# Enhanced Time-based Interest Protocol in Content-Centric Networking (CCN)

Joonghong Park, Jaehoon Kim, Myeong-Wuk Jang, and Byoung-Joon (BJ) Lee
SAIT, Samsung Electronics, Korea

***Abstract*— CCN is considered as an important networking paradigm which can efficiently address traffic explosion issue of the current Internet. The time-based Interest protocol for CCN was introduced to solve an efficiency problem of early implementation of the CCN protocol in CCNx open source project. The initial version of the time-based Interest protocol, however, was able to support only real-time streaming service scenario. In this paper, we propose an enhanced mechanism of the time-based Interest protocol that supports any types of content in CCN and present experimental results demonstrating its effectiveness.**

## I. INTRODUCTION

Content-Centric Networking (CCN) is considered as one of the important network paradigms to address fundamental problems of the Internet, because there is a significant gap between original purpose of the Internet design and the current Internet usage pattern. While the Internet was originally designed to connect end-host devices, nowadays it is mainly utilized for mass distribution of content [1,2].

In CCN, a user requests content by its name without having to know its location. Once the content is delivered through networks, intermediate CCN routers and nodes can store it on their caches since and then reply to other same requests. With this distributed content caching feature, the possibility of congestion on the side of content servers can be dramatically reduced. In addition, the same request suppression feature of CCN can maximize the effect of multicasting without additional membership management for multicast [1,2].

For effective content distribution in CCN, a segment of content is used as a base distinguisher. Therefore, content segments can be delivered from multiple nodes and/or through different routes. It also enables the transfer of each segment to easily adapt to timely changes of congested networks. In the basic CCN protocol, a requestor waits until the previous segment is delivered for the next segment request, but this causes a serious performance declining problem. Pipelining can enhance the performance [3], where multiple content segment requests, called *Interests*, are transmitted within the pipeline window before receiving the previous segments. However, this mechanism still requires a lot of Interest packets for getting one content, and consequently introduces inefficiency in data throughput as a result of both wasting network resource and increased processing overheads of each intermediate node.

To reduce a large number of Interests fundamentally, the time-based Interest protocol was introduced [4]. In the protocol, an Interest that consists of no segment number component in its name field is sent with information about specific time duration, and then unlimited number of content segments can be transferred during the specific time duration. Decreasing the number of Interests using the time-based Interest protocol resulted better performance comparing to pipelining mechanism [4]. However, the initial time-based Interest protocol was able to support only real-time streaming service scenario. This paper proposes an enhanced time-based Interest protocol with experimental performance results.

## II. ENHANCED TIME-BASED INTEREST PROTOCOL

### *2.1 Hole recovery*

The time-based Interest protocol is efficient to enhance performance comparing to sending a lot of Interests to get just one content that is the basic CCN protocol. Because there is no segment information in the time-based Interest, however, content could be delivered with some missing segments or with out of order sequenced segments. In this paper, we will call *holes* for both missing segments and out of order sequenced segments.

Holes can be detected by the content requestor using segment number in the name field of a content segment packet. Requestor checks every delivering content segment whether there are any holes or not. If a hole is first detected, the requestor waits until a given time duration, called *hole timeout*, before sending a hole recovery request. The hole timeout that can be specified or calculated by network conditions or service scenarios is required to prevent transferring unnecessary duplicated content segments, because sometimes a hole is not a real lost packet but just a packet transferred late due to network condition.

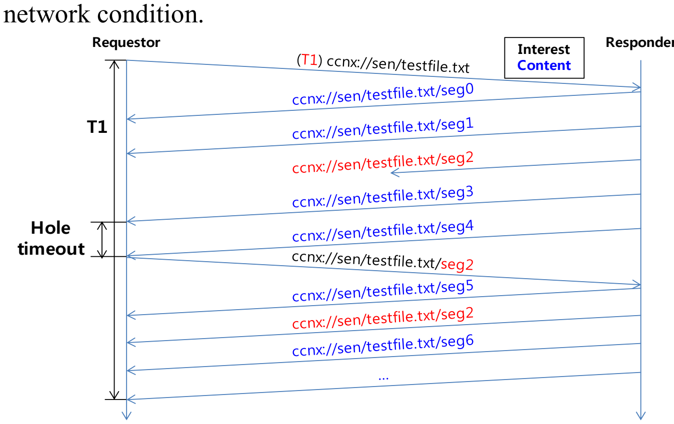


Fig. 1 Hole recovery protocol on time-based Interest protocol

Fig.1 depicts a flow of the time-based Interest protocol and the hole recovery protocol. When a time-based Interest carries the content name ccnx://sen/testfile.txt with time duration T1, multiple content segments are delivered to the content requestor during T1. For the definition and structure of hierarchical CCN naming convention, refer to [1] and [3].

