5G VIRTUOSA

D2.1 – VIRTUOSA LAN pilot system

Version 1.0 Final

November 13, 2020

Public

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Lead Responsible	Thomas Heinzer & Gareth Edwards
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Status	Version 1.0 Final

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0.1	7 Sept. 2020	Initial draft
0.2	15 Oct.2020	Reviewed and updated.
0.3	7 Nov. 2020	Updated with new video.
1.0	13 Nov. 2020	Submitted.

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1. Executive summary

This document of the 5G-VIRTUOSA project gives a brief introduction to the build and setup of the VIRTUOSA LAN pilot system, up and running with solution architecture and final design as part of the deliverable **D2.1 – VIRTUOSA LAN pilot system.**

This **Local Area Network (LAN) pilot system** is made for LIVE Media Production at a **broadcast facility** using an IP based Local Area Network to connect studio, control room and studio equipment like cameras, speaker, video server, video panel, audio router and intercom panel.

The Local Area Network (LAN) pilot system is a **complete VIRTUOSA product solution tailor-made** for the use in **IRT's broadcasting facility** and **IRT's Live IP Studio in Munich (Germany).**

This involves setting up an IP-based studio, built on industry standards (SMPTE ST 2110 and NMOS) and integrating equipment from multiple vendors, including: video cameras, a vision mixer, and a server from **SONY**; a multiviewer from **TAG Video Systems**; an audio mixer from **StageTec**; a media analyzer from **Telestream**; a PTP-compliant time and frequency synchronization from **Meinberg**; IP switches from **Mellanox**; software-defined media nodes from **Nevion**; and all of it managed by an orchestration and SDN control system from **Nevion**.

Due to the COVID-19 pandemic, we have done the initial setup and testing at Nevion in Gdansk, Poland and have shipped the LAN pilot system as entirety to IRT's broadcasting facility for final setup, verification and validation in a real operational broadcasting environment.

The VIRTUOSA LAN pilot system has successfully passed both, the system verification and the validation for live IP-based media production.

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2. Introduction

2.1. About this document

2.1.1. Purpose of this document

The purpose of this document is to present the deliverable **D2.1 – VIRTUOSA LAN pilot system** of the 5G-VIRTUOSA project. This document describes the build and setup of the VIRTUOSA LAN pilot system, up and running with solution architecture and final design.

2.1.2. Document structure

The main part of this document covers:

- **The VIRTUOSA product/solution (section 3):** an overview of the VIRTUOSA products developed by Nevion and Mellanox and the planned **three pilot systems** for real-life LIVE Media Production combining broadcast facilities and remote studios connected by IP networks (both LAN and WAN), combined with remote live contributions from cameras connected via a 5G network.
- **VIRTUOSA LAN pilot system (section 4):** build and setup of the LAN pilot system for LIVE Media Production at a **broadcast facility** using an IP based Local Area Network to connect studio, control room and studio equipment like cameras, speaker, video server, video panel, audio router and intercom panel. Details to:
    - Requirements
    - System specifications and Equipment used
    - Tailor-made network architecture
    - Initial setup and testing of the LAN pilot system at Nevion in Gdansk, Poland
    - Final setup of the LAN pilot system at IRT's broadcasting facility in Germany
    - The success story videos

2.1.3. Audience

This document is public.

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3. The VIRTUOSA product/solution

The overall objective of the 5G-VIRTUOSA project is to create a market ready product - the VIRTUOSA product (or solution) - fully tested technically, validated in a real operational environment.

The product itself is based on three core technical elements (see **Figure 1**):

1) **Architecture:** a tailor-made architecture solution for SDN-based LAN & WAN and 5G acquisition
2) **Equipment:** high performance SDN-based media servers and media routers (Ethernet/IP switches)
3) **Software:** media network management and self-service orchestration.

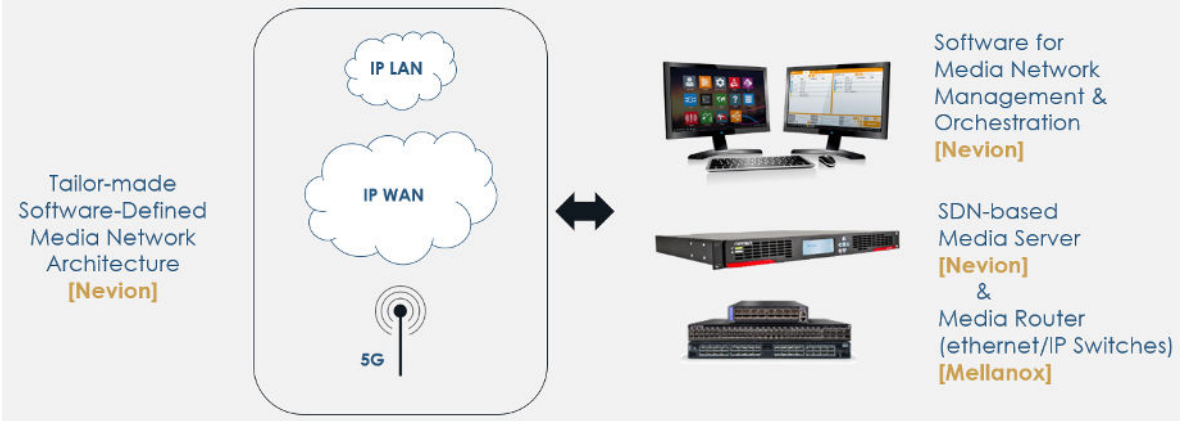

Figure 1: Products developed by Nevion and Mellanox.

