다중 위치인지 네트워크 제공을 위한 네트워크 경로 설정

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Network Path Selection for Provisioning Multiple Location-aware Networks

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요 약

Nowadays, personalization of a network service for each customer becomes a hot issue along with 5G network. It leads network service providers should support variety of flexible and effective services by provisioning their network resources efficiently and effectively. Location-aware network provisioning is one of solutions to support particular needs of customers by generating a subnetwork based on requested locations of users dynamically. In here, establishing a subnetwork requires efficient and reliable connections between devices within the requested locations in order to provide more flexible and effective subnetwork.

In this paper, we proposed a method of calculating more appropriate paths for establishing a location-aware subnetwork by considering the user request of quality of services (QoS) and the user population and the traffic loads of the requested location. Basically, a default subnetwork is generated by calculating shortest paths between every device. Then, by considering the traffic load of each link of a network, the paths are adjusted in order to meet the QoS requirement. Through a simple analysis, the viability of the proposed method is validated.

Ⅰ. Introduction

In modern society, with development of network infrastructure and network technologies as well, the trend of providing flexible network services based on user request is becoming more and more popular. Location-aware network provisioning allows generating dynamically a subnetwork based on requested locations of users to provide services that match particular their needs [1]; moreover, users can also input some service and/or network parameters into their request [2]. However, when many users select one same set of locations, in which they would use network services with same network resources, the network providers have to leverage current network infrastructure by making different paths among same physical devices instead of add new devices into network. This helps them ensure available QoS and save the operating expenses.

In recent years, there have several studies on path finding in location-aware network. For instance, a method of best path finding using Location aware AODV (Ad-hoc On-demand Distance Vector) for MANET (Mobile Ad-hoc NETwork) was proposed in [3]. The authors modified an existed protocol named AODV based on location to find the best path among multi-path routing protocol for MANET using various parameters like node-id, timestamp, GPS, bandwidth, RTT, packet loss ratio, etc. Anagha Raich et.al, proposed a solution which aims selecting the best path based on existing network performance, mobile user location and speed in wireless network environments [4]. However, these studies did not take the user request information such as selected locations into their consideration; they derived all parameters directly from the network rather than from the user. For example, when a user is sitting at his house and send request via a web interface to make a network which connects his office branches. We should determine the requested locations in which he would use to make the network are locations of his office branches, instead of his house's location. In this paper, we propose a method to calculate dynamically network switch paths for location-aware network provisioning. To illustrate our approach, we implement a web interface that allows users to select and send their requested locations along with other QoS requirements. Then, these requirements are packed and transferred to an application for processing. This application finds a set of devices mapped to user requested locations then it calculates the network switch paths in order to make a subnetwork matching the corresponding user request.

Ⅱ. Methodology

In this section, we proposed a method for calculating the network switch paths based on requested locations of the user. In this work, we utilize our proposed system architecture in [1]. Then, we propose two main novel functionalities. First, many users can send their requirements at the same time through our web interface. Second, we add a module so-called *Network Path Calculator* for calculating appropriate switch paths for each user request from a list of same physical devices. Our proposed method is presented more detail in three parts as follows.

1. *Finding list of devices covering all user requested locations*

In order to make a subnetwork based on requested locations of user, we use an algorithm for finding all devices in network which cover requested locations. For each location, the algorithm checks whether it belongs to any cover region of a device. Finally, the algorithm returns a list of devices which could be used to make a subnetwork for the user.

2. *Finding default active path using shortest paths*

As shown in Fig. 1, user can select locations through a map interface like as the above layer, and below layer illustrates

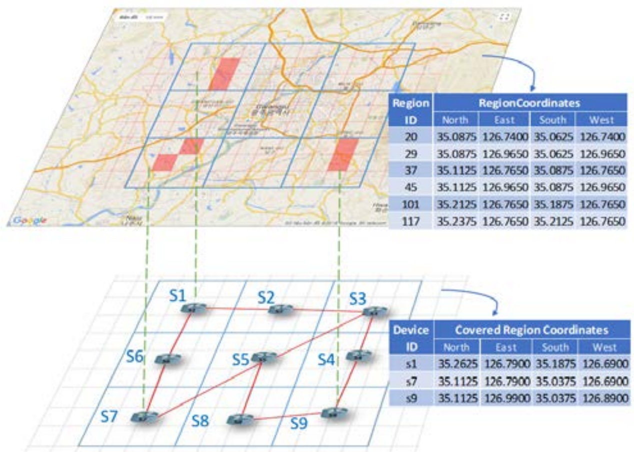

Fig. 1. Modeling for network switch path calculation in location-aware network

network devices connections with nine physical devices. Two tables contain necessary coordinates from user requested location as well as covered regions of selected devices. We assume that all physical links that connect devices together are same quality. There are many paths to link all devices in selected list and make a subnetwork covers requested locations of user. The *Network Path Calculator* should find effective paths to make a subnetwork which uses the shortest paths between each pair of intermediate devices, in other words, it is the active path in the subnetwork. We use *Dijkstra* algorithm to find all shortest paths of each pair of devices. Next, we combine all shortest paths to make an active path which is used by default.

