Named-Node Networking (3N) Implementation Approach

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Abstract Information-Centric Networking (ICN) was proposed focusing on "decentralized communication" networks. In our early work, Named-Node Networking (3N) was introduced for seamless mobility in the Data Aware Networking (DAN). In this paper, we introduce the 3N application on the Linux platform. The application is developed from the 3N architecture and implemented on the Inter-Process Communication (IPC) protocol. The proposed 3N architecture supports seamless mobility in ICN network. In this case, we will be focusing on the seamless mobility and data transmission ability in the evaluation of this paper.

Keywords 3N, ICN, seamless mobility, IPC

1. INTRODUCTION

It is expected that by the year 2020, the global mobile data traffic will be reaching 16% of the total global traffic [1]. That makes it important that our network architectures are inherently supported by data awareness and mobility. Numerous proposals have been written about inherent mobility support in ICN [2]. The development of ICN mobility support has been a continuous process in which new issues are discovered and solutions proposed [12].

Our approach to mobility support in the ICN architecture has been to return to a fundamental mapping-based network naming structure. To realize this, we integrated the basic naming structure detailed in RFC 1498 [4] into the ICN architecture. We created the missing components and had them named by integrating two completely new and independent namespaces to the network architecture. The resulting network architecture was the 3N application which implemented on the Linux platform.

The 3N application mobility support showed lower network delay and higher throughput when compared to NDN's Smart-Flooding forwarding strategy [5] for when the consumer or the producer was mobile while it's counterpart was static, regardless of the node's movement speed [6].

The implemented application approaches ICN-based communication and enhances seamless mobility on a physical machine rather than through a simulator. The application design concept was to realize a fundamental communication mapping-based network naming structure.

The rest of the paper is organized as follow. In section 2 we discuss the basic issues of the mobility support in ICN and explains 3N features. Section 3 explains 3N application mobility features. We present the framework and the parameters used for the evaluation of mobility support and video data transmission along with the results in section 4. Finally, in section 5 we present our conclusions.

2. ICN MOBILITY ISSUES & 3N CONCEPT

For this paper, we based our discussion of the ICN architecture on the NDN architecture. We assume that nodes and named Content Routers (CRs), in the network have a Content Store (CS), Pending Interest Table (PIT), Forwarding Information Base (FIB), have Faces and use Interest and Content Data packets as detailed in [3]. Taking these definitions into account, we can identify the following issues associated with mobility in the ICN architecture and 3N application.

In the scenario that the consumer node is mobile, ICN Content packets can be returned to an area of the network where the consumer is no longer attached after it entering the next area. In order to receive these undelivered Data packets, consumers need to retransmit Interest packets. The ICN CSs within the network help reduce the retransmission delay by being able to offer cached Content packet information. However, depending on the Content packet type and Graph of the Network (GN), the mobility of the consumer and the Interest retransmission times, the recovery process of the undelivered packets may introduce significant delay and large consumption of the network bandwidth.

The common mobility issues for consumers were investigated in [7] using ndnSIM, a ns-3 framework [8] module that implements the NDN architecture. They observed significant performance degradation in the effective throughput for delay-sensitive traffic, when the movement speed was increased. The modifications discussed strongly implied a need to modify the core of NDN's architecture.

The proposal found in [9] attempts to maintain a pure ICN architecture to solve mobility by assigning names to a specific node in the network. This idea seriously complicates the ICN namespace and calls for a more complicated and specific type of management. Due to the ICN namespace being unmanaged, routing protocols based on this namespace do not scale. Therefore, this proposal strictly focuses on intra-Autonomous System, limiting the scope of the proposal for bigger network.

We proposed the 3N application to deal with seamless mobility basing ourselves on the basic ICN communication architecture proposed in [10] and [11]. The 3N application does not have specialized nodes to support mobility as all nodes have the same architectures and capabilities, resulting in network expansion relatively easy. The architecture also does not complicate of generates large payload to the ICN namespace as it uses two new managed namespaces to deal with mobility. This allows the use of the ICN namespace to its full potential and heavily reduces the issues related to overloading the use of the unique names.

