A Framework of N-Screen Services based on PVR and Named Data Networking in Cloud Computing

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ABSTRACT
We develop architecture of a new N-Screen Service which enables application streaming based on N-Screen services using Personal Video Recorder (PVR) and Named Data Networking (NDN) in cloud computing environment. In particular, we propose a framework of N-Screen Services called "ShopMark" based on PVR and NDN technology in cloud computing environment. This service will be provided to user with playback method for their previously recorded multimedia contents which was combined with Advertisement. The user will be able to playback/re-play their multimedia contents, interact with the advertisement and choose their interesting advertised product by scenes. The objective of proposing ShopMark service based on PVR and NDN are to (1) allow user to playback previously recorded multimedia contents anytime with diversity of devices for screen sharing, (2) user are able to easily track and select advertised products in multimedia contents by scenes (e.g. movies scenes, etc), (3) reduce the requested content delay, provide sufficient use of bandwidth and resources (4) overcome limitation of multimedia content and provide efficient approach for content distribution in network and (5) obtain more knowledge and understanding of application NDN. This service will provide an excellent example to show how NDN can offer advantages for the multimedia contents distribution over the internet and provide more space for the development of new other N-Screen services/applications which rely on multimedia contents distribution instead of communication.

Categories and Subject Descriptors
H.4.1 [**N-Screen Scenario**]: *Scenario*; H.4.2 [**N-Screen System Architecture**]: *Design*; H.4.3 [**System Sequence of N-Screen Proposed service**]: *Data request and retrieval steps*; H.5 [**Security and Performance Analysis**]: *Data security, response time/delay.*

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General Terms
Algorithm, Management, Performance, Design, Security.

Keywords
Named Data Networking (NDN), Personal Video Recording (PVR), Cloud Computing, N-Screen, Multimedia contents.

1. INTRODUCTION
Currently N-Screen Service in cloud computing is increasingly gaining a rapid interest by users for the diversity of services the cloud are able to offers. It enables and is provides users with an easy access to multimedia contents or sharing many screens across one or more devices that are Internet connected to each other (e.g. Smart TV, IPTV, PC etc) in a secure, seamless and transparent way. In spite of that, the current N-Screen services in cloud computing platform only are considering application streaming scenario.

The concept of utilizing N-Screen Services based on Personal Video Recorder (PVR) and Named Data Network (NDN) is proposed using a new internet architecture which transforms data, instead of host to a first class entity [1]. It enables user to retrieve and playback recorded contents (e.g. movie, ads, data, voice, etc) from different nearby router/node to variety of N-Screen devices in cloud computing environment was not fully explored or considered yet. In original case [12], user request will be send all the way to server and the desired data will be sent back to user which will result in long delay, inefficiently use of bandwidth and resources.

Personal Video Recorder (PVR) enables the user to record and store multimedia contents for later viewing. Users of the services benefit from time-shifting possibilities [4]. Live television can be paused and users can continue to watch when desired while the content is recorded and stored. PVR can be considered as a service that increases the viewer's flexibility and selectivity in terms of time as well as content. Users have the ability to use their time budget devoted to entertainment more efficiently, increasing the total value of the viewing experience [4].

In order to utilize this service, major issues faced by service providers revolve around 1) how to make ShopMark service enjoyable, easy, compelling, flexible and cost effective. 2) How to make user easily track and select advertised products in multimedia content by scenes. 3) How securely store and deliver the multimedia contents from nearby router/node to user devices (4) How to reduce delays resulted from requesting multimedia contents from different router/node for user different devices. (5) How to overcome limitation of multimedia contents and provide efficient approach for content distribution in network. In the long run, the user will likely to appreciate this service for having the features of being secure, seamless and transparent.

