Case Study

TV 2 Bergen & Oslo

IP FOR A MODERN
TALE OF TWO CITIES
**THE TV 2 PROJECT INVOLVES THE FOLLOWING LAWO PRODUCTS:**

**IP Video**
- 27x C100 processing blades for the V__matrix software-defined IP core routing, processing & multi-viewing platform
- 14x V__link 4/V__remote 4 all-in-one video-over-IP stageboxes

**Video processing (embedding/de-embedding)**
- 3x V__pro 8 video processing units

**Control**
- 2x VSM IP Broadcast Control System (redundant server setup)
- VSM control panels (hardware and software)

**IP Audio**
- 8x mc2 56 audio mixers
- 1x Nova 73 HD incl. DSP processing
- 28x A__mic 8 audio-over-IP nodes
- 2x A__madi 4 audio-over-IP nodes
- 7x LCU IP commentary units
- 20x R Lay VRX4 bundles including A__OnAir4 audio nodes
- 20x R Lay VSC (Virtual Sound Card)
- 3x R Lay VP8 (Virtual Patch Bay)
- 8x VisTool virtual audio control GUIs
- 1x Compact Engine

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**Jumping Into The Deep End**

TV 2 in Norway has always been a forward-thinking broadcaster and can be considered the cradle for a number of familiar names in the broadcast industry, like Vizrt, Mosart (now part of Vizrt), Vimond Media and Storm Geo, to name but a few.

The latest startup to emerge from TV 2 is called Wolftech Broadcast Solutions, whose news management and other solutions are smash hits in the broadcast world.

Then, there are the Electric Friends camera robots used in TV 2’s news studio. The person who invented them used to be the set designer and was notoriously unhappy with cables lying about on the floor, spoiling the view.

It probably comes as no surprise that TV 2 started planning for a big move in 2012—not just to a new building but also regarding the technology to be installed there. IP wasn’t even a buzzword at the time, but the TV 2 team sensed that IP was where the broadcast sector was headed.

Eivind Halle, one of the architects behind TV 2’s IP project explains: “The idea to migrate towards IP was a group decision taken at the occasion of our move to the new building. At first, IP as such was not the focal point—TV 2 just wanted to avoid long cabling in the new building, and IP followed from that.”

Although TV 2’s project team knew that they would have neither the time nor the resources for extensive tests before launch, IP suddenly looked even more alluring; it would allow them to treat their facilities in Bergen and Oslo as well as any remote location as nodes of one giant network.

TV 2 issued a number of RFIs (requests for information), and Jarle Felin of Lawo Northern Europe responded with suggestions for an IP-based audio platform that leveraged the potential of IP to the hilt, while Nevion devised a concept for the IP orchestration. Both proposals were accepted after an RFP round.

Today, TV 2’s operators in one city can use resources in the other, e.g. to change settings on a mixing console that is over 460km away, or to transmit video footage from Bergen to Oslo and back simply because the only free EVS machine happens to be in Oslo.
Cardinal Points

Despite leaving its suppliers a lot of leeway, project manager Svein Henning Skaga and his team had a clear idea about what they were expecting:

- A distributed architecture based on a spine-leaf topology to ensure accessibility of all signals and devices anywhere on the network;
- A setup that allows TV 2 to avoid SDI equipment wherever possible;
- One platform that spans seamlessly across two sites, making the geographical location of operators irrelevant;
- An ST2110 approach for video and AES67 for audio;
- GPS-referenced PTP synchronization on each site.

The system was to be controlled using Lawo’s Virtual Studio Manager (VSM), Nevion’s Video IPPath SDN approach, and a Hiltron control system for RFASI routing via an interface.

Eivind Halle adds that TV 2 also wanted to stick to its multi-vendor policy to avoid any lock-in. The current setup involves Nevion Virtuoso converters, SAM (GV) vision mixers and controllers, Lawo video and audio stagebox nodes, eight Lawo mc156 consoles, a Lawo Nova 73-based hybrid audio router, Embriox monitoring decoders, Riedel intercom, Novelsat and Ericsson ASI, and AppearTV.

The project’s scope looked as follows:

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State of Play

The first all-IP broadcast from Bergen took place on August 10th, 2017, a few months before TV 2 officially moved to the brand-new Media City building. For the first Premier League soccer match of the 2017/18 season, there were exactly one gallery and one studio. Football rights are crucial for TV 2’s OTT services, notably its premium channels, which are highly lucrative. Nobody at TV 2 wanted to start the new season in an old studio.

