User's Guide to Wireless Video

Prevent Costly Mistakes by Choosing the Right Wireless Technology

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Executive Summary

New technologies have greatly expanded the number of choices available to broadcasters for transporting live video from venues to studios. For example, cell-phone circuit bonding has now made it possible to transmit live video from anywhere that has good cellular coverage. Recent advances in Wi-Fi standards have increased the bitrates available for transporting video in local areas. Today, even uncompressed HD video can now be transported wirelessly using 1.5 Gigabit radio links operating at 60 GHz. Each technology has benefits and drawbacks, relative to specific applications and user environments.

Selecting the right wireless technology for each application requires analyzing the cost, bandwidth and reliability of a variety of potential approaches. As a vendor that offers a wide range of different wireless video products, VidOvation is uniquely positioned to provide information about the pros and cons of each different solution. In this whitepaper, we hope to provide clear, useful information to support fair comparisons between the various devices that are available on the market. Our goal is to help you choose the right technology for every network, thereby earning your trust and your business.

Introduction

Wireless video transport has been a key part of television broadcasting since the first over-the-air transmission tests were performed almost a century ago. The methods used to transport video signals from one location to another have continued to push the limits of each new technology that has come along, including coaxial cable, microwave, satellite, fiber optics and cellular radios. With high bandwidth signals, demanding QoS (Quality of Service) requirements and sensitivity to excessive delay, video has often been at the leading (or bleeding) edge of the capabilities of many technologies.

Building on these past successes, television broadcasters today have an enormous range of wireless video transport options. These range from dedicated links that support 1.5 Gbps uncompressed HD video to highly compressed video streams that run over Wi-Fi infrastructure. In between are devices and systems to fit virtually every application. With so many choices, it can be difficult to select a suitable product that offers the best combination of performance and reliability at a price point that makes sense for each project.

VidOvation was founded to offer a wide selection of video transport solutions, including many wireless products. With the perspective gained from this range of offerings, it becomes easy to objectively analyze the relative merits of different technologies. Each one has specific features that may make it suitable for use in particular set of applications but not in others. Because of the overall complexity of comparing such a wide range of technologies, the following discussion will be divided into four major sections. First, a number of criteria that can be used for selecting and comparing various solutions will be defined. This will be followed by a discussion of a few key applications that are particularly common for wireless video links. Then, the actual technologies will be analyzed, based on their potential applications and various selection criteria. Finally, some of the key data will be summarized in a comparison table.

Selection Criteria

Each wireless video technology has strengths and weaknesses that can be analyzed along different dimensions. The following list describes the key parameters that can be used to evaluate and compare the various wireless technologies.

Supported Bit Rates

The number of bits per second that can pass over a wireless connection is affected by many factors, including antenna selection, interference, distance and other factors. However, the two main factors that drive the potential bit rate of a link are the bandwidth of the signal (measured in MHz) and the modulation scheme.

On the basis of raw speed, wider channel slots (i.e. more MHz of signal bandwidth used for a connection) drive higher bit rates. In many frequency bands, particularly ones that are subject to licensing requirements, the width of each channel is regulated. In other bands, there are fewer restrictions, so wider channel widths can be used to support higher bit rates.

Modern modulation technologies can pack more bits into a given amount of channel bandwidth. Changing from a modulation technique that uses two bits per symbol (such as QPSK) to one that uses four bits per symbol (such as 16QAM) will double the bit rate on a wireless link without changing the channel bandwidth. There is, of course, a cost in doing this, with more processing power needed on both ends of the connection to generate and detect these more complex signals. Plus, there is another penalty associated with the more complex modulation schemes: they are more sensitive to noise and interference. This is why Wi-Fi signals, among others, will automatically adjust their modulation (and consequently bit rate) between more simple and more complex schemes to adapt to changing RF channel conditions.

One of the most technically advanced modulation schemes available is OFDM (Orthogonal Frequency Division Multiplexing) and its close relation COFDM (Coded Orthogonal Frequency Division Multiplexing). These technologies use hundreds or thousands of individual RF carriers within the channel bandwidth, each of which carries a low speed data signal. This technique makes it easier for the receiver to handle multi-path distortion caused by signal reflections, and also makes it possible to ignore certain types of interference. Of course, this complexity requires powerful signal processing chips. With COFDM, It also becomes possible for several devices to share a common RF channel, provided that each device is synchronized and controlled by a central base station. Because of these advantages, COFDM technology is widely used in 4G LTE cellular applications and some dedicated wireless video systems.

