Study and Optimization of a Finite Volume Application

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Convexion-Diffusion

What? Simulates the way heat is transfered in a fluid;

How? Uses finite-volumes method;

Why? Represents surface as a mesh, making each cell only dependent of its neighbours;

Convexion-Diffusion

makeFlux	Calculates the contribution from each edge <- VER ISTO;
makeResidual	Calculates the flux for each cell, from each contribution <- VER ISTO;
LUFactorize	Calculate the exact result of the problem <- VER ISTO;

Test Machine

AMD Opt 6174

2	processores;
12	cores per processor;
2.2 GHz	clock frequency;
128 KB	for L1;
512 KB	for L2;
12 MB	for L3;
64 GB	of RAM;

Test Parameters

1. Best of 3 executions;
2. Test for different number of threads;
3. CENAS;

Original version

For each edge:

1. Calculate edge velocity;
2. Calculate flux;

For each cell

Problem

Analyse the performance of a **matrix multiplication** algorithm,

$$MatrixA * MatrixB = MatrixC \tag{1}$$

wich contains a triple nested loop with the indexes i,j and k (line,column and position).
The implementation used runs two versions of the problem, one multipying matrixA with matrixB, and another multipying matrixA with the transpose of matrixB.

Algorithm

Standard implementation of a matrix multiplication in C.

```
for (i = 0; i < size; i++) {
    for (j = 0; j < size; j++) {
        for(k = 0; k < size; k++) {
            acc += matrixA[i][k] * matrixB[k][j];
            }
            matrixC[i][j] = acc;
            acc = 0;
        }
    }
```

Counters Used

Used counters gathered by PAPI:

- PAPI_TOT_CYC Total cycles;
- PAPI_TOT_INS Total instructions
- PAPI_LD_INS Load Instructions
- PAPI_SR_INS Store Instructions
- PAPI_FML_INS Multiply instructions
- PAPI_FDV_INS Division instructions
- PAPI_VEC_INS Vector Instructions
- PAPI_FP_OPS Floating point operations
- PAPI_L1_DCA L1 data cache accesses
- PAPI_L1_DCM L1 data cache misses
- PAPI_L2_DCA L2 data cache accesses
- PAPI_L2_DCM L2 data cache misses

Test cases

Test cases were selected to fit on the multiple memory levels.
Each Test case was run 4 times for each version of the problem.

Memory	Size	Matrix Size
L1	30 KB	50
L2	255 KB	146
L3	3 MB	500
RAM	7.68 MB	800

Table : Test cases

Memory Accesses

The following table shows the number of memory accesses, through PAPI readings.

Test	PAPI	Accesses/Inst
L1_1	380844	0.49033
L1_2	258412	0.33270
L2_1	9411279	0.42860
L2_2	6318058	0.33449
L3_1	7761996	0.00885
L3_2	152192	0.00020

Conclusion

- Some difficulties measuring memory ceilings;
- Lack of analysis of output from PAPI;

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