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Research Article

Content Centric Network: Solution over IP Network Issues

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Abstract

Current internet architecture was designed a long time ago. This architecture was designed considering less number of hosts and scarce computational resources. But now, computational resources are very cheap. So network size is very large now resulting tremendous increase in the traffic over the network. Current IP networks as well as Content Delivery Networks are end point centric. But do end points really matter? Various studies depict that current network is oriented about information mostly. Users are concerned about only information; don't matter from where they get information. Users don't care about the location of the information. So, network should be designed in such a way that information is very close to the user resulting decrease in the traffic over the network. In this paper, we cover the issues of current IP network and then how the CCN (Content Centric Networks) can be solution for these issues. We will also focus on Publish Subscribe paradigm.

Keywords: *Content Centric Network (CCN), IP Network, Publish-Subscribe.*

1. Introduction

Internet's original design was made when computational resources were scarce and storage was very expensive. This resulted in less number of hosts or stations. The basic requirement of Internet at that time was to forward the packets among these fixed hosts / stations. This communication model is the conversation between exactly two hosts. One requests for resources and other provides the access to it. Almost all the traffic on the internet consists of conversation between the pair of hosts. But as computational resources and storage became cheaper, number of users increased over the internet, so the traffic. The increase in the number of hosts raised new issues regarding with traffic over the network, various types of data to be carried over the network, data transport delay etc.

Three billion videos are watched on YouTube every day with 48 hours uploaded every minute. According to Cisco, video represents 40 percent of today's traffic (Bertrand Mathieu *et al*, 2012). Cisco also forecasted that the video traffic will be 91% of the total Internet traffic in year 2014, including videos exchanged by P2P applications or downloaded from Web. On average, more than 250 million photos are uploaded on Facebook per day; in the UK alone (Byungjoon Lee). A recent study by ShareThis has shown that sharing activities on the web represent more than 10 percent of all Internet traffic (Bertrand Mathieu *et al*, 2012) . Now, from this we can calculate the data traffic in the whole world. In all this, mobile usage started to take off significant video traffic. Furthermore, other areas of digital information are accelerating the trend of ever-increasing information dissemination in the Internet. Several national-level 'open government initiatives' make a huge amount of data available from government departments for the usage by citizens and organizations. For areas such as sensor networks, supply chain management, health, retail and many others expect the supply of information into our Internet to grow significantly within the next years. From all this we can conclude that Internet is simply becoming a delivery network of video files or digital files from the popular Over-The-Top (OTT) service providers. In case of cellular networks, there is explosive growth of data traffic in cellular networks. This growth of data traffic usage in the cellular networks is problematic as operators get a high load on their networks and are forced to invest in more infrastructures.

This all have given rise to new requirements from the architecture, such as support for scalable content distribution, mobility, security, trust, and so on. However, the Internet was never designed to address such requirements and in order to help it "evolve" a vicious cycle of functionality patches began appearing, such as Mobile IP. Most of those patches increased the complexity of the overall architecture and proved to be only temporal solutions. In addition, many current and emerging requirements still cannot be addressed adequately by the current Internet. This has raised the question of whether we can continue "patching over patches," or whether a new clean-slate architectural approach for the Internet is actually needed.

The structure of this paper is as follows: In section 2 we overview of problems in current IP network. In section

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3 we will focus on CCN. In this section we will also study about various CCN issues and advantages of CCN over IP network. In Section IV we discuss current projects working on the concept of CCN. In section V conclusions of this paper and future work of CCN is discussed.

2. Problems in IP

Communication will have to be established before any content is transferred between hosts. In other words, we can say that current IP architecture revolve around the host based conversation model. During such communication path is set up from sender to receiver i.e. network allows a source driven approach. One crucial aspect that has been recognized in many research efforts is the robust-yet-fragile nature of the internet as a complex system. It is the robustness against perturbations, for which protocols in individual layers have been designed, while it is the fragility with respect to unforeseen perturbations that can lead to, often catastrophic, failures. These IP based networks are end point centric. Poor performance is observed in digital media distribution. Due to this end centric approach, there are some bad outcomes e.g. DoS Denial of Service) attack, SPAM etc. In host-centric communication model, user is required to specify in each request not only the desired information, but also the specific server from which it can be retrieved from. The second limitation in today's internet is the layering model itself. Although it is generally the foundation for de-constraining the individual protocol constraints, the rigidity of the IP layer model, i.e., the introduction of a particular assembly of layers, limits the ability to flexibly modularize a wide variety of design. Such change in constraints leads to fragility. We can observe examples for this fragility all over the Internet, such as through the introduction design. Such change in constraints leads to a possible of network address translation (NAT) or firewall technology as an additional set of constraints to the originally designed full end-to-end connectivity between IP end hosts. Another example is that of virtual private networks (VPNs), introducing additional security constraints into the communication platform. Moreover, the world of wireless communication has brought about an entire range of new constraints for which the given assembly of layers, in particular the routing and transport layer, proves to be too rigid. While the emergence of these new constraints might pose difficulties for the existing architecture, such as breaking end-to-end connectivity through NATs, it also points to possible solutions for future architectures to come, e.g., by introducing local addressing only.

