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The Summary of Routing Mechanism for Named Data Networking

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Abstract

Currently, the Internet of the future is developing rapidly, Name Data Networking (NDN) has become a representative architecture in the future Internet, and it has become one of a research hotspot of the network. This paper reviews some existing routing strategies of NDN, it firstly introduces the basic structure and forwarding mechanism of NDN, then it narrates intra-domain routing strategy, active publishing routing strategy and routing strategy based on congestion control, it analyses the development and its advantages and disadvantages of the existing routing strategy, then it puts forward the future direction of routing mechanism.

Keywords

Future Internet, Named Data Network, Routing Mechanism

I. Introduction

The demand of the network has evolved to be dominated by content distribution and retrieval, the architecture of TCP/IP exposes many disadvantages at each stage. To solve these exposed problems of Internet, two research methods are introduced, evolution type and revolution type.

The widely used evolution solution includes Peer-to-Peer (P2P) technology and Content Delivery Network (CDN) technology. However, this solution cannot fundamentally change the core architecture of the Internet, it causes the waste of resources and decreases the security issues. In order to meet the demand of the increasing information access fundamentally, there are kinds of revolution solutions have been proposed, NDN [1-3] is a representative architecture in the future Internet, it treats content as the important entities of the network, It transforms host-based network architecture into a content-based architecture, therefore it becomes a research hotspot.

II. The Structure of NDN

A. The Basic Structure of NDN

NDN is a new architecture which established on the basis of named data, consumer demands content in Information Center Networking (ICN)rather than the location of the store content, so NDN directly provides the function of content-oriented, regardless of the physical location of content store, Network communication mode requires mapping from what the users care about to the network's where. NDN is put forward to change the current Internet host-to-host communication mode, using data name rather than IP address for data transmission, so data become the core elements of the Internet architecture. However, NDN maintain the TCP/IP architecture model of the hourglass, it adopts seven-story structure, the biggest difference between TCP/IP model and NDN is that it uses named data content block to replace IP address.

There are two NDN packet types, Interest and Data, these types structure are shown in Fig.1. A consumer asks for data by broadcasting its Interest packet over all available connectivity. Any node would respond with a Data packet according to the original path in the opposite direction when it hearing the Interest packet and having Data that satisfy it.

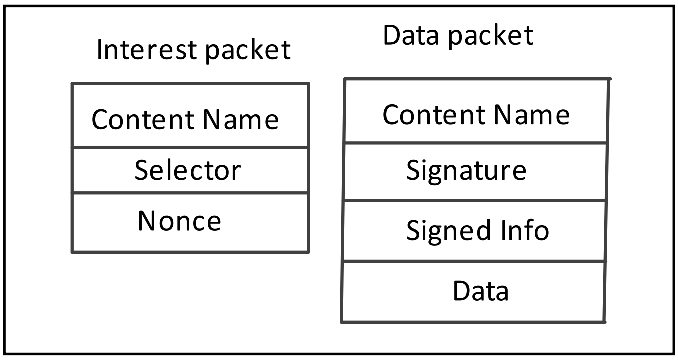

Fig.1: NDN packet type

B. NDN Forwarding Mechanism

NDN forwarding mechanism includes three main structures: Content Store (CS), Pending Interest Table (PIT), Forwarding Information Base (FIB). CS is similar to buffer memory of router, cache data for later use, it is very important in NDN, it can help to reduce content download delay and network bandwidth. In order to maximize the efficiency of the sharing of the stored information in the part, NDN adapt Least Recently Used (LRU) or Least Frequently Used (LFU) replacement strategy to maximize the capacity of storing important information. PIT is used to store Interest packet that has been sent and their arrive interface, waiting for the Data packet. FIB can be set up by broadcasting name prefix announcement among nodes, it is similar to IP router's processing mechanism, but NDN can forward requests to multiple interface at the same time.