In playback recorded multimedia contents with advertisement for more than one time, users should not have to continuously get re-authenticate over and over for the use of different devices or for retrieving multimedia contents. Furthermore, user should not maintain and store multiple profiles for each device which they will use, or untiringly have to search for relevant multimedia contents from the server. Therefore, we proposed a framework of N-Screen new services based on PVR and NDN in cloud computing environment called "ShopMark". Our proposed new N-Screen service is designed to (1) allow user to playback previously recorded multimedia contents anytime with diversity of devices for screen sharing, (2) user are able to easily track and select advertised products in multimedia content by scenes (e.g. movies scenes, drama episode, etc), (3) reduce the requested content delay, provide sufficient use of bandwidth and efficient use of resources (4) overcome limitation of multimedia contents and provide efficient approach for content distribution in network and (5) obtain more knowledge and understanding of application data named networking and their undiscoverable capabilities.

As for the Security of multimedia contents delivery and storage, number of aspects must be considered. The delivery of multimedia contents between users and routers/nodes will contain sensitive information (e.g. signature, digest algorithm, signature information, publisher ID, Key locator, state time, etc) that should be secured. There is a need to assure the identity of communicating users and integrity of delivered multimedia contents as well. We will discuss some authentication mechanisms used to deliver multimedia contents.

The remainder of this paper is organized as follows; in section 2, we review some of the related work. Section 3 we provide background. Section 4, we presents our proposed system architecture of N-Screen new service based PVR and NDN in cloud computing environment as well as scenarios. Section 5, present security and performance analysis, and lastly, Section 6, we present our conclusion and future work.

2. RELATED WORK

There are some research efforts that aim to change their approach from host oriented to content oriented networking to meet the increased need of the content needs CCN [3, 10], SAIL [9], NDN [1] and PURSUIT [8] where they use to name multimedia content instead of naming the host location. Furthermore, the content names are opaque to the network which mean that router/node do not know the meaning of a name that provide flexibility for application to choose the naming scheme that fits its needs and allows the naming schemes to evolve independently from the network [1]. In addition, routing that is based on the naming of contents and the stored content (cached content) can reduce the impact of dynamic topology on the performance of routing [11]. We argue that NDN, and CCN is desirable solution for future since it enables that over to have full control over who can view their published.

There are other researches where they developing new services for N-Screen. In [7], the author describes various kinds of N-Screen service scenario based on overall scenario model over FMC. It explain the advantages of using/providing N-Screen services for IPTV users where they can use multiple devices in seamless and transparent way either by sharing or switching between devices. In [13], the author provide method to enable ATSC mobile DTV standard based digital broadcasting in multiple smart devices (Known also as N-Screen) where Wi-Fi and supports iOS and Android OS based platforms is used as implementation solution. The proposed method helps most of the current smart devices which does not include chipset solution to receive mobile TV broadcasting services. These proposed services are very compelling and try to provide diversity of services to N-Screen users.

However, they might rely on the IP address method in delivering the multimedia content. IP has exceeded all expectation for facilitating ubiquitous interconnectivity, it was designed for conversations between communications endpoint but is overwhelmingly used for content distribution which makes it poor approach for today primary uses [1].

3. BACKGROUND

3.1 Personal Video Recording (PVR)

Personal video recorder (PVR) is also known as Digital Video Recorder where users are able to record and store multimedia contents for later viewing. Users of the services benefit from time-shifting possibilities [4]. PVR can be considered as a service that increases the viewer's flexibility and selectivity in terms of time as well as content. Users have the ability to use their time budget devoted to entertainment more efficiently, increasing the total value of the viewing experience [4].

The advent of the PVR has transformed a world of ever-increasing TV choice into a manageable environment, with increasing control. Television can now be personalized by the viewer-enabling each person to watch what he/she wants, and whenever they want to watch. We have entered a new reality, whereby viewers are in control and can effortlessly pause, fast forward, and rewind the content of their choice with the push of a button [8]. For these feature the PVR are capable of provide extra feature, quality of experience (QoS), and advantages to user in now days.

