A SURVEY ON DIFFERENT CACHING POLICIES IN NAMED DATA NETWORK (NDN)

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Abstract: The Named Data Network (NDN) is evolving as a new Internet architecture, which would become an alternative to the traditional IP bases Internet. It has developed from researches of years into Information-Centric Networking (ICN). The communication in NDN depends on Names irrespective of IP Address or Server. Communication in NDN takes place through the interchange of Interest and Data Packets in place of server and destination addresses. The users send Interest packets to the network as names. Routers forward the packets according to the data names they carry. The data producer responds to the query by the name the Interest packet bears and sends Data packet in the reverse direction, the Interest packet came. The adaptive forwarding plane is the exclusive feature of NDN. This paper discusses different caching policies used in NDN. The basic components of NDN are taken into account. The role of Routers and how Caching helps data management in NDN architecture are also discussed.
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Index Terms - ***NDN, ICN, Caching, Router, Data Packet, Interest Packet, IP Address, Name, Internet, Adaptive Forwarding***

I. INTRODUCTION

The internet has the structure of a packet data network in which, the users and data sources interact over a predefined channel. Here, the data sources have specific IP addresses [1]. The Internet has an hourglass architecture. It concentrates on a universal network layer which implements the nominal functionality essential for worldwide interconnectivity. The narrow portion on the hourglass architecture permits the upper and lower layers to develop independently without any limits. This characteristic enables the Internet to grow broadly. Nowadays, users prefer to get data regardless of where it belongs. The extended use of social networking, YouTube, torrents and smartphones changed the idea of user-generated. This has made the data servers hosting particular content which are identified using IP addresses to lose its importance. The Internet transformed into increasingly content-centric. Since the need for Internet protocol addresses is a long-term issue of the internet community, the modern time needs a networking platform which is content centric that the data hosts have nominal importance. The Named Data Network [1] has been proposed at this juncture. It allows the user to float data request without knowing the host. It also enables user mobility and handles security problems more competently than the present Internet. The existing model of point-to-point communication is complex and may subject to errors. It has the smart routing, and dump forwarding approaches. The NDN is used to enhance dump forwarding approach. The NDN packets carry no source address or destination address. It only carries the names instead.

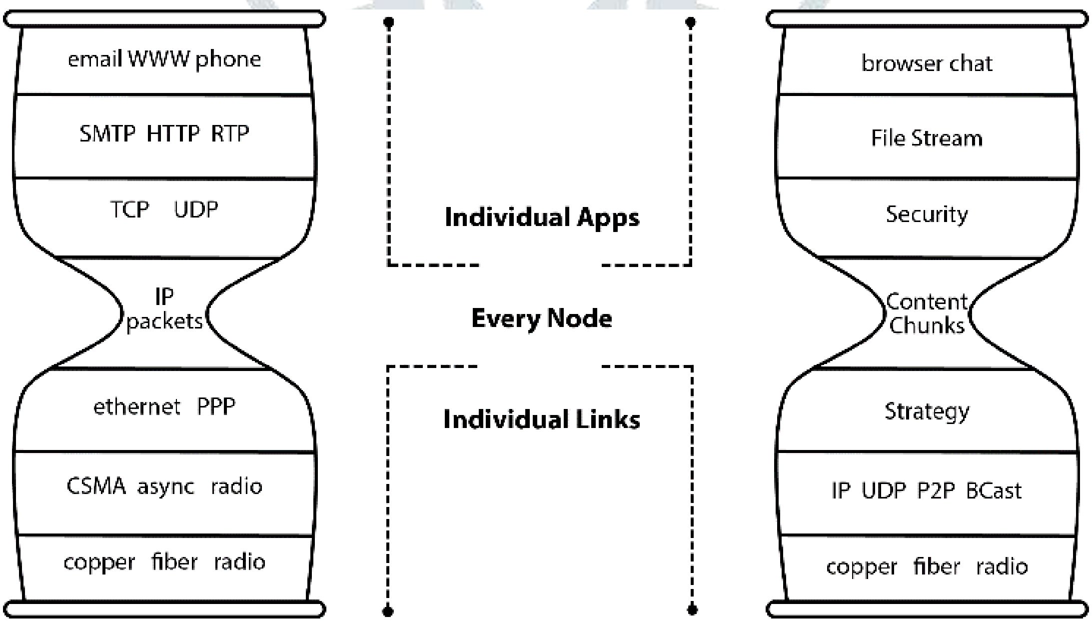

Figure 1: Hourglass Architecture

II. NDN OVERVIEW

The NDN uses Interest packets and Data packets [1] for communication. For specific data, the consumer sends interest packets to the router without mentioning the location. The router retrieves the mentioned data from the original data producers with Cryptographic signature or the router cache. The data packets flow in the reverse direction the interest packet came. The router caches a copy of the data packet when it reaches.