3N application Mobility support is contingent on mobile nodes obtaining 3N names and keeping the relevant mappings updated. If a node in the 3N application does not enroll or cannot complete a dis-enrollment and re-enrollment, then the network cannot guarantee seamless mobility. Since we have designed the protocols timer based, we believe that an adequate setting of the timeouts for the main mechanisms can be set in a way that communication is not completely lost. It is important to point out that the mechanisms are started and ended by the mobile node, so we leave it to them to acknowledge when it is the best time to initiate the procedures.

3. 3N APPLICATION DESIGN & IMPLEMENTATION

The 3N application is a Linux network stack implemented based on IPC protocols as the fundamental communication platform. The application is a prototype and it has realized basic ICN related CS, PIT and FIB, along with 3N names, seamless handoff functionalities and high-speed video data transmission.

The application structure is divided into two parts, the IPC tunnel and the 3N network stack.

The IPC [13] layer of the architecture has many DIFs and 3N is built on it. The distributed IPC facility (DIF) layer provides IPC services over a given topology in the figure. The IPC tunnel is constructed based on existing TCP/IP network.

The 3N stack is built over IPC and exchange data on top of it. The prototype of the system can perform seamless handoff procedure in a low traffic networking situation and high throughput static connection supporting 4K stream level data rate.

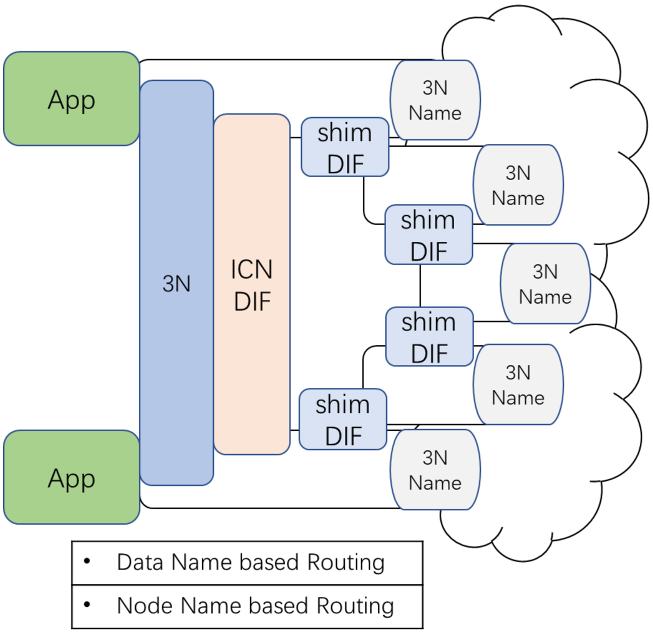

Fig.1 3N application architecture

4. EVALUATION

To evaluate the implementation of the 3N application. We have designed two scenarios, video data transmission and 3N handoff. The topologies should be able to show basic elements of the communication model, which contains content container, router and client.

4.1. 3N Handoff

The handoff demonstration scenario used a 7-node topology. First the routers connect to the content container and initial their IPC connections. Then the next level routers connect to the upper-level routers and initial their IPC connections as well. Finally, the client connects to the edge node, initials IPC connection and obtain its node name. After the preparation, the experiment takes place.

While in the first wireless sector, the client initials the data flow from the content container. During the experiment, the client will switch to a new wireless sector when the wireless signal reaches a point. The handoff processes take place three times.

During a handoff procedure, the client will first notify the edge node and then start to switch to the next wireless sector. After entering the next wireless sector, the client will obtain a new node name, inform the edge node its old name and continue to request for the rest of the contents. Meanwhile, the undelivered contents from the old wireless sector will be redirected to the client which are routed by the node name routing.

