LiveU
Portable Uplink Solutions

# Beating Cellular Congestion

Smartphone and tablet usage is continuing to rise. More devices are appearing, and more users are utilizing data services via a wealth of applications. In congested areas, such as large sporting events, shows, demonstrations, and other situations with large numbers of people trying to use their gadgets at the same time, mobile bandwidth overload can cause services to break down.

Newly introduced LTE networks, which provide tens of megabits of bandwidth in each direction are still limited by the laws of physics, and will not solve congestion, since the content delivery applications are also becoming more and more bandwidth hungry.

Cellular network congestion poses a challenge to live mobile uplink devices and technology, under certain circumstances, since live video transmission from overcrowded areas is a typical scenario that may be susceptible to video quality degradation due to cellular overuse. The physical terrain may also impact cellular connectivity, including distance to towers, and barriers between the cellular devices and the towers such as walls, buildings, and more.

This paper provides an overview of the cellular congestion phenomena, its nature, behavior and effect on the service, and how the LiveU Xtender and Microwave technologies help to overcome this problem:

- The LiveU Xtender external antenna, serving as a bonded cellular relay, provides additional uplink bandwidth, and allows connection to remote, uncongested cells
- The LiveU Xtender external antenna, helping to obtain signal through barriers, such as thick walls inside buildings and other structures, where signal may be too weakend for other cellular devices to obtain.
- A microwave transmitter allows connection directly to a remote internet access point, or to further remote the Xtender to non-congested cellular clusters

## Tackling Cellular Networks Overload

Mobile operators are currently using several techniques to try and resolve network overload:

- Adding temporary radio elements such as micro and Femto cells near the congested area, for the duration of the event
- Diverting traffic to older 2G cellular technologies
- Offloading to Wi-Fi
- Applying traffic management techniques that more efficiently shape, throttle and prioritize the service flows according to flow type.
- Long term: Upgrading the cellular networks to a more advanced generation (LTE, LTE-A)

However, just as in dealing with congested roads and highways, even after applying the above congestion avoidance techniques, some extreme scenarios may simply be too overwhelming and much of the congestion still remains. Essentially, there are too many people using too many network-hungry applications in places where the wireless edge of the network does not have capacity or where there are bottlenecks in the base stations or in the backhaul.

## LiveU Congestion Counter-Measures

Given that cellular congestion cannot be completely avoided for the foreseeable future, LiveU has developed a remote Xtender solution combined with microwave technology, which offers an innovative approach that circumvents the overloading condition, by connecting to remote, uncongested cell towers or directly to the public network.

**Contents:**



### LiveU Xtender

The LiveU Xtender is a portable external antenna unit that increases network reception and provides additional resiliency for live video transmission in extreme scenarios, such as heavily crowded locations. The Xtender essentially increases the network reception of LiveU's field units.

The LiveU Xtender adds enhanced RF antennas and seven additional network connections (six cellular modems and one Wi-Fi) to LiveU's professional-grade devices and covers all current 3G/4G LTE cellular network bands worldwide.
The Xtender connects to LiveU's units by using one of the following:

- LAN (for a direct connection between the LiveU Xtender and the LU device).
- Wireless connectivity between the LiveU Xtender and LU device

### LiveU Microwave link

LiveU's microwave solution is a rugged, hi-power, very linear 2x2 MIMO microwave radio with enhanced receiver performance. It features excellent range performance (several km/miles) and high speed (>15Mbps).

The LiveU microwave link utilizes unlicensed carrier frequency options– either 2.4Ghz or 5Ghz.

The figures in the next section demonstrate how the Xtender can help to overcome network congestion, and to keep the video uplink path clear and fully serviceable.

## Cellular Congestion Scenario

Figure 1 illustrates an example of 4 cellular clusters topology – cluster a, b, c & d. Each cluster is composed of 7 cells, each cell with S duplex channels (total of 7xS duplex channels per cluster).
The figure shows how the same S(i) duplex channels are re-used on each of the four clusters.

