APPENDIX B

NETWORK

Contents

1   NETWORK OVERVIEW

Network is a section within IT, consisting of seven employees with responsibility in the following areas:

Operation and development of network in and between all NRK locations. This includes LAN, WAN, WLAN, IP-SEC VPN and SSL-VPN at approximately 60 locations in Norway and abroad.

Setup and configuration of network solutions for occasional use in studios and "off-premise" locations. Preparation and test of program lines for broadcasts. Operation and maintenance of network-equipment that is used in NRK's mobile units, including cars, OB-buses, etc. Setup and configuration of the equipment when required. Participation and support when new production-equipment or other systems are introduced.

Responsible for network security, also when NRK shares network with external service providers (vendors). Contact with external vendors regarding security monitoring on a 24/7 basis. Setup and operation of Firewalls at Marienlyst (HQ), district offices (DKs) and local offices (LKs) internet routers, peering agreements and follow-up on RIPE. Participates in designing the network for new online NRK-services.

Procurement of cables from vendor, and making sure these are placed correctly. Designs the cabling and cable- and data-rooms when rebuilding or relocating offices. Patch UTP and fiber internally and external vendors (ODF). Patch wireless access points and maintains documentation for all UTP and fiber cabling in 30 wiring closets with network switches and 70 wiring closets for fiber at Marienlyst. NRK use imVision for documentation for cabling.

Follow-up of the IP-telephony service provider, and participates in assessment and implementation of new services.

Prepares technical requirement specifications for framework agreements and contracts with service providers within the network domain.

Broadcast production is currently undergoing a transition from traditional analog and digital technology to IP based solutions. This means high requirements to the network design and performance as well as a thorough knowledge of the challenges of integrating broadcast and IP based networking.

2   SERVICES AND CUSTOMERS

Table 1 - Overview of the Network section's servicesis an overview of the services provided by the Network section. The services are described in detail in chapter 2.1-2.9.

Service	Description
Systems planning	Cables (HQ+DK) and cable-rooms, data-rooms/technical-rooms
IP-Telephony	Service is outsourced
Cabling (wiring)/patching	Patching of data points and coupling of analog lines
Security	Firewall, DDoS-prevention, IPsec for locations and SSL VPN clients
WLAN	Ca. 430 access points (entire NRK)
LAN	Ca. 8500 nodes (entire NRK)
WAN	Ca. 60 locations (entire NRK)
Internet	Details in sub-chapter
Production	Setup of production on-/off-site
Other services	Details in sub-chapter

Table 1 - Overview of the Network section's services

2.1   Systems planning

- Daily follow up of external service provider
- Cabling UTP/Fiber
    - Cables at Marienlyst (HQ) and all regional and local offices
- Data-room
    - Specify room, cable conduits, racks, cabinets, cabling layouts, power requirements etc.
- Responsible for documentation
- Making orders (cables, etc.)
- Maintenance and update of ACAD construction drawings
- Utilizes iPatch/imVision as documentation tool/database

2.2   IP-Telephony

- Service is outsourced to NetNordic
- The IP-Telephony platform consist of Avaya Aura telephony and Trio /Call center
- Vendor management (follow-up)
- Strategic development of service and investments
- Interface and integration (troubleshooting and user-guide)

2.3   Cabling (wiring)/patching

- UTP/Fiber

- Patching data points for all equipment (phones, computers, clocks, security cameras etc.)
- Connecting analogue lines (internal and external mobile-lines)
- District offices do the patching themselves

2.4 Security

- Firewall at Marienlyst, regional and local offices
- Internet security
- Monitoring internet connections
- Follow up NSM and TSOC notification 1600-0800, and weekends.
- DDoS, IDS
- Notifications and mitigation (only on international services – TDC)
- Tender on international lines (for internet)
- Related to "Internet" (see 2.7)
- SSL VPN for clients
- IPSEC and SSL VPN solutions for locations (LAN to LAN)
- Assembly of logs from net, FW DHCP, etc.

