Multi-Source Congestion Control for Content Centric Networks

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ABSTRACT

Content Centric Networking (CCN) is one of the most promising content-oriented network architectures. In CCN, forwarding information base (FIB) is allowed to have multiple entries for a same content name prefix, which means CCN potentially supports multi-source download. When a content is obtained from multiple sources, the technical knowledge obtained for congestion control in the current Internet cannot be simply applied. This is because in the current Internet, FIB is restricted to have only one entry for each IP address prefix, which causes quite different path feature from CCN. This paper proposes a new congestion control for CCN with multi-source content retrieval. The proposed congestion control is composed of end-to-end window flow control and router assisted Interest forwarding control and enables transmission rate regulation only on a congested branch.

Categories and Subject Descriptors

C.2.2 [**Computer-Communication Networks**]: Network Protocols

Keywords

Content Centric Network; Congestion Control; Multiple Content Sources

1. INTRODUCTION

CCN's FIB is constructed by an advertisement of the content name from content sources. Unlike the current Internet, when this advertisement is distributed by multiple sources, there can be multiple out-interfaces in each FIB entry [1]. Namely, since CCN's content retrieval model is multiple sources to one-consumer (many-to-one communication style), users can potentially download a content from multiple sources in parallel. There are some existing works of routing and forwarding that utilize such multi-source benefits of CCN [2][3].

In CCN research fields, congestion control is one of the hottest topics [4]-[9]. A congestion control that can adapt to multi-source content retrieval without breaking content-oriented architecture is required [4][5]. However, Carofiglio et al. [4] rely on location-oriented information for multi-source identification. Feixiong et al. [5] propose Interest rate control adopted to multi-source content retrieval, but rate reduction at the consumer affects all branches, which means rate is regulated even for non-congested path.

In this paper, we propose a new congestion control for multi-source content retrieval in CCN with router branching probability control. The proposed method is based on the window control of Interest transmissions on a consumer. In addition, the proposed method introduces an Interest transmission rate control on a router. The aim of the proposed congestion control is regulating the Interest transmission rate only for a branch suffering congestion.

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2. MULTI-SOURCE CONGESTION CONTROL FOR CCN

2.1 Purpose of Our Congestion Control

Congestion itself has strong relationship with location of a network where traffic concentrates. So, congestion control mechanism naturally should operate in a location-based manner. CCN is a content-oriented architecture trying to weaken or remove location-oriented nature, so it is quite difficult to include some location-oriented operation in CCN. Only one possible element which can get a whole picture of congestion is a "router". A router is a location itself where congestion occurs. CCN has beneficial feature that Data chunk follows reverse path of Interest packets, which enable a router to control transmission rate of Data packet by regulating Interest packets.

2.2 Multi-Source Congestion Control

Our proposed congestion control has the following four features;

i) A router detecting congestion generates and transmits a NAK towards a consumer on the reverse path of the Interest packet.

ii) When a branching router, a router having multiple FIB entries and forwarding arrived Interest packet to multiple interfaces, receives a NAK, it calculates window reduction rate for this NAK arrival branch. This calculated rate is conveyed towards a consumer by a NAK packet.

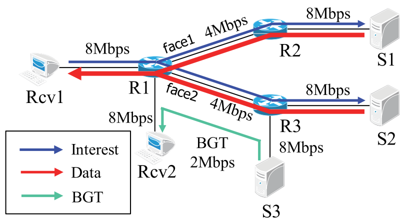
iii) A branching router also reduces its weight of FIB entry for NAK arrival interface. A router having multiple FIB entries has weight for each branch. Arrived Interest packet is forwarded to an interface randomly selected with a probability in proportion to corresponding FIB entry weight. So, reduction of weight means regulating transmission rate towards the corresponding interface.

iv) A consumer controls its congestion window size by AIMD policy. When a NAK packet arrives, window size is decreased in proportion to the calculated reduction rate conveyed by this NAK packet.

We would like to reduce Interest packet transmission rate of only a congested branch by combination of reduction of branching probability to congested interface in iii) and reduction of window size at end host in iv) which is calculated by conveyed information in ii). Sophisticated combination of these two actions enables reduction of half, i.e. multiplicative decrease, of only a transmission rate of a congested branch.

