Forwarding in Named Data Networking

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Abstract— Named Data Networking (NDN) is coined for forthcoming Internet architectures. This futuristic Internet architecture needs innovation cause of the fact that some of the concepts used in existing internet architecture are not appropriate in many circumstances. An important concept of NDN is about forwarding strategies. Routing predetermines the decisions of forwarding in prevailing IP-based networks. This is in sharp contrast between existing IP addressing and NDN, routing shall be a supporting role to forwarding in NDN. Routers in NDN are capable of detecting network problems by observing flow of both Interest and Data packets traffic and then exploring loop free multiple alternative paths. A major issue in overall NDN research area is to design and evaluation of forwarding in it.
Keywords: Named Data Networking (NDN)

I. INTRODUCTION

Proliferation of technologies is moving faster day-to-day, the evolving wireless devices makes them alike multimedia devices with inbuilt advance features, such as camera, media-players, browsing facilities. In today's date and time, the traffic in Internet is exchanging of photo, audio streaming, video transferring, etc.

From a perspective of future, there is a requirement of an architecture that is compatible for the upcoming application's demands. The architecture of a network determines the form and shape of its forwarding strategies. Classical networking is based on host-to-host architecture, which is termed as a limitation in it. One key disadvantage in it is forwarding, which is rigorously predetermined in routing phase ensuring a communication process of loop-free.

In IP architecture the shape of hourglass is identical in NDN too. But the thin waist of the hour glass in NDN, substitute the host-to-host data transfer platform to data retrieval data model as shown in Fig. 1.

NDN's forwarding plane manages the conventional network issues more efficiently than current IP networks, such as congestion and network failures.

Routing in an NDN network computes routing table as the existing IP architecture. Each router in NDN has a strategy module that takes decisions on Interest packet forwarding.

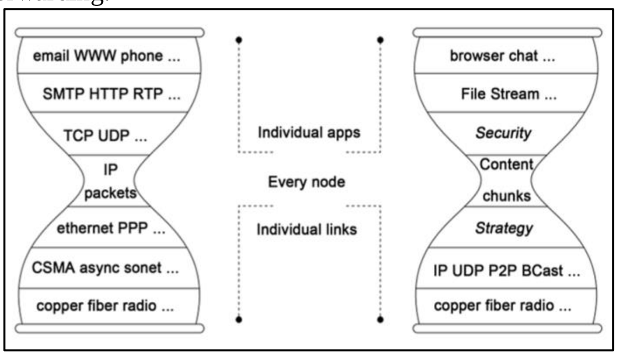

Fig. 1: Difference between NDN and IP addressing

NDN routing supports forwarding by multi-route allowing multiple next hops to each FIB entry without worrying about Interest looping. A small size NDN network may not run any routing protocol but may use self-learning to discover the availability of data instead.

A. *NDN's Data Plane*

NDN is recipient-driven. All communication in NDN uses two different packet types, namely Interests and Data packets, each of which bears a name, which uniquely identifies the piece of information.

A data-consumer sends the Interest packet to the network with the name therein. Route forward the Interest using that name, and return to the user the data whose name provides the best match for the Interest.

All Data packets carry a data producer signature which binds the name securely to the data. If an Interest packet or Data packet is lost, it is the end consumer's duty to retransmit the Interest once exist time of the Interest packet is over.

Unlike IP packets, NDN packets have data names, rather than source or destination addresses. This fundamental difference in architecture leads to two significant operational differences. First, although the name is used in an Interest packet to direct its forwarding, which is identical to the destination address in IP packets, the Interest may traverse a copy of the requested data on an intermediate router that returns the data, while the IP packet always reaches the destination. Second, In NDN for data packet delivery, the data consumers neither have names or addresses.

Instead, NDN routers keep track of the incoming interfaces of each forwarded Interest and use this knowledge to bring matched data packets to consumers.

NDN-based systems are greatly simplified because of direct use of network namespace. Thus, IP address allocation or address storage or DNS services are no longer needed to translate names.

B. *Function of Routing*

Since the NDN forwarding model is a strict IP model superset, any routing scheme that works well for IP should work for NDN as well. But today's IP routing protocols are suffering from problems including slow convergence or poor scalability. NDN also have smart and efficient forwarding techniques, which can take over part of the responsibility of routing in IP.

C. *Forwarding Process*

Once, an Interest packet is received by NDN router, it first checks if there is a corresponding Data in the Content Store. If a match is found, Data will be sent back to the interface from where the Interest packet originated .If no match is found, the PIT entries check the names of the Interest as shown in Fig. 2.

If the name already exists in the PIT, it means that an interest was obtained and forwarded earlier from another user for the same name, in such instance the router simply adds the incoming interface from which the new interest was received to the current PIT entry. If there is no name in the PIT, then the Interest will be added to the PIT and forwarded further.

