PROGRAM STUDI

S1 SISTEM KOMPUTER

UNIVERSITAS DIPONEGORO

MEMORY

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Istilah/Jenis Semikonduktor Memori

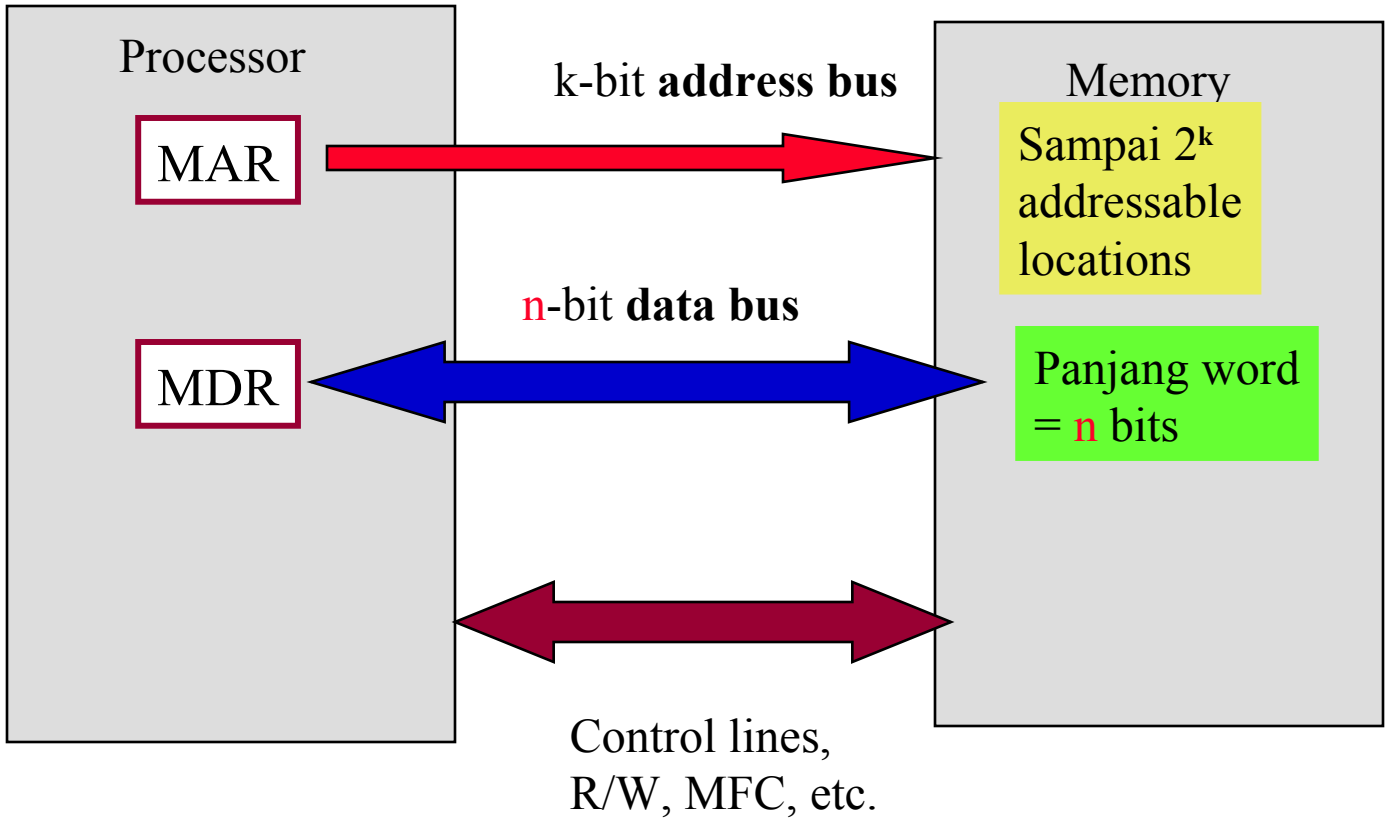
RAM	--Random Access Memory	time taken to access any arbitrary location in memory is constant
SRAM	--Static RAM	A RAM chip design technology (see later)
DRAM	--Dynamic RAM	A RAM chip design technology (see later)
ROM	--Read Only Memory	ROMs are RAMs with data built-in when the chip is created. Usually stores BIOS info. Older uses included storage of bootstrap info
PROM	--Programmable ROM	A ROM which can be programmed
EPROM	--Erasable PROM	A PROM which can be programmed, erased by exposure to UV radiation
EEROM – Electrical **EPROM**		A PROM programmed & erased electrically

Masih tentang Istilah …

Tambahan istilah:

SIMM	Single In-Line Memory Module A packaging technology (single 32-bit data path)
DIMM	Dual In-Line Memory Module A packaging technology (dual 32-bit data paths)
FPM RAM	Fast Page-Mode RAM An older technology capable of about 60ns cycle time
EDO RAM	Extended-data-out RAM More modern FPM RAM, exploiting address coherency (see cache`later) capable of about 20ns access speed
SDRAM	Synchronous DRAM Synchronous Dynamic RAM; allows access speeds as low as about 10ns
	PC 100, PC133, PC2100, PC2600 => memory product you can buy