3.2 N-Screen

Currently, N-Screen is becoming a killer service of smart TV providing various kinds of bi-directional, converged, personalized and intelligent contents and services to multiple fixed or mobile devices[7] N-Screen is composed by various devices such as web, mobile and PCs. N-Screen service attracts increasing attention through between wired and wireless and device is interlinked by various device and communication network is developing which especially enables sharing of multimedia contents and services for various devices [2].

3.3 Named Data Networking (NDN)

Communication in NDN is controlled by the receiving end (i.e. data consumer [1, 3]. The user sends out an Interest packet in order to receive data which include name that identifies the desired data. For example the user may request /PVR/multimedia/drama/fullhouse1/eps1.mpg. When the request is received by router/node, it remembers from which interface it came from. Then perform a search look up in the name using Forwarding Information Base (FIB) before it forward the interest packet. When the interest packet research router/node that has the requested data, the data will be send back to user which includes the name and the content of data together with a signature by the producer's key[1,3]. The data packet traces in reverse the path created by the Interest packet back to the consumer. Interest packet are routed towards data producers based on the names carried in the Interest packets, and Data packets are returned based on the state information set up by the Interests at each router hop [1,3]. Each router/node stores a copy of the data for some period of time. In case more than one interest for the same desired data are received, only one will be send toward the data source. The interest is stored in Pending Interest Table (PIT) where each entry consists of interest name and a set of interfaces from which the matching interest have been received. Upon the arrival of data packet to the router/node, it finds the matching PIT entry and send out the data to all interfaces listed in PIT entry. The corresponding PIT entry is removed and it is caches in the Content store which is considered as a buffer memory. The data take the reverse direction which created in each router/node when is passes by to the consumer device. One Data satisfies one Interest across each hop, achieving hop-by-hop flow balance [1].

The benefit of caching NDN data packet is to satisfy potential future request which enables NDN to automatically support various functionality without extra infrastructure, including content distribution (many users requesting the same data at different times), multicast (many users requesting the same data at the same time), mobility (users requesting data from different locations), and delay-tolerant networking (users having intermittent connectivity). Data cached close to consumers improves packet delivery performance and reduces dependency on a particular data source that may fail due to faults or attacks [1].

3.4 Cloud Computing

A cloud computing is a sort of parallel and distributed system made up of a collections of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more combined computing resources based on service-level agreements established through negotiation between the service providers and consumers [5,6]. Cloud computing provides a shared pools of configurable IT resources (e.g. processing, network, software, information and storage) on demand, as a scalable and elastic service, through a networked infrastructure, on a measured (pay-per-use or subscription) basis, which needs minimal management effort, is based on service level agreements (SLA) between the service providers and consumers, and often utilizes virtualization resources. This frequently takes the form of web-based tools or applications that users can access and use through a web browser as if it was a program installed locally on their own computer [5, 6]. Major advantages of the cloud computing are, Software as a service (SaaS), Utility Computing, Network service, Platform as a service (PaaS), management service provider (MSP), Commercial service platforms, integrating internet [5,6]. Other advantages of cloud computing are 1) Provides faster, simpler and cheaper services. 2) It is highly elastic because resources are easily released or occupied on the basis of demands. 3) It is optimized utilization of computing resources. 4) Users have more resources, unlimited storage and everything is provided as services [5, 6].

3.5 V_Cache

NDN comes with Content Store where multimedia content can be stored after being requested from nearby router/node for a period of time. This feature will improve the performance of network when other users request the same multimedia content. However it has a lack of space when a different user requests different multimedia contents where the content store cannot store all the multimedia content which is requested by different users. Furthermore, it will lead to long delay (response time is longer), inefficient use of bandwidth and resources. As a result, an extra virtual Cache is needed to overcome these problems. Virtual cache will do the same responsibilities as Content Store [1] Furthermore, it will be connected to cloud computing to maintain the location of multimedia content which will even decrease the searching time of the content and therefore providing efficient use of the network bandwidth and resources. As well as providing users with QoS and QoE.

