Optimization Issues in Distributed Computing Systems Design

K. Walkowiak[1] **and J. Rak**[2]

Abstract: In recent years we observe a growing interest focused on distributed computing systems. Both industry and academia require increasing computational power to process and analyze large amount of data, including significant areas like analysis of medical data, earthquake and weather forecast, etc. Since distributed computing systems - similar to computer networks - are vulnerable to failures, survivability mechanisms are indispensible to provide the uninterrupted service. Therefore, in this paper we propose a novel 1+1 protection mechanism of distributed systems.

The considered system is designed to process various computational projects consisting of uniform tasks that require the same processing power given in FLOPS. Each computational project has one source node that provides the input data to be processed and one or more destination nodes interested in receiving results of computations. Protection mechanism assumes that computational task is allocated to two computing nodes: primary and backup. Both nodes simultaneously process the same input data and next send results to all destination nodes. We formulate an ILP model related to optimization of survivable distributed computing systems. The objective is to allocate computational tasks to computing nodes and dimension network capacity in order to minimize the operational cost of the computing system and satisfy survivability constraints. Moreover, we assume that the maximum number of computing nodes involved in one project cannot exceed a limit denoted by S. For instance, if $S = 2$, then only two computing nodes can be used to process tasks belonging to any project. The motivation behind this assumption is related to management issues, i.e., less computing nodes involved in a particular computational project (i.e., lower value of the split factor) foster the management of the distributed computing system.

To facilitate high computation complexity caused by the NP-completeness in solving the ILP model, we propose additional cut inequalities that can be applied in construction of branch-and-cut algorithm. We consider the cut-and-branch variant of the B&C algorithm, in which cut inequalities are added to the root node of the solution tree. It means that all generated cuts are valid throughout the whole B&C tree. To construct additional cut inequalities we use the idea of cover inequalities and mixed integer rounding (MIR) inequalities. Results of experiments conducted using CPLEX solver are provided and discussed.

---

[1] Department of Systems and Computer Networks
Wrocław University of Technology
Wybrzeże Wyspiańskiego 27, PL-50-370 Wrocław, Poland
krzysztof.walkowiak@pwr.wroc.pl

[2] Department of Computer Communications
Gdańsk University of Technology
Narutowicza 11/12, PL-80-233, Gdańsk, Poland
jrak@pg.gda.pl