Exploring Private 5G Networks

acriplex

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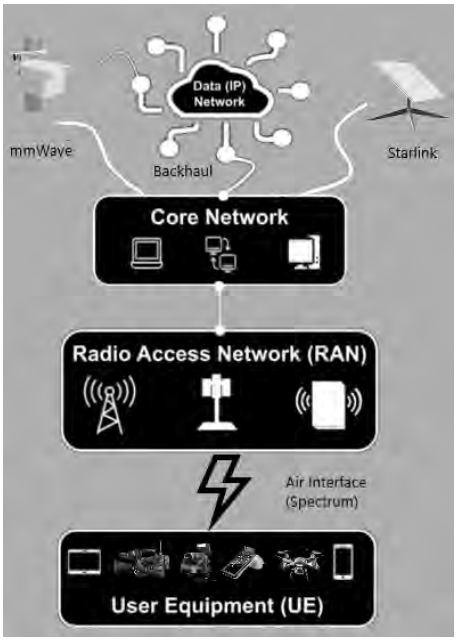
If you are involved with producing live coverage of sports, festivals, and livestreaming events you may have looked into Private 5g Networks (P5GN) as a tool that can enhance and streamline your technical setups and help things run smoother.

When you research what's involved you probably encountered a plethora of acronyms describing the elements of the network and said to yourself, "this is not going to be easy". Undoubtedly, a P5GN can get complicated if it's a large system and especially if you need to involve the cell companies. So, start small and you will find that it can be very easy indeed. A single-radio system is quite powerful and illustrates what is involved with the workflow and deployment.

Broadcast multi-camera contribution is only one use case where a P5GN excels. You can also use the network for many of the services involved with event coverage such as intercom, point-of-sale booths, ticket kiosks, video surveillance, audio and video connectivity, and more.

THE BASIC P5GN ELEMENTS



A basic private 5G network consists of four main components:

- **A Radio Access Network (RAN)** – the radios that send and receive signals
- **A 5G core** – the operational software, computer, and control app
- **User equipment (UE)** – the gear that connects to the network
- **Backhaul connectivity** – systems and networks connecting the private network to external resources

These components work together to provide a dedicated, secure, and high-performance wireless network that can access the web, be controlled from a cloud-based production center, or connect to a local OB Van production vehicle.

WiFi Network Topology

A P5GN is far superior to other wireless technologies such as WiFi, RF, and bonded cellular. While these systems have been around for many years and continue to improve they do not provide the capacity, reliability, latency, and networkability needed for demanding use cases like multi-camera contribution and AI-enhanced workflows.

Bonded Cellular

Bonded Cellular Backpack Contents

RF Wireless System

PRIVATE 5G COMPARED WITH WIFI NETWORKS

A WiFi network can meet the needs of many projects, especially less demanding applications like connectivity for point-of-sale devices, peer-to-peer messaging, and group viewing. In a production environment multiple devices streaming video, transferring files, and accessing the internet simultaneously will significantly reduce the available bandwidth for a single task making Wi-Fi a poor choice for any live production where a delay or frozen picture is unacceptable. WiFi 7 became available in 2024 and is gaining popularity. It offers significant improvement in bandwidth and coverage over WiFi 6; however, it retains its shortcomings when compared with superior networking technologies like P5GN.

Here's how Claude AI answered this question - how many WiFi 7 access points (APs) are required to match the coverage area of a single gNodeB radio running 5G CBRS?:

CBRS gNodeB Coverage:

- Operates in 3.5 GHz band (Citizens Broadband Radio Service)
- Typical coverage radius: 1-3 km outdoors, depending on power and environment
- Can cover roughly 3-28 square kilometers per cell
- Higher power transmission (up to 30 dBm for Tier 1 users)
- Better propagation characteristics for wide-area coverage

WiFi 7 Access Point Coverage:

- Operates primarily in 2.4 GHz, 5 GHz, and 6 GHz bands
- Typical indoor coverage radius: 30-50 meters
- Typical outdoor coverage radius: 100-300 meters, depending on power and environment
- Covers roughly 0.01-0.3 square kilometers per AP
- Lower power transmission (typically 20-30 dBm)
- Optimized for high-density, short-range connectivity

Rough Calculation: If a CBRS gNodeB covers approximately 10 square kilometers and a WiFi 7 AP covers about 0.1 square kilometers outdoors, you'd need roughly **100 WiFi 7 access points** to match the coverage area.

Setting up a WiFi 7 network comparable to a P5GN requires a strategic multi-point setup using point-to-point (P2P) wireless bridges for backbone connectivity, with outdoor and mesh APs providing local coverage. This takes time and technicians to set up every time you need the network.

USER EQUIPMENT (UE)

With a Private 5G Network you essentially become your own cell company and control all aspects of the network. The public never logs on so there's no congestion. Each device you want to use gets a dedicated SIM card (physical or eSIM).

The SIM card itself does not contain nor directly determine your device's IP address. Instead, it stores the unique subscriber number that identifies the device on the network. The private network then assigns an IP address to the device which allows it to route data to and from the network. This provides a high level of security and opens an entire world of connectivity, both locally and on the web.

There is a "data budget" which determines the number of devices that can connect at the same time. That budget is a combination of the MHz of the 5G band and the Mbps of the upload/download on the network. Encoders are used to convert raw camera signals and other sources to streams such as HEVC or ST2110 (plus many others). Some devices have a 5G modem built in so they can connect directly (like some cell phones). The amount of compression of the stream is guided by the signal quality needed for the production.