4. System Architecture of N-Screen New Service "ShopMark"

4.1 Scenario

We consider one Scenario which is illustrated in figure 1, we are assuming that Group *A* is watching movie and ads in live mood. However, Group *B* is request recording it using PVR for later view. Later on Group B is watching their recorded action movie, a certain number of ads (e.g. cloths, sunglasses, electronic devices, etc) are displayed during the movie time. The user might have interest and want to go back to the ads which were displayed during the movie time to find out more details about desired product. Here the user will select desired movie from a list where it will display the movies scene by scene. By selecting the scene, user can view a list of product which was displayed during the movie broadcasting time. The user keep viewing product to find something that interest them. When user is interested in product he/she can click on "Buy" option which will open up a new website that displays a list of other web sites with a list of their product price.

Figure 1. Scenario Idea.

4.2 System Architecture

Figure 2 illustrates system architecture of our proposed N-Screen new service "ShopMark" which consists of User (Group *A* and Group *B*), Access Point, V_Cache, and Cloud Computing. The terminologies used to describe the system architecture are illustrated below in Table 1.

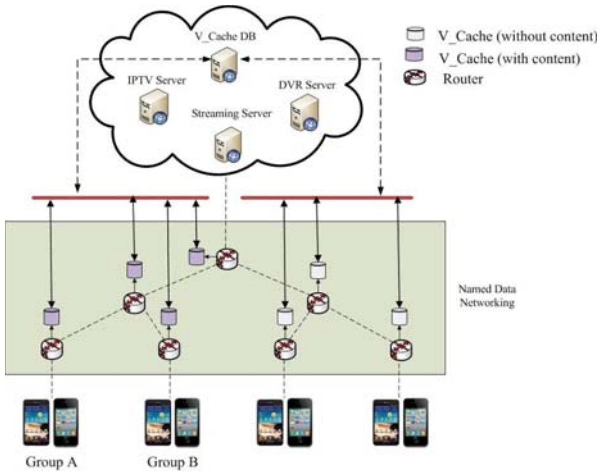

Figure 2. System Architecture of N-Screen ShopMark

Table 1. Component and their role

Component	Role
Access Point	Responsible for providing connection to user devices anywhere anytime.
Router/Node	Responsible for receiving Interest Packet/Data packet, implementing forwarding and buffering.
V_Cache	Responsible for storing user requested multimedia content and sending multimedia content to user devices.
PVR Server	Responsible for recording user requested multimedia content, storing the content for later view
Content Server	Responsible for managing the multimedia content, receiving requested content, preparing user desired content.
Streaming Server	Responsible of receiving the encrypted content from content server and streaming it back to user devices.
V_Cache DB	Responsible of keeping record of router/node and their stored content.

4.3 System Sequence of N-Screen Proposal

Figure 3 illustrates sequence chart of our proposed services scenario. In order to describe figure 3 clearly, we provide description of the system parameters in Table 2

Table 2. System Parameters

Notation	Description
C_{Name}	Content Name
Data	User Data
Sign	Publisher Signature
$Sign_{Info}$	Signature Information
ST_{Data}	Stored Data in Virtual Cache
R_{req}	User Request to Record Content
W_{req}	User Request to Watch Content
C_{FL}	Content Forward Location
D_{Nonce}	User Devices Generated Nonce

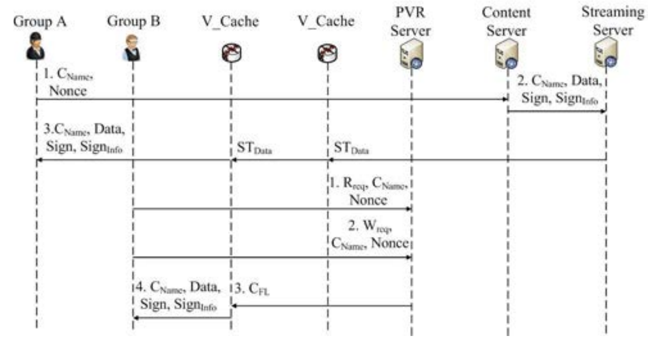

Figure 3. System Architecture of N-Screen ShopMark

In our scenario illustrated in figure 3, when the user in Group *A* request a live broadcast multimedia content from the server, the users proceeds with following steps:

Step 1 Group *A* Users Content Request: The user send/broadcast Interest packet which contains name that identifies the desired data followed with {C_{Name} | D_{Nonce}} and device generated nonce value (prevent any attack) to any router/node which has the desired content. When router/node received the interest packet, it first checks the content store/V_Cache for content. If there is a data whose names match or fall under the interest's name, the data is send back as a response to user request. Otherwise, the interest will be stored in Pending Interest Table (PIT) and forwarding the interest by looking up the name in its forwarding information base (FIB) to next router/node or content server or to V_Cache DB to locate a nearby router/node store the requested multimedia content which will speed up the searching process and reduce delay time.

Step 2 Content Server to Group *A* Users: Upon the receiving of interest to server, it will prepared the requested content and send it to streaming server in data packet which contain both name and content of data with signature by the producer's key followed by {C_{Name} | Data | Sign | $Sign_{Info}$}. Here the data packet will trace in reverse order the path created by the interest packet back to user device and will keep a copy of the content in each content store/V_Cache {ST_{Data}} for later use by other users which reduces delay, efficiently use of bandwidth resources.

In our scenario in figure 3, the user in Group *B* will do the following: 1) requests (R_{Req}) to record the content for later view and 2) requests (W_{Req}) to watch the content whenever they desire. The user proceeds with following steps:

Step 1 Group *B* Users Content Request: We are assuming that user(s) in this group request PVR to record the content. Here the user send Interest packet request to record the content which include content name to identifies the content and user generated nonce to prevent attacks { R_{req} | C_{Name} | D_{Nonce}}. We already assume that PVR Server have connection to router/node with attached virtual cache (V_Cache) which keep list of stored content location. Then the user sends interest packet request to watch the recorded content {W_{req} | C_{Name} | D_{Nonce}} when they come back. The PVR Server already knows a close by router/node which store the current user desired multimedia content and forward location to user {C_{FL}}. User interest packet reach router/node and received data packet which include {C_{Name} | Data | Sign | $Sign_{Info}$}. This will complete the process of request content by user. The advantages here is that users in Group *A* and *B* can have flexibility to request already watched content by sending interest packet to the nearest router/node which is attached with virtual cache(V_Cache) anytime anywhere which will save time and use resources efficiently. The user can go back and forth to close by router/node to request the movie in order to view the product in the ads without reaching content server. Caching content to close by router/node with attached virtual cache (V_Cache) will improves packet delivery performance and reduces dependency on a particular data resource that might be unsuccessful because of faults or attacks.

5. Security and Performance Analysis

In this section we analyses and discusses security issues regarding multimedia content security (i.e. content protection) and performance (i.e. delay latency/response time for content retrieval). We also generate a new data and analyze it with our previous work using the same calculation method for delay latency [12]:

5.1 Security Analysis

Name Data Networking (NDN): NDN security is built in the multimedia contents itself instead of being a function of from where or from whom it was obtained [1]. Each single piece of content is signed together with its name which is securely binding them. The joining of signature with data publisher information enables to determine data provenance which allow the consumers trust in data to be disjoint from how and from where the data is retrieved. In addition, it supports fine-grained trust, which allows consumers to reason about whether a public key owner is an acceptable publisher for a particular piece of data in a specific context [1]. The end to end approach of NDN for security facilitates trust between publisher and consumers which offers publisher, consumers and application a great deal of flexibility in choosing or customizing their trust models.