In July 2017, several Lawo engineers spent a week in Bergen for the commissioning of the only mc156 console that was already up and running. At the time, Nevion, which had supplied the network, was putting the finishing touches to the AES67 features of its network nodes and gateways.

Today, TV 2 is about to complete its last studio and two additional production control rooms. But that will not be the end: “Our IP project is a work in progress that changes as new ideas surface and more equipment is added,” explains Svein Henning Skaga. A new, larger spine will soon be installed in Bergen to replace the original one.

With over 9,000 active streams, TV 2 has every reason to be proud of what has been achieved in less than a year. And there is more good news: with the exception of a PTP conundrum (see below), TV 2 has had far fewer issues than anticipated.
The decision to use Lawo gear and software for TV 2’s audio platform was taken in January 2017, after Lawo’s successful deployment at the European Championship in France. At the time, Lawo was among the few manufacturers to propose an AES67 solution with a demonstrable track record.

Jarle Felin of Lawo is the audio architect for the TV 2 project. He suggested working with preparation stages where the audio and video are “normalized” (i.e. leveled, EQ’d, compressed and/or limited for audio), all of which is controlled via VSM, prior to further processing and mixing.

About 80% of TV 2’s audio is mixed automatically using Vizrt Mosart. For the remaining 20%, the channel strips of the mc2 56 consoles have been equipped with MOS ISO keys (Mosart Isolation) that allow audio engineers to quickly select the channels they want to mix manually.

While for sports coverage, there is a dedicated audio engineer, the news department, which also boasts an mc2 56, doesn’t have one—audio mixing is automated using Vizrt Mosart. The news department’s technician who controls the cameras can, however, override Mosart using VSM if necessary.

The idea behind mixing the audio at an early stage in the signal chain is that this allows TV 2 to save time and resources by using the same mix for a variety of applications (on-air, recording, continuity, OTT, playout and others). “Fix it upstream—right at the entrance—is what we wanted to achieve,” explains Svein Henning Skaga.

Where necessary, the audio is de-embedded and Dolby de- or encoded. Audio shuffling and lip sync adjustments are also performed. All IFBs are accessible here and can be mixed into the returns for on-site or off-tube commentators.

“Fix it upstream—right at the entrance—is what we wanted to achieve.”

—Svein Henning Skaga, Solutions Architect

TV 2
The first thought was to have all audio pass through TV 2’s Nova 73 HD audio router, and from there to the galleries, until TV 2 discovered that this was not really necessary: their IP streams can be sent straight to the galleries. ST2022-7 is used as a redundancy scheme, which was not possible at the start of the project.

The Nova 73 is thus chiefly used for fixing audio signals that need correcting, e.g. for adding delay. For sports broadcasts, for instance, the video may come in via satellite, while the audio is received via ISDN or IP, in which case the commentary needs to be delayed by up to six seconds.

TV 2 has prepared 12 virtual mixers in VSM and is already considering expanding that number to 16 or even 32. These virtual mixers control the Nova 73 in MX mode. They have become an important tool in the MCR.

Other locations where audio is involved are compact video editing stations (see first picture on next page) where operators work with Final Cut Pro or Quantel editing software.

At the edit stations, audio is served via Lawo’s R3LAY VRX virtual mixer software, which is virtualized on VMware, and A_OnAir 4 audio nodes, which are connected to one or two audio monitoring systems and headphones.

TV 2 uses Lawo LCU Commentary Units for off-tube commenting, mainly in Oslo but occasionally also in Bergen. There are no dedicated commentary booths: commenting is performed in meeting rooms, which are not used in the evenings or during the weekend anyway.

They have been equipped with screens, additional soundproofing, the required commentary infrastructure (including Lawo LCU units) and a couple of multiviewers. The commentator’s audio is mixed in the MCR using the Nova 73 HD and then embedded, ready to be sent to playout or to a gallery. TV 2 uses the Lawo LCU commentary units as stand-alone devices and simplified their operation: they are set up to receive and transmit only RAVENNA streams, and their settings can be remotely controlled via VSM.

