Transitioning from serial modems to serial over IP Broadband

Robust Industrial Data Communications - Made Easy

WHITEPAPER

Introduction

It would seem counter-intuitive that serial communications over an IP network would take longer to transmit a packet of data between two serial ports than the legacy modems the IP network is replacing. The issue has nothing to do with the IP network bandwidth available, but it has everything to do with the way the serial data is converted into an IP packet before being forwarded over the network.

So, what causes the delays and how can they the delays be mitigated?

For simplicity, this paper will consider the upgrading of point to point legacy analogue modems to an IP Broadband using ADSL/VDSL. However, the principles can be applied to wide area connectivity over 3/4G or satellite. The significant difference when using wide area communication are the increased latency due to the interconnecting media. For more information regarding wide area connectivity contact Westermo.

Serial over legacy modems or line drivers

Legacy modems or line drivers modulate the serial ones and zeros into an electrical signal that can be transmitted over longer distances than serial RS-232 (15m) or RS-485/422 (1200m). In the case of a modem, the data will be converted into analogue tones within the speech band used by the telephone network (300-4000Hz). There will be a small delay as the 1 and 0 are passed through the modulation process. In the case of a simple 1200 bps, V.23 or Bell 202 modem the 1's and 0's of the serial data is converted into two tones that represents the binary data. This process adds a delay in the order of 15ms to the passage of data from the serial port on the transmitting device to the serial port on the receiving device. More complex modem transmission modulation schemes such as V.32 (up to 14400bps) or V.34 (up to 38800bps) add between 40 and 120ms to the data transfer time. The process of transmitting data over modems is referred to as streaming, as once the data starts to pass from serial port to serial port it does so in a continuous stream. See Diagram 1 below;

