Automatic Parametrization on Divide and Conquer Algorithms

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Introduction

The problem:

- Non-expert users take decisions about computation
- Software should adapt to the continuous evolution of hardware
- Developing efficient code by hand consumes a large quantity of resources
- System computation capabilities are very variable

Solution:

- Development of **Parallel routines** with self-optimization capacities
- Different **Self-optimization techniques** applied successfully in different fields
The Problem

Our proposal to obtain self-optimized parallel routines consists on the

Parameterization of the model of the execution time

- a model of the execution time is developed
- parameters are included in the model
- some of the parameters represent the system characteristics
- other parameters are selected to obtain a reduced execution time
The problem: Divide and Conquer

- The application of this technique to the Divide and Conquer paradigm is analyzed.
- The Divide and Conquer scheme consists on
  - The *descomposition* of a problem in smaller subproblems of the same type
  - The *solution* of the subproblems
  - And the *combination* of the partial solutions to obtain the solution of the original problem
The Problem: a parallel Divide and Conquer scheme

Parallel_DC_Scheme (p: problem, n: size): solution
IF MASTER
divide p in subproblems p₁, p₂, ..., pₖ
distribute subproblems to SLAVE processes
receive results from SLAVES
combine solutions of subproblems
ELSE
receive from MASTER subproblem pᵢ
sᵢ = Sequential_DC_Scheme (pᵢ, nᵢ)
send sᵢ to MASTER
ENDIF
ENDParallel_DC_Scheme
The Problem: Model of the Execution Time

The execution time can be represented:

\[ t_{\text{parallel}} = t_{\text{arith}} + t_{\text{comm}} \]

- To estimate the arithmetic cost parameters representing the cost of basic arithmetic operations are obtained: solving small problems and with least square estimation

- The communication parameters are estimated with a ping-pong

- These are the System Parameters, and represent the system characteristics
The Problem: Parameterization of the Model

There are Algorithmic Parameters:

\[ t_{\text{parallel}}(n, \text{AP}, \text{SP}) \]

which can be selected to obtain a reduced execution time: number of slave processors, base of the recursion in the sequential scheme, direct method to solve the basic problems:

\[ t_{\text{parallel}}(n, \text{casoBase}, \text{MD}, p) \]
Optimization proposal
Optimization proposal

**INTERFACE DE CONFIGURACIÓN**

- Generación de los Datos Experimentales
  - Estimación de los Parámetros SP
  - Estimación del Tiempo de Mezcla
  - Estimación del tiempo de comunicación

**ORDENACIÓN**

- Estimación de los Parámetros AP
- Modelo Matemático

**EJECUCIÓN**

**INSTALACIÓN**

#define k_bubuja
#define k_insersion
#define k_selleccion
#define k_merge
#define c_merge
#define t5
#define tv

**Tamaño del problema**
### Experimental results

Comparison of the execution time with the parameters selected by the model and the lowest execution time

<table>
<thead>
<tr>
<th>Size</th>
<th>Lowest Exe. Time</th>
<th>Model Time</th>
<th>Deviation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 mill.</td>
<td>1.04</td>
<td>0.96</td>
<td>7</td>
</tr>
<tr>
<td>4 mill.</td>
<td>1.68</td>
<td>1.53</td>
<td>8</td>
</tr>
<tr>
<td>6 mill.</td>
<td>2.46</td>
<td>2.69</td>
<td>9</td>
</tr>
<tr>
<td>8 mill.</td>
<td>3.30</td>
<td>3.60</td>
<td>9</td>
</tr>
<tr>
<td>10 mill.</td>
<td>4.23</td>
<td>3.90</td>
<td>8</td>
</tr>
</tbody>
</table>
Experimental results

Execution time of the Parallel Algorithm, varying the number of processors, with problem size 1 million
Experimental results

Comparison of the execution time obtained with the model and with base size = 1
Conclusions and Future Works

- The technique of parameterization of the model of the execution time can be applied successfully to obtain Selfoptimizined Parallel Divide and Conquer routines

- In the future:
  - Work with other problems solved with the Divide and Conquer scheme
  - Extend the work to other algorithmic schemes
  - Modify the technique to obtain self-optimized routines for Heterogeneous Systems
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Thanks for your attention!

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