Wisconsin Computer Architecture

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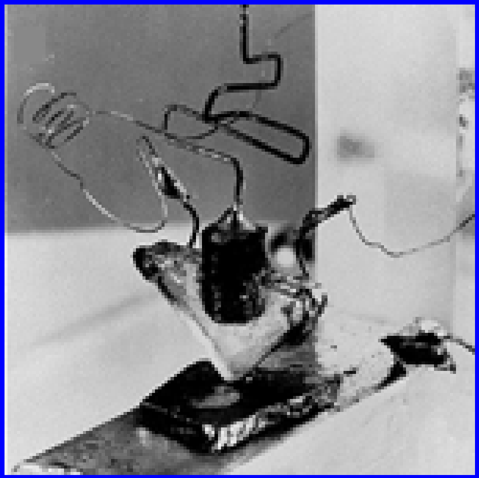
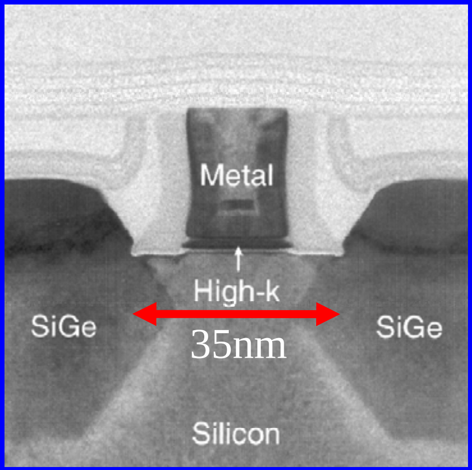
Technology & Moore's Law



Transistor
1947

Integrated Circuit
1958

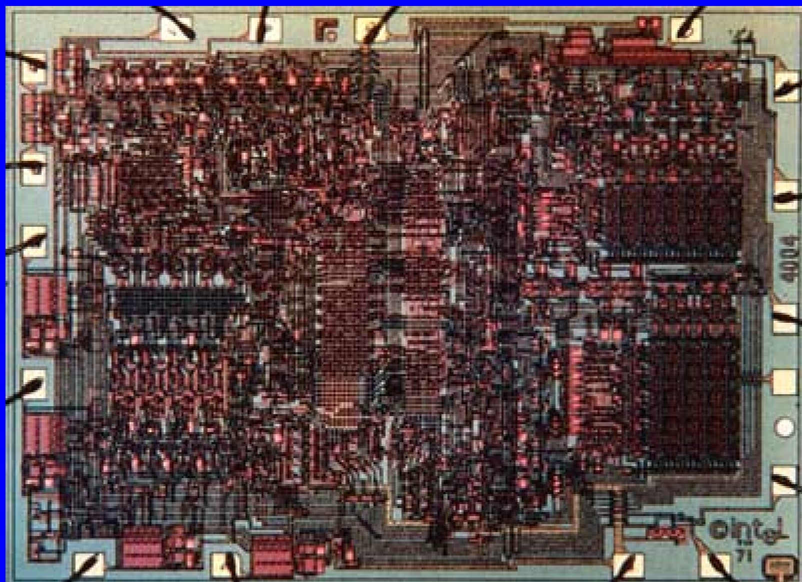


Transistor today

Moore's Law 1964:

Transistors per IC doubles every two years (or 18 months)

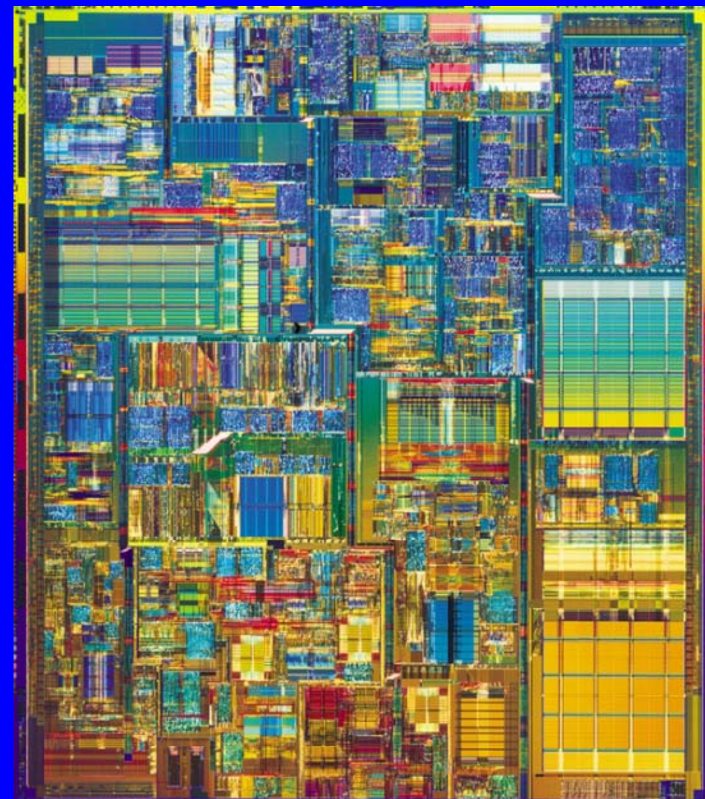
Architects & Another Moore's Law



Microprocessor 1971

(2002) 55M transistors →

Pentium 4



Popular Moore's Law:

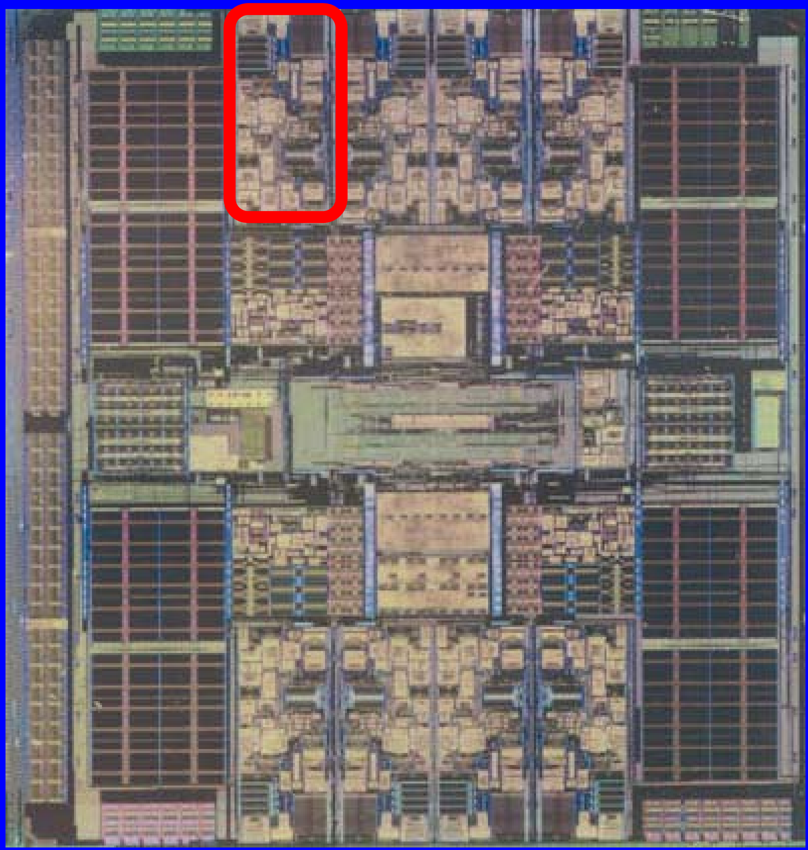
Microprocessor performance doubles every two years

Houston, We Have Problems!

- Memory Wall
  - 1980 Memory Latency ~ 1 instruction
  - 2008 Memory Latency ~ 1000 instructions
- Other Problems
  - Power & cooling
  - Cross-chip wires
  - Complexity & test

Chip Multiprocessor (a.k.a Multi-Core)

- Replicate
  - processor “core” &
  - Caches
- Uses more transistors
- Tolerates “memory wall”
- Simpler lower-power cores
- Reduces complexity



Houston, We Still Have ~~a Problem~~ an Opportunity

- Recall Popular Moore's Law:
  - Microprocessor performance doubles every two years
- Future CMP Performance Doublings Require
  - Effective multithread programming!
  - Better communication
  - Faster synchronization
  - More cores

Why Computer Architecture at Wisconsin? 1 of 2

- Strong History
  - processors: branch prediction, decoupled architectures, precise interrupts, out-of-order processors, pipeline clocking, speculative execution, speculative multithreading
  - memory: snooping coherence, 3Cs model, memory consistency, non-blocking caches, token coherence
  - simulation: simplescalar, pharmsim, & GEMS
- Strong Present
  - speculative multithreading, speculative coherence, chip multiprocessors, virtual machines, transactional memory
  - awards: Eckert-Mauchly, Wilkes, IEEE/ACM Fellows, National academy of engineering members
  - 20 grad students & several well-funded projects

Why Computer Architecture at Wisconsin? 2 of 2

- Former Graduate Students Prospering
  - Over a dozen in academia: CMU, Duke, Illinois, Maryland, Michigan, NCSU, U Penn, Purdue, Texas, Toronto
    - Nearly all winners of NSF CAREER awards
    - 4 winners of Sloan Research Fellowships
  - Several in key industrial positions: AMD, Cray, IBM, Intel, Sun, others
    - Includes principal architects of important products (Alpha 21264, Cray T3EX1/)
- Strong Future
  - We average 15-20% ISCA papers since 2000
  - Our grads average another 15-20%
  - We want to add you to this slide!

Selected Projects 1 of 2

- Multifacet: Multicore design (Hill & Wood)
  - Recent: Log-based Transactional Memory
  - Future: Deterministic Execution & Replay
- Vertical: Technology-driven architecture (Sankaralingam)
  - Reliability aware systems
  - Copernicus: future graphics architectures
- Multiscalar: Processor Design (Sohi)
  - Past: Speculative multithreading and variants
  - Recent/Current: Non-traditional multicore architectures and solving the multicore programming problem.

Selected Projects 2 of 2

- Many-Core Power and Performance(Kim)
  - Power, performance optimization considering process variability
  - Reliable, low-power computing
- Pharm: System and processor design (Lipasti)
  - Optimized software & hardware for commercial servers
  - Novel and power-efficient cache coherence and interconnects
  - High ILP processors with low power and low complexity

http://www.cs.wisc.edu/~arch/uwarch