2.1 Router Segments

An NDN Router has three major parts, which are a Content Store (CS), a Pending Interest Table (PIT) and a Forwarding Information Base (FIB). When an interest comes, the router examines its Content Store for the requested data. If the data is available, the router returns it directly. If it is not available, the router enquires whether a PIT entry has been created. If it is already done, the router adds the new request to the PIT so that when the Data packet arrives, it could forward the data to previous interests as well. The PIT archives a list of unsatisfied Interest Packets. The listed Packets are then forwarded to the next hop according to the Forwarding Information Base (FIB) lookup. But it is done after PIT confirms no pending interests with similar names.

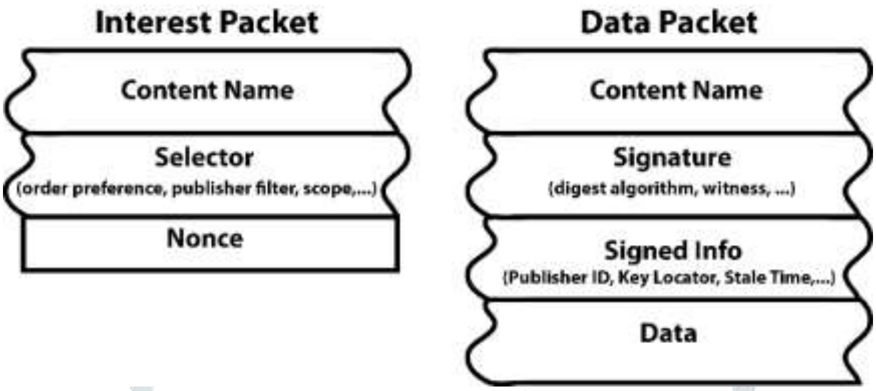

Figure.2: Packets in the NDN architecture

2.2 The Forwarding Plane

The forwarding plane mentioned earlier is the characteristic which gives NDN the facilities such as Caching and Multicast Data Delivery. Adaptive routing is enabled by maintaining this state. The performance of the packet delivery is calculated by listing pending interests and monitoring Data coming back on each router. As the name suggests, the NDN architecture is constructed on the concept of named data. To retrieve certain data from the network, one has to pass Interest Data to the router. There is a chance of loss of packets in this operation. Then the end user has the responsibility to retransmit the Interest until the data being delivered.