Connection: Memory - Processor



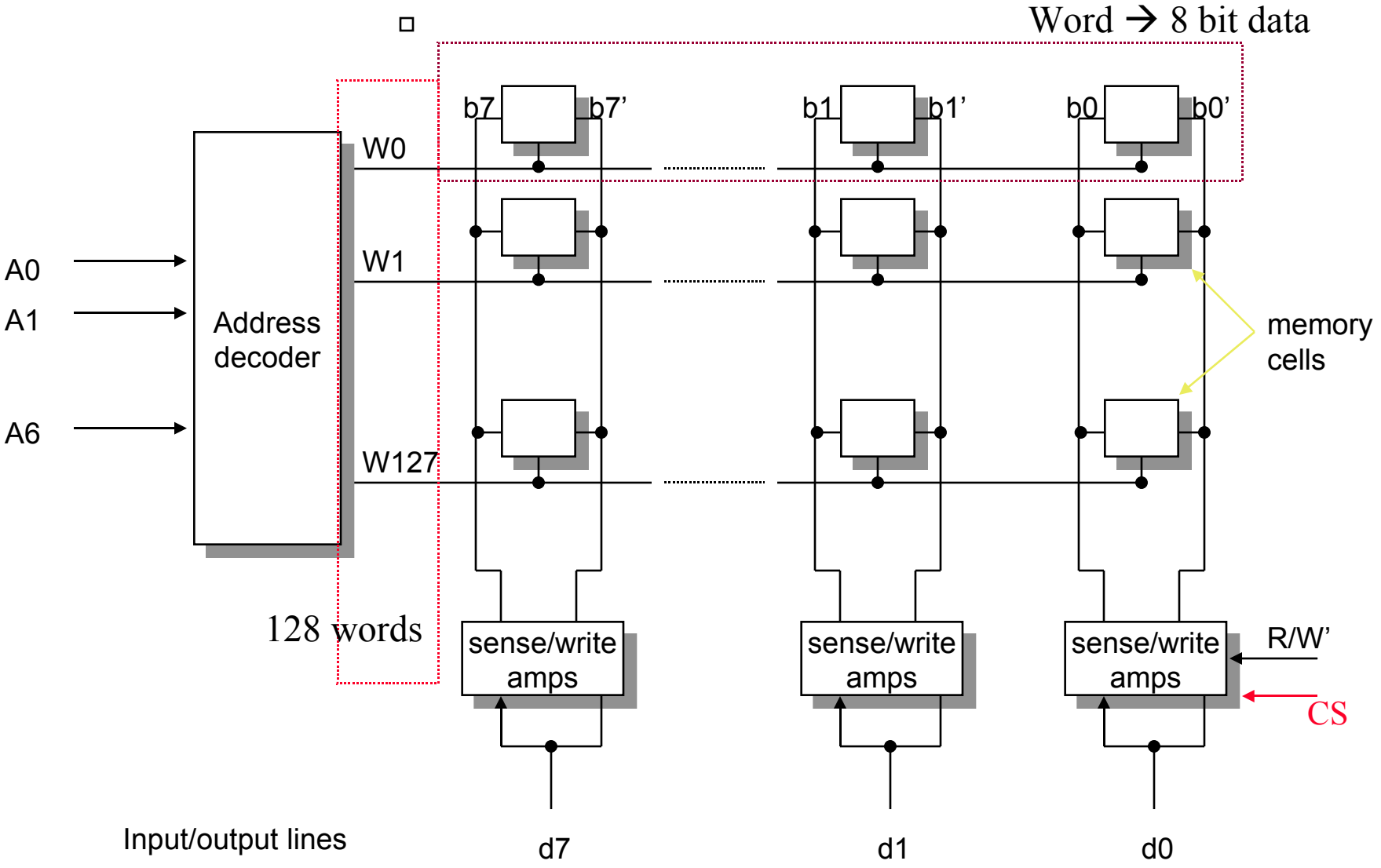
Konsep Dasar

- **Memory: akses per byte**
  - **Transfer dilakukan per-word (cepat, kelipatan bytes)**
  - **Misalkan: 32-bit komputer => address 32 bit Kemampuan addressing: 2 ^ 32 = 4 Gbytes**
  - **Jika transfer data per-word: 32 bit (data bus) => 4 bytes**
  - **Bytes mana yang diakses dari kemungkinan word tsb?**
    - **Perlu 2 bits untuk menentukan bytes yang mana dari word**
    - **Sisa bit: 30 bits digunakan untuk address word**

Organisasi Internal Memori

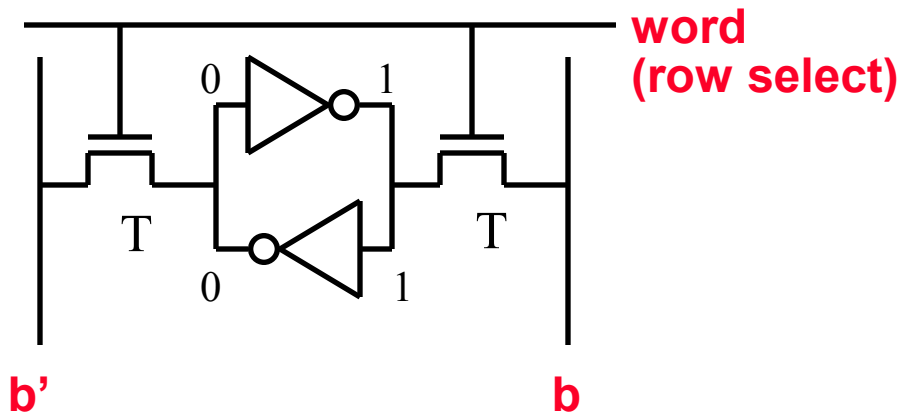
- Bentuk array: terdiri dari sel memori
  - Sel berisi 1 bit informasi
  - Baris dari sel membentuk untaian satu word
  - Contoh: 16 x 8 memori
    - memori SRAM mengandung 16 words
    - setiap words terdiri dari 8 bit data
    - Kapasitas memori: 16 x 8 = 128 bits
  - Decoder digunakan untuk memilih baris word mana yang akan diakses
    - Tipikal SRAM, array 1 dimensi => indeks dari baris pada array tersebut.

Organisasi Memori: 1-level-decode SRAM (128 x 8)



Review: Static RAM Cell

6-Transistor SRAM Cell



Latch → menyimpan state 1 bit
Transistor T bertindak sebagai switch
Contoh: state 1

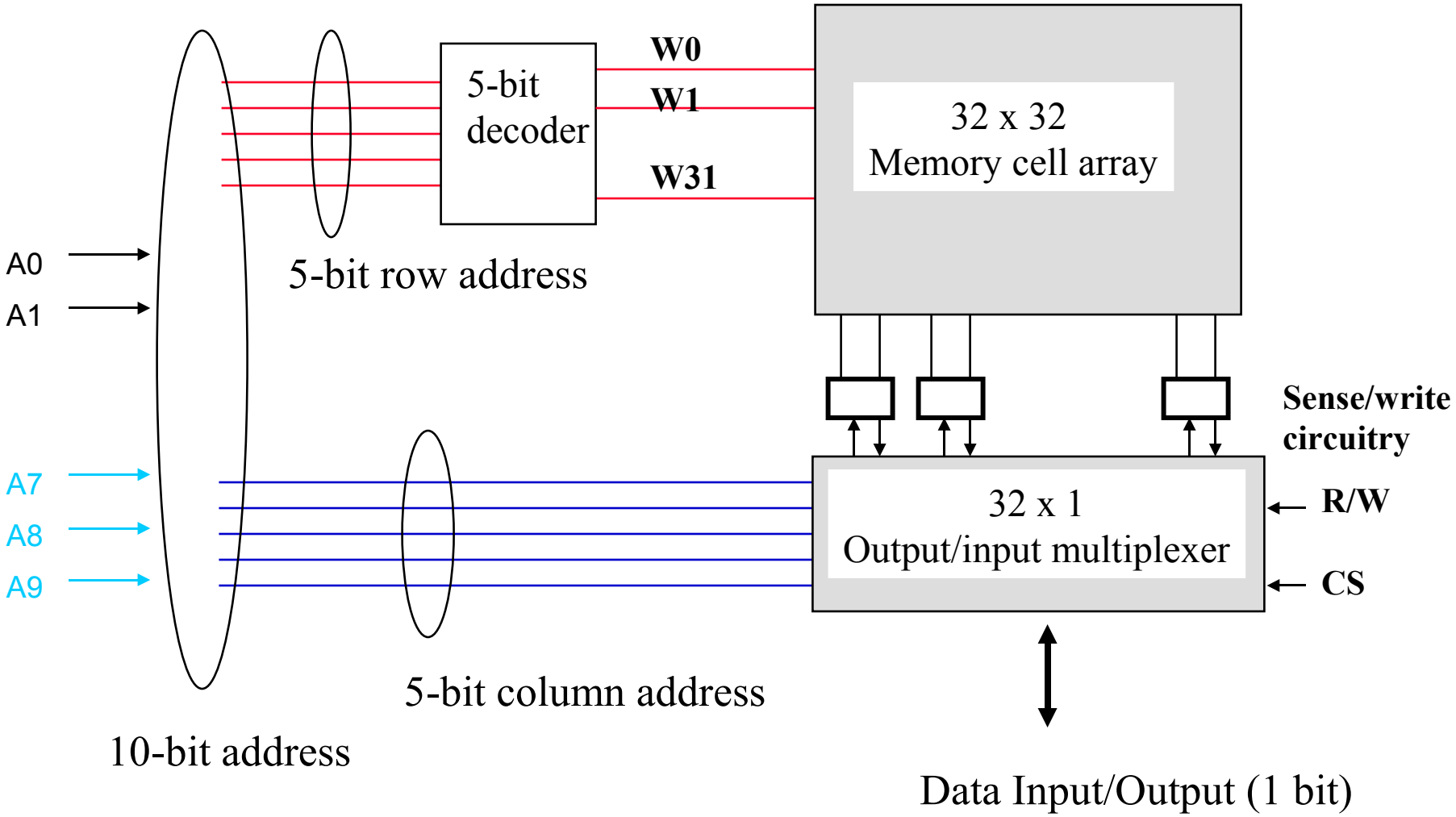
Latch dapat berubah dengan:
- put bit value pada b dan b'

- **Read:**
  1. **Jika sel dalam keadaan 1, maka bit b akan memberikan sinyal high, dan b' memberikan sinyal low**
  2. **Jika sel dalam keadaan nol, maka bit b dan b' merupakan komplemen dari keadaan 1**
  3. **Sirkuit sense/write mengawasi keadaan b dan b', mengawasi output sesuai dengan keadaannya**
- **Write:**
  1. **Sel di-set dengan meletakkan nilai yang tepat pada jalur bit b dan b'**
  2. **Sinyal yang diminta dihasilkan oleh sirkuit sense/write**

