Concurrent Programming

Session 7: Multi-Core Programming

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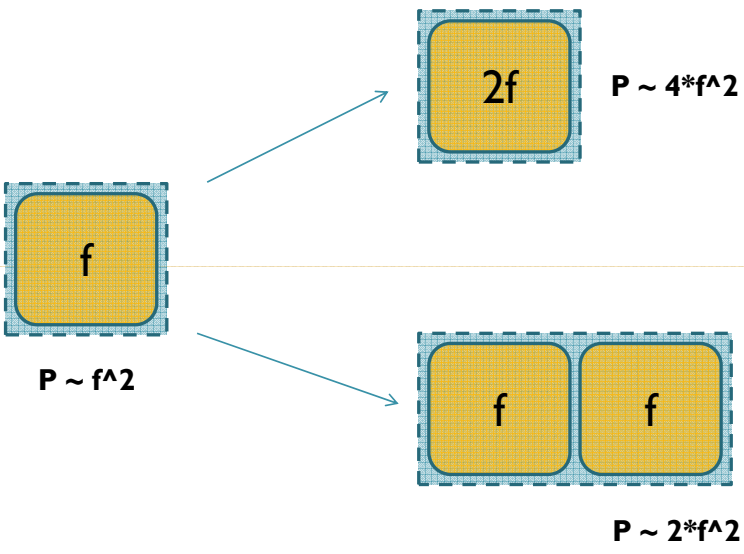
Introduction

- Recent CPU design involves putting multiple processors on a single computer chip.
- IBM, Sun, Intel and AMD have changed their chips to multi-core ones.
- The primary problem is that regular desktop software has not been designed to take advantage of the new architectures.
- Desktop software will have to be redesigned

What's a Multi-Core?

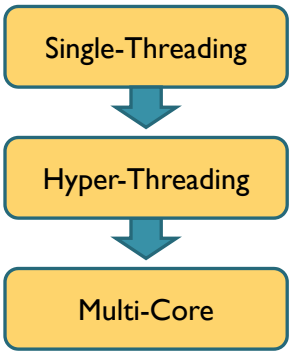
- A multi-core is an architecture design that places multiple processors on a single die.
- Each chip processor is called a core.
- These designs are known as Chip Multi-Processors (CMPs).
- The CMP programming model for is very similar to SMP one.

Power vs. Frequency



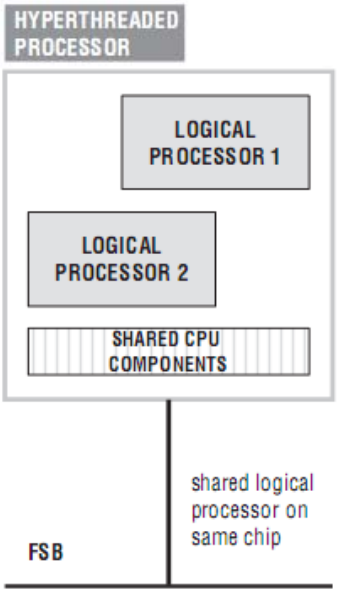
Evolution of Technology

- Single Threading
- Hyper Threading
- Multi-Core



Hyper Threading

- Hyper-Threading Technology (HTT) makes a single physical processor appear as two logical processors.
- The physical execution resources are shared and the architecture state is duplicated for the two logical processors.



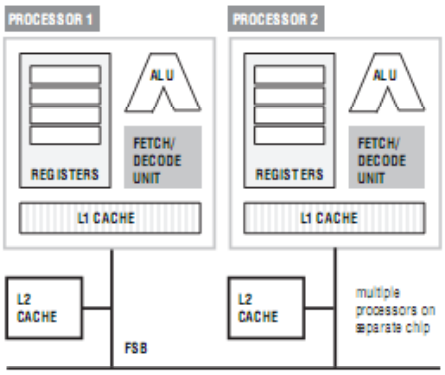
Hybrid Architectures

- Hybrid Multi-Core Architectures mix multiple processor types and/or threading schemes on a single package.
  - A dual-core processor, each core contains two logical CPUs
  - Different processors in a chip

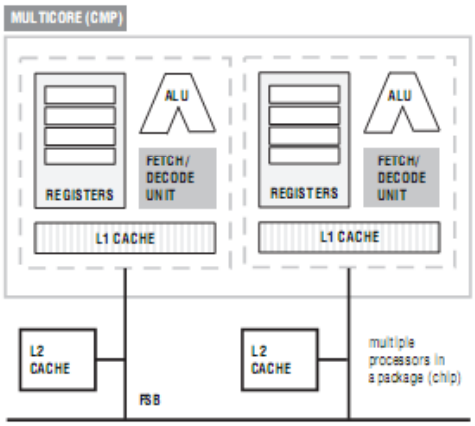
Two Questions

- From the view-point of an operating system, is there any difference between a logical CPU and a real CPU?
- Is it important for an operating system to be aware of hyper-threading technology?

