# Cluster-Based Link Service Management with User Mobility in Named Data Networking

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**Summary**
Named Data Networking (NDN) is considered as an alternative to existing IP-based internet architecture. Unlike current host-based internet architecture, NDN is a data-centric. There are several issues NDN faces like security, privacy, and mobility. Link service management and data transmission with less latency due to consumer mobility is a challenging issue in NDN. In this paper, we propose a cluster-based mechanism for link service management with consumer mobility for efficient data transmission. Our proposed scheme maintains the link service in an efficient manner for smooth data transmission in NDN.

***Keywords:***
*Information-Centric Networking (ICN), Named Data Networking (NDN), Mobility,*

## 1. Introduction

The traffic of the Internet has been growing rapidly and it is estimated that more than 80 % of Internet traffic would be video traffic till the end of 2021. The mobile devices would reach to almost 20 billion that would become 3 times to world population. Every day almost 2.5 zettabytes new data are uploaded on the Internet [1]. The existing Internet architecture is host-based while Information-Centric Networking (ICN) is a data-centric network. In ICN, interest is routed name by name and content is accessed by name in contrast to current internet architecture that works on IP addresses.

Different architectures have been proposed by researchers for ICN such as NDN (Name Data Networking) [2--6], DONA (Data-Oriented Name Architecture) [7], CCN (Content-Centric Networking) [8], PURSUIT (Publish Subscribe Internet Technology) [9-11] and SAIL (scalable and adaptive internet solution) [12], but NDN has attracted researchers the most.

### 1.1 Name Data Networking (NDN)

NDN is future internet architecture [2-3] that has been a lot of attraction of research in recent years. Two types of packets are used in NDN; one is an interest packet and second is the data packet. The consumer sends an interest packet for the desired content while publishers or routers provide data packet in response to this interest packet through a reverse path. Each Name Data Networking router maintains three tables in response to an interest packet. One is Content Store (CS), second is Pending Interest Table (PIT) and the third table is of Forwarding Information Base (FIB). When an interest packet is received from a consumer to the router, the router first checks the desired content in its CS. If the desired content is found in the table, it provides that content to the consumer from this router otherwise interest packet is forwarded to the PIT. PIT checks if it has already assigned an interface for the desired content. If not PIT makes an entry in its table for this interest. PIT receives the same content from FIB and forwards it to the consumer on the reverse path of an interest packet. This process is continued in each router. NDN has some major issues such as security, mobility and access control but the mobility of consumers is the main challenge in NDN architecture.

### 1.2 Mobility

Mobility means if a consumer moves from one network/router to another network. There are three types of mobility (a) user mobility (b) network mobility (c) provider mobility. In user mobility consumer move and change its connection, in network mobility the whole network will move from its area and provider mobility change the provider position. User mobility is an issue in NDN architecture. How can we sustain the link status with the mobility of users so as to provide the desired content to the consumer with less latency?

The rest of the paper is organized as such: section 2 discusses related work to our proposed solution. In section 3, we discuss the proposed mechanism, Section 4 as about the comparison, and section 5 we conclude the paper

## 2. Related Work

Here we discuss and analyze some of the work related to our proposed scheme. In [13], the authors presented KITE, a trace-based producer mobility support NDN. In the proposed scheme, state full forwarding plane

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supports the mobility of data consumers locally. At the network layer, KITE supports various mobile communication scenarios and name-based rendezvous. A KITE prototype is implemented and evaluated in this paper. In [14], the author discusses the consumer mobility and mobility link service in NDN. The analytical investigation and the simulation result show that the proposed scheme reduces the total of the retransmitted data and the handover latency compared with the original NDN mobility solution. In this [15] paper the author proposed a mobility link service (MLS) based on their previous work for enhancing mobility link services. The main difference between this new MLS and their previous work is that some control messages were removed that were unnecessary and the investigation results were corrected.