Static RAM (SRAM)

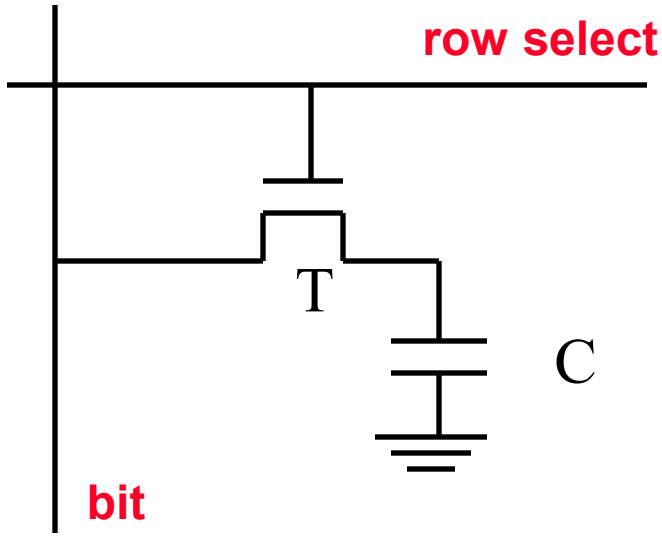
- SRAM dapat menyimpan “state” (isi RAM) selama terdapat “tegangan” power supply
- Sangat cepat, 10 nano-detik
- Densitas rendah (bits per chip) → memerlukan 6 transistor per-sel → mahal
- Pilihan teknologi untuk memori yang sangat cepat dengan kapasitas kecil → cache

Organisasi Memori: 2-level-decode SRAM (1 K x 1)



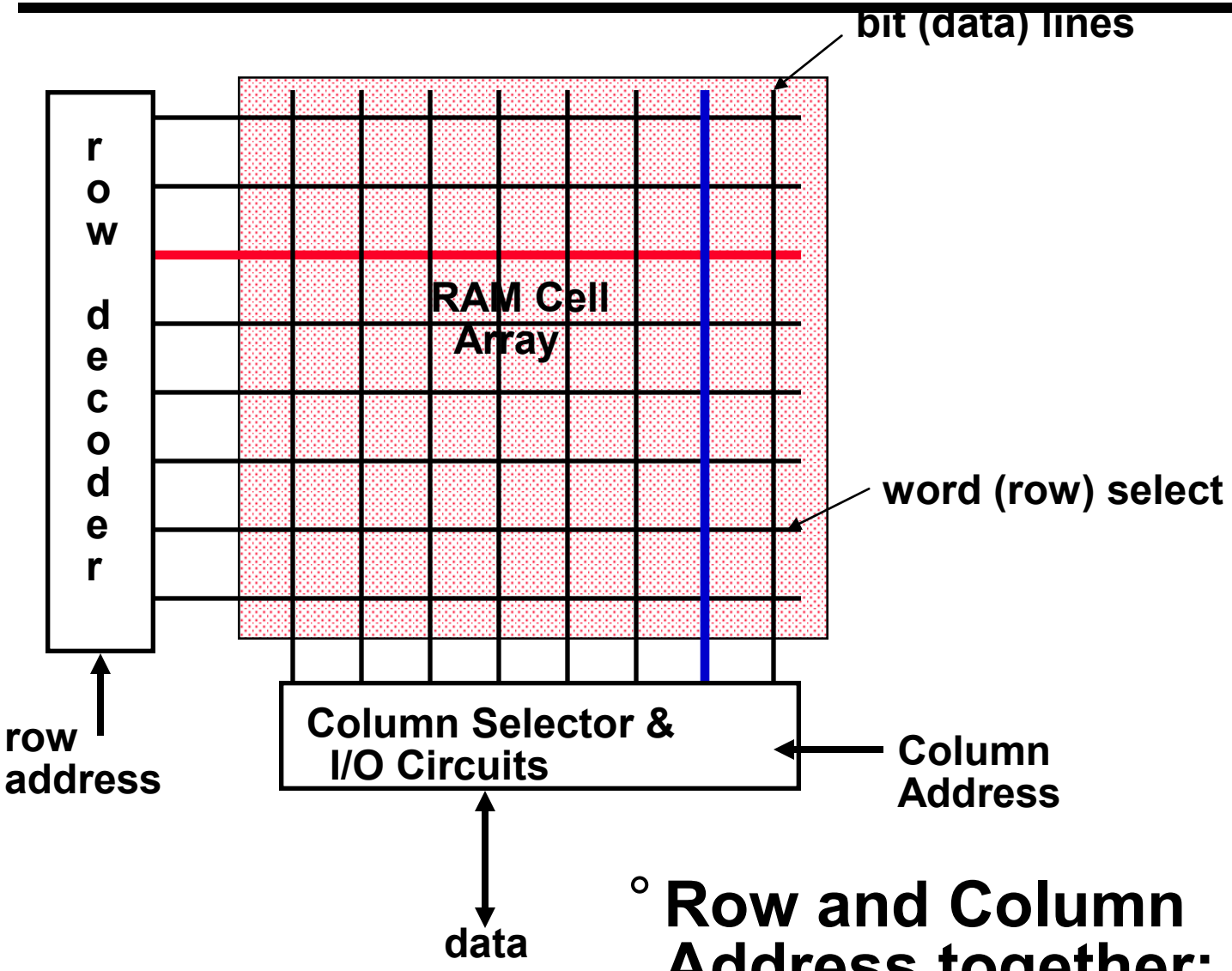
Review: 1-Transistor Memory Cell (DRAM)

Kapasitor menyimpan
state 1 (charged) atau 0 (discharge)
Hanya bertahan sepuluh milidetik
Perlu refresh secara periodik!



- **Write:**
  - **1. Drive bit line**
  - **2. Select row (T sebagai switch)**
- **Read:**
  - **1. Select row**
  - **2. Sense Amp (terhubung dengan bit line): sense & drives sesuai dengan value (threshold)**
  - **3. Write: restore the value (high or low)**
- **Refresh**
  - **Just do a dummy read to every cell.**

Classical DRAM Organization (square)