Figure 4 illustrates interest packet sample describing the information that it contains when a packet is broadcast to nearby router/node for multimedia contents retriever [10]. The interest packet will contain requested multimedia contents name as well as publisher information and security such as generated nonce. The nonce will carries a randomly generated byte-string that used to detect and discard duplicated interest messages which can be used in order to improve the efficiency of the detection [10].

Figure 5 illustrates Content Packet sample describing the information which is carried when desired data is retrieved from nearby router/node or server [10]. Every content packet will contains Signature, Content name, signed info and data. The signed info field carries PublisherPublieKeyDigest which identifies the publisher that signed this content where the public key of the publisher value is a SHA-256. This will not only improve the security of content while it being delivery but also will provide a strong trust between publisher and users.

Interest Packet

…/IPTV/Movies/MissionImpossible/1/2.mpg
MinSuffixComponents : : = 0
MaxSuffixComponents : : = Infinit
PublisherPublicKeyDigest : : = BLOB
Exclude : : = (Any | Bloom)? (component (Any | Bloom)?)
ChildSelector : : = 1
AnswerOriginKing : : = 3
Scope : : = 1
InterestLifetime : : = ¼ sec
Nonce

Figure 4. Interest Packet Sample [10]

Content Packet

SHA-256 (1.2.840.113550.11.1.2.2)
…/IPTV/Movies/MissionImpossible/1/2.mpg
PublisherSigned Info
Data

Figure 5. Content Packet Sample [10]

Interest Recording Packet

…/IPTV/Movies/MissionImpossible/1/2.mpg
Recording Request : : = 1
Min/Max SuffixComponents : : = 0 ~Infinit
PublisherPublicKeyDigest : : = BLOB
Exclude : : = (Any | Bloom)? (component (Any | Bloom)?)
ChildSelector : : = 1
AnswerOriginKing : : = 3
Scope : : = 1
InterestLifetime : : = ¼ sec
Nonce

Figure 6. Interest Recording Packet Sample [10]

Interest Watching Packet

…/IPTV/Movies/MissionImpossible/1/2.mpg
Watching Request : : = 1
Min/Max SuffixComponents : : = 0 ~Infinit
PublisherPublicKeyDigest : : = BLOB
Exclude : : = (Any | Bloom)? (component (Any | Bloom)?)
ChildSelector : : = 1
AnswerOriginKing : : = 3
Scope : : = 1
InterestLifetime : : = ¼ sec
Nonce

Figure 7. Interest Watching Packet Sample [10]

In figure 6 and 7, we illustrate sample of Interest Recording Packet request sample and Interest watching Packet request sample, respectively [10]. Both of interest will carry the same information as the original interest packet. It is possible that when sending an R_{Req} to record certain content, the server will check with a previously requested request to the same content in V_Cache storage because it is connected to the server. Upon the existing of content the server will keep a record of that content and when receive the Interest W_{Req}, it will send that content to user. As a result, it decrease delay time and efficiently using space in V_Cache.

5.2 Performance Analysis

The goal of providing V_Cache mechanism is to reduce the time it takes to retrieve the multimedia content from server to user, efficiently use the bandwidth and resources. In this section we will analyze performance of our proposed system where we focus our analysis in the response time it takes to send the interest packet to retrieve the desired multimedia content and return back to user device as well as to the V_Cache to retrieve desired multimedia content.

Average time response from user to V_Cache to server: it is the time it takes interest packet to traverse from user device to router/node, V_Cache and Server to return back to user device.

Average time response from user to nearest router/node: it is the interest packet to reach nearest router/node and return back with data packet.

