Application Note

Optimizing the Onsight Experience in Low and Variable Network Bandwidth Environments
v5.0
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Introduction

Onsight Devices work with a variety of networks including standard WiFi, LAN/WAN (Ethernet), cellular and satellite. Due to the sometimes scarce and variable nature of bandwidth, Librestream has included a number of bandwidth management features and configuration options to optimize the collaboration experience with Onsight.

The purpose of this Application Note is to identify the bandwidth management options, recommend optimal configurations and share best practice tips for operation in the different network environments.

Network Overview

There are many factors that can affect bandwidth and the impact of these factors differs across the network types. Onsight devices are often connected through WiFi networks, but there are a growing number of use cases where Onsight devices are connected through cellular and satellite networks. While all networks share bandwidth limitations, cellular and satellite networks introduce additional management requirements.

Cellular

The Onsight devices operate in cellular environments with 3G-WiFi router products like the CradlePoint PHS300. When connected to the network through one of these products, the Onsight collaboration experience can encounter both low and variable networks. Issues such as signal strength and the number of users connected to a particular cell tower will impact both the amount and variability of available bandwidth. To provide a high quality live video collaboration session, this variability must be managed.

Satellite

Satellite networks through BGAN and VSAT terminals introduce additional requirements to limit bandwidth usage. These networks typically have less bandwidth available for Onsight video sessions and can also incur substantial costs if usage exceeds contracted levels. For this environment, Onsight provides many options that can reduce bandwidth requirements and also ensure that bandwidth levels stay within the required levels.
Onsight Sample Network Diagram

- **Internet**
- **SIP Server**
- **FireWall**
  - Open Ports:
    - SIP udp/tcp: 5060
    - SIP-TLS tcp: 5061
    - UDP ports: 58024 - 58523

- **PHS300 with USB Cell Modem inserted**
- **LAN**
- **Onsight Device**
- **Onsight Expert**
- **Cellular Link**
- **WIFI Link**
Onsight Bandwidth Optimization Options

There are many features built-in to Onsight that enhance performance on low or variable bandwidth networks. These options include:

- Video Media Configurations
- Audio Codec Management Options
- Image Sharing Collaboration
- Deferred Collaboration
- Bandwidth Adaptive Streaming
- Bandwidth Restrictions
- Bandwidth Test Tool
- Quality of Service (QoS)

Media Configurations

Video Parameters

You can set-up custom video and audio media configurations that use as little as 24 Kbps all the way up to 2.5MB. The video parameters for these media configurations include:

- Configurable Video Resolution e.g. “Viewfinder video” – 160 x 112
- Frame Rate: 1 – 30 frames per second
- Group of Pictures (GOP) settings
- Target bit rate: 8 Kbps – 2500 Kbps
- Hard Limit or Soft Limit Bit rate control

The default ‘Low’ Bandwidth configuration that ships with Onsight (i.e. 320x240 – QVGA) uses approximately 250-300 Kbps for video.

Onsight Expert Media Configuration

1. Go to the Edit/Media Configurations menu.
2. Press ‘Add’ to enter a new configuration, ‘Modify’ to edit an existing one or ‘Copy’ to start with an existing configuration

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1 New Feature: Version 4.2, added Viewfinder video resolution 160 x 112
2 New Feature: Version 4.2, added 1 to 30 frames per second
3 New Feature: Version 4.2, added Group of Pictures (GOP) configuration
4 New Feature: Version 4.2, added Hard and Soft limit bit rate control
5 New Feature: Version 4.2, added option to Disable Subject Audio
3. When adding a configuration, set the name.

4. Select the configuration options you want, as below.
Onsight Device Media Configuration

1. Go to the Onsight device main menu.
2. Select ‘Stream Setup’.
3. Choose stream quality ‘Custom’.

4. Select the Custom Stream Configuration settings for low bandwidth. E.g. 160x112, 3 FPS, Target Bit Rate: 96 Kbps, Target Video Bitrate: 96 Kbps, Hard Limit.
5. Tap on the ‘Audio’ tab.
6. Set the Preferred audio codecs. E.G. Voice: Low bitrate (GSM6.10), Subject audio: Disabled, Audio efficiency: Lower bandwidth
7. Tap on the ‘Details’ tab.
8. The current bandwidth details are displayed based on the current Custom stream configuration.

