• Examples of parallel computers
• CTA: a model for predicting performance
Intel Core Duo

Use: Typical PCs
## AMD Dual Core Opteron

![Diagram of AMD Dual Core Opteron](image)

- **Use:** Typical PCs
Generic SMP

Use: Both multi-core and multi-CPU PCs
Sun Fire E25K

Use: High-end servers from Sun
Use: PlayStation 3, Roadrunner supercomputer (w/Opterons)
Cluster

Use: Low-cost large-scale parallelism, Emulab

Internet as network $\Rightarrow$ grid computing
BlueGene/L

Use: Supercomputing
BlueGene/L Networks (2 out of 3)
Spectrum of Machines

- A few processors up to thousands
  - Product roadmaps point to more and more cores
- Shared memory versus distributed memory
  - but always a notion of “here” versus “elsewhere”

⇒ need scalable, portable programs

Expect a **MIMD** perspective, mostly ignoring **SIMD**:

- MMX instructions (width 4 or so)
- GPU instructions (width 64 or so)
- Vector machines like Convex
Models of Computation

Most successful sequential model:

*RAM*, a.k.a. *von Neumann*

For example, predicts that binary search will be much faster than serial search

[confirm by timing C and Java programs]
Models of Parallelism

• Not a good model: PRAM
  ◦ Assumes the same cost for accessing any memory location
  ◦ Fine for asymptotic lower bounds, misleading for practice

• A good model: CTA
  ◦ Stands for Candidate Type Architecture
  ◦ Makes useful predictions about real performance
accessing memory “elsewhere” takes $\lambda$ times as long as “here”
Measuring Approximate $\lambda$

```c
static volatile int val;
...

void read_loop(int id)
{
    int j;

    for (j = 0; j < iters; j++)
        result += val;
}

void write_loop(int id)
{
    int j = 0;

    for (j = 0; 1; j++)
        asm("mfence");
    val = j;
}
```

32-bit 2 Pentium D: 100
32-bit Core Duo: 100
64-bit 2 Opteron: 40
64-bit Opteron 2-Core: 40
64-bit Athlon 2-Core: 40
64-bit 4 Xeon: 50
## Estimated $\lambda$ for Various Architectures

<table>
<thead>
<tr>
<th>Family</th>
<th>Computer</th>
<th>$\lambda$</th>
</tr>
</thead>
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<tr>
<td>Chip Multiprocessor</td>
<td>AMD Opteron</td>
<td>100</td>
</tr>
<tr>
<td>Multiprocessor</td>
<td>Sun Fire E25K</td>
<td>400-660</td>
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<tr>
<td>Co-processor</td>
<td>Cell</td>
<td>N/A</td>
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<td>Cluster</td>
<td>HP BL6000 w/GbE</td>
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