2.5 WLAN

- Solution provided by Fortinet (Meru)
- Ca. 430 access points (entire NRK)
- Ca 2000 connected devices at peak times
- Installed in 2011
- Also used for events, outside broadcast, etc.
- At the NRK-office in Hordaland, the WLAN is provided as a service by the owner of the building, but it is integrated with NRK AD

2.6 LAN

- Ca. 8500 nodes connected to the network (entire NRK), on approximately 60 locations
- Utilizes Cisco Nexus Core (primarily), distribution consists of Cisco Nexus. Access consists mainly of Cisco Catalyst 3750 and 3850 switches.
- The network topology is based on standard Ethernet
- Core and distribution network are fully redundant
- Datacenter network is fully redundant
- vPC (virtual PortChannel) runs both in Distribution and Datacenter
- VLANs based on 802.1Q tagging
- Protocols based on IP is implemented
- For monitoring NRK use HP NNM, Cacti, Dude, Observium, FortiSiem
- For config management NRK use Cisco Prime infrastructure
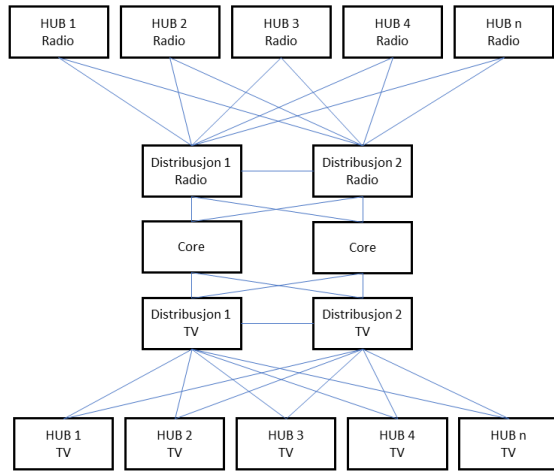- For access control to network equipment and 802.1x NRK use Cisco ISE

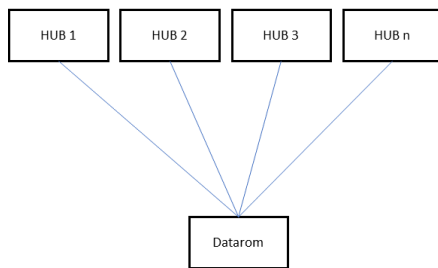*Figure 1 - Network design Marienlyst (HQ)*

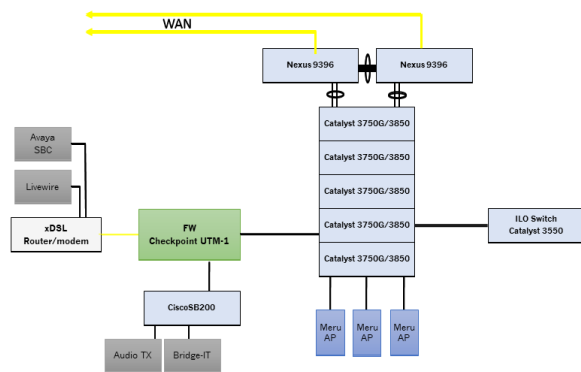*Figure 2 - Network design Trondheim and Bergen*

Figure 3 - WAN - Network design rest of district offices ("DK")

