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BIFROST RELIABLE TRANSPORT FOR VIDEO OVER INTERNET

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Live events have traditionally been transmitted using satellite and dedicated fiber. Today, when the number of events is increasing, production companies and broadcasters are looking for more cost-efficient ways to do their contribution.

Internet can be used for sending video at a very low cost. But the global network provides no guarantee for a specific capacity, which makes it dangerous to use for sending important events.

Intinor develops products and technologies to make contribution over Internet easy and safe. The purpose of our transport protocol “Bifrost Reliable Transport” (BRT) together with our robust and easy-to-use hardware is to provide the best solution for live video over Internet.

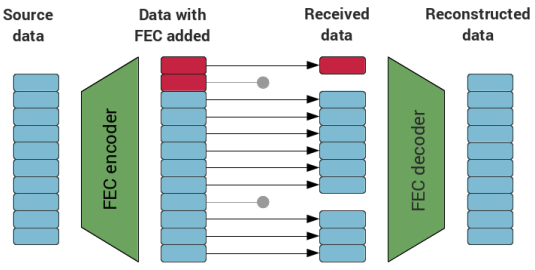
ERROR CORRECTION

Most Internet connections have more or less packet loss. This is usually handled by using Transmission Control Protocol (TCP) which includes error correction trough communication between sender and receiver and retransmission of lost data. The error correction method for TCP is called Automatic repeat request – ARQ. It is very good for applications where latency is not so important. ARQ needs buffering enough data for multiple resend requests for a robust transmission.

For low latency live video transmission, a protocol based on Forward Error Correction (FEC) is much better since it adds a smaller amount of latency and also a constant bitrate over time. No data burst is caused by the transport protocol because of packet loss.

When using forward error correction, the sender calculates redundancy data which can be used by the receiver to reconstruct lost data packets.

Bifrost uses a very efficient forward error correction. When adding for example 20% redundant data, the receiver can handle up to 15% packet loss. Increasing the amount of redundant data makes the transmission even more robust.



From firmware 4.6.0, Intinor Direkt series of products also includes ARQ, which improves error correction not only when end-to-end delay is several seconds long, but also for low latency

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Solid Solutions for Live Broadcasting

settings when the network round-trip time is short.

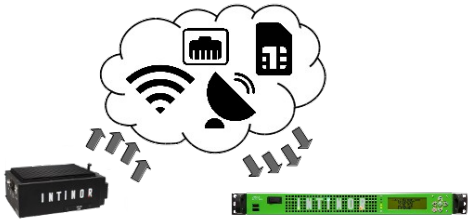
By combining FEC and ARQ, Bifrost Reliable Transport provides the best possible error correction for both low and high latency applications.

NETWORK BONDING

Using only one Internet connection is still very risky. Capacity can be too low, bursts of packet loss can interrupt the transmission or the network can suddenly fail during the live event for many different reasons.

An Intinor Direkt link encoder using the network bonding algorithms in the Bifrost protocol can balance the load over multiple Internet connections. If Wifi and/or fixed Internet connections are available, they can be used in combination with one or multiple 3G/4G wireless networks and even KA satellite Internet connections.

Network bonding enables higher bandwidth (higher video quality) and also robustness through redundancy.



Encoder with BRT Receiver with BRT

It also helps the field operator relax since if one network fails, the transmission can continue on the ones that are remaining.

Any temporary or permanent reduction in network capacity is quickly detected and compensated for. The encoder does this automatically, either by moving data over to any connection with available unused capacity or by lowering the encoder bitrate. This usually does not affect the video on the receiving side.

RECEIVER BONDING

Using network bonding also on the receiving side can further reduce the risk of interruptions on a live video stream. Using two different Internet providers in your studio/control room avoids issues caused by
* Internet provider technical issues
* Temporary high network load last mile
* Bad capacity on ISP peering points

Using only one Internet on sender side but two on receiving side has a lower risk of failures compared to 1-to-1. Bonding on both sender and receiver side is very robust.