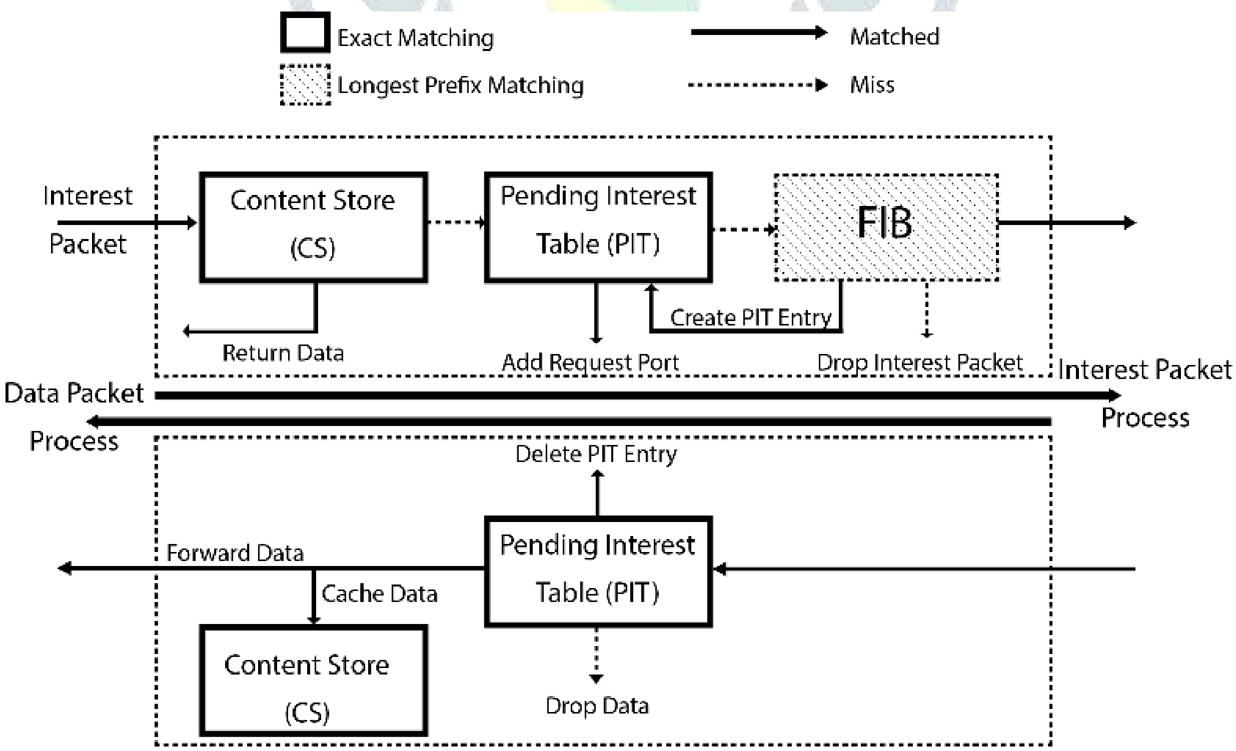

Figure 3: Forwarding Process at an NDN node

When comparing the NDN and IP networking, the data delivery operation has two differences. The names in the Interest packets are similar to the destination addresses used in IP packets. Both are given for navigation. If an Interest packet crosses a requested data copy in a source or intermediate router, the data will be delivered. But in IP networking, the packet always delivered to the destination only. Secondly, the interest packets never carry the identity, address or names of the consumer. They only return the requested data. Interest packets carry a user generated random number which is a nonce field. The NDN routers keep record of incoming interfaces for every forwarded Interests. The name and nonce field of every interest received in the PIT will be recorded. With this information, the router can check if interests of similar names arrive from different consumers or not.

III. CACHING

A Cache is defined as a software or hardware element in which the data is stored for a faster serving of data in future requests. Caching intends to spare information at some area and after that utilize it whenever if necessary. The benefits of caching are that they improve the accessibility of data transmission by preventing the transmission of the same content repeatedly. It eliminates the time for content recovery and reduces data transmission costs. Caching in NDN eases the overhead at the data producer. It makes multiple copies of similar content in the network by which avoids chances of failure. It has several other benefits like the dissociation of content from producers and reduction of network load and data dissemination latency.

IV.CACHING POLICIES

The caching policy [2] determines the replacement of content from the content store (CS). The default caching policy in NDN is the FIFO [3]. In this policy, the older contents in the CS get replaced with newly arrived contents. Yet another caching policy is the LRU [3] which natively supported by ndnSIM. LRU replaces cache according to the time of usage of the content i.e. a data which is not being used for a long period will be replaced.

4.1 Cache Placement

Cache placement is the process of placing a content in a network. It determines where the content to be placed. NDN uses Leave Copy Everywhere policy for caching. This unique feature caches every content in all routers across the network.

4.1.1 Leave Copy Everywhere

LCE [4] allows the users to take data from anywhere, from data producers to intermediate routers. The burden of seeking servers in all operations could be omitted with this. As the network congestion and redundancy transmission are reduced, the peer to peer traffic is also limited. LCE is a built-in cache placement policy in NDN. The operation of caching data in routers which passes through defines the cache management in LCE. A Data packet is cached in all routers between the provider and the user during every operation. The major drawback in this method is the cache redundancy in routers. To get away from this problem, some cache placement algorithms are used. LCProb and LCUniP are some examples.

