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Demonstration of SDN Application for Multilayer Video Contribution Network Service

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Abstract: This paper describes a demonstration of an end-to-end, SDN-controlled Video Contribution Network providing dynamic service set-up, using optical switching to enable flexible provisioning of resources. We show seamless operation of legacy and future technologies.

OCIS codes: (060.4252) Networks, broadcast; (060.4510) Optical communications

1. Introduction

Media consumption increases exponentially adding pressure to broadcast network operators for fast and reliable connectivity. There is growing demand for increased capacity and reduced service setup times, leading video contribution networks to require seamless, resilient, uncompressed and real-time transmission of multi-format content between the stakeholders. At the same time broadcast network operators depend on expensive dedicated specialist hardware that rapidly becomes obsolete, while there is always the danger of vendor lock in due to lack of equipment interoperability between different vendors [1]. Gradually, broadcasters are transitioning from specialist synchronous interfaces to IP based video production [2], reducing the costs significantly by integrating commodity-based Ethernet switches and virtualized functions to their production processes.

In the broadcast network, each broadcaster's contribution flows use their own formats, underpinned with the use of Serial Digital Interface (SDI). Media is encapsulated and transported across the network in well-defined standards and protocols (e.g. the SMPTE 2022 family of protocols), while traffic is routed through MPLS [1]. However, in a programme production environment, multicast traffic increases the bandwidth requirements and stretches the network's capabilities for seamless content transmission [2]. Uncompressed video at the best quality possible is required for content storage that will be accessible in the future [1,2] and research has visited uncompressed video transmission issues [3]. Furthermore, recent research has showcased the transmission of uncompressed 8K Ultra-High Definition [4] attesting to the fact that higher capacity demands are not of immediate concern. The use of Optical Switches, has been suggested as a possible solution [1,2] due to their bandwidth agnostic capabilities.

The current networks consist of switches and routers that operate under traditional control planes and data plane technologies, ensuring limited efficiency due to the use of complex protocols and procedures. The use of SDN (Software Defined Networking) and NFV (Networks Functions Virtualization) in the broadcasting chain has been proposed [1,2], either for automated deployment of compute and storage, or for more efficient and centralised network control. Moreover, there has been work on SDN for optical networks [5] and multilayer networks [6].

Recent work [7], has studied cloud architectures for live TV distribution, suggesting that a distributed architecture scales best and with lower CAPEX. Such architectures sit at the ends of a contribution network or is an expansion point to bring the uncompressed streams closer to a production point. However, every cloud node requires Video Encoders/Decoders as a physical resource in order to enable programme production. The placement of such devices imposes limitations due to interoperability issues, or licensing of their features, making a service available only to certain locations under certain conditions (i.e. certain nodes offering 4K encapsulation for only one vendor).

In this paper, we demonstrate a broadcaster network's IP linear contribution service, that supports uncompressed 4K contributions and has the network capacity to evolve beyond 100Gb/s and 8K. At the same time, it casts aside the need for content encoding and format decisions to be made prior to the service request. This is achieved by providing the combinations of available source node and the corresponding end nodes with their equipment, upon source node to video feed connectivity request. Thus, the user has the option to choose among the equipment/format that is available at the end node of his choice, or in the case of a cloud based video editing service, let the system decide among the possible end-to-end pairs. This demonstration tackles issues regarding the danger of vendor lock in, by showcasing a multivendor, multilayer network and a multivendor video encoding/decoding service. Moreover, it showcases fast automated service provisioning, while using at the same time low complexity equipment that is already available and in use by network operators.

2. Architecture of the application

The results of [8], suggest the introduction of baseband video into the network through use of optical switching. However, such an approach does not comply with current multilayer networks and IP production adopted by broadcasters. In our work, we introduce an optical cross connection switch (OXC) as the baseband video carrier to the source contribution node, where video encapsulation for packet network traversal is happening. The contribution service is orchestrated by an application called Equipment and Path Computation (EaPC), that collects the user's service request, gathers information from a database about the network topology and available encoding/decoding equipment at the different contribution nodes, and communicates the network service request to the network's SDN controller. The EaPC application comprises of three modules, the Matching module, the Parser and the API module.