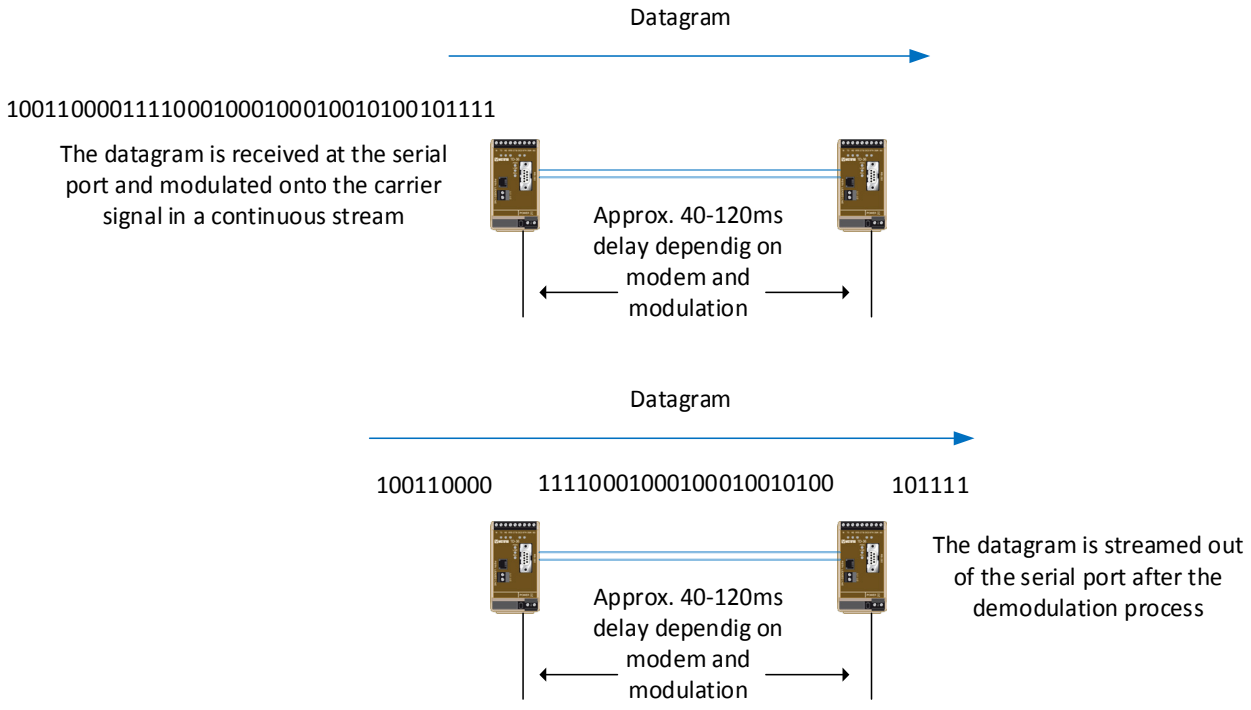


Diagram 1

Serial to IP

When serial data is sent over an IP based network, it is no longer possible to stream or modulate the 1's and 0's directly. Ethernet or IP networks all send data at its simplest level, in packets tagged with a source and destination IP address. To efficiently send serial data over an IP network, the serial to IP converter must first receive all the bytes in the datagram from the sending device. Once the whole datagram has been received data is wrapped inside a UDP or TCP IP frame and then forwarded to the network. When the packet is received at its destination the wrapper placed around the serial data is stripped off, and the serial datagram is then forwarded out the serial port. This process is referred to as packetisation. It is this packetisation process that accounts for the transmission delays. See Diagram 2 below;