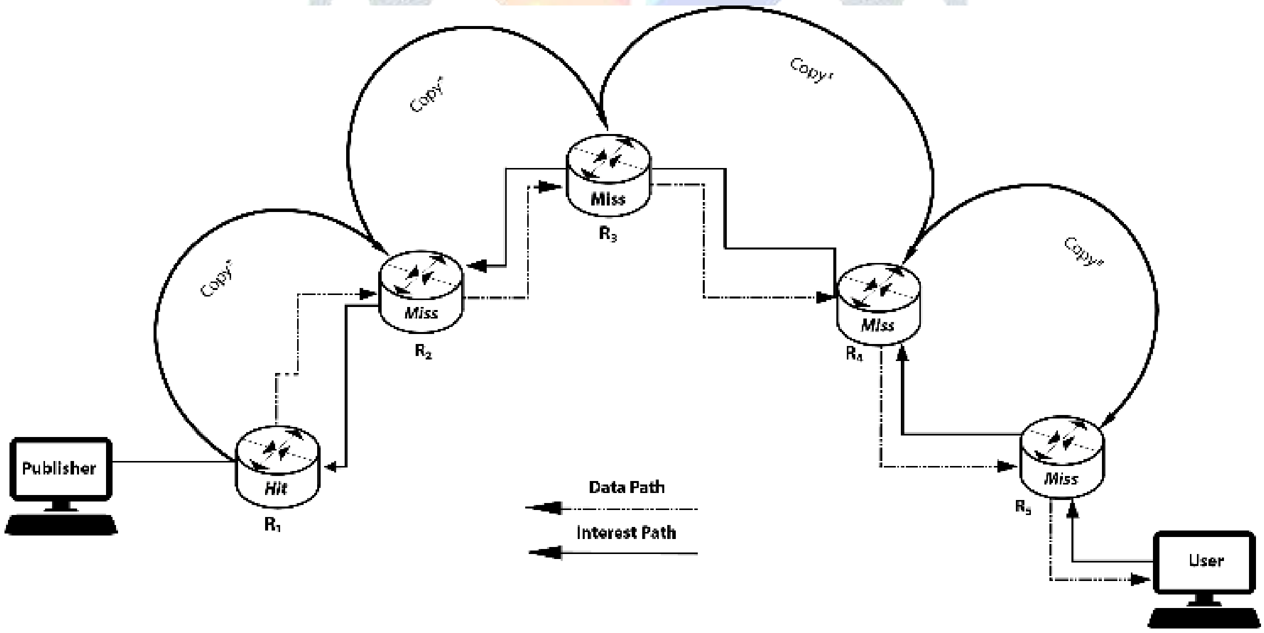

Figure 4: LCE (Leave Copy Everywhere)

4.1.2 Leave Copy Down (LCD)

LCD [4] is a cache management strategy which defines the method and style of data caching on nodes. It operates similar to ‘drop at the first neighbour’ process. Once a request is posted in an LCD, a path link is created to the Publisher of the data or the node where the data holds. When the content records a hit, it stores a copy in its direct neighbour node.

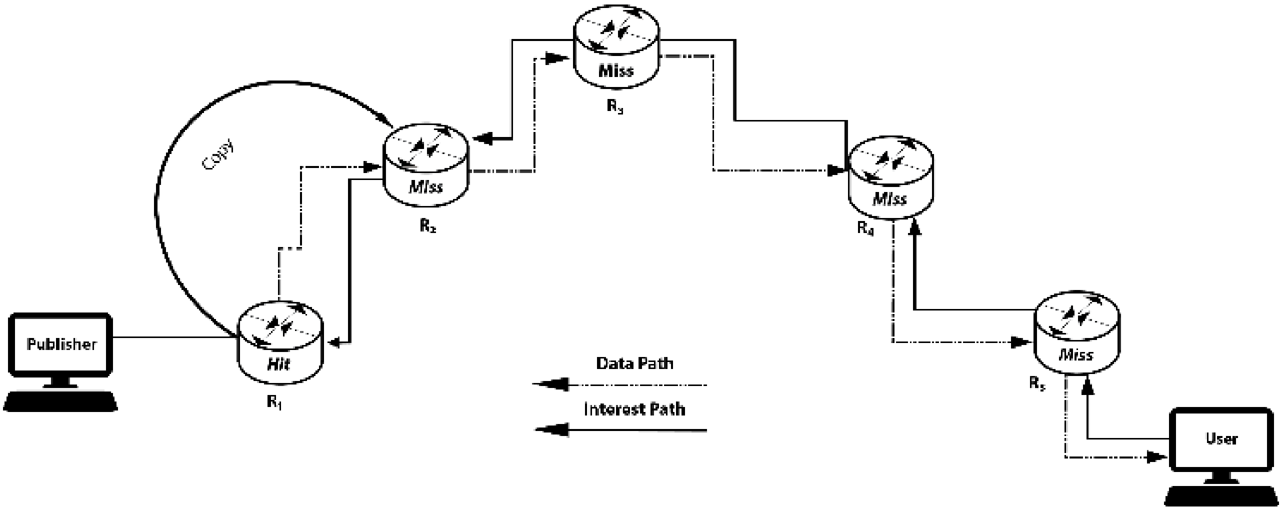

Figure 5: Leave Copy Down

4.1.2 Probabilistic Cache

A random probabilistic LCE is considered as the Probcache. The major difference is that its ability to keep cache copy in an immediate neighbour router (n) with probability m. Therefore, Probcache will not preserve a cached copy in a router with r (1-m) probability. On a cache hit, a probability calculation is carried out according to the preferred distribution from the user to the producer.

