Primary storage (RAM, ROM, cache, virtual memory)

1.2.1 · Computer systems (Paper 1) · revision notes

Primary storage is the memory the CPU can access directly: RAM, ROM and cache. You need to know why computers need primary storage, the difference between volatile and non-volatile memory, the differences between RAM and ROM and what each is for, and how virtual memory works. Expect definitions, RAM/ROM tables and 'explain why the computer slows down' questions.

Key facts

- Primary storage: accessed directly by the CPU (RAM, ROM, cache)
- Volatile = contents lost when the power is off
- RAM: volatile, read and write, holds the OS, programs and data in use
- ROM: non-volatile, read-only, holds the start-up (boot) instructions
- Cache: small, very fast, holds frequently used instructions and data
- Virtual memory: part of secondary storage used as extra RAM when RAM is full
- Virtual memory is slow because secondary storage is much slower than RAM
- More RAM → less use of virtual memory → better performance

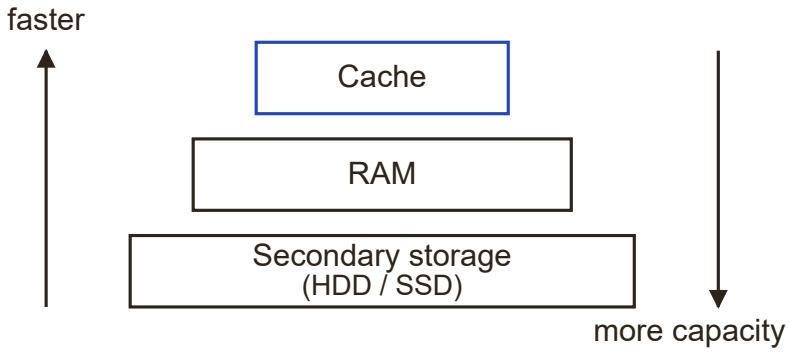
Notes

Why primary storage is needed

- **Primary storage** (main memory) is memory that the CPU can access directly: RAM, ROM and cache.
- The CPU fetches its instructions and data from primary storage. Secondary storage is far too slow for this, so programs and files are copied from secondary storage into RAM before they are run or used.
- **Volatile** memory loses its contents when the power is turned off. **Non-volatile** memory keeps its contents without power.

RAM, ROM and cache

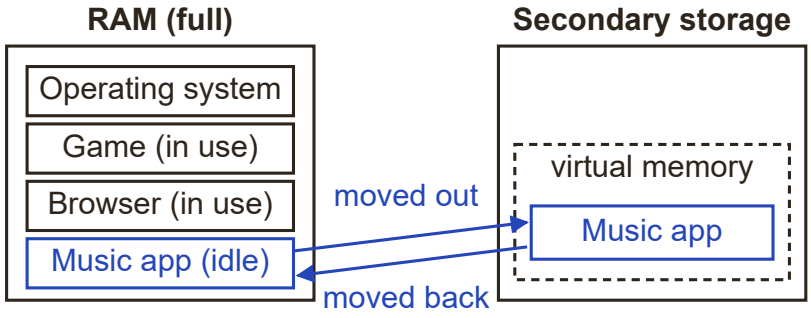
- **RAM** (random access memory) holds the operating system, programs and data that are **currently in use**.
- RAM is **volatile** and can be read from and written to. Its contents change all the time as programs are opened and closed.
- **ROM** (read-only memory) holds the **start-up (boot) instructions**, e.g. the BIOS, which run when the computer is switched on.
- ROM is **non-volatile** and read-only in normal use, so the boot instructions are always there when the computer is switched on, even though RAM starts empty.
- **Cache** is a small amount of very fast, expensive, volatile memory in or next to the CPU. It holds frequently used instructions and data so the CPU waits for RAM less often.
- Speed order, fastest first: cache, RAM, secondary storage.



Cache is fastest but smallest; secondary storage is slowest but biggest

Virtual memory

- If RAM becomes full (for example, too many programs are open), the operating system uses part of secondary storage (an HDD or SSD) as **virtual memory**.
- Data and parts of programs that are not currently needed are moved from RAM to virtual memory, freeing space in RAM.
- When they are needed again, they must be moved back into RAM (and something else moved out) before the CPU can use them.



Virtual memory: data not in use is moved out of full RAM onto secondary storage, and moved back when needed

- Secondary storage is much slower to access than RAM, so this swapping slows the computer down. If it happens constantly, the computer can become very unresponsive. Grade 7+ only
- Virtual memory lets more programs be open than RAM alone would allow. Adding more RAM means virtual memory is needed less often.

