Improving Data Accessibility in Named Data Networking based on Mobile Crowd Sensing

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ABSTRACT:
Scalability, security, resiliency, and efficiency are Named data networking's (NDN) main features which have attracted many researchers' attention to be considered for IoT. In this field of study, many research areas still need improvements like accessibility. In this paper, an NDN-based protocol is proposed for reducing data access time in the discovery phase in mobile crowdsensing by using a category table (CT). This protocol makes it possible to access semantic information through the category table. The efficiency of the proposed protocol is measured by simulation and demonstrated that in packet end-to-end delay is lower than the existing methods' (NDN and Geo-NDN). Also, the proposed protocol was found to has the highest rate successful message delivery rate.

KEYWORDS: Named Data Networking, Ad Hoc Network, Mobile CrowdSensing.

1. INTRODUCTION

NDN works based on named contents instead of IP addresses. It is essential that NDN support semantic-based networking which is an intelligent transport of information. It's programmed to operate on top of unstable packet delivery networks with unpredictable connectivity [1]. With the rapid development of mobile devices equipped with wireless communication interfaces, Mobile Crowd Sensing (MCS) networks have emerged as a new paradigm. Mobile Crowd Sensing improves data aggregation operations. MCS creates the possibility of contribution and collaborations of different devices in a way that devices can issue interest packets to get needed content as opposed to sending ordinary requests [2]. From another perspective, smart devices can be considered as nodes of this network due to their embedded radar sensors, camera sensors, GPS, et al.

In this paper, we our emphasis is on data access time in the discovery phase based on MCS. To achieve this purpose, the structure of this article is as follows.

The Section 2 reviews the previous works, assumptions, and problem statement. The proposed framework has illustrated in Section 3. Section 4 deals with introducing the simulation parameters. Evaluation and analysis of end-to-end delay, network overhead and rate of successful message delivery have been submitted in Section 5. To sum up, section 6 terminates the paper.

2. RELATED WORKS

Named-data networking (NDN), proposed by L Zhang [3, 4], is introduced based on CCN, improve the message delivery model. The notion of content-aware networks has been notably studied in the literature [5, 6]. Since the last decade, CCN has been extended to different networks. Different papers based on CCN such as timer-based CCNs [7] have been proposed. compared to CCN, NDN's simple communication model made it superior [8]. There are three features in NDN that make it useful in different environments of IoT: supporting access restrictions, consistency in facilities and installations, and delay-tolerant networking [9].

In NDN, all communications execute by using Interest and Data packets. these packets have a name, which uniquely determines a datum that can be carried in one Data packet. A user restores data by putting the requested data's name into an Interest packet and sending it over the network. Routers transmit the Interest to the data producer(s) based on the specified name, and the Data packet whose name matches the name in the Interest is returned to the consumer [10]. NDN enables applications to entitle devices in networks while keeping associated forwarding data [11]. NDN can fulfill IoT requirements at the network layer while also supporting mobile device security and mobility [12]. Video online learning, a solution for partially disconnected networks,

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virtual reality, and unscrupulous network security are among the NDN-IoT-based projects described [11].
There are certainly significant reasons behind observing NDN in IoT. It Some of the reasons include [13]:
(a) NDN integrates data-centric security into the network layer by insuring data directly in a local network system.
(b) Naming conventions provide an open environment for applications and services to cooperate and function together.
(c) NDN provides host multi-homing and smooth use of all communication interfaces by identifying data.
(d) NDN provides content multicast and in-network caching out of the box.
(e) NDN simplifies application development by allowing developers to focus on the data rather than DNS or IP setups.
Many researchers have previously sought to increase the accessibility of data on NDN-based networks [14-16]. Some of these ideas are edge-based [17]. Some have been more realistic and have come up with ideas for real-time access [18].
In this paper, we present a new strategy that utilizes the rate of successful message delivery. We provide a suggestion table based on different categories on our framework. It is also shown in the literature that increasing mobility could help in improving connectivity. Accordingly, the more the network becomes crowded, the more the suggestion tables get loaded.

