

# A Framework for Accurate Measurements with Low Resolution Clocks

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# Outline

A Framework for  
Accurate  
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J.R. Herrero

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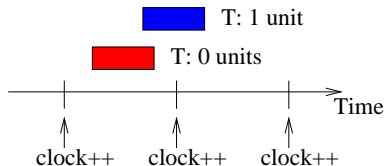
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# Motivation & Goals

## Motivation

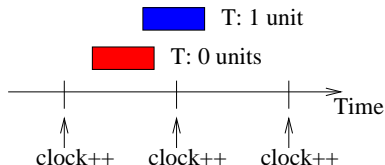
- ▶ Need for accurate measurements of execution time in order to compare the speed of one algorithm with another
- ▶ Clock resolution may be too low for some small problems



# Motivation & Goals

## Motivation

- ▶ Need for accurate measurements of execution time in order to compare the speed of one algorithm with another
- ▶ Clock resolution may be too low for some small problems

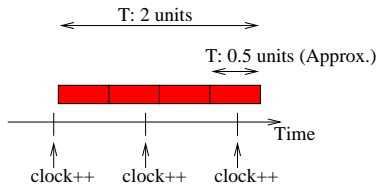


- ▶ **Alternative: Hardware counters**
  - ▶ High accuracy
  - ▶ Not always available



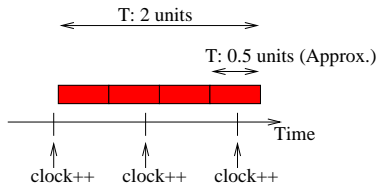
# Idea

Repeat execution a number of times

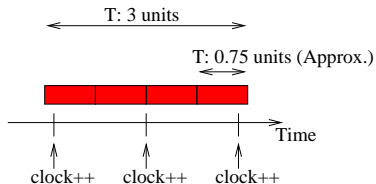


# Idea

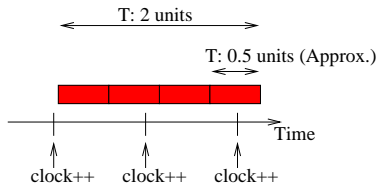
Repeat execution a number of times



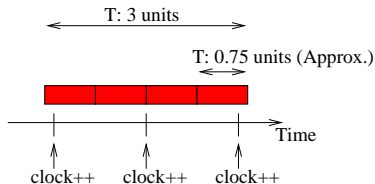
Another run may get different results



Repeat execution a number of times



Another run may get different results



How many repetitions?

# Refined Goal

Determine

- ▶ Minimum number of iterations necessary to obtain results to a desired precision

## Determine

- ▶ Minimum number of iterations necessary to obtain results to a desired precision
- ▶ Automatically

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# Our Context: High Performance Computing

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Obtain the highest *Mflop* rate

$$Mflops = \frac{\#flops \cdot 10^{-6}}{Time}$$

- ▶ Choose the fastest algorithm/implementation
  - ▶ Need to get accurate measurements of their executions

$$|\Delta Mflops| \leq Threshold \quad (1)$$

- ▶ On different plaforms.

Perform execution several times.

$$Mflops = \frac{\#flops \cdot Iterations \cdot 10^{-6}}{Time} \quad (2)$$

How many times?

*Iterations* = ?

$$\frac{\partial Mflops}{\partial Time} = - \frac{\#flops \cdot Iterations \cdot 10^{-6}}{Time^2} \quad (3)$$

$$\frac{\Delta Mflops}{\Delta Time} = \frac{\#flops \cdot Iterations \cdot 10^{-6}}{Time^2} \quad (4)$$

$$Time = \frac{\#flops \cdot Iterations}{Mflops \cdot 10^6}$$

$$\frac{\Delta Mflops}{\Delta Time} = \frac{Mflops^2 \cdot 10^6}{\#flops \cdot Iterations}$$

Hence:

$$Iterations = \frac{Mflops^2 \cdot 10^6}{\#flops} \cdot \frac{\Delta Time}{\Delta Mflops} \quad (5)$$

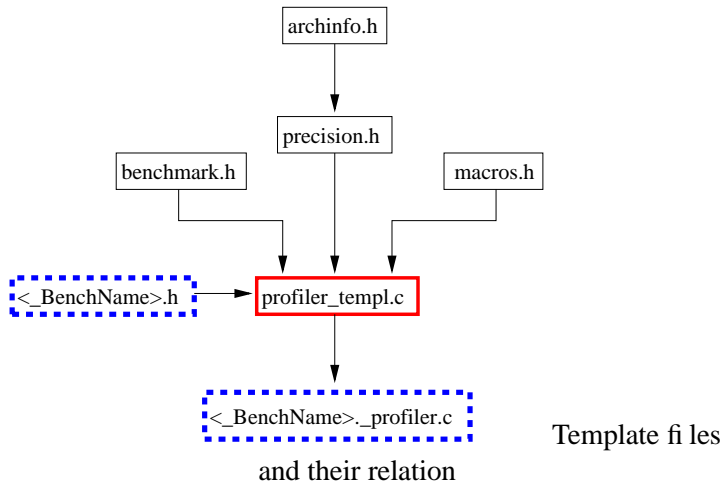
# Example

Determine the number of iterations necessary to obtain results within the desired precision.

- ▶ timing routine with a precision of  $10^{-2}$  seconds ( $\Delta Time = 10^{-2}$ ).
- ▶ desired error in the estimation of its Mflops of approximately 1 Mflop ( $\Delta Mflops \approx 1$ ):

$$Iterations = \frac{Mflops^2 \cdot 10^6}{\#flops} \cdot \frac{10^{-2}}{1} = \frac{Mflops^2 \cdot 10^4}{\#flops} \quad (6)$$

```
#include <...>
main()
...
it = GET_NUMITERATIONS (_NUM_OPERATIONS);
...
GET_MFLOPS (CALL_ROUTINE, ti,it,
            _NUM_OPERATIONS, mflops);
...
```



# User files: mtxms\_profiler.c

```
#ifndef _BenchName
#define _BenchName mtxms
#endif

#include <profiler_templ.c>
```

# User files: mtxms.h

```
/* $Id: mtxms.h,v 1.1 2005/01/21 08:05:31 myusername Exp $ */

#ifndef _BenchRoutine
#define _BenchRoutine _BenchName
#endif

#ifndef _NUM_OPERATIONS
#define _NUM_OPERATIONS 2*i*j*k
#endif

#ifndef CALL_ROUTINE
#define CALL_ROUTINE \
    ad2(_BenchRoutine, _)( pdA, pdB, pdC )
#endif

#ifndef CALL_TEST_ROUTINE
#define CALL_TEST_ROUTINE \
    mtxms_test_ (pdA,pdB,pdD, &i,&j,&k, &lda,&ldb,&ldc)
#endif

#ifndef MATRIX_INITIALIZATION
#define MATRIX_INITIALIZATION \
    inimat_at_bn_(pdA,pdB,pdC,&i,&j,&k,&lda,&ldb,&ldc)
#endif
```

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- ▶ Lack of precision can be avoided by repetition
  
- ▶ Adequate number of iterations can be automatically determined

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