An Energy-Efficient Bandwidth Assignment for Large File Transfer with Time Constraints

Tumentsatsral Badraa[1], Masahiko Aihara[2], Kazhiko Kinoshita[1], Nariyoshi Yamai[3], Takashi Watanabe[2]
[1]Tokushima University, [2]Osaka University, [3]Tokyo University of Agriculture and Technology

***Abstract*—In recent years, the increase of network traffic leads to large power consumption. On the other hand, various types of data have become available in large quantities via large high-speed computer networks. As an advanced service, time-constrained file transfer receives much attention. We investigate to reduce the energy consumption of network by bandwidth assignment based on large file transfer with a time constraint.**

I.INTRODUCTION

The development of network technology leads to high speed and huge computer networks. Therefore, increase in power consumption of the communication devices has become a severe problem [1] [2].

Many studies to reduce network power consumption reported according to dynamic adaptation approach [3]. This paper has a contribution for this problem in focusing to reduce the energy consumption of network node.

We focus on a non-real-time application such as backup application which may require large bandwidth. A transfer request must either be completed by a user-specified deadline or rejected if the deadline cannot be met [4].

Traditional studies of file transfer assume a best-effort manner that does not guarantee the bandwidth and focus on shortening the average transfer completion time [5] [6]. On the other hand, we previously proposed methods about scheduling with hard deadline. It reduces call blocking probability by considering the difference of the deadlines [7] [8].

In this paper, we propose an energy-efficient bandwidth assignment method named Waiting Crossing Requests (WCR). It reduces the network power consumption by waiting the requests until the request that uses the same node but does not uses the same link arrives.

II. PROPOSED METHOD

A. Network model

We assume the following network characteristics. A network topology is represented by a graph $G(V,E)$ consisting of a node set V and a link set E. The bandwidth allocated to each transfer connection is guaranteed, as in Software Defined Network (SDN) [9]. There is a database for managing essential information, such as network topology, link capacity, and ongoing requests, which is used for routing and bandwidth scheduling. The access networks are sufficiently fast so that they cannot become potential bottlenecks.

In addition, we assume the following power consumption model. All nodes and links in the network consume constant power P_N and P_L while they provide any communications, respectively. On the other hand, they consume no power while they do not support any communications. The time and the power consumed when a node or a link goes to sleep, or restart is sufficiently small. Consequently, energy consumption E_{all} and power P_{all} of the network are calculated by the following formula.

$$E_{all} = \sum_{e \in E} P_L \cdot t(e) + \sum_{v \in V} P_N \cdot t(v)$$

$$P_{all} = \frac{E_{all}}{T}$$

Here, $t(e)$ and $t(v)$ mean the total active time of link e and node v, respectively. T is the total active time of the network. Show the example of the power model in Fig.1. When there are two requests R_1 and R_2 in the network, the nodes and the links which are used by each request consume power P_N and P_L, respectively. After R_1 has been completed, the nodes and the links which are used by only R_1 consume no power.

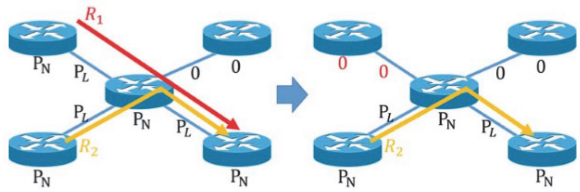

Fig.1 Example of power model

B. Concept

The proposed method assigns all available bandwidth to each request like Earliest Deadline First (EDF) to maximize the sleeping time of nodes and links. However, EDF method is not necessarily appropriate from the power saving viewpoint. Particularly, when there are two requests whose paths are not node disjoint but link disjoint, the power consumption can be reduced by assigning the bandwidth to these requests at the same time. Hereinafter, such a state of these requests is called crossing.