In each Interest packet with addition of data name, it also carries a random nonce that the data consumer generates. NDN router remembers both the name and nonce of all the Interest received, which ensures that a newly arrived Interest is indeed a new or an old one that has looped backwards. Therefore, Interest packets cannot loop and therefore Data packets follow the reverse direction of the relevant Interest packets, so they do not loop either.

Upon receiving a Data packet, the name in it is used to lookup the PIT. If a match is found with the PIT entry, the NDN router will send the data packet to the interface from which the Interest packet was received, cache the data and remove it from the PIT entries.

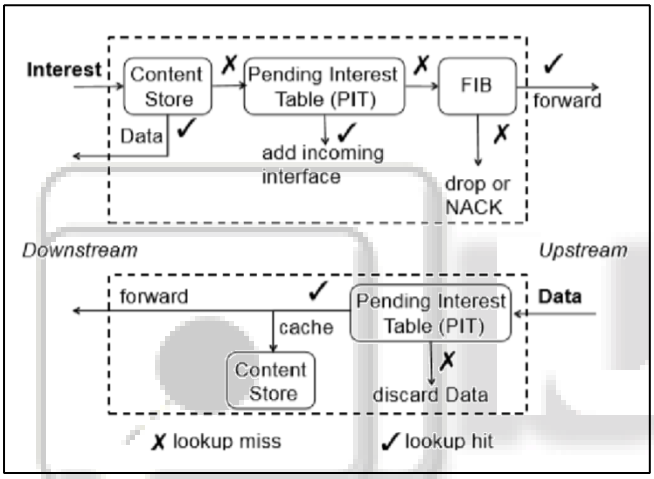

Fig. 2: Interest and Data Packet processing in NDN.

Each Interest Packet also has a lifetime associated with it; the PIT entry is removed once the lifetime expires.

D. Datagram State

We say the routers in NDN contains "datagram state" cause it maintains an entry for every pending interest packet in its PIT. This state leads to a symmetric two-way closed-loop packet flow; each Interest packet pulls back exactly one Data Packet over each path, preserving one-on-one flow balance.

Except in rare cases where packets get lost or no match found.

E. Name

NDN is designed to network the world of computing devices by naming data bits, ranging from IoT sensors to cloud servers.

In NDN network names are opaque in nature. Growing application may pick the naming scheme to suit its needs. Naming scheme is therefore independent of network. The hierarchically structured names in NDN assumes that it help to reflect the context and relationships between elements of the data.

The dynamically generated can be retrieved data by: The deterministic algorithm helps the data creator and the data user to get the same name on the basis of the information available to both and Interest selector together with the longest matching prefix collect the desired data through one or more iteration.

As we know address space management is not equally part of the IP architecture, namespace management is not part of the NDN architecture. Naming data allows for features like content distribution, accessibility, etc.

II. LITERATURE REVIEW

A. Comparison between [1] and [3]

Typical forwarding strategy in NDN has three tables, Content-Store, Pending Interest Table and Forwarding Information Base [1].

Requirement for Content Store: NDN router buffer memory is Content Store. Content Store caches that arrive Interest packets to meet future Interest. A Content Store generally consists of index and packet buffer [1].

Requirement for Pending Interest Table: It stores all the Interest packets that have been sent to the network but not yet satisfied [1].

Requirement for FIB: FIB is responsible mainly to read the information for forwarding to next hop for an Interest [1].

On the other hand, Adaptive Forwarding Strategy in NDN design includes how to handle New Interest and Retransmitted Interests, Interest NACKs and conduct probing of interfaces which are proactive [3].

Goal of adaptive forwarding is retrieve data using the best possible route and Fast identification and recovery of any problem regarding data delivery [3].

B. Comparison between [2] and [3]

The ultimate goal of Stochastic Adaptive Forwarding is to perform optimally with the given measure so that node's forwarding behavior is optimized [2].

Stochastic forwarding strategy is probability-based forwarding. It ensures effective forwarding in case of incomplete and invalid routing information. SAF does not depend on routing to address unexpected network topology changes. SAF is of a sort that can be congressed with various measures denying the goals of the forwarding. The only conclusion SAF has on the measure is that it requires preferences to be listed as fulfilled and unsatisfied [2].

The main goal adaptive forwarding is retrieve data using the best possible route and Fast identification and recovery of any problem regarding data delivery [3].

The model of an NDN node using SAF Adaptive routing uses Interest NACK. In NDN a timer is started as a router forwards an Interest packet based on estimated RTT. When the anticipated Data packet comes back before the timer expires, the RRT is updated; if not, there may be a potential problem on the route. The unsatisfied interest persists in the network until it expires, probably blocking other data consumer's interest packets [3].

