

**ORARKOM**  
Computer Evolution and Performance

UNIVERSITAS DIAN NUSWANTORO  
UDINUS  
FACULTAS TEKNIK  
SEMARANG

**Organisasi & Arsitektur komputer**

**Computer Evolution and Performance**

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Computer Timeline

Better, faster, cheaper!

| 1950s                                                                               | 1960s                                                                               | 1970s                                                                               | 1980s                                                                               | 1990s                                                                               | 2000s                                                                               | 2010s                                                                               |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Single Transistor                                                                   | TTL Quad Gate                                                                       | 8-bit Microprocessor                                                                | 32-bit Microprocessor                                                               | 32-bit Microprocessor                                                               | 64-bit Microprocessor                                                               | 320p-Core GPU                                                                       |
|  |  |  |  |  |  |  |
| 1 Transistor                                                                        | 16 Transistors                                                                      | 4500 Transistors                                                                    | 275,000 Transistors                                                                 | 3,100,000 Transistors                                                               | 592,000,000 Transistors                                                             | 8,000,000,000 Transistors                                                           |

Gambar : <http://www.computerhistory.org/siliconengine/>

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Computer Timeline

**ENIAC** (Electronic Numerical Integrator And Computer)

- Eckert and Mauchly University of Pennsylvania
- Trajectory tables for weapons,
- 1943 -1946 Used until 1955

Gambar : <http://www.columbia.edu/cu/computinghistory/eniac.html>

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# ORAKOM

## Computer Evolution and Performance

### Computer Timeline

#### ENIAC (Electronic Numerical Integrator And Computer)

- Decimal (not binary)
- 20 accumulators of 10 digits (ring of 10 tubes)
- Programmed manually by switches
- 18,000 vacuum tubes
- 30 tons, 15,000 square feet
- 140 kW power consumption
- 5,000 additions per second

Gambar : [www.thecompuuseum.org](http://www.thecompuuseum.org)

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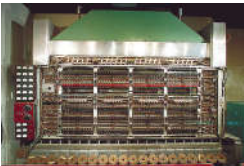
# ORARAKOM

## Computer Evolution and Performance

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### von Neumann/Turing

- Konsep **Stored Program**
- Dibagi menjadi 4 bagian utama
  - **Memory**
  - **ALU**
  - **CU**
  - **I/O**
- Princeton Institute for Advanced Studies
  - IAS
- Completed 1952



Gambar : <http://americanhistory.si.edu>

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# ORAKOM

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### Structure of von Neumann machine