C. Data Packet Forwarding Process

Fig.2 shows the NDN specific forwarding process of Interest and Data. When an Interest packet arrives on a node, a longest match lookup is done on its Content Name, it is used to check if there is a corresponding data packet in CS, if it exists, it will be sent out the face which the Interest packet arrived on and the packet will be discarded. Otherwise, Interest will be detected in the PIT, if its name already exists in the PIT, then the Interest's arrival face will be added to the PIT entry list and the Interest will be discarded. Otherwise, both Interest's name and interface will be added to the PIT entry and it will be further forwarded according to FIB. When Data packet is returned from upstream node, the node firstly use its name to find the matching PIT entry, and forwards the Data packet to all the interfaces in the matching PIT entry, then the node also adopts some cache strategies to store Data and discards the PIT entry. Otherwise the node will discard the Data packet if there is no matching PIIT entry.

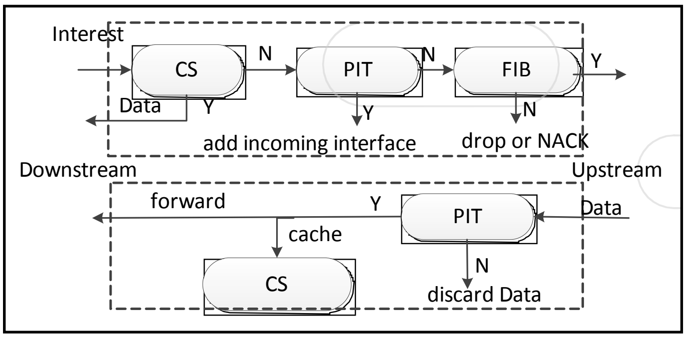

Fig.2: Packet Forwarding Process in NDN

III. NDN Routing Mechanism

A. The Challenges of NDN Routing Mechanism

The router is the most important equipment in the Internet, it is important transport hub in the network, the architecture of TCP/IP exposes many disadvantages, in order to satisfy the requirement of increasing access to information in the network fundamentally, we main center on ICN communication model. As a new system architecture, NDN is a typical representative of ICN, so the routing mechanism of NDN has become a hot topic to research.

Due to the change of the current network architecture, the research of routing mechanism has experienced a renaissance currently, the routing mechanism that adapted to the IP network is also adapted to the NDN network. Firstly, the problem must be solved in terms of routing in NDN is routing scalability [4], with the continuous expansion of the Internet, the size of the corresponding routing table will increase exponentially, this becomes a bottleneck of scalable routing in future Internet. There are a lot of researches of NDN routing strategies, the following summarize several important routing strategies.

B. The Research of Routing Strategy

1. Intra-domain Routing Strategy

There are two basic functions of domain routing protocol, one describes links in the graph while other describes what is available at particular nodes in the graph. Literature [5] describes the most basic coexistence NDN and IP network, fig.3 illustrates this condition in detail, the single circles only signify IP routers and the double circles signify IP and NDN routers.

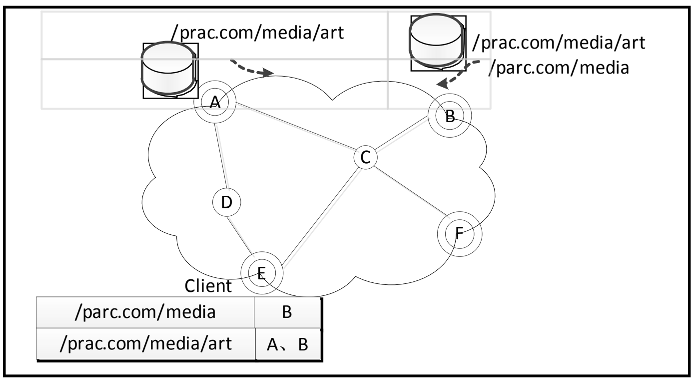

Fig.3: Routing Interests to intra-domain

The repository next to router A announces that it can serve a matching prefix '/parc.com/media/art', when an application of router A receives this announcement, it will installs a local NDN FIB entry for this prefix for this incoming face, and router A packages the prefix into Link State Advertisement (LSA) which will be flooded to all other nodes. Node E receives announces from both node A and node B, and adds them to its own FIB, the FIB of node E is shown as Fig.3. When node E receives a name prefix of '/prac.com/media/art/impressionist-history.mp4', it will be forwarded to both A and B, however, node C and D are IP nodes, they are not content routers so they cannot cache, if C and D get the NDN software upgrade, node E and F will forward their interests via them and the distribution will be optimal.