For a typical CBRS 40 MHz band, a single radio P5GN can accommodate 10 HD broadcast cameras at a modest 6 Mbs stream, or as many as 64 Smartphones, while still able to connect other services like remote camera shading, IFB and intercom, and return video.

What Devices Can Connect?

- **HD/UHD/4K Camera encoders:** Haivision Pro460, BSI Mini TX 5G, TVU systems, Vislink, LiveU, Peplink/Vitek, Teradek.
- **Smartphones and tablets:** Apple iPhone with IOS14+, Apple tablet with iPadOS 17+, iPad Pro (6th generation) and later, many Samsung smartphones like Galaxy S23, any other modern 5G compatible device.
- **Point-of-Sale systems:** Through 5G SA N77/N48 and any WiFi access point that supports 5G connectivity like Mikrotik Chateau 5G, Netgear Nighthawk M6 pro, Peplink with 5G like MAX BR1 Mini 5G.
- **Supports up to 64 devices per small cell:** When used with more than one small cell we can calculate 50-55 SIMs per cell to allow a headroom for handovers when devices are moving from Cell to Cell, so 200 devices in a four small-cell system.

Starlink Antenna Uplink

AcriPlex with mounted Starlink Mini

60 GHz mmWave System

5G Concentrator Antenna

BACKHAUL

A private network connects the User Equipment *within* a high bandwidth low latency coverage area, so now it needs to connect to the internet, external networks, or destinations like a location-based OB Van. The main methods of backhaul are satellite (Starlink), 60GHz mmWave wireless transmission, and direct Ethernet connection using fiber (SFP+) or copper (RJ45) cables. A 5G concentrator antenna can also point to a tower to access a cellular provider

The most secure and interference-free backhaul is wired Ethernet when you are close enough to an outlet in a building, but that is not always available for the types of productions best suited to a P5GN. When out in the field a Starlink connection is the easiest to set up, but bandwidth is somewhat limited for uploads and is subject to environmental interference. 60GHz mmWave connections offer a high-speed pathway from the 5G core CPU to a receiver that can be located near an internet connection or a local recorder, but the signal can be interfered with by rain, birds, trees, etc.

Backhaul does add latency from the source device to the destination, as low as 80ms using Haivision encoders. Encoders add their own latency at the source which establishes the baseline, then other processes the signal goes through will add their own. Starlink backhaul has the largest amount of latency as the signal gets encoded and then uplinked through space to a ground station connecting to the internet.

ENGINEERING VS. INTEGRATION

T-Mobile P5GN System

There are several single-radio systems introduced in the past year by System Integrators, typically a collection of off-the-shelf components secured in a small case or rackmounted in standard enclosures. Their orchestration software or front end to the 5G core are what sets them apart from each other. Most are geared for Industry 4.0 applications like Smart Cities, Smart Agriculture, mining and port automation. Some are for Europe and some for the US markets (related to the frequency bands they employ).

Neutral Wireless Etive System

Only AcriPlex has original engineering and manufactured components that truly make it a versatile, rugged, AC/DC-powered, plug-and-play single radio system that is easy to deploy and easy to use. It specifically targets broadcast production and livestreaming and can be used in any appropriate use case. The system works in both European (N78 band) and US markets (N48 CBRS, N77, N78 bands). We talked to rental companies to find out what they want to see and what they can readily support.

Waveriders 5G2Go

Obvios Dome 5G System used at Paris 24 Olympics

Radio with Starlink Mini Mount

AcriPlex connector panel

AcriPlex Backhaul Adapter

Pelican Air Shipping case

ENGINEERING VS. INTEGRATION (Cont'd)

AcriPlex incorporates a powerful computer that runs the 5G core software built into the radio unit which reduces the amount of cabling and simplifies installation. We developed a custom air-cooling system so the computer can use an advanced AMD Ryzen CPU with AI processing on board. It has plenty of cores to run additional software locally which reduces latency. It can run local AI agents for video analysis, image recognition, and network optimization. The system is controlled remotely by an app that runs on any device.

The power sub-system is custom-designed to run on either AC or DC. We had to design our own power system because off-the-shelf power supplies didn't work in our application. The batteries can be hot-swapped for continuous operation off the grid.

We built a custom mount attaching to readily-available heavy duty tripods used with HMI lights. There are also custom mounts for a Starlink Mini dish (with Power-over-Ethernet) and 60 GHz mmWave transmitter for backhaul. The radio has an Ethernet port to complete the backhaul options.

All the components fit into a single Pelican Air shipping case that can be checked in as airline luggage.

SUMMING UP

Many broadcasters, video production companies, and equipment rental agencies operate in fragmented environments that have evolved to their current state over decades. Essential elements of the production process are often executed in siloed environments and managed in islands of automation that are not well integrated. As a result, disconnected processes are cobbled together to capture images, process and edit content, and then prepare programming for distribution to audiences.

The Private 5G Network industry stems from the original work of the major cellular providers, who thrive on complexity and high entry barriers to promote reliance on their services. For P5GN to work, it needs plug-and-play simplicity that hides the complexity of 3GPP jargon behind interfaces that automate the hard parts. This is now possible with systems from AcriPlex and others that are beginning to make an impact.

Industry leaders are accelerating efforts to modernize investments in production and information technology to support new workflows and operations that will enhance their market positions. Private 5G Networks can lower operational costs, simplify location setups (no cables!), and diversify distribution mechanisms through the strategic application of internet protocol-based (IP) infrastructures.

Wireless Private 5G Networks will play an increasingly important role in the months and years to come.