Dynamic Tunnel Switching using Network Functions Virtualization for HA System Failover

Hery Dian Septama
Departement of Electrical Engineering
University of Lampung
Lampung, Indonesia
hery@eng.unila.ac.id

Gigih Forda Nama
Departement of Electrical Engineering
University of Lampung
Lampung, Indonesia
gigih@eng.unila.ac.id

Ardian Ulvan
Departement of Electrical Engineering
University of Lampung
Lampung, Indonesia
ardian.ulvan@eng.unila.ac.id

Melvi Ulvan
Departement of Electrical Engineering
University of Lampung
Lampung, Indonesia
melvi@eng.unila.ac.id

Robert Bestak
Departement of Telecommunication Engineering
Czech Technical University in Prague
Prague, Czech Republic
robert.bestak@fel.cvut.cz

Abstract— **High Availability (HA) is an ability of the system to operate continuously in desired amount of time. Telephony system, for example, should operate 99.999%, that means the system should have only 5.26 maximum downtime for a year. Provide high available IP based service such as Voice over IP for telephony is difficult since IP is not designed for reliable connection. A lot of research has been conducted to overcome these drawbacks. This paper works by enhancing the failover mechanism of Remus as a high availability solution using server virtualization. This paper proposed network function virtualization in order to create a dynamic tunnel switching between primary and secondary server to the clients gateway. The result shows the jitter level and downtime of modified failover using dynamic tunnel switching did not make the jitter or amount of downtime higher. The server downtime using dynamic tunnel switching were varied between 1.3 - 1.5 second that is still comparable with basic Remus downtime with gratuitous ARP means the proposed idea using network function virtualization works well. This paper extends the ability of failover to adapt the wide area condition.**

Keywords—high availability; failover; NFZ; virtualization; Remus

I. INTRODUCTION

Nowadays, the internet became one of main humans need in their daily life. Downtime of a service is one of the modern human nightmare. In order to support the service uptime, well know as high availability, a lot of research has been conducted. IP based service is believed will be the future generation of various services exist nowadays. A lot of service has been provided their service into IP based, i.e telephony, television. However, those emerging technologies have to fulfill the availability standard. A highly available of telephony system, for example, should operate for the 99.999 %, that means the system should only have 5.26 minutes maximum downtime for a year. This availability of telephony system well known as five-nine rules.

Provide highly available of Internet Protocol (IP) based service is more difficult. In fact, IP is not designed for reliable connection. Packetization procedure created more delay and jitter and also the probability of packet loss. Virtualization has then become a popular technique for cost reduction and hardware efficiencies and also to support high availability. Server virtualization and network function virtualization (NFV) is used for more scalable and efficient networks function. Virtualizations are believed to be one of the key of IP based service to deliver high availability connection. High availability service using server virtualization has been studied. Continuous live migration of a virtual server is introducing to make the server more high available. However, this emerging technology needs more improvement for scalability. Scalability improvement using network function virtualization of high availability server in order to support failover is conducted in this paper.

II. RELATED WORKS

Study of virtualization server for high availability using continuous live migration processes in Local Area Networks (LAN) environment works well with Remus as the XEN virtualization extensions. The Remus high availability is provided by enhancing the XEN live migration process of virtualized server continuously. If the primary server is failed the failover procedure will occur and secondary server would take the service request without disruption. The process is application transparent and the service is still available with minimal downtime. If the primary server is available the synchronization will occurs and failback mechanism may happen [1].

Scalability and performance of high availability using Remus are two of the main drawbacks that need to be improved. The failover mechanism only works in local area networks since it is using gratuitous ARP packet to announce the running server. The Seamless live migration over Metropolitan Area Network (MAN) and Wide Area Network (WAN) [2] and the failover live migration process in wide area environments using dynamic Domain Name Server (DNS) [3] is a proposed technique to overcome that drawbacks. However, both papers only studied the failover of live migration not the continuous live migration. Border Gateway Protocol (BGP) update to announce client the new path after failover [4] is then proposed to overcome that drawbacks for continuous live migration.