VidOlink COFDM Low Delay HD SDI Wireless Transmitters & Receivers

Link Distance

The total distance that can be covered between endpoints in a wireless link is affected by a combination of factors including frequency, antenna geometry, interference, and obstructions. These factors make precise distance calculations extremely dependent on local environments. However, some general rules can be defined to help guide technology selection.

Rule 1) Lower frequency bands support greater transmission distances, and are less sensitive to signal path obstructions. But low frequency bands are more likely to be restricted by the FCC (or other national authorities) to narrow channel bandwidths and hence limited bit rates.

Rule 2) More complex modulation schemes (such as 16QAM as compared to QPSK) that deliver more bits in a given channel bandwidth require greater signal to noise ratios to deliver an acceptable error rate. Other things being equal, shorter usable link distance limits will apply for more complex modulation.

Rule 3) Narrow-beam antennas produce higher gains than wide-beam ones, thereby permitting longer link distances to be used. Omnidirectional antennas having shorter range than either panel or parabolic antennas (See *Figure 1*).

Rule 4) Greater levels of interfering signals will reduce usable link distances due to a reduction in signal to noise ratio. Interference can come from many sources, including other equipment occupying the same frequencies nearby and consumer devices such as microwave ovens that emit RF energy. In general, heavily populated areas have much more ambient interference than rural environments.

Rule 5) Path obstructions, including buildings, power lines and trees or other vegetation will attenuate wireless signals and reduce usable range. High frequency signals tend to suffer greater attenuation than low frequency signals for a given obstacle. Extremely high frequency signals may only work if there is a clear line of sight from the transmitter to the receiver.

Video Interfaces

Video signals come in many different forms, and there is a wide range of products to support the various types of signal interfaces. This range of offerings can best be understood by separating them into several categories, such as analog vs. digital, consumer vs. professional, and by whether or not the signal is targeted for further editing and post production versus simply being sent to a display. Each of these criteria will determine the set of applications that can be supported by each technology and device.

Wireless analog video transmission has for the most part become obsolete, due to the inefficient use of RF spectrum that was typical for these devices. Instead most analog signals today are digitized and also compressed before wireless transmission. This includes audio signals even though these signals consume much less RF bandwidth. One application where analog video signals are still widely used today is (ironically) for delivering signals from computers to displays. Formats including VGA, RGB and DVI-A are all analog in nature, and therefore are rarely transmitted in their native form over wireless networks. Several different types of converters are available that can digitize and optionally compress these analog signals to make them easier to transport over digital wireless links.

Outputs from digital video cameras of all types, including professional, prosumer and consumer models are easily adapted for wireless video transport. The most prevalent professional interface is SDI (Serial Digital Interface), which comes in three main versions: SD operating at 270 Mbps, HD operating near 1.5 Gbps, and 3G operating at almost 3 Gbps. Each of these is an uncompressed digital video signal, using 10-bit resolution, 4:2:2 color sampling and a standard 75 ohm BNC interface (although several other connectors are used by various camera manufacturers). SDI can be video only, but it also supports multiple embedded audio channels and various forms of metadata, such as SMPTE time code.

Another increasingly popular camera output connector is HDMI, a 19-pin connector that supports multiple bit rates and resolutions of digital video, along with multiple channels of digital audio. The major advantage of an HDMI signal is that it can be connected directly to consumer displays, which are inexpensive and offer extremely high quality for all but the most demanding applications. Note that wireless transport of HDMI signals that originate from copyrighted sources (e.g. DVDs and Blu-ray discs) may not be possible due to the encryption system known as HDCP (High-bandwidth Digital Content Protection). The HDMI connector is relatively inexpensive and low profile, but it does suffer the drawback of not having a built-in cable retention system that locks the connector in place when being used. As a result, HDMI is most often found on consumer and prosumer cameras. Captive screws can be found on HDMI connectors and equipment in higher end Professional Audiovisual applications.

Other types of video interfaces are less prevalent for wireless applications, including S-video and DVB-ASI, and have little support in the wireless product space. S-Video, being an analog, SD signal is no longer in widespread use in most organizations. DVB-ASI (Digital Video Broadcasting Asynchronous Serial Interface) is common for systems that are transporting multiple signals over a single path, but in wireless deployments it is mainly used over fixed microwave links between facilities.

