2009 International Solid-State Circuits Conference

Intel Paper Highlights

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Intel Senior Fellow

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Intel Fellow

2009 ISSCC Intel Paper Summary

Under embargo until February, 4, 9 p.m. PST 2009

- **The New Era of Scaling for SoC:** Fundamental shifts required in both transistor development and circuit design to continue innovation in microprocessors and SoC products
- **Microprocessor:** Intel will lead half of the microprocessor session with four papers discussing future industry leading 45nm enterprise processors
- **Wireless Technology**: Three research papers on new wireless developments which will enable more capabilities in the future SOC
- **Graphics for Mobile Technology**: A new technique for small mobile devices like laptops, MIDs and nettops for rich multi-media, bringing additional graphics capabilities onto the processor using SIMD
- 15 total papers presented

Industry-Leading Enterprise Processors

Unquestioned enterprise performance leadership

Paper 3.1: A 45nm 8-Core Enterprise Intel® Xeon® Processor

- Codename: Nehalem-EX
- 8-core 16-thread enterprise Xeon® processor
- 2.3B transistors

Paper 3.2: A Family of 45nm IA Processors

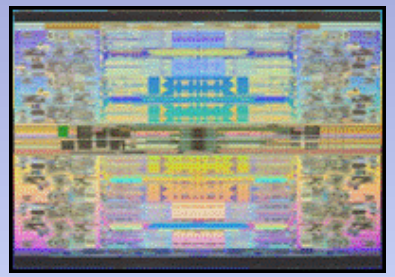
- Codename: Nehalem
- Enhanced Intel® Core™ microarchitecture
- Mobile, desktop and server applications

Paper 3.4: Dynamic Frequency-Switching Clock System on a Quad-Core Itanium® Processor

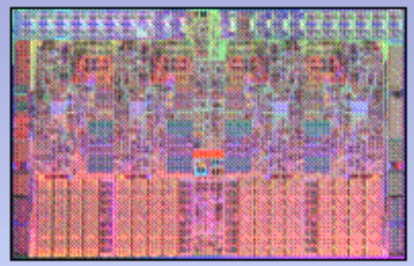
- Codename: Tukwila, 2B+ transistors
- Clock design allows frequency-power optimization without stopping the clock

Paper 3.8: Over One Million TPCC with a 45nm 6-Core Xeon® CPU

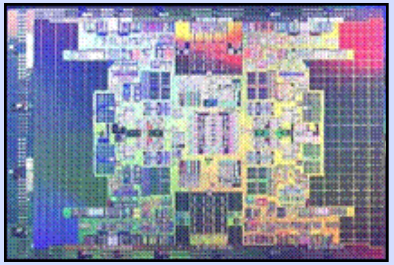
- Codename: Dunnington
- 1.9B transistors, 16MB L3 cache
- 1M transactions/minute TPCC in 8-socket configuration