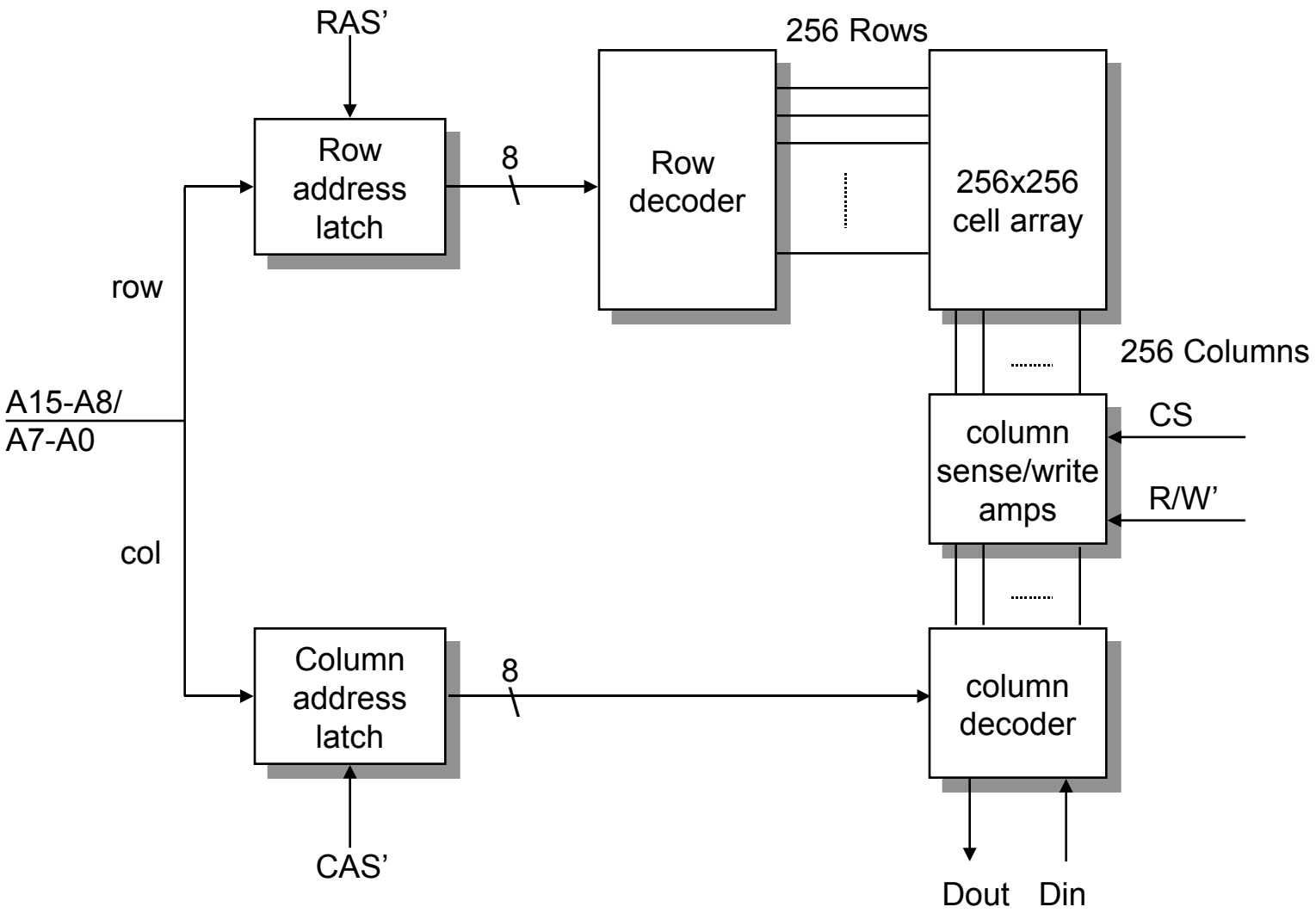


- Row and Column Address together:
  - Select 1 bit a time

Dynamic RAM (DRAM)

- Slower than SRAM
  - access time ~60 ns (paling cepat: 35 ns)
- Nonpersistent
  - every row must be accessed every ~1 ms (refreshed)
- Densitas tinggi: 1 transistor/bit
  - Lebih murah dari SRAM
  - ~$1/MByte [2002]
- Pilihan teknologi memori untuk kapasitas besar dan "low cost" → main memory

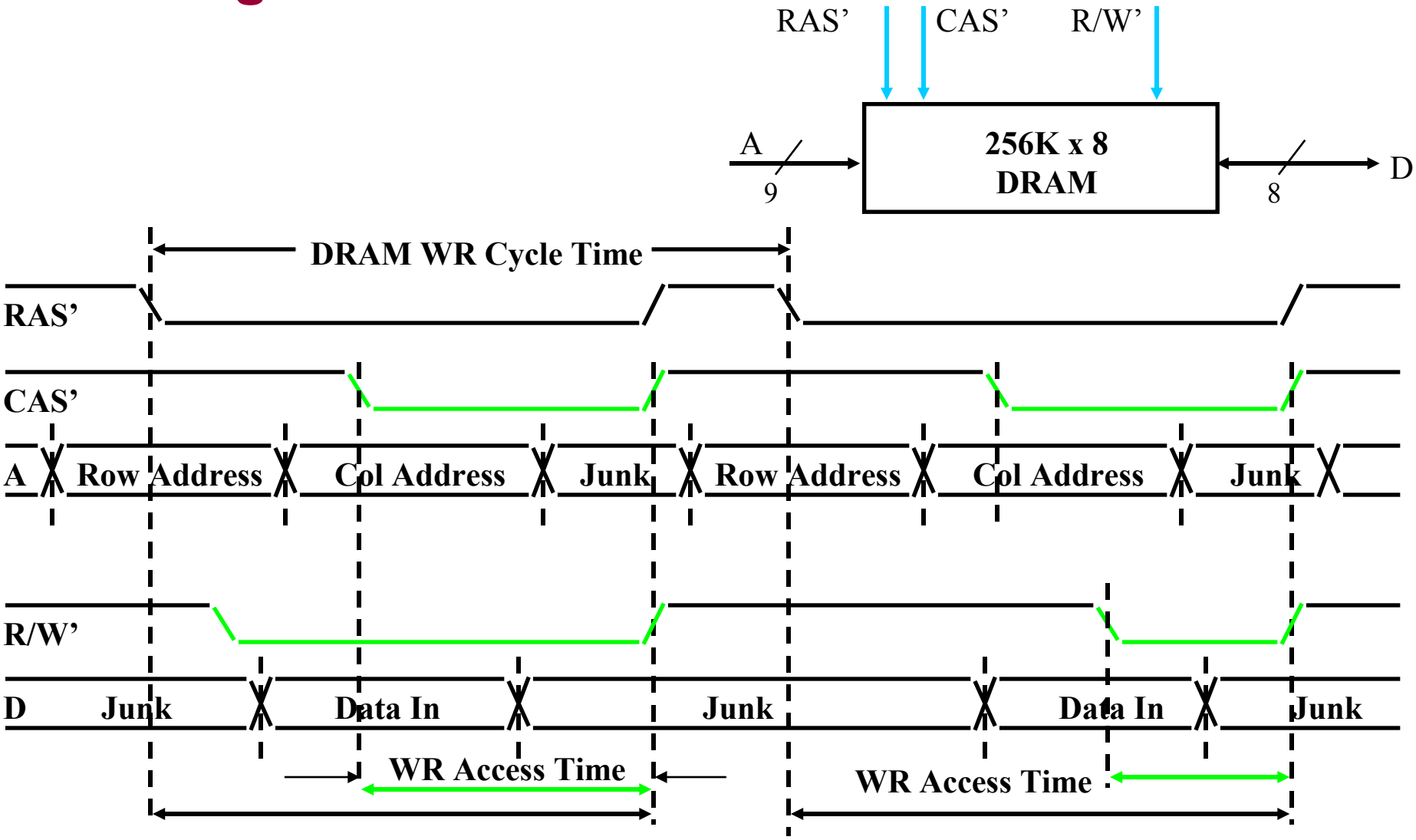
Organisasi DRAM 2-level (64Kx1)