Video Formats and Compression

The best format for transporting video is in its native uncompressed state. Using this format prevents image distortions that arise from compression and eliminates the delays incurred by encoding and decoding the signal. There are a few wireless technologies that can support these bit rates; these can be easily deployed by broadcasters if the system setup rules are properly followed.

The vast majority of wireless transmission systems use compression to reduce the bit rate of standard definition and HD signals enough to fit within the channel capacities of the various wireless frequency bands. In a few cases, this compression is relatively light (meaning that a high bit rate channel is used), but in most cases heavy compression is required to reduce the bit rate so that it will fit within the available channel.

Compression technologies can be divided into two distinct categories: intra-frame and inter-frame. Intra-frame (also called I-frame-only) compression processes each image (frame) of a video sequence separately, with no dependence between adjacent frames. Inter-frame (or motion-compensation-based) compression can achieve higher amounts of compression (i.e. lower resulting bit rates) by only transmitting the differences between adjacent video frames.

In general, I-frame-only compressed streams are easier to edit and offer lower end-to-end delay, with the tradeoff of higher bit rates as compared to inter-frame compression. Technologies such as Motion JPEG, JPEG 2000, and AVCi use intra-frame compression and are commonly found on surveillance cameras that need to provide traceability of every frame of video for possibly use as evidence in the court of law. MPEG2, H.264, HEVC and related technologies that use inter-frame compression are widely used for wireless applications, particularly those that require very low bit rates.

Initial and Recurring Costs

Any wireless video solution will have some sort of an up-front expenditure, related to the costs of purchasing, installing and configuring the necessary equipment. Some solutions will also have a cost associated with each use. For example, a system that uses a cell-phone network for backhaul will need to pay for the data consumed by each transmission, either directly (as a bill for gigabytes) or indirectly (built into the cost of the service/device).

License Requirements

Essentially all of the wireless radio frequencies (literally DC to light) have been allocated to specific uses by the FCC or similar regulators in other countries. Most of the available frequencies require users to get licenses that specify exactly which RF channels can be used in which locations at specified power levels for defined applications. A few frequency bands are unlicensed, such as the 2.4 GHz Wi-Fi and the 60GHz bands, and are therefore available for anyone to use in any location provided certain limits on effective radiated power are observed.

Licenses to use specific radio frequencies are a good news/bad news proposition. The good news is that a license gives a broadcaster an exclusive right to use a particular frequency in a defined location for a specific period of time.

This helps ensure that other users will not create destructive interference with the signal. The bad news is the cost and the paperwork that are necessary to obtain the license, not to mention the time for the application to be processed. In addition, licensed frequencies may only be available in specific, pre-defined locations, making "grab and go" shooting more difficult.

Portability

The meaning of the term "portability" depends (like the meaning of "beauty") on the observer. In some contexts, portability means the ability to take a set of equipment, pack it into the shipping cases, and transport it from one location to another. In other contexts, portability means the ability to move cameras around a set or a location while they are in use to follow the action of a particular shot or scene. Fortunately, wireless technologies exist to support each of the following cases of "portability."

Case 1) On-camera portability requires wireless equipment to be fairly light and battery powered. In general, this also requires the use of omnidirectional antennas on the camera, which limits the amount of gain for the antenna and therefore the usable range of the wireless link.

Case 2) Site-to-site portability requires equipment they can be packaged appropriately for shipment and is able to be setup in a variety of physical environments. This type of equipment can use high-gain directional antennas to cover long distances, provided that secure mounting points can be provided and the enough time is available to properly install and aim the antennas prior to their use.

Case 3) Metro-area portability requires a means to transmit wireless camera signals from locations across a large geographic area back to a broadcaster's facility. For the past couple of decades, this has been done using central receive locations (often antenna masts on top of tall buildings) and using a portable news gathering vehicle with a telescoping antenna mast. In most cases these systems required a direct line-of-sight between the remote antenna and the fixed central antenna. Today there is a different option that uses wireless mobile telephone infrastructure installed by a mobile phone service provider that collects signals at multiple base stations (i.e. cell phone towers) located throughout the metro area. This new solution offers an unprecedented amount of flexibility for camera deployment in exchange for the ongoing expense of data subscription fees. Because the mobile telephone network is shared by all the devices in a given area, service degradations are not uncommon, particularly when large numbers of people are in the same location (perhaps at a breaking news event). At times, it can be difficult or impossible to transmit video signals when these networks are heavily loaded. The latest advancements in bonded cellular technology, proprietary high gain cellular antennas and cellular extender technology can combat these conditions in most cases and transmit a video signal out from a congested area.

