

COSMOS: Optical Architecture and Prototyping

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ABSTRACT

The Cloud Enhanced Open Software Defined Mobile Wireless Testbed for City-Scale Deployment (COSMOS) platform is a programmable city-scale shared multiuser advanced wireless testbed that is being deployed in New York City [1]. Open APIs and programmability across all the technology components and protocol layers in COSMOS will enable researchers to explore 5G technologies in a real world environment. A key feature of COSMOS is its dark fiber based optical x-haul network that enables both highly flexible, user defined network topologies as well as experimentation directly in the optical physical layer. A paper on the COSMOS optical architecture was previously presented in [2]. In this talk, we briefly introduce COSMOS' optical x-haul network with SDN control, and its integration with the software-defined radio (SDR) and mobile edge cloud.

COSMOS Architecture

High capacity SDR mmWave (28 and/or 60 GHz bands) access points in COSMOS will need substantial baseband computing resources in the RAN. This situation motivates the development of front and mid-haul (or x-haul) C-RAN capabilities for investigating different approaches to offloading a node's workload to an infrastructure-based, more powerful edge computing cluster. The same edge cloud on top of the optical x-haul transport system can also be used for network- and application-layer processing, especially in scenarios requiring low end-to-end latency. The COSMOS architecture provides four technology layers for experimentation: user device layer, radio hardware and front-haul network resources, radio cloud, and general purpose cloud. In particular, an RF thin client can flexibly partition signal processing and NFV between a local SDR (with FPGA assist) and a C-RAN with distributed x-haul processing scalable to massive CPU/GPU and FPGA assist. Further, these two computing layers are backed up by a third layer of general purpose cloud computing useful for network and application level functions associated with an experiment.

Optical Architecture in COSMOS

The COSMOS optical network design makes use of wavelength division multiplexing (WDM) and optical switching to provide two important capabilities: 1) flexible experimentation and network topology reconfiguration of large numbers of radio and computing connections, and 2) multi-layer optical networking for experimentation on novel optical devices, systems, SDN/NFV optical control planes, and optical architectures. Fig. 1 shows a schematic of the planned core network connecting the large radio nodes shown in the bottom inset. The COSMOS testbed includes 4 universities, where Columbia is the targeted deployment area of ~1 sq. mile. The

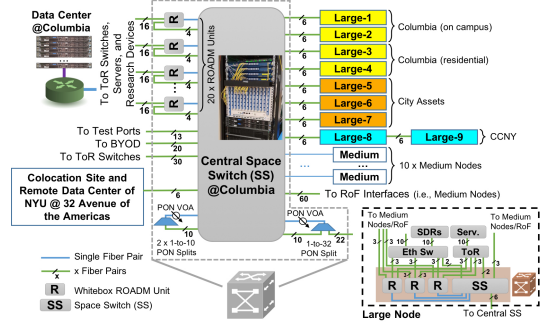


Figure 1: COSMOS' core optical switching architecture and the switching architecture of a large node.

colocation site and an NYU data center are located ~7 miles from the testbed.

A Calient S320 320×320 space switch forms the core of the network in the main computing research facilities (CRF) at Columbia University. Dark fiber pairs will connect this switch with similar smaller space switches at each of the large nodes. These space switches allow for remote and automated re-fibering of connections and devices throughout the testbed. WDM is provided by whitebox reconfigurable optical add drop multiplexing (ROADM) units connected to the space switches. Other devices such as splitters for passive optical networks (PON), test equipment, and other experimental hardware will also be attached to the central space switch. Using these capabilities, each of the six fiber pairs between any two large nodes can be configured for combinations of point to point, PON, and ROADM/WDM networks.

The fully equipped testbed will include 20 programmable ROADM units connected to the space switch via 20×4 wavelength filtered add/drop fiber pairs and another 20×16 add/drop pairs for connecting to computing resources or research devices. The 20 line side fiber pairs connect to the space switch for WDM transport over the dark fiber pairs to other nodes. These ROADMs can be reconfigured to support various requirements from connected servers and research devices through top-layer user applications orchestrated by a COSMOS SDN controller.

The SDN framework will allow experiments to implement application driven control of optical and data networking functionalities, and radio resources. Further, the SDN framework will support visualization and will allow for logical separation of the same radio or network resource into multiple distinct networks with their own topology and routing protocol. The open network operating system (ONOS) platform and Ryu OpenFlow controllers will be used as a standard platforms for SDN and NFV experimentation.

REFERENCES

- [1] COSMOS. 2019. COSMOS. <https://cosmos-lab.org/>.
- [2] Jiakai Yu, Tingjun Chen, Craig Gutterman, Shengxiang Zhu, Gil Zussman, Ivan Seskar, and Dan Kilper. 2019. COSMOS: Optical architecture and prototyping. In *Proc. OSA OFC'19*.