

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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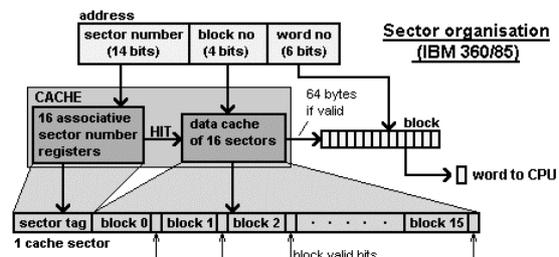
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Major Inventions in Computer Architecture

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



1968



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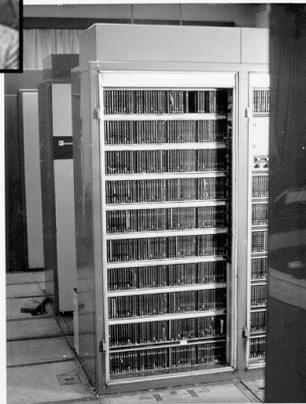
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Major Inventions in Computer Architecture



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

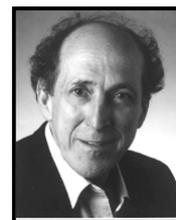
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Major Inventions in Computer Architecture

- 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

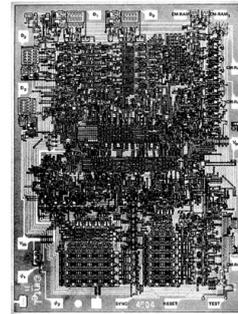
- Single chip microprocessor

- Marcian E. (Ted) Hoff, (+ Federico Faggin & Stan Mazor ?)



- Intel 4004, 1971

- 2300 transistors, 60K OPS Hoff Faggin Mazor
- "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)



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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

- ... ??? ...

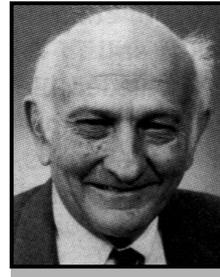
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Major Inventions in Computer Architecture ⁽²⁾

- 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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