



Designing Tomorrow's Microprocessors

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Agenda

- Overview of Today's Microprocessors and Future Trends
- Design Cycle for Microprocessors
- Methodology for Research in Microprocessors
- Multi-core Processor Architectures
- Parallel Programming
- Systems-on-Chip
- Techniques for Power Reduction
- Reliability
- Hardware/Software Co-designed Microprocessors

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Overview of Today's Microprocessors and Future Trends

- Computing Evolution
- Technology Scaling
- Microprocessor Families
- Microarchitecture Overview
- Future Challenges
- Some Research Projects of Intel Labs

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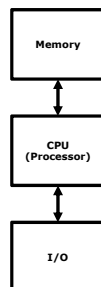


Changing the World



Initial Developments

- 1946: ENIAC by J.P. Eckert and J. Mauchly
- 1945: Stored program by J.V. Neuman
- 1949: EDSAC by M. Wilkes
- 1952: UNIVAC I and IBM 701

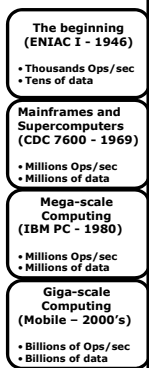


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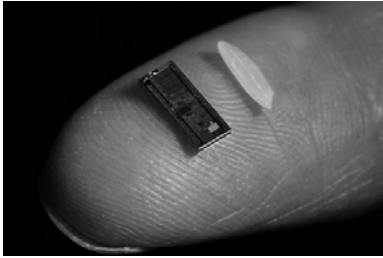
Computing Evolution



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At the Heart of This Evolution: The Microprocessor



**The Microprocessor
(Intel 4004 - 1971)**

- 2300 transistors
- Tens of thousand ops/sec

**High Performance
(Intel Core i7)**

- Around 800M transistors
- Billions of ops/sec

**Ultra Low Power
(Intel Atom)**

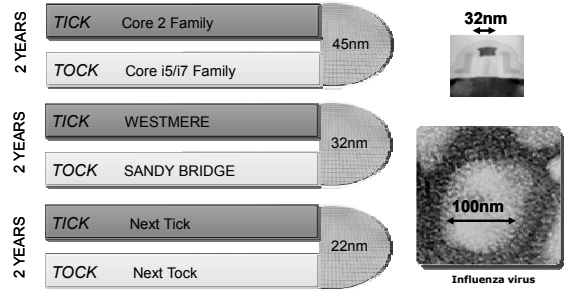
- Around 50M transistors
- Billions of ops/sec

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Intel's Tick Tock Model



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Gordon Moore's Law

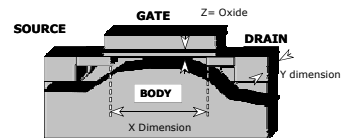
- The number of transistor in a chip doubles every 2 years
 - Based on 4 points (year/transistor count) (1959, 1), (1962, 8), (1964, 32), (1965, 64)
 - Established on April 19, 1965 in the Electronics Magazine, predicting 65000 transistors in 1975
- Revised in 1975 in IEEE International Electron Device Meeting

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Technology Scaling Theory



X & Y Dimensions scale down by 30%	Doubles transistor density
Z-Oxide thickness scales down	Faster transistor, higher performance
Vcc & Vt scaling	Lower active power

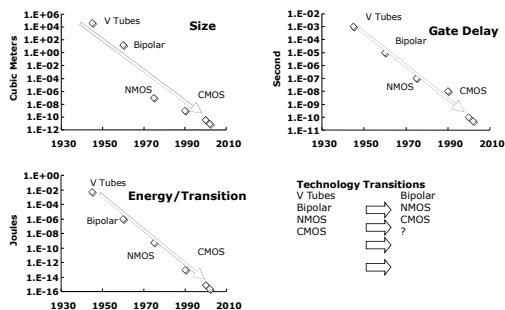
Technology scaling is a great thing

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Technology Scaling Trends



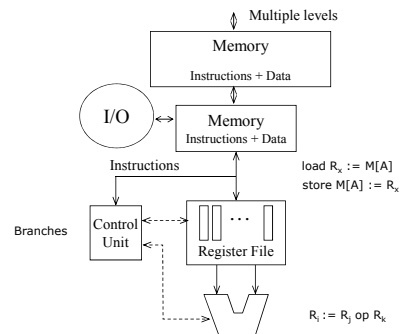
Scaling Will Continue

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Today's Computers



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Microprocessor Families

- Pipelined / non-pipelined processors
- In-order / out-of-order processors
- Scalar / superscalar processor
- Vector processors
- Multithreaded processors