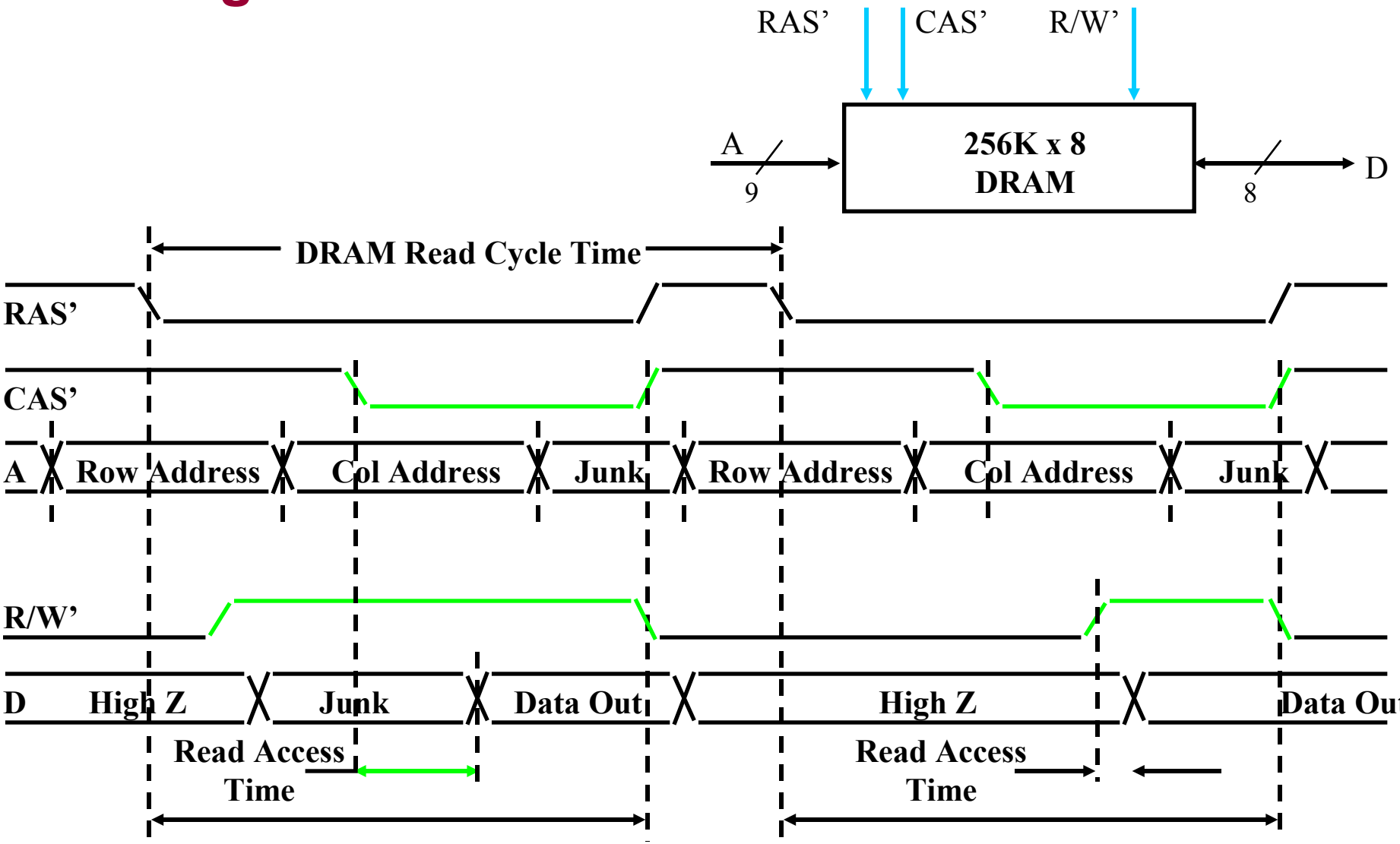
Operasi DRAM

- Row Address (~50ns)
  - Pilih Row address pada address lines & strobe RAS
  - Alamat di-load ke latch baris sebagai respon sinyal RAS
  - Read diinisiasi, sel baris yang dipilih akan dibaca dan di-refresh
- Column Address (~10ns)
  - Pilih Column address pada address lines & strobe CAS
  - Jika sinyak kontrol R/W mengindikasikan :
    - READ: transfer from selected column latch to Dout
    - WRITE: Set selected column latch to Din
- Rewrite/Refreshed (~30ns)
  - Write back entire row

DRAM Write Timing



DRAM Read Timing



DRAM: Kinerja

- Timing
  - Access time = 60ns < cycle time = 90ns
  - Need to rewrite row
  - Model asinkron: operasi memori dilakukan oleh controller circuit → delay
    prosesor menunggu sampai cycle time selesai lalu melakukan request lagi.

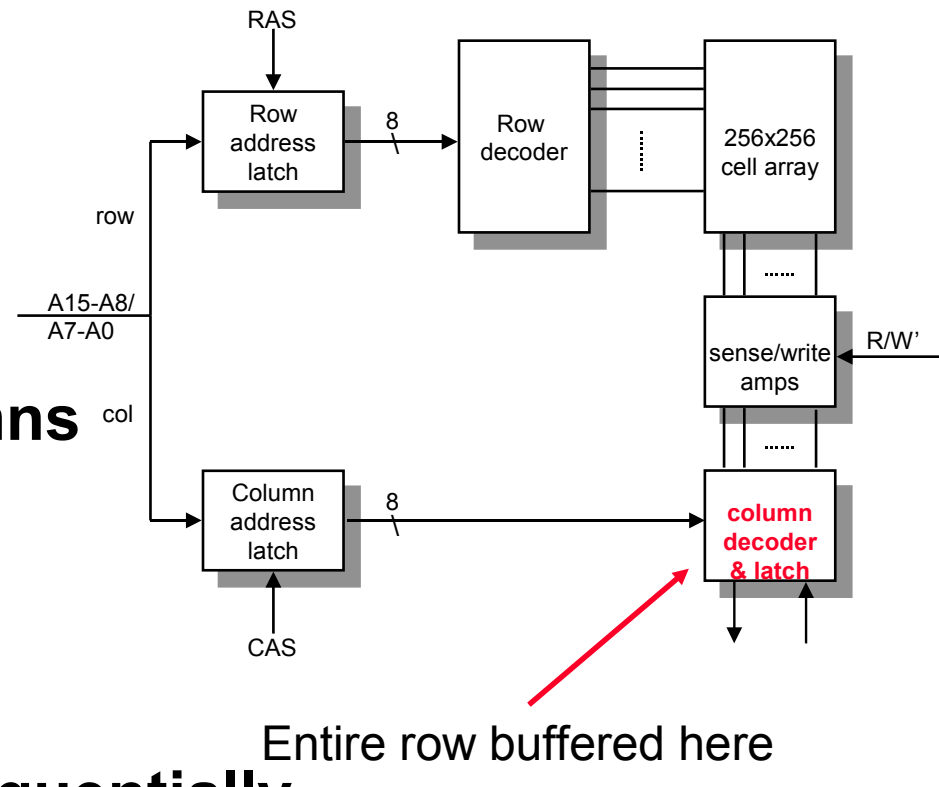
- Must Refresh Periodically
  - Perform complete memory cycle for each row
  - Approx. every 1ms
  - Handled in background by memory controller

Perkembangan Teknologi Memori DRAM

- Teknologi memori: segi kecepatan akses berkembang sangat lambat
  - Gap yang semakin membesar dengan kecepatan prosesor (cycle sangat kecil => 1 nsec, akses memori orde puluhan nsec).
- Perkembangan teknologi DRAM
  - Basis tetap sama: 1-transistor memori cell (menggunakan kapasitor)
  - Inovasi dilakukan dari segi: cara melakukan akses
    - memotong waktu akses (mis. CAS tidak diperlukan)
    - burst mode: sekaligus mengambil data sebanyak mungkin (seluruh word)
    - perlu tambahan rangkaian: register, latch dll

Enhanced Performance DRAMs

- Conventional Access
  - Row + Col
  - RAS CAS RAS CAS ...
- Page Mode
  - Row + Series of columns
  - RAS CAS CAS CAS ...
  - Gives successive bits
- Video RAM
  - Shift out entire row sequentially
  - At video rate

