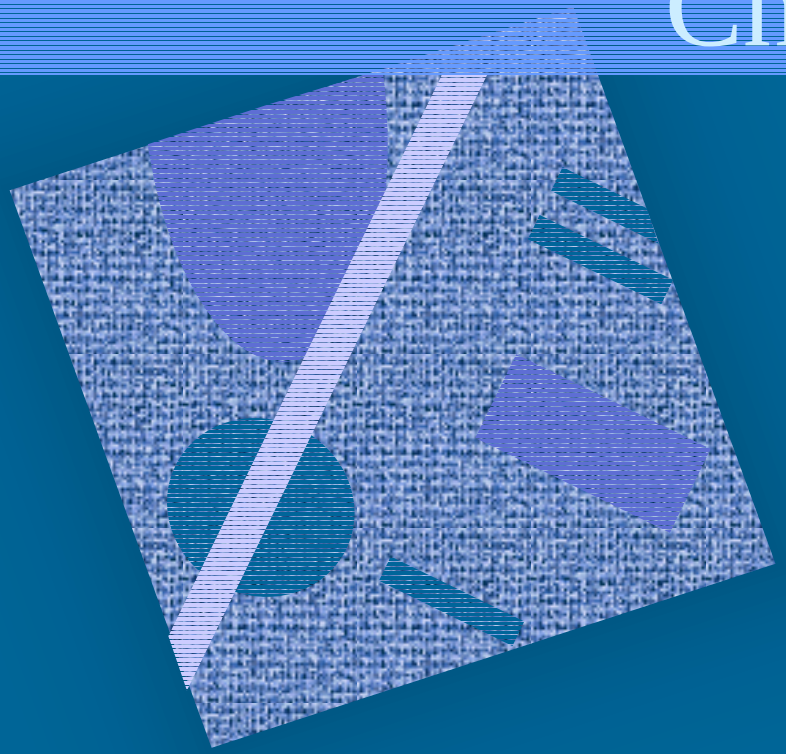
RISC Architecture
Ch 13



- Some History
- Instruction Usage Characteristics
- Large Register Files
- Register Allocation Optimization
- RISC vs. CISC

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Major Inventions in Computer Architecture

- General purpose computer
  - Howard Aiken, Mark I, 1944
    - relays, 17m long, 2.4m tall
    - 500 miles of wire, 5 tons
    - 3 million connections
    - 6 sec mult, 12 sec div
    - IBM ASCC (automatic sequence controlled calculator)
    - turned off last time 1959

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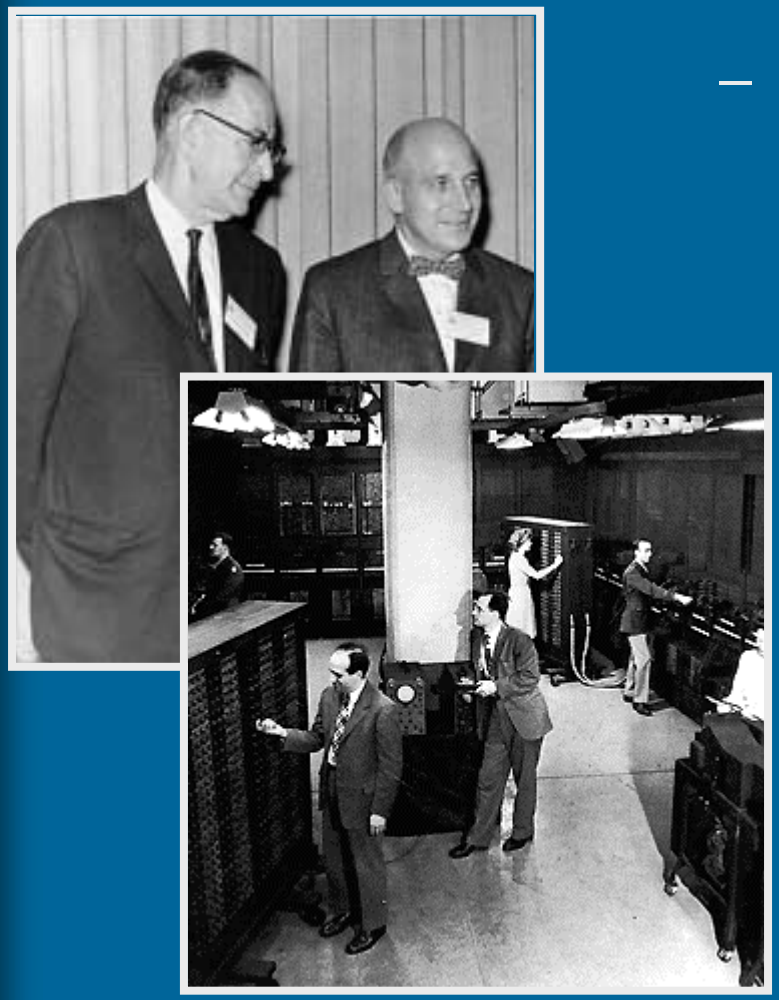
Major Inventions in Computer Architecture