The 5G-VIRTUOSA project builds a real-life live production set-up combining broadcast facilities and remote studios connected by IP networks (both LAN and WAN), combined with remote live contributions from cameras connected via a 5G network as illustrated in **Figure 2**.

The solution involves products developed by Nevion and Mellanox as well as 3rd party equipment from various companies (Sony, StageTec, Meinberg, Dell, TAG Video Systems, HD2line, Genelec), sourced by IRT and LOGIC.

The solution will be implemented in three individual phases:

Phase I is a **Local Area Network (LAN) pilot system** for LIVE Media Production at a broadcast facility using an IP based Local Area Network to connect studio, control room and studio equipment like cameras, speaker, video server, video panel, audio router and intercom panel.

Phase II is a **Wide Area Network (WAN) pilot system** for LIVE Remote Media Production using IP based LAN and WAN to connect a broadcast facility with remote locations like a remote studio or a sports event.

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Phase III is a **5G pilot system** for Live Remote Media Production. Including Live 5G wireless content acquisition to connect to a professional camera using 5G wireless networks.

All three pilot systems represent each a complete VIRTUOSA product solution. The three pilot systems itself can be considered as three tailor-made, independent network architecture solutions.

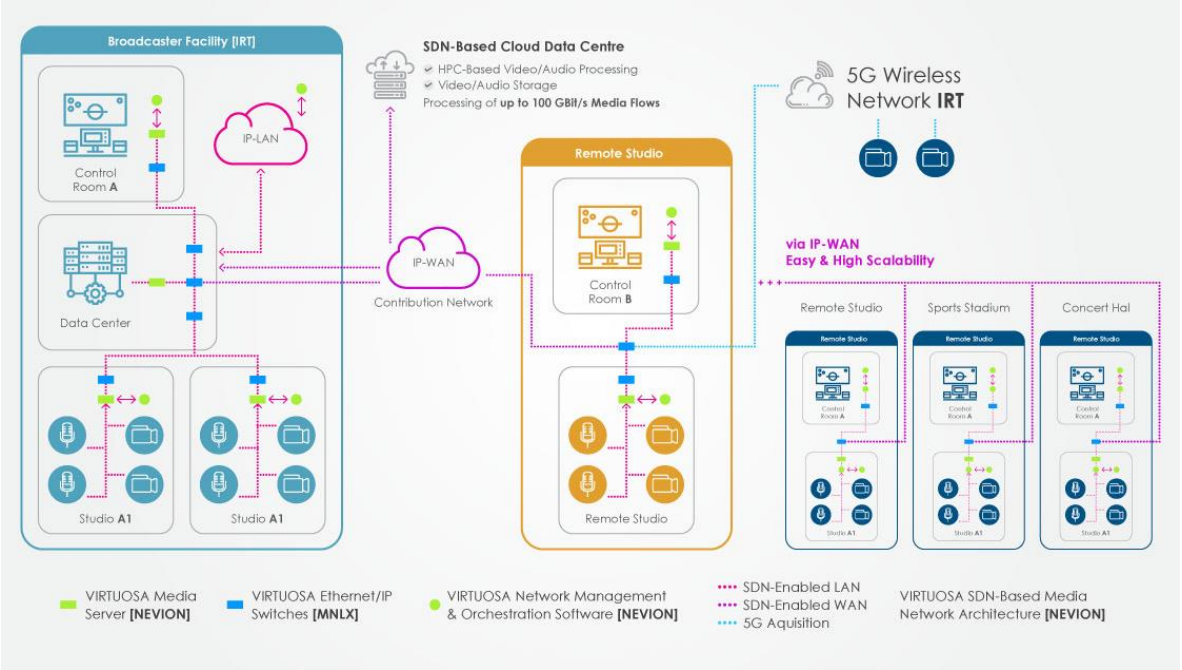

Figure 2: Three complete VIRTUOSA product solutions (LAN, WAN & 5G).

In this document, Phase I of the project - the **Local Area Network (LAN) pilot system** is presented.

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4. VIRTUOSA LAN pilot system

The **Local Area Network (LAN) pilot system** is made for LIVE Media Production at a **broadcast facility** using an IP based Local Area Network to connect studio, control room and studio equipment like cameras, speaker, video server, video panel, audio router and intercom panel.

The Local Area Network (LAN) pilot system is a **complete VIRTUOSA product solution tailor-made** for the use in **IRT's broadcasting facility** and **IRT's Live IP Studio in Munich (Germany).**

This involves setting up an IP-based studio, built on industry standards (SMPTE ST 2110 and NMOS) and integrating equipment from multiple vendors, including: video cameras, a vision mixer, and a server from **SONY**; a multiviewer from **TAG Video Systems**; an audio mixer from **Stagetec**; a media analyzer from **Telestream**; a PTP-compliant time and frequency synchronization from **Meinberg**; IP switches from **Mellanox**; software-defined media nodes from **Nevion**; and all of it managed by an orchestration and SDN control system from **Nevion**.