Now let's locate an LU70 device at cell S3a. This LU70 will be able to connect to cluster "a" (any of 7 cell towers - S1a to S7a) and transmit live video. If this cluster becomes congested with cellular users, total uplink will rapidly deteriorate, and the resulting service will be poor or even non-existent.

Unfortunately, the LU70 will not be permitted to connect to remote clusters (b, c or d), since this would violate channel re-use policy.

## Cellular Congestion Scenario With LiveU Xtender

Let's add a LiveU Xtender adjacent to the LU70, as shown on figure 2. The Xtender will likely alleviate the bandwidth deterioration, since it will add more uplink channels, and will improve the signal quality, and the associated bit rate per channel.

However, neither the LU70 nor the Xtender will be permitted to connect to the remote clusters, since this will violate the channel re-use policy.

The Xtender will add more uplink bandwidth, but since it is in the same congested cluster, its additional bandwidth gain will be relatively low.
See Figure2

## Cellular congestion Scenario with Remote LiveU Xtender

Let's leave LU70 at S3a cell, but relocate the Xtender to S3b cluster vicinity, as shown in Figure 3. The Xtender will now be able to connect to cluster "b" (any of 7 cell towers – 1b to 7b), which is far from the congested area and thus much less prone to congestion. The Xtender will be connected to the LU70 via a point-to-point microwave link, as depicted by the arrow above. Since the Xtender is using another, non-congested cell cluster, it will provide significantly higher bandwidth than in the previous scenario.
The further away the Xtender will be located, the less it will be affected by network congestion experienced in cluster "a"'s vicinity.

The effective distance that yields a good bandwidth gain varies and depends on the specific cell topology, local topography, antenna gain, weather and RF obstacles. If the Xtender is located at a distance of 1000 yds (approx 1 km) or more from the congested area, and has Line of Sight to the LU70, in most cases the video bandwidth will be sufficient for HD streaming.

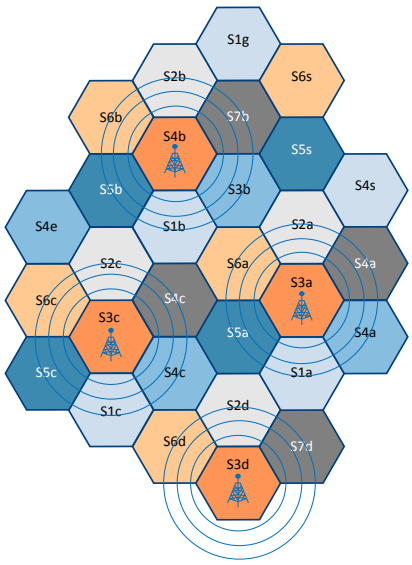


Figure 1: Cellular Clusters

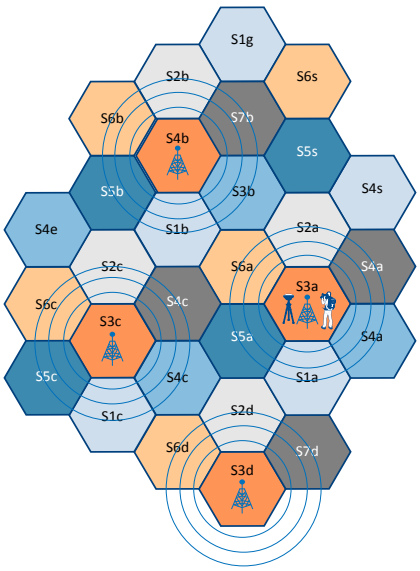


Figure 2: LU70 + Xtender at cluster "a"