Antenna Types

Antennas are a critical item for any wireless video solution, as they can have a big influence on the physical placement of transmitters and receivers. Some technologies can easily support omnidirectional antennas that broadcast equally in all directions, enabling great flexibility in device location. Other technologies use high-gain parabolic antennas, which must be properly aimed to permit communication. In between are a range of choices, including sector antennas covering various angles and multi-antenna solutions that deliver increased throughput using MIMO (Multiple Input Multiple Output) antenna arrays.

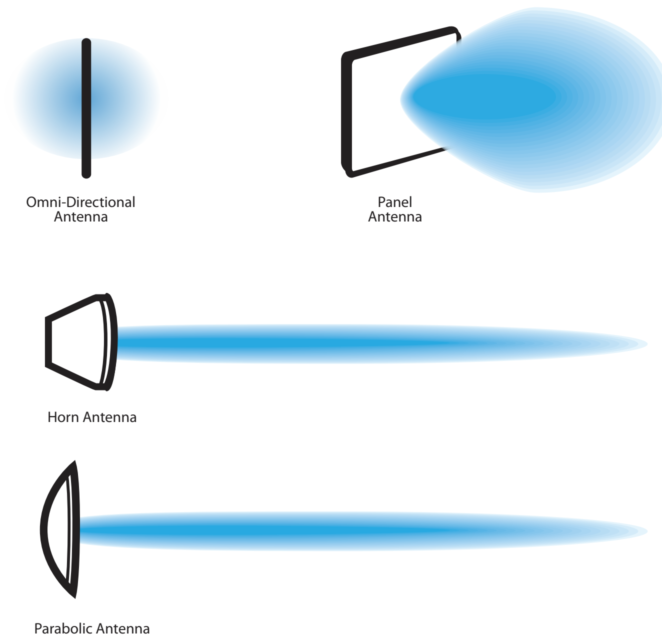

FIGURE 1 Antenna Coverage Comparison

Figure 1 illustrates four common types of antennas.

- *Omnidirectional antennas* can send and receive signals in from any direction, but have the lowest gain and the shortest range.
- *Panel and sector antennas* use a more focused beam that provides higher gain and greater range. Many different types are available, covering angles from 10 to 180 degrees.
- *Horn antennas* provide higher gain and a focused beam, often down to just a few degrees of angle. Careful aiming

is required to use this type of antenna, but they support long distance connections but have less range and less gain than its close cousin the parabolic antenna. Horn antennas have the advantage of a much smaller profile when compared to a parabolic antenna.

- *Parabolic antennas* provide the greatest gain and the most focused beam, often down to a single degree of angle. Careful aiming is required to use this type of antenna, but it can support the highest possible gain and the longest connection distance.

Wireless Applications

Sports

Live television coverage of sporting events has long been a major focus for wireless video technology. With predetermined schedules, predictable camera locations, and carefully negotiated broadcaster rights, these events are near-ideal sites for wireless technology. Prior to an event, antenna and receiver equipment can be installed in strategic locations. RF channel usage can be coordinated and tested in advance to prevent harmful interference between systems.

Many of the systems commonly used for sports today rely on private, licensed wireless frequencies. These same technologies can also be used for outdoor concerts and other forms of entertainment. Through the use of high-gain (i.e. narrow beam) antennas, potential sources of interference can be avoided. Handheld portable cameras can be equipped with omnidirectional antennas provided that adequate RF coverage can be generated in areas where the cameras will be operating. Video compression is used as needed to allow the signals from multiple cameras to fit within licensed bandwidth ranges.

News Gathering

News events fall into two broad categories: appointment-based and spontaneous. Appointment-based news includes events such as news conferences, public gatherings, feature stories, and other occurrences that allow a news team to pre-plan coverage and setup equipment in advance. In many ways, the technologies and practices used in this type of coverage are similar to those used in sports applications.

Spontaneous news coverage can be much more challenging from a technology standpoint. Fires, floods, accidents, and other unplanned events can happen in any location at any hour of the day. Traditionally, methods used for spontaneous live broadcasts typically involve sending a vehicle equipped with either a satellite uplink antenna or a telescoping mast carrying a microwave antenna. To work properly, these antennas need to be pointed directly at the receive antenna with few or no obstructions in-between. Cameras are typically tethered to the live remote vehicle using a fiber-optic, coax or triax umbilical to carry video, audio, and power to handheld or tripod-mounted cameras. In some cases, wireless links are used to connect between cameras and the vehicle.

