Media Flow Rate Allocation in Multipath Networks ERRATA

Dan Jurca and Pascal Frossard
Ecole Polytechnique Fédérale de Lausanne (EPFL)
Signal Processing Institute
CH-1015 Lausanne, Switzerland
Email: {dan.jurca,pascal.frossard}@epfl.ch

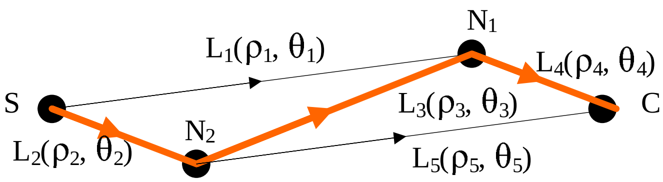

Fig. 1. Simple network scenario with two joint bottleneck links.

I. ERRATA

In [1] we claim that our rate allocation algorithm, especially, Theorem 3 concerning the optimal split of resources of joint bottleneck links, works for every possible network graph $G(V, E)$. However, this is certainly not true, as seen from the following example.

Let the link bandwidths of the network segments in Figure 1 be equal, e.g., $\rho_1 = ... = \rho_5 = B$. Observe that the network scenario presented in Figure 1 offers three possible end-to-end paths between S and C, namely $P_1 = \{S, L_2, N_2, L_3, N_1, L_4, C\}$, $P_2 = \{S, L_1, N_1, L_4, S\}$, and $P_3 = \{S, L_2, N_2, L_5, C\}$, each characterized by the end-to-end available bandwidth $b_i = B$, and end-to-end loss probability p_i, $1 \leq i \leq 3$. Let $p_1 < p_2$, and $p_1 < p_3$, e.g., $1-(1-\theta_2)(1-\theta_3)(1-\theta_4) < 1-(1-\theta_1)(1-\theta_4)$, and $1-(1-\theta_2)(1-\theta_3)(1-\theta_4) < 1-(1-\theta_2)(1-\theta_5)$.

The rate allocation algorithm from [1]picks path P_1 as the optimal transmission path, after which it stops as there is no more available bandwidth in the residual network graph. Therefore, the streaming application streams at rate B, and the media packets are affected by the loss probability p_1, hence the client perceiving a total media distortion D_1. However, please observe that there might be a different solution where paths P_2 and P_3 are used simultaneously for transmission, hence offering the media application a total bandwidth of $2B$, at a higher loss probability, obtaining a perceived media distortion D_2. If $D_2 < D_1$ our rate allocation algorithm fails to find the optimal solution for the path selection and rate allocation problem, especially if the loss probabilities p_1, p_2 and p_3 are very close.

Considering the previous example, please observe that the algorithm from [1]is guaranteed to provide the optimal solution only for network graphs where the choice of transmission paths does not affect the total available bandwidth offered to the application. Hence, we limit here the claim of optimality of the algorithm to these types of network graphs, called **flow-equivalent graphs**.

More formally, for any graph $G(V, E)$, and its equivalent flow transformation $\mathcal{F}$, let path P_i be occupied by flow $\mathcal{F}_i$ characterized by its rate r_i, and let G' be the residual graph, after isolating flow $\mathcal{F}_i$. We define $f = maxflow(G(V, E))$ as the maximum flow rate sustained by the network graph G. For general network graphs the following relation is always true:

$$f \geq r_i + f', \tag{1}$$

where f' is the maximum flow of the residual graph G'.

Definition: We define the **flow-equivalent graphs** as a special category of network graphs for which the previous relation always yields an equality, independent of our choice of $\mathcal{F}_i$.

Flow-equivalent graphs contain every possible network graph that exhibits a single joint network segment, or multiple joint network segments belonging to independent network subgraphs. More general network graphs may also belong to the category of flow-equivalent graphs, depending on the network segment parameters. Flow-equivalent graphs represent most common streaming scenarios, where the bottleneck links are generally shared by all paths as they lie on the last hop segment, or between ISPs.

II. ACKNOWLEDGEMENT

We would like to thank Prof. Patrick Thiran for mentioning this problem, and for the helpful comments and discussions on the subject.

REFERENCES

[1] D. Jurca and P. Frossard. Media-Specific Rate Allocation in Multipath Networks. *IEEE Transactions on Multimedia*, 9:1227–1240, October 2007.