ADAPTIVE BITRATE

For most live events, the target is high quality HD video in 5 to 10 megabits per second. An Intinor encoder using Bifrost tries to send the bitrate configured using network bonding over the available Internet connections. In some

cases, the total bitrate is still not enough, or it may fluctuate over time due to local wireless conditions or Internet congestion.

The sender and the receiver using Bifrost are constantly monitoring the available capacity on each available Internet connection. With adaptive bitrate the sender can quickly react to capacity fluctuations by decreasing or increasing the video bitrate. This results in the best possible video quality for any situation.

When adaptive bitrate is used, there is no need to reserve a capacity headroom, and video can be sent with the highest possible quality and the least risk of interruptions.

ADAPTIVE RESOLUTION

The target bitrate is usually set based on the resolution and the kind of content to be send. For example, 10 megabits per second is good for a high quality 1080i live sport contribution.

Intinor encoders using Bifrost adapt the bitrate if needed based on the Internet connections available. When the bitrate is reduced, the encoder can also reduce the resolution. By doing this, the bitrate can be reduced further without introducing excessive visible artifacts such as blockiness.

On the receiving side, the picture is transparently scaled back to the original resolution so that an SDI output or re-encoded web stream is not affected by the resolution change.

REDUNDANT AUDIO

In some rare cases, there are interruptions in the stream despite error correction, network bonding and adaptive bitrate. For example, two 3G/4G modems are used and the video is balanced equally with 20% redundant error correction data. One of the 3G/4G connections suddenly disconnects due to a network error. With low latency settings, it takes a small amount of time for the receiver to identify this and report to the sender to move data to the other connection and/or adapt the bitrate.

Such sudden network drops can cause interruptions in both audio and video. Video artifacts or sub-second freezes are annoying to viewers, but are usually considered acceptable. On the other hand, an interruption in the audio can be really bad, for example if the reply from a person being interviewed is lost.

To reduce the impact for the viewer, Bifrost can makes sure audio is always sent redundant over at least two Internet connections (unless only one connection is available). The result of a sudden network interruption when using Bifrost is at worst visual artifacts or freeze in the video, but the audio is never interrupted.

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LEAST COST MANAGEMENT

It is common that different Internet connections have different cost. For example, a Wifi or fixed Internet connection from the event is usually free to use, and local pre-payed SIM-cards are less expensive than international SIM-cards with roaming.

Bifrost takes care of least cost management of Internet connection in the most optimal way fully automatic.

The sending device can be pre-configured with different price priority on the different Internet connections. In the above example, fixed Internet and Wifi will be the only connections used if capacity on those are enough.

If only one low-cost connection is available, redundant audio will be sent over 3G/4G until error is detected and data is moved over to the modem.

If one SIM-card with an unknown amount of remaining data is used, capacity will move over to the modem with a more expensive SIM-card when low-cost data is finished etc.

This way, the event is always transmitted in the most cost-efficient way by Bifrost while the field operator can take care of other things.

DIFFERENT USE CASES

There are many ways to configure a complex system based on Bifrost. For example:

1) Low latency for news reporting with optimized redundancy. Sub-500-ms SDI to SDI
2) High quality and high redundancy with 5-10 seconds latency
3) Balanced latency/redundancy 1-2 seconds
4) Low cost – best effort
5) Full redundancy at a higher cost

Example number 5) above means that at least one Internet connection can suddenly drop on a low-latency transmission without any interruption. But, if the encoder sends 10mbps over two LTE modems it means that double data volume is used.

The settings can easily be pre-configured before the event, changed by the operator on site or remotely from the MCR.

In most cases however, with Bifrost everything automatically happens in the most optimal way without manual adjustments.

The user powers up the Direkt link, connects the video source, connects Wifi and fixed Internet if available and then let Bifrost take care of the rest.

Factual text: In Norse mythology, **Bifrost** is a burning rainbow bridge that reaches between Midgard (Earth) and Asgard, the realm of the gods *[wikipedia]*.

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