V__matrix-based Multiviewers

In late 2020 and early 2021, TV 2 began equipping 6 replay positions with V__matrix-based vm_dmv18-4 multiviewers, which can be configured using Lawo’s theWALL software.

theWALL runs on desktop and laptop computers as well as on tablets. It allows operators to configure any monitor wall, route signals, change mosaic layouts as well as to save and load user presets.
Studio/Remote Production

The overarching idea is that it shouldn’t make any difference where a production is done—everything needs to be consistent, logical and familiar, with little or no complex setups. TV 2’s new IP network can be extended to a remote location, which still “feels” like any other studio on TV 2’s premises. Such sources are labeled “Remote” in VSM and can be in any Norwegian city—or even on a different continent.

TV 2 has streamlined its remote productions through consistent labeling. In the audio gallery, the engineer operating the Lawo mc² 56 mixing console sees the remote location as “Studio 2”, microphones 1~8. Each channel handles a specific signal that is always assigned to it. The engineer can send back IFBs 1~4 in the same way as for a local setup. Audio shuffling, for its part, is handled in the MCR.

Remote productions have a long history at TV 2. TV2 was an early adopter of Lawo’s V__remote 4, in time for the 2016 Olympics in Rio de Janeiro. The V__remote 4s (and A__mic 8s) are often used for projects involving TV 2’s sister company Screen Media and NEP Norway.

TV 2 will soon perform tests with Lawo’s new Power CoreRP Remote Production Audio Nodes for high-profile sports productions.

Stageboxes similar to the ones used for remote productions are fitted with an additional wireless microphone receiver and an in-ear system and are used in all studies.

Remote setup at Aker Brygge (A__line 8): a remote location connected to the “main” remote setup.

V__matrix-based UHD Service for OTT Premium Subscribers

Most of the sports rights held by TV 2 are available in UHD at the source: English Premier League, Champions League, the upcoming Euro 2020 (2021), etc. This sparked the idea at TV 2 to pamper its premium subscribers—most of them avid sports consumers—with UHD productions for its OTT offering.

Launched in October 2020, this bonus is currently included in the regular premium subscription fee. TV 2 therefore looked for a way to provide it with as little manpower and additional handling as possible.

Given that TV 2 currently produces its content in HD, only the games and matches are actually available in native UHD. TV 2’s studio content, commercials and promos are upconverted for the UHD service using vm_udx.

“This strategy adds serious value, because our studio footage, and even the commercials, look much better when upconverted to 4K/UHD. I guess this is an important lesson we learned,” comments Svein Henning Skaga, TV 2’s Solutions Architect.

TV 2 initially wanted to deliver its UHD service almost as an afterthought and see how it went. This explains why no special UHD gallery was set up—it would have been TV 2’s first. Instead, they looked for a highly automated approach.

When it became clear that the HD footage derived from downconverted UHD signals had more sparkle and detail than HD-native material, the team furthermore decided to “work the other way around”: for its regular sports content, TV 2 now downconverts incoming UHD signals to HD whenever possible.
UHD Premium Workflow

The satellite signal received from the host broadcaster is passed on via IP, which is rather unusual, as most European broadcasters handle incoming 4K/UHD signals via SDI (using 4 cables per UHD signal).

Because an HD gallery is used for the “standard” (HD) production, TV 2 leverages the Kahuna video switcher’s “salvo” feature and VSM. This allows the team to have the UHD production run—almost completely automatically—in the background.

As stated above, the project is based on ingesting and quality-checking UHD satellite signals in the MCR, performing some routing tasks and then leaving those signals to themselves.

All blue boxes in the drawing to the right are V__matrix C100 processing blades with different roles (their physical location is of no consequence). Two blades are available in each instance for redundancy purposes.

- **C100-1-1**: UHD–HD conversion (and HDR–SDR) for the regular program and audio de-embedding. “The HD signal we use for our productions is actually a UHD signal which we downconvert using vm_udx. We collaborated with Lawo to fine-tune the vm_udx app, and I must say that both the downconversion and the upconversion towards the end of the signal chain produce excellent results. (The HD signal received via satellite is only used for backup purposes in the event the incoming UHD signal drops out.)

  The first blade also de-embeds the audio signals and transmits them to the Lawo Nova 73 HD audio router via AES67/RAVENNA.

