Towards a New Internetworking Architecture: A New Deployment Approach for Information Centric Networks

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Abstract. New research efforts are trying to evolve the current Internet. With satisfying communication hardware, the intent is to switch to data oriented networks. In this new vision, data will be the heart of the architecture and protocols have to be changed to dial with this concept. Promising ideas are proposed up in order to develop clean slate design solutions. However, these propositions encounter many deployment problems. In this paper, we propose new approach based on Bloom Filter to cope with storage space problem in data oriented architecture DONA.

Keywords: Future Internet, Information Centric, Internetworking, Bloom Filter

1 Introduction

Despite its tremendous success, the internet architecture is facing serious scalability and flexibility problems. In recent years, the use of the internet has changed from machine interconnection to data or service oriented communication. This new purpose has increased the number of internet users and the variety of applications supported leading to the emergence of many limitations in term of mobility, security, routing and content delivery scalability [15, 3]. To overcome these problems, the research community is presenting two alternatives. One side is proposing an *evolution approach* by continuously patching the internet with overlay protocols. The other side is proposing a *revolution approach* by re-architecting the internet and giving a new design. New architecture propositions are mostly information centric. They change radically the internetworking concept from simple host to host communication to data delivery. These new approaches have revealed that many original assumptions about internetworking are no longer valid [1, 3] specially the paradigm of: Naming, Forwarding and Name Resolution.

Although this promising success, many problems slow down the re-architecting ambitions [3]. Splitting naming from routing and forwarding reveals new challenges. Making the *name* or the identifier related to the data drives on the researchers to use *cryptographic identifiers* to guarantee uniqueness and data security. But, these identifiers are no longer understandable by internet user and need a new search engine to find from list of key words the correspondent identifier. Also, by identifying data instead of the host, a huge storage space is needed in the network routers to save routing information about transmitted data. This kind of problem is crucial especially for DONA proposition and its deployment seems impossible due to the huge amount of storage space needed. In this paper, we try to dial with this problem. It's a new attempt to reduce used storage space by exploiting Bloom Filter structure [10]. Also, we improve DONA resolution process by adding the possibility of route selection.

The rest of this paper is organized as follows. In section 2, we present the information centric networking by discussing architectural specification. Section 3 highlights DONA deployment problems and introduces our proposition. Section 4 concludes the paper.

2 Information centric networking

New internetworking researches introduce information centric paradigm as the natural model for the internet architecture [3]. ICN has drawn a lot of attention from the research community, some of its challenges include: secure and persistent naming, name based routing, name resolution, network caching, replication, mobility. Any ICN approach is based especially on splitting: naming, name resolution and forwarding.

2.1 Naming

Naming means to attribute a unique identifier for an element. IP address was used as host name and location indicator in the same time. In data/content oriented system, the name will be attributed to some data, content or service unit. Naming mechanism can be flat, hierarchical and cryptographic.

2.2 Name resolution mechanism

Name resolution means trying to find any suitable location for the sought data from a given name. It's the mapping between the name and one of the data copy holder address. It's almost like name resolution in the web, when a client web browser is trying to find IP address of a known URL. Different solutions are proposed *hierarchical resolution* [4], *DHT based resolution* [15], *CHORD* [6] and *Publish/subscribe paradigm* [5, 15].

2.3 Forwarding mechanism

After name resolution is achieved, the client has located one of the hosts holding the sought data. It means that he has a valid address (locator) to contact this host. Then data delivery can be started. In data oriented mechanisms, two different ways are used: the traditional IP way [2] and content routing [**?**].

3 BADONA: Bloom filter Aggregated DONA

3.1 DONA deployment problems

DONA is facing some problems disabling its deployment. One of the bothering problems is the huge storage space needed to save all location information. Naming data instead of the host holding the data will raise the number of entries in routing or resolution tables. This giant space is making natural deployment of data oriented approaches impossible. Moreover, the numbers of data units will increase the traffic between resolution handlers.

Using cryptographic names, in DONA, guarantees data authenticity, integrity and identifier uniqueness. But, names will be incomprehensible. User will be unable to memorize these names. Then, specialized search engine has to be used at application level allowing users to access to related names only by giving keywords.

An important benefice of data oriented architecture is the possibility to have many copies of the same data deployable in the network architecture. Each copy holder will announce that it can provide this data. Doing so, we can reduce data delivery latency. However, changing a data leads to an update of all the copies. In this paper, we focus on the problem of storage space in DONA and our contribution is based on using bloom filter in order to reduce needed space in RH.