3. CCN

Basic aim of the CCN is to access the required information or content regardless of its location. CCN is also called as Information Centric Networks. In CCN, focus is shifted from the end-points in the network to the information objects themselves, with less care being placed on from where the information is fetched. CCN aims to reflect current and future needs better than the existing internet architecture by naming information at the network layer. The general proposal of content-centric networking recognizes that a great deal of information is produced once, then copied many times. Therefore, it makes sense to distribute the copying and any related activities into the network's tree of equipment. In many cases, substantial storage is already available, and could be used more efficiently if it could recognize particular content and only keep one copy of it. In CCN, instead of specifying a source-destination host pair for communication, a piece of information itself is named. Assumption behind the CCN is that information is named, addressed, and matched independently of its location; therefore it may be located anywhere in the network. Naming is the main objective of the CCN. Information retrieval becomes receiver-driven, because in CCN no data can be received unless it is explicitly requested by the receiver. In CCN the network may satisfy an information request not only through locating the original information source, but also by utilizing (possibly multiple) in-network caches that hold copies of the desired information. In CCN native caching function can be included in the network, in such a way that nodes can cache the contents passing through it for a while (depending on the cache size and replacement algorithm) and deliver them to requesting users. Content-centric networking uses a practical data storage cache at each level of the network to dramatically decrease the transmission traffic, and also increase the speed of response. The cache envisioned by CCN is a packet-level cache present at each node in the tree of network equipment not a complete copy of some media file. In that way, the worst case is that everything behaves as it does now: A consumer requests some data and it propagates through the network. However, the second time the data is requested, if it is still in the cache at some level, there are dramatic savings. A number of studies have verified the potential benefits of this approach.

Figure 1 may be seen as the example of the CCN. In this figure we can see that at each level there is caching. In CCN, each node has the caching capability, so users in the same network will get the same cached copy of the tweet. Thus, traffic is significantly reduced in CCN.

Publish Subscribe Model

This is the simple model which gives idea about the CCN. In this model five basic modules can be included. Publisher, Subscriber, Publish-subscribe router, Information Item Table and Topology Manager. and that produced information is consumed by the subscriber. This produced information is routed with the help of special routers. Those routers are called as Publish Subscribe routers. In content centric networking information is accessed independent of location. So, publishers and subscribers are always unaware about the each other's existence. Now we will see each module in detail.

a) Publisher: Main focus in the CCN is on information. Publisher is an entity which produces the information. At any time publisher can perform publications. Publisher can create multiple publications. Each link of a Publisher is connected with only one Publish

Subscribe Router. Publisher should have two choices for publications. Publisher should be able to publish new publications as well as to create publication to the existing information.

b) Subscriber: Subscriber is an entity which consumes the information. At any time subscriber can perform the subscriptions.

c) Publish Subscribe Router: When information is published or subscribed information pass through number of elements that calculate the correct path they should follow. These elements are routers. But with this model they are referred as Publish Subscribe Routers.

d) Information Item Table: Whenever publisher or subscriber performs publications or subscriptions respectively, a piece of information, they should inform the central entity of the network. Then this entity will determine whether that requested or offered information matches any other requests or offers. This way it maintains the records of all publications and subscriptions requests. This entity is called as Information Item Table.

e) Topology Manager: If in Information Item Table match is found then best path between the publisher and subscriber is computed for that specific piece of information. This work is done by the Topology Manager. But for that publisher router links must be registered in the topology manager.

Topology manager also informs the network publishing nodes on how to publish the information correctly, so that the subscribers are reached.