The Matching module is the core of the EaPC application. It is responsible for collecting equipment availability details from the database, calculating the possible equipment matches across different sites, and computing the end-to-end path for the selected equipment/contribution node pair. The Parser module, receives the end-to-end path configuration from the Matching module and parses it in a form that can be understood by the SDN controller. Finally, the API module collects the parsed configuration from the Parser module and passes it to the controller's Northbound interface through the appropriate API.

Initially the user informs the application about the node of the video source and the port on the source Optical Switch that will be used. Afterwards, the Matching module consults the database and establishes the SDI Media Encoder availability on the video source node. If there is equipment available for use, it returns to the user a list of the available pairs of encoder and decoder between the different network nodes and the source node. If there is no availability the service informs the user about the lack of available encoding/decoding resource pairs and denies the service. Afterwards, the user selects the pair of his choice. The encoder/decoder pair is translated into a source/end node pair and the application proceeds in calculating the network path based on topology information provided in the database. If no path can be found that satisfies the service's capacity requirements, the user is notified that no path could be established and the service is denied. Otherwise, the nodes and the ports that will be used in the service path are sent to the Parser module, which translates the configuration compatible with an SDN controller's northbound interface.

In the final step, the Parser module forwards the configuration to the API module, which in turn uses northbound interface API calls to communicate the configuration to the SDN controller. When the latter has configured the network the EaPC application returns a successful service installation message, or a failure message with the corresponding reason.

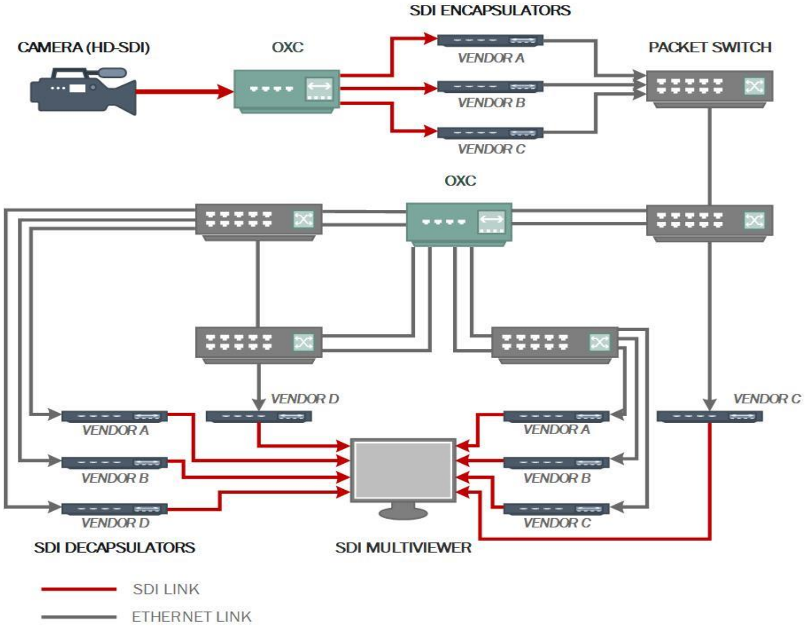


Fig. 1: The experimental contribution network

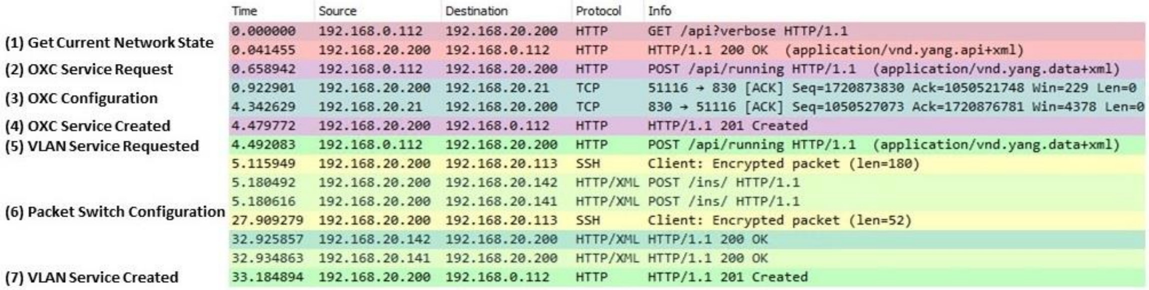
3. Experimental demonstration

The network (Fig. 1) is implemented with a combination of 5 x Packet Switches (3 x Cisco and 2 x Juniper) and 2 x OXC. The camera provides an uncompressed HD-SDI baseband feed that is connected to a port of the user's choice on the first OXC. Each contribution node has a collection of encoders and decoders from different vendors. By trying different combinations of vendor encoders and decoders, we ascertained that some encoder/decoder pairs of different vendors are interoperable (using SMPTE 2022-6). This increased the amount of possible encoder/decoder pairings, which were added to the database.