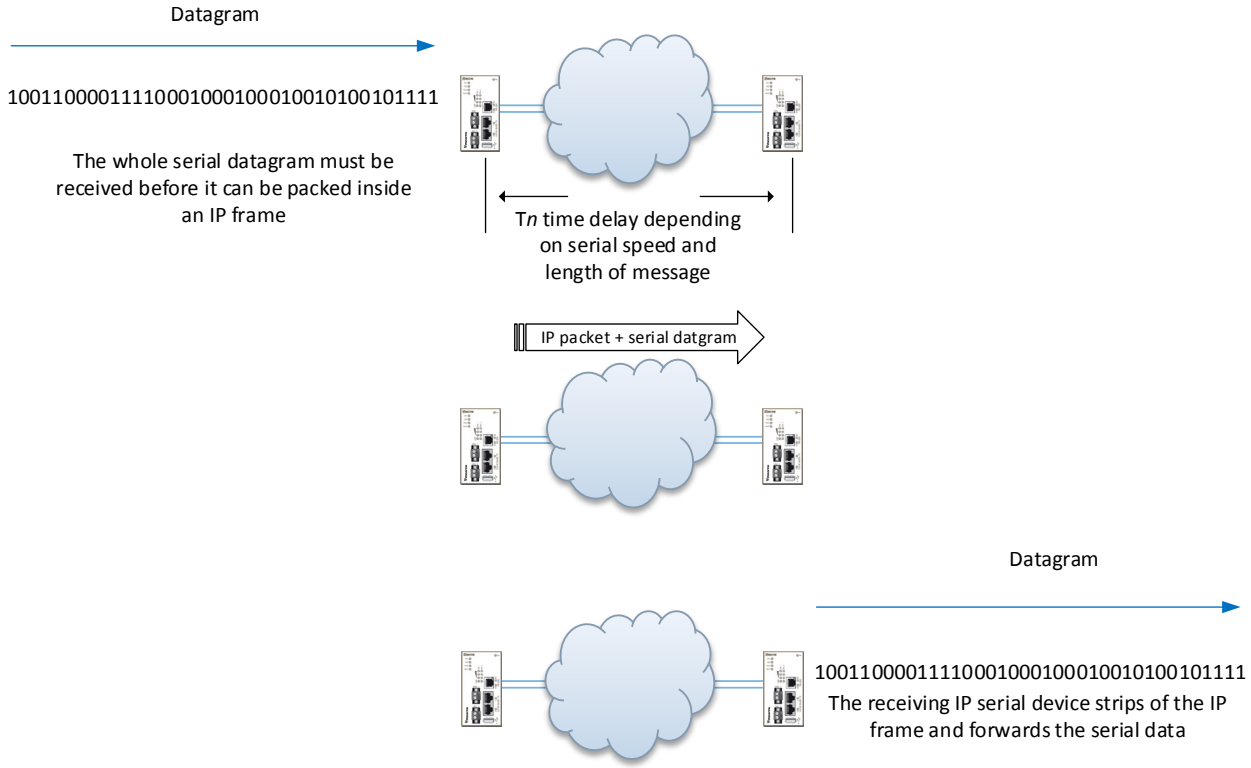


Diagram 2

In this simple case a 100 byte message @9600 8,n,1 (10 bits) is to be sent over IP, the timing would be;

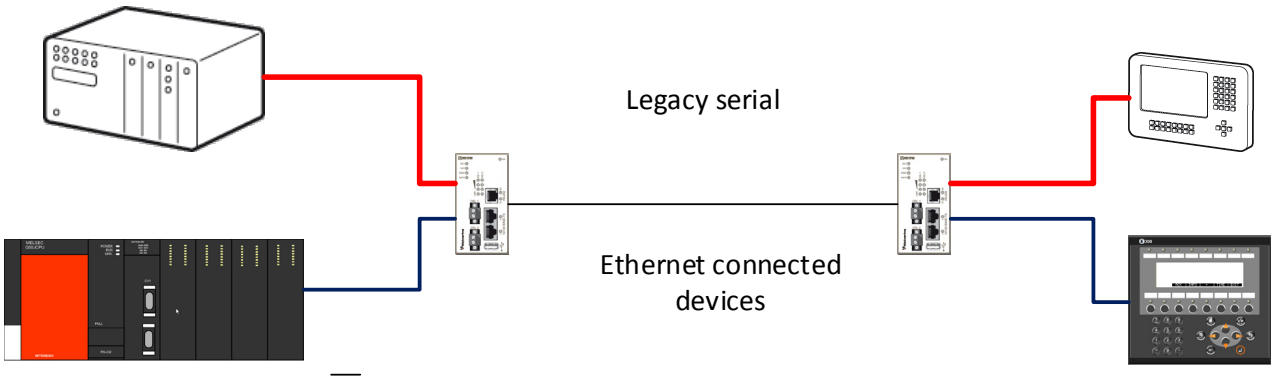
Example 1

((1/Serial speed) x word length x number of bytes in message) + end of message wait + IP stack delays
((1/9600)x10x100) +5 + 7ms = 116ms
The total time for the serial message to reach its destination will be 116 + 116 =232 ms.
The return message will be delayed to the same extent. So, for a symmetrical datagram of 100 bytes in each direction, there would be a total roundtrip delay of 464ms, approximately twice the length of time as a legacy (V32/V34) modem.

Why change to serial over IP

So, if the serial datagram now takes twice as long, why change to IP and what can be done to mitigate the transmission delays?
There are many reasons why moving to serial over IP will be a good idea, and in a lot of circumstances, it will be the only option. One of the biggest drivers to move to serial over IP is the revolution in the way the telecom providers are providing service and type of services for the transportation of data over wide geographic areas. Service such as analogue/ISDN leased line modems or CSD dialup over 2G will cease to be available in the next couple of years. If the service provider is still able to maintain the legacy services the cost will rise incrementally to the point where it is not economical. The alternative to legacy service will be 3/4G or a broadband service such as ADSL/VDSL. Other services such

as dark fibre or high-speed fibre networks will be available but usually, carry a bigger price tag than broadband services.
Another key driver is the digitalisation of utilities. For example, the electricity industry is about to undergo a complete overhaul due to the distribution network needing to become smarter and better able to cope with the peaks and troughs in demand from micro generations (small wind turbines and solar panels)and the increased number of electric vehicles.
The level of investment required to replace the legacy serial-based equipment would not be economical and in a lot of cases unnecessary. However, there is a benefit to the digitisation of the communications media regarding reduced running costs, reliability and resilience. The upgrading to an IP network can provide a migration path as newer IP devices can run alongside the existing legacy serial equipment utilising the same media connection.



