“5G” TECHNOLOGY FOR LIVE PRODUCTION BEYOND THE ARCTIC CIRCLE

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ABSTRACT

A nationwide broadcasted live TV documentary programme in Norway was sent April 2017 and lasted 150 hours showing the trekking of reindeer from the inland to the coast of Norway. The TV programme was produced by the Norwegian Public Broadcasting Corporation during late wintertime along a 100 km route with constant movement of the production along the reindeer herd. With no infrastructure in the Arctic areas of Norway and no feasible satellite contribution service, a new emerging “5G” technology with phased array antennas was used for the contribution. A mobile ad hoc mesh network combined with the high power phased array antennas provided an IP mesh network with bi-directional data services from the mobile production room on a sled to the broadcasting infrastructure.

Figure 1 – Mobile production system for the live nature documentary programme (1)

INTRODUCTION

Making a live documentary programme of a constantly moving event in some of the most uninhabited, harsh and deserted places in the world presented an array of technical challenges with respect to production and contribution.

- **No available infrastructure.** Most areas between the start and end of the route had no roads, no houses, power or available telecom network infrastructure. All production units had to move on off-piste terrain covered by snow.
- **No planned route and timetable.** The production followed the reindeer herd as it moved along in the valleys and on the hills. The exact location and time of movement of the production of the reindeer herd could not be planned well in advance. The documentary production team had to follow the animals at their natural pace and route they chose.
- **Not feasible with satellite uplink.** Being above 70° on the northern hemisphere, conventional satellite uplink would require very high power, heavy support equipment and large parabolic dishes. The low, almost horizontal elevation angle would mean that uplinks station would have to be placed on high altitude mountain locations and exposed to harsh, highspeed wind conditions. Snow on the ground and lightweight mobile systems on small sleds would most likely have caused large vibrations on the parabolic dish, limited the quality and could have disrupted the contribution link.

New microwave technology with compact and powerful phased array antennas with narrow beams focusing the transmission power and reception power has some useful properties for live production and contribution. Digital phased array systems have the same functionality as conventional antenna systems on mobile installations as they appear to work like omnidirectional antennas. The antennas can be placed on units in movement, but with a significant difference since the antenna beams are narrow just like highly directive fixed antenna beams. The technology development towards phased array antenna systems can offer mobile operations significant increase of range, less multipath problems, less interference to other systems, and more efficient frequency utilisation with less demand for different frequencies in an area. All this is possible if the antenna beam is narrow like a spotlight beam.

Figure 2 – Location for the production in the northern part of Norway

The motion speed of the antenna beam in a digital phased array is so fast that no physical vibration or movement can break or disrupt the communication. To give an example, the antenna beam steering on a digital phased array antenna can maintain the beam direction to another unit even if these units would pass at a few meters distance from each other at the speed of sound.

The IP based contribution enabled by phased array microwave technology enables both video contribution on the move and other support services such as return video streams back to the field production unit, voice control services, remote control services, system maintenance services and other general IP networking services for the production team in the field.

SMART ANTENNAS

The wireless systems development is moving in the direction of smart antennas for increased capacity, bandwidth range and mobility based on making use of changing the radiation beam of the antennas itself. The common term of such antennas is “smart antennas” with several types of implementation.