3.2 BADONA presentation

In BADONA we try to cope with the storage problem. we propose that each router will not forward any received registration. Instead, it will make a Bloom Filter from all received registrations. Then, only the Filter will be forwarded. Routers don't need to forward received filters from their children to higher level node. Each router combines these structures and forwards only the resulted filter. Such operation is possible because Bloom filter structure enables merge operation [10]. Thus, our solution will be based on a modified version of standard bloom filter [8, 9]. Our approach will insert location information like hop count in the BF vector and we use counting structure [8] to enable deletion from the filter. Moreover, we rely on a clearing mechanism from [9] to reduce false positive.

3.3 BADONA details

In our proposition, we use counting Bloom filter endowed with two vectors. The principal one is used to add data registration and to answer membership queries. The second counts the number of insertion operation for each cell. To answer membership query, it is necessary to check positions obtained by hash functions. Three cases are possible:

- First case: one of the cells is not used and it's set to **0**. Therefore, we can confirm that this element is not inserted in the filter.

- Second case: all cells are used and contain the same value. Thus, we can confirm that this element is a filter member. The found value is an approximation of the *hop count* between the router and the data provider. The real *hop count* is equal or lower than the given value.
- Third case: All cells are used but they contain different values. Then, we can confirm that this element is a filter member, and the lowest value is given as hop count approximation. Again, the real hop count is equal or lower than the given value.

Adding new data registration in the filter In hierarchical data oriented approach, any data provider or holder has to announce its location and the list of data units under its responsibility. This information (node address/name, data name, next hop, etc) will be sent to the nearest router. The router saves each registration in a table called registration table in addition to a Bloom Filter. To add new registration to this filter, the router hashes the new registration with every hash function. For each generated position, we check related cell. We have three possible cases:

- First case: If the cell is set to 0. We conclude that it's not yet used. The hop count between router and data provider will be inserted in this cell. In addition, the correspondent counter cell will be set to 1.
- Second case: The hop count found in the cell is equal to hop count of the new registration. Then, this cell is not modified. Only the correspondent counter cell will be increased.
- Third case: The found hop count is different from the new one. We will save the higher value and we increase the counter.

Processing deletion request Deletion is possible in our approach because we use counting Bloom Filter. When any node announces that its no longer provider for some data units, we have to propagate this information in the network. First of all, the data provider forwards the deletion request to the nearest router. The router will delete the correspondent registration from its registration table. Then it updates its filter and forwards the deletion request to higher level routers. Any router receiving the forwarded request will do the same actions. It checks its *registration table*. Commonly, it will not find a correspondent entry. But it's possible with node mobility. If it's the case, the entry will be deleted. Then the filter will be checked and if the element is filter member, deletion will be processed. Finally, the request will be again forwarded. This process guarantees that the location information will be erased from all routers.

Information forwarding Each router will receive many data filters from its children. Every filter will be saved separately labelled by origin router. Doing so, we can later forward resolution requests to the corresponding router. To propagate registration information to higher level, the router has to merge received filters with the local one and only resulted filter will be forwarded. By doing this in all the hierarchical organisation from the bottom to the root, name resolution will be possible throw the whole network. Each resolution request will be handled locally as possible. In the worst case, the request reaches the root.

Processing resolution request When a client is trying to contact data provider, he initiates a resolution request. This request will be processed by routers through the network. The local domain router receives the request from the client. Then, it follows these steps:

– First: the router checks its registration table If a valid entry for the sought data unit is found, then it responds positively to the client request.
– If no entry was found, the router checks received filters. If the verification process gives a positive answer in one or many received filters, the router giving the smallest hop count will be chosen. Then, the request will be forwarded to this router.
– When the verification process gives a false answer in all saved filters, it means that neither the router nor its *children* has any information about the requested data unit. Then, it forwards the request to higher level router.

When, the router receives forwarded requests from other routers, it processes them following the same steps. In the worst case, the request reaches the root. It's the highest router in the hierarchical organisation. Obviously, it will have location information about all manipulated data units making it able to answer any request. The positive answer will be back forwarded to the requestor. When the client gets the answer, he can initiate its communication with the data provider. It's the traditional IP layer responsibility to manage this communication. The router chooses the next hop giving the smallest hop count. This choice reduces the resolution time and gives a quick answer. This criterion can be replaced by another one to improve different network proprieties (line speed, false positive rate, activity rate, etc)

4 Conclusion

Clearly, data oriented architecture are the internet future. Users and applications are no more interested by host to host communication. Most of recent studies propose information centric rearchitecture plans. Until no, there's no agreement about evolution approach or revolution approach. Anyway, data oriented solutions have serious deployment problems. Switching to data identification reveals storage problem due to the huge number of manipulated units.

In this paper, we have proposed the use of Bloom filter to face this problem. Each data registration will be hashed and added in the Bloom vector and membership queries can be easily solved. Data registration will be represented by the correspondent hop count to improve route selection. Filter updating is also allowed spatially deletion due to the counting vector. In our solution, only filters are exchanged between routers to limit control traffic. Due to the hierarchical organisation information will be propagated up to the root and any query can be achieved.

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