The SDN controller used in the demonstration is Cisco's NSO 4.4.3. NSO offers a Northbound API that is implemented in REST. The controller is using NETCONF to push configuration to the switches. It can detect the underlying Packet Switches, but has no visibility of the OXC as part of the network, thus although it can push configuration to it, topology information extraction is not possible. This led to the need to store the topology information in a database separate to the SDN controller. When a service is setup, it is placed in a VLAN and the appropriate ports in the path switches are configured to accept its traffic. A list of used VLANs is provided to the application from the NSO's REST API. At the same time, a different configuration set is pushed to the OXCs to setup the required cross-connections. The reason for the different configuration sets lies in the service implementation required to support

The VLAN and OXC services are modelled using YANG along with XML templates that are used to specify the required device configurations needed to implement the service. Once the controller receives a new service request in the form of an XML instance document, it is processed along with the current network configuration by the controller logic to determine the configuration changes that needs to be issued to the network devices.

The user provides the EaPC application with the connection port and the service type (i.e. 3G-SDI) to the first OXC. The application, searches the database for available equipment at the source node and the possible end-to-end encoder/decoder pairs. Afterwards, the user is prompted to select an available pair and the application continues with the service setup. The proposed EaPC application has been developed with Python. The library used for the path computation is NetworkX In Fig.2, a truncated wireshark capture, shows the communication between EaPC, the NSO controller and the network devices



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Time       Source          Destination     Protocol Info
0.000000   192.168.0.112   192.168.20.200  HTTP     GET /api?verbose HTTP/1.1
0.041455   192.168.20.200  192.168.0.112   HTTP     HTTP/1.1 200 OK  (application/vnd.yang.api+xml)
0.658942   192.168.0.112   192.168.20.200  HTTP     POST /api/running HTTP/1.1  (application/vnd.yang.data+xml)
0.922901   192.168.20.200  192.168.20.21   TCP      51116 → 830 [ACK] Seq=1720873830 Ack=1050521748 Win=229 Len=0
4.342629   192.168.20.21   192.168.20.200  TCP      830 → 51116 [ACK] Seq=1050527073 Ack=1720876781 Win=4378 Len=0
4.479772   192.168.20.200  192.168.0.112   HTTP     HTTP/1.1 201 Created
4.492083   192.168.0.112   192.168.20.200  HTTP     POST /api/running HTTP/1.1  (application/vnd.yang.data+xml)
5.115949   192.168.20.200  192.168.20.113  SSH      Client: Encrypted packet (len=180)
5.180492   192.168.20.200  192.168.20.142  HTTP/XML POST /ins/ HTTP/1.1
5.180616   192.168.20.200  192.168.20.141  HTTP/XML POST /ins/ HTTP/1.1
27.909279  192.168.20.200  192.168.20.113  SSH      Client: Encrypted packet (len=52)
32.925857  192.168.20.142  192.168.20.200  HTTP/XML HTTP/1.1 200 OK
32.934863  192.168.20.141  192.168.20.200  HTTP/XML HTTP/1.1 200 OK
33.184894  192.168.20.200  192.168.0.112   HTTP     HTTP/1.1 201 Created
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Fig. 2: Service provisioning capture.

4. Conclusion

We demonstrate a full end-to-end Video Contribution Network enabling dynamic service provisioning from the camera, the specialised video format conversion boxes, through to an Ethernet over optical network. The architecture is fully SDN-controlled, enabling dynamic circuit provisioning for high bandwidth, uncompressed video paths from the cameras themselves, across an Ethernet and optical core network, to potential remote production studios, as required by the Media and Broadcast industry. We show a novel application for SDN-controlled optical fibre switches, which enable multiple resources and technologies (legacy, current and potential future solutions) to be provisioned dynamically according to availability and other service requirements. This solution combines SDN and optical switching with the wide range of industry standard video technology to produce a solution that is urgently required by video network operators.

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