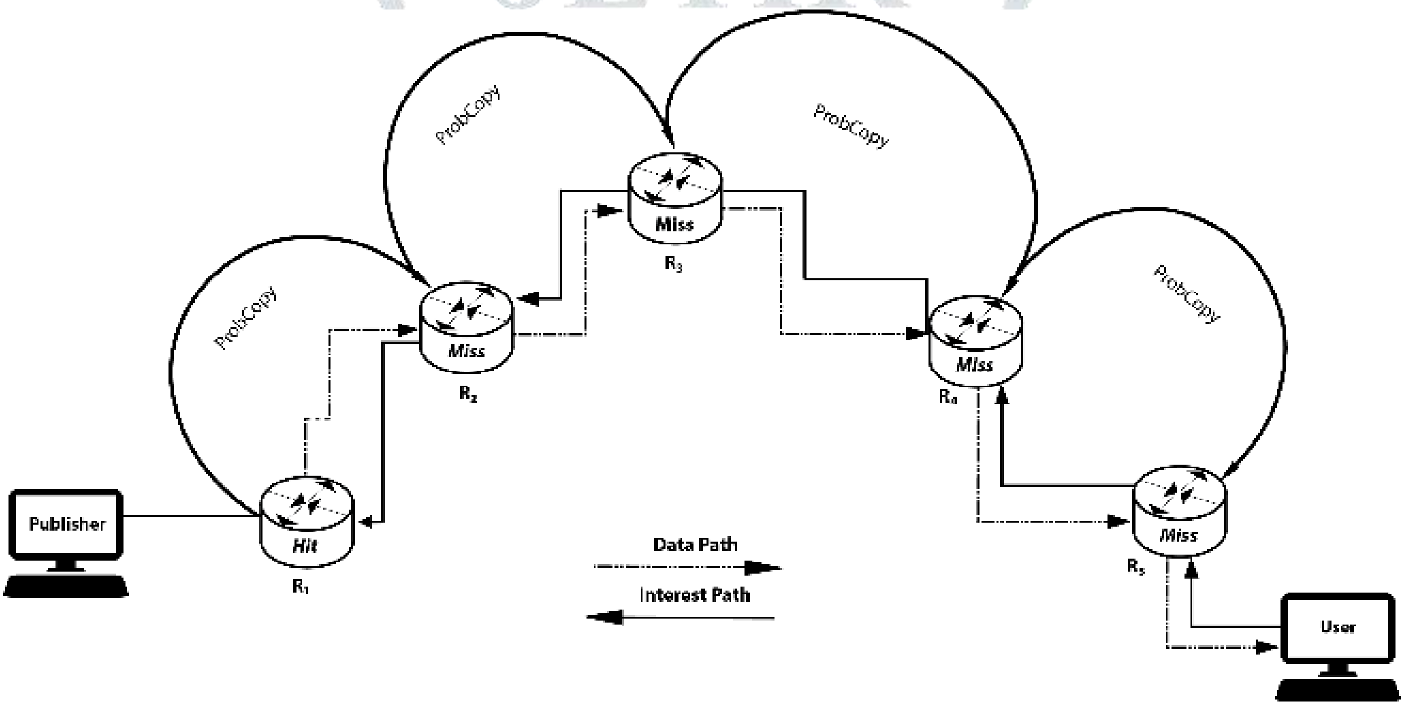

Figure 6: Probabilistic Cache

V. CACHE REPLACEMENT

The redundancy of caching in routers reduces diversity of the cached contents in the whole network. Routers may flood with data which cannot be used in future. It is regulated with Cache Replacement methods. Least Recently Used (LRU) and Least Frequently Used (LFU) policies are certain cache replacement methods.

5.1 Cache Replacement Strategies

The caches cannot be stored for a long time because of its bigger size and catalogue nature. The main difference of caches with primary and secondary storage is the time taken for data to stay in memory. Many replacement policies have been introduced into an information-centric network for cache replacement. Among which the LRU offers better results compared to others as many pieces of research suggest.

