



Modeling the Data Object Routing in Data Aware Networking

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Abstract. Data Aware Networking (DAN) is one of the key technologies coined by the International Telecommunication for Technology. It aims to provide a system and method for managing data over the Internet. It also considers the needs of diverse users using the Internet and keeps track of their usage history to make the data proactive for them. Four key components of Data Aware networking include the documents called Data Objects which are the focal point of attention, authors who create the documents, publishers who will maintain the documents along with a catalog of documents and access rights, the End users who will be utilizing the documents in a sophisticated way provided by the concept of DAN. Considering the architecture and the way the data objects are published in data-aware networking, this paper aims to suggest a dynamic and sophisticated routing system that will study the needs of diverse users and attempt to route the data either in a proactive or reactive manner to suit the needs of the users. This paper also proposes routing algorithms to be utilized in data-aware networking for both reactive and proactive routing.

Keywords: Data Aware Networking · Data Objects · Named Data Objects · Data Driven Networking

1 Introduction to Data-Aware Networking

Depending on the use case scenarios that are being active in the field of communications and networking, the International Telecommunication Union for Technology coined the term Data Aware Networking clearly mentioning the requirements from the viewpoint of Data Forwarding, Data Routing, Mobility, Security, and Performance Management of the telecommunication networks [13, 14]. The major objective of Data Aware Networking is to come up with efficient and effective data maintenance and utilization system for consumers with the most recent data that is on demand [1]. Along with this, Data Aware Networking also attempts to create a layer over the traditional TCP/IP model to take care of the data routing and object modeling aspects.

Data in Data Aware Networking (DAN) may be of any kind like Text, Numbers, Images, Audio, Video, Links, and any other multimedia data. The data is termed a Data Object in DAN which is created by its author for distribution over a community of users or for the public. Such data created by the author will be given a unique name and will be made available on the internet via the publisher who takes the opportunity to maintain the data objects created by several authors [5–8]. On the other hand, the publisher also maintains the user bases who are utilizing the data objects that are available. The publisher-centered method to access data objects enables keeping track of the errant users and is also helpful to provide data on demand to the required users.

A productive Systematization of data objects makes the data objects simple to find, recover and circulate from their related DAN segments and furthermore patches up their execution and usage. This can be acknowledged by ordering and formulating the information process in like manner into different classifications of their significance [11, 12]. The routing of the data object may be reactive or proactive. In reactive routing, the data objects will be supplied to the users on demand, and in proactive routing, the history of the data object and respective users will be taken into consideration based on which the data objects will be automatically made available to the users.

2 Concept of Data-Aware Networking

The Major Contributors to the concept of Data Aware Networking are the Authors of the Data, Publishers of the Data, Data Managers, and finally the consumers of the Data who follow a sophisticated procedure to store the data files which are termed as data objects. It all starts with the creation of a data file by the author. The author will submit the same to the publisher to make the data available to the public. On receipt of the file from the author, the publisher allows a unique Id to the data file which is then called a Named Data Object. The publisher holds the responsibility to maintain a categorical catalog of data objects that he maintains and makes the catalog available to the public through the web media. The consumers on the other hand are the users in read of data. The consumers can make a request to the data manager who is responsible for maintaining the consumer base and serving the request of the consumers. On receipt of the request from the consumer regarding a particular data object, the data manager transfers the same to the publisher who in turn will reply to the consumer through the data manager with the required data object. Hence, the whole process involves the secure data transfer between Author, Publisher, Data Manager, and Consumer.

Apart from this, the concept of data-aware networking introduces the concept of networking based on data. It means that the data should be the one with which the entire networking is going to operate and it requires certain facilities to be made available in data-aware networking which are discussed in Sect. 3.

3 Requirements of Data-Aware Networking

Data Consumers in Data Aware Networking will acquire data by searching for the data using the Id or Unique Name that is given to the data object by the publisher. As there will be a huge number of data objects that relates to a particular domain, the data objects

need to be categorized and kept in a particular to facilitate ease of use [9, 10]. This task can be facilitated by preparing a proper data structure for the content to be uploaded by the publisher using a suitable relational database management system. In our earlier work, we proposed a data structure to maintain a database of objects and named it a Data Object Bank so as to facilitate the categorical storage of data objects. It is also proposed to maintain the database with a suitable relational model so as to maintain the Consumer data as well as the maintenance of Consumer history. Reliability is one aspect also needs to be paid attention to build a secure and trustable system [3, 9].