- **C100-2-1**: This is used to set audio and video delays, because both the UHD/HD and the audio signals need to be in perfect sync at the end of the processing chain. The decision to induce delay already at this stage was taken to avoid that the commentary runs ahead of the video footage. During the pandemic, all commentary is contributed off-tube rather than on-site. One advantage of this approach is that TV 2 has better control over the delay. (Such commentary signals are transmitted by a Lawo LCU to the Nova 73 HD.)

  **C100-3-1**: This processing blade performs additional video and audio delays and also takes care of audio shuffling.

  **C100-4-1** upconverts HD commercial and promo footage coming from playout as well as studio contributions to UHD. The PCR transmits an HD signal to playout (TV 2’s Evertz playout system does not support UHD) and a 4K/UHD stream to the C100-4-1 (called “Switch” in the drawing on the previous page). “One of the many things a C100 does is clean switching,” explains Svein Henning Skaga. The C100-4-1 blade therefore also switches between the UHD program and the commercial clips, based on GPI/O signals transmitted by the playlist in the playout department. In addition, it performs audio embedding.

The entire system is controlled by Lawo’s VSM for advanced automated operation. This functionality was programmed by internal TV 2 staff as well as Lawo’s Henrik Halvorsen.

“Sumo” is the current name of TV 2’s OTT platform, which will be rebranded to “TV 2 Play” in June 2021.

• The vision mixer receives both the HD and the UHD signals, which are processed in parallel even though the producer only switches the HD signal: UHD signal switching is handled automatically in the background (in C100-4-1, see below).
How does it Work?

“It’s quite a complex setup, I would say, and only a few people at TV 2 really understand all its ins and outs. Without Lawo’s VSM and V__matrix, this initiative would not have been possible,” says Skaga.

TV 2’s UHD system will be used for the upcoming Champions League semi-finals as well as the Euro 2020 matches (which take place in 2021, as we all know) that are aired by TV 2.

While the UHD offering is only served via the OTT platform for the time being, TV 2 is already in talks with its regular distributors about a 4K/UHD channel via satellite and terrestrial lines.

What started out as a proof of concept and evolved into a pilot project is now served several times a week. This bonus service is highly appreciated by TV 2’s OTT subscribers, most of whom are able to receive the UHD quality. Those who do not yet have a UHD-compliant TV set nevertheless benefit from a better picture quality than regular HD.

Another aspect TV 2 wanted to explore with this project was the robustness of subscribers’ internet connections, which turns out to be better than expected. Of course, the UHD signals (eating up 20Mbps in their raw state) are heavily compressed using H.265/HEVC (as opposed to H.264 for the regular HD signal) as well as at CDN level whenever the internet connection requires it. Even in such a scenario, “the resulting picture quality is still much better than HD,” concludes Skaga.

“Our UHD OTT service is quite a complex setup, I would say, and only a few people at TV 2 really understand all its ins and outs. Without Lawo’s VSM and V__matrix, this initiative would not have been possible.”
—Svein Henning Skaga

IP Network

TV 2’s data center is wired to several rooms on each floor, and those rooms are connected to the studios, galleries, etc., in a spine-leaf topology.

TV 2 chose single-mode fiber runs between floors, and CAT-6 cabling on the floors. There are two separate networks: one for control, a second for audio and video.

VSM and Vizrt Mosart are connected to the mc2 56 mixers via the office network, which is also used for management purposes and intercom. KVM is hardly used, because most of TV 2’s computers have been virtualized and can be accessed from anywhere. Even Vizrt Mosart has been moved to the virtual plane. This virtualization saves TV 2 so much space that they can rent out rack capacity to other companies in the Media City building.

Only graphics operators still use dedicated machines that are far more powerful than the virtualized computers.

The mc2 56 consoles are connected to the Nova 73 core via a direct VPN connection, i.e. as a pipe-through. There are no direct cable connections between the console in the MCR, for instance, and the Nova 73 core on the ground floor—this is handled over the network.

The IP media network is configured for SMPTE 2022-7 (hitless merge). TV 2 opted for a spine-leaf configuration controlled via SDN (software-defined network) to preserve redundancy under all circumstances. In the event of a failure, Video IPath attempts to re-route the broken path while avoiding the same route as the one used by the other path. Even though the cure doesn’t come instantly, the SDN approach has worked well so far.