<table>
<thead>
<tr>
<th>Video</th>
<th>Audio</th>
<th>Details</th>
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<tbody>
<tr>
<td>Voice</td>
<td>Low bitrate (GSM8.10)</td>
<td>Preferred audio codec:</td>
</tr>
<tr>
<td>Subject audio</td>
<td>Disabled</td>
<td></td>
</tr>
<tr>
<td>Audio efficiency</td>
<td>Lower latency, lower bandwidth</td>
<td></td>
</tr>
</tbody>
</table>

Note: Subject Audio is disabled so 0 bps is displayed for the stream, however there is still some Overhead traffic (533 bps) associated with Subject Audio to keep the channel available to the Session.


**Best Practice Tips**

1. Setting a ‘Hard Limit’ for the Target Video Bitrate will constrain bandwidth so that video performance will be poor if you have set a resolution and frame rate too high for the specified bandwidth.

2. When setting the Target Video Bit Rate use the table below to approximate the required bit rate for the video parameters. The bitrate required to stream video is associated with the amount of motion in the video, a lot of motion means more information is sent therefore a higher bitrate is required, less motion requires less bitrate. The following table represents an average bit rate assuming moderate motion in the video, i.e. walking while streaming video or scanning the surface of an object during inspection e.g. a pipe or circuit board.
### Suggested Target Video Bitrates

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<tr>
<th>Resolution</th>
<th>160x112</th>
<th>320x240</th>
<th>352x240</th>
<th>352x288</th>
<th>480x320</th>
<th>528x368</th>
<th>640x480</th>
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<td>550</td>
<td>600</td>
<td>620</td>
</tr>
</tbody>
</table>

Note: NA* 160 x 112 viewfinder video is not recommended as higher resolutions are preferred.
Note: All bitrates are based on a GOP setting of 5.

3. When you are using the low resolution video such as 160x112 viewfinder video, we recommend that you take high quality image snapshots when you are ready to collaborate in detail. To do this, the Onsight Device operator simply holds down the image capture button to automatically send the still image to the Onsight Expert. "Image Sharing Started" is displayed on the device.

### Audio Codec Management Options

Audio Codec management options that conserve bandwidth include:

1. Low Bitrate Audio Codec: The default audio codec for Voice and Subject Audio is G7.11 (requires 64 Kbps), enable the Low Bitrate option of GSM 6.10 (requires 13.5 Kbps). The Low Bitrate audio codec, GSM, saves considerable bandwidth approx. 50kbps.
2. The Subject Audio Codec also includes an option to disable it. Unless you require Subject audio included in the video, you should disable Subject Audio for low bandwidth environments.
3. You can ‘Enable voice silence suppression to minimize the Voice audio traffic sent from the device when ‘silence’ is detected. Voice silence suppression means that the device will NOT send ‘empty’ audio packets to indicate silence.
   a. To further reduce Voice traffic (with silence suppression enabled), mute the Voice audio. Subject audio will still be sent from the Onsight Device provided it has not been disabled.

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6 New Feature: Version 4.2, added Disabled Subject Audio for Low Bandwidth Optimization
Onsight Expert Configuration

- To configure low bandwidth Audio, go to the Edit\Media Configuration\Audio tab
- Select Voice Codec: Low bitrate (GSM 6.10)
- Select Subject Audio Codec: Disabled (or Low Bitrate, if you require this audio)
- Select the Audio Efficiency
- Click ‘Save’

Note: The Audio settings are global for each collaboration setting.

Onsight Device Configuration

- Go to the Onsight device Main menu.
- Tap the ‘Configuration’ button on the Main menu
- Go to Control\Bandwidth
- Select the following Preferred audio codec:
• Press ‘Accept’

When either the Onsight Expert or the Onsight Device has these audio settings the current call will minimize the bandwidth used for audio.

**Best Practice Tips**

- Mute Voice Audio on the Onsight Device while video is streaming. This will minimize the amount of Voice audio traffic sent over the link.
- Use the GSM audio Codec when you are in low bandwidth environments. The quality is still very good and it saves 40 Kbps of bandwidth.
- If your use case does not include the use of the secondary audio channel (i.e. Audio included with the Video), Disable Subject Audio to achieve an immediate 20 – 25 Kbps savings in bandwidth.

**Image Sharing**

1. The ability to share high quality images is an important part of low bandwidth optimization. You can take high quality 720 x 480 images either from Onsight Expert or from the Onsight Device to share in a live session at anytime.