For finding the respond time, we assume the T is the time. Here, T_{Device} donates the time it took device to send interest packet to first router/node; $T_{Router/Node}$ represent the time for forwarding the request; T_{V_Cache} is the time it takes to check for multimedia content. The formula is as follow:

Average Time Response from User_Server = $(T_{Device} + T_{Router/Node1} + T_{V\_Cache1} + T_{Router/Node2} + T_{V\_Cache2} + \ldots + T_{Device} + T_{Router/NodeN} + T_{V\_CacheN})$ **(1)**

Average Time Response from User to Nearest Router/Node = $(T_{Device} + T_{Router/Node1} + T_{V\_Cache1} + \ldots + T_{Router/NodeN} + T_{V\_CacheN})$

(2)

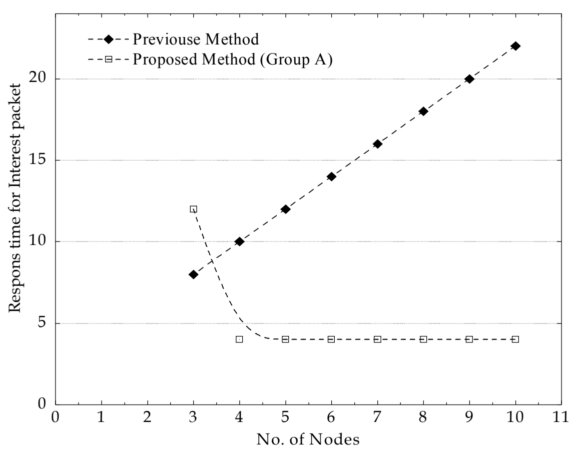

Figure 8. No. of Nodes vs. Time Response to Interest Packet for Group *A*

In figure 8, we consider our analysis for Group *A* which is possibly could consist of more than one user. Group *A* will consist of users who request to watch multimedia content in live mode. Group *B* will consist of users who requested to record the multimedia content. When broadcasting interest packet by Group *A*, it will traverse all the way checking every V_Cache in router/node to the server and back carrying the desired multimedia content to user where it will store a copy of the multimedia content in each router/node. For other users whom desired to watch the same multimedia content will have less delay/ response time assuming that they will access from the first router/node or the same path.

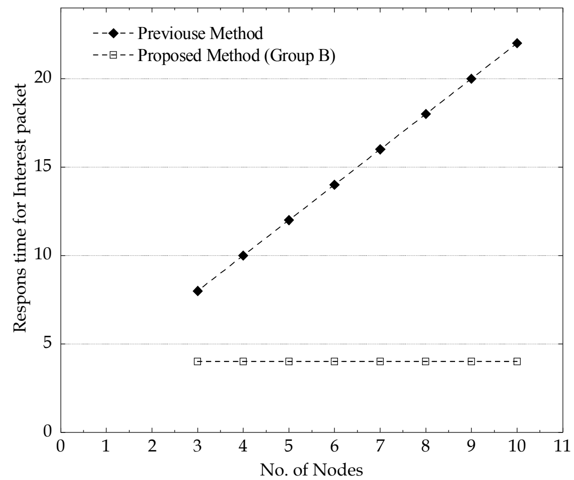

Figure 9. No. of Nodes vs. Time Response to Interest Packet for Group *B*

In figure 9, As for Group *B* user(s), they will send Interest packet request to record the multimedia content and then watch it in later time. When the data packet traverse back to user, it will save a copy in the V_Cache store for later on retriever by other users in Group *B*. It also possible that user in Group *B*, receive the multimedia content from the nearest router/node. The result show that for the original case where user request multimedia content from server every time, the increase of router/node number will result in increase of time which will cause long delay. In our case, any user either from Group *A* or *B* can retrieve multimedia content from any router/node that already have the same multimedia content and the increase in router/node number will not increase the retrieval time (delay time) of multimedia content. In addition, when interest packet reached first router/node, it will be forward to next router/node as well as to V_Cache DB where it have list of previously requested multimedia contents to locate nearby router/node with the same requested multimedia contents which will decrease the searching time for multimedia contents. As a result, both users from Group *A* and *B* will have flexibility to either request their desired multimedia contents in the same time or by recording it for later view. In the original case where user request traverse all the way to server every single time, the requested multimedia contents increases delay/response time, inefficient use of bandwidth and resources.