In [16], the authors introduce a proxy node at the edge of 3G/4G architectures and use tunnels to forward Interest from the former PoA to the current edge. But it is particular to cellular networks.

The authors in [17] discuss CCN architecture in which CCN support mullet point if a given consumer move from its own position to another position and connected there. Then it will be identified by its name. The information will be sent to that router from the previous router to identify it. CCN architecture reduces hand over the problem but does not completely remove.

Authors in[18] discuss consumer mobility and its main challenges, when a consumer misses the data during moment time the router save it address and id (Name, address, ID,) and multicast its information to all connected nodes. This scheme has center controller SDN in cloud scenario if the missed is not received then it will send to the cloud and it will also share that information for the finding of the connected consumer.

In [19], authors used four approaches to discuss NDN-based producer mobility support. In the first approach, they use location information for solving producer mobility. They find the location information by location resolution system (LRS). After the movement of a producer from one location to another, it updates the location resolution system about its current position. LRS saves the record of producer and the prefix of a content name. The consumer sends the prefix of the content to LRS for finding out the location of producer. In the second approach, an interest packet is sent to producer prior location. It is forwarded to the new location through the FIB update table. The data packet is sent to the previous location and then from there to the consumer. In the third approach, content is handled in two sections. The first section of content is used for identifier and the second is used for the locator. In the first section of content, prefix or name is used and in the second section, the router location from which it is currently connected is stored. When the producer moves from its location it changes the location value of a router from old to its newly connected router. In the fourth routing-based approach, content is found through the name-based routing protocol. This protocol works in such a manner that it tries to find out the replicated data in the way towards the original producer. The authors expect that this protocol can perform efficiently in IoT because of less handover latency, the average cost for delivery of packets and a minimal length of the routing path. But the authors have not proposed any mechanism for producer mobility of NDN-IoT.

In [20], authors presented a solution for reducing data loss in real time application that is occurred due to mobility in NDN. They propose three approaches for this purpose. In the first approach, they use point of access (PoA) for registering a mobile node with the nearest PoA. PoA works as such that it just sends the entire interest and data packet to a mobile node. The authors used rendezvous point strategically located router for seamless mobility in their second approach. For solving mobility issue they used multipath interest and multipoint content in their third approach.

In [21] MNA this paper about the cluster base mobility. Different node are connected to the specific cluster head. All information is present to the cluster head. When a consumer move from one cluster head to another all information will sent to that cluster head. The author used NDNSIM and its value is nodes=11, link capability 100, 50, 20 but we are take one value 100 link delay=1, 10, 20 but we can take one value like 10.Wifi bandwidth =24 and simulation time 15 second.

In [22] SGH the author discuss that he can work on the NDN base architecture du to different problem is arising of IP base searching in mobility like non optimal routing the proposed scheme faster hand over. And shortest path communication Numerical comparisons.

In [23] STZ paper have three main segment. Fist is they can develop a Markov Decision Process (MDP) model for the whole forwarding process in a one node. Second is to build the output of the request on the base of content utilize queuing theory for the estimate the real-time Network status. Last one is to control rate of mechanism to provided and solve the rate issues caused by the fast forwarding of request packed. On the base of MDP modal it can used in NDN simulator which is used lank capacity is 200MBP interest packet size is 126B,data packet size is 60KB, maximum delay 2second and some data taken about round up.

In[24]ARG This paper is based on the NDN name data networking Architecture and its different types and mobility also reduced the problem of scalability delay throughput and overhead performance is comparing to existing scheme. The author used NDN SIM in performances evaluation the data will take in supposition form such as latency of delay 50ms ,20 packet,64 nodes and 10bandwidth.But some data we can convert some other unit and some ware taken round up.