**Best Practice Tips**

- When you are sharing an image within an extremely low bandwidth environment (i.e. less than 80 Kbps), the audio may stop to conserve bandwidth. As soon as the image is received, audio will begin again.

**Deferred Collaboration**

In situations where the available bandwidth is not sufficient to support voice, image sharing or video, the Onsight Device’s recording function can be used instead for a deferred collaboration session. The Onsight Device must have an SD card installed to record an offline session.

The Onsight recording will contain voice, video, still images and telestration. This recording can be streamed to the Onsight Expert at a later time when sufficient bandwidth is available e.g. at a remote office location.
Onsight Device Usage
As soon as the Onsight device operator and Onsight Expert user are in a live Onsight session, the Onsight device operator simply selects the recording from the ‘File Browser’ menu (as below) and selects ‘Play’ to share it with the Onsight Expert participant.

While sharing the recording, both the Onsight Expert user and Onsight device operator can telestrate, share images, and talk just like they would during a live session.

Bandwidth Adaptive Streaming
Bandwidth Adaptive Streaming (BAS) can be enabled to automatically adapt video parameters for variable networks. BAS monitors network conditions and dynamically adjusts video parameters in order to improve overall call quality and stability.

BAS will reduce the video frame rate when the available bandwidth decreases. While this may reduce video quality, in many situations it is preferable to the loss of audio quality caused by an overloaded pipe (increasing latency, lost packets which show up as video breakup, etc).

Onsight Expert Configuration
- Go to the File\Preferences\Bandwidth menu option as shown in Audio Codec Management Options
- Select ‘Enable Bandwidth Adaptive Streaming (BAS)’

Onsight Device Configuration
- Go to the Onsight device Main menu.
- Tap the ‘Configuration’ button on the Main menu
- Go to Call Control\Bandwidth. Select ‘Enable Bandwidth Adaptive Streaming (BAS)’
Best Practice Tip

- BAS is not recommended for all situations. The default setting is disabled because in some cases it does not improve video delivery over the link. Librestream recommends that users only enable BAS if they are experiencing poor performance (either voice issues that make communication difficult or frequent video issues). It shouldn’t be relied upon to operate with higher bandwidth settings than the link can normally support.
Bandwidth Test Tool

The Onsight Collaboration System provides a Bandwidth test tool that can be used at the start of the session to determine the available bandwidth between the Onsight Device and Onsight Expert PC. Once a call has been established, either Onsight endpoint can run the test tool.

Onsight Expert Usage

From Onsight Expert the Bandwidth test is available by selecting Tools\Test Bandwidth.

During the test, voice audio is not available between the two Onsight endpoints. Once the test is completed, voice audio is restored and the results of the test are displayed.

If the user accepts the test results by pressing ‘OK’ only the bandwidth configurations that are equal to or less than the measured results will be selectable for the duration of the call. If there is
no media configuration that works within the bandwidth constraints, Onsight will create a new recommended configuration for you.

The user can choose to select ‘Cancel’ so that all bandwidth configurations will remain selectable for the current call.

**About Video Rates:** The bitrate for the video stream is shown in various places throughout the Onsight product. However the audio and data streams also contribute to the total bandwidth consumption. The Bandwidth Test Tool takes all of these components into account when measuring the current available bandwidth and recommending the range of useable stream settings.

**Best Practice Tips**

- If the bandwidth environment is unknown or variable, Onsight users should run the Bandwidth Test Tool prior to streaming video to select the most effective media configuration.
- In variable networks, it can also be useful to run this tool multiple times, especially if there are any voice quality issues.

**Bandwidth Limits**

Onsight system administrators or users can restrict the maximum bandwidth available for video within an Onsight session. By using this ‘Enable Bandwidth Control’ option, only media configurations that fit within this parameter will be available for selection.

Administrators can also pre-set this limit using the Onsight Management Suite tool. Using the bandwidth level restriction, they can cap the Maximum Bitrates that can be configured for the video. For example, if you set the Maximum Bitrate to 500 Kbps, only Onsight configurations that fall within a Target Video bitrate of 8 to 500 Kbps will be available. It will not allow any configuration with a Target Video bitrate greater than 500 Kbps. This restriction is displayed within Onsight Expert as below.
Quality of Service (QoS)

Network QoS support through Differentiated Services (DiffServ) was added to allow network administrators the ability to set the priority for the various Onsight media components. Diffserv DSCP values can be set for the 4 streams that are normally running during an Onsight collaboration session including:

- Video
- Voice audio
- Subject Audio
- Data (includes telestration and remote control commands from Onsight Expert)

The DSCP Values are used to classify the network packets and are used to determine which packets should be given priority over the network link. The QoS settings may improve link performance in an environment where a low bandwidth network is being shared by multiple users.