4.1. Requirements

Demonstration of a fully functioning end to end IP production standards compliant workflow using SDN:

- Solution needs to be secure in the media network
- IP enabled cameras as well as IP handoff of produced content will be used
- IP switching under SDN control
- Full 2110 connectivity using video, audio and ancillary data flows
- Full synchronization of media essences through production infrastructure via PTPv2
- NMOS integration as far as equipment allows
- Dynamic assignment of resources e.g. studio floor, gallery
- Agility - workflow control - using predefined workflows
- Usable & deterministic speed of response of system
- Nominally HD production environment with 50FPS
- Entire system performance needs to be reliable
- Scalability of architecture
- Monitoring of system integrity
- Aim for a total of 8 video flows, including at least 2 cameras
- Capture/recording and replay capability
- Intercom & tally to be included in system
- Redundancy - one 2022-7 service but most connections to be non-redundant

4.2. System specifications & Equipment used

System specifications and equipment used to build the Local Area Network (LAN) pilot system are described in detail in deliverable **D2.1 System specifications for commercial product**.

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Nevion, Mellanox & 3rd party equipment used to build the Local Area Network (LAN) pilot system:

- Switches: Mellanox **[ethernet/IP switches 'SN3700'],** Nevion
- Cables & SFPs: Mellanox, Nevion
- Gateways: Nevion **[media server 'Virtuoso']**
- Control: Nevion **[software 'VideoIPath']**
- Multiviever: Mellanox, Dell, TAG Video Systems
- PTP: Meinberg
- Audio Core: StageTec
- Screens: SONY, HD2line
- Speaker: Genelec
- Cameras & CCUs: SONY
- Vision Mixer: SONY.
- Video Server: SONY.

SONY has provided studio equipment, worth 750,000 EUR, for testing within the Local Area Network (LAN) pilot system.

The network is based on a **distributed Spine-Leaf-Architecture**, with **Mellanox Spectrum-2 spine switches at the core, as well as Mellanox Spectrum-2 leaf switches (trade name: Mellanox SN3700C)**. All leaf-spine connectivity is 100 GigE. The deliverable **D1.4 Final Ethernet/IP switch system prototype (public)** provides a detailed description of the switch specifications, openflow interface, PTP, extended features as well as the clean switching idea and implementation.

Nevion's software driven media nodes (trade name: Virtuoso) has been used to provide adaptation, processing, and monitoring of uncompressed video/SDI and SMPTE ST 2110-20 signals for in-facility adaptation requirements. SDI video signals has been carried on the network as SMPTE ST 2110. The deliverable **D1.5 SDN-based Media Server Prototype (public)** provides a detailed description of all software defined Media Functions and hardware specifications.

Nevion's Orchestration and SDN Control Platform (trade name: VideoIPath) has been used for connection management, including network media flow provisioning as well as monitoring, inventory/maintenance, and discovery & registration for NMOS-IS04 and IS05 supported devices. The deliverable **D1.6 Final Software for Network management and self-Service Orchestration (public)** provides a detailed description of all software modules, functionalities, and user interfaces.

Media transport within the facilities has been essence based on SMPTE ST 2110-20 for uncompressed active video, SMPTE ST 2110-30 for uncompressed audio transport and SMPTE ST 2110-40 to cover the transport of ancillary data and metadata. Aspects of system timing and synchronization are based on SMPTE ST 2110-10 and compliant to PTP/SMPTEST 2059-1/2.

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4.3. Tailor-made Network architecture

The design is based on 3G-SDI (3Gbps) for all video signals.

For the Local Area Network (LAN) pilot system, devices like cameras, mixers, monitors and gateways are connected to the two leaf switches (Mellanox SN3700C) which are connected with **2 x 100 GigE** into each of the two spines (Mellanox SN3700C). This design guarantees high availability due to the redundancy of the paths from leaf to spine and a maximum non-blocking capacity to each leaf of 200 Gbps, if both spine switches are up. This means, that, although the proposed leaf switches are non-blocking and each have 32 x 100 GigE access ports, the total non-blocking bandwidth is limited to the bandwidth between leaf and spine.

If one spine switch fails, then the total capacity is halved, and the capacity to each leaf is reduced to 100 Gbps. There will still be full connectivity between the two leaf switches via the other spine switch.

The 10 GigE connections between the Virtuoso High-Bit-Rate-cards (HBR-cards) and the leaf switches are made with 40 GigE breakout cables, which each provides 4 x 10 GigE. Each Virtuoso HBR-card supports up to 3 x 3G-SDI inputs and 3 x 3G-SDI outputs. This gives a total utilization of 9 Gbps on the 10 GigE connections from each HBR-card.

The connections between the SONY CCUs and the SONY servers on the Leaf switch are realized with 100 GigE breakout cables, which each provides 4 x 25 GigE.

The RJ45 1 GigE connections, needed for the audio devices and the PTP grandmaster (Meinberg M3000), are made with RJ45 copper cables on the end-device side, and QSA QSFP to SFP+ adapters on the switch side.