3. Calculating alternative paths

In above part, we have an efficient way to connect all selected devices together. However, there are several situations in reality that cause the active path may not operate effectively such as one or more links in this subnetwork are overloaded or occur unexpected problems. For example, when so many users request a set of same devices with different required bandwidth, their data may be transferred in the same subnetwork at the same time. This makes links in subnetwork become overloading. As shown in Fig. 2, the blue number indicates number of users are currently sharing the corresponding devices in their subnetwork; the color link indicates traffic state in each link between two devices; and the two numbers in format (450/500) illustrate current used traffic (450) by users and maximum traffic in the link (500). Suppose we receive a new user request that uses three devices: s1, s7, s9 with required bandwidth is 100. Number of users sharing these devices are sequentially 15, 5 and 10. If we apply a shortest path from s1 to s9 for this request, it causes the link between s1 and s2 overloading. This also affects to other users who are sharing that link in their subnetwork. Then, from s1 to s9, the next intermediate device should be selected is s6 rather than s2, because the link (s1, s6) has lower traffic than link (s1, s2). To avoid this unexpected situation, the *Network Path Calculator* calculates alternative paths between each pair of devices instead of their shortest paths based on QoS given by user.

The used traffic of a link is defined as follows:

$$T_{used} = \sum_i^k B_i^{required}$$

where T_{used} denotes traffic was used by other users in a link, $B_i^{required}$ denotes required bandwidth of user ith in total k users are sharing that link.

The remained traffic of a link is defined as follows:

$$T_{rm} = T_{max} - T_{used}$$

where T_{max} denotes maximum traffic in link.

The mechanism to calculate an alternative path goes through following steps:

(1): Check the current traffic load in network.
(2): Choose any pair of device needs to find path
(3): From source device, we select an adjacent device which their link has remained traffic greater than required bandwidth of user and add it to expected path or $B^{required} < T_{rm}$.
(4): Continue selecting next adjacent link like step 3
(5): Repeat step 4 until reaching destination device, otherwise return no path is found
(6): Perform similarly with next other pair of devices

Finally, we calculate a set of alternative paths, and after combining these paths we make a better subnetwork for the user in comparison with shortest paths.

Ⅲ. Analysis

In this section, we present an example for calculating the shortest path among network switches and discuss on this study. We deploy our proposed system sequentially: launching the web server for users, launching the application that contains *Network Path Calculator* for request processing. We assume that users send their request with six locations (marked red) via our web

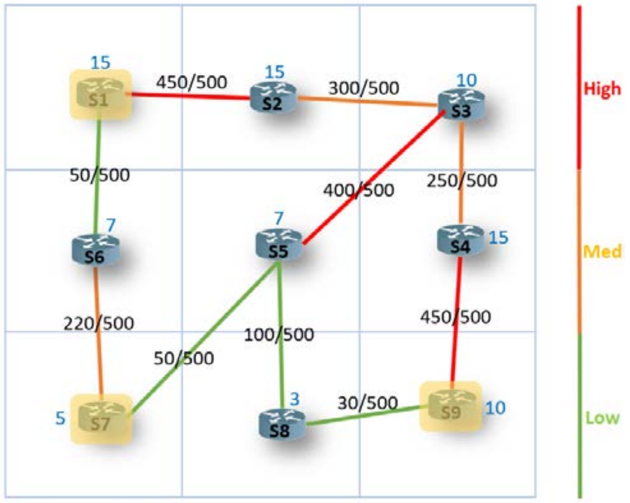

Fig. 2. Traffic load map

interface, then our proposed system selects three devices mapped user requested locations as shown in Fig. 1. Two tables show needed information for calculation, the first one contains coordinates of requested locations and the second one contains a list of selected devices based on data from the first table. In this example, three selected devices are s1, s7 and s9. To connect three devices (s1, s7, s9) together, in case of all links are same quality, it exists several routes (e.g., s1-s2-s3-s4-s9-s8-s5-s7, s1-s6-s7-s5-s8-s9, etc.). Applying our method in section II, we obtain active paths including shortest paths: {s1, s2, s3, s4, s9}, {s1, s6, s7}, {s7, s5, s8, s9}. In addition, if given bandwidth of user is 100, the active path between s1 and s9 is overhead, so we establish an alternative path is {s1, s6, s7, s5, s8, s9}.

IV. Conclusion

In this paper, we propose a method for calculation of network switch paths for location-aware network provisioning, especially in multi-routes network. Our proposed system contains a module named *Network Path Calculator*, which finds appropriate paths based on existed network resources to meet requested locations of the user. We are to implement a location-aware dynamic network provisioning has flexibility and adaptability to variety of user request but utilize effectively available network resources of a provider based on locations and QoS are given by the user.

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