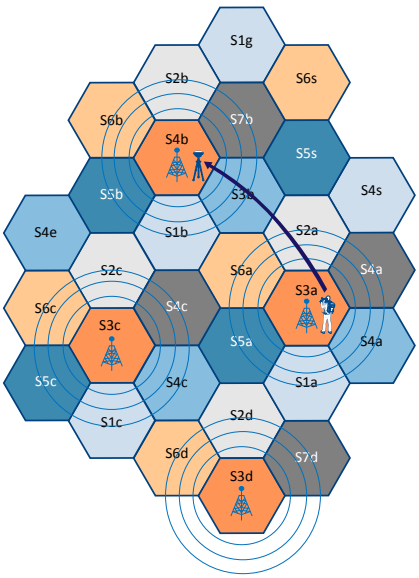


Figure 3: Remote Xtender Topology

## Effective use of the Xtender with a Microwave link

As explained above, we should aim to locate the Xtender as far as possible from the congested network area.

When possible, site planning should be done prior to the live event in order to ensure reliable, stable and high quality video streaming throughout the whole event period in the active area.

The planner must take into consideration the technical constraints of the wireless link, the local topography, the anticipated congested area boundaries, the desired location of the camera and LiveU unit, country regulations, previous field tests results, and more.

The LiveU field device transmission profile should also be optimized for the specific type of the broadcasted event:

Longer delay profile will yield better streaming stability, while maintaining high video quality. Long delay profile is an excellent choice for events such as press conferences, court room trial coverage, or a similar events. Lowering the video resolution will further increase the session resiliency and stability, at the expense of the video sharpness, and will allow reasonable quality even when the overall uplink bandwidth is poor.

Proper planning, based on all applicable considerations, will yield an optimal and satisfying use of the Xtender.

### Microwave link with Line Of Sight

The camera operator is shooting at a crowded sports stadium. The Xtender is placed either at the top of the stadium, or on a hill nearby, a tall building, or on a tall mast, with line of sight (LoS) to inside the stadium. The recommended distance between the LiveU device and the Xtender is about 1 mile (1.6km).

A 5 GHz LiveU microwave device, functioning as a base station, is attached to the Xtender, with a 180 degree directional antenna aimed towards the stadium at the center of the antenna radiation lobe. Another 5 GHz device, functioning as a client side, is attached to the LU device, with an Omni antenna (360 degrees). The point-to-point microwave link between the LU and the Xtender is automatically established once the microwave device is powered up and aimed correctly. Wrong alignment of the antenna will yield poor on no reception signal.
See Figure 4