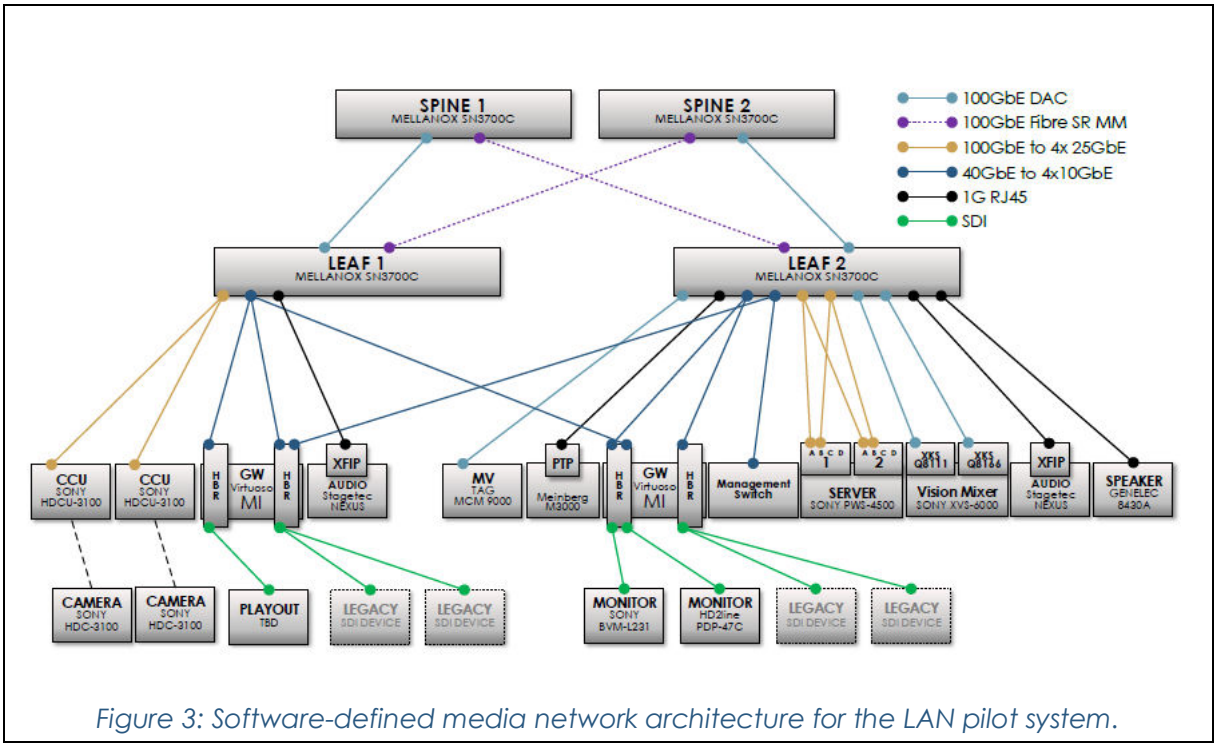

Figure 3: Software-defined media network architecture for the LAN pilot system.

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4.4. Initial setup and testing of the LAN pilot system at Nevion in Gdansk, Poland

The integration of all components of the LAN pilot system was done at NEVION in Gdansk, Poland. This included components finalised within the 5G-VIRTUOSA project (media server, software, switches) and off-the-self components from various other vendors as specified in deliverable **D1.1 System specifications of a commercial product**.

Figure 4 shows the initial setup of the LAN pilot system at NEVION in Gdansk, Poland.