How to answer each type of question

RAM, ROM or both? (table)

1 mark per row | Grade 4

1. Test each statement against: volatile or non-volatile, read-only or read/write, and purpose.
2. Choose 'both' when the statement is true of RAM and of ROM, e.g. 'it is primary storage'.
3. Give one answer per row.

Example. Complete the table by writing **RAM**, **ROM** or **both** for each statement. [4]

Statement	RAM, ROM or both
(a) Its contents are lost when the power is turned off.	
(b) The CPU can access it directly.	
(c) It holds the instructions used to start up the computer.	
(d) It holds the programs the user currently has open.	

Model answer.

Statement	RAM, ROM or both
(a) Contents lost when the power is off	RAM (1)
(b) The CPU can access it directly	Both (1)
(c) Holds the start-up instructions	ROM (1)
(d) Holds the programs currently open	RAM (1)

Explain the need for RAM or ROM

2 marks | Grade 5

1. State what the memory holds.
2. Explain which property (volatile or non-volatile, read/write or read-only) makes it right for that job.

Example. Explain why a computer needs ROM as well as RAM. [2]

Model answer. ROM holds the start-up (boot) instructions (1). RAM is volatile, so it is empty when the computer is switched on, but ROM is non-volatile, so the instructions are there at start-up (1).

Explain why a computer slows down (virtual memory)

3 to 4 marks | Grade 7

1. Start with the cause: RAM is full.
2. Say what virtual memory is: part of secondary storage used as if it were RAM.
3. Describe the swapping of data between RAM and virtual memory.
4. Give the effect: secondary storage is slower than RAM, so the computer slows down.

Example. Leila has many browser tabs, a music app and a game open at the same time. Her computer becomes slow. Explain why, with reference to virtual memory. [4]

Model answer. RAM is full, so virtual memory is used (1). Virtual memory is an area of secondary storage that is used as if it were extra RAM (1). Data is swapped between RAM and virtual memory as she switches between programs (1). Secondary storage is much slower to access than RAM, so the computer slows down (1).

Recommend an upgrade and justify it

3 marks | Grade 8

1. Make a clear recommendation.
2. Explain how it tackles the actual cause of the problem.
3. Say why the alternative would not help as much.

Example. Leila's computer has 4 GB of RAM. She can either add 4 GB more RAM or buy a larger hard disk drive. Recommend which upgrade would make her computer faster when she has many programs open. Justify your answer. [3]

Model answer. Add more RAM (1). More programs and data can be held in RAM at the same time, so virtual memory is needed less often (1). Less time is spent swapping data with slower secondary storage; a larger hard disk would give more storage space but would not reduce the swapping (1).

Don’t lose marks

- Saying RAM stores files permanently or 'saves your work'. That is secondary storage.
- Saying ROM stores the operating system. On a PC the operating system is kept on secondary storage and loaded into RAM; ROM holds the start-up instructions.
- Saying virtual memory is 'extra RAM chips' or 'memory in the cloud'. It is part of secondary storage used as if it were RAM.
- Saying virtual memory makes the computer faster. It lets more programs stay open, but the computer runs more slowly while it is being used.
- Mixing up memory and storage: 8 GB of RAM is not the same as 8 GB of free space on a hard disk.

More tips

Memory tricks

- RAM = 'right now' memory (what you are using now). ROM = 'read only, remains when off'.
- Volatile sounds like 'vanish': volatile memory vanishes when the power goes.
- Virtual memory is like having a desk that is too small: you keep moving books to a shelf across the room and fetching them back. It works, but it is slow.

Exam technique

- Use the key words: volatile, non-volatile, start-up (boot) instructions, 'currently in use'.
- For virtual memory, follow the chain: RAM full → part of secondary storage used → data swapped → secondary storage slower → computer slows down.
- If asked why a computer doesn't just use more cache or ROM instead of RAM, mention cost and capacity, and that ROM cannot be written to in normal use.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Define volatile and non-volatile memory**
Volatile memory loses its contents when the power is turned off; non-volatile memory keeps them.

Grade 4 — **State the purpose of RAM and ROM**
RAM holds the programs and data currently in use; ROM holds the start-up (boot) instructions.

Grade 4 — **Explain why computers need primary storage**
The CPU can only access instructions and data directly from primary storage, which is much faster than secondary storage.

Grade 5 — **Compare RAM and ROM**
RAM is volatile and can be read from and written to; ROM is non-volatile and read-only.

Grade 6 — **Describe how virtual memory works**
When RAM is full, data that is not currently needed is moved to an area of secondary storage, and moved back when needed.

Grade 7 — **Explain why virtual memory slows a computer**
Secondary storage is much slower than RAM, and data must be moved back into RAM before the CPU can use it.

Grade 8 — **Recommend and justify a memory upgrade**
Explain why more RAM reduces the use of virtual memory, and why other upgrades may not help as much.

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