- Approx. 60 locations

- Norkring provides WAN to all district offices and five local offices (LK)
- Approx. 25 locations with VPN over internet
- Local routers /VPN units are operated by NRK
- Fiber perimeter ("Fiber ring") in Oslo (news ring and event ring)
- Fiber to meteorological offices in Tromsø, Bergen and Oslo
- VIPRINET vpn for approx. 20 mobile units connected to a central redundant hub in Oslo.
- Various layer 2/3 point to point networks for occasional use related to content production activities. This could be dark fiber or other types of connections. For combining TV signal and network we use products from Evertz, Nevion and Norwia.
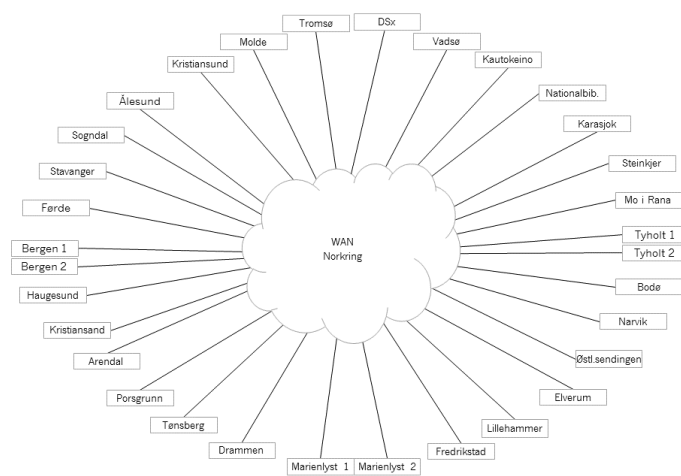- For international networks we often use the EBU FiNE network.
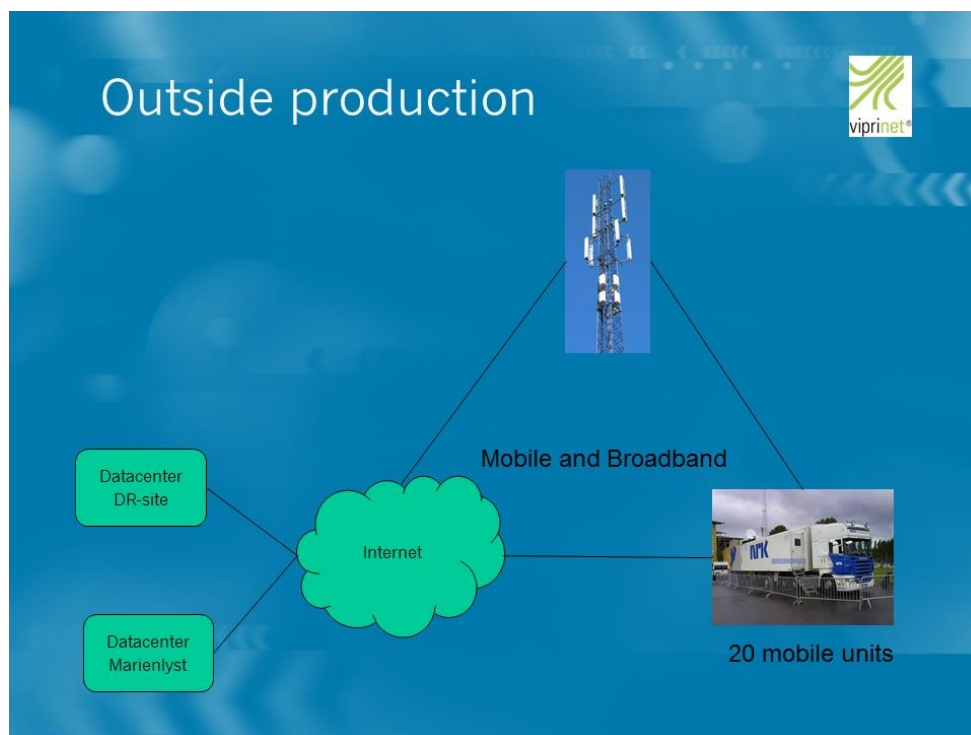

Figure 4 - Network design WAN

Figure 5 - OB production principle

2.7   Internet

- NRK is an ISP
- Connection to NIX1 and NIX2
- Internet transit provided by TDC
- Load balancing of external services
- Private peering with NEP, Telenor and NextGenTel
- Monitoring of internet lines
- Internet security monitoring services provided by TDC, Telenor (TSOC) and NSM

2.8   Production

- Network design for both on- and off-premise production.
- Establishing «off-premise» productions (athletic events, concerts, etc.), which includes supplying, configuring and installation of network equipment and cabling. Responsible for setup and configuration, when not in charge of cabling and installation.
- Configuration of mobile production units when required.
- Participate in implementation of new broadcasting-equipment, and troubleshooting on the implemented solutions. In the last 10 years broadcast production technology has been in a transition phase where traditional analog and digital solutions have been gradually replaced by IP technology. This transition is still ongoing. The implementations are often lacking in

standardization and network competence is required to achieve the desired result. This represents a significant part of the network section's workload.

- Integrate various commentary and result systems provided by the host organizations of large events, like the Olympic Games, into internal systems.

2.9 Other services

- Support for the cash register system in the NRK cantinas
- Support for NTP based architectural and studio clock systems
- Lab for application tests (provided for "Media development" – the business area responsible for NRK Super, yr.no, etc.)
- Network competence in the LAWO broadcast control system implementation project
- CCTV surveillance cameras (competence, consulting, troubleshooting)
- Door entry systems (competence, troubleshooting)
- Network support for various system for distribution of audiovisual content as multicast for digital signage screens and meeting rooms e.g. MediaCento and ZeeVee.