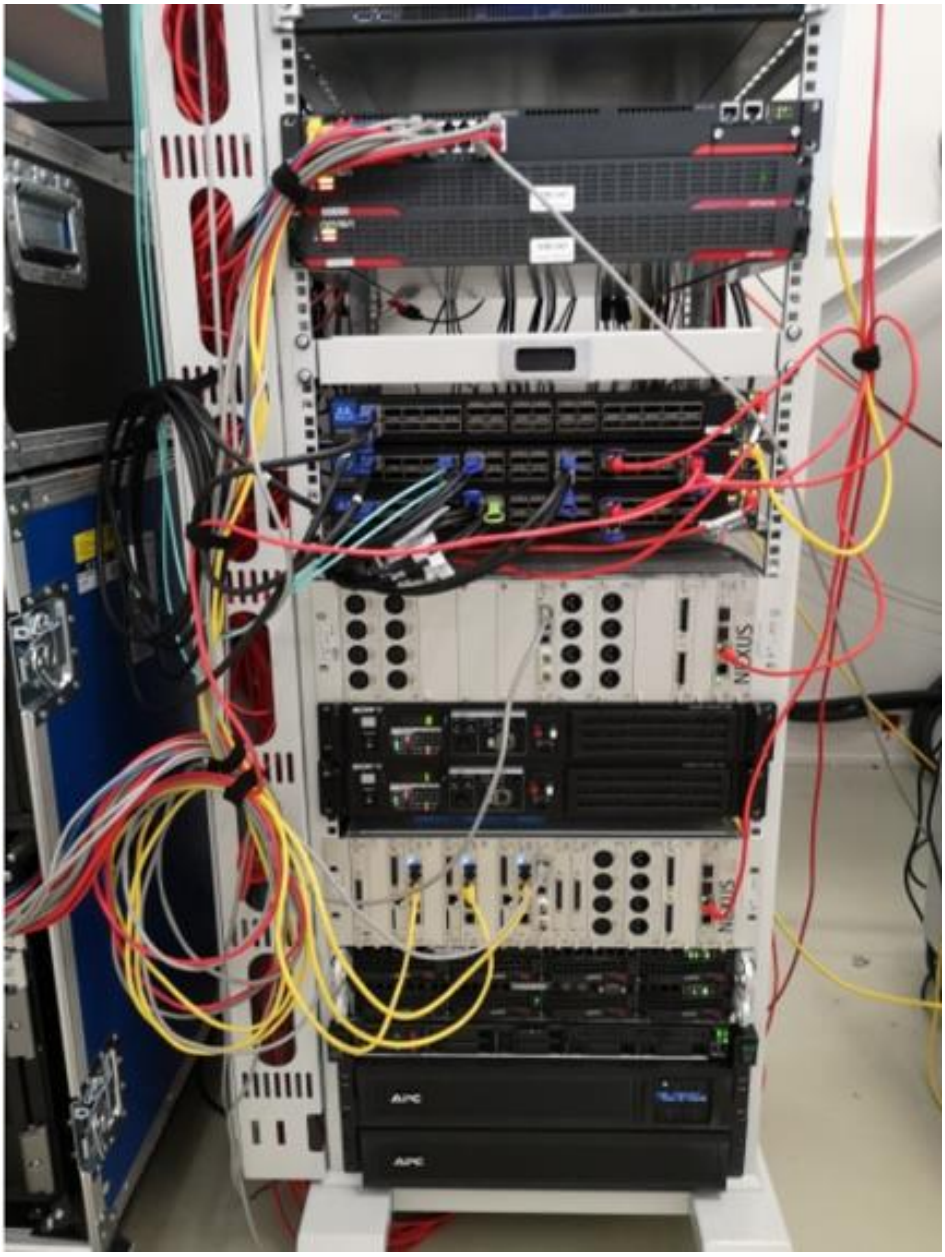

Figure 4: Initial setup of the LAN pilot system at Nevion in Gdansk, Poland. A tower with equipment and a dimension of about 0.7m x 0.5m x 2m.

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At Nevion in Gdansk, Poland, following configurations and system tests has been done:

1. Configuring the server with new 100GB Mellanox cards
2. Cabling and system configuration
3. Cabling of SONY equipment
4. Upgrading cards on Nevion's Virtuoso and creating licenses for both units
5. Configuring the management network (in-band and out-of-band) and testing of connectivity to all devices
6. Configuring the real-time network and connecting all devices to media switches (Vision mixer, Audio mixer, Video server, Multiviewer, Cameras and Gateways).
7. Configuring StageTec's Audio core devices
8. Configuring the PTP distribution for the system.
9. Installing and configuring Nevion's VideoIPath.
10. Building topology in Nevion's VideoIPath
11. Testing of Nevion's VideoIPath's drivers for all devices.
12. Preparing basic functional test of the system.
13. Preparing system and troubleshooting documentation.

Functional testing was based on the test parameters defined in deliverable **D1.2 Test Plan for Verification and Certification**.

The Nevion team liaised extensively with the project partners including meetings with:

- Mellanox (12 May 2020) for testing the Boundary Clock features and NAT.
- StageTec (18 May 2020) for configurating the Audio Matrix and Audio Console.
- SONY (21 May 2020) for configurating the Cameras/CCUs and Vision Mixer.

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4.5. Final setup of the LAN pilot system at IRT's broadcasting facility

The initial setup of the LAN pilot system at Nevion in Gdansk, Poland, was shipped on 01 June 2020 in its entirety to IRT's broadcast facilities in Munich, Germany, for final setup and verification and validation in an operational broadcast environment.

IRT has conducted a long list of standardised tests for system verification and validation in operation.

The VIRTUOSA LAN pilot system has successfully passed both, the system verification and the validation for live IP-based media production. The test results have proven that the VIRTUOSA LAN pilot system and its components are fully compliant with the relevant SMPTE, AES and IEEE standards. On top, the VIRTUOSA LAN pilot system has demonstrated an extremely high stability, suitable for high quality live media production. The technical tests did not show any critical problems in the whole LAN pilot system. All components have worked problem-free and has shown a high reliability. All test results have been documented in **D2.1 Test report on verification of VIRTUOSA LAN pilot** and in **D3.1 Test report on validation of VIRTUOSA LAN pilot**.

Figure 5 shows the final design of the LAN pilot system for installation at IRT's broadcasting facilities in Munich, Germany.

