Math Co-processor
and
Multi-core Processor

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Lecture References:

- Book:
  - *Microprocessors and Interfacing: Programming and Hardware*, **Author:** Douglas V. Hall
  - *An Introduction to Parallel Programming*, **Author:** Peter Pacheco

- Lecture Materials:
  - *M. A. Sattar, BUET, Dhaka, Bangladesh*.

Math Co-processor

- Intel family of math coprocessor are generally labelled as 80x87, which support 80x86 processors in computing.
- Instruction sets and programming of all devices are almost identical
- Intel family of math-coprocessors is able to
  - ***add***
  - ***subtract***
  - ***multiply***
  - ***divide***
  - ***find square root***
  - ***calculate partial tangent***
  - ***calculate partial arctangent***
  - ***logarithms***

Intel Processors and Co-processors

Processor	Corresponding Co-processor
8086/8088	8087
80186/80188	80187
80286	80287
80386	80387SX, 80387DX
80486SX	80487SX

CISC and RISC Processors

- **CISC (Complex Instruction Set Computers):**
  - CISC was developed to make compiler development simpler.
  - It shifts most of the burden of generating machine instructions to the processor.
    - ***For example**, instead of having to make a compiler write long machine instructions to calculate a square-root, a CISC processor would have a built-in ability to do this.*

CISC and RISC Processors

- **RISC (Reduced Instruction Set Computers):**
  - RISC is a type of microprocessor architecture that utilizes a small, highly-optimized set of instructions, rather than a more specialized set of instructions often found in other types of architectures.
  - **History**
    The first RISC projects came from IBM, Stanford, and UC-Berkeley in the late 70s and early 80s. The IBM 801, Stanford MIPS, and Berkeley RISC 1 and 2 were all designed with a similar philosophy which has become known as RISC.

CISC and RISC Processors

The main characteristics of **CISC** microprocessors are:

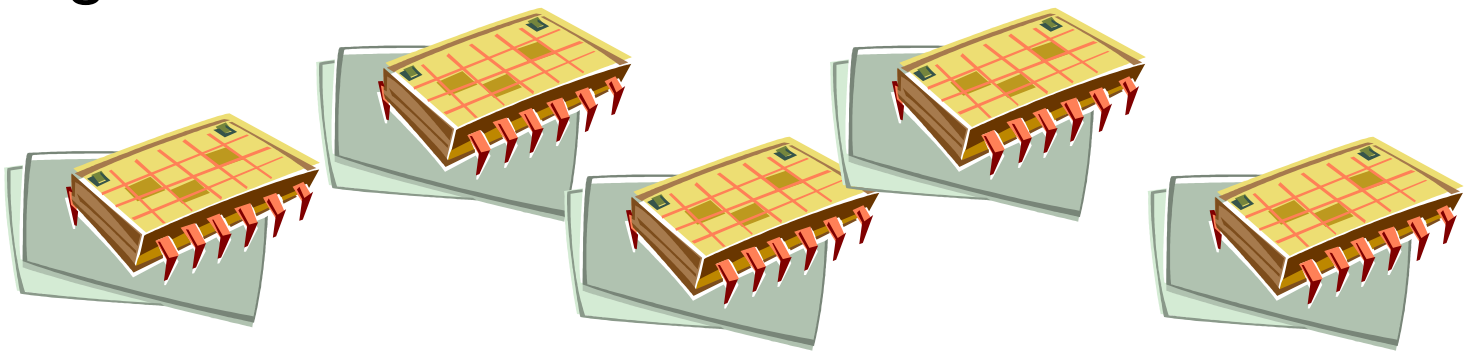
- Extensive instructions.
- Complex and efficient machine instructions.
- Extensive addressing capabilities for memory operations.
- Relatively few registers in use.

In comparison, **RISC** processors are more or less the opposite of the above:

- Reduced instruction set.
- Less complex, simple instructions.
- *Pipelining* is used to allow for simultaneous execution of parts, or stages, of instructions
- Many symmetric registers are used.

Age of Multi-core Processors

- From 1986 – 2002, microprocessors were speeding like a rocket, increasing in performance an average of 50% per year.
- Since then, it's dropped to about 20% increase per year.
- **An Intelligent Solution:**
  - Instead of designing and building faster microprocessors, put multiple processors on a single integrated circuit.



