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Contents

Keynote Speech

Presentation Session 1-1: Digital Technology

▌Presentation Session 1-2 Digital Information

▌Presentation Session 1-3: Digital Convergence

▌Poster Presentation Session

▌Presentation Session 2-1: Digital Innovation

▌Presentation Session 2-2: Digital Management

Congestion Control Strategy in NDN-RIOT-OS Powered IoTs

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Abstract

Named data networking (NDN) is tremendously evolving into a network for futuristic devices. Since NDN is in its early years of recognition, the architectural research is still in process. One of the few limitations in NDN exists in its forwarding strategy due to CSMA unavailability. The forwarding mechanism is performed by strategy layer of NDN. During packet forwarding, due to the collision at consumer-end results in considerable network congestion. Our work tests the NDN on RIOT-OS powered IoTs. RIOT-OS powered IoTs create the actual NDN dynamics. We further propose a forwarding strategy based on congestion control scheme at strategy layer. Results show proposed scheme is flexible, effective and efficient for futuristic IoTs.

I. Introduction

In perspective of Named Data Network (NDN) [1] transport control/forwarding strategy, serves the two

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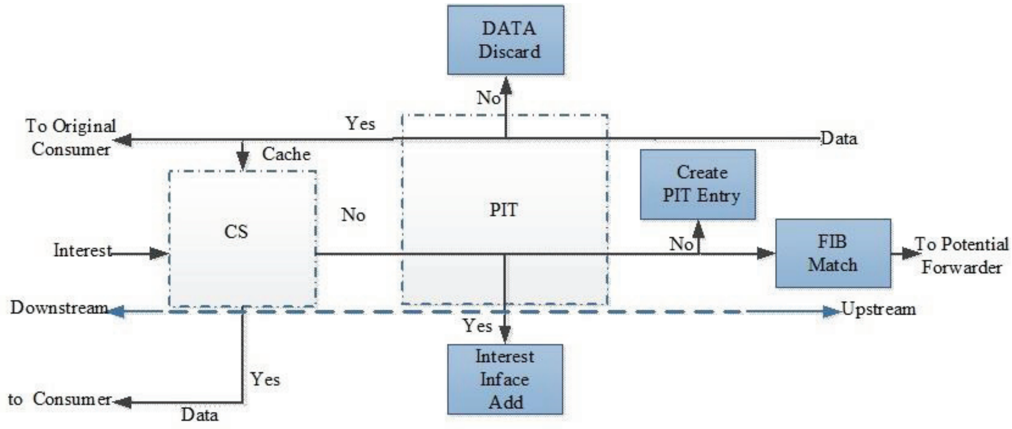

Fig.1. NDN Forwarding Scheme.

fundamental packet flows; 1) Interest flow from consumer to provider/s, and 2) Data flow from provider/s to a consumer. Both flows have some limitations. However, our work is mainly focused on Data flow from provider/s to consumer. The main reason is congestion caused due the absence of CSMA/CA [2]. This occurs when multiple providers respond to the same interest packet at the same time. This causes considerable amounts of delay. These delays further result in increased Packet Loss Rate (*PLR)* and overall network delay, and decreased Interest Satisfaction Rate *(ISR)*, and throughput at consumer node. We study the working of NDN on RIOT-OS [3] powered IoT devices. This provides the real-system NDN network configuration and environment dynamics. Our tests confirm the presence of congestion caused due to the absence of channel access mechanism in NDN. Further details of experimentation are discussed in later section II and III. In response to this, we propose a forwarding strategy to mitigate the channel congestion. Our simulations and tests show enormous decrease in PLR, delays and an incredible increase in ISR and throughput rates.

This paper, presents the real testbed analytical results of NDN on RIOT-OS powered devices in section II. It also discusses the packet collision problem of basic NDN when considering multiple providers and a single consumer scenario. Later in section III, a controlled Data-flow Scheme is proposed to mitigate the packet collisions. Moreover graphical representations of results testify the efficiency and effectiveness of proposed scheme.

II. Named Data Network Propagation In RIOT-OS: Testbed and Analysis

In Future, NDN is supposedly going to play a major role in redefining the wireless networks [4][5]. Next generation devices such as IoTs will require simple and effective wireless networking architecture to cope up with unwanted delays and low throughput rates exhibited by current TCP/IP networks [6][7]. This drives NDN towards one of the most researched and invested projects of ICN for futuristic IoTs [8]-[12]. Further, a detailed NDN forwarding strategy and Interest-Data transport mechanism is represented in Fig.1 and briefly presented.