2. Active Publish Routing Strategy

The difference of routing mechanism between the IP network and the NDN network is NDN network uses content name instead of IP address of IP network to lookup the content, the router of NDN network has a cache function, which makes NDN network users can get the require data at any nodes with requested data on the paths when they request required data, and do not have to go to the server to find the data. Literature [6] described a two layer domain routing mechanism of the NDN, this mechanism is composed of topology maintenance layer and prefix circular layer. The topology maintenance layer maintains the whole NDN network domain topology and calculates the shortest path tree. The prefix circular layer provides contents in two different ways: active release and passive service. Because separately using one of these two ways may lead to scalability problem, so there put forward a strategy of active release which based on the popularity [7-8], and compromise on the active and passive way.

NDN treats LSA as the unit of data to describe the situation of the local router, each router send LSAs that are encapsulated in Link State Update (LSU) to other routers. Each LSA will be flooded to the whole routing domain, and the received LSAs make up Link State Database (LSD), and finally all routers have their own LSD. Fig.4 shows the flooding process of LSU, arrow represents the LSU, router R sends LSU to its three adjacent routers at time t1, these three routers continue to send the LSU to their own adjacent routers at time t2 (not including the upstream router).

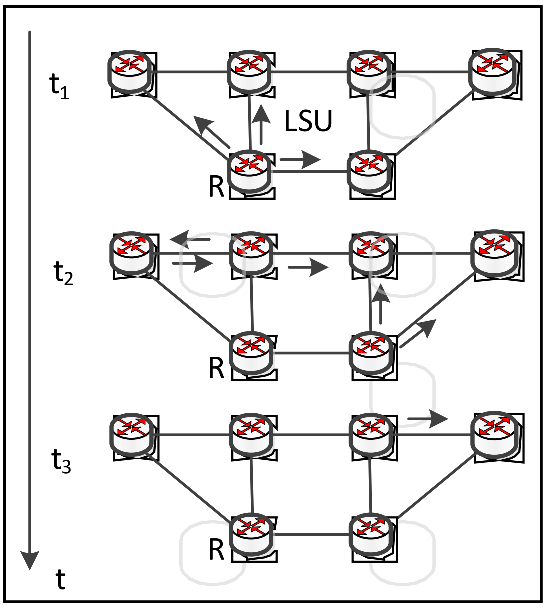

Fig. 4 : LSU Flooding Process

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This paper puts forward the routing strategy which based on popularity. It actively publishes popular contents, and passively serves unpopular contents. Finally, it simulates the FIB table size and network traffic to get the best popularity of content threshold, this threshold can divide the content which can be actively published and which can be passively served by threshold value. The active routing policy will not lead to the surge of FIB. It can control the network traffic, and reduce the size of FIB by aggregating name prefix at the same time.

(C) Routing Strategy Based on Congestion Control

The multipath transmission characteristics of CCN has considerable promises for improving flexibility in the aspects of mobility management, increasing the performance of CCN end-user [9] and the utilization of network resources [10]. In the network topology, the number of Interest package is increasing, too much requests of Interest package will lead to path congestion problem in the process of routing congestion. So the literatures [11-12] propose a multipath congestion control mechanism which based on ICP [13]. Firstly, this paper puts forward and analyzes a congestion control mechanism based on Remote Adaptive [14] Active Queue Management (RAAQM), then valuates the performance of the mechanism through packet - level simulations on the random and optimal path, it proves this mechanism to be stable and efficient.

RAAQM mechanism is mainly to control the queuing delay at receiver, its basic principle is according to the changes of the round-trip delay (RTT) predicts the decrease of the window, so as to achieve the reduction of congestion window, which is similar to the mechanism of the Additive Increase and Multiplicative Decrease (AIMD). Figure 5 shows the increase and decrease of the windows, the receiver window W defines the maximum number of outstanding Interests a receiver is allowed to send, it is the maximum amount of untreated interest packages which are allowed to send by the receiving end. When a Data packet is received, the window W will be increased by η/W, and when a complete window of Interest is recognized by the data reception, window W will increase by η (η defaults to 1).The window W in the agreement by multiplying attenuation factor β to decrease window, its process is less than the time of the timer, as shown in the right picture of Fig.5.

