Enhanced Content Navigation Using Edge Routers in Content Delivery Network

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Thesis Abstract

The Internet can be defined as a network composed of geographically dispersed servers and clients. In principle, clients request content from servers, and the servers respond to the requests by sending the requested content to the clients. The content should be navigated among networks, and certain rules and methods have been developed to achieve optimized navigation. Navigation is definable as the process of finding a destination and reaching that destination using a preferable route. Hence, the main challenges for achieving content navigation on the Internet can be summarized in the following two directions: 1) to determine and select service points and 2) to route users to selected service points.

The need for optimized content delivery accelerates the development of the Internet by proposing content delivery networks (CDNs). CDNs use content cache servers within Internet Service Provider (ISP) networks and select a service point for a content request of a client by using the Domain Name Service (DNS). ISPs, on the other hand, can route a client to a service point according to a selected network path by using routing protocols, which are optimized based on the link state information. Namely, content providers and ISPs are separated in content navigation. Thus, researchers are proposing that "the effectiveness of content navigation is doubtful in the absence of a reliable collaboration between the ISPs and CDNs." Meanwhile, network device manufacturers have been upgrading servers, routers, and links to provide innovative services to enhance content navigation.

To this end, dissertation proposes an approach to enhance content navigation in CDNs by using edge routers of ISPs. Edge routers can be utilized to create a collaboration between ISPs and CDNs by collecting and using both the network state information of the ISPs and the content server state information of the content providers simultaneously to leverage content navigation in a CDN. Dissertation proposes a solution for the collaboration by using a Service-oriented Router (SoR) as an edge router. The SoR is a novel router architecture for providing content-based services by shifting the current Internet infrastructure to an information-based open innovation platform. SoR uses the Server Link Router-state Routing (SLRouting) protocol to collect both network and server state information. The SLRouting protocol hypothesis is a new paradigm of network path selection using network device states to calculate the network path selection metric. SoR utilizes the collected information for selecting a service point that is appropriate to a user request and routes the request to the selected service point by leveraging the DNS-based user redirection and by performing content-aware packet redirection.

Consequently, the structure of the dissertation is divided into three main sections: 1) design and development of a software SoR, 2) design and implementation of the SLRouting protocol, and 3) the use of both SoR and the SLRouting protocol to enhance content navigation by creating a collaboration between ISPs and CDNs. In addition to the evaluation of the software SoR and SLRouting protocol as individual units, dissertation implemented an emulator-based environment using Planet Lab and a simulator-based evaluation environment using ns-3 for evaluating the proposed CDN architecture supposing a wide area network. In conclusion, the proposed architecture yields better performance in terms of request redirection and effective network resource utilization, and serves as a guideline for future content service models by addressing adequate ISP-CDN collaboration through enhanced content navigation.