is

particularly beneficial in devices powered by batteries, such as mobile devices, IoT devices, and wearable technology.

4. **High Endurance:** Many NVRAM technologies offer high endurance, meaning they can withstand a significant number of read and write cycles. This makes NVRAM suitable for applications that require frequent data updates or modifications.
5. **Instant Recovery:** NVRAM ensures that systems can recover instantly after power interruptions or failures. Critical data is immediately available upon system restart, reducing downtime and minimizing the impact of disruptions.
6. **Data Integrity:** The non-volatile nature of NVRAM helps maintain data integrity by preventing data corruption due to power loss. This is especially important in applications where consistent and accurate data storage is essential.

Applications of NVRAM:

1. **Embedded Systems:** NVRAM is widely used in embedded systems, such as industrial automation, automotive electronics, and medical devices. It stores firmware, configuration settings, and critical data that need to persist even in challenging environments.
2. **Servers and Data Centers:** NVRAM is employed in servers and data centers to accelerate data-intensive tasks. It can be used as cache memory or to store metadata for faster access, reducing latency and improving overall performance.
3. **Network Equipment:** Networking devices like routers, switches, and firewalls utilize NVRAM to store configuration settings, routing tables, and connection information. This ensures consistent network behavior even after power outages.

4. **Consumer Electronics:** NVRAM is found in various consumer electronics, such as smart TVs, gaming consoles, and home appliances. It stores user preferences, configuration settings, and firmware updates.
5. **Automotive Systems:** In vehicles, NVRAM stores critical data for engine control units, infotainment systems, and driver assistance technologies. It helps maintain functionality and safety features even during power interruptions.
6. **Financial and Transactional Systems:** NVRAM is used in financial applications where transactional data needs to be preserved without risk of data loss. It ensures accurate record-keeping and prevents financial discrepancies.
7. **IoT Devices:** Internet of Things (IoT) devices benefit from NVRAM for storing sensor data, device configurations, and firmware updates. It enables reliable operation and communication in IoT ecosystems.
8. **Real-Time Applications:** NVRAM is suitable for real-time applications like robotics, where data persistence and rapid response are crucial for accurate operation.

Resources:

-https://www.techtarget.com

-Chatgpt (for more info and explanation)

- https://www.wikipedia.org