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Efficient algorithm for traffic engineering in Cloud-of-Things and edge computing☆

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ABSTRACT

We propose a scheme for Cloud-of-Things and Edge Computing (CoTEC) traffic management in multi-domain networks. To direct the traffic flow through the service nodes, we assign a critical egress point for each traffic flow in the CoTEC network using multiple egress routers to optimize the traffic flow; this is known as Egress-Topology (ET). Therefore, the proposed ET incorporates traditional multi-topology routing in the CoTEC network to address the inconsistencies between service overlay routing and the border gateway protocol policies. Furthermore, the proposed ET introduces a number of programmable nodes that can be configured to ease the ongoing traffic on the network and re-align services among the other nodes in multi-domain networks. The results show that our algorithm has a lower execution time and better quality of service than that obtained without using our algorithm, thus allowing us to satisfy the flexibility and efficiency demands of multi-domain networks.

1. Introduction

The complexity of the Internet continues to show a growing trend over the last few years, particularly with the development of Cloud-of-Things and Edge Computing (CoTEC), which are aimed at improving traffic and processing millions and billions of data in the network [1]. By combining these technologies, CoTEC gains the following advantages. First, more sources, dimensions and availability of data can be collected and then processed by more resources, services and service providers. Second, boundaries between different service providers, application programming interfaces (APIs), and standards can be thinner and less restricted since real interoperability and integration of shared resources, outputs and analyses can be offered [2,3]. However, the demands to process and analyze millions and billions of data and the ability to manage traffic in the billions have become increasingly important. Therefore, we need to address the interoperability, performance, and security as well as the traffic monitoring and re-distributing of CoTEC. CoTEC Internet technology is not only a medium for communication between machines and people but also provides an infrastructure for developing a range of applications and

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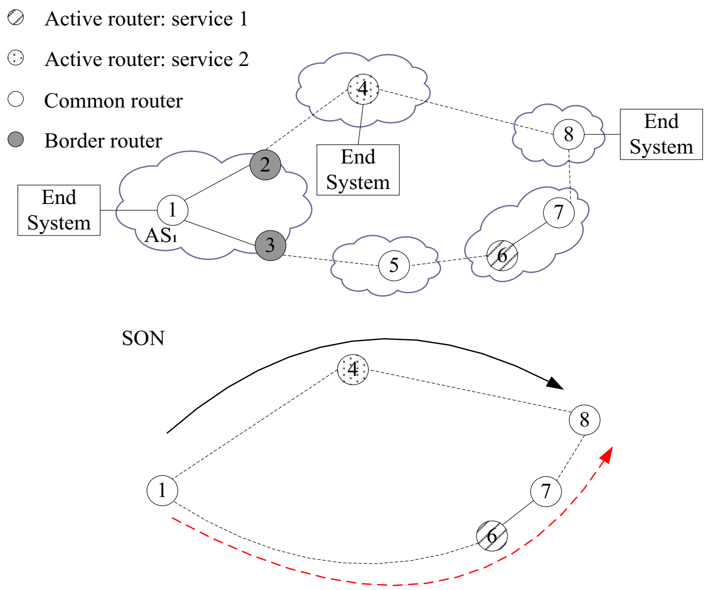

Fig. 1. Examples of SONs for CoTEC in multi-domain networks.

services that can run on globally distributed Internet technologies that combine Cloud, IoT and Edge Computing. Service overlay networks (SONs) for CoTEC have been proposed as a solution to provide desirable service applications, which are essential for future network services [4].

As an application-layer network, an SON for CoTEC is constructed based on traditional IP-layer networks. Currently, SONs are linked with a huge number of autonomous systems (ASs), which are operated by various Internet service providers, financial institutions and academic institutions. In this case, cooperation among numerous service providers may occur for the purpose of providing CoTEC services on a shared, global infrastructure. In addition, the components of the management infrastructure in the CoTEC network service of a local network can be renewable resources for providing various services for other uses. Therefore, globally distributed network technology also allows us to share resources and services to reduce the management costs of maintaining a large-scale distributed network system [5].

Recently, under the background of SONs for CoTEC, many researchers have focused on active networks [6-7] consisting of router nodes that can be programmed. Deploying separated or interacting services and directing traffic flow through the routers mentioned above can meet the requirements of particular services. Fig. 1 illustrates a simple example. Deployed on individual nodes (i.e., active/programmable routers), two kinds of services, named s1 and s2, are assumed here. The filled solid circles on a node represent the active programmable routers, while the empty circles indicate the common routers where there are no special services. In Fig. 1, we consider that traffic flow D(1, 8) owns service demand set {s1} and traffic requirement D(1, 4) owns {s2}. In the example, two routes are available for traffic flow D(1, 8) to meet the service requirements in the SON. With the given position of the service nodes, traffic flow D(1, 8) would choose the route along the dotted line through border router node 3 to meet the service requirements. As illustrated in the example, there exists an influence or relationship between the service node placement strategy and the traffic flow routing in CoTEC. Furthermore, the traffic flow should choose the border router 3 as an egress node of AS 1. However, this may lead to an inconsistency between the service overlay routing and border gateway protocol (BGP) [8] routing policy is used between ASs when multiple border routers exist in the CoTEC network.

In this context, we propose a CoTEC network traffic engineering problem in multi-domain networks in this paper. A kind of deployment scenario for this problem is displayed in Fig. 1. It shows that some CoTEC programmable routers are spread across the multi-domain network. To meet the demands of service, CoTEC traffic flow can go through these routers directly. The CoTEC traffic engineering problem described in this paper involves two sub-problems. The first sub-problem for the CoTEC network service management scheme is to jointly optimize the deployment of CoTEC programmable routers, distribute the network services on the nodes and overlay the routing of the traffic flow. Furthermore, to solve the inconsistency between the overlay CoTEC routing of traffic flow and the BGP policy used in inter-AS, we introduce multi-topology routing (MTR) [9–11] to offer various alternative paths on the top of multiple link weight sets (more details will be provided in Section 2.2). Therefore, to optimize the link weights, MTR for CoTEC becomes the main issue to be solved in this study.

The major research contributions of our paper are as follows. First, a solution is proposed to solve the CoTEC network service engineering problem through the optimal deployment of routers that can be programmed and the placement of the service across these routers with accurate traffic routing. Second, a solution is also proposed to solve the inconsistency between the overlay routing and BGP policy in a realistic CoTEC multi-domain scenario with MTR. Finally, we formulate two

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