6.189 IAP 2007
Multicore Programming Primer
and Programming Competition

(or Learn to Program the Sony PS3)

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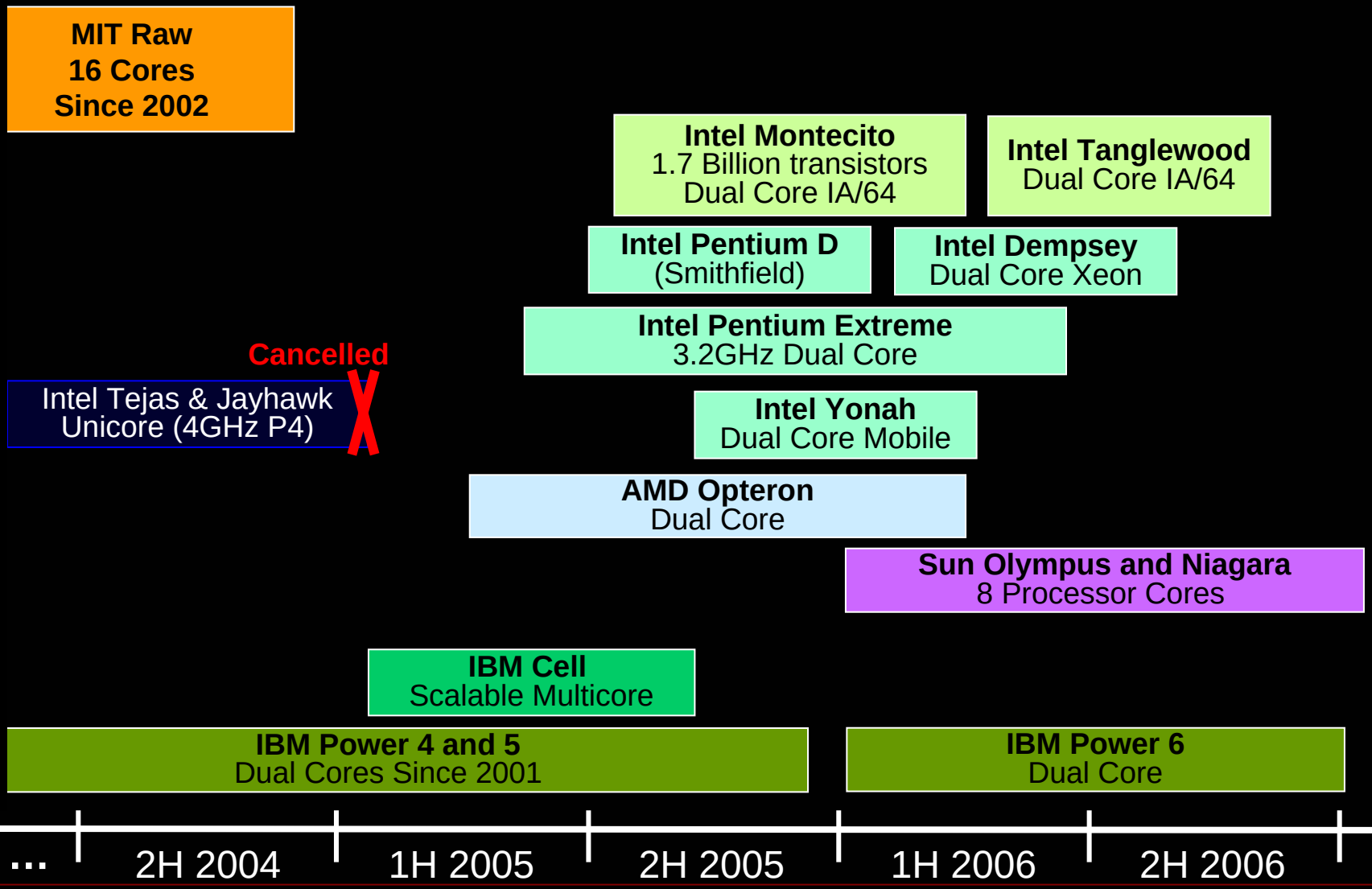
A new processor design pattern emerges: The Arrival of Multicores



What is Multicore?

- Multiple, externally visible processors on a single die where the processors have independent control-flow, separate internal state and no critical resource sharing.

- Multicores have many names…
  - Parallel Processors on a Chip
  - Chip Multiprocessor (CMP)
  - Tiled Processor
  - …