The QoS levels can also be managed remotely using the Onsight Management Suite tool or locally on the Onsight Device and Onsight Expert application.

Additional Best Practice Recommendations

Onsight Configuration-Usage

1. Register directly to the SIP Server; do not use OHTS as it adds overhead to the network traffic.
2. Create custom Media Configurations that will allow you to operate in various low bandwidth environments such as:
   a. ‘128K’ Media Configuration
      i. Resolution: 320 x 240
      ii. FPS: 5
      iii. GOP: 5
      iv. Hard limit: 90 Kbps
      v. Audio settings: GSM audio, ‘Disable’ subject audio
   b. ‘64K’ Media Configuration
      i. Resolution: 160 x 112
      ii. FPS: between 3-5
      iii. GOP: 5
      iv. Hard limit: 41 Kbps
      v. Audio Settings: GSM audio, ‘Disable’ subject audio

   NOTE: In low bandwidth areas consider using the smallest size, lowest frame rate to provide “Viewfinder” video. Share high quality snapshots to collaborate more fully on a specific area.

3. Configure low bandwidth Audio as described in section Audio Codec Management Options
a. When either the Onsight Expert or the Onsight Device has Low Bitrate (GSM) or Disabled Subject audio settings the current call will minimize the bandwidth used for audio.

4. When you initiate an Onsight session from a new location, run the Bandwidth Test Tool to determine the available bandwidth and identify which media configurations to use.
   a. The test results will list the Media Configurations that will work within the current available bandwidth. It will also create a new media configuration, if required.
   b. Note: You may want to run this tool more than once during an active session if you are experiencing voice quality problems due to a variable network.

5. Start calls using a lower bitrate media configuration. Switch to a higher bitrate media configuration if the connection seems like it can support the higher bandwidth.
   a. You can change the media configuration during an active Onsight session by selecting it from the ‘Configuration’ list box on the Audio/Video Settings tab of the playback window, as below.

6. Mute Voice Audio on the Onsight Device while video is streaming. This will minimize the amount of Voice audio traffic sent over the link.
   a. Note: You must have ‘voice silence suppression’ enabled on the device for this to be effective otherwise empty ‘silence’ packets will still be sent.

**Cellular 3G Network Best Practices**

1. Do not connect your laptop to the 3G router when streaming video from the Onsight Device. The laptop may consume available bandwidth resulting in less available bandwidth for the Onsight Device.
2. Use an external antenna for the cellular modem if available. Contact the cell modem vendor for more information.

3G Router/Access Point Location
The placement of the 3G Router is important when trying to get the best possible connection to the local cell tower. Placement should consider both the cell tower connection and the WiFi connection to the Onsight Mobile Device.

1. Outdoors: place the 3G router away from any large structures.
2. Indoors: place the 3G router close to a window to improve cellular reception.
   
   ***Never place the 3G router in a basement or inside a metal enclosure.

3. Operate the Onsight Device with in 50 feet of the CradlePoint with clear line of sight to the device. Obstructions will diminish this range. (Note: the WiFi range of the CradlePoint is not limited to 50 feet; however this guideline will ensure a good connection when operating the device.)
4. Elevate the 3G router off the floor or ground.

Using a Cell Phone for Audio
In areas with very poor cellular coverage you may restrict the Onsight Device to video-only, and use a separate cell phone with a Bluetooth headset to speak to the Expert over a conventional telephone connection. Mute the Onsight Device microphone if using a cell phone for audio using the Mic Mute button. See Configuration\Audio – enable 'use Voice Silence Suppression'.

Interference & Signal Strength
2.4GHz home telephones or microwave ovens can interfere with the WiFi connection between the Onsight Device and the 3G Router. Avoid operating the 3G router in the proximity of these devices.

The WiFi signal strength can be affected by structures such as walls, steel beams, etc. The placement of the 3G router should be such that it is line of sight with the Onsight Device to optimize signal strength.

Placement of the 3G router should be such that obstructions are minimized. When connecting from inside a building try to stay close to windows.