Grab-and-Go-Anywhere Cameras

The ability to deploy a camera to an unknown location at any time without warning can give a great deal of flexibility to broadcasters, both for covering spontaneous news events and for truly mobile applications such as in a moving vehicle. To make this scenario practical, receive antennas need to be liberally distributed around a service area to pick up signals from cameras wherever they may be located. The logistics and expense of doing this would be beyond the means of the most broadcasters were it not for the widespread availability of cell phone towers. This infrastructure, which has been installed at huge expense over several decades is a near-ideal path for live video signals throughout a metropolitan area. Instead of having to build their own infrastructure, broadcasters can simply pay for bandwidth when and where they need it. Of course, since this infrastructure is shared by other broadcasters as well as by the general public, there is no way for a broadcaster to control how much (or how a little) bandwidth is actually available for a given video signal at a particular time and location.

Phased array satellite antenna technology is another option for moving vehicles. In this scenario a compact satellite antenna is mounted on the roof of the vehicle. Using GPS, the antenna tracks the satellite in the sky while the vehicle is in motion. One limitation of this technology is the necessity for a clear view of the satellite in the sky, which may make it impractical in urban areas with tall buildings or other obstacles.

Wireless Technologies

Traditional Private Microwave

Systems that use licensed, private microwave frequencies for video transmission have been in existence for over 50 years and have supported many live broadcasts. There are three main deployment scenarios in common use for this technology, including fixed links, central antenna systems, and fully portable versions. The equipment and antenna configurations differ among these applications:

Fixed link systems can be used to provide one-way and two-way connections between a pair of fixed locations, such as between a television studio and a transmitter site. Typically, these links use parabolic antennas that are located on towers to permit clear line-of-sight paths.

Central Antenna systems use antenna(s) located at a convenient location for the broadcaster, potentially on top of a tall building in a downtown environment or on the television transmitter tower. These systems can either use multiple fixed antennas pointed in different directions or a movable antenna that can be focused on different locations such as a news helicopter.

Fully Portable systems can be packaged into shipping cases and transported to the location of a shoot. Typically, these systems consist of a combination of camera-back units with omnidirectional antennas and rack-mount electronics packages that are connected to directional antennas that are mounted on portable towers or brackets.

From a technology standpoint, equipment to support these different applications is fairly similar. There are a number of different frequency bands in common usage (2 GHz, 6-7 GHz, 12-13 GHz and some others above 20 GHz). In general, these systems require licensing and frequency coordination, to make sure that each user has a dedicated RF channel to use in a defined area. As a result, the channel bandwidths are limited, forcing the use of video compression and advanced modulation techniques to squeeze as many bits as possible into a narrow frequency band. In addition, there is significant competition for some of these frequencies (particularly those that are desirable for other applications such as mobile telephones and satellite earth stations) which can make obtaining new channel licenses difficult or impossible in some circumstances.

Unlicensed Wi-Fi

Wi-Fi technology is familiar to most modern computer users as a primary means for connecting computers and tablets to network infrastructure. Many consumers and businesses operate private Wi-Fi networks, and a number of providers offer Wi-Fi connections in public areas such as airports, stores and restaurants.

Advances in Wi-Fi technology have driven bit rates higher over the past fifteen years, making it feasible to use it for some video applications. However, before deploying these solutions, it's prudent to analyze their benefits and drawbacks.

The 2.4 GHz Wi-Fi frequency band (ranging from 2.4 GHz to 2.47 GHz) is extremely crowded. *Figure 2* shows the channels that are available – notice that only channels 1, 6 and 11 do not overlap when used at their full bandwidth of 20 MHz. The heavy traffic within this frequency band is due to the great popularity of wireless connections for all types of portable equipment including laptops, tablets, security

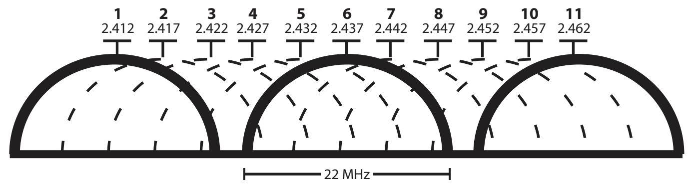

FIGURE 2 2.4 GHz Wi-Fi Channel Assignments

cameras, and many other devices. Also, because this band is unlicensed, there are essentially no protections that prevent another user from turning on their device and causing harmful interference at any time in any location. These factors often combine to make the 2.4 GHz band of Wi-Fi less desirable for professional quality wireless video transmission.