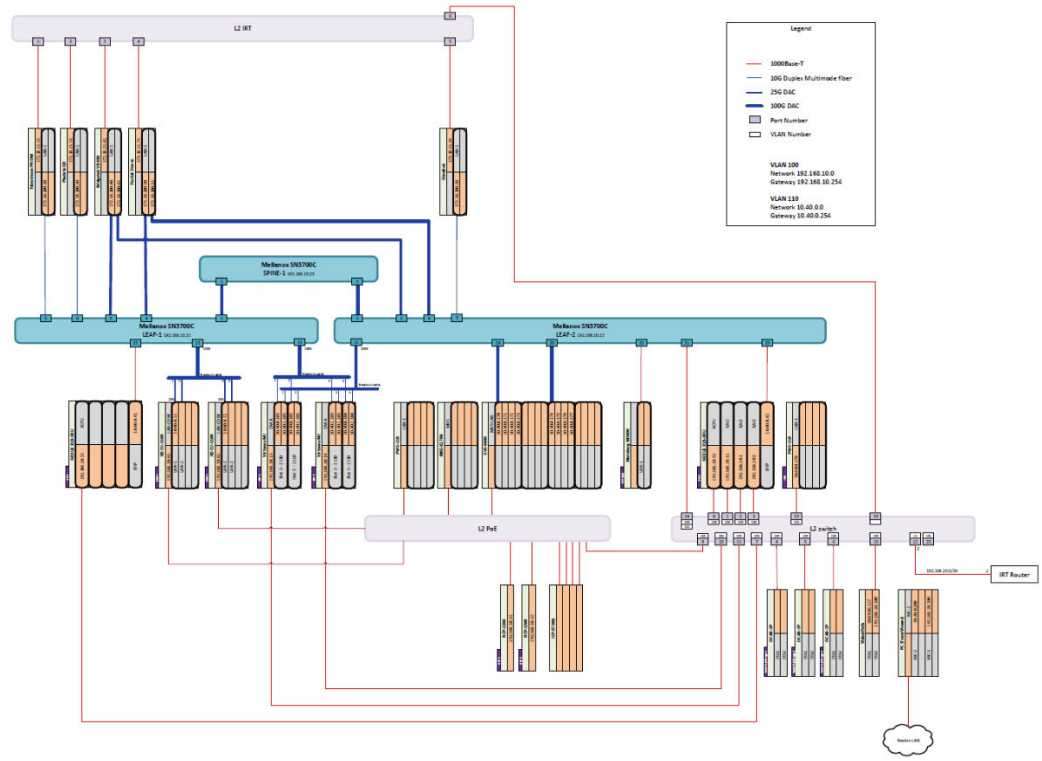

Figure 5: Final design of the LAN pilot system for IRT's broadcast facility in Germany.

Figure 6 shows some photos of the final setup of the LAN pilot system at IRT's broadcast facilities in Munich, Germany.

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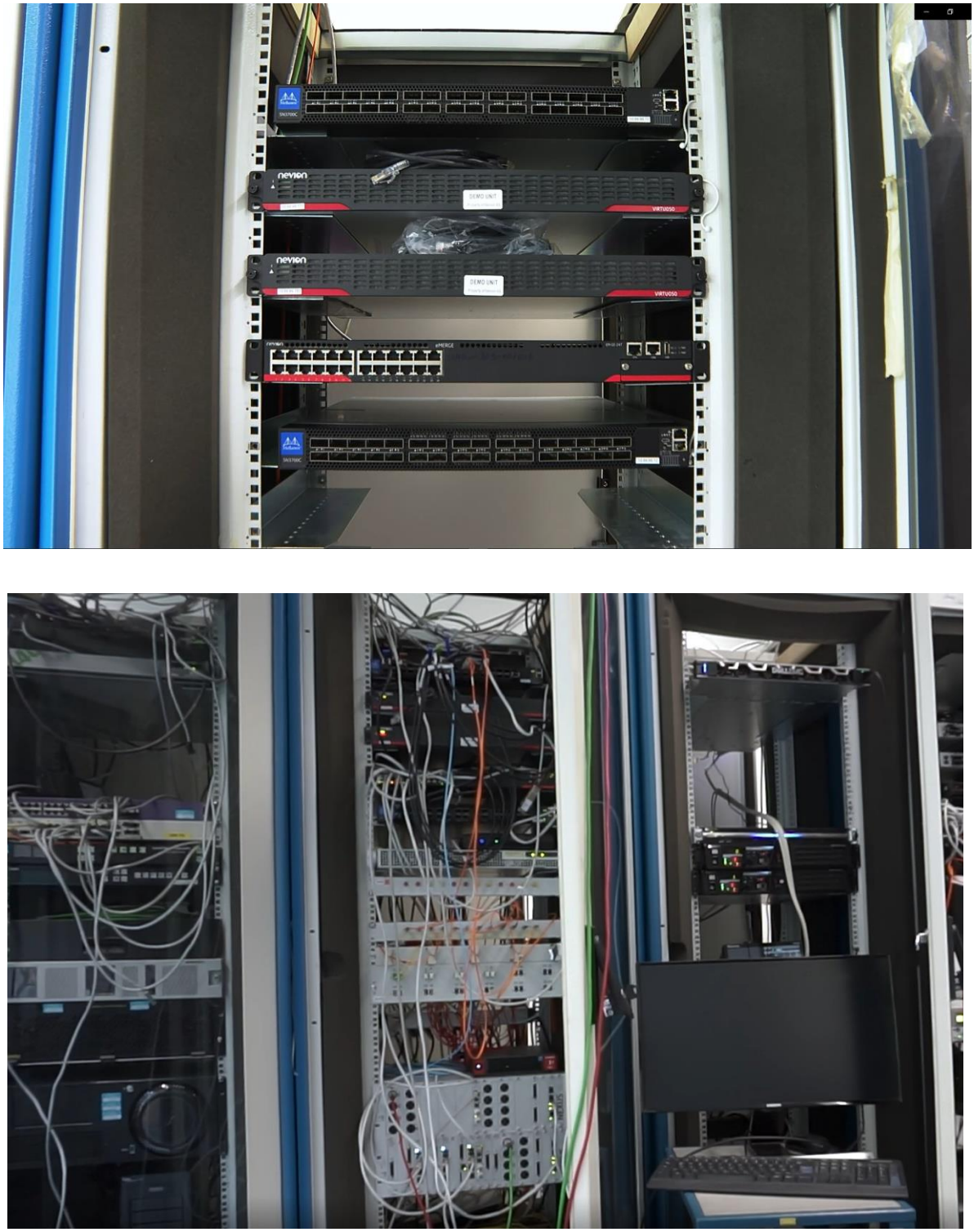

Figure 6a: Final setup of the LAN pilot system at IRT's broadcasting facility in Germany – Tower with Nevion's Media Server ('Virtuoso') and Mellanox's switches ('SN7000').'