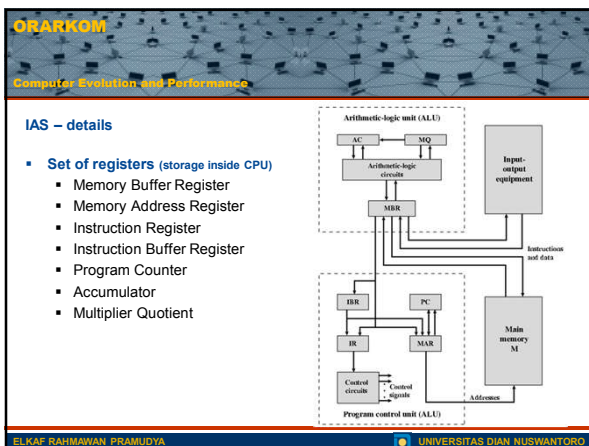
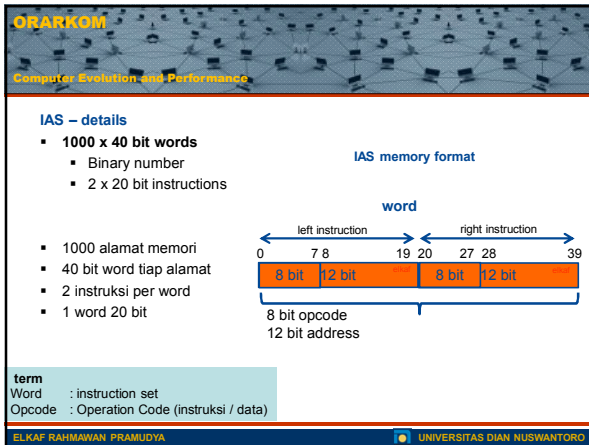
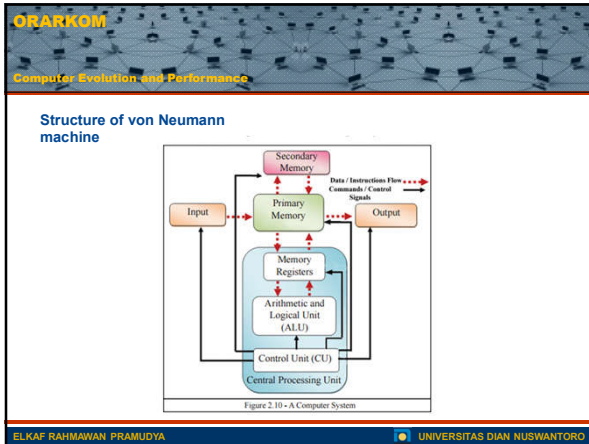
- **Memory** utama, menyimpan data and instructions
- **ALU** mampu memproses data biner
- **Control Unit**, Menerjemahkan perintah untuk disimpan memory agar bisa dieksekusi
- **I/O** perangkat yang dioperasikan oleh CU

```
graph LR; M[Main Memory (M)] <--> CA[Arithmetic Logic Unit (CA)]; M <--> CC[Program Control Unit (CC)]; subgraph CPU [Central Processing Unit (CPU)]; CA <--> CC; end; CPU <--> IO[I/O Equipment (I, O)];
```

The diagram illustrates the von Neumann architecture. It features three main components: Main Memory (M), the Central Processing Unit (CPU), and I/O Equipment (I, O). The CPU is enclosed in a dashed box and contains two sub-units: the Arithmetic Logic Unit (CA) and the Program Control Unit (CC), which are connected to each other. Bidirectional arrows show the flow of data and instructions between Main Memory (M) and both the CA and CC. Additionally, a bidirectional arrow connects the entire CPU to the I/O Equipment (I, O).

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**Commercial Computer**

- **Fourth Computer Generation:** 1970s to Present (The Microprocessor, OS and GUI)
  - OS, PC, workstation, Smartphone etc



Gambar : <https://turbofuture.com>

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**Commercial Computer**

- **Fifth Computer Generation :** The Present and The Future
  - artificial intelligence (AI) and machine learning (ML)



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**Moore's Law**

- Gordon Moore –Intel co Founder "Jumlah transistor pada chip akan berlipat ganda setiap tahun dengan biaya separuh lebih murah"
- Peningkatan kepadatan komponen pada chip
- Kepadatan kemasan yang tinggi berarti jalur listrik yang lebih pendek, memberikan kinerja yang lebih tinggi
- Ukuran yang lebih kecil memberikan peningkatan fleksibilitas
- Mengurangi daya dan kebutuhan pendinginan
- Interkoneksi yang lebih sedikit meningkatkan reliabilitas

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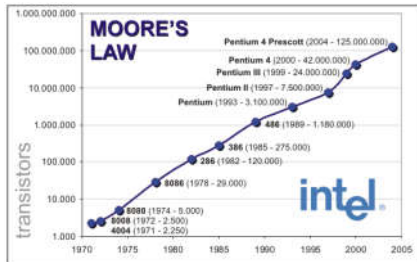
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**ORARKOM****Computer Evolution and Performance****Moore's Law**

Apakah Masih relevan?

