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Design of Routing Scenarios for Terrestrial Network Interworking with Satellite Network

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Abstract All terminals in terrestrial network interworking with satellite network will be deployed on all-IP network. Therefore, the selection of effective routing path in interworking network is important. In this paper, we design the network architecture and the routing scenarios on interworking network. We consider open shortest path first (OSPF) and border gateway protocol (BGP) as routing protocols. We derive criteria to design the network architecture, and then we model the routing scenarios. Then we evaluate the advantages and disadvantages on each scenario.

Key words Routing, Satellite network, Network architecture

1. Introduction

The communication networks such as cellular network and satellite network operate independently. Therefore, a user in a network cannot access to another network. Thus, a service for a user can be disrupted in various reasons, for example, the signal quality degradation of a base station. However, people depend more and more on advanced communication technologies such as the internet, computers, and mobile phones, and would like to have these technologies anywhere and at any time. For these purposes, it is expected that the satellite community will consider the satellite as an integrated part of the global telecommunications infrastructure rather than as an individual entity [1], [2]. Also, all terminals will be deployed on all-IP network with end-to-end connections. Thus, the routing protocols are very important to guarantee the end-to-end connections.

Many routing protocols are defined in RFCs. The routing protocols are classified into Interior Gateway Protocol (IGP) and Exterior Gateway Protocols (EGP) [3-5]. IGP exchanges routing information in a single routing domain, Autonomous System (AS). IGP includes Routing Information Protocol (RIP), OSPF, and etc. RIP uses hop counts as cost metric of a path [3]. OSPF can use link-state information, such as bandwidth, delay, and etc. [4]. EGP offers network reachability between ASs. The most widely used EGP is the Border Gateway Protocol (BGP) [5]. BGP is policy based routing, thus all connections are established based on the customized manner. In this paper, we assume that the satellite network interworking with terrestrial network uses OSPF and BGP as IGP and EGP, respectively. In this paper, we introduce several criteria to design network architecture of the satellite network interworking with the terrestrial network and design network architecture using these criteria. Then we apply the routing protocols to the network architecture and set up the routing scenarios. Also, we assess the advantages and disadvantages for each routing scenario.

The remainder of this paper is organized as follows. In Section II, we introduce several criteria and design the network architectures. Also, we set up the several routing scenarios and assess the trade-off of the routing scenarios. Finally, the conclusions are discussed in Section III.

2. Network Architecture Design

In this section, we consider three assumptions. First, the Internal Routers (IRs) use OSPF to calculate the optimal path in an AS.

Table 1. Criteria to classify the routing scenarios

Index	Criteria	Explain
1	AS separation	- Location based AS - Device type based AS
2	NCC configuration	- NCC operate with BGP router - NCC operate without BGP router
3	Topology of satellite link	- Star topology - Mesh topology
4	Device configuration	- Device operate with IR - Device operate without IR
5	Position of source and destination	- Source and destination are in same AS - Source and destination are in different AS
6	Device type of source and destination	- 4 case: (Source, Destination) · (Terrestrial, Terrestrial) · (Satellite, Satellite) · (Terrestrial, Satellite) · (Satellite, Terrestrial)