We show the example of crossing requests in Fig.2. There are three requests R_1, R_2, and R_3 in ascending order of the deadline. R_1 and R_2 are not crossed because they do not use a same node and R_2 and R_3 are not crossed either because they use the same link C-D, but R_1 and R_3 cross each other. In this situation, assigning the bandwidth to R_1 and R_3 at the same time shortens the uptime of nodes A and B compared with assigning it at the different time. Hence, it is appropriate for saving power consumption to transfer crossing requests at the same time. However, such a pair of requests does not always

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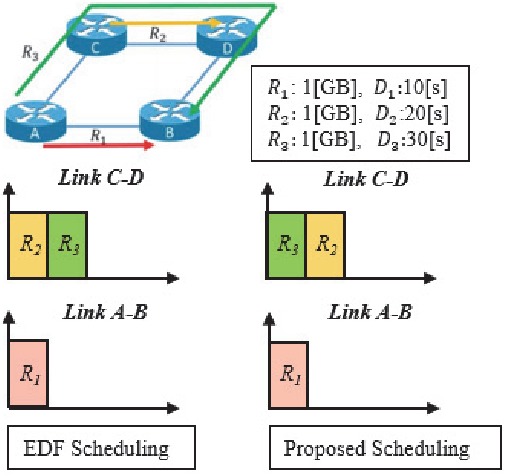
exist. Especially, in a network where requests do not frequently arrive, the probability that crossing requests exist is too small. To reduce the power consumption efficiently in such a situation, we propose the method that makes an arrival request wait until the request crossing the arrival request arrives.



uptime [s]	A	B	C	D
Proposed	8	8	16	16
EDF	16	16	16	16

Fig.2 Power saving scheduling of the crossing requests

C. Waiting Crossing Requests (WCR)

Whenever a new request arrives, the proposed method re-assigns appropriate bandwidth to all ongoing requests.

This method focuses on the request R_i with the earliest deadline among the requests which have not been scheduled yet. All the available bandwidth to transfer $F_{min}=min(F_i, Fj)$ is assigned to requests R_i and R_j in the nearest interval to current time. Two or more requests correspond to request R_j, the bandwidth is allocated in ascending order of the deadline. If no request that is across R_i and has not been scheduled exists or the enough amount of bandwidth to meet R_i's deadline are not allocated, all the available bandwidth is allocated to transfer R_i's remaining file size after the waiting time W_i.

$$W_i = \begin{cases} D_i - \frac{F_i}{C} \times \alpha & (D_i - \frac{F_i}{C} \times \alpha \geq T) \\ T & (D_i - \frac{F_i}{C} \times \alpha < T) \end{cases} \quad \alpha \text{ is a constant}$$

If the amount of bandwidth to complete R_i cannot be guaranteed, the bandwidth is assigned to R_i in the nearest time to W_i and before W_i. If bandwidth assignment does not complete, the arrived request is rejected, and the assignment is restored to the previous assignment. For example, Fig.3 shows requests from R_1 to R_4 with the different arrival time arrive. Waiting time of R_1 request is $W_1 = 30[s]$ calculated then waiting the arrival cross request and transferring the requests at the same time.

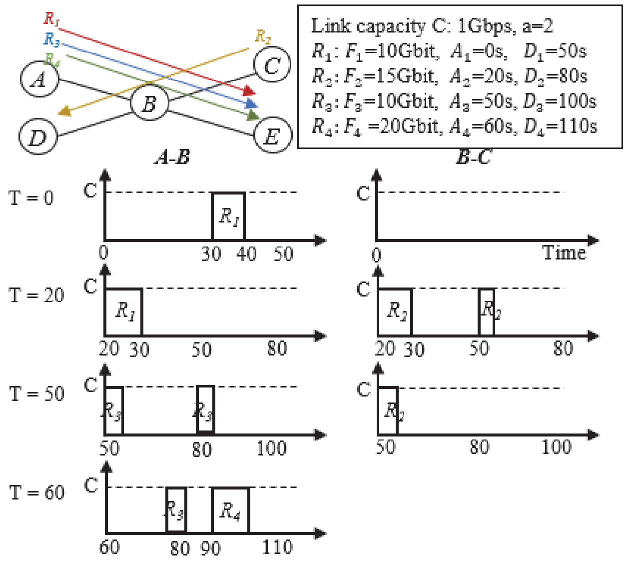


Fig.3: Execution example of WCR method

III. CONCLUSION

We defined the network model and introduced the concept of the crossing requests. The proposed bandwidth assignment method for reducing the network power consumption named WCR reduces the node power by waiting the crossing requests and transferring them at the same time. As a future work, we evaluate the proposed method by simulation experiments.

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