## 3. Proposed Solution

We propose a cluster-based mechanism for a smooth handover and data transmission in NDN. In our proposed scheme we solve the consumer mobility issue in NDN. The proposed scheme support link-service management effectively with consumer mobility. In our proposed scheme, data is transmitted with low overhead. Our proposed scheme consists of two parts; one, handover and data transmission in the same cluster area and two, handover and data transmision in a different cluster area. Figure 1 shows the first part of our proposed mechanism where handover and data transmission occur in the same cluster area. We discuss our proposed scheme through figures here.

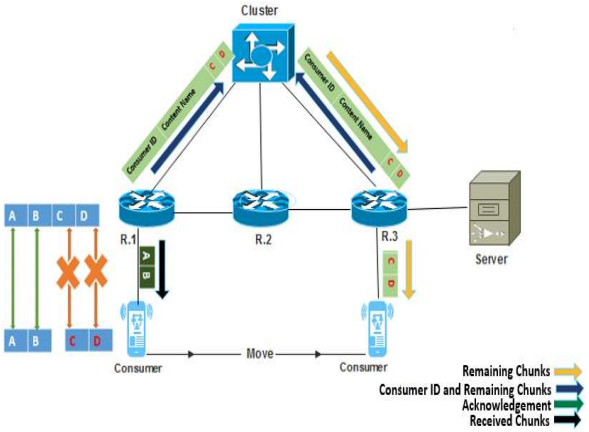



**Figure 1:** Handover and Data Transmission through Cluster Head

### 3.1 Inter Handover Mechanism

In Figure 1, we have three routers R1, R2, R3, and one cluster head. The consumer is connected with router R1 and receiving chunks of content that it has requested. Suppose consumer has received two chunks i.e., A and B of content and consumer moves from its current location to another location. It gets to disconnect from that access point from where a consumer is receiving chunks. In our proposed mechanism, the router receives an acknowledgment of each chunks that it has delivered. In this case we can say that router R1 has received acknowledgment of chunks A and B and is waiting for an acknowledgment of chunk C. But the consumer has moved from its current location to its new location. Router R1 set a timestamp for each chunks of a content that it delivers to consumer. R1 will wait for acknowledgement of chunks C till this timestamp. If R1 do not receive any reply in this time, it sends remaining chunks of content and consumer ID to its cluster head. In this case, it sent chunks C and D to cluster head with a consumer ID. Cluster head waits for the coming interest for the remaining chunks of content from this consumer ID. During this duration, consumer gets connected with router R3 and sends interest for the remaining chunks of the same content with its ID, content name and chunks C and D. Router R3 sends this interest to its cluster head for the provision of remaining chunks of desired content. Cluster head checks its ID and interest and starts provisioning of remaining chunks through router R3.

The second part of our proposed scheme provides a solution when a consumer moves out from one cluster area to another. Suppose consumer is connected with router R3 of the last router in the range of cluster head 1 as shown in Figure 2 and consumer receive two chunks A and B of the desired content and get disconnected from router R3. Here again, router R3 will wait for a specific timestamp *t*. If it does not receive any reply from a consumer in this specific time *t*. It sends the remaining chunks C and D of content to its cluster head. Cluster head wait for a specific time t, if it does not receive any interest for these chunks of content, it forward remaining chunks of content to its connected cluster head. Now this cluster head will wait for interest. In the given Figure 2, a consumer is connected with router R1 in the range of second cluster head 2 and we can see that it has started sending remaining chunks of content to the consumer.

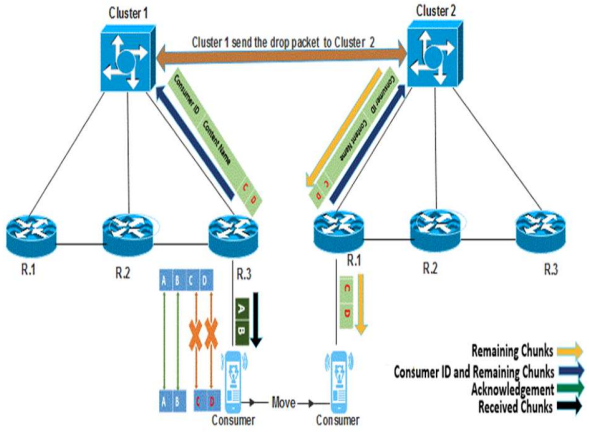



**Figure 2:** Handover and Data Transmission between Clusters

The proposed scheme is illustrated in the following steps.