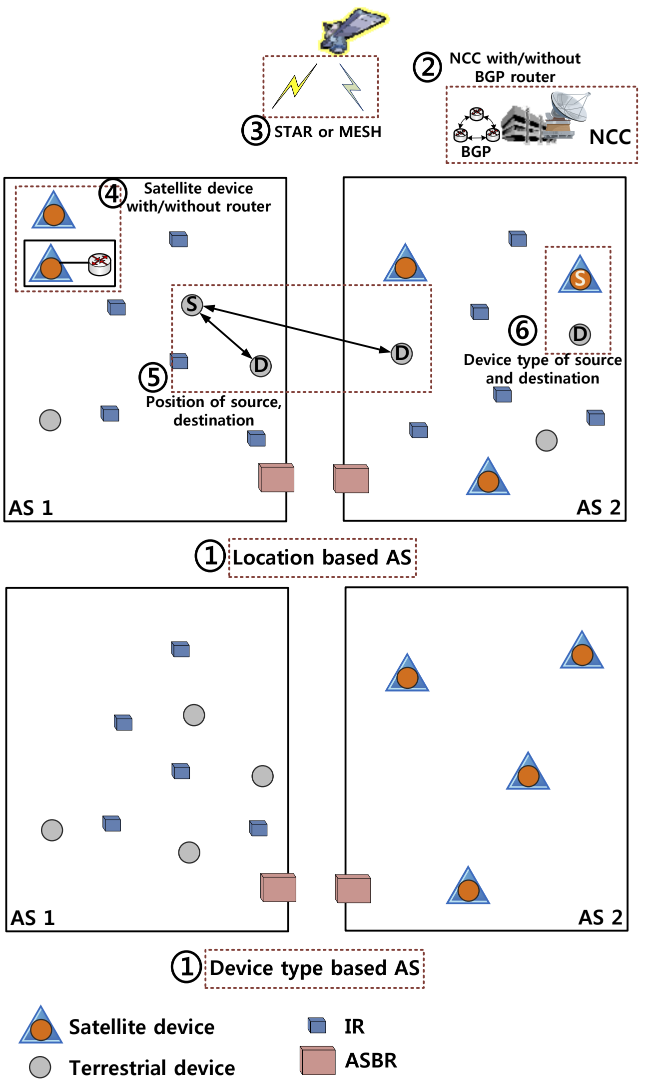


Figure 1. Criteria to classify the routing scenarios

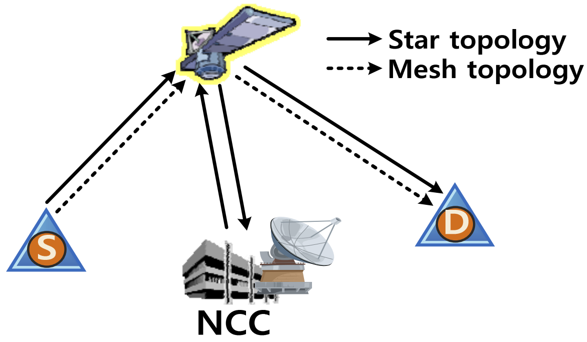


Figure 2. Difference between star and mesh topology

Second, the number of area in an AS is one. Third, Autonomous System Border Router (ASBR) has satellite links, but Internal Router (IR) operates without satellite link. To classify the routing scenarios, we use the six criteria as shown in Table 1 and Fig. 1. One of those is the topology of satellite link. The topology of satellite link is star or mesh topology. In the star topology, a data packet is transferred from a source to a destination through Network Control Center (NCC). On the other hand, a data packet does not pass through NCC in the mesh topology. Fig. 2 explains the difference between star and mesh topology. The star topology has longer path than mesh topology. This cannot affect routing path. Thus, we consider star topology only. The total possible number of scenarios based on the six criteria is 128. However we can reduce the number of scenarios to 64 when the satellite topology is fixed to star topology. In this paper, we assess the 64 routing scenarios and compare the performance for each scenario. We explain a scenario within the 64 routing scenarios and simply present the performance of other scenarios in the Table 3 because the number of scenarios is too many to deal with all scenarios in this section. We consider the scenarios as defined in Table 2. In the Scenario 1 and the Scenario 2, NCC operates with and without BGP routers, respectively, and the source and destination devices can access the satellite only, {Satellite, Satellite}. In the Scenario 3 and the Scenario 4, a source device can only access the satellite link and a destination device can only access the terrestrial network, {Satellite, Terrestrial}. We do not handle {Terrestrial, Satellite} case because the {Terrestrial, Satellite} case has same routing path with the {Satellite, Terrestrial} case.

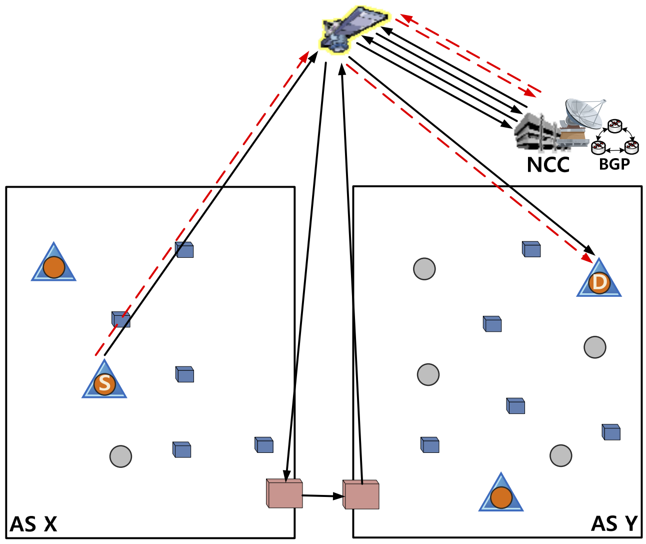
Fig. 3 depicts the Scenario 1 to the Scenario 4. In Fig. 3 (a), the

