Multicore Computing

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OpenMP

- Open Multi-Processing
- An API that supports multi-platform shared-memory multiprocessing programming in C, C++, and Fortran

OpenMP: Quick Start

```
for (int i = 0; i < N;++i){
        b[i] = a[i] + 1;
}
```

OpenMP: Quick Start

```
#pragma omp parallel for schedule(static) num_threads(8)
for (int i = 0; i < N;++i){
        b[i] = a[i] + 1;
}
```

- g++ test.cc –fopenmp -o test -O2

- brew install libomp
- clang++ test.cc -o test -O2 -Xpreprocessor -fopenmp -I/usr/local/include -L/usr/local/lib -lomp

OpenMP: Quick Start

```
int sum = 0;



for (int i = 0; i < N; ++i){
        sum += a[i];
}
```

OpenMP: Quick Start

```
int sum = 0;
#pragma omp parallel for schedule(static) default(shared) reduction(+:sum) num_threads(8)
for (int i = 0; i < N; ++i){
        sum += a[i];
}
```

OpenMP: Slow Start

- #include<omp.h>
- void omp_set_num_threads(int num_threads)
- int omp_get_num_threads()
- int omp_get_thread_num()

- #pragma omp atomic (update/read/write/capture)
- #pragma omp critical

Gauss-Seidel Smoother

- Solving PDE

- Parallel
- Synchronization
- Lock
- Communication

Matrix Multiplication (in Theory)

$$\begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix} = \begin{bmatrix} A_{11}B_{11} + A_{12}B_{21} & A_{11}B_{12} + A_{12}B_{22} \\ A_{21}B_{11} + A_{22}B_{21} & A_{21}B_{12} + A_{22}B_{22} \end{bmatrix}$$

Matrix Multiplication (in Theory)

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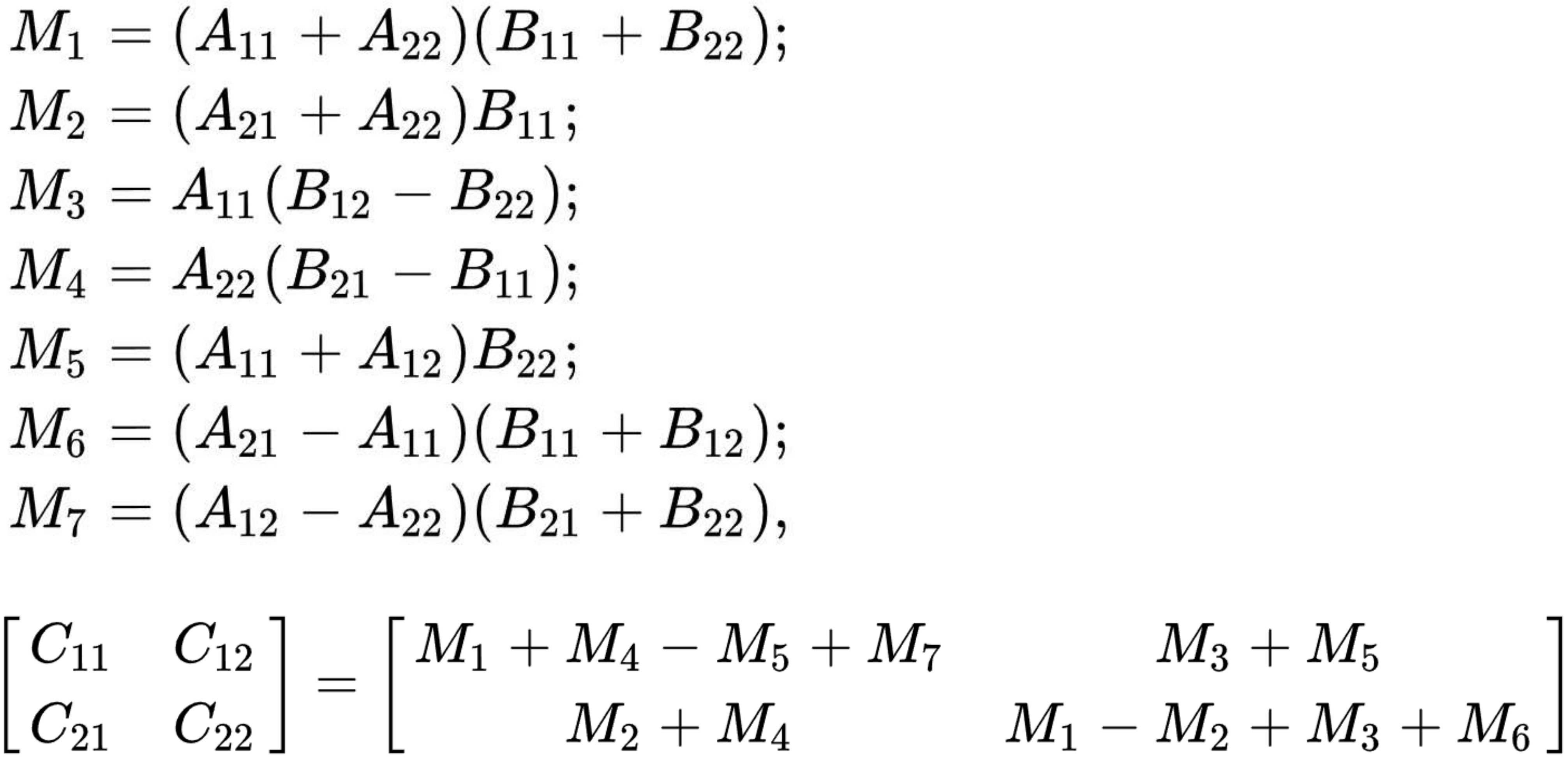
Arithmetic intensity: the ratio of the work to the memory traffic

Strassen Algorithm



$$
\begin{aligned}
M_1 &= (A_{11} + A_{22})(B_{11} + B_{22});\\
M_2 &= (A_{21} + A_{22})B_{11};\\
M_3 &= A_{11}(B_{12} - B_{22});\\
M_4 &= A_{22}(B_{21} - B_{11});\\
M_5 &= (A_{11} + A_{12})B_{22};\\
M_6 &= (A_{21} - A_{11})(B_{11} + B_{12});\\
M_7 &= (A_{12} - A_{22})(B_{21} + B_{22}),
\end{aligned}
$$

$$
\begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix} = \begin{bmatrix} M_1 + M_4 - M_5 + M_7 & M_3 + M_5 \\ M_2 + M_4 & M_1 - M_2 + M_3 + M_6 \end{bmatrix}
$$