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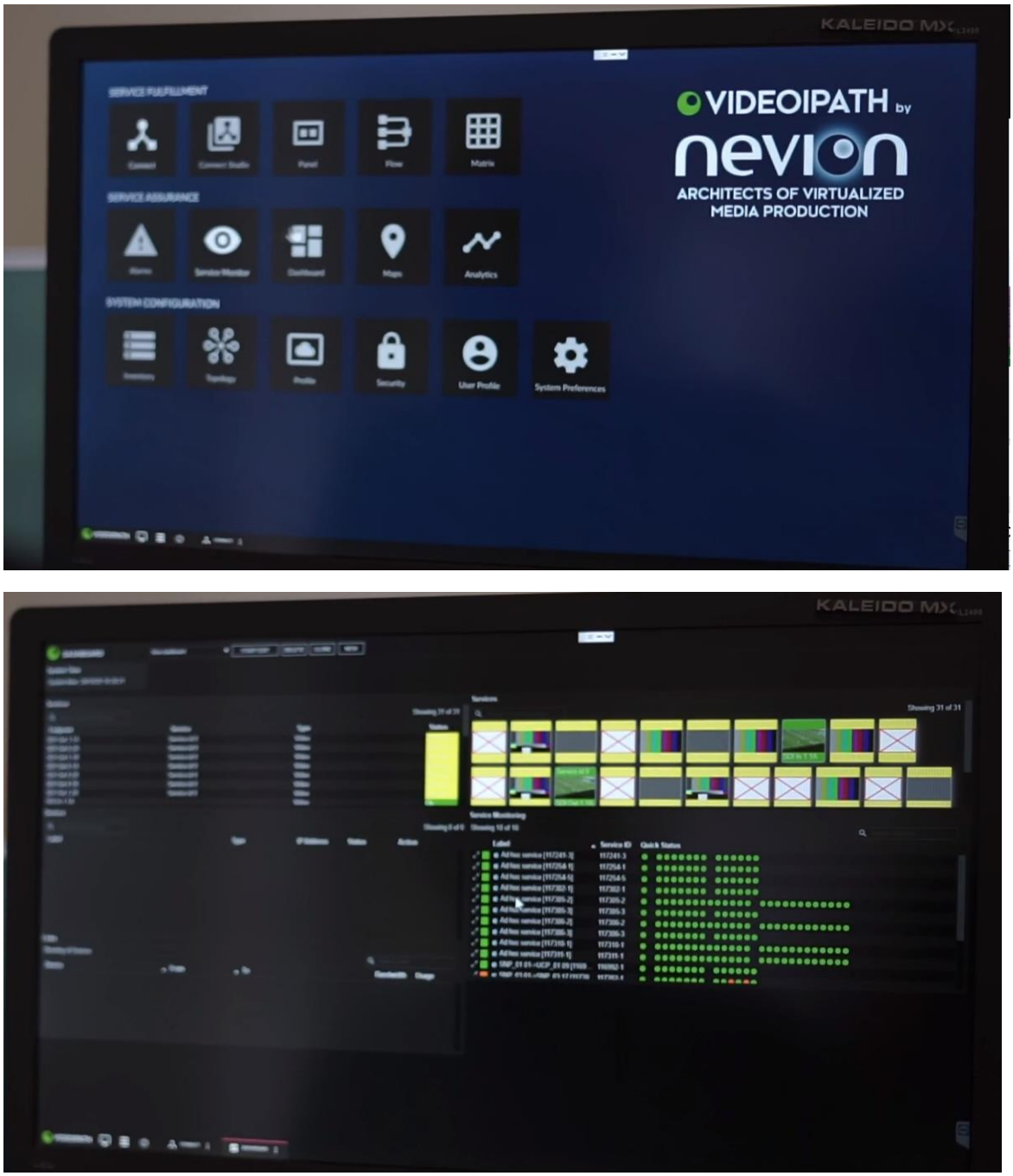

Figure 6b: Final setup of the LAN pilot system at IRT's broadcasting facility in Germany – Nevion's Software for Media Network Management & Orchestration ('VideoIPath').

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Figure 6c: Final setup of the LAN pilot system at IRT's broadcasting facility in Germany. – Third Party equipment (cameras & CCUs, vision mixer, etc.).

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4.6. LAN pilot system – the success story videos

Watch our videos to learn more about the LAN pilot system and its benefits:

- **Video no1 (in English):**
  The video lasts 6:42 minutes and was produced under the lead of LOGIC. It describes the final setup of the LAN pilot system at IRT's facilities and its benefits with interviews of all project partners (Nevion, Mellanox, LOGIC, IRT) to attract potential users and customers.
  https://5g-virtuosa.eu/5g-virtuosa-phase-1-video/

- **Video no2 (in German):**
  The video lasts 2:50 minutes and was produced under the lead of LOGIC. It describes the purpose of the project and project partners, the planned three use cases for real live testing of the VIRTUOSA innovation, and the preparation work for the first use case at IRT to attract potential users and customers.
  https://www.film-tv-video.de/technology/2020/06/24/5g-virtuosa-projekt-ip-studio-laeuft/

