Interactive SW/HW partitioning based on TABU search

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1 Introduction

The increasing complexity of electronic systems, which requires the use of high-level development methodologies as well as partitioning approaches based on optimization methods to ensure getting the best implantations, represents a challenge for designers. In this paper we propose the application of TABU search in the context of Model Driven Engineering (MDE) for an interactive SW/HW Real Time Embedded Systems (RTES) partitioning. Our approach takes benefit from TABU's memory to support the designer's interactivity while choosing a realizable solution.

2 Operational research and SW/HW partitioning:

The partitioning theory allows scheduling tasks on the available computing resources while seeking a minimal cost, it represents a branch of the operational research. Actually, there are two principal optimization approaches: exact approaches and heuristic ones; the first one can be only applied on minor problems. Otherwise, we will be confronted with a temporal explosion. However, the heuristic approach can be applied on complex systems; it generates realizable solutions close to the most optimum one. Such methods enable solving combinatorial problems in a fast and robust way. Two principal heuristic approaches are available in the literature: classic heuristic and approaches based on metaheuristic. The principal objective of a metaheuristic is not simply to generate a solution but, to judge its quality in terms of the best solution obtained and compromise between cost and quality. Indeed, metaheuristics are more efficient than classic heuristics since they resolve the problems caused when using classic heuristics such as the early termination, the determinism of the starting point of research etc.
Some research works have focused on partitioning systems using metaheuristic approaches such as Simulated annealing in [2] [4], yet the proposed partitioning is automatic excluding then the designer's expertise which may lead to unacceptable solutions. Other works [1] have proposed manual partitioning founded essentially on the designer's expertise. It is worthy to note that any wrong decision on the optimum realization can cause development risks. In that context, our approach supplies an interactive SW/HW partitioning based on MDE [6]. The process of partitioning is founded on TABU search which keeps a research's history through the TABU List supporting then the interactive partitioning. In [5], a TABU-based SW/HW partitioning tool has been proposed using a cost function that minimizes only the surface cost and the execution time, however in our case, we use to further minimize the energy cost.

3 TABU based-tool for an interactive SW/HW RTES partitioning: IDSET (Interactive Design Space Exploration Tool)

The exploration phase for optimal solutions should be guided by an objective function which will be based, in our case, on the use of a cost function including the needed constraints variations.

3.1 Objective function:

The generated implantation should meet the designer requirements in terms of the compliance of time requests, minimization of power and energy consumption, and lastly, the minimization of system cost surface. The respect of time behavior will be done using a schedulability analysis

tool such as PTPN in [3]. However, the minimization of consumption and surface is ensured by the proposed tool through the objective function (1) which guides the TABU-based partitioning process.

$$\text{MinZ}= \text{C}_{ij} \times X_{ij} + D_{ij} \times X_{ij} \quad (1)$$

$\forall i, j \in \ 1, ..., n\} \times \{1, ..., m\}$

Knowing that:

- D_{ij} is a characteristic of the task T_i when affected to CR_j : We opt for the execution time that Ti needs on each computing Resource.
- X_{ij} $\begin{cases} 1 \text{ if the task is affected to } CR_j \\ 0 \text{ else} \end{cases}$
- C_{ij} is the cost of implanting a task T_i on a computing resource CR_j, computed by the function (2).

$$cost(sol) = \alpha \times ((AreaCost - minArea)/minArea) + \beta((PwCost - minPw)/minPw) \quad (2)$$

Given that: α and β are two coefficients ranging from 0 to 1 chosen by the designer to lead to the compromise area/consumption such as $\alpha + \beta = 1$.

3.2 Normalization of the proposed objective function:

As it is not allowed to summon a variation (Cost C_{ij}) with an execution time D_{ij}, it becomes necessary to normalize/ standardize the different function's members in order to stay in the same range of values. So, we set x and y two variables strictly positive such us: x=C_{ij} and y=D_{ij}. Then, the objective function will be in the following form function (3):

$$MinZ = f(x) + g(y) \quad (3)$$

f and g are two strictly increasing functions given that the maximum values of x and y will be Xmax and Ymax such as f (Xmax)=g(Ymax)=1 respectively. We take f(x) = x/ Xmax and g(y) = y/ Ymax. In this manner, the different members of the objective function will be in the same range of values.

4 Conclusion

The validation of the proposed interactive TABU-based partitioning method through a case study based on a robot player [7] has proved that the TABU search is an effective method to deal with interactive SW/ HW partitioning for complex RTES.

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