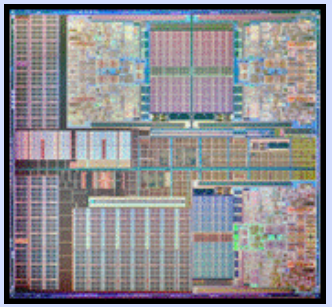
Nehalem-EX



Nehalem



Tukwila



Dunnington

Chip photos not to scale

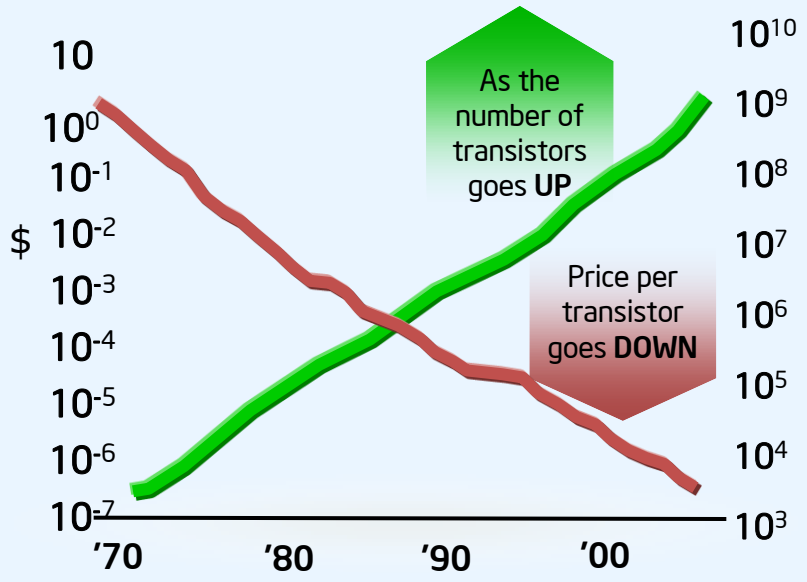
Mark Bohr, Intel Senior Fellow

ISSCC Plenary Talk, Feb 9th

THE NEW ERA OF SCALING IN AN SOC WORLD

Moore's Law Enabling … More

Economics of Moore's Law



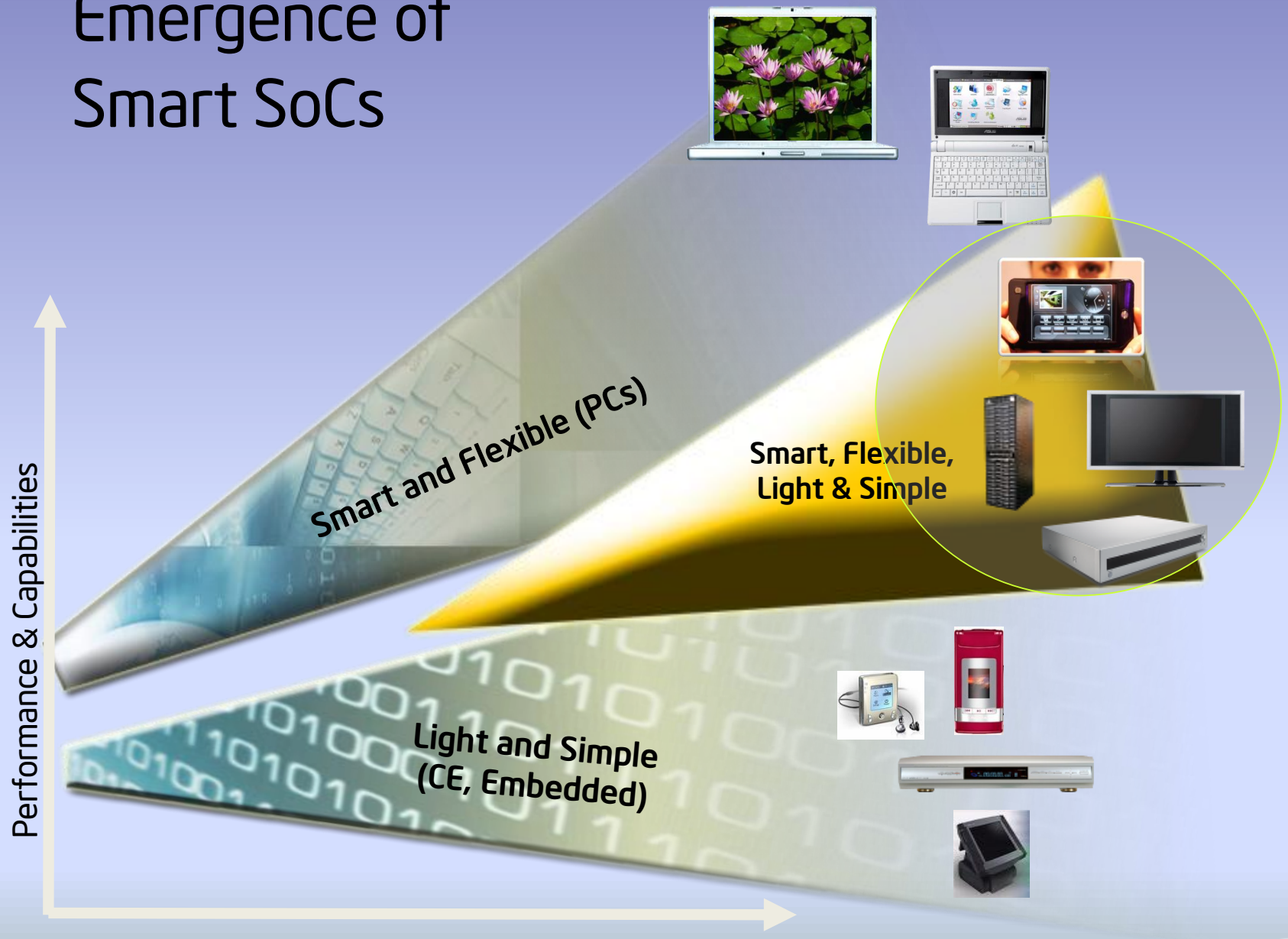
Continue the pace of dimension reduction and feature improvement

Enabling

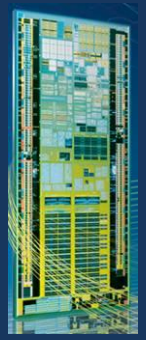
- Supporting unprecedented complexity
- 45nm -> 32nm -> 22nm
- 100s of millions of transistor SoCs