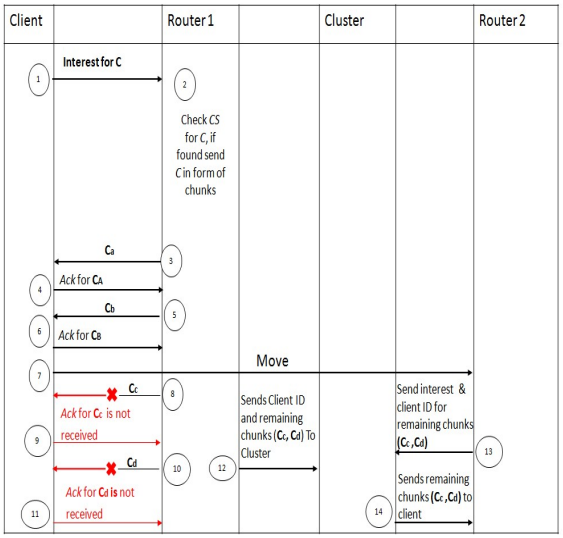



**Figure 3:** Flow Chart of the Proposed Solution

Here are the notations we used in designing an algorithm for our proposed solution.

| Symbol notation | Description |
|---|---|
| *Cl* | Client |
| $Cl_{id}$ | Client ID |
| *INT* | Interest |
| *C* | Content |
| *CS* | Content Store |
| *CHK* | Chunk |
| *ACK* | Acknowledgment |
| *R* | Router |
| *CLT* | Cluster |
| *t* | Time |

**Algorithm**

1) **If** *CL* sends *INT for C* to *R* **then**
2) *R* check *CS* for *INT*
3) If found **then**
4) *R* sends $C_{CHKs}$ to *CL*
5) *R* received *ACK* of every $C_{CHKs}$ from *CL*
6) **end if**
7) **if** *CL* moves and connection gets drop **then**
8) **if** *R* do not receive *ACKs* of remaining $C_{CHKs}$ in time *t* **then**
9) *R* sends remaining $C_{CHKs}$ + $CL_{id}$ to *CLT*
10) **end if**
11) **end if**
12) **if** *CL* connect to another *R* **then**
13) *CL* sent *INT* to *R* for remaining $C_{CHKs}$
14) *R* sends INT for *C* & $CL_{id}$ to *CLT* for remaining $C_{CHKs}$
15) *CLT* check $CL_{id}$ & *INT* for remaining $C_{CHKs}$ in its *CS*
16) **if** found
17) sends remaining $C_{CHKs}$ to *CL*
18) **else**
19) *CLT* sent $CL_{id}$ & INT to neighbors *CLT*
20) **end if**
21) **end if**