Table 2. Routing scenarios

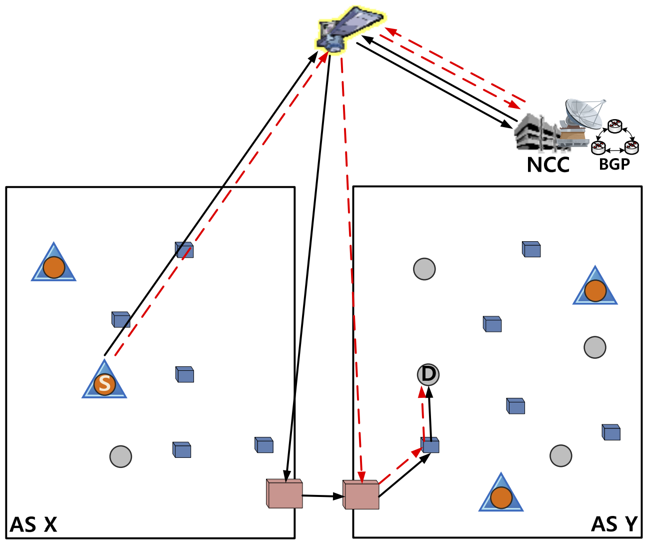
Scenario index	Assumptions
Common assumptions in Scenario 1-6	- The source and the destination are in the different area
Scenario 1	- NCC operates without BGP routers - The source and the destination pair is {Satellite, Satellite}
Scenario 2	- NCC operates with BGP routers - The source and the destination pair is {Satellite, Satellite}
Scenario 3	- NCC operates without BGP routers - The source and the destination pair is {Satellite, Terrestrial}
Scenario 4	- NCC operates with BGP routers - The source and the destination pair is {Satellite, Terrestrial }
Scenario 5	- Location based AS - The source and the destination pair is {Satellite, Satellite}
Scenario 6	- Device type based AS - The source and the destination pair is {Satellite, Satellite}
Scenario 7	- Satellite device operates with IR - The source and the destination pair is {Satellite, Terrestrial} - The source and the destination are in the same area
Scenario 8	- Satellite device operates without IR - The source and the destination pair is {Satellite, Terrestrial} - The source and the destination are in the same area

solid line and dotted line are the routing paths in the Scenario 1 and the Scenario 2, respectively. In Fig. 3 (b), the solid line and the dotted line are the routing path in the Scenario 3 and the Scenario 4. In the Scenario 1 and the Scenario 3, the data packet must pass the ASBRs to reach a destination device. On the other hand, the data packet can be directly transferred to the destination in the Scenario 2 and the Scenario 4 because the BGP router performs function of ASBR to all ASs in the network. Thus, the routing paths in the Scenario 2 and the Scenario 4 are short compared with that of the Scenario 1 and the Scenario 3. Therefore, the end-to-end delay and the usage of resource of satellite link are reduced. In the Scenario 2 and the Scenario 4, this happens more and more as increase the number of ASs between AS X and AS Y because the data packet must pass the ASBRs of the every ASs on the routing path.

Table 3 shows the results of analysis of routing scenarios. The routing path can be changed according to the classification of AS. We classify the AS with two types. In the Scenario 5, we consider



(a) (Satellite, Satellite) case



(b) (Satellite, Terrestrial) case

Figure 3. Scenarios for NCC configuration

the location based AS. In this case, the satellite devices belong to an AS with terrestrial devices within same area. In the Scenario 6, we consider satellite device type based AS. In this Scenario, an AS is composed of only the satellite devices without the terrestrial devices even though they are in the same area. In the Scenario 5, the routing path between satellite devices is long compared with the routing path in the Scenario 6 because the data packet of a satellite device must pass through the ASBRs to be transmitted to another AS. Thus, the data packet may pass through the several ASBRs to reach destination. However, in the Scenario 6, the satellite devices belong to same AS. Thus, a satellite device can

Table 3. Advantage/disadvantage of routing scenarios

	Advantage	Disadvantage
NCC without BGP router	- Decrease a role of NCC	- Long routing path between a source and destination device which exist in different AS
NCC with BGP router	- Short routing path between a source and destination device which exist in different AS	- Increase a role of NCC
Location based AS	- Easy to location management of satellite device	- Long routing path between satellites devices which exist in different AS
Device type based AS	- Short routing path between satellite devices which exist in different area	- Long routing path between satellite and terrestrial device which exist in same AS
Satellite device without IR	- Low operational expenditure	- Long routing path between satellite and terrestrial device which exist in same area
Satellite device with IR	- Short routing path between satellite and terrestrial device which exist in same AS - Satellite device can function as relay node	- Need a modification of IP protocol of satellite devices to perform relaying

send a data packet to a satellite device directly.

The routing path can be reduced according to the configuration of the satellite device. In the Scenario 7 and the Scenario 8, we consider a configuration of satellite device. In the Scenario 7, the satellite device can operate with IR and the source and the destination pair is {Satellite, Terrestrial}. Then, the routing path can be reduced because a data packet of a satellite device passes through the IR to reach terrestrial device. However, in Scenario 8, a data packet can be transferred through satellite link. Thus, the routing path in the Scenario 7 is short compared with that of the Scenario 8. Also, the satellite devices can operate as relay node in the Scenario 7. A terrestrial device can send a data to a terrestrial device in another AS by using a satellite device as a next hop router. This may reduce the length of the path between terrestrial devices. However, the IP protocol of satellite device should be modified for using the satellite device as a relay node.

From the evaluation results, the network architectures such as NCC with BGP router, satellite device type based AS, and satellite device with IR can reduce the routing path. But, the additional costs occur for investment of the network equipment and maintenance of the network.

3. Conclusions

In this paper, we introduced the six criteria to design network architecture and routing scenarios for the terrestrial network interworking with satellite network. We assessed the trade-off between the routing scenarios. From the results, we found that the routing paths can be reduced in the several network architectures. In the future, we will design a simulator and evaluate the routing performance on each scenario. Also, we will study on the multi cost metric of OSPF.

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