The state of the arts NFV also help companies to reduce capital expenditures (CAPEX) and operating expenditures (OPEX) by using virtual networks instead of dedicated hardware. The NFV made revolutional changes on how companies implement their data center. Therefore, leading telecommunication companies support and belief that NFV is one of the main key of future telecommunication technologies [5]. The use cases of NFV on the wireline access networks and also the NFV standard landscape is also standardized by the forum. The standard also describe several cases of how the NFV could help driving a transition towards future programmable carrier grade networks [6,7] .

The HA system of VoIP server failover mechanism over WAN is also interesting topic to study. The WAN give more challanges need to overcome such as different IP networks address, higher jitter, delay, packet loss and lower bandwidth. Dynamic tunnel switching for traffic redirection is one of interesting proposed idea [8]. The results show that the voice quality and measured downtime is promising. However, the works still using traditional ways to create the interfaces and bridges. This paper improves the dynamic tunnel switching using network function virtualization for better network management process. The idea is replaced the basic XEN virtual interfaces with NFV to create the virtual interfaces and bridges. The NFV features also made it is easier to run the dynamic tunnel switching scenarios. The interfaces and bridges is created with only few command lines and executed with minimal time.

III. HIGH AVAILABLITY SYSTEM VIRTUALIZATION

High Availability (HA) is an ability of the system to operate continuously in desired amount of time. Availability of system is usually expressed as a percentage of uptime in a given year. The reason for the unavailability of systems were varied i.e. hardware maintenance or failure, network failure, server down. Therefore, to deliver a highly available system is difficult and expensive. Remus [1], a Xen virtualization extension proves that virtualization is one of emerging technology in order to support high availability. Fig. 1 depicts how Remus works by doing the continuous live migration process iteratively.

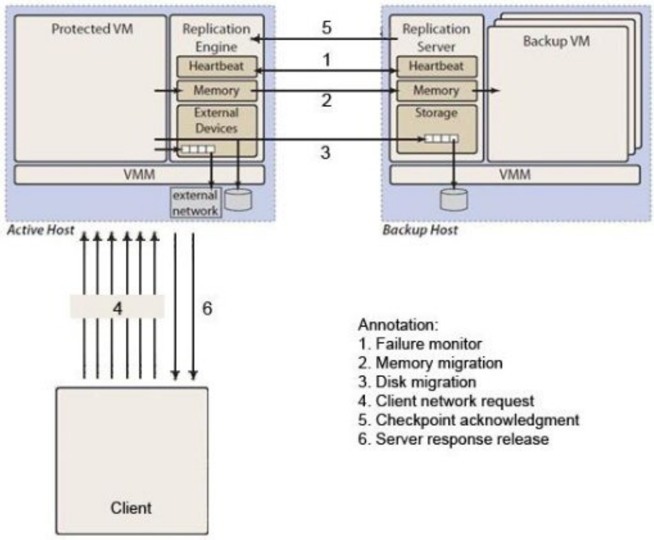


Fig. 1. Remus High Avalability Works [1]

Each copy of running server (primary server) is copied to secondary server periodically called as a checkpoint. If the problem occurs on primary server that made the service unavailable, then secondary server will take over the service request in minimal downtime with its last checkpoint states. The basic Remus scenarios made its unable to run realtime IP based service because its buffers the client request and server responses every checkpoint interval. The Remus buffering rules create high delay, jitter and packet loss. The Remus buffering rules is then modified and the impact is studied [9]. Those works results show that high available system using modified Remus buffering rules is feasible to deliver high availability IP based service.

Besides server virtualization, network virtualization also improves the hardware based network deficiencies. Network function virtualization becomes popular and a lot of big network companies upgrade their products with these new emerging technologies. Fig. 2 depicts the ETSI high level NFV framework. The figure shows the relation of hardware resources, virtualization layers/hypervisor and virtualised network function that runs on top of it. NFV management and orchestration is used to manage and control the virtual network functions.