**end** procedure

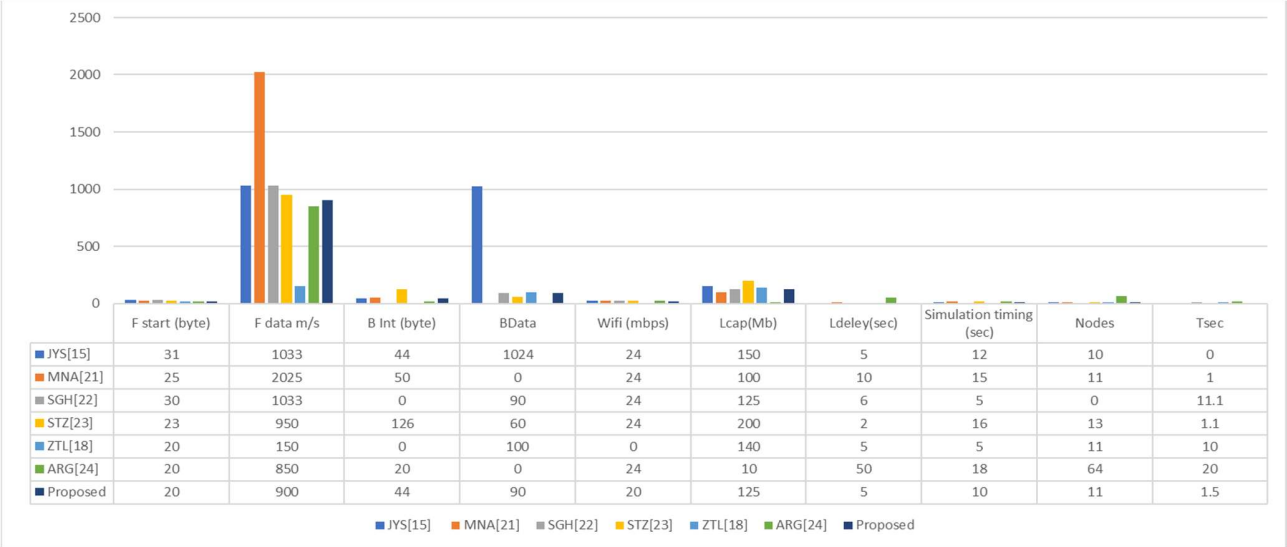
## 4. Comparison and Results

For the comparison we used fuzzy logic approach that discussed below.

### 4.1 Fuzzy logic approach

Fuzzy logic was introduced by Lotfi zada in 1960.Thas is the modal of university of natural language at California University. Fuzzy logic is supersets of convention (Boolean) logics that is being the concept of partial true value between completely true and completely false. There are two values 0, 1. Zero represent false and one represent true. E.g. Temperature is a input values and cold, hot [15] In our scheme Fuzzy logic is used for compression different equation values and till us what is the best of given among values.

To find the efficiency of the proposed scheme compared it with the existing schemes on the basis of eleven attributes using fuzzy logic approach shown in the final table. Moreover the graph show the results of overall comparison.




| | F start (byte) | F data m/s | B Int (byte) | BData | Wifi (mbps) | Lcap(Mb) | Ldeley(sec) | Simulation timing (sec) | Nodes | Tsec |
|---|---|---|---|---|---|---|---|---|---|---|
| JYS[15] | 31 | 1033 | 44 | 1024 | 24 | 150 | 5 | 12 | 10 | 0 |
| MNA[21] | 25 | 2025 | 50 | 0 | 24 | 100 | 10 | 15 | 11 | 1 |
| SGH[22] | 30 | 1033 | 0 | 90 | 24 | 125 | 6 | 5 | 0 | 11.1 |
| STZ[23] | 23 | 950 | 126 | 60 | 24 | 200 | 2 | 16 | 13 | 1.1 |
| ZTL[18] | 20 | 150 | 0 | 100 | 0 | 140 | 5 | 5 | 11 | 10 |
| ARG[24] | 20 | 850 | 20 | 0 | 24 | 10 | 50 | 18 | 64 | 20 |
| Proposed | 20 | 900 | 44 | 90 | 20 | 125 | 5 | 10 | 11 | 1.5 |

**Figure 3**. Comparisons results

## 5. Conclusion

Our proposed scheme supports consumer mobility under the NDN forwarding plane by removing the existing limitations through the clustering scheme. Our proposed scheme provides a simple solution for consumer mobility in NDN. This scheme also saves the time of resending new interest for content. It also reduces overhead by managing missing chunks of content instead of the whole content. In future, the proposed scheme will be evaluated for producer mobility. The scheme will also be simulated against existing schemes on consumer mobility in NDN.

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