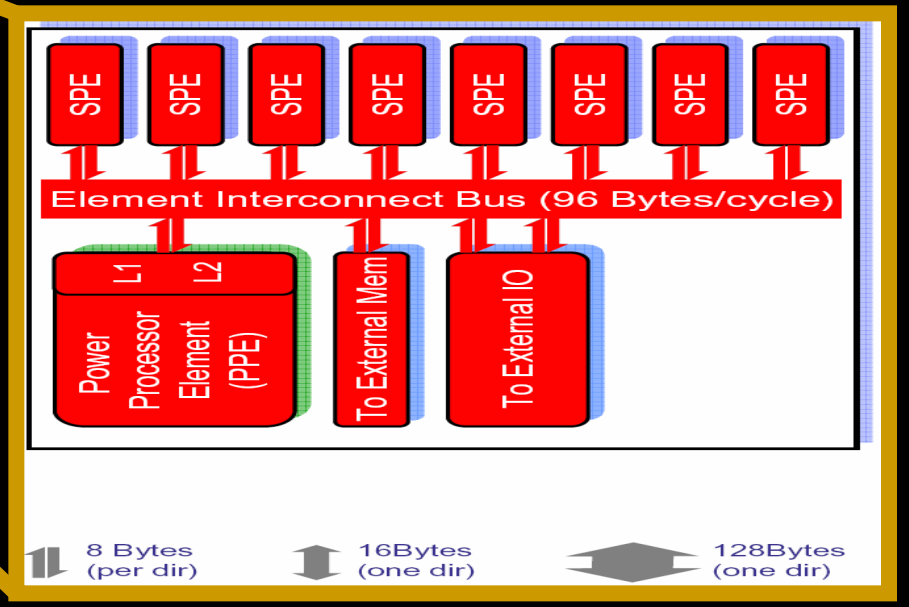
Why Move to Multicores?

- Many issues with scaling a unicore
  - Power
  - Efficiency
  - Complexity
  - Wire Delay
  - Diminishing returns from optimizing a single instruction stream

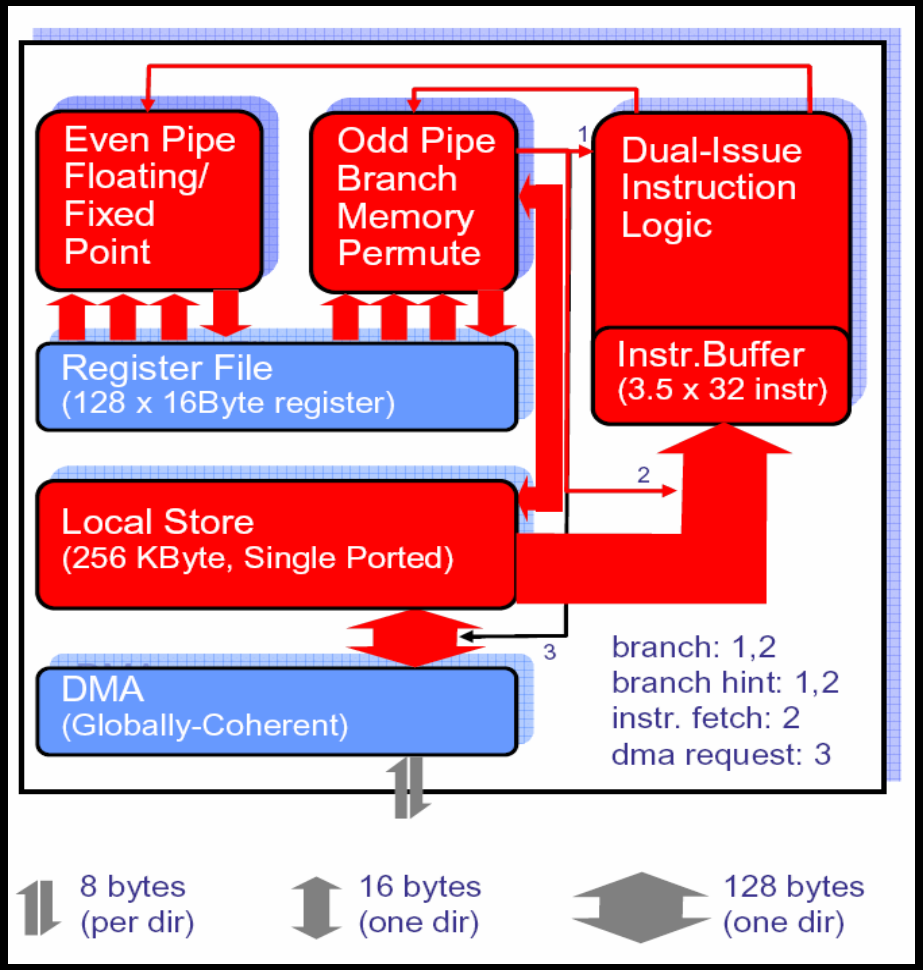
Multicores Of The Future

The PS3: A Multicore Architecture

- "Cell Inside"
  - 9 processing units
    - 8 cores are the same (SPE)
    - 1 Power PC core (PPE)



Synergistic Processing Element (SPE)



- Short vector processor
- SIMD-only
  - 16 bytes register/memory access
- 128 x 128-bit registers
- 256KB local store
  - Aligned accesses only
  - 16 byte for load/store
  - 128 byte for IFETCH/DMA
- Dedicated DMA engine
  - Explicitly move data in and out of the local store
  - 16 outstanding requests
- Dual issue (under certain constraints)
- No H/W branch prediction
  - Compare/select predication
  - Branch hint instruction

Programming Multicores

- Programming multicores is different from traditional programming (for uniprocessors)

Uniprocessors
Single flow of control
Single memory image
Sequential Programming: no explicit need for orchestration of computation or communication