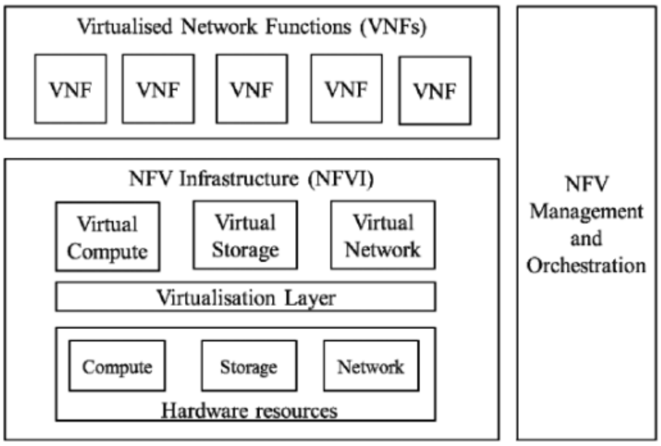


Fig. 2. High-level NFV framework [10]

IV. Simulation and Result

This paper enhanced the dynamic tunnel switching using NFV. The NFV replaced the basic virtual interfaces and bridges configuration in Xen virtualization. NFV offer more network management functions. The basic idea is to create a GRE tunnel between primary and secondary server and also to the client gateway. The tunnel is used to improve the failover mechanism for more scalable implementation. The tunnels allows the virtual machine to share the same IP networks. Since all communication between primary and secondary server is done using the tunnels, both server is assumed that their located on the same local area networks.

All communication from the virtual machine is forwarded to its virtual interfaces and then to the its virtual bridge. Then, communications from the virtual bridges is forwarded to physical interface to the GRE tunnels until reach the target server. At least, 3 GRE tunnels is needed to deploy the idea. The proposed scenario is depicted in Fig. 3.

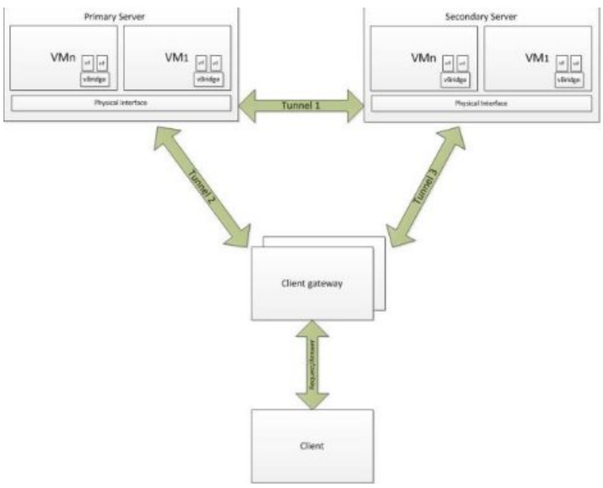


Fig. 3. Failover Simulation Tesbed

The Openvswitch is used to deploy virtual interface, bridge and GRE tunnel feature is used in simulations. Since only Xen XCP tool stacks natively support Openvswitch, therefore Xen with xm or xl tool stack is need a modification to be able to working with Openvswitch. The Remus also needs to modified to be able to run the dynamic tunnel switching. The tunnel 1 is used for continuous live migration of a virtual machine link from the primary to the secondary server in order to create a high availability. Tunnel 2 and 3 is used for the client access channel, only one of tunnel 2 and 3 is up at the same time depends on which server is running the service. The scenarios will work as stated in the algorithm 1 :

Algorithm 1 Dynamic tunnel switchning method

```
begin
{
  repeat;
      {
      check running server;
         if (running server = primary)
         then
            add tunnel 2, remove tunnel 3;
         else
            add tunnel 3, remove tunnel 2;
         end if
      }
  }
```