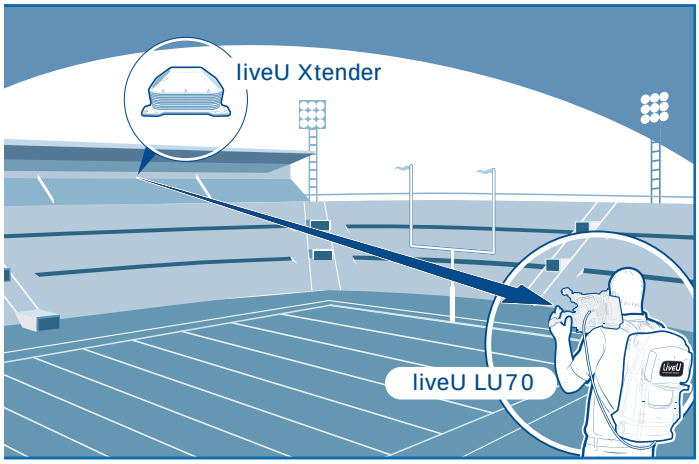


Figure 4: Microwave Link with LoS

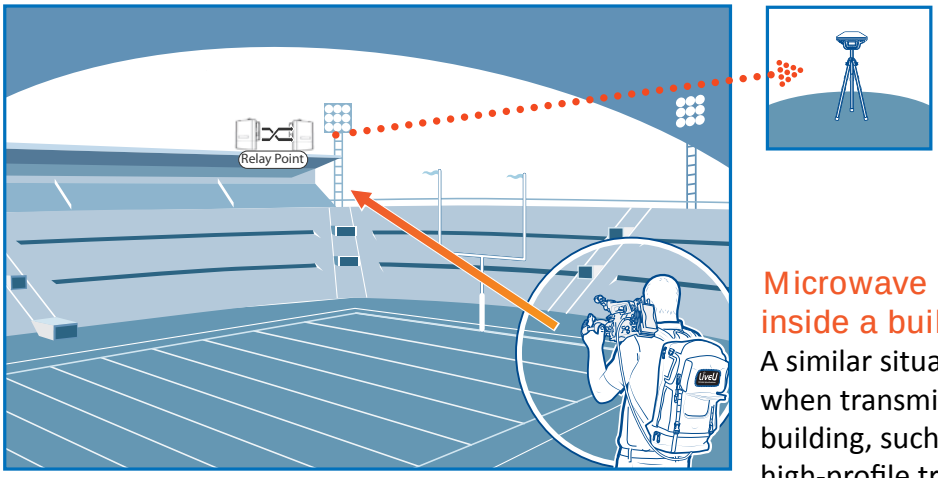


Figure 5: Microwave Link without LoS

## Microwave Link with no Line-of-Sight

If the site and surrounding area topology do not allow positioning the Xtender far away enough at line-of-sight, we can use a relay topology, in order to allow smooth streaming under no line-of-sight conditions.
For this purpose, we will use an additional pair of LiveU Microwave devices connected back to back (Ethernet to Ethernet), in the following topology:

The LiveU device / Camera will move freely in the stadium, transmitting to the Xtender through the relay point.

The Relay point will be located at the top of the stadium, with one set of directional antenna aiming towards the stadium area (~180o), and the other set towards the remote Xtender (Directional antenna can be as narrow as 45º, aiming towards the Xtender). The overall wireless p2p delay, even with two hops, will still be negligible, compared to the overall glass to glass delay.

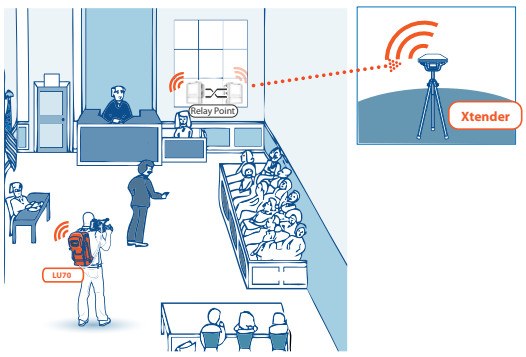


Figure 6: Microwave Link Indoors

## Microwave link with no Line-of-Sight inside a building

A similar situation might be encountered when transmitting from a room within a building, such as a court room, where a high-profile trial is being conducted: Live streaming at low delay from this court room can be challenging, since the cellular coverage might be poor or even actively jammed. In such situation, we can apply one of the following topologies:

- Locate the Xtender at an external window or open space area near the court room, with line-of-sight to the microwave transmitter/LiveU device.

- If a window or open space is too far from the camera location (that is - no good connectivity between the LiveU microwave transmitter and the Xtender microwave receiver), we can locate the relay point at a midpoint between the Xtender and the LiveU device. The mid-point relay will forward the stream to the LiveU server via the Xtender, which is located at a nearby open space location, as depicted in Figure 6

For the inside building wireless p2p segment, a 2.4 Ghz pair will likely work better, since it penetrates solid obstacles more efficiently than 5Ghz as shown in Figure 7.