TV 2 uses its office network for controlling the RAVENNA cards in the Nova 73 HD, while the nodes are controlled by in-band management on the media network. Given that the Nevion switches use 10Gbps ports, connecting RAVENNA directly to these switches would have been a waste of resources. TV 2 therefore decided to add so-called “audio aggregation switches” (Cisco) to which all IP audio equipment is connected.

“…we wanted a scalable topology, not least because we operate from two cities. And we were looking for COTS technology,” comments Eivind Halle.

TV 2 is currently producing in HD. And while UHD/4K was not a topic when the network was designed and built in 2018, it was added in late 2020. This provided the ultimate proof that TV 2’s IP network scales and handles this flawlessly.
Right now, TV 2 has ample bandwidth to work with, and even moving to 8K at some stage should pose no serious challenge.

The link between Oslo and Bergen offers 100Gbps, of which 40Gbps is currently used for audio and video. Including J2K applications, this comes down to about 40 lines (video streams require 1.5Gbps, while J2K lines use 100~200Mbps). J2K is now being phased out and replaced with JPEG-XS.

TV 2 currently boasts about 10,000 configured endpoints (5000 senders and 5000 receivers).

“**We wanted a scalable topology, not least because we operate from two cities. And we were looking for COTS technology.**”
—Eivind Halle

### VSM
Lawo’s Virtual Studio Manager (VSM) is used as TV 2’s top-layer end-user interface. VSM was programmed by TV 2’s four internal programmers, with some help from Lawo engineers.

Examples of how VSM is used are:
- For TV 2’s galleries, connections are made via VSM, which set up all required return feeds based on which input is used in a given gallery. This is not only user-friendly, but also takes the complexity out of the MCR engineer’s task.
- All on-air camera switching takes place within the vision mixer and is performed using a VSM panel. (This is actually the only instance where TV 2 needs clean switching.)
- TV 2 uses 12 VSM-based virtual mixers that control the Nova 73 HD in MX (DSP card) mode, with more virtual mixers to come. No physical controllers are used.
- LCU commentary units are configured to receive and transmit RAVENNA streams, with VSM controlling their parameters, allowing operators to override a commentator’s LCU settings.
- VSM is also used for the dynamic allocation of the Lawo A__mic 8 units in both Oslo and Bergen.

### PTP Synchronization
One lesson TV 2 learned is that without a robust network monitoring solution, troubleshooting an IP network is more difficult than with baseband devices: issues can only be solved once you know what causes them. Unplugging cables to isolate the troublemaker no longer works…

Another experience is related to PTP synchronization, which TV 2 uses extensively. Svein Henning Skaga is happy to share one important finding regarding PTP: simply assuming that there is only one PTP master on the network is not enough. If the network goes down when a new device is connected (either in Bergen or Oslo, in TV 2’s case), disconnect it immediately and check its PTP Master status. Or better still: first check the device’s PTP Master status, set it to “Slave-Only” (or something similar) and only then connect it to the IP network. There can only be one PTP Master on any given IP network.

TV 2 also learned that, although most switches are able to handle PTP, they implement it in different ways: some only support it on a software level, which may cause issues.

“For a long time, a broadcast guy like myself was merely aware of network switches. Nowadays I find myself studying data sheets and learning as much as I can about them, because our network people don’t know much about broadcast. Luckily, one of our engineers got really interested in the subject and is now gradually becoming our specialist.” (Svein Henning Skaga)

Wrap-Up

Thanks to in-depth discussions with Lawo’s Andreas Braun, Roland Hodapp, Jürgen Sigrist, Henrik Halvorsen, Jarle Felin, and Lawo’s VSM specialists, TV 2 today boasts a flexible IP setup with a powerful audio platform. Setting up the system, defining the philosophy and accounting for all required signals was no mean feat, but the effort is beginning to pay off handsomely. One notable addition since 2018 has been the new OTT service in the UHD format for its premium subscribers with next to no handling.

TV 2’s IP infrastructure delivers on all counts that Svein Henning Skaga and his team expected, any source is available at any destination, any production can be controlled from any gallery, everything is based on decentralized production principles, and serviceability over IP has become a reality. The system uses open platforms throughout: audio, video and control (SMPTE 2022, 2110, AES67, EmberX).

TV 2’s all-IP setup is a resilient network that has redefined the way in which TV 2 serves its large audience.