3. PROPOSED TABLE

Some concepts in the proposed protocol are known in content-based networks. Namely [20]:
Content Store: used for storing data packets temporary
Pending Interest Table: used for storing sent Interest packets forwarded to sources which are still waiting for replies (as soon as finding the right reply, PIT's input will be deleted, if not, after a specific time will be dropped)

Searching CS[1] entries are performed based on the exact matching of names [19]. To make this information available semantically, in the proposed protocol, we make it possible to access semantic information through the category table. After receiving an interest packet, the words are first checked character by character through CS. If no appropriate answer is found, the request will be considered meaningfully.

As it has shown in Fig 1, all communications in the proposed framework are carried out based on Interest and Data. These packets have a common field named Content Name, which identifies a piece of data that can be carried in the packets. Each Interest packet has a selector field with more information about the desired Data, as well as a nonce field with a random number created by the consumer. The need for having the Sender's Position is obvious since the network is geographically based. The Next-hop field is used for finding the data in the neighborhood. Actual data can be found in a Data field. In the category table, appeared in Fig 2, the main sections that the client demands carry some subsections. For instance, the main section named "food" needs to have some subsections like KFC, McDonald's, Noodles, and et. al. After receiving information from a geographic map, the request is directed to the same category as needed based on the content of the Interest Packet.

We need to apply spatial index to improve semantic cache management. Based on the idea in [21], a Quadtree is used to manage the category table. The implementation structure of the semantic cache contains a cache index which comprises query and dataset sections. each query has an attribute and a predicate. As appeared in Fig 2, the two-dimensional space is recursively partitioned into four sections each time.

Since the sensors of this network provide high-speed data, establishing a stable FIB tab-le will not be possible but designing the Sender Position and Next-hop fields will make requested in the network possible. Therefore, each vehicle knows its location and its neighbor beside the location of source data for a specific Interest. Once a vehicle is about to begin an Interest, after checking the CS and updating PIT, it needs to select the next-hop as it's shown in Fig. 3.

Category Table	Interest Packet	Data Packet
Emergency	ContentName	ContentName
Entertainment	Selector	Signature
Events	Nonce	Signed Info
Food	Sender Position	Data
Shop	Designated Neighbour (next hop)	Sender Position
Places To See		

Fig. 1. Communications packets and Category Table.

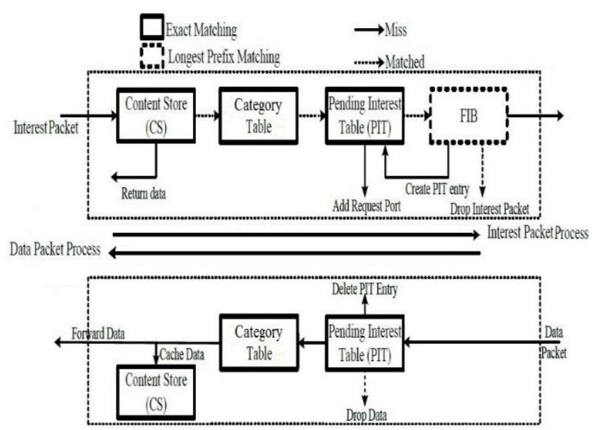

Fig. 2. Index structure for the semantic cache introduced in [21].

By receiving an Interest packet, sending the Interest packet passes through a flow as Fig 3. As you can see, the process of selecting the Next hop when sending an interest packet in the proposed method is shown in it.

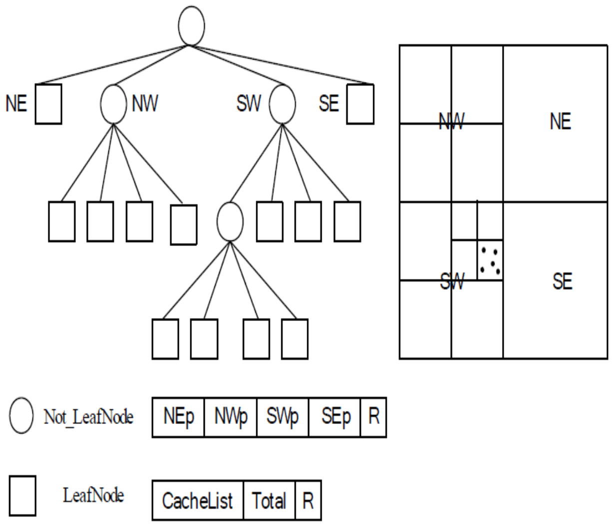

Fig. 3. The interest packet and data packet processes.