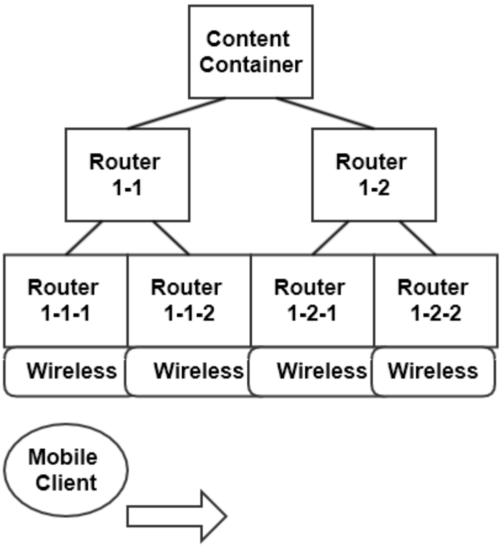

Fig.2 7-node topology

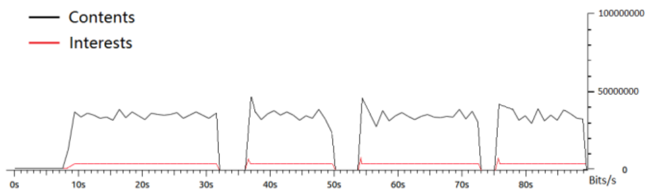

Fig.3 7-node handoff throughput

From the chart, we could see that there are three drops in the data flow, which represent the three handoff procedures. After each handoff procedure, the interest flow is not peaking for requesting timed out contents, while the content flow retransmitted for the old requested contents. This means the 3N architecture applied in this topology successfully performed a seamless mobile scenario.

4.2. 4K Video Data Transmission

To preview the possibility of delivering high-speed video streaming and large file transmission, the application should be able to handle data flows above 30Mbps (typical 4K video stream).

The topology of this evaluation used wired connections in a 3-node scenario, which are the content container, the router and the client. After the nodes obtaining names, the consumer started to retrieve a large binary file from the content container. The router node routes the packets between the server and the consumer. Finishing the file transfer, the received file in the consumer would perform a md5sum check with the original file on the server. Ideally the file should be identical and the overall transfer speed should be reaching the wired connection's bandwidth limit.

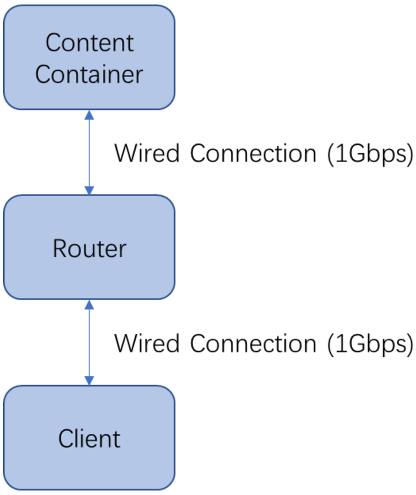

Fig.4 Data transmission topology

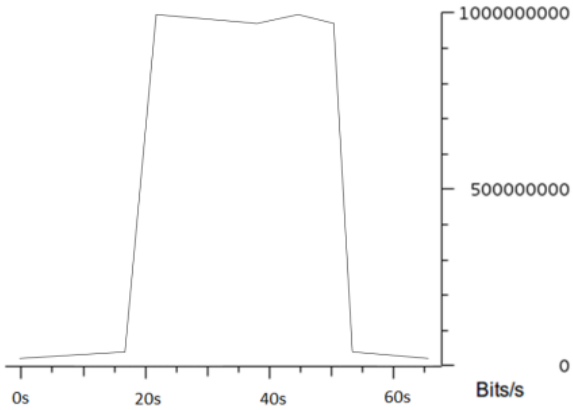

Fig.5 Data transmission throughput

From the figure, we can see that the transfer speed has reached the bandwidth limitation of 1Gbps. We consider the transmission experiment a success when the total transfer speed reached about 1Gbps without influenced by any possible bottleneck in the router node.

5. CONCLUSION

In this paper, we have investigated the possibility of implementing 3N architecture in the ICN architecture. We focused on the performance of the prototype 3N application delivery in wireless handoff scenarios and wired high-speed transmission scenario.

The result of the scenarios above leads us to conclude that overall performance of the seamless handoff and large file/high-resolution video stream is heavily dependent on the effectiveness of routing in the consumer mobile network of ICN, as is shown by the experimental results above. The implementing of effective FIB related routing methods is a priority for ensuring the performance of ICN.

The results, coupled with 3N application and content naming method implementations, showed great possibility and promises in the mobile support in future ICN architecture.

A further extended project implemented with IoT device naming is receiving great benefit from the node naming network architecture.

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