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Fog Route: Distribution of Data using Delay Tolerant Network

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Abstract - *Fog Computing is an extension of Cloud Computing. As in a Cloud, Fog computing also provides data, compute, storage, and application services to end-users. The difference is Fog provides proximity to its end users through dense geographical distribution and it also supports mobility. Access points or set-up boxes are used as end devices to host services at the network. These end devices are also termed as edge network. Fog computing improves the Quality of service and also reduces latency. A Fog computing system is of a three tier Mobile-Fog-Cloud structure; mobile user gets service from Fog servers using local wireless connections, and Fog servers update their contents from Cloud using the cellular or wired networks. This, however, may suffer high content update cost when the bandwidth between the Fog and Cloud servers is expensive, e.g., using the cellular network, and is therefore inefficient for non-urgent, high volume contents. In this paper, we address the issue by proposing a hybrid data dissemination framework which applies DTN (delay tolerable network) approaches in Fog computing. We decompose the Fog computing network architecture with two planes, where the cloud is a control plane to process content update queries and organize data flows, and the geometrically distributed Fog servers form a data plane to disseminate data among Fog servers with delay tolerant network technique.*

Key Words*: *Fog Computing, Delay Tolerant Network, Data Dissemination

1. INTRODUCTION

Fog computing – a term created by Cisco that refers to extending cloud computing to the edge of an enterprise's network. Also known as edge computing or fogging, fog computing facilitates the operation of compute, storage, and networking services between end devices and cloud computing data centers. While edge computing is typically referred to the location where services are instantiated, fog computing implies distribution of the communication, computation, and storage resources and services on or close to devices and systems in the control of end-users. Fog computing is a medium weight and intermediate level of computing power. Rather than a substitute, fog computing often serves as a complement to cloud computing. Fog computing concept, actually a Cloud computing close to the 'ground', creates automated response that drives the value. Both Cloud and Fog provide data, computation, storage and application services to end-users. However, Fog can be distinguished from Cloud by its proximity to end-users, the dense geographical distribution and its support for mobility.

Fog computing typically has a three-tier Mobile-Fog-Cloud structure [3]. In the Mobile tier, it could include all wireless devices, such as smartphones, tablets, laptops. In the Fog tier, Fog servers provide services to the end users and synchronize data with the Cloud. In the Cloud tier, Cloud provider provides content service required by geo-distributed Fog servers. Data dissemination between a mobile user and a Fog server is occurred when this mobile user retrieves content. If this Fog server has the required content, it sends the content to the mobile user. Otherwise, this Fog server needs to send a query to its Cloud provider to find and download it into its local storage. On another side, Fog servers need to regularly check with their Cloud providers whether the Fog servers have the updated contents or not; if not, they need to update their storage by retrieving from the Cloud via either wired or wireless networks, e.g., cellar networks. Such data disseminations may involve a huge cost due to the large data volume. According to the report from Cisco [4], the overall mobile data traffic is expected to grow to 24.3 exabytes per month by 2019 and more traffic will be offloaded from cellular networks, such as Fog devices, than remains on cellular networks by 2016.

1.1 Related Work

1.1.1 Cloud computing

Cloud computing, [5] a kind of Internet-based paradigm, refers to both the applications delivered as services over the Internet and the hardware and software in the data centers that provide these services. The research on cloud computing has attracted great attention with a large quantity of literatures. For example, Armbruster et al. quantify comparisons between cloud and conventional computing, and identify the top technical and non-technical obstacles and opportunities of cloud computing. The emergence of cloud computing has established a trend towards building massive, energy-hungry, and geographically distributed Internet data centers as cloud servers. Due to their enormous energy consumption, Rao etal. [13], [14] investigate how to coordinate the collection of data centers so as to minimize the electricity expense while maintaining the quality of the cloud computing service. Our work extends from the existing related papers on cloud computing to a newly emerged paradigm named fog computing. However, the transition is not trivial, since fog is quite different cloud in terms of location, distribution, and computing capability.