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Microprocessor Segments

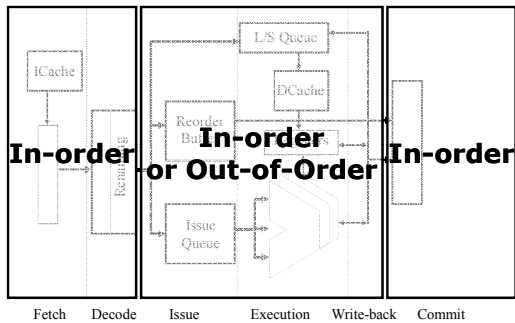
- Servers
- Desktop
- Mobile
- Embedded

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Processor Uarch Overview



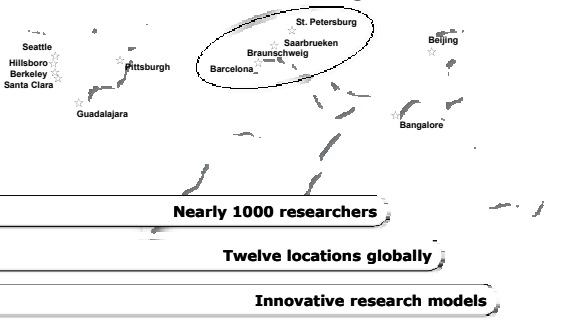
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Intel Labs

Intel's Central Research Organization



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Future Technology Challenges



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New Technology for the Sake of New User Experiences

- In the past: Computing
- At present: Computing + communication
- In the future: Computing + communication + perception

COMPUTATIONAL PERCEPTION

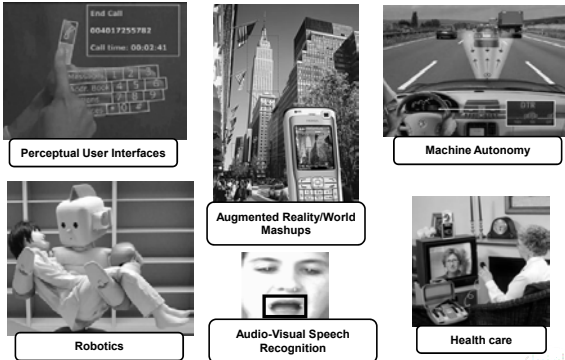
The expansion of human capabilities through improved machine understanding of our world

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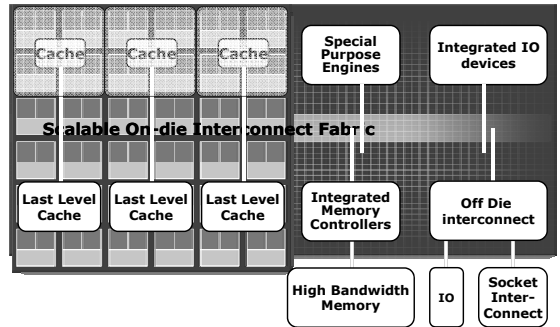
Computational Perception



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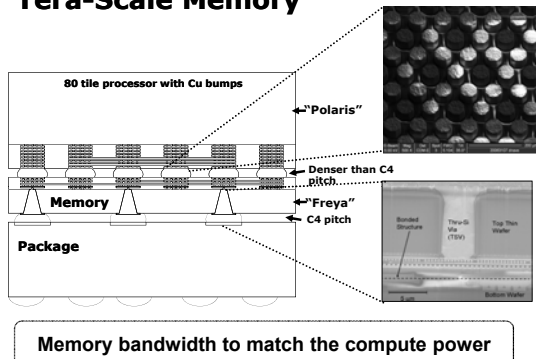
Tera-Scale Processors



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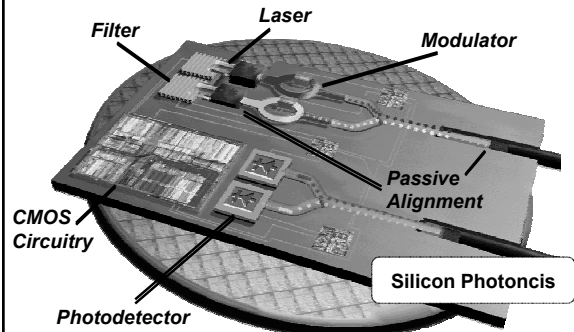
Tera-Scale Memory



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Tera-Scale IO



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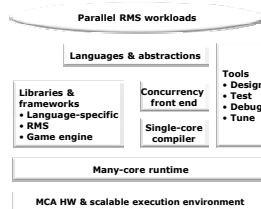
Tera-Scale Programming

• Languages & programming abstractions

- Transactional Memory
- Data parallel operations
- Lightweight tasks
- Fine-grain synchronization

• Compilers

- Multi-language support
- Dynamic compilation
- Speculative multithreading

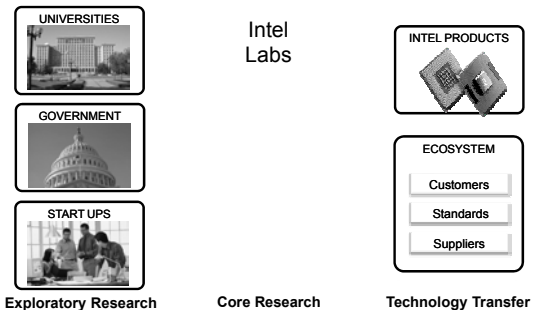


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We Can't Do it Alone

Collaborative R&D Model



Exploratory Research

Core Research

Technology Transfer