Source: WSTS/Dataquest/Intel

Emergence of Smart SoCs

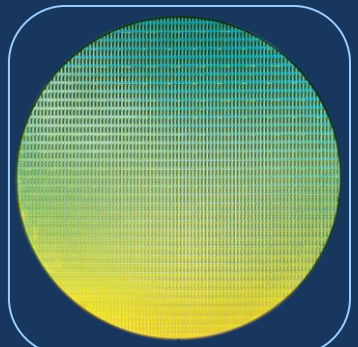


Intel Advantage



Intel Architecture

High performance computing leadership



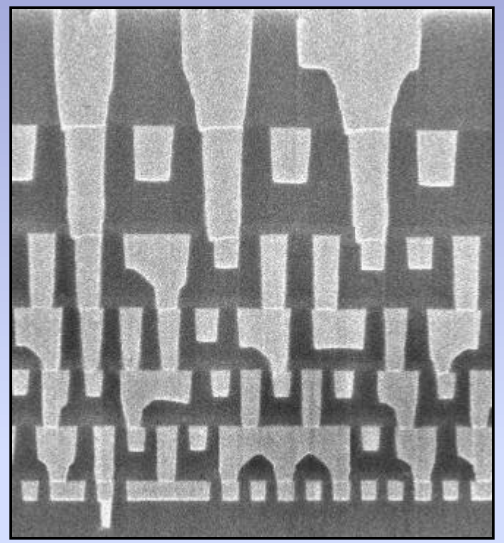
Process technology & high volume manufacturing

High HW & SW complexity handling expertise

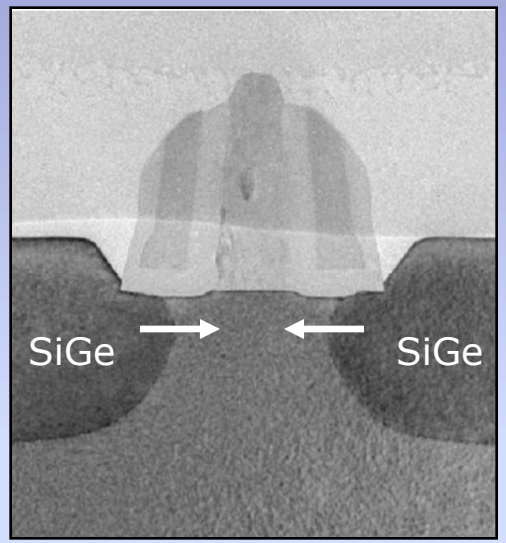
Extensive R&D investment

intel

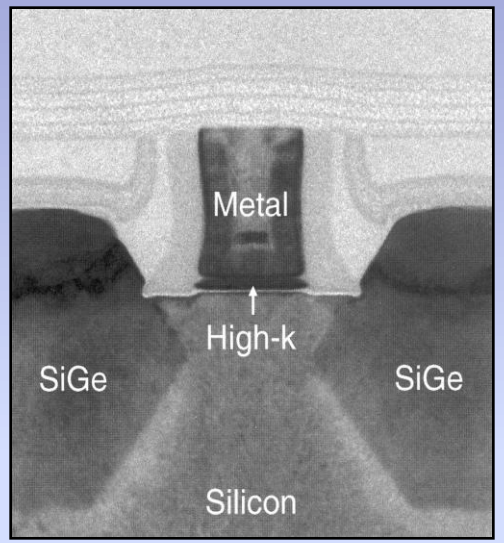
The New Era of Device Scaling



Copper + Low-k



Strained Silicon

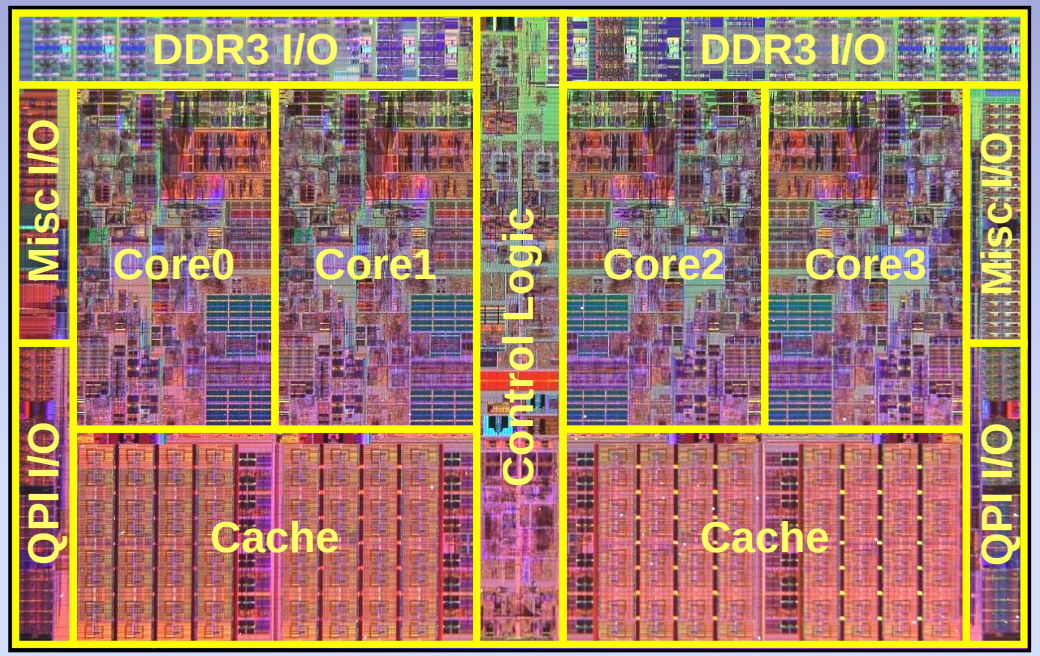


High-k + Metal Gate

Modern CMOS scaling is as much about
material and structure innovation as dimensional scaling