Appendix

Section 1.01 Bandwidth – Hard and Soft Limit
Hard Limit and Soft Limit control the way the Target Video Bitrate is managed when streaming from the device. When Hard Limit is selected the Video Bitrate will not be allowed to exceed the set value and the frame rate will be reduced in order to stay below the set Target Video Bitrate. When Soft Limit is selected, the Video Bitrate will be maintained in a Best Effort fashion however the set Bitrate may be exceeded in order to maintain the set Resolution, Frame rate and the GOP size.

Section 1.02 Group of Pictures - GOP
• GOP is a video encoding structure used to increase efficiency when sending video over a network.
• Video is a series of images sent at a particular frame rate e.g. 10 fps
• GOP allows partial images to be sent rather than full images for each frame sent.
• GOP uses the terms I-Frame and P-Frame to distinguish between full images and partial images.
• Imagine rather than sending a full jpeg image (Intra-coded Frame, I-Frame) for each frame you are sending only part of the image (Predicted Frame, P-Frame) for a frame being sent. What part? You’re sending only the part of the image that changed from the previous full frame that was sent.

E.g. For a GOP of 4 the frame sequence would look like: I, P, P, P, I, P, P, P, I, P, P, P. Here the I-Frame is followed by 3 P-Frames.

What impact does losing the I-Frame packet have during streaming?

The I-Frame contains the full image data for the video frame being displayed. When an I-Frame packet is lost on the network the video stream must wait for the next complete I-Frame to arrive before it can update the image on the screen. The amount of time before the next I-Frame arrives can cause the video to freeze on the display.

What impact does adjusting GOP have on Image Quality?

In General:
• The lower the GOP, the more I-Frames will be sent and therefore the network bandwidth efficiency will be reduced. The Image Quality will be poorer on a stable network but may be better on a lossy network. Thus, lower GOP should be considered when operating on unreliable networks. The result is a more robust* video stream at the expense of video detail.
• The higher the GOP, the less I-Frames will be sent and therefore the network bandwidth efficiency will be greater. The Image Quality will be better on a stable network but may be poorer on a lossy network. Thus, higher GOP should be considered when operating on reliable networks. The result is a less robust* video stream but the benefit is that image detail will be improved.

*’Robust video stream’ refers to the resiliency towards packet loss. The more robust, the less affected by packet loss.

How does Frame Rate and GOP impact Image Quality?

The combination of the Frame rate and the GOP setting can affect the video image quality dramatically on a low bandwidth network connection. For Example a frame rate of 3 fps in combination with a GOP of 30 would result in a video stream that is sending an I-frame once every 10 seconds.

\[
\text{GOP/Frames per Second} = \text{frequency of I-frames in seconds}
\]

E.g. GOP 30 / 3 fps = One I-Frame every 10 seconds

On an unreliable network, such as a 3G network, this could result in poor image quality at the receiving end i.e. the Onsight Expert. The loss of an I-Frame would result in video that would have long periods of frozen images, in the example given the periods could last at least 10 seconds. The video would not be updated until the next I-Frame is received. Lowering the GOP would decrease any periods of video freeze due to lost I-Frame packets.
In General:

- On an unreliable network, try to match the GOP with the Frame rate (fps) so that one I-Frame is received at an interval no greater than once every 2-3 seconds.
- On a reliable network a higher GOP can be used regardless of the set frame rate.
- If unsure of how to set GOP leave it set at 5. That is usually sufficient for most networks when packet loss is not excessive.

Section 1.03 Audio Settings

- Moving the slider from lower latency to lower bandwidth increases audio delay because it groups more audio packets into each RTP packet thus lowering overhead. For example, if audio packets are changed from 40ms to 120ms, then you will cut down the packet ratio 3:1 since you only need to send a packet 1/3 as often.
- Audio overhead bitrate for both GSM and G.711 is 11 Kbps.
- Data bitrate:
  - G.711 is 64 Kbps.
• GSM is 13 Kbps.

• 40ms packets:
  • G.711 is about 64(data) + 11(overhead) = 75 Kbps.
  • GSM is about 13 + 11 = 24 Kbps.

• 80ms packets:
  • G.711 is about 64 + 5.5 = 69.5 Kbps.
  • GSM is about 13 + 5.5 = 18.5 Kbps

• 120ms packets:
  • G.711 is about 64 + 3.7 = 67.7 Kbps.
  • GSM is about 13 + 3.7 = 16.7 Kbps

• So, as audio packets are grouped you can see that the overhead part of the audio bitrate shrinks. Going from 40 to 80 halves you packet overhead. Going from 40 to 120 reduces overhead to a third.