High Availability Aspects of SDN-IP Reactive Routing

A Friyanto
Departemen Sistem Informasi, Universitas Komputer Indonesia, Indonesia

Email : *gafriyanto@email.unikom.ac.id

Abstract. SDN (Software-Defined Network) is a new paradigm in the world of networks that separates the control plane from the data plane. Over the past few years, SDN network deployment has been difficult because it was isolated from the current IP network. SDN-IP is an ONOS (Open Network Operating System) application used to connect SDN networks to external networks using the standard Border Gateway Protocol. The SDN device will create a path with OpenFlow after receiving a route from an external peering network with BGP speakers on the SDN network. SDN-IP Reactive Routing will calculate and create paths for traffic when receiving ipv4 or ipv6 packets. Therefore, with SDN-IP Reactive, Routing can make host communication between two SDN Network or SDN Network with the internet network. As a core network that connects autonomous systems to internet network, SDN-IP networks need to pay attention to aspects of redundancy. In this research, SDN-IP Architecture use many OpenFlow Switches that are connected to an external BGP are not sufficiently controlled by one controller because if the controller is down, the forwarding plane will be lost. Multiple controllers and multiple links are required to ensure the system continues to run when the controller or link is broken. The purpose of this research is to analyze the High Availability aspects of SDN-IP Reactive Routing. This is done by making multiple onos controllers in one onos cluster system. The testing process is carried out on aspects of BGP speakers, ONOS controller and links between components.

1. Introduction
Network systems technology did not experience many changes before the advent of SDN technology. SDN or Software-Defined Network is a new paradigm which is to foster innovation and flexibility because of centralized network control and standard interfaces[1]. The fundamental difference of SDN technology is separating control plane with data plane in a device. This control plane separation can move the control plane function of several devices to be centralized in a control device, which makes it more flexible to manage and operate. The need for network access makes the development of network systems growing rapidly. The breadth of the network makes more and more network devices. SDN technology can make device management and control simpler with programmed devices and automation.

In the hybrid SDN model, the whole network consists of two parts. One space is SDN network and another space is Ground IP network[2]. legacy IP networks and SDN networks work according to the character of their own work methods. CSMA/CD technology and IP technologies such as static routing and routing protocols work to interconnect nodes on legacy IP networks. Whereas on the SDN network it is very much different. The centralized control plane functions to carry out the forwarding functions on all switches, programmed devices and the ease of scaling up and scaling down into special characters and ways of working on the SDN network. Nodes in each of these technologies can communicate with each other by utilizing an external routing protocol, namely BGP on legacy IP networks.
networks and using SDN-IP applications on SDN networks so that it can exchange routing information through the BGP routing.

One of SDN that conduct an open SDN development is the ONF (Open Networking Foundation). ONF has produced a lot of SDN technology knowledge and products. A consortium consisting of companies and communities that collaborate on research such as ONOS as a controller in SDN. ONOS or Open Network Operating System provides the control plane for a software-defined network (SDN), managing network components and running software programs or modules to provide communication services to end hosts and neighboring networks[3]. SDN network is considered to be established to be used on a running system. Even some providers used it in their production system but it is still separate from the legacy network that is already running. SDN-IP (Software-Defined Network / Internet Protocol) is an ONOS application that makes software defined network can connect to external network using the BGP (Border Gateway Protocol). SDN-IP works as a single Autonomous System (AS) and is connected to any traditional AS or connecting between AS. In ONOS, SDN-IP is an application or service that makes install and update the forwarding state to device or we call in the SDN data plane. In legacy networks, BGP routing is used to exchange routing information between ASs. And on the SDN network, routing information received by the BGP speaker will convert it into an intents then translate the intents to OpenFlow entries for switch decisions data forwarding. SDN-IP Reactive Routing is advance feature of SDN-IP provide reactively compute and install the routing path when receives packet-in. SDN-IP reactive routing can make two hosts communication with each other, both two host are in SDN network or another host in internet.

The controller becomes an important part as a control center for forwarding decisions. If the controller fails or the controller link is broken, the switch device cannot work properly. Redundancy is needed either BGP speaker, ONOS controller or a link that connects between all components. This research conducted a study of the high availability aspects of SDN-IP reactive routing to ensure the process of routing or data forwarding continues to work normally when a component fails. For run this scenario, in this research using ONOS as a controller. It works as a data forwarding or data plane in the SDN network are OvS (Open vSwitch). Quagga is used as an external network router to exchange routing information including with BGP speakers. All of these components run in the GNS3 emulator.

2. Method

The methodology used in this research is experiment. Based on figure 1, this research was started from building a SDN network system with ONOS as a controller and integrated to legacy IP Network by BGP. Redundancy made by ONOS cluster with two controllers and two BGP speakers. High availability testing and analysis is done by turning off one of the controllers, one of the BGP speaker. Then breaking the link both to the controller and BGP speaker.