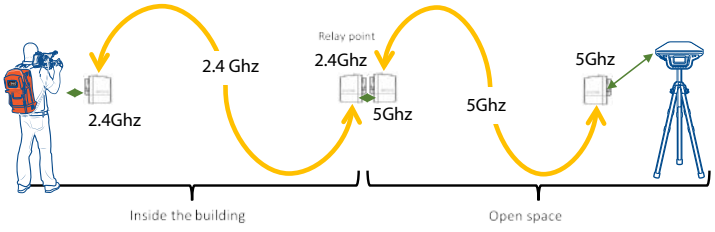


Figure 7: Reciever Frequencies

## Direct Microwave Link to a Public Network

In many cases, a nearby location has access to the public internet.
This might be the case when the nearby location is one of the following:

- Wideband Ethernet connection to the internet– either a home router, corporate network, or similar established connection
- A satellite truck with Ethernet connection and >5Mbps active satellite data channel
- A Microwave tower that is point-to-point connected to a far away Microwave dish with corporate network or public network connectivity
- Established fixed receiver hub network for wireless reception in major cities. Such fixed wireless networks can eliminate the need for satellite or cellular based streaming

In such cases, the LU device can connect directly, via a pair of microwave devices, to the public network, even without the Xtender, as depicted in Figure 8.