The Remus failover mechanism will resume the paused virtual machine on the secondary server and immediately notify the client gateway if primary server become unavailable. We take the advantage of this Remus works by add the additional code to run the algorithm. As soon as the secondary server is assumed primary server is down and run the failover process, the algorithm also executed. The algorithm will check which server is running and decide which tunnel should dropped and added. Secondary server then send notification to client gateway to direct the request packet to the secondary server. The dynamic tunnel switching is used to guide the data packet to which server is active to serve the client request with minimal downtime. If the primary server is available again the synchronization will occurs and failback mechanism may happen repeat the dynamic tunnel switching process. Since the server downtime is minimized therefore the availability is also improved.

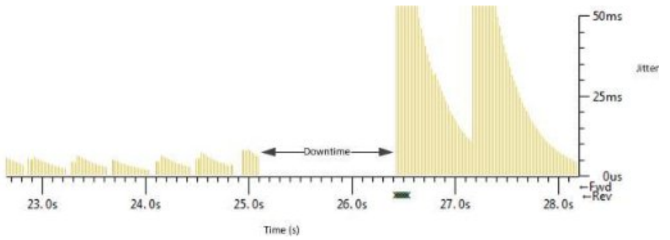
Jitter calculation is considered to present the result. Interarrival jitter (J) and mean deviation of the difference (D) defined for pairs packet by comparing packets spacing at the receiver and sender as shown on equation 1 [11]. Packet spacing is the difference between the RTP packet timestamp from sender and receiver time when arrived packet also knows as relative transit time.

$$D(i,j) = (R_j - R_i) - (S_j - S_i) = (R_j - S_j) - (R_i - S_i) \quad (1)$$

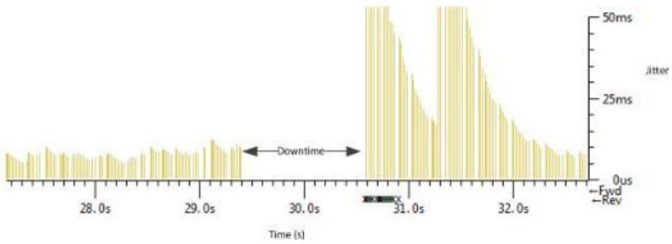
Si, Sj is a RTP timestamp from packet i and j. Ri, Rj is time of arrival in RTP timestamp units for packet i and j. Since the RTP packet arrived continuously at the receiver then Difference (D) from pairs of packets (n packet and n – 1 packet) also calculated continuously. Therefore, the interarrival jitter could be calculated using equation 2 [11] as follows:

$$J(i) = J(i-1) + \frac{(|D(i-1,i)| - J(i-1))}{16} \quad (2)$$

Jitter from the sniffed packet while running VoIP call in high availability environment is calculated using equation above and graphed as shown in Fig. 4. Those figure depicts the jitter level both for original Remus failover and modified failover using dynamic tunnel switching. The figure shows not only the jitter level but also amount of downtime. Since the packet is sniffed continuously, there will be no sniffed packet while failover process because the packet is buffered due to service is down. Therefore, the spacing that shown on Fig. 4 will also express the amount of service downtime.



(a)



(b)

Fig. 4. (a) Jitter and downtime of original failover
(b) Jitter and downtime of modified failover

The result shows that the jitter level and downtime of modified failover using dynamic tunnel switching did not make the jitter or amount of downtime higher. The comparison of original and modified downtime result is presented in Fig. 5. This paper also research the effect of checkpoint interval configuration of Remus to the service downtime. 40 – 800 ms is used as the Remus checkpoint interval. The results shows that Remus checkpoint does not have an effect to the downtime both for original Remus and modified remus using dynamic tunnels switching for failover mechanism. The downtime was varies between 1.2 – 1.5 ms. Since the basic Xen and Remus virtual interface is replaced with NFV there will be more network management feature added.