- J. P. Eckert and John Mauchly, Eniac, 1946
  - 1500 relays
  - 18000 vacuum tubes
  - 70,000 resistors
  - 20 accumulators
  - 10 digits
  - modify program by rewiring

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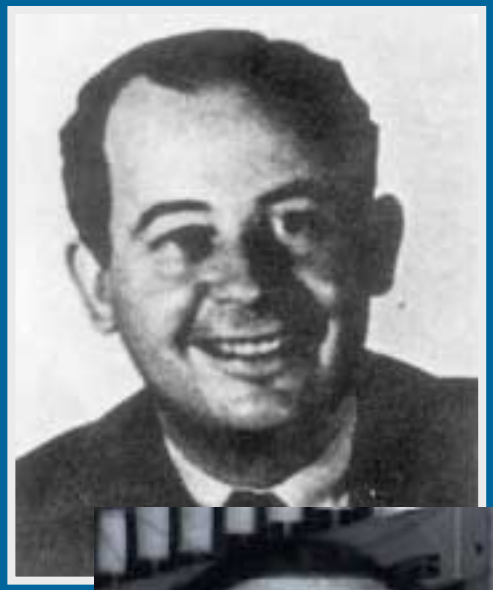
Major Inventions in Computer Architecture

- Stored Program Computer
  - store both program and data in memory
  - John von Neumann, 1945
    - Electronic Discrete Variable Automatic Computer (EDVAC) prototype
  - Maurice Wilkes, 1949
    - Electronic Delay Storage Automatic Calculator (EDSAC)
    - first fully operational stored program computer
  - software was born



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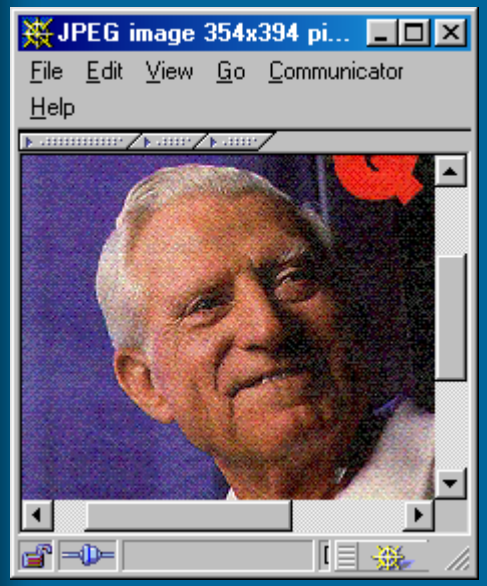
Major Inventions in Computer Architecture



- Floating Point hardware
  - Gene Amdahl, 1953
  - IBM 704
    - OS allowed for batch processing
      - combine existing commands into new commands
    - 5 kFLOPS
    - 19 units produced