The 5 GHz band is a significant improvement over the 2.4 GHz band, although it is subject to most of the same technical issues. Historically, most laptop and tablet devices have not included 5 GHz Wi-Fi radios, so in general, the level of interference is much lower than at 2.4 GHz. In addition, there are significantly more non-overlapping channel frequencies available (a total of 21) in two blocks from 5.15 to 5.35 GHz and 5.47 to 5.825 GHz These factors combine to make the 5 GHz band a much better choice for professional video applications that use unlicensed Wi-Fi connections.

The latest generation of Wi-Fi devices (including 802.11n and 802.11ac) support MIMO capabilities. This requires the transmitter and/or the receiver to use several antennas to create multiple signal pathways. The data transmitted over these channels can be added together to boost the overall transmission rate to 600 Mbps and beyond. To achieve these extreme bit rates over short distances, three antennas must be installed on both the transmitter and receiver, and the local RF environments must be relatively quiet.

VidOlink 5G Low Cost HD SDI HDMI Wireless Link with Anton Bauer Battery Mount

As a rule, Wi-Fi systems use adaptive bitrate algorithms to ensure connectivity under rapidly varying RF channel conditions. While this is very desirable for forming reliable connections, it can cause havoc with video streams that won't work below a minimum bit rate threshold. Accordingly, some wireless systems built for video transmission have the ability to disable this feature, but these run the risk of losing connectivity if the RF environment deteriorates too much.

4G LTE/Bonded Cellular

Many manufacturers have recently come to market with video transmis-sion systems that combine multiple data links established using 4G LTE cellphone radio modems. To get the high data rates required for profes-sional video, multiple channels are "bonded" together. At the signal source, the video is parceled out into packets that are distributed across multiple cellular modems. These packets are then fed into one or more commercial mobile phone networks and subsequently delivered via IP connections to the receiving device which is typically located at the broadcaster's facility. *Figure 3* shows a typical architecture for these systems.

At the receiver, the multiple packet streams are gathered and realigned to put them back in the proper order since the delay through each channel may be different.

For routine usage these systems are very reliable and easy to operate. As long as adequate mobile phone network coverage is available, the signals are cleanly delivered with reasonably low amounts of delay. Problems can arise in two circumstances: on the edges of cellular coverage areas, and in locations where large gatherings of other users are present. As traffic loads increase, most mobile phone systems are designed to allocate smaller amounts of bandwidth to each user, which includes cellular data modems. When this happens,

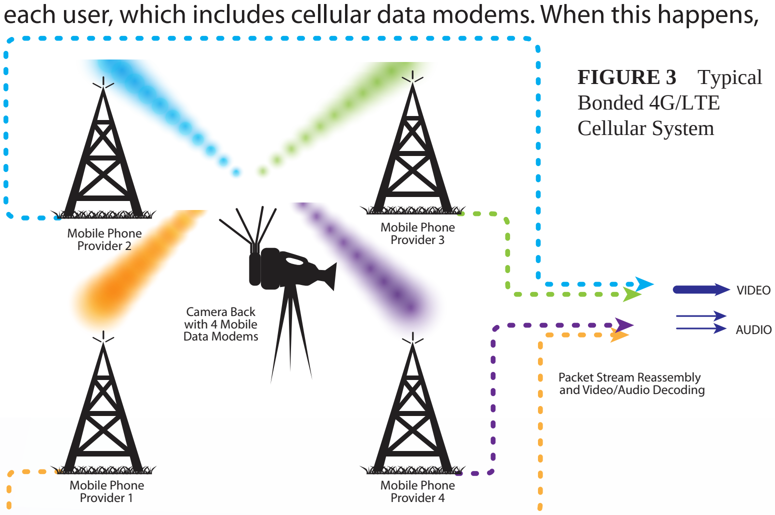

FIGURE 3 Typical Bonded 4G/LTE Cellular System

the encoder at the camera site must either drop the connec-tion or reduce the bit rate by using lower frame rates, reduced image resolution, or lower quality factors. In some extremely overloaded instances, the mobile phone infrastructure may refuse to permit new connections to be made or potentially even drop existing connections.