4. EXPERIMENTAL SIMULATION RESULTS AND ANALYSIS

4.1. The Simulation Parameters

The simulation platform is created by combining three tools: OMNeT ++, Inet, and NDN-lite. OMNeT ++ network simulator tool, as well as the Inet, is used as an ad hoc network simulator. Two different tables indicate the simulation's initial parameters. The Base values for network layout parameters that are taken into account are shown in Table 1. Table 2 shows the parameters used for performance evaluation.

In the following, network evaluation metrics in this protocol are described.

4.2. The Simulation Criterion

a) End-to-End Delay: The average latency of arrived packets at the destination node from the time the request was sent, until the late arrival of the request is called End-to-End Delay (1).

End-to-End Delay= n (T+P+PR+Q) (1)

Where n stands for the number of links in the networks, T shows the Transmission delay, P=Propagation delay, Pr =Processing delay and Q= Queuing delay.

Table 1. Simulation's Parameters.

Category	Parameter	Value
Physical layer	bandwidth	5.9GHz/10MHz
	Range	200m
	CT	2
	SAT[1]	-77dbm
monitoring layer	Slot Time	13µs
	Sensitivity	-82dbm
application layer	Data Size	1400Byte
NDN	Interest Package	20Byte
GeoNDN	Interest Package	40Byte
NDNwithTimer	Interest Package	40Byte
Map	Size	4850*4850

b) Network Overhead: The bandwidth used to control and manage network routing is called Network Overhead. In the other definition, the total number of received packets ratio to the total number of downloaded packets is overhead.

Network overhead = (Sum of packet received by the destination(s)) / (sum of packet sent by a source (s)) *100 (2)

c) Correct Suggestion Rate: There is an exact answer to each request on the network, and if the answer is not available, the network, based on its meaning, offers close suggestions to the requester. The accuracy in the accurate response of the network for each request is Correct Suggestion Rate which determines the performance of the semantic structure and overall network performance.

d) Rate of Successful Message Delivery: The average successful delivery rate of a message in a communication channel is referred to as the Rate of Successful Message Delivery in communication networks or packet transmission. These data can be transmitted across a physical or logical link, or via a specialized network node. The operating power is often measured in bits per second, but it can also be measured over a given time period. The total amount of data sent to all terminals in a network is known as throughput. Queuing theory can be used to analyze throughput mathematically.

The Rate of Successful Message Delivery = (number of bits succeassfully received)/ (transmission time) (3)

[1] signal attenuation threshold

Table 2. Parameters Used for Performance Evaluation.

Parameters	Values
Simulation Time	1000s
Nodes' Speeds	2-5Km/h
Transfer Rate	6 Mbps
Maximum number of nodes	200
Minimum number of nodes	50

5. THE SIMULATION RESULTS

In the following, the simulation results of the proposed protocol are introduced by 4 metrics and compared with three protocols that include NDN-base, Geo NDN, and NDN with Timer. According to Fig. 4, the highest delay belongs to NDN, NDN with Timer, and proposed protocol, respectively.

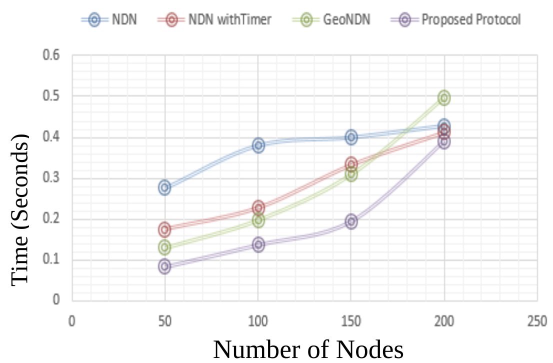

Fig. 4. Comparison based on end-to-end delay criterion.