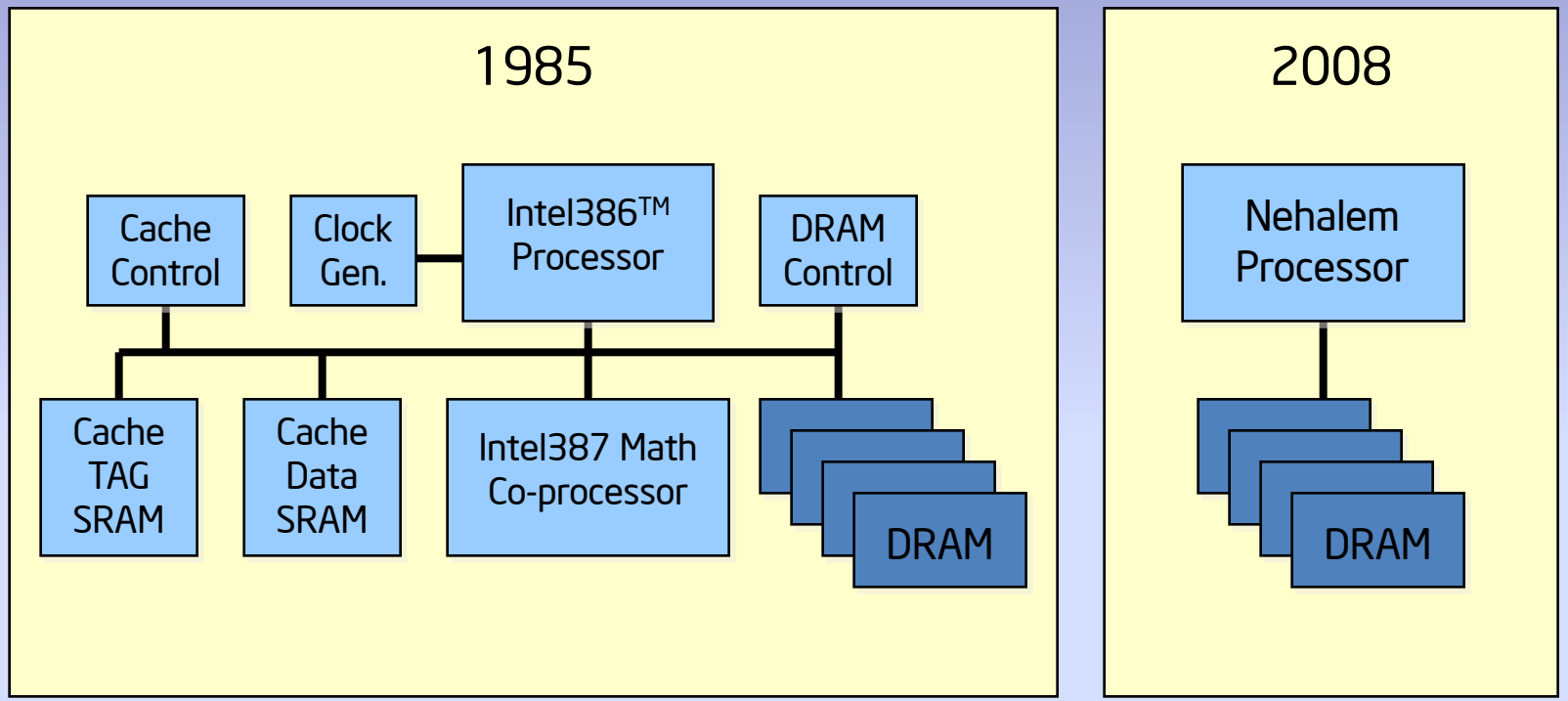
intel

45 nm Nehalem CPU



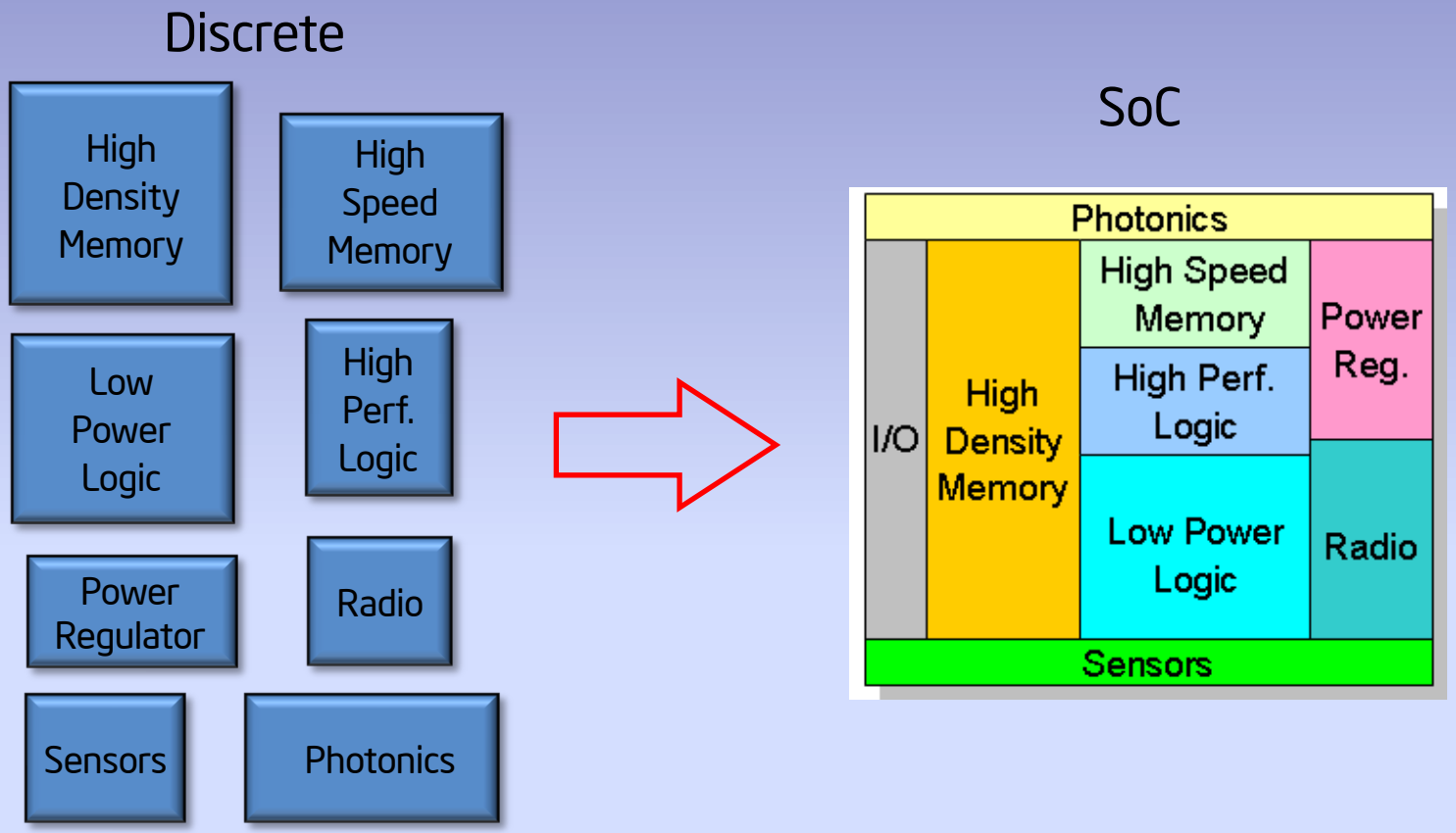
Modern microprocessors are a complex system on a chip with multiple functional units and multiple interfaces

PC Platform Comparison