Advantages of CCN over Current Network

1. **Information Accessibility**: Depending on the CCN nodes location and the cache efficiency, the network load can be significantly reduced and the response time to get the content can be faster up to 60 percent (Bertrand Mathieu *et al*, 2012). For Twitter, for instance, sending one tweet to 1000 followers can be considered as a mix of multicast delivery and caching. CCN networks, having such behavior, could really help in the delivery of tweets while caching contents on the path and providing it to requesters. The same method can be applied for the delivery of Facebook or Google+ data.
2. **Mobility:** Statistics show a constantly increasing number of non-fixed hosts accessing the Internet, with forecasts saying that by 2015, traffic from wireless terminals will exceed traffic from wired ones. A patch to remedy the problem of locating moving hosts imposes "triangular routing" (George Xylomenos *et al*, 2013). In CCN, host mobility is addressed by employing the publish/subscribe communication model. In this model, users interested in information *subscribe* to it, i.e., they denote their interest for it to the network, and users offering information *publish* advertisements for information to the network. In CCN, publish involves only announcement of the availability of information to the network, whereas subscriptions by default refer to already available information, leaving the option of permanent subscriptions (i.e., receiving multiple publications matching a single subscription) as optional. The strength of the publish/subscribe communication model stems from the fact that publication and subscription operations are decoupled in time and space. The communication between a publisher and a subscriber does not need to be time-synchronized, i.e., the publisher may publish information before any subscribers have requested it and the subscribers may initiate information requests after publication announcements. Publishers do not usually hold references to the subscribers, neither do they know how many subscribers are receiving a particular publication and, similarly, subscribers do not usually hold references to the publishers, neither do they know how many publishers are providing the information. These properties allow for the efficient support of mobility.
3. **Security:** The Internet was designed to forward any traffic injected in the network, resulting in an imbalance of power between senders and receivers. These characteristics allow attackers in general to launch Denial of Service (DoS) attacks against the internet infrastructure or against Internet hosts and services. Though firewalls, spam filters or add-on security patches have been developed, bad traffic still flows in the network. CCN architectures are in contrast interest-driven, i.e., there is no data flow unless a user has explicitly asked for a particular piece of information. Also it benefits user privacy, as a publisher does not need to be aware of the identities of its subscribers. The fact that CCN messages can talk only about content, and simply cannot talk to hosts, makes it very difficult to send malicious packets to a particular target.

CCN Issues

1. **Naming:** There are no clear understandings on whether hierarchical or flat names should be used in the CCN (George Xylomenos *et al*, 2013). Hierarchical names can be human-readable and are easier to aggregate in principle, but it is unclear whether they can scale to Internet levels without turning into DNS names due to aggregation. On the other hand flat names can be easily administered and also they do not impose any processing requirements for longest prefix matching. They can be self-certifying and they can be easily handled with highly scalable structures such as DHTs (Distributed Hash Tables).
2. **Processing Of Name:** One of the problems of CCN is the cost to process the name. The length of the names might put a negative impact on the overall performance of CCN routers. For example, D. Perino have pointed out that contemporary memory technologies are not good enough to support CCN (Byungjoon Lee).
3. **Simulator:** We should show the implementation to prove that CCN works. There should be the proper simulator for simulating the CCNs. There is a

simulator which has been developed specially for CCN. That simulator is OMNET++ (Nikolaos Vastardis *et al*). Simulations can be done in C/C++.

4. **Cache Management:** When caching takes place inside the network, as in CCN, several types of traffic will compete for the same caching space. Cache space management therefore becomes crucial for the network.
5. **Threats:** CCN architectures can create severe privacy threats, as users reveal their interest in particular information and the name of the information being requested is available to all the CCN nodes processing the request.

4. Related Work

There are various CCN oriented projects under development. DONA project at Berkeley, the EU funded projects Publish-Subscribe Internet Technology (PURSUIT) and its predecessor Publish-Subscribe Internet Routing Paradigm (PSIRP), Scalable & Adaptive Internet soLutions (SAIL) and its predecessor 4WARD, COntent Mediator architecture for contentaware nETworks (COMET), CONVERGENCE, the US funded projects Named Data Networking (NDN) and its predecessor Content Centric Networking (CCN) and MobilityFirst, project ANR Connect which adopts the NDN architecture

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Conclusions & Future Work

We have attempted to expose the problems in the current IP network. We also attempted to expose the problems introduced in the CDN. To avoid such problems there is a need of another solution i.e. CCN. In this paper, we have explained the benefits of the CCN over current IP network. Originally CCN is aimed to replace IP, but it can be incrementally deployed as an overlay network, so that application can take functional advantages of CCN without requiring universal adoption. With the help of this paper, we can state that CCN is a promising and fertile research field that has shown its potential for addressing at least some of the current problems of the Internet. We have stated problems that might be faced while implementing the CCN. More research should be done on those problems. Searching for information in CCN has also not received much attention. Research should be done on that.

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