Any cast routing : design using Column Generation

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I. Introduction

In this poster we address the issue of resiliency against network failures in a Grid scenario and show how the anycast principle can be exploited in providing shared protection. We propose a novel formulation for the relocation protection scheme, using column generation (CG). This approach decomposes the original ILP into (i) a Restricted Master Problem (RMP) and (ii) a Pricing Problem (PP) which are iteratively and alternatively solved until the optimality condition is satisfied. Such a CG decomposition has a significant impact on the complexity of the model, leading to a significant improvement over previous ILPs in term of scalability and running times.

II. Any Cast Routing

An important aspect of network deployment is the ability to survive from certain network failures. To deal with those, a network operator can opt to provide network protection. We compare two protection schemes where to protect a connection path from one point to another, a back-up path is reserved. Each primary path has a backup path where wavelengths can be shared between several back-up paths, as long as their corresponding primary light paths do not overlap. We have extended this shared path protection algorithm in a Grid context: multiple processing locations exist and any of those is an equal candidate for processing (hence there is no a priori fixed destination). Thus, instead of reserving a back-up path to the original destination, we may relocate the job to another, possibly closer resource and thereby reduce overall network capacity. Traditional computing methods suffer from the drawback that they are highly unscalable, and thus are not suitable for find a solution for real world instances.

III. Column Generation

The philosophy of CG is to limit the number of variables explicitly included in the ILP problem. This amounts to leaving out columns in an implicit matrix form of the LP. This reduction of the problem size is motivated by the fact that the values of the associated variables are zero in the optimal solution. CG corresponds to an iterative procedure where columns are added one at a time and only if their addition allows reducing the value of the cost objective function. Hence, the original cost minimization problem is split into two sub-problems: the RMP and the PP. The RMP is a restricted version of the original problem as it only contains a subset of the original columns. This RMP needs to be solved optimally after which we formulate a reduced cost function which serves as the objective function of the second sub-problem, the PP. The PP needs to be minimized under the constraints defining the relations among the coefficients of a column. If the reduced cost solution is less than zero, it means we have identified a variable whose addition in the RMP will improve the objective value and the RMP needs to be solved again with the added variable. If PP has no solution with a negative reduced cost, the current LP solution is the optimal solution and all what remains, is to derive an ILP solution.