In [3], NDN is extensively studied using RIOT OS based IoTs. This motivated us to perform real time testbed evaluation on NDN-RIOT OS based IoT devices. Beginning with, we considered a real testbed scenario of multiple providers and a single consumer. The detailed simulation parameters follow

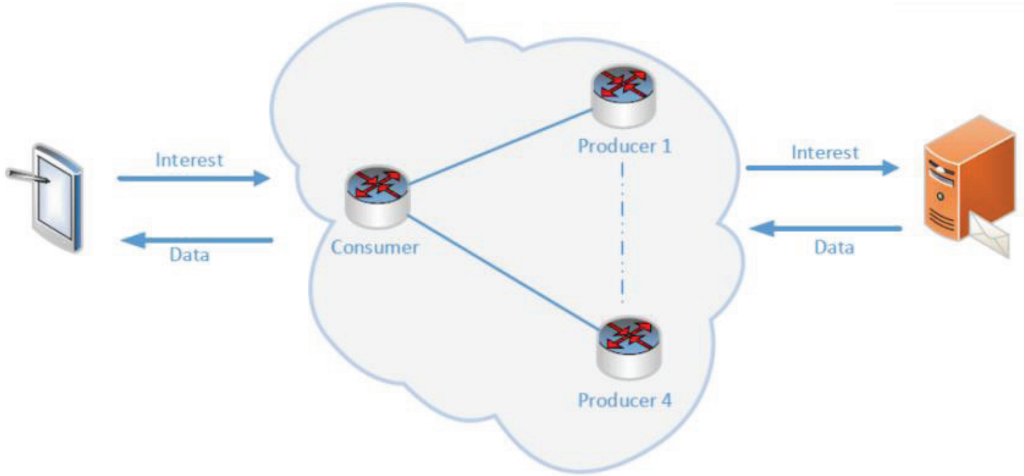

Fig.2. Scenario(s) of Single consumer and (1-4) producers.

the Real time-scenario constituting 1-4 providers, shown in Fig.2.

We study the working of IoT devices in correspondence to given real system scenarios 1-4. Firstly, we consider one consumer and one producer IoT devices working on RIOT-OS in base NDN networking scheme. The results show no amount of congestion or packet losses because of absence of any other provider sending similar data packets for same Interest. However as the number of Producers for a single. NDN-Consumer is increased; the amount of packet collision also increases. This in return result in higher Packet loss Rates (PLR), and decreased number of Interests that are satisfied (ISR), respectively. Concluding to this, one of the efficient ways to implement such congestion control is on end nodes (Consumer or Provider) [2]. In our work we lay emphasis on the controlled data flow from multiple Providers to a single Consumer. So, basically our work is based on preventing the Data-packet collision at consumer node.

III. Controlled Data Packet Flow Scheme.

It is presumed that every provider in the multiple Providers scenario has the required Data packet that satisfies the same Interest at the same time. Also the efficient range of the devices is around 100m. This plays an effective role in NDN-RIOT-OS configuration. Every consumer node has Interest Timeout timer, beyond which the Interest packet expires and is dropped. In NDN, it is calculated to be around 1 second or 1000000 microseconds. After 1000000 microseconds, if a consumer does not receive Data packet, it drops the Interest and fails to satisfy its requirement. Our tests show that within the range of 100m the average Round Trip Time (RTT) of NDN packet from consumer to producer is 845721 microseconds. So basically this gives every consumer enough time to satisfy the Interest. However due to packet collision at Consumer node, the timer expires and NDN network suffer from considerable packet losses, and minimal ISR. So we propose a scheme to control the flow of Data from provider to consumer.

Considering the average RTT of 845721 ms which is within the delay bound Interest timeout of 1000000 ms, the remaining 154279 microseconds can still be utilized to form a random backoff window. Basically when every Provider in multiple Provider scenario is sure of Data availability in its CS, all of them dissipate the Data packets at same time. This further as discussed leads to congestion. However, we propose that every provider after CS lookup runs a random backoff (0-130000 microseconds). This backoff range is calculated to be efficient without causing any delays as it is within Interest Timeout range. As well as 130000 microsecond is a minuscule time entity in real system scenario. Random backoff ensures that multiple providers do not overlap data dissipation times. Further when consumer receives the required data from the smallest backoff-node, it validates and authenticates the packet received. Moreover the consumer discards the data packets received after this because its Interest is already met. This method efficiently improves the congestion rate without even modifying the event-driven Interest rate generation. Further details of the Proposed Model are given in the Algorithm 3.