6. CONCLUSTION AND FUTURE WORK

In this paper we have proposed architecture of a new N-Screen Services which enables application streaming based on N-Screen services using Personal Video Recorder (PVR) and Named Data Networking (NDN) in cloud computing environment. In particular, we propose a framework of N-Screen Services called "ShopMark" based on PVR and NDN technology in cloud computing environment.

This service will provide user with playback method for their previously recorded multimedia contents (e.g. Movies, Drama, Shows, etc) which was combined with Advertisement. The user will not only be able to playback their multimedia contents but also can re-playback and interact with the advertisement and choose their interesting advertised product by scenes. We also provide security and performance analysis to our system to show the result of our work. As for future, it would good advantage to explore Named Data Networking in other field to have a wide diversity of experience with this technology.

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REFERENCES

[1] Zhang, L., Estrin, D., Burke, J., Jacobson, V., Thornton, J. D., Smetters, D. K., Zhang, B., Tsudik, G., Claffy, K. C., Krioukov, D., Massey, D., Papadopoulos, C., Abdelzaher, Wang, T. L., Crowley, P., Yeh, E., 2010. Named Data Networking (NDN) Project.

http://www.named-data.net/techreport/TR001ndn-proj.pdf

[2] Song, J. H., Byeon, J. H., Moon, N. M. 2011. Design and Implementation of Metadata for n-Screen UCC Recommender. Multimedia and Ubiquitous Engineering (MUE), 2*011 5th FTRA International Conference on*, pp.263-266, (June 28-30).

[3] Content-Centric Networking, http://en.wikipedia.org/wiki/Content-centric_networking

[4] Pourasghar, D. 2009 CRM in the Convergence of Telephony, TV and Broadband Internet Access (triple play). Place of pub: Germany, publisher: Grin Verlage.

[5] Wang, X., Wang, J. H. 2011. Cloud Computing and its key techniques. *2011 IEEE International Conference on Computer Science and Automation Engineering* (CSAE), vol. 2, pp.404-410, (June 10-12).

[6] Rajan, S., Jairath, A. 2011.Cloud Computing. *The Fifth Generation of Computing, Communication Systems and Network Technologies (CSNT)*, 2011 International Conference on, pp.665-667, (June 3-5).

[7] Yoon, C. W., Um, T. W., Lee, H. W.2012 Classification of N-Screen Services and its Standardization. *14th International Conference on advanced communication technology (ICACT 2012),* pp. 597-602, (February 19-22).

[8] PURSUIT Project, http://www.fp7-pursuit.eu/PursuitWeb/>

[9] Ohlman, B., Ahlgrn, M.B., D'Ambrosio, Dannewitz, M., C., Eriksson, A., Gronvall, B., Horne, D., Marchisio, M., Marsh, I., Nechifor, S., Pentikousis, K., Randriamasy, S., Rembarz, R., Renault, E., Strandberg, O., Talaba, P., Ubillos, J., Vercelone, V., Djamal, Z. First NetInf Architecture description. http://www.4ward-project.eu/index.php?s=file_download&id=39

[10] CCN Technical documentation, http://www.ccnx.org/releases/latest/doc/technical/

[11] Zeng, Y. G., Hong, X., 2011. A Caching Strategy in Mobile Ad Hoc Name Data Networking. *6th International ICST Conference on Communication and Networking (CHINACOM)*, China.

[12] Alsaffar, A. A., Nguyen, T. D., Shin, Y. R., Huh, E. N.2010 Secure Migration of IPTV Services from a STB to Mobile Devices for Pay per View Video. *Digital Content, Multimedia Technology and its Application (IDC), 2010 6th International Conference on*, pp.91-97, (Aug 16-18).

[13] Park, S. H. Park, Y. S., YU, S. B., Choi, J. R.2012. Implementation of ATSC Mobile DTV Broadcasting for N-Screen Smart Devices." *2012 IEEE International Conference on Consumer Electronics (ICCE),* pp.331-332,(Jan 13-16).