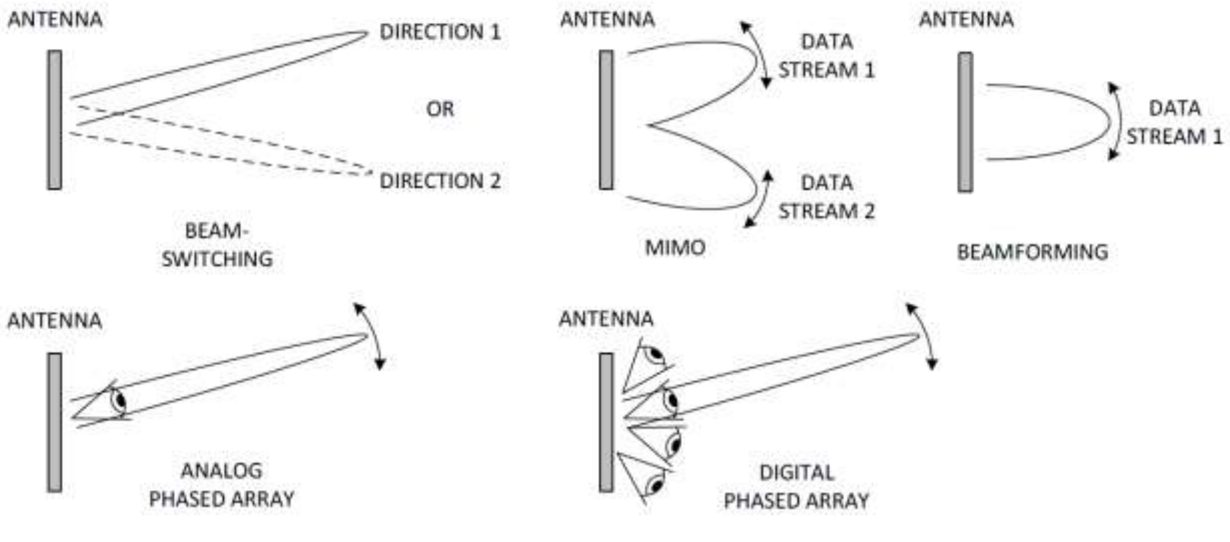

Figure 3 – Different types of smart antennas

Since there are so many different terms related to as smart antennas, we’ll try to explain the difference between some of the most common smart antenna implementations:

- **Beam switching.** Several conventional gain antennas are switched with RFswitches. The antenna needs to know from where a signal should come from.
- **MIMO.** 2, 3, 4 or 8 antenna elements are used with digital signal processing. Optimized to provide high bandwidth in areas with many reflections and limited speed of movement. Multiple streams are transmitted over a wide area and the different reflection paths available result in a very high transfer bandwidth.

- **Beamforming.** If a MIMO system is operated in an area with pure line of sight conditions between transmitter and receiver, it will by default change to a beamforming system. The digital signal processing and beamforming gives increased range, the antenna beam is steered to the direction of interest, and the bandwidth is reduced to a single data stream. The limited numbers of antenna elements in MIMO systems gives a wide beam depending on the number of antenna elements.
- **Analog phased array.** Consist of a high number of elements optimized to make a narrow antenna beam for long range communication. Analog phase shifters are used at the antenna elements to control the beam direction. The antenna can only focus the reception from a single selected direction, and hence, the antenna needs to know the direction from which a reception is supposed to come from.
- **Digital phased array.** Like analog phased array with a narrow antenna beam, but all processing is done by digital signal processing. The antenna looks for energy and reception in all directions simultaneously, and hence, doesn't need to know the direction of an incoming signal. The antenna can operate narrow beams in one or multiple directions simultaneously. The emerging 5G technology takes full use of digital phased array implementations with multiple digital antenna beams to enhance bandwidth and frequency spectrum utilisation, Figure 4.

MOBILE MESH NETWORK

The module network was configured for an IP connection from the mobile production sled to the headquarters with 7 Mbps live feed and 7 Mbps capacity for a return feed back to the production team on the sled with a view of the live broadcasted video. In addition, some capacity was used for IP connectivity, service, monitoring, control and voice over IP services. The maximum available transfer capacity for the data link system is 15 Mbps.

The operational range of the system is shown in Figure 5. Because of the terrain topography, the maximum operational range achieved for one hop was 63 km while the potential maximum range of each hop with this technology exceeds 200 km that has been demonstrated in other projects.

Figure 4 – Digital phased array panel mounted on top of the production sled. A single cable contains power supply and Ethernet.

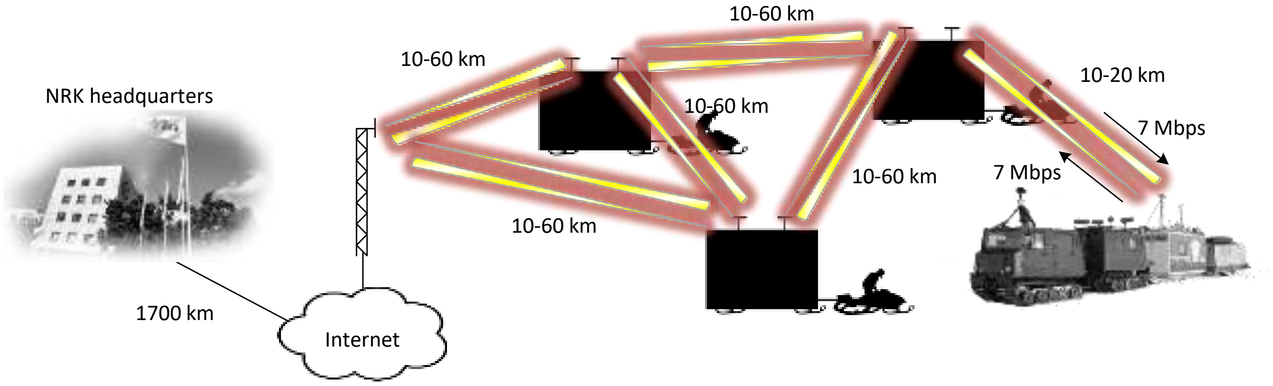

Figure 5 – IP Mesh based contribution system used in the production

As the operation moved along the route, the contribution coverage maps were updated using terrain model simulations. The IP relay sleds were moved into position, and the routes in the mesh were changed as the production entered new areas. Relay sleds released from service were then constantly moved to new locations and then re-joined the mesh network giving the network new routing alternatives.