Modern microprocessors integrate many of the separate system components from past platforms

System Integration



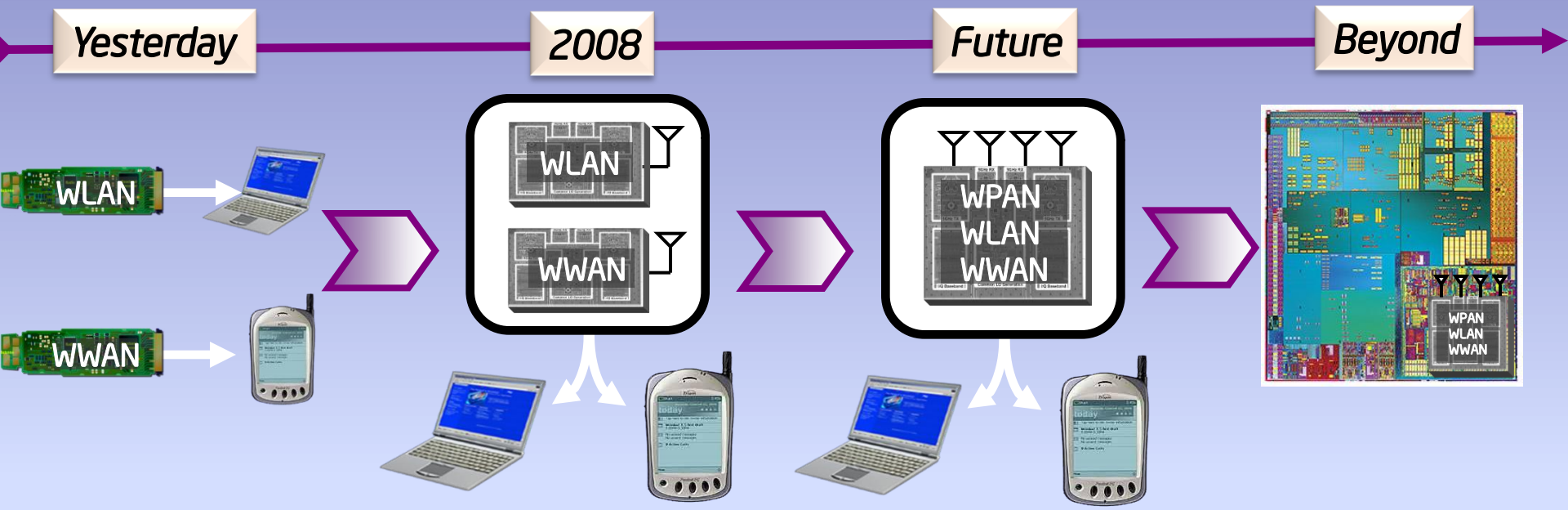
System integration will continue, using key elements such as the Atom™ core, to realize improved performance and power in a smaller form factor