3 STRATEGY

The Network section's strategy is highly correlated with the strategic decisions in NRK's broadcast-production. When it comes to services provided to the administrative part of the organization, Network makes sure their services are in line with the development in the market.

NRK normally edits on 50 Mb/s video streams, usually with six streams in parallel. However, NRK is in the process of increasing the speed to video streams with 100 or 150 Mb/s. This requires more bandwidth for the network.

In addition, NRK is one of the first broadcasters to introduce live multi-camera production over IP. This requires synchronization of uncompressed video from multiple cameras for live broadcasts. NRK already has an installation like this on its district office in Bergen. The installation is based on the implementation of PTP and SMPTE 2110, and the goal is to combine live radio and TV on the same network. The installation works as a "pilot" on how the new headquarters in Oslo could be designed. For the smaller district offices, the installation will most likely be scaled down e.g. Caspar CG.

4 PROJECTS

Project	Start	Due	Description
IP-telephony	2017	Q1 2018	Transition from landline telephony to IP-telephony
Replacement of cables and switches	2004	Q4 2018	Achieve ≥ 1gbit as soon as possible (goal: Marienlyst during 2018). DK's are done

Uncompressed live video over IP in Bergen	2017	Q2 2018	Cooperation with Cisco and Lawo.
Uncompressed live video over IP in NRK	2017	No due date	Production using live uncompressed video will be deployed throughout NRK but may be different from the one used in Bergen depending on the development in the broadcast technology market.
Change of editing format			Requires 2-3x more bandwidth. Video editing 100-150 Mbit/s
Wireless network upgrade	TBD		Requirement specification in progress Further progress depends on this process
Relocating DKs	2016	2019	Bergen (MCB), Steinkjer, Kristiansand, Lillehammer, Hamar (Elverum), Bodø, Porsgrunn
Mini CDN	2017	No due date	Streaming cache for internet providers
Archive to National Library ("Nasjonal-biblioteket")	2017	2018	Archiving of NRK's content
New Broadcast control system in NRK	2016	2018	VSM from Lawo. Controlling video routers and broadcast equipment.
New network solution for MET	2017	Q1 2018	Establishing NRK network in studio for meteorological in Oslo, Tromsø and Bergen
Procurement agreements	2017	2018	Internet transit (TDC) WAN upgrade
Internal projects in Network-section		2019	- Datacenter upgrade - Marienlyst site distribution layer upgrade. - Replace load balancers for internet services - New WAN solution for local offices - Upgrade core and replace access switches at Tyholt district office - Replace distribution and access switches in "ENG" datacenter at the Marienlyst site

Table 2 - Overview of the Network section's projects

4.1   IP-telephony

Transition from PABX to IP-telephony. Sourcing agreement entered June 2017. Project in progress, expected completion in January 2018. The project is not affected by this process.

4.2 Replacement of cables and switches

Upgrade UTP cabling at Marienlyst site (HQ) from category 3/5 to category 6A.
10/100 Mbit/s network switches from year 2000-2003 will be replaced in parallel, to multigigabit switches.
The actual cabling will be installed by an external vendor, but internal resources will handle the planning, network installation, configuration and patching.

4.3 Uncompressed live video over IP

Changing the basis of the video production platform from SDI to IP. In SDI, sound, video and meta-data is in one stream, whereas in IP there are available standards (TR-03/SMPTE 2110, etc.) where sound, video and meta-data are sent on separate multicasts. This enables new workflows and better utilization of content. With IP, changes in format is possible without having to change the entire platform, because all transport (sound, video and meta-data) is the same. This will also have a positive long-term effect on costs.
The transition from HD to 4K means a transition from 3Gbit/s streams to 12Gbit/s, but the technology remains the same. Time-synchronization between frames/pictures in multi-camera productions will have to use PTP. Broadcast equipment providers are in the process of adapting to these changes, both in terms of standardization and equipment that is used for production.
The project is trying to find a way to utilize this technology in the future. The Bergen office, "Media City Bergen", is a pilot on how this can be done. (Production and playout entirely on IP.)

4.4 Change of editing format

NRK uses Adobe and Quantel for editing. The current editing format uses 50 Mbit/s, and usually six parallel streams while editing. The goal is to change to 150 Mbit/s and six parallel streams. This entails greater requirements to the network, in terms of latency and loss. The applications create traffic bursts, which is challenging for the network to handle.