3. PERFORMANCE EVALUATION

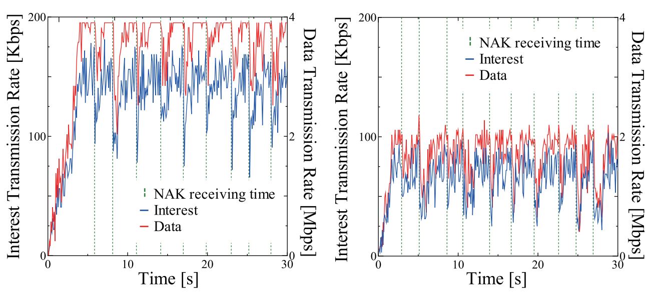
We evaluate our proposed congestion control by computer simulation. ndnSIM1.0 [10] is used for our evaluation. Figure 1 shows simulation model of one branch model with two content sources, S_1 and S_2.



link delay [ms]	10
buffer size [pkt]	30
Data size [Byte]	1000
BGT traffic [Mbps]	2
threshold [%]	60
simulation time [s]	30

Figure 1: Simulation Model

Figure 2 shows Interest transmission rate and Data transmission rate at branch router, R_1. It has two interfaces, face1 and face2, and each graph shows these characteristics of a respective interface. Green dashed lines show NAK receiving time periods at each interface. When a congestion notification NAK arrives at an interface, weight for the corresponding interface is reduced, which causes immediate decrease of Interest transmission rate (Interest arrival rate). At about 3sec, face2 receives NAK which decreases its weight by half. After this time period, face1 and face2 receives almost the same number of NAKs during some long period, which means from long-term view these two interfaces keep its weight ratio without the first weight decrease at 3sec. This difference of weight decrease operation at 3sec makes face1 has almost double weight value of face2.



(a) face1 (b) face2

Figure 2: Interest/Data Transmission Rate in R1

Figure 3 shows ratio of weights of face1 and face2 (face1 / face2). This figure confirms that face1 has almost double weight value of face2 with some small spikes. When S_1 path has congestion, its weight is decreased by congestion notification NAK sent by a router, R_2. After this weight and window size reduction, congestion on S_1 path is resolved. With additive increase of end consumer window size, transmission rate for both directions increases linearly, which causes in turn congestion on S_2 path. Congestion on S_2 path generates a congestion notification NAK from router R_3. This alternately generated NAK and caused alternately decrease of weight at each interface keeps weight ratio of these two interfaces.

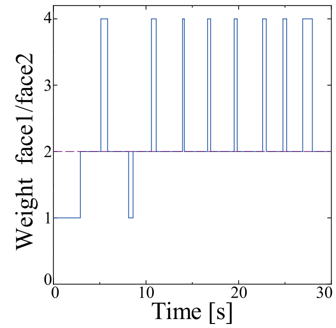


Figure 3: Weight Ratio

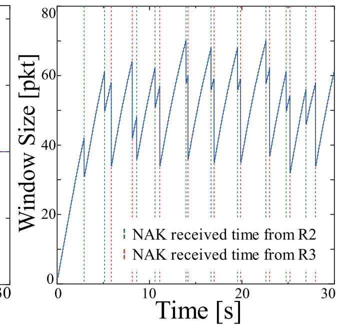


Figure 4: Window Size

Figure 4 shows window size of consumer Rcv_1. Red and green dashed lines show respective NAK arrival time periods for face1 and face2. Window size is adequately decreased according to traffic volume ratio between these two interfaces, i.e. decrease of window size is not a fixed multiplicative decrease shown in TCP and is adaptively adjusted.

4. CONCLUSIONS

In this paper, we proposed multi-source congestion control for CCN. In multi-source content retrieval, content download path has tree-shape with root node of the end consumer. When congestion occurs at some branch, ideal congestion control regulates Interest transmission rate only for this branch and does not regulate other branches. To enable this ideal operation, we combine end consumer window control and router-assisted branch probability control.

5. ACKNOWLEDGMENTS

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