
Mixed Integer NonLinear Programming Models for the Delay Constrained Routing Problem

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October 2009

1 Problem Statement

We study an application occurring in Telecommunications, first introduced by Ben Ameer and Ouorou [1]. Modern telecommunication services include group-based real-time applications, such as online games and video conferencing which are very sensitive to transmission delays. These types of applications require consideration of both source-to-destination delay (i.e., packet delay from the source to all destinations) and inter-destination delay variation (i.e., the difference in packet delay from the source to different destinations) constraints. Commonly, routing problems are studied under mean end-to-end delay constraints. This approach is not appropriate when dealing with these new services since it ignores the heterogeneous nature of real world networks. The models we consider take into account a delay for each type of commodity as well as a limit on the authorized number of active paths per commodity. We define the transmission delay through a link as a nonlinear function depending on c_e , the installed capacity on this link as well as on x_e , the traffic carried through. Given a set of commodities K , a subset of candidate paths for each commodity $P(k)$, one should be able to route the whole demand by activating a subset of candidate paths with cardinality respecting the authorized limit N and satisfying the delay constraints α_k for any commodity k . This application can be formulated as a mixed integer nonlinear program including "on/off" constraints (see [2]). We note that the model introduced in [1] is a particular case of ours, where the number of authorized paths is equal to one (mono-routing).

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References

1. W. Ben Ameer and A. Ouorou. Mathematical models of the delay constrained routing problem. *Algorithmic Operations Research*, 1(2):94–103, 2006.
2. H. Hijazi, P. Bonami, G. Cornuéjols, and A. Ouorou. Mixed integer nonlinear programmes featuring "on/off" constraints : convex analysis and applications. *Computational Optimization and Applications*, Submitted October 2009. available on *Optimization online* : http://www.optimization-online.org/DB_HTML/2009/10/2442.html.