Comparison



Multi-Processor



Multi-Core

When Parallelism?

- In fact, some software solutions and computer algorithms are better implemented using sequential programming techniques.
- Parallelism and multiprocessing come at a cost.
- If the amount of work required to solve the problem sequentially is less than the work required to coordinate between tasks or thread creation, then the sequential approach is better.

CPU Interface

- From a developer's point of view, the primary interface to the processor is compiler.
- Operating system is the secondary interface for a developer programming on a multi-core processor.

Compiler Interface

- Example I: Loop Unwinding
- The goal of loop unwinding is to increase the program's speed by reducing (or eliminating) the "end of loop" test on each iteration

Loop Unwinding

```
for (int x=0;  x < 100 ;  x+=1)
   A[x] = 0;
```

Can be transformed to:

```
for (int x=0; x < 20;  x+=5)
{
   A[x] = 0;
   A[x+1] = 0;
   …..
   A[x+5] = 0;
}
```

Loop Unwinding (cont.)

- How much unroll a loop?

```
for (int x=0; x < 20;  x+=5)
```

or

```
for (int x=0; x < 10;  x+=10)
```

or

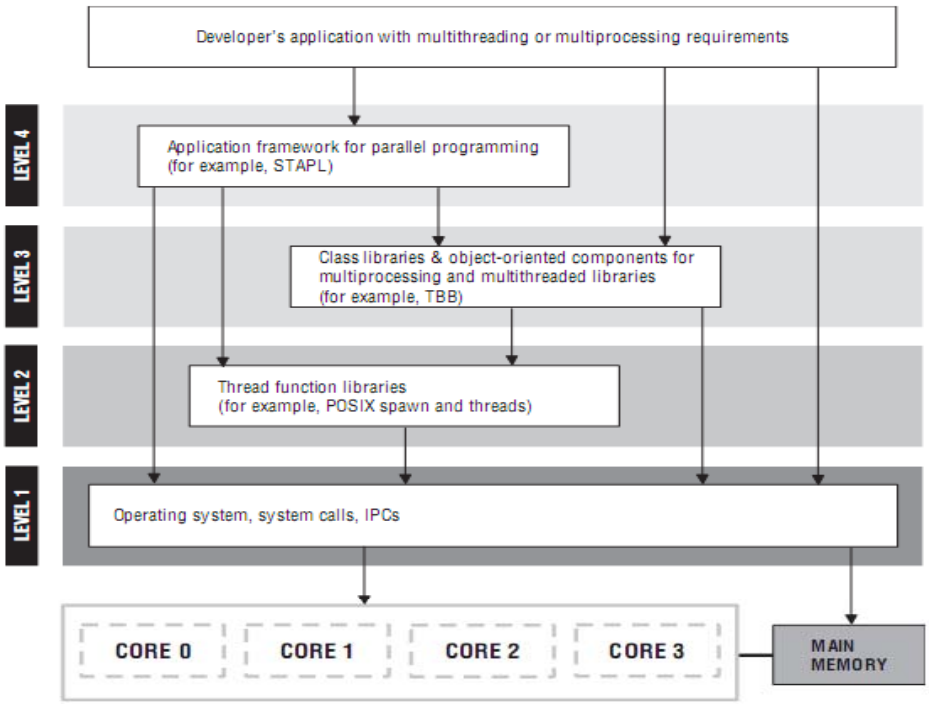
```
for (int x=0; x < 5;  x+=20)
```

Compiler Interface

- Example II: Cache Structure

- Can you give an example of a case where awareness of compiler from cache structure could help?

Operating System Interface



Programming Environments

- Cilk
- OpenMP (Open Multi-Processing)
  - Data Scoping
  - Synchronization
  - Scheduling
- Intel's Thread Building Blocks (TBB)