1.1.2 Fog Computing in Distributed Data Management

In the paper given in [1] emerging area of the Internet of Things (IoT), the exponential growth of the number of smart devices leads to a growing need for efficient data storage mechanisms. Cloud Computing was an efficient solution so far to store and manipulate such huge amount of data. However, in the next years it is expected that Cloud Computing will be unable to handle the huge amount of the IoT devices efficiently due to bandwidth limitations. An arising technology which promises to overwhelm many drawbacks in large-scale networks in IoT is Fog Computing. Computational power and storage capacity could be offered from the Fog, with low latency and high bandwidth. This survey discusses the main features of Fog Computing, introduces representative simulators and tools, highlights the benefits of Fog Computing in line with the applications of large-scale IoT networks, and identifies various aspects of issues we may encounter when designing and implementing social IoT systems in the context of the Fog Computing paradigm.

1.1.3 Delay tolerant network

Nowadays, the research and application about delay-tolerant network (DTN) have become more and more popular. DTN is a new kind of network derived from deep space communication. Differed with traditional network, DTN network has the following several characteristics: long delay, limited resources, interval connectivity, asymmetric data rate, low signal to noise ratio, and high error rate. In this paper, we present the development and basic characteristics of DTN, and discuss the network architecture in details. In addition, the issues of reliability transmission, congestion control, security and applications are also be covered in this paper [2].

1.1.4 Dissemination based on Delay Tolerant Network Technique

For high volume and non-urgent data, it is not wise to use expensive network transmission techniques. Instead, delay tolerant network technique could be used to provide data dissemination between Fog servers and between mobile users and Fog servers as well. Delay Tolerant Network (DTN)[9] [10] is featured with long latency and unstable network topology, where end-to-end delay can be measured in hours or days and data dissemination paths may not exist. Data dissemination in DTN uses store-carry- forward techniques; if there is no connection available at a particular time, the source node needs to store and carry the message until the next available node is encountered. DakNet is a DTN technique based application and developed by researchers from the MIT Media Lab. It has been deployed in remote parts of Cambodia and India at a cost two orders of magnitude less compared to traditional landlines networks. DakNet uses existing communications and transport infrastructure to form a delay tolerant network, where it combines physical transportation with a wireless data transferal function to extend Internet connectivity to a central hub, such as cyberspace or a post office. DakNet does not need to relay data over a long distance, which is an advantage because it would reduce costs and save a lot of power. Instead, DakNet transmits data over short point-to-point links between kiosks and portable storage devices called mobile access points (MAPs). A MAP can exchange data among public kiosks, Internet enabled devices and non-Internet accessed hubs by using mobile generators mounted on and powered by a bus or motorcycle.

2. System Design and Model

2.1 System Architecture

To have an efficient data dissemination in Fog computing, DTN is used to offload data transmitted among Fog servers. In Fig, if Fog server A has some small contents, such as a new video ads, but Fog server B does not. In previous, Fog server B needs to get the update from Cloud server directly. With DTN technique, user 1 could download this content when he has a coffee in this cafe shop. After a couple of hours, he goes to shopping center for shopping. When he moves into the transmission range of Fog server B, this content storied in user 1's mobile device automatically upload to Fog server B and this store-carry-forward process is finished. For large content, e.g. a high definition movie, transmitted from Fog server B to Fog server A, vehicle based DTN is used. In this example, if car 2 is parked in the shopping center and within the Fog server B's transmission range, it downloads this movie into its local storage. Once this vehicle moves to the transmission range of Fog server A, this movie is uploaded to it and this data dissemination is completed.

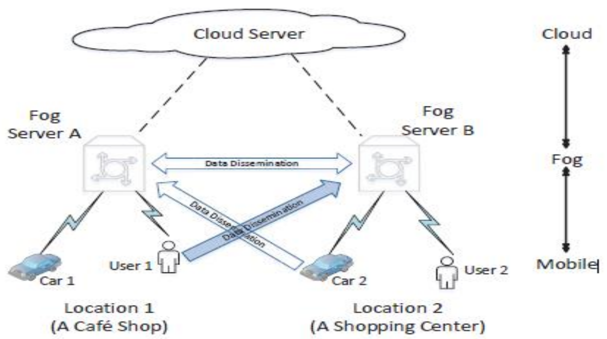

Fig- 1: Three Tier Architecture Based on Delay Tolerant Network Technique

2.2 Hybrid Data Dissemination

Hybrid data dissemination is determined by control plane, as shown in below Fig 2. Where Cloud provider in the control plane has the global information to control the data plane. The main data flow control algorithm conducted by Cloud provider is illustrated in Algorithm, where Cloud provider checks its global Fog server and content lists to determine the Fog server that needed to be updated, and the required content. It also checks which Fog server has this content. If none of Fog server has this content, Cloud provider sends updated content to that Fog server directly by using traditional Cloud based techniques, such as broadband and cellular networks. Other- wise, the DTN based data dissemination is applied by using Algorithm 2 to choose mobile devices, which are connecting with these selected Fog servers, as carriers to provider DTN based data dissemination services.