Whenever the consumer is in need of data and puts the data request, we need to verify the authenticity and authorization of the user in order to prevent errant users from accessing the most secure data. At the same time, the concept of data networking ensures that the data that is being accessed by the user is the latest version and most appropriate to him. This keeps the user satisfied and helps the consumer to prevent himself from gaining wrong knowledge.

There will be some consumers who are going to access the data on a daily basis. As the recommended system is data-aware, it should keep track of the user requirements and help the user to find the data required and make it available to the consumer in time without any request. These facilities require some automated mechanism needs to be implemented while providing access to the data to the consumers based on their usage history. We may also prepare a machine learning model that used the dataset of usage history and predicts the data requirements.

In this paper, we proposed two different routing models to facilitate secure data transfer between the said entities in the data-aware networking system. One routing technique holds the responsibility to transfer data on demand and is named as On-Demand Routing. The other routing technique keeps track of consumer history and makes the proactive data transfer by making the data object available to the consumer as and when it is required. Methods for applying both routing algorithms are described in detail in the next sections.

4 Reactive Routing Algorithm for Routing in DAN

One can find different ways and algorithms to route the data objects in a variety of ways to serve the consumer base with ease and efficiency. As the focal point of attention here is the Named Data Object (NDO) and the entire functionality to be achieved is based on the, the routing here is to happen a little different than the traditional routing. We can assume this is an additional layer on the traditional layered TCP/IP network which acts based on the NDO. Hence, the routing takes two different versions based on the NDO namely Reactive Routing and Proactive Routing. The algorithm that we proposed for the reactive algorithm that is written below will provide a way to route the NDOs on demand in a very fast, effective, and efficient manner by incorporating the features of software-defined networking which is a trending domain in the era of computer science.

The goals for defining the reactive routing system include centralized control over the data and its related resources for efficient routing and distribution of resources. The conceptual diagram for the reactive routing in Data-aware networking is shown below (Fig. 1):

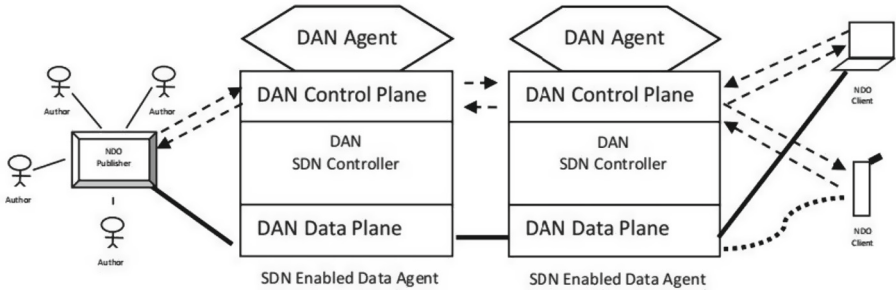


Fig. 1. SDN-Based Reactive Routing System for Data-Aware Networking

The SDN-based reactive routing system is built by adding a new layer on the conventional TCP/IP-based routing system with three agents to take control over the data-based networking namely the DAN Data Plane, DAN Control Plane, and the DAN Agent [2, 4, 15, 16]. The Control plane has the ability to be an interface between the traditional network and the DAN network and is a set of functions to receive the data from the underlying network, store and forward Named Data objects as directed by the traditional networking system. The DAN Data Plane implements physical control of underlying networks and holds the ability to change routing statistics so as to implement data-based networking. The DAN-SDN Controller will have complete control over the routing system and holds the ability to control all entities of the Data Aware Networking system.