Gambar: intel

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**ORARKOM****Computer Evolution and Performance****Evolution of Intel Microprocessor**

(a) 1970s Processors

|                       | 4004      | 8008    | 8080   | 8086                 | 8088         |
|-----------------------|-----------|---------|--------|----------------------|--------------|
| Introduced            | 1971      | 1972    | 1974   | 1978                 | 1979         |
| Clock speeds          | 108 kHz   | 108 kHz | 2 MHz  | 5 MHz, 8 MHz, 10 MHz | 5 MHz, 8 MHz |
| Bus width             | 4 bits    | 8 bits  | 8 bits | 16 bits              | 8 bits       |
| Number of transistors | 2,300     | 3,500   | 6,000  | 29,000               | 29,000       |
| Feature size (µm)     | 10        | 6       | 3      | 3                    | 6            |
| Addressable memory    | 640 Bytes | 16 KB   | 64 KB  | 1 MB                 | 1 MB         |

(b) 1980s Processors

|                       | 80286          | 386TM DX      | 386TM SX      | 486TM DX CPU  |
|-----------------------|----------------|---------------|---------------|---------------|
| Introduced            | 1982           | 1985          | 1988          | 1989          |
| Clock speeds          | 6 MHz-12.5 MHz | 16 MHz-33 MHz | 16 MHz-33 MHz | 25 MHz-50 MHz |
| Bus width             | 16 bits        | 32 bits       | 16 bits       | 32 bits       |
| Number of transistors | 134,000        | 275,000       | 275,000       | 1.2 million   |
| Feature size (µm)     | 1.5            | 1             | 1             | 0.8-1         |
| Addressable memory    | 16 MB          | 4 GB          | 16 MB         | 4 GB          |
| Virtual memory        | 1 GB           | 64 TB         | 64 TB         | 64 TB         |
| Cache                 | —              | —             | —             | 8 KB          |

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**ORARKOM****Computer Evolution and Performance****Evolution of Intel Microprocessor**

(c) 1990s Processors

|                       | 486TM SX      | Pentium        | Pentium Pro           | Pentium II      |
|-----------------------|---------------|----------------|-----------------------|-----------------|
| Introduced            | 1991          | 1993           | 1995                  | 1997            |
| Clock speeds          | 16 MHz-33 MHz | 60 MHz-360 MHz | 150 MHz-200 MHz       | 200 MHz-300 MHz |
| Bus width             | 32 bits       | 32 bits        | 64 bits               | 64 bits         |
| Number of transistors | 1,180 million | 3.1 million    | 5.5 million           | 7.5 million     |
| Feature size (µm)     | 1             | 0.8            | 0.6                   | 0.35            |
| Addressable memory    | 4 GB          | 4 GB           | 64 GB                 | 64 GB           |
| Virtual memory        | 64 TB         | 64 TB          | 64 TB                 | 64 TB           |
| Cache                 | 8 KB          | 8 KB           | 512 KB L1 and 1 MB L2 | 512 KB L2       |

(d) Recent Processors

|                       | Pentium III | Pentium 4   | Core 2 Duo   | Core 2 Quad |
|-----------------------|-------------|-------------|--------------|-------------|
| Introduced            | 1999        | 2000        | 2006         | 2008        |
| Clock speeds          | 450-660 MHz | 1.3-1.8 GHz | 1.06-1.2 GHz | 3 GHz       |
| Bus width             | 64 bits     | 64 bits     | 64 bits      | 64 bits     |
| Number of transistors | 9.5 million | 42 million  | 167 million  | 820 million |
| Feature size (nm)     | 250         | 180         | 65           | 45          |
| Addressable memory    | 64 GB       | 64 GB       | 64 GB        | 64 GB       |
| Virtual memory        | 64 TB       | 64 TB       | 64 TB        | 64 TB       |
| Cache                 | 512 KB L2   | 256 KB L2   | 2 MB L2      | 6 MB L2     |

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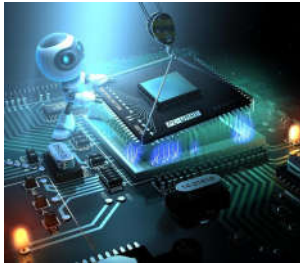
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### Designing for Performance

- Image processing
- Speech recognition
- Videoconferencing
- Multimedia authoring
- Voice and video annotation of files
- Simulation modeling



Gambar : <http://inf.co.ua>

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### Microprocessor Speed

- Pipelining
- On board cache
- On board L1 & L2 cache
- Branch prediction
- Data flow analysis
- Speculative execution