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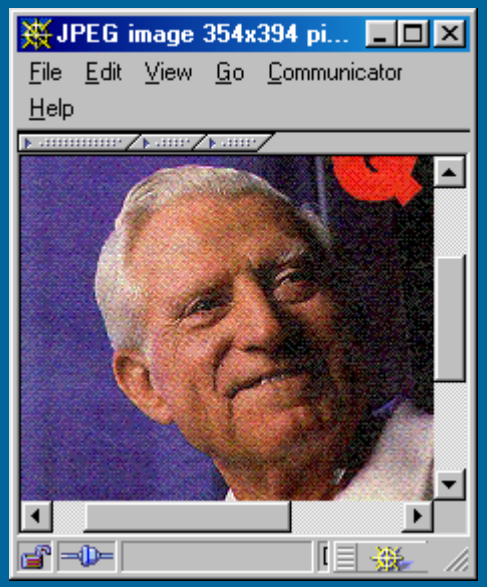
Major Inventions in Computer Architecture

- Family of computers with different implementations of the same architecture
  - Computer system can grow within the family and all SW will still run
  - Need faster/bigger
    ⇒ buy a faster/bigger system in the family
  - Gene Amdahl
  - IBM S/360
  - DEC PDP-8

1964



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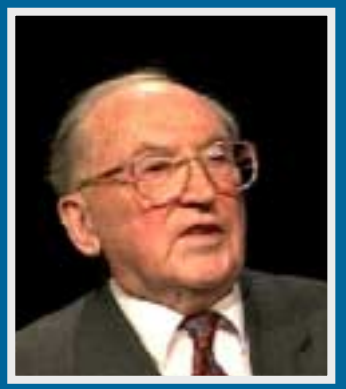
Major Inventions in Computer Architecture

- Microprogrammed control unit
  - can modify implementation easily
  - makes it easier to implement families of systems
  - can have different instruction set architecture (ISA) on top of the same HW
  - Maurice Wilkes, 1951
  - IBM System/360, 1964



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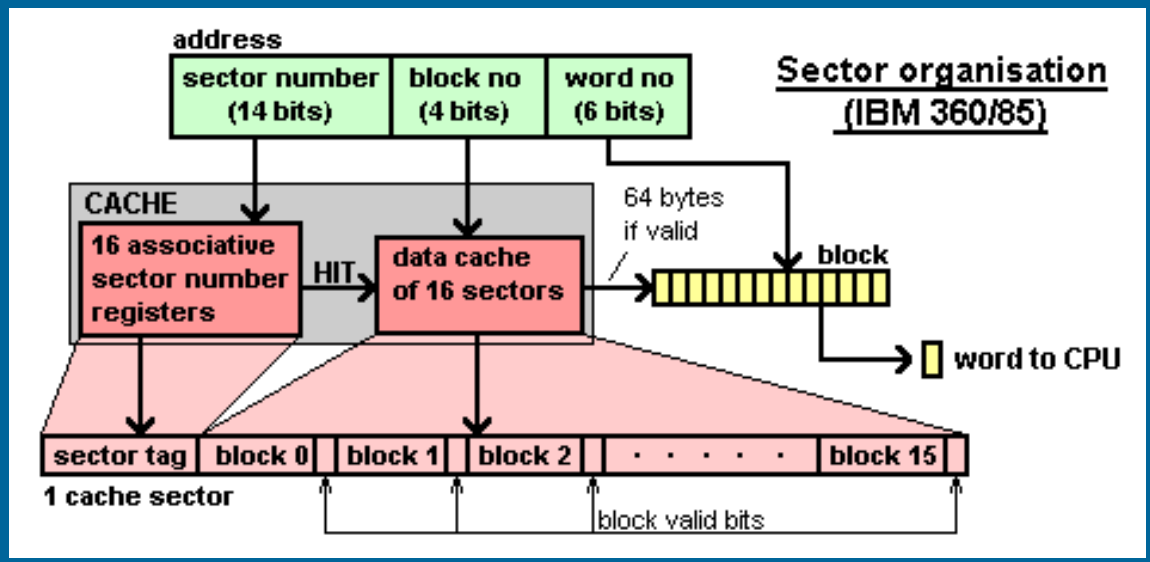
Major Inventions in Computer Architecture