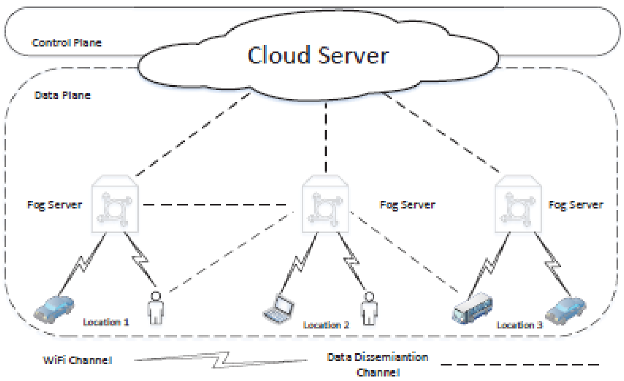

Fig- 2: Hybrid Data Dissemination Model in Fog Computing

2.3 Algorithm

Step 1: Cloud provider compares its "Global Content List" table with "Fog Server List" table to determine which Fog server is needed to be updated. In this case, Fog sever Fd is determined and content C needs to be update.
if There is no other Fog server having this content **then**
Cloud provider sends this content to the Fog server directly, which is the same as traditional Cloud service and this dissemination process is finished.
else Move to the next step
end if
Step 2: Cloud provider determines a list of Fog servers, < Fc1, Fc2, Fc3, · · · >, which have this content.
Step 3: Algorithm is used to select n most suitable carriers, Carrier n, to provide this DTN dissemination service.
if n greater than 0 **then**
Move to the next step
else Cloud provider sends this content to the Fog server directly, which is the same as traditional Cloud service and this dissemination process is finished.
end if
Step 4: Cloud provider sends "DTN Data Dissemination Request" message to each of selected Fog servers to ask them send the content C to Fd by using the carrier (mobile device) determined in **Step 3**.
Step 5: Once a Fog server receives "DTN Data Dissemination Request" message, it sends the content C along with the destination, Fd, to the selected carrier.
if Content C is transferred to the selected carrier completely **then**
This Fog server sends the "DTN Data Dissemination Accept" message to its Cloud provider and move to the next step.
else This Fog server send the "DTN Data Dissemination Decline" message to its Cloud provider. When Cloud provider receives this message, it repeats **Step 3** to get the "n+1" Fog server, if it has, and continue from **Step 4**.
end if
Step 6: Once Fd receives the content C, it sends "DTN Data Dissemination Acknowledgement" message to Cloud provider.
Step 7: **if** Cloud provider receives the "DTN Data Dissemination Acknowledgement" message within a pre-defined period, T delay, **then**
It updates "Fog Server List" and "Global Content List" tables, and this data dissemination is finished
else It repeats from the **Step 1**
end if

3. EXPERIMENTAL RESULTS

This following section shows snapshots of our system web application. It shows how our system works and gives us an idea about the system.

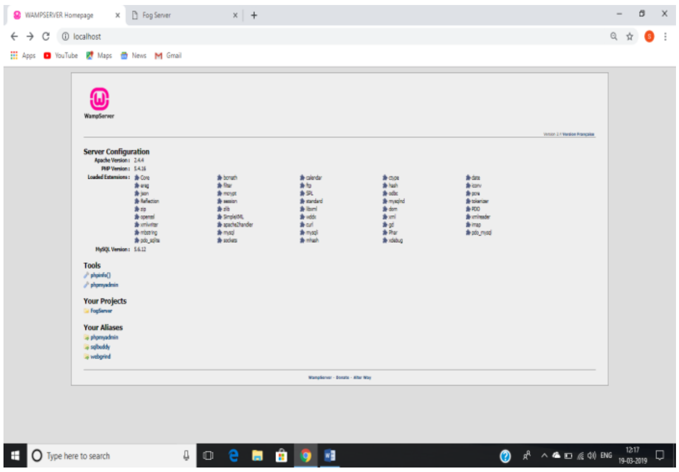

Fig- 3: Project Name in WampServer

The above screenshot shows the wampserver page with project name.