According to Fig 5, in the beginning, the recommended protocol overhead is at the worst point due to the suggestion table updates. The NDN and NDN with Timer protocols have the least amount of overhead respectively. By increasing the number of nodes in the network, the category table is more completed and the information insertion time is reduced. As a result, it is observed that if there are more than 150 nodes in the network, the volume of the network overhead is more controlled and stands in a better position close to GeoNDN 's position.

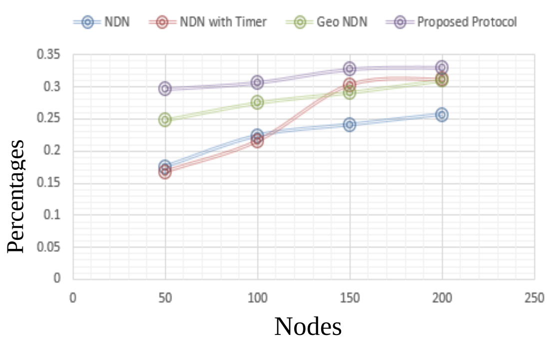

Fig. 5. Comparison based on network overhead criterion.

Fig 6 shows the total number of Suggestions (Total Suggestions) sent to the nodes involved in the network and the percentage of selected Suggestions (Used Suggestions) of the total suggestions. With increasing nodes, the rates of accepted offers have also increased significantly.

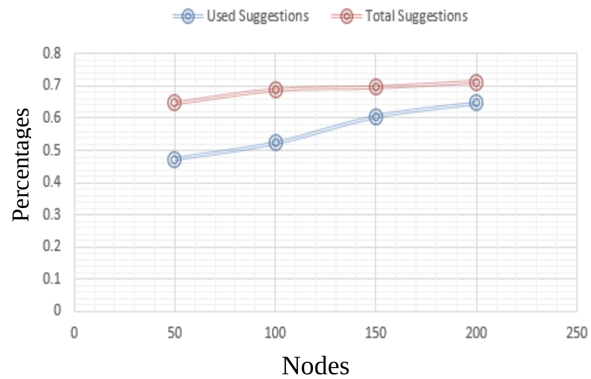

Fig. 6. Comparison based on the total number of Suggestions criterion.

The highest Rate of Successful Message Delivery belongs to the proposed protocol. The results are shown in Fig 7. Since the proposed protocol is an upgraded version of the Geo NDN and NDN with Timer protocols, these results were predictable.

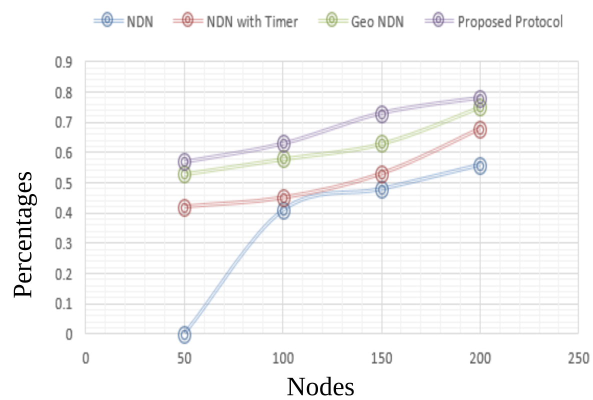

Fig. 7. Comparison based on Rate of Successful Message Delivery criterion.

6. CONCLUSION

The proposed protocol was simulated and compared by four main criteria and in four different number of node levels. For End-to-End Delay, NDN has the highest value and GeoNDN respectively, and in this metric, despite the increase in nodes above 100, the proposed protocol is successful in comparison with other protocols. More suggestion tables are completed; more capable our protocol appears. Until reaching 150 nodes in the network, the overhead network is not acting properly, but then it reaches a balanced situation and its growth rate breaks. The total number of Suggestions is not defined in other networks and is specific to the proposed protocol. Simulation results show that with the growth of the network, the Suggestion tables are more completed and by reaching 200 nodes, 90% of the requests are answered through the tables. The most significant outcome of the proposed protocol was found to be the Rate of Successful Message Delivery criterion.

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