Krishnamurthy Soumyanath (Soumya)
Intel Fellow, Corporate Technology Group
Director, Communications Circuits Research

FUTURE SOC TECHNOLOGIES:

DIGITAL MULTI-RADIO, GRAPHICS FOR MOBILE & SENSORS

The Wireless "Radio" Evolution



Discrete Radios
One standard
Bulky, costly
Inflexible

Integrated Radios
Full CMOS Integration
Dual-standard
+Performance, -Cost, -TTM

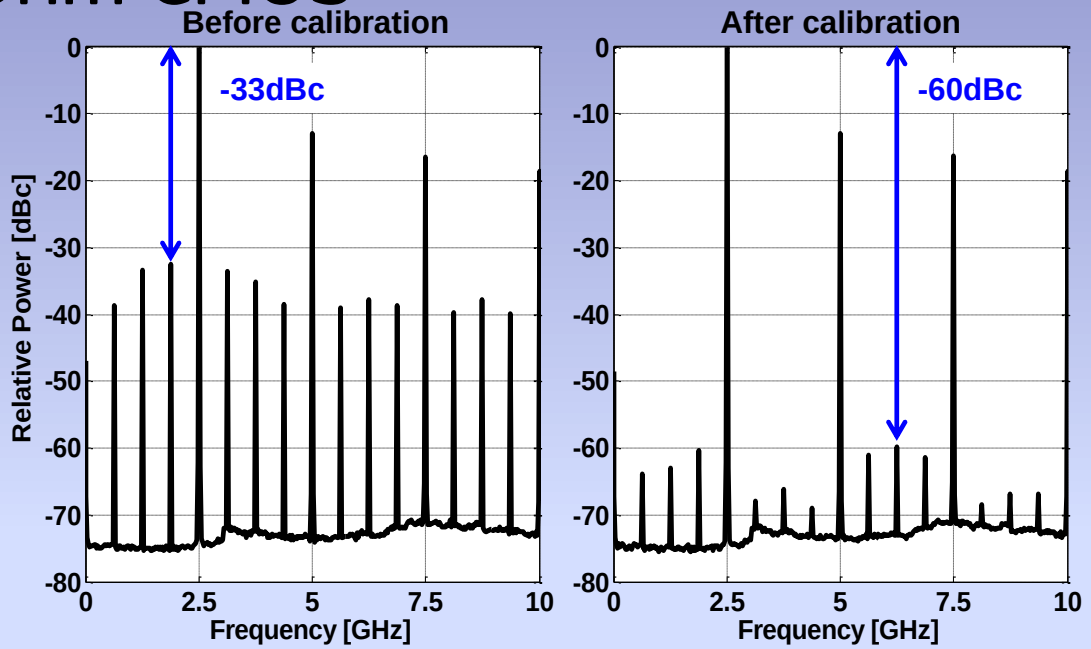
Digital Multi-Radios
Reconfigurable CMOS Radios
Multi-standard
Tunable antenna

SOC
Full DMR on SOC
New Embedded Apps
--Cost, --TTM, ++Perf.

Vision: Connectivity Anytime, Anywhere for Everyone

Digital Techniques for radio data transfer in 45nm CMOS

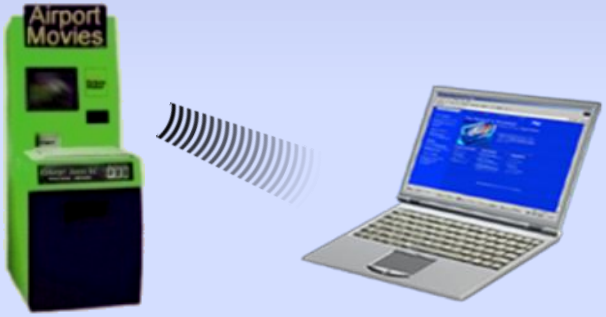
- Pulling-free LO generation by means of fractional division
- Reduced amount of components required, saving silicon area, power and cost
- Takes advantage of inherent statistical variations in the 45nm CMOS process to measure and calibrate mismatches