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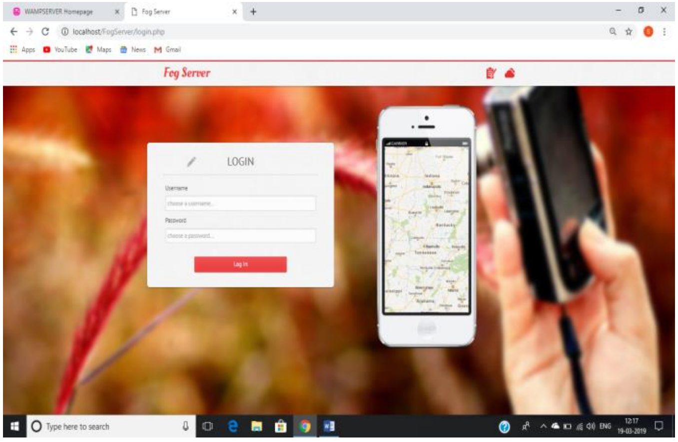

Fig- 4: Admin Login Page

The above screenshot shows the admin login page with admin name and password.

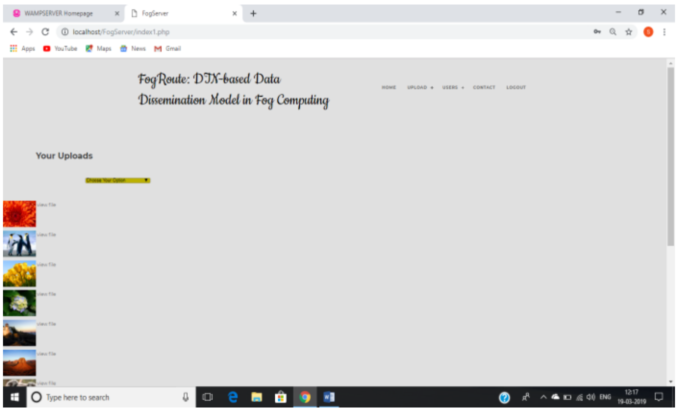

Fig- 5: Image Files Uploaded By Admin

The above screenshot shows the image files which admin are uploaded.

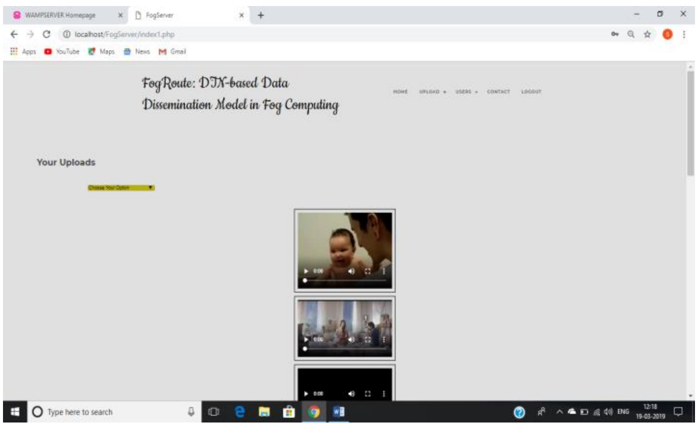

Fig- 6: Videos Uploaded By Admin

The above screenshot shows videos which are uploaded by admin.

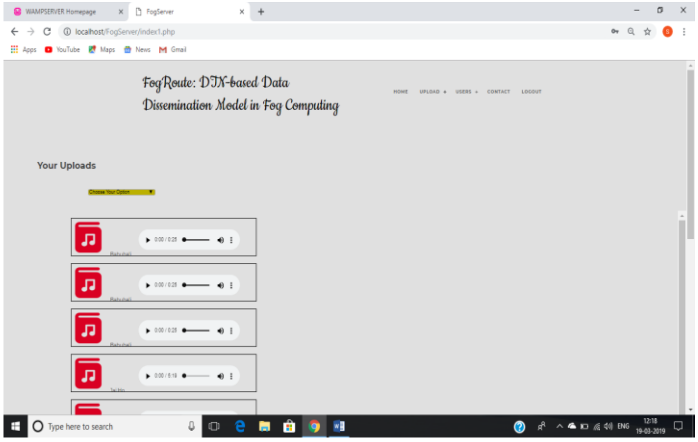

Fig- 7: Music Files Uploaded By Admin

The above screenshot shows music uploaded by admin.