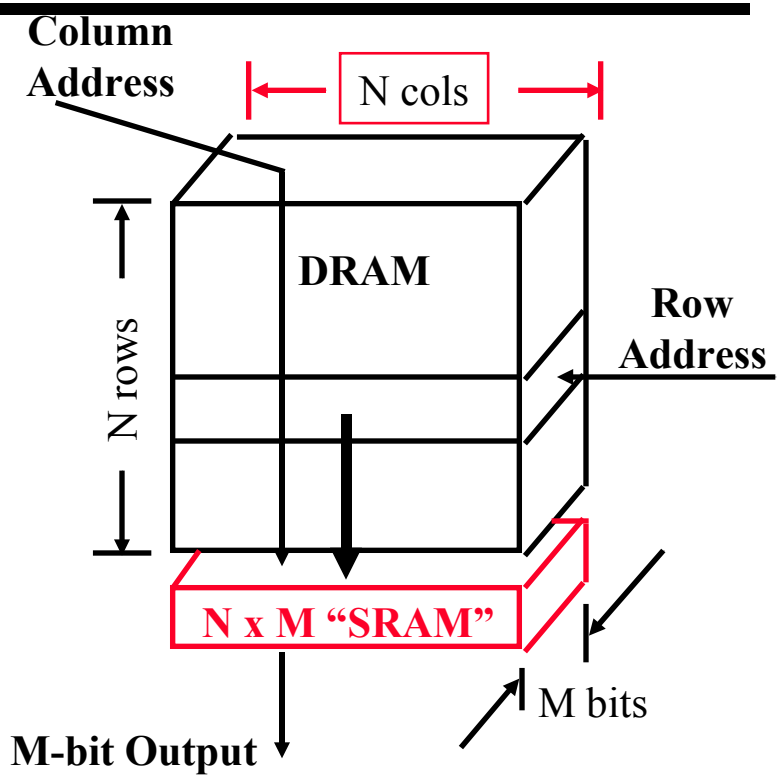


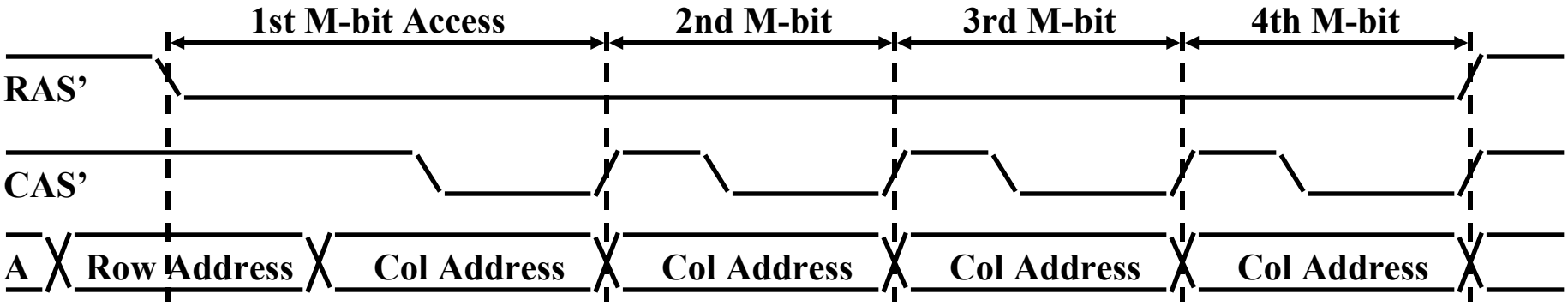
Typical Performance

row access time	col access time	cycle time	page mode cycle time
50ns	10ns	90ns	25ns

Fast Page Mode Operation

- Fast Page Mode DRAM
  - N x M "SRAM" to save a row
- After a row is read into the register
  - Only CAS is needed to access other M-bit blocks on that row
  - RAS' remains asserted while CAS' is toggled





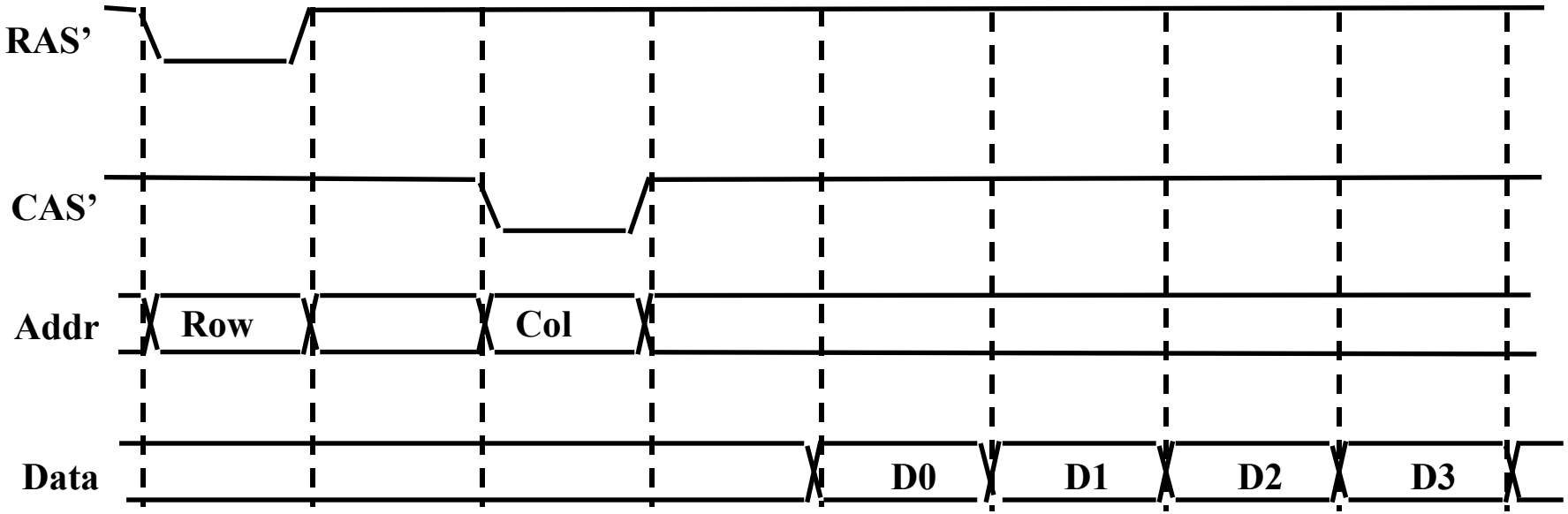
SDRAM & DDR SDRAM

- SDRAM: Synchronous DRAM
  - Address & Data are buffered in registers
  - Burst Mode:
    - Read/Write of different data lengths
      → CAS signals are provided internally
  - Standards: PC100, PC133

- DDR SDRAM: Double-Data-Rate SDRAM
  - Data is transferred on both edges of the clock
  - Cell array is organized in 2 banks
    → allows *interleaving* of word's access
  - Standards: PC2100, PC2300

- RDRAM: Rambus DRAM
  - High transfer rate using differential signaling
  - Data is transferred on both edges of the clock
  - Memory cells are organized in multiple banks
  - Standards: proprietary owned by Rambus Inc.

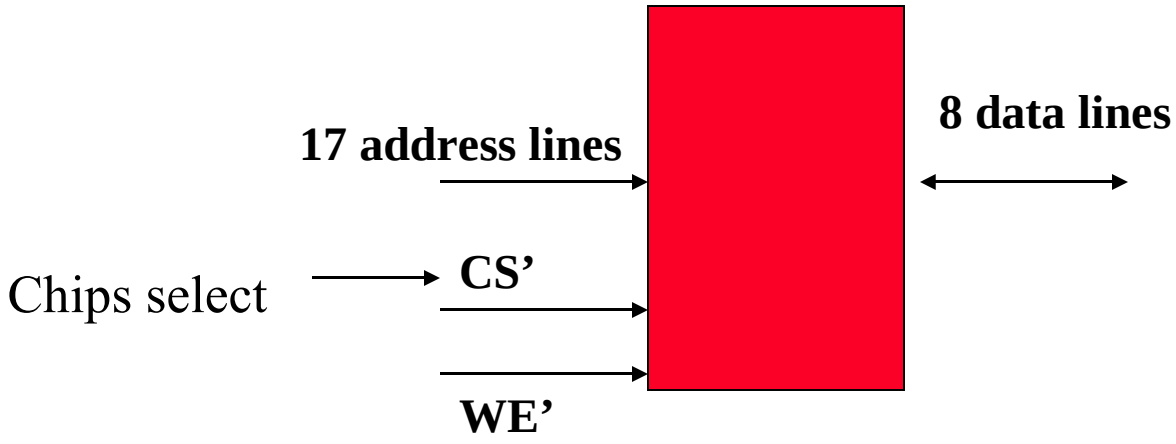
SDRAM Operation



- **Memory Latency:**
  - Waktu yang dibutuhkan untuk mentransfer word pertama
- **Memory Bandwidth:**
  - Jumlah word (byte/bit) yang dapat ditransfer per satuan waktu