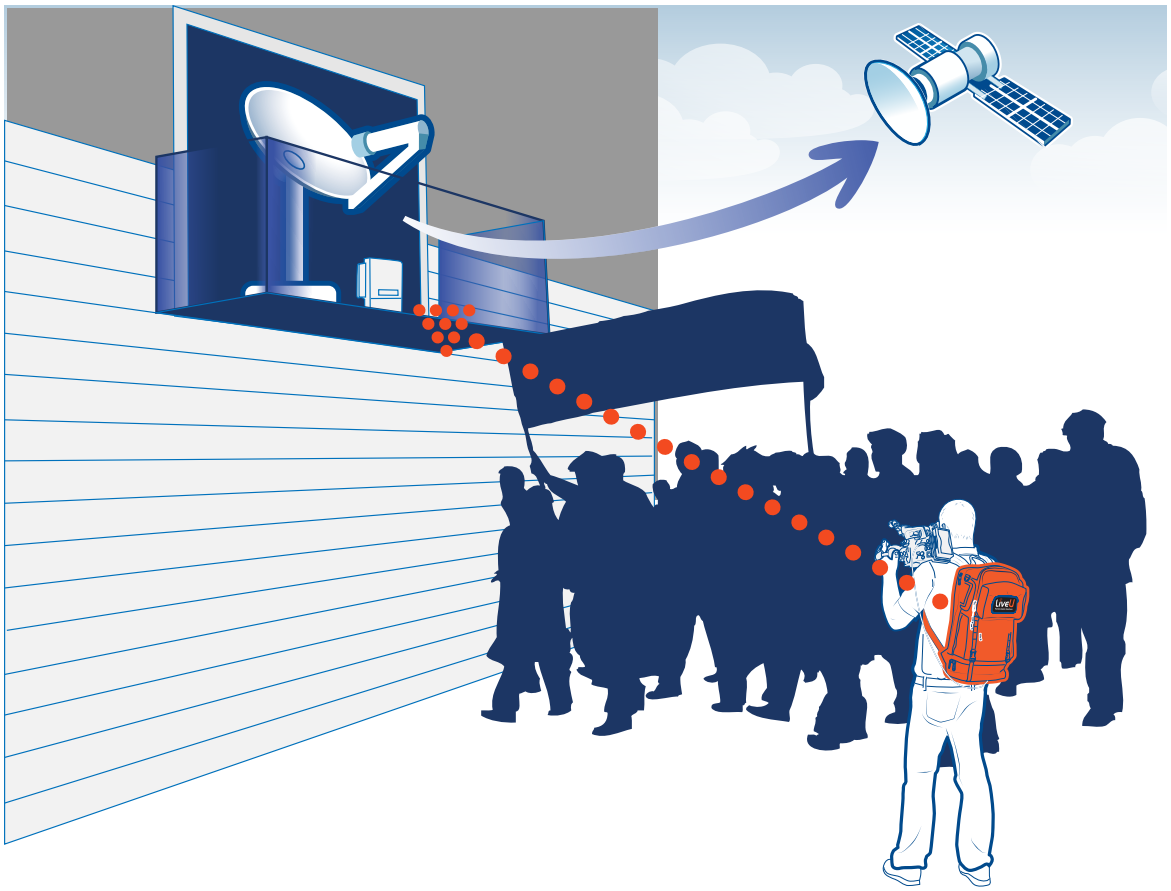

Figure 8: Direct Microwave Link

## Real World Examples

At two large events (30,000 and 55,000 people), and once inside a building with poor reception, the LU70's performance was tested with and without the LiveU Xtender. The outdoor events both took place in crowded stadiums in the center of a large city, where the large number of visitors caused cellular congestion.

The tests at these events demonstrated the LiveU advantage: The combined Microwave link & remote Xtender significantly increases streamed bandwidth performance, especially in extremely crowded and congested areas.

### Sporting Event

At a large sporting event, the LiveU LU70 was placed on the ground near the field in the stadium. The LiveU Xtender was positioned on top of the bleachers of the full stadium in a heavily crowded area (See Figure 4). The LiveU Xtender and the LU70 were connected using the wireless connectivity kit to provide aggregated bonded bandwidth. Analysis of internal log files compared the LU70 performance alone versus its performance with a LiveU Xtender proved a significant additional aggregated bandwidth Results are listed in the table (top right).

### Rihanna Concert

At a Rihanna concert in an outdoor venue (55,000 fans), the LiveU LU70 was placed on the ground about 150 yards (137m) from the stage. The uplink bandwidth for the stand-alone LU70 was almost null at the beginning of the concert. The LiveU Xtender was then positioned on top of a hill about 1000 yards (914m) away, with line-of-sight to the LU70 unit.

The LU70 established a microwave connection to the remote Xtender a few seconds after the Xtender completed its power up boot, and achieved over 1 Mbps stable streaming. While the LU70 operator had no cellular service, and could not even send a single SMS, the LU70 was seamlessly streaming through the remote Xtender with no interruptions.

| LiveU Xtender Adds ~132% to Streamed Bandwitdth | | |
|---|---|---|
| **Device** | **Aggregated bandwidth** | **Kbps per Modem** |
| **LU 70 Alone** | **581.1 kbps** | **83.3** |
| **LU70 + Xtender** | **1.3-1.6 Mbps** | **193.7** |

### Xtender inside a Building

The Xtender was tested while trying to transmit from a high-rise building in a large city. The test took place on the 14th floor of the a regional court building.

Prior experience at this venue was that cellular signal reception was poor, and in order to get any signal, the LU70 had to be placed near the window. Under such set-up, a typical aggregated bandwidth was 200 to 400 kbps.

An Xtender was positioned near the window and was connected wirelessly to an LU70 that had been re-located into an internal office room.

Figure 9: Xtender in a Low Service Area

# Summary

LiveU combined Xtender and microwave technology demonstrated its power and ability to boost the quality and stability of live video transmission from congested or poorly covered locations, without sacrificing the freedom of the camera operator to walk around and capture ongoing events at high resolution and stability. The Xtender's quick set up, and its lightweight packaging, enables the user to easily carry it to the best uplink point and establish live streaming in few minutes.

The Xtender will boost video streaming quality and stability in the following typical cases:

- Poor cellular coverage areas
- Inside a building , with many RF obstacles and attenuators
- Remote relay for cellular congested locations/events

The Microwave link, along with its optional relay mid-point, enables further service boosting, by:

- Remote connection to the Xtender from as far as 3 km (about 2mi)
  - Point-to-point direct connectivity with Line Of Sight
  - Point-to-point connectivity through a relay point for Non Line Of Sight situations
- Connecting to a remote internet access point / Satellite truck
- Connecting to the internet through an established  microwave receivers network