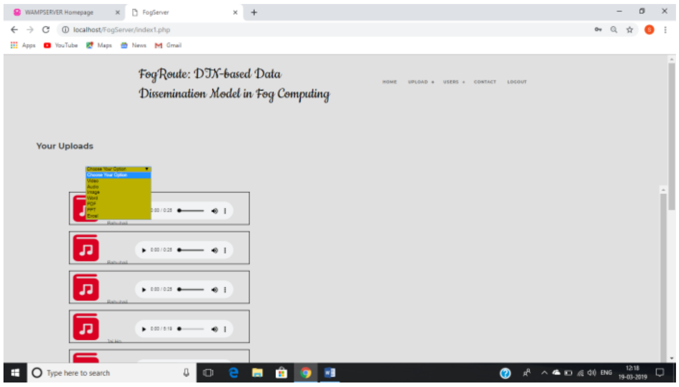

Fig- 8: Different Types of Files

The above screenshot shows the types of files which are uploaded by admin

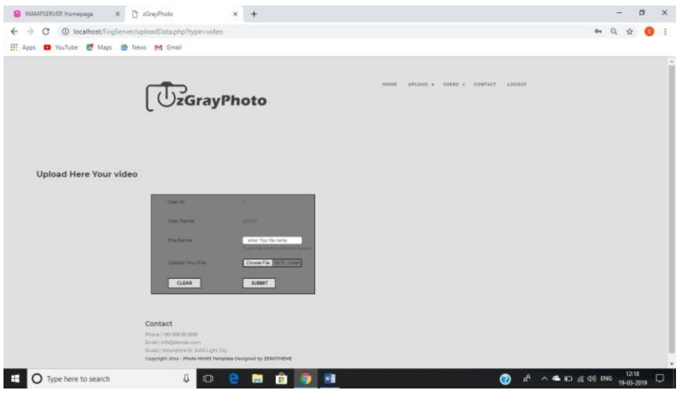

Fig- 9: How to Insert New File

The above screenshot shows that how to upload new files on the server page.

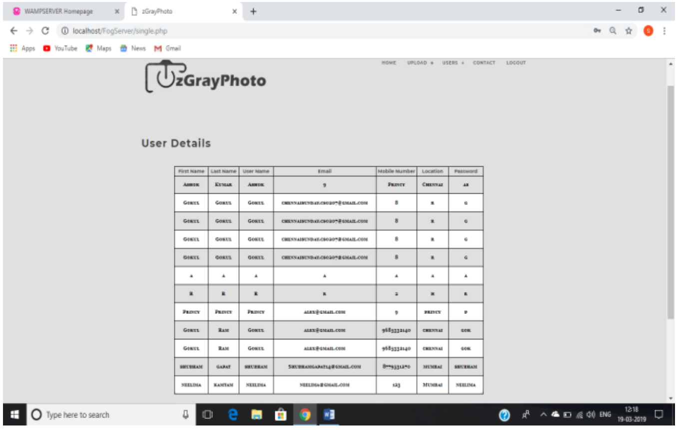

Fig- 10: User Details

The above screenshot shows the user details.

4. CONCLUSION

We have outlined the vision and delayed key characteristics Of Fog Computing, a platform to deliver a rich portfolio of new services and applications at the edge of the network. The motivating examples peppered throughout the discussion range from conceptual visions to existing point solution prototypes. We envision the Fog to be a unifying platform, rich enough to deliver this new breed of emerging services and enable the development of new applications Future work will expand on the Fog computing paradigm in Smart Grid. In this scenario, two models for Fog devices can be developed. Independent Fog devices consult directly with the Cloud for periodic updates on price and demands, while interconnected. Fog devices may consult each other, and create coalitions for further enhancements.

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