Struktur Memori Besar (1/4)

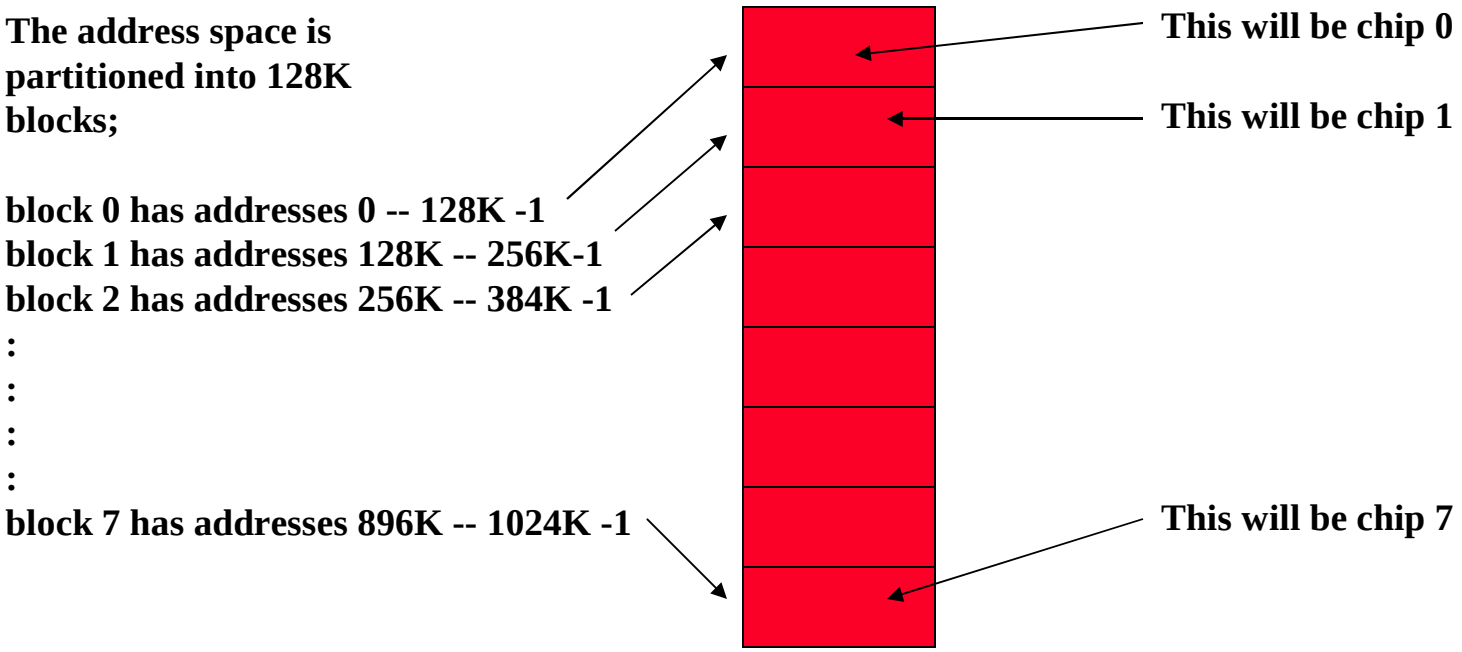
Misalkan: Chip memori 128K x 8



CS'	WE'	Function	Data Lines
H	X	not selected	Hi-Z
L	H	Read	data at location on address lines
L	L	Write	write data on data lines to address on address lines

Contoh: Struktur 1 MB (2/4)

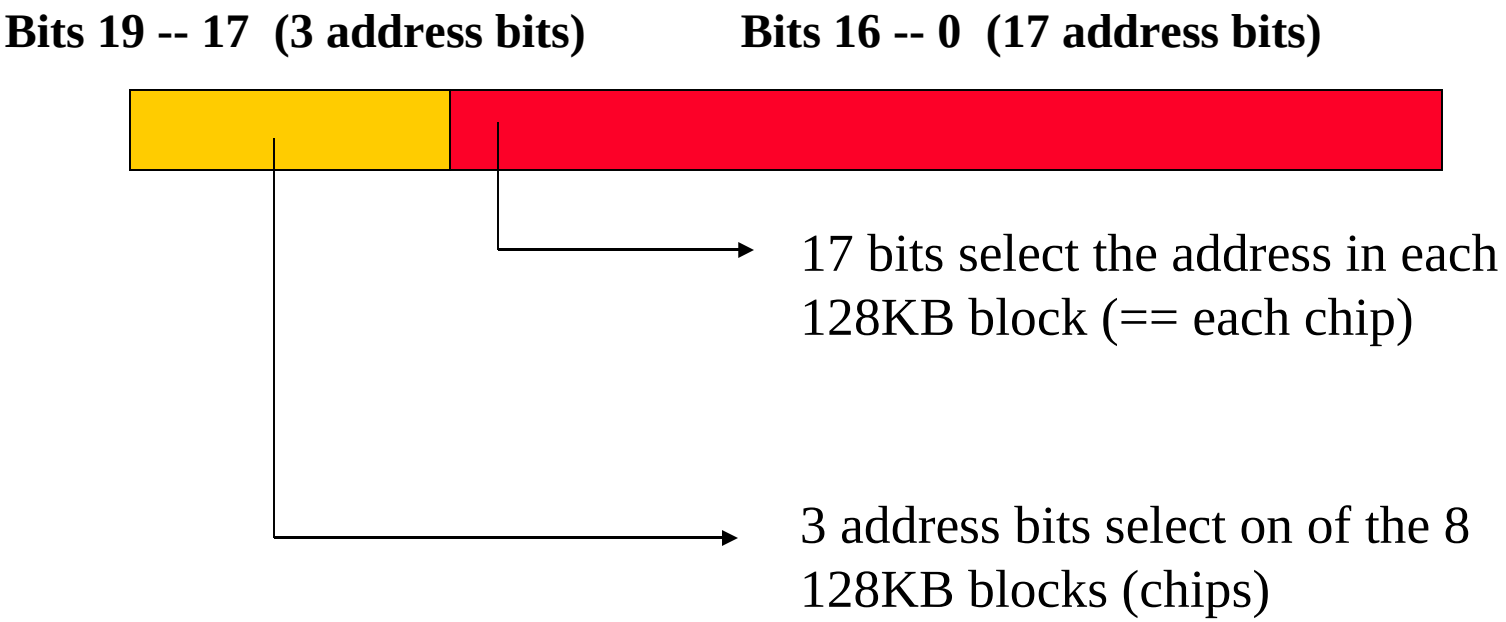
1 MB dapat dikonstruksi dengan
organisasi 8 chips memori 128 KB (8 x 128 x 8 = 1 MB)