5.1.1 Semantic Replacement

The semantic replacement may be defined as a strategy that sticks some rules and a define-syntax. A cache administrator defines tags, fields and forms of conditions in this method. Otherwise, this condition can be called a grammar nature of replacement strategies. The strong set of defined rules are a projected disadvantage. If the contents are placed unfairly, it may require a complete redesign due to this disadvantage.

5.1.2 Random Replacement

In the Random strategy, if a data request is made and a copy of which is found and served, the data procured is then saved in the neighbouring nodes temporarily. The Rand replacement uses a uniform distribution, i.e. the contents are replaced according to a uniform selection after draining the available memory and catalogue sizes in the routers. One disadvantage found in this strategy is the replacement of important content instead of non-popular data.

5.1.3 Least Recently Used (LRU)

The LRU [4] discards the redundant cache by analyzing its use with time. Or in other words it is an access-time-pattern based replacement policy using the recent information of cache hit ratio. But the process does not consider Content Popularity. Popular contents may be replaced by a newly requested content, even if it is less popular.

5.1.4 Least Frequently Used (LFU)

This is also an access-time-pattern-based replacement policy and uses frequency information to increase cache hit ratio. There is a possibility of some contents of temporary popularity to be stored in the cache permanently. It may lead to a condition where the cache to be occupied by data which was popular earlier and now used less. So, a newly arrived data with more hits cannot be saved. Both of these may be further classified according to *Content Popularity* and *Content Prioritization*.

a) Content Popularity

The above discussed LRU and LFU [4] cannot make complete use of the popularity of content in an NDN network as they are replacement policies based on the access-time-pattern. For an efficient caching algorithm, NDN needs a content popularity- based replacement scheme. Ran, et al [7]. have proposed a cache replacement scheme in this manner (CCP). Here the CS is associated with a content Popularity Table. As the CS keeps the information as a cache hit, CN, current and previous popularity, the CCP measures the popularity of content periodically based on content access frequency and cache hit. By this, the less popular contents will be replaced.

b) Content Prioritization

As the name suggests, the replacement is carried out according to the priority of content. Content priority [4] has a major role in applications performance in a highly dynamic network. During a data exchange between two mobile nodes, the high priority contents may be exchanged through the encounter time. And low priority contents suffer from high access latency also. The priority may be defined according to content demand and the common information exchanged between nodes.

5.1.5 Alternate Router Caching Policy

Alternate Router Caching Policy [5] is an approach to reduce the cache replacement overhead at each router. In NDN, the communication carried out by the exchange of Interest Packets and Data Packets. To help this process, each router in the network keeps a Pending Interest Table (PIT), which contains an entry for every Interest packet forwarded and awaiting a response by the router.

The naming in NDN uses a hierarchical "/" limited name structures. NDN gives a signature to the data packet sent by the producer so that it gets an integrity. Every router in the NDN allows caching of data. With this characteristic it reduces the response time required to get the desired data at the consumer. This also moderates the problem imposed on the server by multiple client systems. The NDN network saves the contents in its Content Store using the Leave Copy Everywhere (LCE) policy. This has a drawback of filling the content store with data that may have been requested for one-time use. The fast filling up of content store leads to invoke cache replacement policy frequently. An Alternate Router Caching Policy resolve this issue by storing data retrieved in alternate routers. It increases the response time for the consumers, reducing the memory requirement and also the frequent cache replacement overhead at the routers.

5.1.6 Cluster Based Routing Caching Policy

Cluster-based Routing caching policy [6] is an approach to tackle the mobility problems arises with Alternate Routing Caching Policy. The Alternate Router Caching Policy enables the content retrieved from the producer to store on every alternate router. This method reduces the fast filling of the Content Store Table and thereby increase the response time. It also reduces the frequent cache replacement overhead and memory requirement.

Mobility management is the main issue in Alternative Routing Caching Policy. Consumer mobility can be solved within the NDN. But the producer mobility will be a main issue. A Cluster-based mobility management scheme is used to manage the problem.

The cluster head bears every information of the attached devices. It updates the routers according to its position. This periodic update in the cluster heads solve the mobility issues.

VI. CONCLUSION

This survey explains basic NDN architecture primarily. It concentrates mainly on different caching policies used in NDN. They include cache placement and replacement policies. Their advantages and disadvantages are discussed and also discussed alternative policies. The future work focuses on how to cache and retrieve a real time process with real time data.

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