![Figure 1. Research methodology](image)

3. Results and Discussions

In this section, the discussion will begin with develop SDN network system and join to existing legacy IP network by BGP. With the concept of centralized control, the analysis carried out is about how high availability aspects of SDN-IP Reactive Routing.

ONOS controller as one of the SDN controller operating systems has many communities that develop various applications. SDN-IP is an application on the ONOS controller that aims to make the SDN network able to communicate with legacy IP networks. SDN network architecture is designed
with the ultimate goal of getting compatibility, operational flexibility, high availability, scalability, protocol compatibility and vendor independence [4]. The SDN-IP architecture makes the SDN network work in tandem with the legacy IP network that is already running. SDN controller as a centralized control provides the control plane function of the SDN switch device about how a data will be forwarded or the data plane.

SDN-IP utilizes the BGP protocol which has been running massively on wide area network IP technology. BGP as an external routing protocol works to exchange routing information between service providers. In SDN-IP architecture, SDN networks communicate with external networks through BGP speakers. BGP speakers advertise networks and receive various routing information. BGP speakers make iBGP peering (Internal BGP) with the ONOS controller to forward the routing information that has been received from various external BGP to the ONOS controller. SDN-IP will change the routing information or network prefix into an intents and then ONOS translates the intents into rule decision forwarding in a data plane.

As seen in Figure 2. SDN-IP architecture, BGP external network routers communicate routing information with each other. BGP speakers have the same status as BGP routers to exchange routing information. The BGP speaker communicates with the ONOS Controller to send routing or prefix information via iBGP. The routing information is translated into intents and then becomes a policy forwarding to the SDN switch through OpenFlow.

![Figure 2. SDN-IP Architecture](image)

In running SDN networks with IP Legacy using BGP, SDN networks can be AS (Autonomous System) transits that connect various external networks using ONOS SDN-IP applications or become a single US that runs SDN networks as an autonomous system. In this study a high availability analysis was carried out on an SDN network running as an autonomous system. To make internal and external network routing in the SDN network using ONOS SDN-IP Reactive Routing application that works as part of the main application SDN-IP. In a single autonomous system, SDN networks are known by other external networks as other BGP routers. BGP speakers on the SDN network serve as a link for SDN network communication with other external networks. BGP speakers and other BGP routers exchange routing information or network prefix for later conversion to intents and OpenFlow entries as described in the previous.

In general, SDN-IP is an ONOS application in translating routing into intents and OpenFlow entries. To do routing on different subnetwork nodes in the internal SDN network, routing nodes in the SDN network to the external network or vice versa requires ONOS application SDN-IP Reactive Routing [5]. Reactive routing is part of the SDN-IP. The reactive routing (onos-app-reactive-routing) application to function requires the running SDN-IP (onos-app-sdnip) application. ONOS application
reactive routing is an onos application that performs calculations and makes a routing path in passing a traffic when the ONOS controller receives an IP packet either IPv4 or IPv6 [5]. The reactive routing application will also create a virtual gateway on the SDN network. Similar to legacy IP networks, this virtual gateway also functions as a next hop when a packet needs to be sent to different subnetworks. Apart from that, the virtual gateway of the reactive routing application also works to perform ARP requests to find out the MAC Address of a host. Thus the nodes in the SDN network can communicate with different subnetworks and external networks as in legacy IP technology through several next hops, but in the SDN network it uses a virtual gateway because hardware in the SDN network uses SDN switches instead of routers.

In the network used as a backbone, the aspect of high availability becomes very important. The system must continue to run when a component fails. In an SDN-IP one instance or one cluster ONOS controller runs as one AS. The more alternatives, the higher the availability aspect, but the higher the inefficient aspect which is at risk of looping. High availability for SDN-IP is to make a redundancy controller. Creating multiple instances including BGP speakers is done to ensure that the exchange of routing information does not stop with the external network when it fails.

As in Figure 3 ONOS redundancy of controllers, there are 2 instances of ONOS controller and 2 BGP speakers. Each BGP speaker conducts session peering with each BGP router or external BGP AS identified by 2 different ASs. The two BGP speakers exchanged routing information or prefixes they obtained using internal BGP with 2 ONOS controllers. Of the 2 controllers, only 1 controller will work at a time and the others will use standby mode. Determination of primary and secondary controllers using the leader election calculation. Each BGP speaker is connected to both ONOS controllers, so that whenever the main controller moves, the iBGP link will always be established.