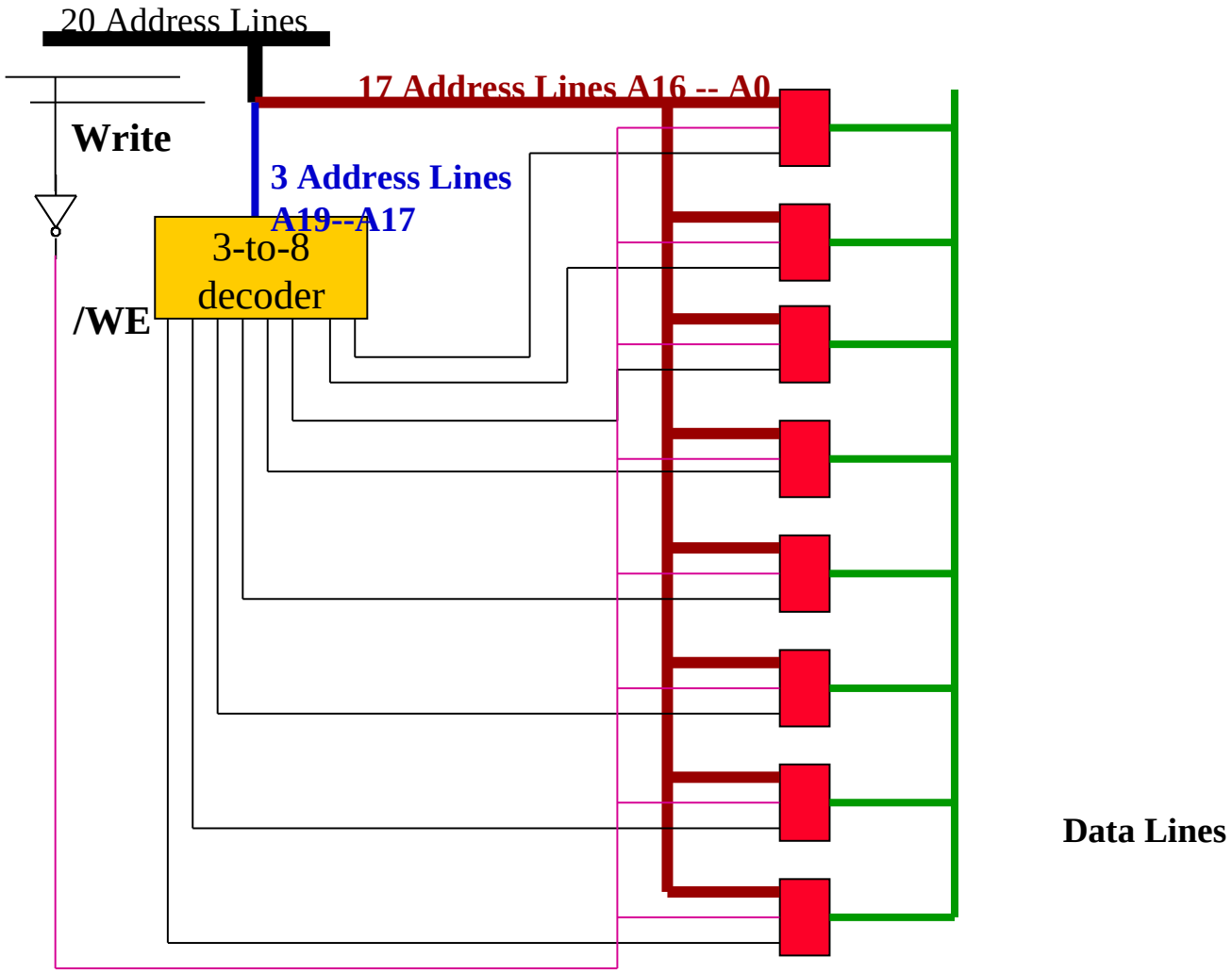
Berapa banyak bits yang diperlukan untuk alamat pada chips?
memilih chips yang mana?

Contoh: Pembagian field address (3/4)

1MB membutuhkan alamat sebesar 20 bit,
Ide: membagi field address menjadi 2 yakni:
bits untuk memilih chips dan address pada field tsb.



Contoh: Struktur 1MB memory (4/4)



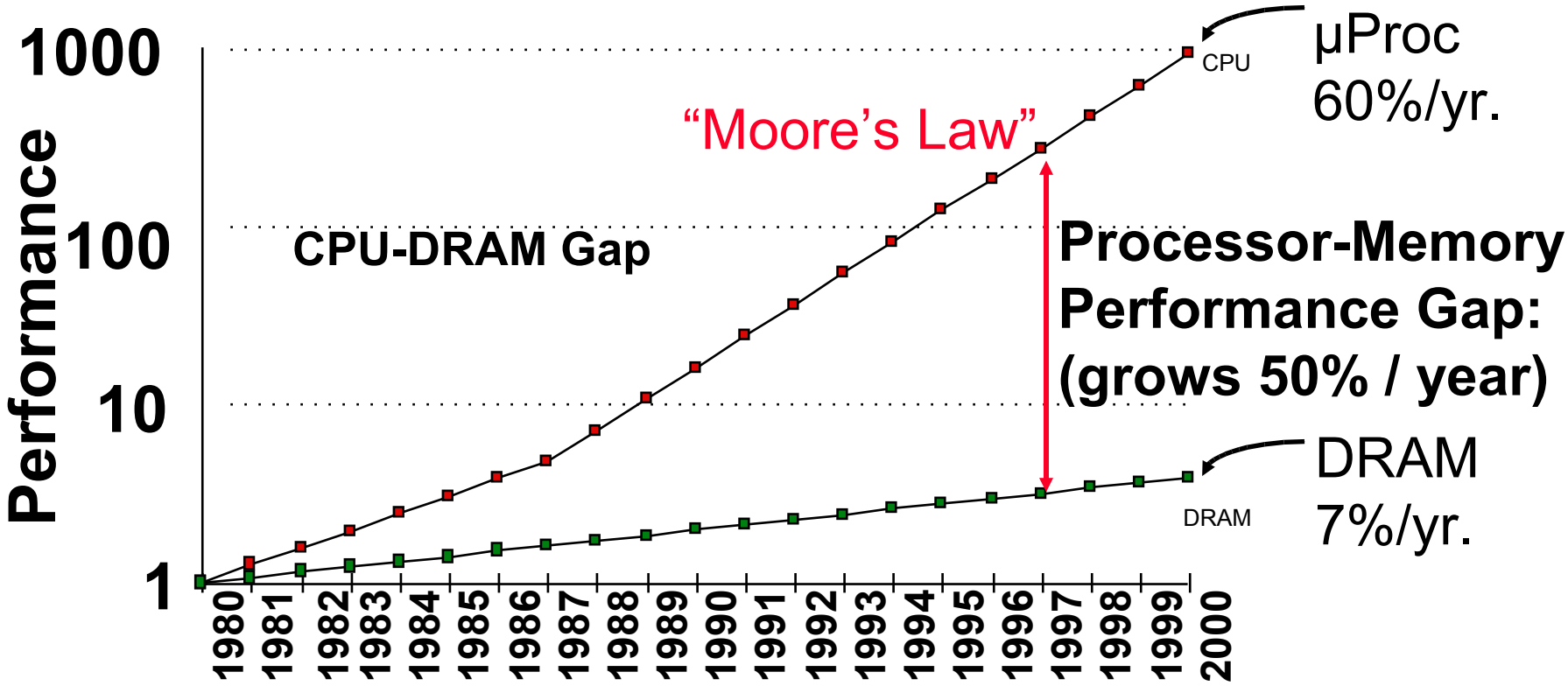
Read-Only Memory

- **ROM**
  - **Write once, by manufacturer**
- **PROM**
  - **Write once, by user**
- **EPROM**
  - **Erasable PROM (by exposing it to ultraviolet light)**
- **EEPROM**
  - **Electrically, Erasable PROM**
- **Flash**
  - **~EEPROM**
  - **Write in blocks**
  - **Low power consumption → battery driven**
  - **Implementation:**
    - **Flash Cards**
    - **Flash Drives:**
      - Better than disk (no movable parts → faster response)

Ringkasan (.. To remember)

- DRAM lambat tapi murah dan kapasitas besar (densitas tinggi)
  - Pilihan untuk memberikan kapasitas BESAR pada sistem memori.
- SRAM cepat tapi mahal dan kapasitas kecil
  - Pilihan untuk menyediakan sistem memori yang waktu aksesnya CEPAT.
- Struktur memori besar dapat dibangun dari kumpulan chips memori kecil:
  - Field alamat dibagi: field address dan field untuk memilih chips/memori yang mana.
  - *Next topic: Trend teknologi memori (go to: http//www.tomshardware.com, search SDRAM guide)*

Trend Teknologi Memori (DRAM)



Prosesor sangat cepat tidak efektif => kendala "bottleneck" berada pada sumber/tujuan data yakni memori.