Algorithm 3: Received Interest in Proposed NDN Scheme
Received Interest [Name, Selector(s), NONCE]
if Content Not in CS **then**
    if Name in PIT **then**
    Drop Interest.
    else // if name is not in PIT.
    Add [Name, NONCE, Face] in PIT.
    Initialize Timer(s).
    Forward Interest using FIB.
    endif
else
DATA[Name, MetaInfo, Content,]
Random backoff [0-130000 ms]
Send DATA.
end if

In Fig.3, and Fig.4 as the number of providers increase with respect to a single consumer node, proposed scheme shows considerable improvement in Interest Satisfaction and Packet Loss Rates over the basic NDN model. One of the main reasons for such a drastic improvement is, consumer node receives first data packet and satisfies its Interest. Moreover when other Data packets arrive to satisfy an already satisfied Interest, they get dropped immediately at verification. Therefore, the proposed scheme is effectively able to eliminate any case leading to packet collision. Thereby contemplating an efficient and effective way towards futuristic NDN for real systems.

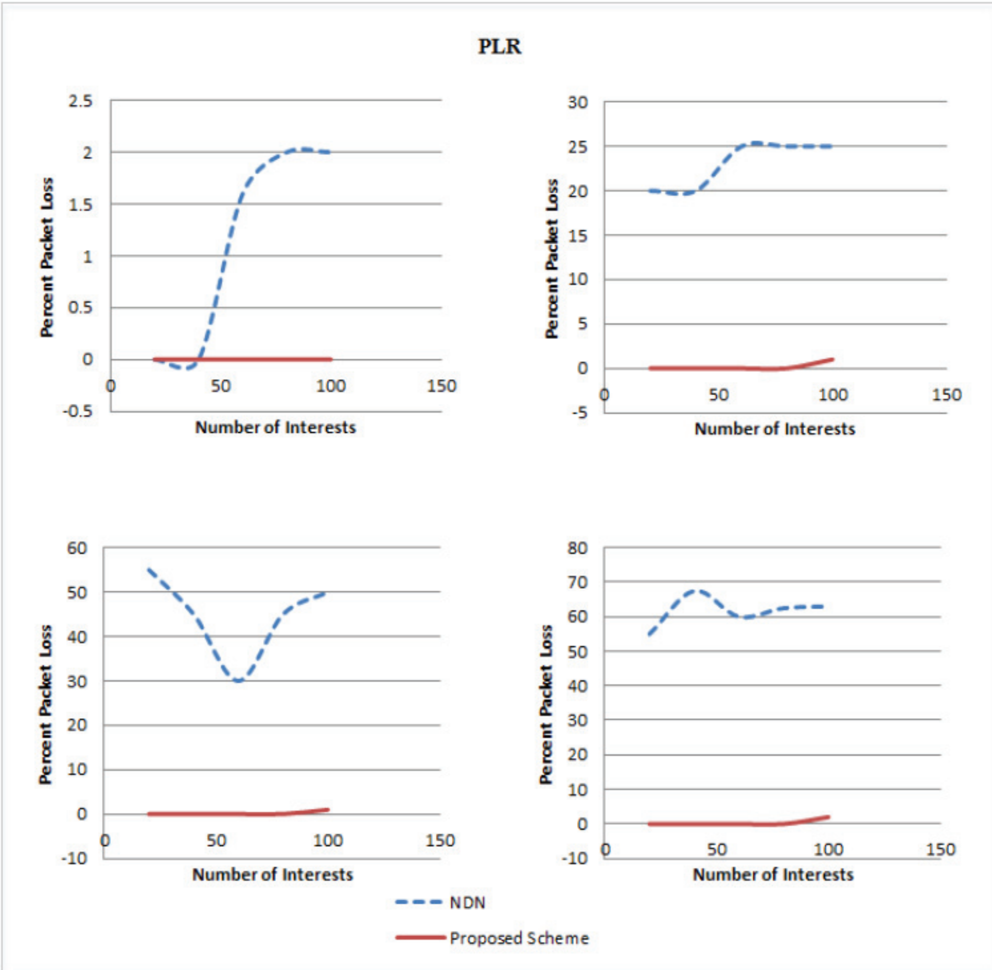

Fig.3. Packet Loss Rate comparison between Basic NDN and Proposed scheme for (a) one consumer and one producer, (b) one consumer and two producers, (c) one consumer and three producers, and (d) one consumer and four producers.