- Cache memory
  - Maurice Wilkes, 1965
  - major speed up (12x ?)
  - IBM System/360 Model 85 1968



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Major Inventions in Computer Architecture

Atlas accumulator cabinet

- Virtual memory
  - Tom Kilburn, 1962
  - Atlas, 1962
    - 20 bits for virtual address space
    - 512 word (each 48 bits) page
    - 16 KB main mem
    - 2 units sold

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Major Inventions in Computer Architecture

- Pipelining
  - Tom Kilburn (?)
  - Atlas, 1962
    - 2 ALU's
    - overlap execution of 3 instructions

Atlas Main and B-Arithmetic Units

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Major Inventions in Computer Architecture

- Multiple processors
  - J. P. Eckert and John Mauchly
  - Sperry Rand Univac 1108II (1108A), 1964
    - 3 CPU's
    - 2 I/O controllers
      - DMA
    - 36 bit words
    - test-and-set instruction was added for synchronization between processors

Mauchly & Univac console

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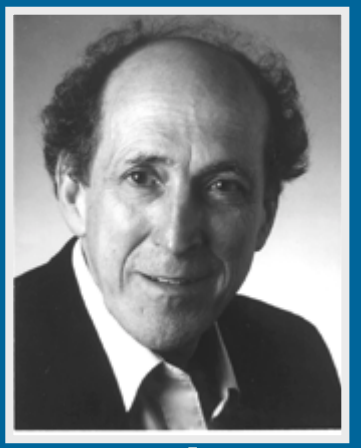
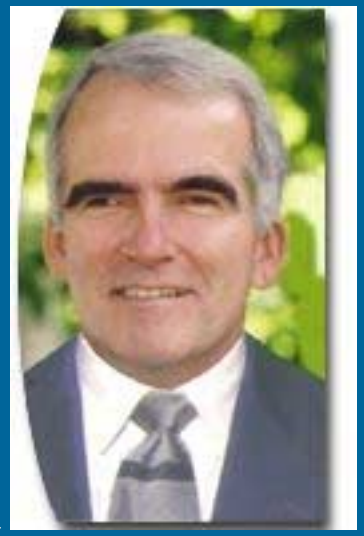
Major Inventions in Computer Architecture

- Static RAM
  - Fairchild 4100, 1970
    - 256 bits
- Dynamic Random Access Memory
  - Robert Dennard, IBM, 1966
  - Intel 1103, 1970
    - John Reed
    - 1024 bits
    - replaces magnetic core memory by 1972



Dennard



Reed

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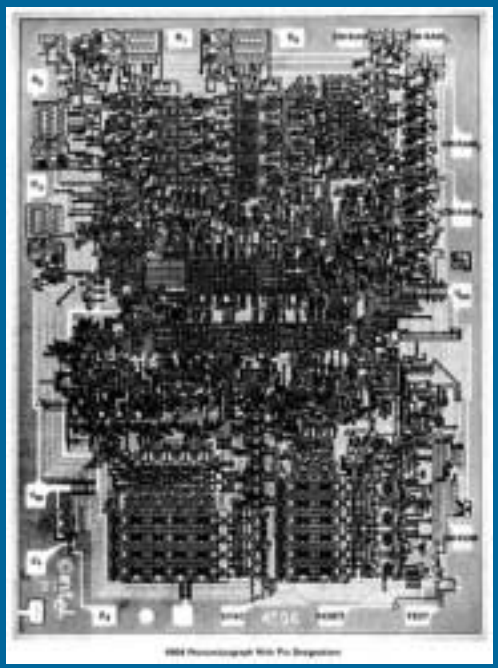
Major Inventions in Computer Architecture