There are some hidden benefits of moving to digital serial over IP solutions. Some protocols are sensitive to small delays introduced in the data stream between characters. A classic example of this would be Modbus RTU, where just a small gap between characters in the datagram will be enough for the receiving device to reject the whole datagram. Upgrading to serial over IP will reduce any such errors to practically zero as the datagram is moved inside one packet and then streamed out the remote serial port. In short moving to an IP based communications system will increase the reliability of the communications.

Mitigating the increased time delays

There are several ways to mitigate the additional time delays when moving from analogue modems to serial over IP communications.

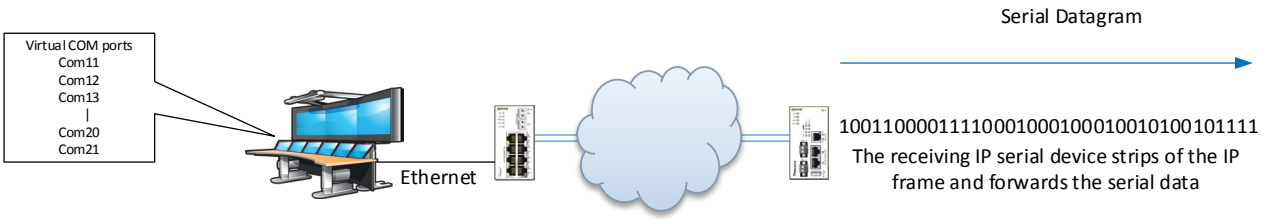
Increase the serial port speed

Most legacy systems use a relatively low serial port speed between 300-9600bps. The low serial data rate is primarily driven by the limitations of the legacy analogue modem technology.
As we have seen from the formula above, the serial speed dictates the length of time the message takes to be fully received by the serial port on the serial to IP converter, before being placed in a UDP to TCP packet. As shown in example 1, a 100 byte message at 9600 8,n,1 takes approximately 104ms to be fully received. Just doubling the serial speed to 19200bps will shorten this time to 52ms, at 57600bps the message would take just 17.3ms!
From the above example, the overall roundtrip delay would be approx. 60ms for a 100 byte message @ 57600 which would be 130ms faster than the legacy modem.

Virtual serial port emulation

Another way of decreasing the latency is to replace the physical serial ports at the SCADA or DCS location with virtual serial ports. The virtual serial port as the name implies emulates a serial port on the host machine eliminating the need for the serial RS-232 or RS-485 hardware. The virtual serial port emulator creates a serial port in the machine resources that look and feel just like a conventional hardware serial port to the application. The SCADA or DCS application can send and receive the serial

datagrams directly from the virtual serial port eliminating the packetisation delays at the SCADA end.



Using virtual communications ports approximately halves that round-trip delay when compared with packetisation at both locations, as the only packetisation process taking place will be at the remote site. Using virtual serial comms ports has many other benefits when compared to the legacy system it is replacing. Since the serial ports are all virtual, there is no hardware or interrupt restrictions on the host machine. Free of the physical limitations the host machine can comfortably host ten times the number of virtual serial ports making it possible to communicate with 100 or more sites simultaneously. Being able to communicate simultaneously with more sites has the added benefit of decreasing the overall cycle time of the SCADA system or increase the number of devices scanned in the same cycle time. Some SCADA and DCS system support the ability to encapsulate the serial data into an IP packet directly from the application layers eliminating the need for hardware or virtual comms ports altogether.

For more information from Westermo regarding serial over IP communication or migration for analogue communication to digital, please contact your local Westermo office of or a Westermo distributor in your country. A full list of offices and distributors can be found at Westermo.com

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Westermo designs and manufactures data communications products for mission-critical systems in physically demanding environments. The products are used both in social infrastructure, such as transport, water and energy supplies, as well as in process industries, such as mining and petrochemical.

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