Interest NACK is used to solve the above issues. If a node in NDN is unable to either fulfill or forward an Interest packet, it will return an Interest NACK to the node downstream. A NACK carries both, an error code that explains why NACK is being created along with the same name as the related Interest packet. In case downstream node has exhausted, it send the NACK further downstream. Interest NACK easily identifies the downstream node of network issues, which can then take appropriate action based on the error code and eliminate the unsatisfactory interest from PIT [3].

C. Comparison between [5] and [2]

Due to increase of the number of users in Internet, exchanging of information of path and for the large forwarding tables of routers, it leads to overhead processing and storage in larger networks. Scalability, then, is the black hole in the existing IP architecture. Parallel multi-path forwarding strategy (PMP-FS) can be a choice for use of scaling network [5].

The use of hierarchical naming structure in NDN architecture made the PMP-FS more flexible. PMP-FS, has to see different granularities. Setting the degree of granularity totally depends upon the router's role in the network [5].

The following sets should be highlighted in PMP-FS: The degree of granularity controls the processing time and storing space and ensures the handling of any number of any numbers of flows depending on the degree of granularity along the weights of the NDN flows [5].

The Parallel Multi-Path Forwarding Strategy is a framework for implementing differentiated service by routable name-prefix of service quality. Extra hardware is needed to implement the proposed forwarding strategy, which is major drawback of it [5].

The foundation for Stochastic Adaptive Forwarding (SAF)'s performance is extensive use of multi-path transmission. SAF is a technique for NDN forwarding. It is a forwarding based on probability which is based on a per-content / per-fix basis [2].

The design of SAF is done by following steps: Network, Content and Node Models, A Throughput-based Forwarding Measure, Identifying Unsatisfied Traffic, Update Operations, Adaptation of Forwarding Probabilities, Probing to Identify Unknown Paths [2].

SAF ensures efficient forwarding of information with incomplete or even invalid routing. Without depending on the SAF routing plane, it resolves unexpected network topology changes [2].

D. Comparison between [5] and [4]

Parallel Multi-Path Forwarding Strategy (PMP-FS) optimizes throughput of the network. The significant of PMP-FS are maximizing its throughput and PMP-FS should take real-time constraints into account. The disadvantage is usage of extra hardware [5].

In contrast, On-demand energy-based forwarding strategy (OEFS) is designed for ad hoc mobile networks based on NDN. For communication process, it considers a node's residual energy. We introduced two different types of packets, Interest message (INTMsg) and Data message (DATAMsg), with each node containing two different types of data structures. One of them is content store (CoS) and the other is Interest information table (IIT). Because of its on-demand and reactive communication mechanism, the OEFS protocol does not take data structure from the FIB [4].

The four metrics used for measuring OEFS efficiency - CONTENT DOWNLOAD; the average time taken by the user to download all the DATAMsg packets of the content, INTEREST RETRANSMISSION; the average number of INTMsg packets which the user node retransmits to get all the DATAMsg packets of the desired content, TOTAL NUMBER OF INTERESTS; the total number of INTMsg and INTMsg retransmitted packets provided by the consumer node and also the relay nodes to retrieve the requested packets from DATAMsg, DATA REDUNDANCY; the average number of duplicate DATAMsg packets a customer node receives because of the NDN's multi-homing feature [4].

The four characteristics of OEFS – Firstly, for communication, the residual node energies are considered. Secondly, Energy-based forwarding approach improves node lifetime as well as efficiency in the network. Thirdly, If nodes are in Danger States, they focus more on their neighboring nodes, pending request for data packets to be delivered and lastly, to minimize the collision, it eliminates flooding of Interest packets and Data packets in network [4].

III. Proposed Work

In future, a forwarding strategy will be implemented to reduce packet collision and is expected to give a better result using less bandwidth than the existing forwarding strategies. The research focuses only on problems caused by the unreliable connectivity. One problem is the question of flooding caused by broadcasting Interest packets. Since, forwarding tables in highly dynamic topology is difficult to maintain, each forwarder simply retransmits Interest to all its neighbors. The blind broadcast leads to a flooding of Interest and causes congestion in the network, which makes increased use of bandwidth and prolongs data recovery.

A timer-based retransmission system is proposed to decreases packet collision probability and eliminates bandwidth usage.

The one with the highest forwarding priority will have a shortest waiting timer to delay the actual transmission among all devices that need to retransmit the Interest packet. If the vehicle overhears an incoming interest / data packet which has the same name as its already scheduled transmitted Interest, this means that the Interest has been transmitted by other devices with higher forwarding priorities than themselves. Then it cancels its already scheduled Interest. Ultimately, only devices with higher forwarding priorities actually carry the Interest packet forward.

IV. Conclusion

It is expected that the proposed forwarding strategy would collect traffic data in NDN with a view to improving the packet delivery ratio without having to introduce any overhead transmission. It will be simulated and evaluated as per requirement using an existing NDN test-bed.

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