Radar and Video Distribution: Typical Network Data Rates

An overview of data rates that may be expected for various types of network data

Summary

Modern military and security systems rely heavily on the use of IP networks to transport data between subsystems. When designing complete systems it is useful to have an overview of the typical data rate that may be expected for each source of data on the network, so that the total bandwidth requirements may be estimated. This application note aims to give an appreciation of the data rates for various types of data that may be present on the network.

Introduction

Radar processing and display systems may require distribution of various different data streams, including radar video, plot/track messages and NMEA data between sources and consumers. These may be complemented by other related streams, such as camera video data. IP networks provide a low cost, convenient and widely-supported method of data transport. If the network is based on cable or fibre then it will typically support at least 1Gbps of data flow. This is often ample for applications involving a handful of sensors. However, if the network includes microwave or satellite links then the available bandwidth may be at a premium, possible only a few Mbps.

Data compression may help in the case of high bandwidth streams, such as radar or camera video. Where data is compressed, the effectiveness of that compression is usually dependent on the content of the video itself, it is therefore non-deterministic. By considering the "worst case", where no compression is applied, the maximum network loading can be estimated.

The following sections outlines typical data rates for some common data types that Cambridge Pixel handles.

Radar Video

The bandwidth consumed by radar video data is determined the rate at which returns are being sent onto the network, the length (i.e. number of samples) of those returns and the number bytes per sample.

Typically, each radar return may be 4096 samples in length, with each sample requiring a byte (8 bits) to hold its value. Each return is introduced by a short header of around 100 bytes. These returns may be sent onto the network at a rate of the order of the radar's PRF, typically around 1kHz. These figures would therefore imply a data rate of $(4096+100) * 1000 \approx 4MB/s$. However, this is without any compression and therefore represents the maximum network load for the given parameters.

The amount of compression achieved depends on the contents of the radar video. Clean, heavily-processed video compresses very well, whereas noisy video does not compress very well. Compression ratios of between 2:1 and 10:1 are typical for many radars. When applied to the previous example calculation, this would give typical data rates between 0.4MB/s and 2MB/s.

It should be noted that there can be quite a wide variation in the data rates that may be expected from short-range high accuracy radars (e.g. for airport surface movement) and long range naval/air surveillance radars. The short range radars may have very high PRF (e.g. 10kHz or more) and provide 2k samples per return, giving 20MB/s of uncompressed data. Whereas the long range radars will have a lower PRF (maybe 500Hz or less) and provide 8k samples per return, giving 4MB/s of uncompressed data.

The bandwidth usage may be reduced by applying some processing to the radar video data prior to compression. By removing some noise, or even reducing the bit-depth of the radar samples, the data will typically compress more readily. Alternatively, the data may be subsampled in range and/or azimuth prior to distribution, thereby reducing the payload size and/or frequency of messages.

As a rough rule of thumb, compressed radar video data may be measured in the 100kB/s to 1MB/s range.

Plot/Track Messages

Plot and track messages are typically sent once per radar scan, per detection/target. Plot messages will generally be a similar size to track messages but there may be many more of them per radar scan. As a rough guide, plot and track messages each require around 100 bytes. The frequency of messages will be dictated by the rotation rate of the radar and the number of targets visible to the radar.

As an example, if a radar with a 4 second rotation period has 500 targets within its coverage, the data rate for track messages would be 500 * 100 / 4 = 12.2 kB/s. This is clearly a much lower data rate than radar video and is well within the bandwidth of most networks.

NMEA-0183

The NMEA-0183 format is used to transport AIS and navigation data. NMEA-0183 sentences are normally very small, generally between 10 and 100 bytes per sentence.

Navigation data messages may typically be sent at a rate of between 1Hz and 50Hz, implying a maximum data rate of about 50 * 100 = 5 kB/s.

AIS sentences are generally sent at a rate of no more than 1Hz per target. If there are, say, 1000 targets within range of the AIS receiver then the corresponding data rate is 1000 * 1 * 100 = 100kB/s. This is a somewhat pessimistic figure because in practice the

AIS message rate per target will be much lower than 1Hz, the message length will be less than 100 bytes and there probably won't be 1000 targets within range.

Image Data

It is possible to distribute radar video in Cartesian form, i.e. after scan conversion. However, this is not often the recommended method and normally the polar format data would be distributed instead. As with polar format data, the compression achieved will depend on the contents of the video data and also how it changes over time.

An uncompressed bitmap that is 1024 pixels wide by 1024 pixels high and 32 bits (RGB plus alpha) deep will be 1024x1024x4 = 4MB in size. If these images are sent once per second onto the network then the data rate is obviously 4MB/s.

Depending on the compression algorithm applied (e.g. PNG, JPEG etc.), the data rate may typically be decreased by a ratio of between 2:1 and 10:1. This implies realistic data rates for the example case above of between 0.4MB/s and 2MB/s.

This applies equally for other 2D image data, such as screen captures or still camera images.

Camera Video

Camera video is almost always distributed over the network using an inter-frame compression method. The most commonly encountered compression method is H.264. The data rate for H.264 compressed video is dependent on the resolution of the video and the desired quality (in terms of framerate and visual appearance).

The table below gives some indicative data rates. The quality of video is subjective, so these data rates are only to provide rough guidance. Broadly, the "low" quality would be equivalent to YouTube video whereas as "high" might be what BBC iPlayer streams.

Resolution	**Framerate (fps)**	**Quality**	**Data Rate (MB/s)**
848x480	30	"low"	0.10
		"medium"	0.12
		"high"	0.15
1920x1080	30	"low"	0.35
		"medium"	0.50
		"high"	0.70

For comparison, if the video were not compressed then the data rate for HD resolution video at 30 frames per second would be 1920x1080x30x3 = 186MB/s, assuming 24-bit (3 byte) RGB video samples.

Conclusion

Camera and radar video are generally the dominant sources of data on the network. Particularly in a security application, there may many more camera videos present than radar videos. So it is often the camera videos that dictate to total network capacity requirement. Other sources, such as navigation data and track reports are small by comparison.

In the case of both radar video and camera video, dropping the quality allows the data rate to fall. This may mean subsampling the data (spatially or temporally) or simply dropping information, for example by dropping the resolution of the data samples.

Status messages and control commands are send at such low rates and consist of such small packets that they are not worth considering.

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