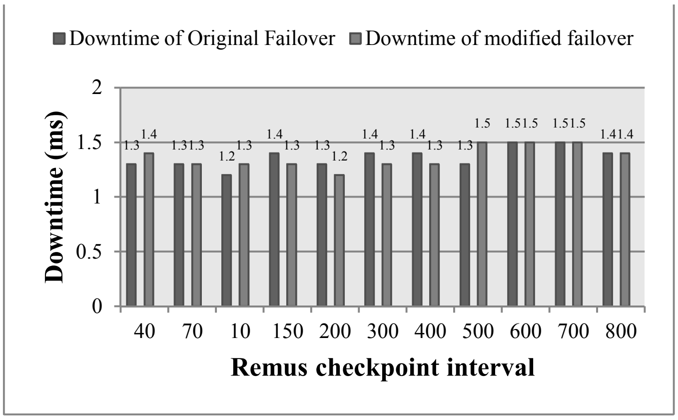


Fig. 5. Measured downtime

Future Works

For the future works we consider deploying Software Defined Networks (SDN) for NFZ orchestration. However, this approach should consider how to integrate the orchestration process with Remus.

Acknowledgment

This works is supported by Directorate General of Higher Education, Republic of Indonesia, through the International Collaboration Research Grant. It is also supported by research grant of Czech Technical University in Prague.

References

[1] B. Cully, G. Lefebvre, D. Meyer, M. Feeley, N. Hutchinson, A. Warfield, “Remus: High Availability via Asynchronous Virtual Machine Replication”, NSDI'08 Proceedings of the 5th USENIX Symposium on Networked Systems Design and Implementation, 2008

[2] F. Travostino, P. Daspit, L. Gommans, C. Jog, C. de Laat, J. Mambretti, I. Monga, B. van Oudenaardec, S. Raghunatha, P. Wange, “Seamless live migration of virtual machines over the MAN/WAN”, Future Generation Computer Systems 22, Elsevier, 2006

[3] R. Bradford, E. Kotsovinos, A. Feldmann, H. Schi¨oberg, “Live Wide-Area Migration of Virtual Machines Including Local Persistent State”, VEE '07 Proceedings of the 3rd international conference on Virtual execution environments, 2007

[4] S. Rajagopalan, B. Cully, R. O'Connor, A. Warfield, “SecondSite: disaster tolerance as a service” VEE '12 Proceedings of the 8th ACM SIGPLAN/SIGOPS conference on Virtual Execution Environments. 2012

[5] H. Hawilo, A. Shami, M. Mirahmadi, R. Asal, “NFV: State of the Art, Challenges, and Implementation in Next Generation Mobile Networks (vEPC)”, Networks, IEEE Volume 28 Issue 6, 2014

[6] B. Kozicki, N. Olaziregi, K. Oberle, R. B. Sharpe, M. Clougherty, “Software-Defined Networks and Network Functions Virtualization in Wireline Access Networks”, Globecom Workshops (GC Wkshps), 2014

[7] ETSI Group Specification NFV, Network Function Virtualization (NFV) use cases, ETSI GS NFV 001, European Telecommunications Standards Institute (ETSI), 2013

[8] HD. Septama, A. Ulvan, J. Hlavacek, R. Bestak, “High Available VoIP Server Failover Mechanism in Wide Area Network”, Telkomnika UAD Volume 13 number 2, 2015

[9] HD. Septama, A. Ulvan, J. Hlavacek, R. Bestak. “Voice Quality of VoIP in High Availability Environment”. International Conference on Electrical Engineering and Computer Science. 2014

[10] ETSI Group Specification NFV, Network Function Virtualization (NFV) Architectural Framework, ETSI GS NFV 002, European Telecommunications Standards Institute (ETSI), 2013

[11] Schulzrinne, H. Casner, S. Frederick, R. Jacobson, V. RTP: A Transport Protocol for Real-Time Applications. IETF RFC 3550. Internet Engineering Task Force (IETF). 2003