4. Conclusion

Based on the discussion on redundancy of controllers, apart from the main aspects of the availability of multiple controllers and BGP speakers, here are some supporting aspects that can make high availability realized in SDN-IP. BGP speakers are routers that serve as a connecting bridge with IP networks. Measuring the routing information of all prefixes on the IP network to the SDN network or advertise network SDN network to the IP network is done through the BGP speakers. When this BGP speaker fails, the communication node will still be running for a while because OpenFlow is obtained from the ONOS controller directly to the switch. However, when the ONOS controller detects the BGP, communication with BGP speakers failed and the received prefix is reduced. Therefore, the ONOS controller will update the Intents and OpenFlow information according to the latest prefix it receives. Making high availability of BGP speakers by providing several BGP speakers is certainly needed to ensure the exchange of routing information that run with the external network. However, the thing to note is that each BGP speaker conducts session peering with each BGP router external network. This makes each BGP speaker need one AS number and each external network must conduct session peering to each AS number. This means that if we have 2 BGP speakers, then our SDN network is identified by 2 AS numbers and the external network must be peering the two AS. Each AS number is certainly not arbitrary to use, we must register and get permission from the Internet.
Assigned Number Authority (IANA) for each AS number that we install on the BGP router or BGP speakers. High availability ONOS controller has become one of the focuses of design from the start of this ONOS controller made to run to support the SDN network. The ONOS cluster is the deployment of one or more ONOS instances. The running of several ONOS instances combined in one cluster makes the high availability of the controller very high. There are 3 controller modes in this ONOS cluster, NONE: there is no interaction and activity with the device; STANDBY: established with a device but does not have a control function; and MASTER: established with the device and has full control functions over it. In SDN-IP several BGP Speakers are connected with several ONOS instances that are one cluster. There is only one instance with MASTER mode at a time and the other is STANDBY mode. Every ONOS instance peer BGP with the BGP speakers so that it will get ready if at any time the ONOS master instance fails. To support multiple BGP speakers and multiple instances, multiple links are needed so that all can be connected to each other and be prepared if one component fails. With multiple links, one BGP speaker will communicate with several different instances. When many links are connected, there is a risk of inefficiency and looping. With STANDBY mode, although there are two controllers that have knowledge to all devices, but this mode does not have the function of controlling the device but is ready if a MASTER controller fails then this STANDBY controller is because it is always connected.

References
[1] Ventre, P. L., Salsano, S., Gerola, M., Salvadori, E., Usman, M., Buscaglione, S., ... & Snow, W. 2017. SDN-Based IP and Layer 2 Services with an Open Networking Operating System in the GEANT Service Provider Network. IEEE Communications Magazine, 55(4), 71-79.
[2] He, L., Zhang, X., Cheng, Z., & Jiang, Y. 2016. Design and implementation of SDN/IP hybrid space information network prototype. In 2016 IEEE/CIC International Conference on Communications in China (ICCC Workshops), pp. 1-6.
[3] ONOS 2019 “Introduction: What is ONOS” [online]. Available: https://wiki.onosproject.org/display/ONOS/ONOS [Accessed: Januari 30, 2020]
[4] Ayaka K 2016 “SDN-IP Architecture” [online]. Available: https://wiki.onosproject.org/display/ONOS/SDN-IP+Architecture [Accessed: Januari 30, 2020]
[5] Pingping L 2016 “SDN-IP Reactive Routing” [online]. Available: https://wiki.onosproject.org/display/ONOS/SDN-IP+Reactive+Routing [Accessed: Januari 30, 2020]
[6] Kumar, D., Srivastava, A., & Gupta, S. C. 2012. Performance comparison of pro-active and reactive routing protocols for MANET. In 2012 International Conference on Computing, Communication and Applications, pp. 1-4.
[7] Sanvito, D., Moro, D., Gulli, M., Filippini, I., Capone, A., & Campanella, A. 2018. ONOS Intent Monitor and Reroute service: enabling plug&play routing logic. In 2018 4th IEEE Conference on Network Softwarization and Workshops (NetSoft), pp. 272-276.
[8] Amin, R., Reisslein, M., & Shah, N. 2018. Hybrid SDN networks: A survey of existing approaches. IEEE Communications Surveys & Tutorials, 20(4), 3259-3306.
[9] Narantuya, J., Yoon, S., Lim, H., Cho, J. H., Kim, D. S., Moore, T., & Nelson, F. 2019. SDN-Based IP Shuffling Moving Target Defense with Multiple SDN Controllers. In 2019 49th Annual IEEE/IFIP International Conference on Dependable Systems and Networks—Supplemental Volume (DSN-S), pp. 15-16.
[10] Al-Shabibi, A., O’Connor, B., & Vachuska, T. 2016. Building Highly-Available Distributed SDN Applications with ONOS. In 2016 46th Annual IEEE/IFIP International Conference on Dependable Systems and Networks Workshop (DSN-W), pp. 266-266.