

**Joint Resource Allocation for Software-Defined Networking, Caching, and Computing**

**Abstract:**

Although some excellent works have been done on networking, caching, and computing, these three important areas have traditionally been addressed separately in the literature. In this paper, we describe the recent advances in jointing networking, caching, and computing and present a novel integrated framework: software-defined networking, caching, and computing (SD-NCC). SD-NCC enables dynamic orchestration of networking, caching, and computing resources to efficiently meet the requirements of different applications and improve the endto- end system performance. Energy consumption is considered as an important factor when performing resource placement in this paper. Specifically, we study the joint caching, computing, and bandwidth resource allocation for SD-NCC and formulate it as an optimization problem. In addition, to reduce computational complexity and signaling overhead, we propose a distributed algorithm to solve the formulated problem, based on recent advances in alternating direction method of multipliers (ADMM), in which different network nodes only need to solve their own problems without exchange of caching/computing decisions with fast convergence rate. Simulation results show the effectiveness of our proposed framework and ADMM-based algorithm with different system parameters.

**Existing System:**

Although some excellent works have existed on networking, caching and computing, most of these three important areas have traditionally been addressed separately. Jointly considering these three underlying resources will significantly improve both the applications and system performances. Recently, these three areas have been considered together in some research projects to provide better services in future networks. Some proposals have addressed networking and caching areas by combining SDN with ICN technologies. On one hand, SDN brings low maintenance and reduces network complexity, on the other hand, in-network caching of ICN brings high efficiency on content

distribution. Most of these combination solutions focus on using SDN technology to facilitate the ICN implementation such as, or using ICN information-centric concept to enhance SDN to become content-awareness such as. However, they do not fully explore the potential of SDN programmable control: the ability to fully orchestrate the global IT infrastructure. The Network Functions Virtualization (NFV) framework proposed by ETSI ISG focuses on providing “Platform as a Service (PaaS)- type” capabilities by visualizing and scheduling compute, caching and networking resources which span across several data centers. This overlay scheme jointly considers these three areas on the top of IP networks. Although this scheme enables good network resources scheduling, it needs a complicated intermediate layer with incremental functionality patches, making existing networks more complicated.

**Proposed System:**

We describe the SD-NCC framework that integrates networking, caching and computing in a systematic way to enable dynamic orchestration of these three dimensional resources to meet the requirements of different applications and improve the system performance. Besides, we also discuss the differences between SD-NCC and other related solutions.

We present a comprehensive system model for the SD-NCC framework. Then we formulate the joint caching, computing and bandwidth resources allocation as an optimization problem to balance the energy consumption and network usage cost. Specifically, we develop the gain function to describe the benefits of SD-NCC framework on combination evaluation of energy consumption and network usage. In order to reduce computational complexity and signaling overhead of the centralized solution, we develop an efficient *alternating direction method of multipliers* (ADMM)-based distributed algorithm in which in-network servers only need to solve their own problems without exchange of caching/computing decisions.

We conduct simulations to evaluate the effectiveness of the proposed scheme with different system parameters. Our proposed SD-NCC framework significantly reduces the traffic traversing the network and has performance advantage on energy consumption reduction.