Is Multi-core Processors is the Solution?

- Up to now, performance increases have been attributable to increasing density of transistors in multiple microprocessors.

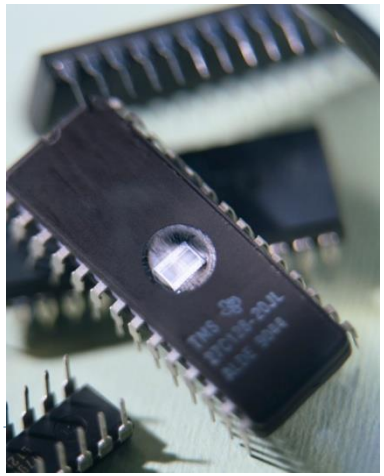
- But there are inherent problems:
  - *Smaller transistors = faster processors*
  - *Faster processors = increased power consumption*
  - *Increased power consumption = increased heat*
  - *Increased heat = unreliable processors*

Multi-core Processor and Parallel Programming

- Adding more processors doesn't help much if programmers aren't aware of them…
- … or don't know how to use them.

- Serial programs don't benefit from this approach (in most cases).
- Move away from single-core systems **to multi-core processors** and **Introduce parallelism**!!!

- "Core" = central processing unit (CPU)



Parallel Programming Concept for Multi-core Processors

- Compute n values and add them together.
- **Serial solution:**

```
sum = 0;
for (i = 0; i < n; i++) {
    x = Compute_next_value(. . .);
    sum += x;
}
```

- n iteration requires to add.

Parallel Programming Concept for Multi-core Processors

- 8 cores, n = 24, then the calls to
- 1,4,3, 9,2,8, 5,1,1, 5,3,7, 2,5,0, 4,1,8, 6,5,1, 2,3,9
- The Master Core runs the serial program

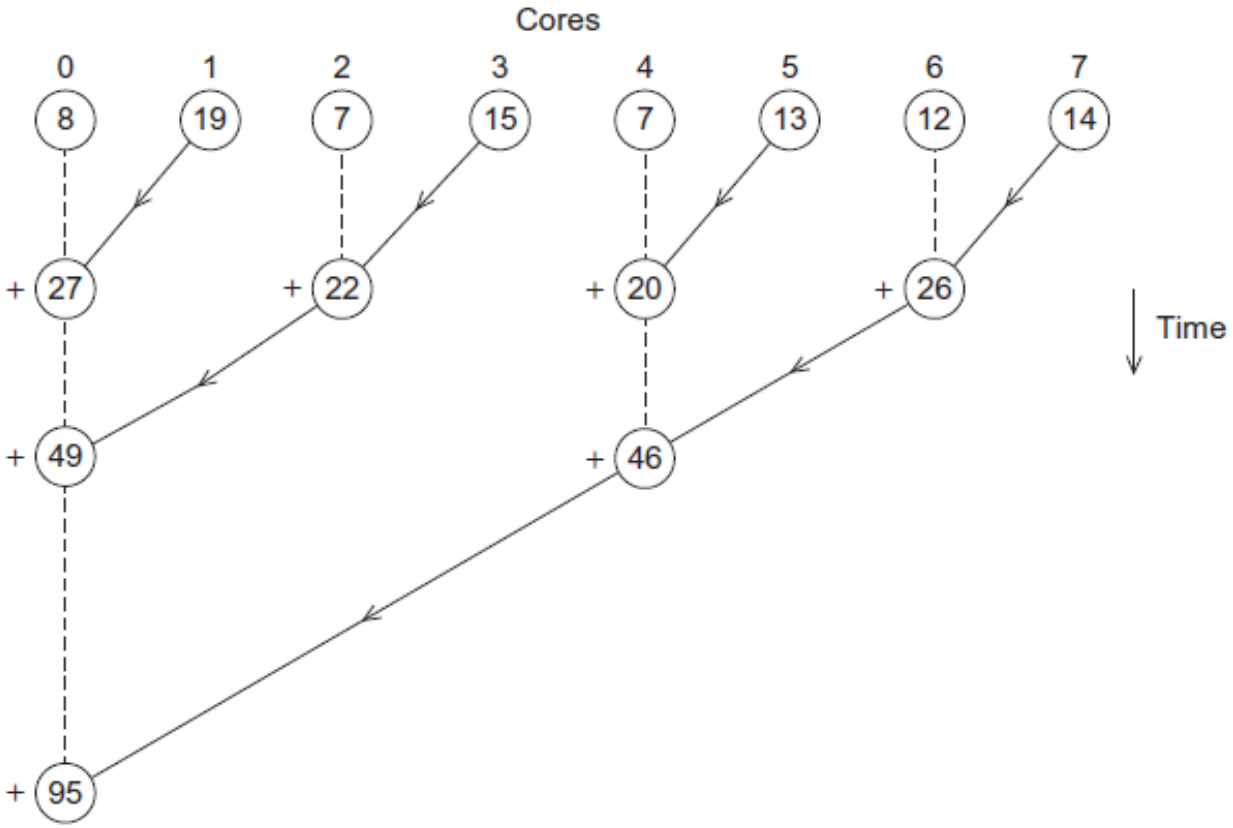
```
if (I'm the master core) {
   sum = my_x;
   for each core other than myself {
      receive value from core;
      sum += value;
   }
} else {
   send my_x to the master;
}
```