When the requestor detects a certain hole, segment 2(seg2) in the Fig. 1, it waits during a specified hole timeout. If the hole is not recovered during the hole timeout, the requestor sends a normal Interest, not the time-based Interest, with a segment number in its name field such as ccnx://sen/testfile.txt/seg2.

### *2.2 Cache process for Time-based Interest*

The most important functionality of CCN for network efficiency is based on cache in networking nodes. Any node can reply a certain content segment in cache when its content segment name is exactly matched with the Interest name. In the initial time-based Interest protocol a requestor sends an Interest without segment number component in the name field for matching multiple content segments using one Interest. To get replies from cache sequentially, an enhanced time-based Interest is sent with not only specific time duration, T1, but also the starting segment number in its header.

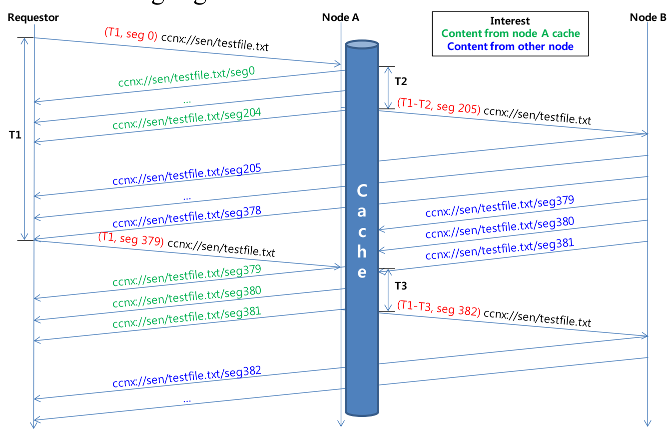


Fig. 2 Cache process for time-based Interest with starting segment information

Fig. 2 depicts a cache process using the starting segment information in the time-based Interest header. Adjacent node A that received a time-based Interest first replies all content segments in its cache sequentially from the starting segment number in the Interest header. If there are not enough content segments for the requested content in the cache of node A, node A forwards the received time-based Interest to the next node B with decreased time duration, T1-T2 or T1-T3 due to cache processing time, and information about starting segment number that is not stored in the cache of node A. Once receiving the time-based Interest from node A, node B replies all content segments in its cache sequentially from starting segment number in the Interest header or transmit another time-based Interest to the next node. If time, T1, expires after transmitting a time-based Interest, the requestor sends the next time-based Interest with the next segment information calculated from the last received content segment packet.

## III. Performance Evaluation - Experimental Results

Our experiments are conducted with prototype implementation based on an enhanced version of CCNx open source code [3]. The testbed consists of two sets; One set is comprised of two Android phones (Galaxy S3 with Android 4.0) with 1.4GHz quad-core processor connected through IEEE 802.11n Wi-Fi, and the other set includes two notebooks (Samsung NT700) with i7 2.3GHz quad-core processor connected through 1Gbps wired network. We developed a simple file transferring application using both pipelining mechanism and the enhanced time-based Interest protocol.

To compare the performance of the proposed protocol with that of the pipelining mechanism, the received data rate is considered. Pipe size when using pipelining mechanism was 25 as a result of the best performance making size by several experiments. Time duration when using the time-based Interest is set as 4 seconds.

### *3.1 Wireless Performance*

Table 1 shows the performance comparison experimental result between the enhanced time-based Interest protocol and the pipelining mechanism on a wireless environment; the time-based Interest protocol is about 33% faster than the pipelining mechanism. Transferred file size was 50MB. We set hole timeout as 4 seconds that is the same as Interest retransmission timeout of the pipelining mechanism in CCNx open source.

Table 1 Wireless performance comparison

| | Pipelining mechanism | Time-based protocol | Performance increasing rate(%) |
|---|---|---|---|
| Data rate (Mbps) | 19.97333 | 26.50667 | 32.71028 |

### *3.2 Wired Performance*

Table 2 demonstrates the performance benefit of the proposed scheme as compared to that of the pipelining mechanism on a wired environment; the time-based Interest protocol is about 55% faster than the pipelining mechanism. Transferred file size was 100MB. We set hole timeout as 500 milliseconds.

Table 2 Wired performance comparison

| | Pipelining mechanism | Time-based protocol | Performance increasing rate(%) |
|---|---|---|---|
| Data rate (Mbps) | 280.4711 | 435.5909 | 55.30689 |

## IV. Conclusion

The proposed enhanced time-based Interest protocol significantly reduces not only the number of Interests but also processing overheads of Interest packets when transferring contents. Our experimental results demonstrated superiority of the proposed protocol by providing much higher data throughput than the pipelining mechanism. The enhanced time-based Interest protocol can contribute to reduce bad effects of CCN on a performance viewpoint due to a lot of Interest packet occurrences, so future research plan includes maximizing performance of CCN among many mobile devices in wireless networks using beneficial cache effects in each network node comparing to not only the basic CCN protocol but also the current Internet protocol.

## Reference


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