Some bonded cellular systems provide a range extender function. This may consist of special antennas designed to reach cell towers that are further away from crowded areas or a deployable device that connects remotely to the camera backpack system to perform the same function. Most devices also provide a mechanism to locally record video in the event of a complete loss of cellular connections; this content can then be transmitted once a cellular connec-tion is re-established.

60 GHz Uncompressed

New high-speed semiconductor technology has enabled the development of affordable, compact wireless systems that can operate in the unlicensed 60 GHz frequency range. 60 GHz systems on the market today offer completely uncompressed HD-SDI operation at 1.5 Gbps, including any embedded audio channels, metadata, SMPTE time code, etc. Because the signals are uncompressed, no encoding/decod-ing delay is present in the system, making it ideal for sports, live interviews and other time-sensitive applications. Solutions are also available in the 70/80 GHz and the 90 GHz frequency bands, including high speed Ethernet links that can support bi-direction GigE speeds, which is great for high performance IP video and audio networking.

Signals operating at these very high frequencies (also known as the millimeter band) have properties that offer some important advantages for video transmission. First and foremost, these signals are readily absorbed by the atmo-sphere, so there is a significantly reduced chance of a signal propagating beyond its intended receiver. This property also greatly reduces the amount of interference from other sources, and makes it possible for many devices to be used in close proximity. Another advantage of high radio frequen-cies are their short wavelengths, which permit use of very small, high-gain parabolic or horn antennas. These allow highly focused radio beams to be used, further limiting spurious reception and signal interference. Of course, there are limits to the distances over which these signals can be

VidOlink 60G-7 Single, Dual & Bi-Directional Channel 60GHz Microwave RF Wireless HD SDI Video Link with up to 750m Range

used, with a practical limitation of about 600m or 2000ft. Fortunately, this range is more than adequate for most venues.

One other significant advantage of the 60 GHz band is the fact that these frequencies are globally unlicensed. This means that 60 GHz systems can be used essentially anywhere, and do not require a permit from the FCC or other local agency. This can be a boon for rapid deployment applications where quick installation is paramount.

Choosing the Best Solution

Each of the wireless solutions discussed in this white paper have benefits and drawbacks, and no single product will work in every situation. As a result, many broadcasters routinely use two or more different technologies, and frequently combine technologies for specialized applications. Answers to the following questions will help determine which wireless technology is the best fit for each potential user's application.

1) *What is the typical amount of time available to deploy the system before use?* Are deployments normally made on a schedule that is known well in advance (such as for a sporting event) or is the system to be used for breaking news? The answer to this question helps determine whether or not a licensed technology can be used, and how much time can be spent to erect antennas, run cables, etc.

2) *For each deployment, will the cameras be used within a relatively small area, or will a large degree of mobility be required?* The answer to this question has a big impact on the types of antennas that can be used and how the coverage area is planned.

3) *How often will the system be used, and for how much time will the link be active during each use?* The answer to this question will help determine if a system with a monthly recurring cost or a usage cap is appropriate.

The staff at VidOvation have experience with all of the major wireless video technologies, and can offer relevant advice on selecting the right solution for each application. Please call 1-855-VidOvation (843-6828) to speak with one of our experts.

Comparison Matrix

	Fixed Microwave	Portable Microwave	Unlicensed Wi-Fi	Bonded Cellular	60 GHz
Bit Rates	20-50 Mbps	5-50 Mbps	5-200 Mbps	1-20 Mbps	1.5 Gbps
Link Distance	1-50 km	1-10 km	0.1-5 km	N/A	300-500m
Video Interfaces	ASI, SDI, HD-SDI	ASI, SDI, HD-SDI	SDI, HD-SDI, IP	SDI, HD-SDI	HD-SDI
Video Compression	Light to Medium	Light to Medium	Light to Heavy	Heavy	None
Initial Cost	High	High	Low	Medium	High
Recurring Cost	None	None	None	$500/month for up to 50 Gbytes	None
License Required?	Yes	Yes	No	No	No
Portability	Not	Limited	High	Within Cell Coverage	High
Antenna Types	Parabolic	Parabolic	Omni or Dish	Omni (typical)	Parabolic
Example Product	TBD	TBD	VidOlink COFDM & VidOLink 5G	LU-500	VidOlink 60G