Core	0	1	2	3	4	5	6	7
my_sum	8	19	7	15	7	13	12	14

Core	0	1	2	3	4	5	6	7
my_sum	**95**	19	7	15	7	13	12	14

Parallel Programming Concept for Multi-core Processors

But wait! There's a much better way to compute the global sum.



Parallel Programming Concept for Multi-core Processors

- **Analysis**
  - In the first example, the master core performs 7 receives and 7 additions.
  - In the second example, the master core performs 3 receives and 3 additions.
  - The improvement is more than a factor of 2!
  - **Imagine, If we have 1000 cores:**
    - The first example would require the master to perform 999 receives and 999 additions.
    - The second example would only require 10 receives and 10 additions.
  - That's an improvement of almost a factor of 100!

Salient Features: Dual Core and Core 2 Duo

- **Architecture**

- *Dual Core:* The dual core is the older of the two having an architecture that sports two cores on one processor, but its older technology puts it in a position of disadvantage.

- *Core 2 Duo:* The core 2 duo has two cores on the same processor. However while the architecture sounds vaguely the same, it is more advanced than the dual core processors.

Salient Features: Dual Core and Core 2 Duo

- **Performance**
- *Dual Core:* This is without a doubt one of the best Intel processors, however it lacks the bite in terms of performance. Acceptable enough clock speeds of about 2.33 GHz for the best ones.

- *Core 2 Duo:* This newer processor beats the dual core in all bench-marking tests and therefore performance-wise, is definitely the better pick. Slams the opposition clocking speeds of 3.33 GHz clock as seen of the higher end ones.

Salient Features: Core i3

- Entry level processor
- 2-4 Cores
- 4 Threads

(a **thread** of execution is the smallest sequence of programmed instructions that can be managed independently by a scheduler, which is typically a part of the operating system. Multiple threads can exist within one process, executing concurrently and sharing resources such as memory, while different processes do not share these resources.)

- Hyper-Threading (efficient use of processor resources)
- 3-4 MB Catche
- 32 nm Silicon (less heat and energy)
- Core i3 processors do support 64-bit versions of Windows
- **Suitability:**
  - If you use your computer for basic tasks such as word processing, email, surfing the web, etc., a Core i3 processor is more than enough to handle all of that with ease

Salient Features: Core i5

- Mid range processor
- 2-4 Cores
- 4 Threads
- Turbo Mode (turn off core if not used)
- Hyper-Threading (efficient use of processor resources)
- 3-8 MB Catche
- 32-45 nm Silicon (less heat and energy)
- Suitability:
  - Core i5's offer enough performance to do stuff like video editing and gaming, and more than enough performance to do basic stuff like-word processing, internet surfing, and email.

Salient Features: Core i7

- High end processor
- 4 Cores
- 8 Threads
- Turbo Mode (turn off core if not used)
- Hyper-Threading (efficient use of processor resources)
- 4-8 MB Catche
- 32-45 nm Silicon (less heat and energy)

Thank You !!