Gambar : <https://www.rarecpu.com>

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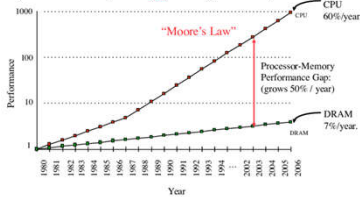
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### Performance Balance

- Peningkatan **kecepatan** Processor
- Peningkatan **kapasitas** Memory
- Kecepatan memory **tertinggal** dengan kecepatan processor



Gambar : <https://www.researchgate.net>

Teknologi chip memory yang umum adalah DRAM = Dynamic Random Access Memory

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**Performance Balance**

**Solusi Pendekatan**

- Menambah **jumlah bit** yg diambil sekaligus, untuk diproses
  - membuat DRAM "wider" dibanding "deeper" dengan menambah jalur data
- Merubah **interface** DRAM
  - Cache
- Mengurangi **frequency access** ke memory
  - Cache lebih kompleks dan cache on chip (dlm CPU)
- Increase interconnection bandwidth
  - High speed buses
  - Hierarchy of buses

Problem yang sama dengan I/O devices,  
misal graphics, network  
Perlu balance pada computer design

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**Typical I/O Device Data Rates**

10<sup>1</sup> 10<sup>2</sup> 10<sup>3</sup> 10<sup>4</sup> 10<sup>5</sup> 10<sup>6</sup> 10<sup>7</sup> 10<sup>8</sup> 10<sup>9</sup>

Data Rate (bps)

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**Improvements in Chip Organization and Architecture**

- Meningkatkan **kecepatan hardware** prosesor
- Meningkatkan **size** dan **kecepatan** cache
- Perubahan pada organisasi dan arsitektur prosesor

**Multiple processors on single chip**

- Large shared cache

Intel Core i7-2600K - CPU  
Gambar : <https://www.pcimag.com>

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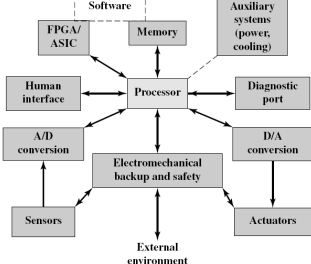
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### Embedded systems and the ARM

*embedded system* adalah sistem kontrol dan Sistem operasi dengan fungsi khusus sebagai bagian dari perangkat sistem yg lebih besar.



An embedded system on a plug-in card with processor, memory, power supply, and external interfaces  
Gambar : <https://en.wikipedia.org>



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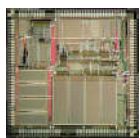
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### Embedded systems and the ARM

ARM processors didesain untuk 3kategori system :

- **Embedded real-time systems:** sistem untuk storage, automotive body dan power-train, industrial, dan networking applications
- **Application platforms:** Devices running open operating systems including Linux, Palm OS, Symbian OS, and Windows CE in wireless, consumer entertainment and digital imaging applications
- **Secure applications:** Smart cards, SIM cards, and payment terminals

Die of an ARM M0 microprocessor  
Gambar : <https://en.wikipedia.org>

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### Key term

|                                   |                               |                                       |
|-----------------------------------|-------------------------------|---------------------------------------|
| accumulator (AC)                  | instruction cycle             | opcode                                |
| Andahl's law                      | instruction register (IR)     | original equipment manufacturer (OEM) |
| arithmetic and logic unit (ALU)   | instruction set               | program control unit                  |
| benchmark                         | integrated circuit (IC)       | program counter (PC)                  |
| chip                              | main memory                   | SPEC                                  |
| data channel                      | memory address register (MAR) | stored program computer               |
| embedded system                   | memory buffer register (MBR)  | upward compatible                     |
| execute cycle                     | microprocessor                | von Neumann machine                   |
| fetch cycle                       | microcore                     | wafer                                 |
| input-output (I/O)                | multiplexor                   | word                                  |
| instruction buffer register (IBR) |                               |                                       |

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