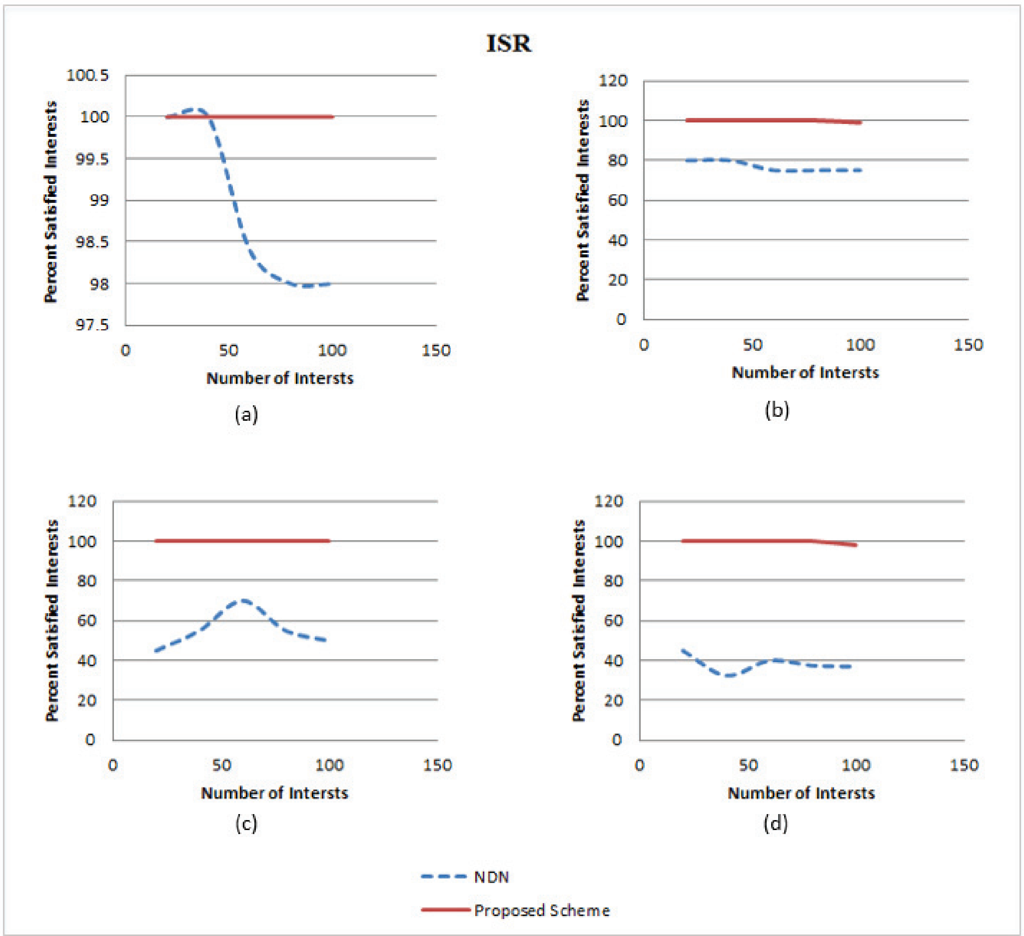

Fig.4. Interest Satisfaction Rate comparison between Basic NDN and Proposed scheme for (a) one consumer and one producer, (b) one consumer and two producers, (c) one consumer and three producers, and (d) one consumer and four producers.

IV. Conclusion

We study the basic networking technique of Named Data Networking on NDN-RIOT-OS powered IoT devices. It is inferenced that NDN is a network technology suitable for future. However, some improvements are required to be made in forwarding mechanism to prevent the problems of congestion. We propose an efficient and convenient random backoff technique to prevent the packet collisions. Our technique eliminates the packet losses occurred and shows significant improvement in PLR and ISR. In, Future research we are planning to optimize the packet priority in NDN on real systems.

Acknowledgement

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