Comments on “Optimal Resource Allocation in Overlay Multicast”

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***Abstract*—In this comments paper, we revisit the network model introduced in [1]. We discuss the inaccuracy of the model and, to correct the network model, we propose to apply directed capacity constraints for directed flows. Based on comparison of numerical results, we show that the corrected model leads to better accuracy than the original model.**

***Index Terms*—Multicast, algorithm/protocol design and analysis, nonlinear programming**

I. INTRODUCTION

IN [1], Y. Cui et al extended the utility-based network model [2] to apply it to overlay multicast with the goal to maximize the aggregate utility of all receivers. Due to the dual role of end hosts as receivers and senders in overlay multicast, two constraints were introduced, namely a data constraint and a network capacity constraint. Unfortunately, the network model was inaccurate with regard to the capacity constraint. In this comments paper, we propose to apply directed capacity constraints for correcting the network model.

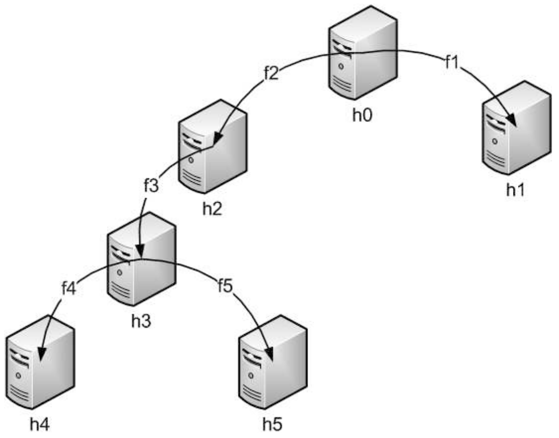
II. THE CORRECTED NETWORK MODEL

In Section 2 in [1], the authors assume links and flows to be undirected, while in reality flows are directed. Indeed, each physical link consists of two directional links, either it is symmetric in bandwidth such as in PSTN or asymmetric as in ADSL. As a consequence, we consider the overlay network to be directed. Therefore we formulate our corrected model as follows: $\Gamma = \{1, 2, \dots, L\}$ is a directed link set in the directed network. The link capacity of $l \in \Gamma$ is c_l. We set $A_{lf} = 1$ if flow f goes through the link l in the direction, here flow f has the same direction of link l. Otherwise $A_{lf} = 0$. The directed capacity constraint is expressed as follows: $A \cdot x \leq c$.

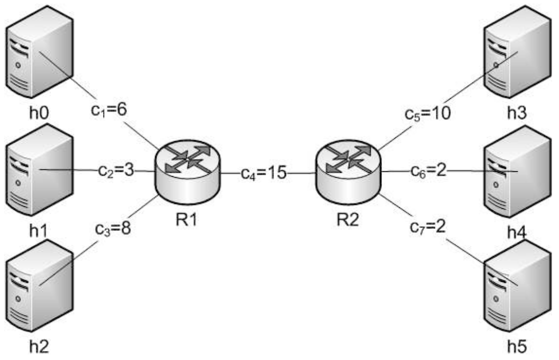
Indeed, the capacity constraints in [2] and [3] could be conceived for directed flows. In particular flows in an IP multicast session transfer data over the same physical link only in one direction [3]. And in the network model for unicast [2] we observed that only flows and links in a single direction were considered. In an overlay multicast session however, flows might go through a physical link in both directions.

III. EXAMPLE RESULTS AND ANALYSIS

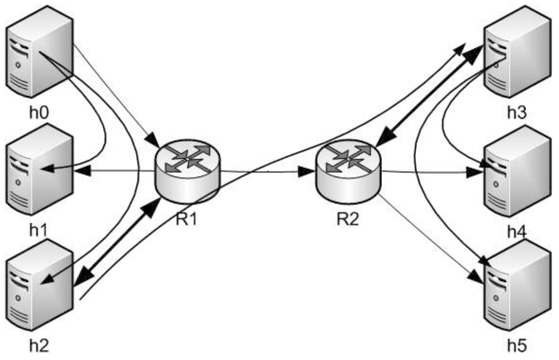
As shown in Figure 1(a), 1(b) and 1(c), we use the same example as in [1] to illustrate the shortcoming in their network model. Inequality (2), which is also presented on page 3 in [1], is the capacity constraint using an undirected network model. Actually, the capacity of physical links, in particular link 3 and link 5, constrain the flows that pass through it in each direction



(a) Application-layer multicast tree



(b) Physical network topology with physical links and their capacity



(c) Directed capacity constraints (the arrow indicate the direction of the link. The bold links, i.e. physical link 3 and link 5, constrain the flows in both directions.)

Fig. 1. Illustration sample of the corrected network model

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independently, hence links and flows are directed. Using the corrected network model, we get the directed capacity constraints as inequality (1) instead of inequality (2). We assume all physic links are duplex and symmetric in bandwidth as indicated in the example: $c_3 = c(R1,h2) = c(h2,R1) = 8, c_5 = c(R2,h3) = c(h3,R2) = 10$.

$$\begin{pmatrix} 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} \leq \begin{pmatrix} 6 \\ 3 \\ 8 \\ 8 \\ 15 \\ 10 \\ 10 \\ 2 \\ 2 \end{pmatrix} \tag{1}$$

$$\begin{pmatrix} 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} \leq \begin{pmatrix} 6 \\ 3 \\ 8 \\ 15 \\ 10 \\ 2 \\ 2 \end{pmatrix} \tag{2}$$

We compare the allocated rates of the corrected network model with the ones of the original one. Using the corrected network model, we determine the algorithms in the same way as proposed in [1]; we set $U_f(x_f) = \ln(x_f)$ for each flow. In the given example the inaccuracy of the model does not affect the optimal rate allocation because physical link 3 and 5 are over-provisioned. However, when link capacity c_3 and c_5 are becoming constraints in terms of bandwidth (for example $c_3 = 6$ and $c_5 = 6$) the situation changes. In this condition, with the corrected network model we get the rate allocation by the algorithm: $x_1 = 2, x_2 = 4, x_3 = 4$, and $x_4 = x_5 = 2$, and the aggregate utility is 4.852. Whereas, with the original model the allocated rates are $x_1 = 3, x_2 = 3, x_3 = 2$, and $x_4 = x_5 = 2$, and the aggregate utility is 4.277. Clearly, our corrected network model is more accurate than the original network model and leads to improved and optimal rate allocations determined by the algorithm.

IV. CONCLUDING REMARKS

The corrections presented in this paper do not affect the final conclusion that the utility-based network model is extendable to overlay multicast while maximizing the aggregated utility of all receivers. Moreover, the distributed algorithm based on the network model converges to the optimal point. However, the corrected network model, as well as the distributed algorithm, is more accurate than the original one in terms of resulting rate allocation.

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