WiFi/WiMax 2.5/3.5GHz LO generation with digital calibration with no filtering

Next-Gen WLAN

Wireless Display



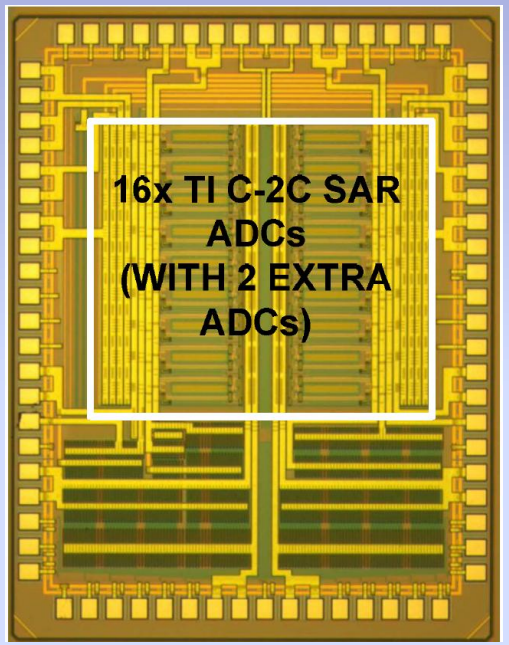
Sync-n-Go

Wireless Computing

Gigabit wireless enables better user experience and new applications

Low power, high data for 60Ghz communication

Convert analog signals to digital by using multiple SAR ADCs and spreading task across all of them.



Data rates in excess of 3Gb/s to allow a DVD quality movie to transfer wirelessly in less than 15 seconds

First ADC that can resolve 7 bits at 2.5Gb/s in pure CMOS, Key step toward digital radios with high performance and low power

Power comparable to the state of the art ADCs available today, but with better accuracy

First 7 bit 2.5GS/s ADC in 45nm CMOS process.

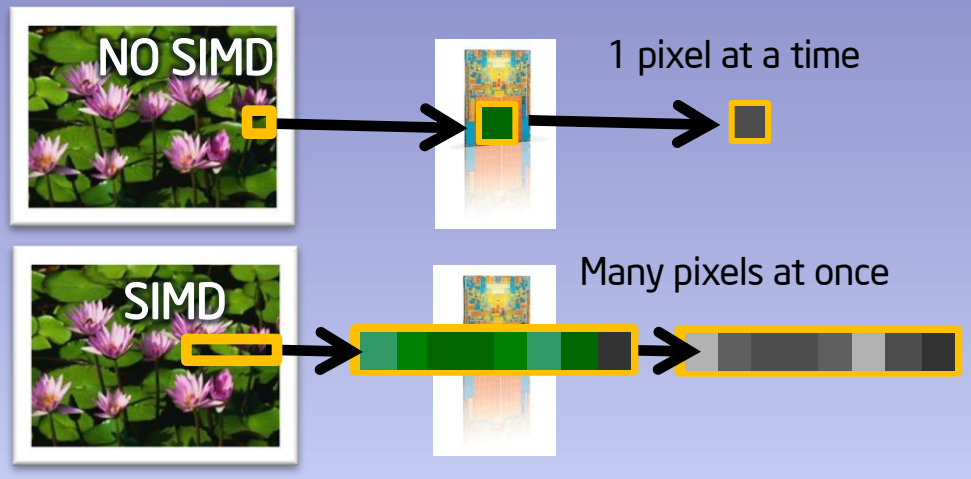
SIMD Accelerator

"A 300mV 494GOPS/W Reconfigurable Dual Supply 4-Way SIMD Vector Processing Accelerator in 45nm CMOS"

Great multimedia experiences require high-performance **SIMD** processing in the CPU or GPU

SIMD = Single Instruction Multiple Data

SIMD Example: Make an image black & white



Can we bring great SIMD performance to highly mobile devices?

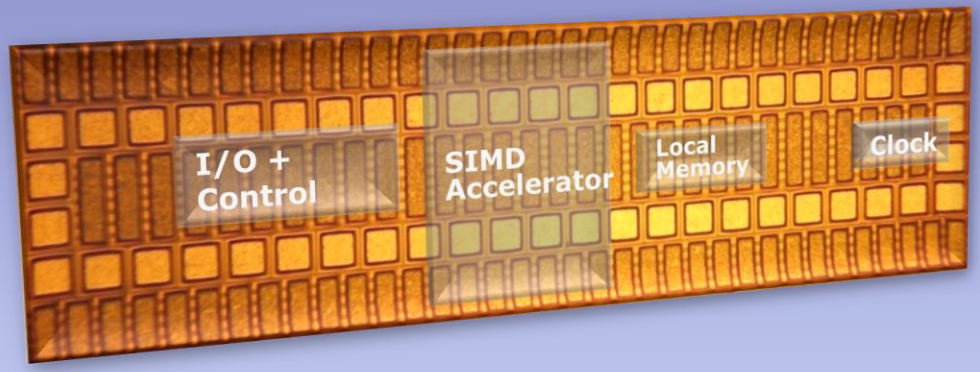
Desktops

Laptops

Netbooks

Mobile Internet Devices

A Low-power, Scalable SIMD Accelerator



SIMD Accelerator Prototype

SIMD Challenges		Our Solutions
• High leakage currents and poor power management	→	• Fine-grain power gating and active power management
• Do not scale down to ultra low voltages	→	• New ultra low voltage circuit techniques