- Single chip microprocessor
  - Marcian E. (Ted) Hoff, (+ Federico Faggin & Stan Mazor ?)
  - Intel 4004, 1971
    - 2300 transistors, 60K OPS
    - ”single chip which implements and interprets all microinstructions”
    - 4 bit words, 16 GPRs, 4-bit accumulator, operation register, instruction decoder
    - good for BCD operations (BCD = Binary Coded Decimal)
    - Japanese Busicom abandoned failed (!) project and bankrupted next year
    - Used in Pioneer 10 spacecraft (1972)

Hoff

Faggin

Mazor



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Major Inventions in Computer Architecture

- Vector processors
  - operate on entire vectors with one instruction
  - Texas Instrument Advanced Scientific Computer (ASC), 1971
    - W. Joe Watson
    - 4 pipelines
    - vectors stored in memory
    - 7 machines built
    - vectorizing Fortran compiler
    - theoretical max speed 50 MFLOPS
    - slow scalar unit

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Major Inventions in Computer Architecture

- … ??? …

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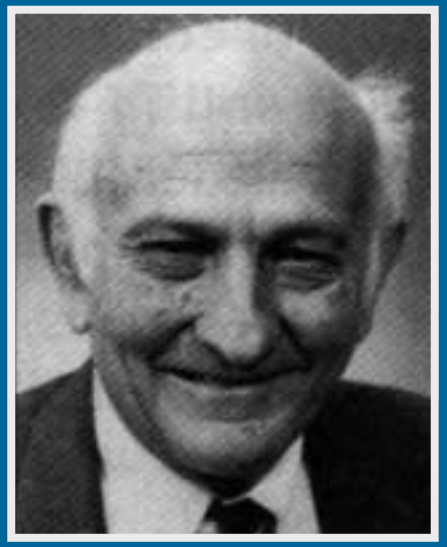
Major Inventions in Computer Architecture (2)

- Reduced Instruction Set Computer (RISC)
  - John Cocke, 1974
  - IBM 801 (prototype), 1979
  - project cancelled because instruction set not compatible with OS/360



- Try again … and succeed
  - Hennessy (1981) & Patterson (1980)
  - Proved, that even CISC machines may work faster if only simple instructions and addressing modes are used

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Major Inventions in Computer Architecture -- ??

- Cross-platform emulation could be made faster/use less energy than direct execution
  - Edmund J. Kelly, Malcolm John Wing & Robert Cmelik, Transmeta Corp., 1996
  - Can optimize and dynamically rebuild code (translation & code optimization)
    - lots of work, possibly big gains
    - E.g., emulators for other architectures (x86)
  - Crusoe processor, 2000

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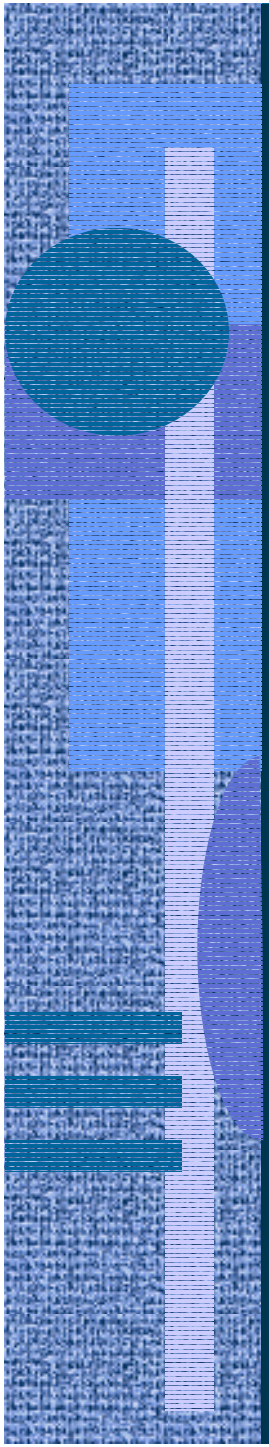

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