Table 1: 5G-VIRTUOSA videos explaining 5G-VIRTUOSA and the LAN pilot system

Video no.	1
Title	5G-VIRTUOSA-HORIZON 2020
Lead	LOGIC
Speaker	Andy Rayner, Chief Technologist, Nevion Markus Berg, Head of Future Networks, IRT Haci Cengiz, Solution Architect, LOGIC Oliver Schmid, Solution Architect, LOGIC Yonatan Piasetzky, Software Architect, Mellanox
Language	English
Duration	6:42
Channel	**Project website, LinkedIN, Twitter**
Link	• Website: https://5g-virtuosa.eu/5g-virtuosa-phase-1-video/ • LinkedIn: https://www.linkedin.com/posts/5g-virtuosa_new-5g-virtuosa-video-activity-6730054058821877761--9bH • Twitter: https://twitter.com/5G_VIRTUOSA/status/1324291323671781379
Published	Nov 3, 2020

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Video	
Interview	 **Andy Rayner, Chief Technologist, Nevion:** *"… our vision is to explore the potential of **distributed IP production** and look at the way future technology such as **5G** can provide further capability and flexibility."* *"…with the convergence of IP technology, both in the broadcast facility and the WAN network, there is great potential for enabling broadcasters to do more and to **make events and productions viable that has previously been to cost prohibitive without these technologies**."* *"… the **funding from the EU is absolutely vital** for advancing capabilities and helping to take the technology focus away from the media short-term commercial pressure into longer term innovation and exploring potential."*

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Interview	
	Markus Berg, Head of Furture Networks, IRT: "*…the migration to IP- and Cloud-enabled production is one of the biggest challenges in the next years but also brings new chances to* ***improve workflows, reduce costs,*** *and* ***reduces the time to playout system*** *- the* ***Next Big Thing for Audio Videa Production***"
Interview	
	Haci Cengiz, Solution Architect, LOGIC: "*…this project is special because it is a kind of* ***Blueprint dedicated to broadcasters in the European Union*** *to get reliable information and perfomance in terms of LIVE production in LAN, WAN and 5G enviroment. This will give them a really good overview how a setup like this will work.*"

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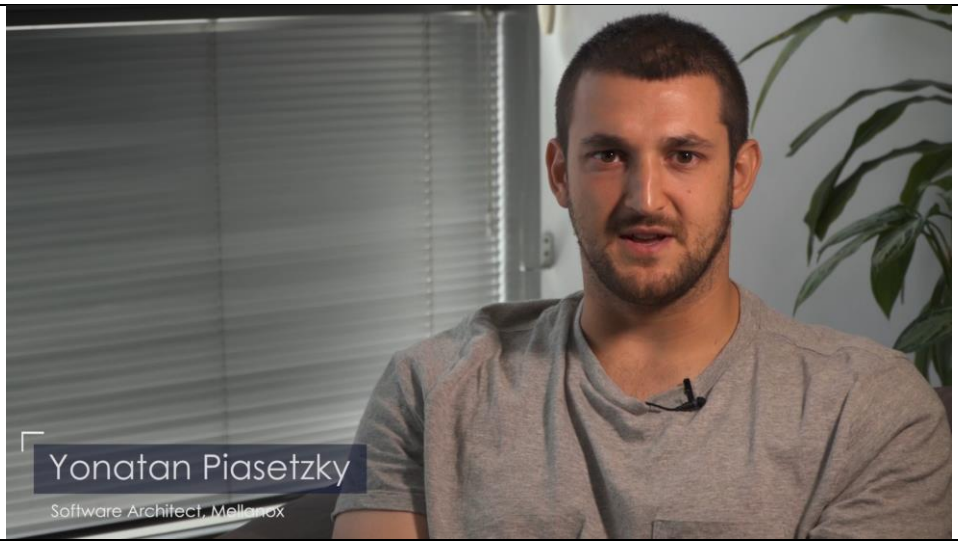
Interview	
	Oliver Schmid, Solution Architect, LOGIC: "*…make LIVE Media Production a way more effective, a way more cost-efficient and* ***more scalable****. As a result of this project, we can* ***reduce the costs by 30-40%*** *and can do* ***a lot of more productions in the same time*** *and* ***at the same cost level***"
Interview	
	Yonatan Piasetzky, Software Architect, Mellanox: "*…the ability to add advanced features [like* ***clean switching****] shows the* ***great advantage of using flexible and programmable network over SND and commodity off-the-shelf internet switches*** *for broadcast media*"

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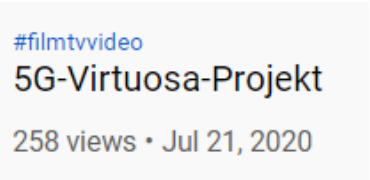
Video no.	2
Title	5G-VIRTUOSA-Projekt
Lead	LOGIC
Speaker	Haci Cengiz, Solution Architect, LOGIC Jessica Volk, Solution Architect, LOGIC
Language	German
Duration	2:50
Channel	**Film-TV-Video** (a platform to promote news in broadcasting)
Link	https://www.film-tv-video.de/technology/2020/06/24/5g-virtuosa-projekt-ip-studio-laeuft/
Published	Jun 24, 2020
Photos	 
Channel	**YouTube**
Link	https://www.youtube.com/watch?v=eWvGDRUcIRQ
Published	Jul 21, 2020
Photos	 

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