Operation from 1.3V down to ultra-low **0.23V.**
Energy-efficiency up to **10X better** at normal voltages
and up to **80x better** at ultra-low voltages

Potential: Much better graphics on small devices

First 32nm thermal sensor for multi-core microprocessor applications

Achievement:

Numerous remote sensors used to accurately measure temperature over the entire multi-core die in 32nm CMOS

Results:

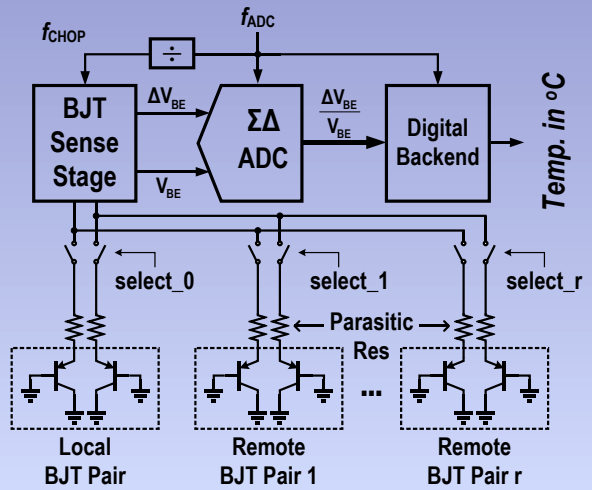
Improves processor power management

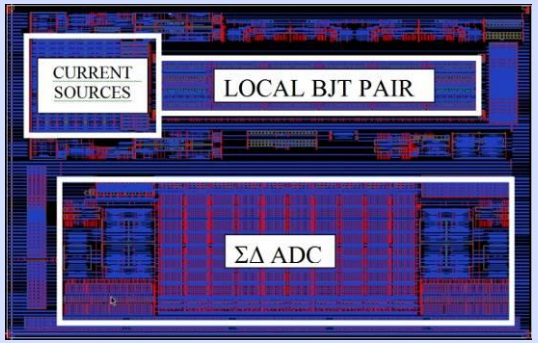
Ability to maximize microprocessor performance, reliably.

Limit leakage through load-balancing with multiple location hot spot temperature measurements

Extend life of processor components by maintaining lower operational stress

Multiple sensors allow more precise identification and intervention





CPU Thermal/power management is crucial to platform performance and energy efficiency

Session 20.1: "A 1.05V 1.6mW, 0.45°C 3σ Resolution ΣΔ based Temperature Sensor with Parasitic Resistance Compensation in 32nm Digital CMOS Process"

Thank You

- Attend Mark Bohr's plenary session:
  - *Feb 9th: 10:30am*
  - *Press Q&A: 1:30pm*

Contact Intel for more info:

- *www.intel.com/pressroom*
- *Megan Langer: megan.e.langer@intel.com, 503-333-1121*

BACKUP

List of Papers (15)

Microprocessor:

- A 45nm 8-Core Enterprise Xeon® Processor
- A Family of 45nm IA Processors
- Dynamic Frequency-Switching Clock System on A Quad-Core Itanium® Processor
- Over One Million TPCC with a 45nm 6-Core Xeon® CPU

Wireless:

- A 1.1V 50mW 2.5GS/s 7b Time-Interleaved C-2C SAR ADC in 45nm LP Digital CMOS
- A 4.75GHz Fractional Frequency Divider with Digital Spur Calibration in 45nm CMOS
- A 1MHz-Bandwidth Type-I ΔΣ Fractional-N Synthesizer for WiMAX Applications

Mobile:

- A Scalable 3.6-to-5.2mW 5-to-10Gb/s 4-Tap DFE in 32nm CMOS
- A 1.1V 5-to-6GHz Reduced-Component Direct-Conversion Transmit Signal Path in 45nm CMOS
- 13.1 A 172mm2 32Gb MLC NAND Flash Memory in 34nm CMOS

Graphics on Mobile:

- 14.6 A 300mV 494GOPS/W Reconfigurable Dual-Supply 4-Way SIMD Vector Processing Accelerator in 45nm CMOS

Process Technology:

- 22.3 A Single-Chip Highly Linear 2.4GHz 30dBm Power Amplifier in 90nm CMOS
- 27.1 A 4.0GHz 291Mb Voltage-Scalable SRAM in 32nm High-κ Metal-Gate CMOS with Integrated Power Management
- Optical I/O Technology in Tera-Scale Computing
- A 1.05V 1.6mW 0.45°C 3σ-Resolution ΔΣ-Based Temperature Sensor with Parasitic-Resistance Compensation in 32nm CMOS

Forum:

- RF Transceivers from 3.x Toward 4G/OFDM-Based Systems

SIMD Accelerator Results

Prototype Results:

- 41% lower power overall
- 6.5x lower active leakage
- 10x lower standby leakage
- 494GOPS/W peak efficiency
- Operates from 0.23V-1.3V
- 161mW @ 2.3GHz, 1.1V