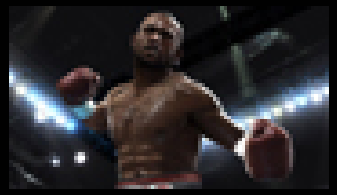
Multicores
Multiple flows of control
Multiple local memories
Parallel Programming: orchestration of computation and communication is a sure necessity

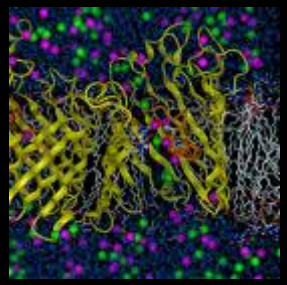
- Parallel programming traditionally in exclusive domains
  - NASA, Scientific codes, and the like

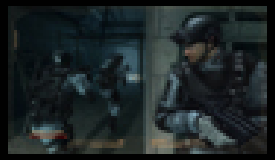
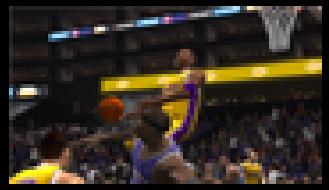
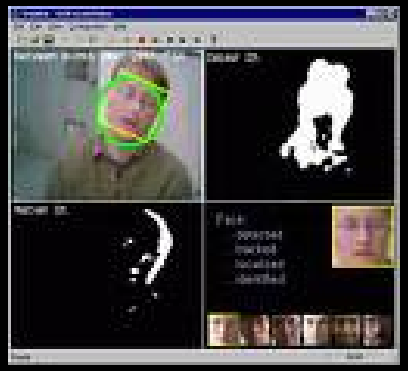
What's New in Parallel Programming

- Parallel programming for the masses
- Parallel programming in many domains
- Parallel programming can be fun

The New Parallel Programming Phenomenon



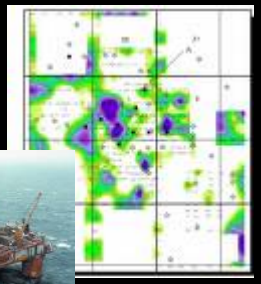









What Is This Course About

- Learn about the emergence of multicores
  - Why is parallel hardware finally becoming mainstream
- Learn about parallel programming patterns
  - Classical and new work in the field
- Learn about challenges in parallel programming with hands on experience
  - Programming languages, tools for debugging, tools for performance monitoring
- Get your hands on a PS3 to make it all fun
  - Group projects will run on PS3 hardware

Project Ideas

- New feature rich games or applications
  - Exploit available resources for new effects or features
  - Multimedia feature extraction and indexing
- Simulation of molecular dynamics
  - For drug discovery, protein folding
- Security applications
  - Feature detection (face recognition), pattern matching (network intrusion detection, gene discovery)
- Monte Carlo simulations
  - Medical imaging to recognize abnormal tissues
  - Oil field analysis to find oil rich wells
  - Models for financial markets to maximize profits
- Algorithms that exploit SIMD properties of SPEs

More Project Ideas

- Linear Algebra Library
- Multi-pattern string matching
- Black Scholes PDE Solver
- JPEG or MPEG encoding
- Viterbi Algorithm applied to bioinformatics

Examples of Project Scope

- Can take existing algorithms and re-implement them in a parallel or SIMD equivalent
  - Pattern matching for security applications
- Can take existing applications and modify them for the PS3 adding new capabilities
  - Add new features to the Quake 3 game engine
- Design and implement a new project form scratch that harnesses the power of the Cell and PS3

Course Organization

- Lectures three times a week
  - Monday, Wednesday, and Friday
  - 2 – 1 hour lectures with small break between lectures
  - 10 am – 12:15pm
- Labs and recitation two times a week
  - Tuesday and Thursday
- Group project
  - Small teams (no more than 4-5 per group)
  - Project presentation on Thursday January 29
  - Each group will have dedicated access to PS3 and tools
- Awards and Reception on Friday January 30
- Course will be available on OCW

Course Enrollment

- Interested students should discuss project ideas first by Friday December 15
  - Choose from existing ideas
  - Or come up with your own project idea
  - We'll help you
- Enrollment limited and by invitation
  - Preference to interesting projects

Project Support

- Direct access to PS3 hardware
- Direct access to Tools from Sony and IBM
  - Compilers, tutorials, example codes
- Projects can be implemented in
  - C using threads and Cell intrinsic instructions for direct access to the bare metal
  - StreamIt and StreamIt virtual machine which hides the bare metal and provides a rich programming interface
  - Other approaches are also possible (e.g., OpenMP or MPI)

Project Resources

- Go to the course Wiki
  - Browse list of projects idea
  - Submit your project idea
  - Sign up for a project
  - Find team members
- Follow link from course web page
  http://cag.csail.mit.edu/ps3

Who to Contact

- 6.189-chair@mit.edu
  - Email to ask general questions about the course
  - Or to discuss (feasibility of) project ideas
- 6189@lists.csail.mit.edu
  - Students and instructors
  - Send project ideas
  - Find team members

Acknowledgements

- Sony
- IBM
- Toshiba