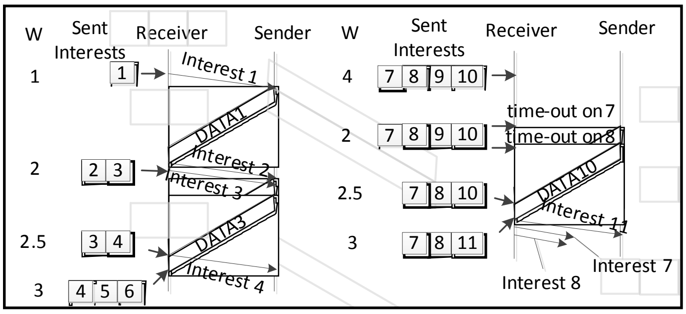

Fig. 5 The increase and decrease of congestion window

When a Interest package is sent, the receiver measures the instantaneous round-trip delay R(t) and estimates the values of minimum and maximum of round-trip delay R_{min} and R_{max}. Therefore the measured instantaneous round-trip delay R (t) and the estimated R_{max} and R_{min} concur to determine the probability p(t) of windows decrease with time, as is shown in the Fig.6, p(t) is considered a monotone increasing function of R (t), from a minimum value p_{min} (the default value is 10^{-5}) to a maximum value $p_{max} \leq 1$. In this implementation, the formula of p(t) is shown in (1):

$$p(t) = p_{min} + \Delta p_{max} \frac{R(t) - R_{min}(t)}{R_{max}(t) - R_{min}(t)} \quad (1)$$

Among the formula, the $\Delta P_{max} = P_{max} - P_{min}$, R_{min} (t) and R_{max} (t) respectively express the maximum and minimum RTT of t moment estimation. As figure 6 shown, when R(t)= R_{max} the reduced probability of window equals p_{min} in the window model, under the condition of the window to reduce, the window W multiplied by a attenuation factor β < 1. This routing strategy which based on congestion control can provide efficient and fair resource utilization when it couples with an optimal Interest forwarding strategy.

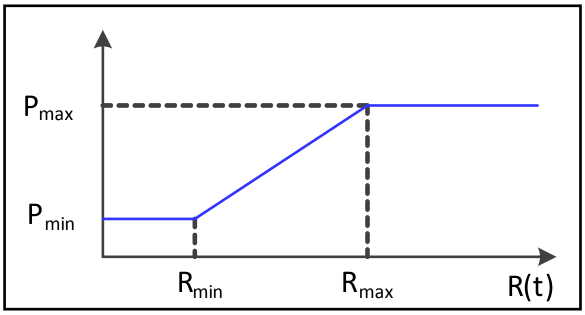

Fig. 6: The reduced probability of windows

C. The further research of NDN routing strategy

At present, the link congestion of NDN routing mechanism has become an important problem to be solved. In a network topology, because the performance of each link is different, interest packages tend to select the optimal link to forward requests. Then the bandwidth of links which have better performance will be occupied completely, and it not only causes the phenomenon of link congestion, but also will cause imbalance of the links. Therefore, the next step of the research direction of routing policy should be to solve the problem of link congestion and link imbalance.

IV. The simulation platform of NDN routing policy

The simulation platform of NDN routing mechanism is ns-3 software under the LINUX system. First, we need to set up the network topology which we want, and then simulating according to our theory innovation. The framework of simulation platform mainly consists of three parts: application layer, network layer, data link layer. And the application layer includes the generation process of interest packets and data packets; the network layer mainly includes how to receive interest packets, how to deal with data packets; The data link layer is mainly provide path for the forwarding process of interest packets and data packets.

V. Conclusion

The research of NDN routing mechanism has become a important part of NDN, there are many routing strategies have been produced to improve all aspects of performance. This article mainly overviews the routing mechanism in the NDN, and introduces a few of important routing strategies by analyzing and comparing the advantages and disadvantages of them. Then it produces the further research direction of NDN routing mechanism. Finally, it summarizes the simulation platform of this mechanism.

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