4.5 Wireless network upgrade

Today, NRK uses wireless network from Fortinet (Meru). An upgrade of the network is needed in order to provide a better WLAN service.

4.6 Relocating DKs

Several of the district offices (DK) are in the process of relocating. The offices in Bergen and Steinkjer have already moved.
In 2018, the office in Kristiansand is scheduled to move, and the local office (LK) in Hamar will be expanded or relocated to facilitate overtaking some of Elverum's duties.

On these locations, parallel networks will have to be built, so that the moving process minimizes broadcast production impact.

The Network-section designs and engineers the network, the structed cabling system and the fiber.

4.7 Mini CDN

Distribution of streaming services is currently outsourced to external vendors, such as Akamai. There is an ongoing process in designing network solutions where NRK takes greater responsibility for this service.

4.8 Archive to the National library ("Nasjonalbiblioteket")

Part of the Origo-project. The goal is to increase the transfer capacity to the national library. The library forms the backup-solution for NRK's main video storage system.

4.9 New broadcast control system in NRK

NRK has entered into an agreement with Lawo to utilize VSM as control system for contribution of sound and video. The Network-section assists in the systems integration.

4.10 New network solution for MET (Norwegian Meteorological Institute.)

The scope of the project is to replace analog audio lines with IP technology in studios at MET locations in Oslo, Tromsø and Bergen.

4.11 Procurement agreements

- Ongoing benchmarking of WAN-prices, in cooperation with the Procurement department. The Network section specifies the technical requirements.
- Tender for internet transit is almost ready, and will be published soon.
- Framework agreement on wireless network will most likely be made in 2018

4.12 Internal projects in Network-section

Ongoing internal upgrades of the network, due to outdated/obsolete equipment or the need for more capacity or new services.

5   SERVICE LEVELS

There are no official requirements regarding service levels; however, it is expected that network services are always up and running. The network has redundancy for its components. End-user equipment rarely has more than one network interface controller (NIC), therefore an error in one component will have great consequences.

There is a lot of activity after regular business hours, for instance scheduled broadcasts, setup of broadcast-equipment for the next day and the need for network on external productions. Maintenance is mainly performed at night, due to the 24/7 nature of NRK's business operations. The Network-section often assists with adjustments and troubleshooting, even when the maintenance is performed on components outside the network-domain.

- WAN: Network section supplies Norkring with network SLA statistics related to the WAN service
- LAN: No formal SLA agreement.
- General network: Network monitoring and statistics
- Bifrost: No monitoring, but may see statistics.

6   SPENDING AND BUDGET

This information will be disclosed at a later stage in the process.

7   EMPLOYEES

The Network-section has nine employees, including the leader of the section.
The average age is rather high, with two employees over 60 and only one under 50 years old. One employee is on a 100 % long-term sick leave, and the section has hired a substitute to fill the gap. The employees mainly have technical education, and 2-3 are engineers (or equivalent). One of the employees has CCIE (Cisco Certified Internetwork Expert) certification.

Area	Position (FTE)	Comment
Systems planner	2,0	50% available position
Patching	1,0	100% sick leave (partly covered by substitute. In addition, some external resources)
IP-Telephony	0,5	50% available position
Security	1,3	
WLAN	0,2	
LAN	2,0	
WAN	0,6	
Internet	0,3	
Production	0,5	

Other services	0,1	

Table 3 - Employees

NB: the section-leader's contribution to operations is set to 50%

Two external consultants utilized on 40 % each, to compensate for a Network-section employee 80 % leased out. The external consultants contribute to daily operations.

8   NECESSARY HARDWARE, SOFTWARE AND FACILITIES

HW/SW/Facility	Description
Datek	Structured cabling and fiber infrastructure
Fortinet (Meru)	Wireless network. Maintenance contract with Atea.
Cisco	Switches, routers, etc. Maintenance contract with Atea and Datametrix (Internet routers)
F5	Load balancers, SSL-VPN. Maintenance contract with Atea (SSL-VPN) and Datametrix (load-balancers)
Checkpoint	Firewall security solutions. Maintenance contract with Atea
Avaya	IP-telephony solution (NetNordic)
Trio	Call center (NetNordic)
Viprinet	VPN for mobile production units
Internet security	Security monitoring of internet traffic provided by Telenor and NSM

Table 4 - Necessary hardware, software and facilities