Figure 6 – One of the IP relay station sleds in position. Photo by Jon Are Kolstad.

Since the production was constantly following the reindeer trekking, the exact route was not fully known in advance, and a mobile network planning tool was therefore used to plan the next positions of the relay stations as the route of predicted movement was updated.

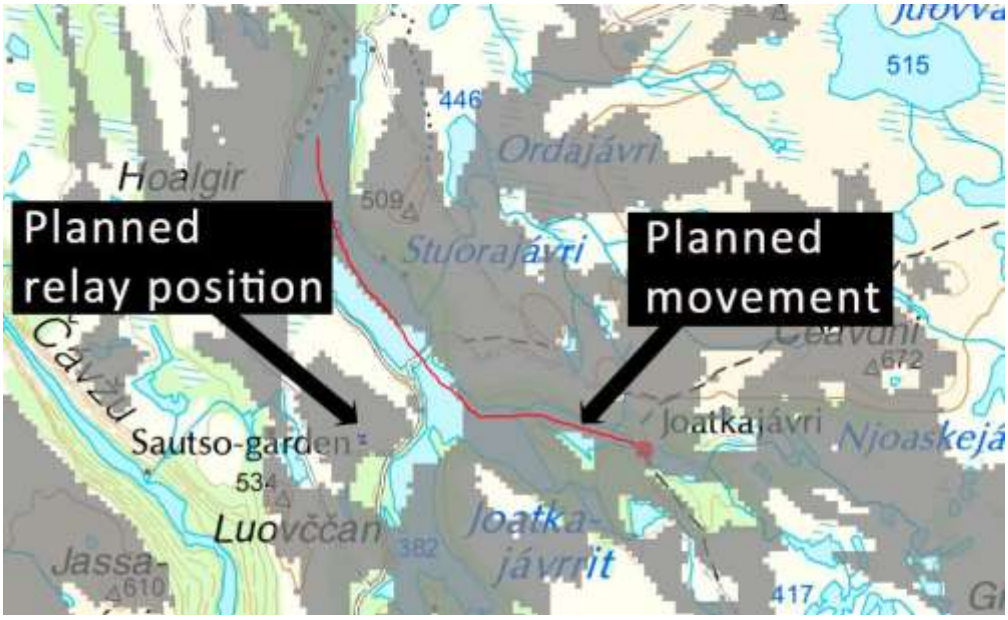

Figure 7 – Network planning on the move. Adjusting positions of the relay stations.

Movement along valleys required accurate coverage simulations while the production was on the move. The production used a field situation awareness/moving map/network planning tool that is currently used by the Norwegian Defence (2) for the coverage simulation and route planning. Figure 7 shows a typical situation where the grey parts are within coverage. By moving the relay station slightly more to the north east, the remaining part of the planned route would then be covered and the driver of the production team could then follow the planned route for the movement.


Figure 8 – Inside the mobile production room on the sled. Photo by Sindre Skrede, NRK.

The programme showed the reindeer in their natural environment with an example of the finished produced picture as shown in Figure 9. The programme also showed the life of the Sami people who shepherded the reindeer on their way to the coastline, and contained interviews as an uncut view of their living and culture. The concept of showing life live over a long period of time is commonly referred to as “slow TV”, and is a type of TV genre of live “marathon" television coverage of an ordinary event in its complete length. The recording of the complete programme can be viewed at NRK web service (3).

Figure 9 – Reindeer and nature shown live at morning sunrise

CONCLUSIONS

New digital phased array technology with powerful narrow beam antennas were used for a live documentary and nature programme broadcasted on the Norwegian nationwide broadcast channel NRK2. Three mobile IP relay stations on sleds were dynamically placed into positions and an IP based mesh system provided routing of the contribution stream from a mobile production room on a moving sled. In addition, return video stream and other IP networking data was routed back to the production sled in the field. The live documentary programme showed the nature, the trekking of reindeer and how the Sami people were living for a period of 150 hours.

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