The DAN agent holds the functionality to define the new route based on the data that is being transferred based on the earlier history of data transfer. The set of entities in the routing architecture will interact through the SDN agent which can be an integration of all entities covered in the routing system. In the mechanism of reactive routing, authors will initially create the data file and submit it to the publisher. The author may also have the possibility to publish the same data object with multiple publishers.. The publisher will maintain the catalog of data objects. The consumer data maintenance is taken care of by the DAN Agents on the other hand where the consumer will register themselves with the DAN agent. Consumers may request for a data service through the DAN agent. The DAN agent then in turn makes a request to the publisher and the publisher will be in service of data to the DAN agent with the required data object.

Proper authentication and authorization rules will be implemented for the consumer before the service is made available. The data object is then served from the DAN agent to the consumer through intermediary agents. The intermediary agents based on the statistical analysis, may keep a copy of the data object.

Algorithm for Reactive Routing of NDOs in DAN

- i. Data Created by the author will be submitted to Publisher along with relevant information.
- ii. The publisher prepares the Data Object Header and allots a unique Identity to the data object (NDO).
- iii. The publisher prepares the NDO by attaching a header to the Data object.
- iv. The publisher pushes the NDO to the DAN publishing System/Database.

- v. The Published data will be updated for all agents of DAN agents to be of service to consumers.
- vi. Consumers may request the service of a nearby DAN Agent for the NDO.
- vii. The DAN Agent searches the publisher's database for the availability of the NDO. If available, the request will be served with the required NDO, or else the request will be forwarded to the publisher.
- viii. The Publisher will serve the NDO to the Consumer through the DAN agent to be on service to the consumer.
- ix. DAN Agents will also copy the NDO based on the demand as per the statistical information.

5 Proactive Routing Algorithm for Data Routing in DAN

Apart from reactive routing, proactive routing holds some special responsibilities as listed below:

- It should keep track of the earlier history of the consumer data access and find the best suitable object to access next.
- It should be able to observe patterns in the data access pertaining to that particular user to serve him with the best available choice
- The data access history will also aid in timely data transfer with which the consumer will be more comfortable

As there is no initial data available for the first time proactive routing is applied, it takes the data from the reactive routing the history of data objects transferred, and the user access of particular data, dates, and times of data transfer along with all the required statistics to route the data automatically. Hence, we can presume that the proactive routing will be using the data transfer statistics from the reactive system only. The caching system in the reactive routing system will help to transfer the data objects with ease and faster as the data may not be only accessed from the server but also can be from the intermediary nodes as maintained by the reactive routing mechanism. From this point of view, the reactive routing and proactive routing are working in integration with each other and hence there is no any sort of ambiguity in the data transfer mechanisms. The step wise algorithm that we proposed for the proactive routing of NDOs in data-aware networking is given below:

Algorithm for Proactive Routing of NDOs in DAN

- i. Data Created by the author will be submitted to Publisher along with relevant information.
- ii. NDO Publisher prepares the header of the data object and will allot a unique ID and a unique Name to the data object.
- iii. The publisher makes NDO by adding header data to the Data object
- iv. The publisher will publish the document in DAN databases and updates the catalog of available data objects.
- v. The Publication detail will be updated with DAN Agents as per the demand and supply statistics available with the publisher.

- vi. The NDO Agents will also copy the NDO at various intermediary nodes based on the required statistical information available with the DAN database.
- vii. Final Publication data will be updated with all DAN agents to be on service to the future request of Consumers.

6 Conclusion and Future Work

Both the reactive routing and proactive routing algorithms will cache the data objects at the time of data transfer and a common database of all data usage statistics will be made available with all required statistics to both algorithms. The outcome of the reactive routing system will depend entirely on the NDO and the network route will be finalized based on the availability of NDO in various intermediary nodes. This routing may also differ in different situations for the same NDO. The outcome of the proactive routing depends not only on the NDO but also on the earlier data usage statistics, and consumer base statistics, and the route will be finalized based on all the aspects of data-aware networking. Hence we may assume that the proactive routing may perform well over hundreds of data transfers and the reactive routing will start performing the best from the initial data transfer onwards.

As proactive routing takes into consideration the usage statistics of data with respect to every user, one may consider applying different machine learning techniques to classify the data statistics based on consumer's usage and predict the upcoming specifications of the same consumer. The inclusion of machine learning techniques may help the realm of data-aware networking to grow much better and more flexible and may also provide the consumers with much better data accessing platform.

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