Industrial Protocols and
Westermo devices Compatibility

Before Ethernet became the most widely use media standard for the transmission of industrial protocols, nearly every manufacture, had their own standard of electrical interfacing and protocol formats. This resulted in incompatibility and "supplier lock in", great for the supplier but bad for the purchasing organisation. The emergence of Ethernet as a common media for industrial communications reversed the situations for the purchasing organisation who are no longer locked into a manufacture and are now free to select the communications infrastructure from multiple sources. The market demand from the purchasing organisations is for the equipment suppliers to use common protocols. Pre Ethernet and more specific TCP/IP communications there were more than 20 different protocols for the control of substations now there are just a few common protocols such as DNP3, IEC61870 or MMS. There are still supplier specific protocols for example to configure or program a PLC or RTU, but on the whole they can use the same Ethernet TCP/IP infrastructure as the data exchange protocol and rarely present any specific issues when being carried over the range of Westermo Ethernet devices.

Industrial Ethernet Protocols

The majority of industrial buses follow the standard TCP/IP frame formatting. This means that the packets can be easily transmitted over a switched network (L2) or and be routed (L3) between VLAN's or wide area connections such as a VPN. The protocols use standard IP addresses (e.g. 192.167.23.1) to select a destination as defined in the ISO and IEEE standards. Examples of industrial protocols using standardised framing would be Modbus TCP/IP, DMP3. MMS. EtherNet IP or IAC. Some of the protocols mentioned above use a special messaging type known as multicast. The Multicast messages still comply with the general norm of IP communications, but this message type does need specialised support within the switch, if the full benefits of this method of messaging is to be realised. It is beyond the scope of this document to cover the specific ways of handling each protocol and the setup required.

There are however a number of Ethernet industrial busses that do not use standard IP addressing. These more speclist protocols use various methods to address or exchange data. For example the 61850 GOOSE protocol, uses a MAC (Media Access Control) level broadcast to exchange data with other device listening on the same network. The vast majority of these specialised protocols can be carried over a Westermo switch, but in some cases the switch will require a particular configuration to pass the packets correctly.

This guidance paper will show which protocols are compatible, how they can be handled and any inherent limiting factures of the protocol e.g. Profinet RT or GOOSE cannot be routed using standard IP routing techniques due to the message structure and timing restrictions.

Industrial protocols and cyber–security

From a cyber-security perspective the way the security can be applied to a system will depend on the how quickly the packets need to pass through the network and the type of address i.e. TCP/IP or MAC broadcast. Protocols such as PROFINET, GOOSE and SV use MAC level communications for some or all of the data exchange. The protocol is limited to L2 communications and are very time sensitive. This means that a standard WeOS firewall cannot be used to filter and secure these protocols. However this does not mean that there are no cyber security measures that can be taken. In the case of PROFINET, GOOSE and SV protocols the WeOS operating system does support MAC filters and 802.1x port authentication. These methods are compatible with L2 protocols and are available on all WeOS L2 and L3 devices including the Lynx-1xx and DDW-142 families.

Protocols using standard TCP/IP addressing are generally routable and more forgiving to the time delays incurred when passing data through a firewall. The firewall built into all L3 WeOS devices already has a number industrial protocol definitions configured making configuration easy. The full extent of the cyber-security features built into WeOS are outside of the scope of this document to explain in full. For more information on the cyber-security capabilities of WeOS please refer to the documentation on the Westermo.com WEB site.

Westermo switch & router protocol compatibility

Modbus TCP/IP

Modbus TCP/IP is based on standard TCP/IP frames making Modbus TCP/IP a very straight forward plug and play protocol. No special measures are required when handling Modbus TCP/IP at the L2 (switched) or L3 (routed). There are some vender specific implementations of Modbus TCP/IP but these all conform to the standard ISO model so again no special considerations are necessary when being used with a Westermo switch.

Within the Westermo family of device there are a number of devices that provide a gateway between Modbus TCP/IP to Modbus RTU or ASCII i.e. IP to legacy serial conversion. Modbus RTU and ASCII are asynchronous serial protocols based on RS-232 or RS485 electrical interfaces. The Gateway functionality built in as standard into the EDW-1xx and WeOS devices supports either, a master on the serial interface or the Ethernet interface. The extensive support for Modbus also allows for multiple Modbus Masters to be connected on the Ethernet side and read data from the same Slave on the serial interface. Allowing multiple masters could result in confusion, but an algorithm built into the software ensure that messages are correctly queued and only forwarded to the slave when an answer to the previous message has be received from the slave or no response has been received within a defined time period. The WeConnect VPN remote access solution is fully compatible with Modbus TCP/IP and can provide wide area connectivity to Modbus nodes anywhere there is Internet connectivity.

Modbus TCP/IP is routable i.e. the Mater and the Slaves do not have to be in the same subnet. This means that the protocol can be used over routed links and or VPN's to locations remote to the main network. The MRD, ADSL-350, and L3 WeOS products all support VPN connectivity over the internet compatible with Modbus TCP/IP.

Within the family of Modbus protocols are MODBUS Plus and FIPIO. MODBUS Plus is based on synchronous RS-485 running at a clock rate of up to 2Mbit/s. MODBUS Plus is considered to be legacy and will be most likely associated with a so called 'Brown Field' update of an existing system. There is no support in the Westermo range to convert or provide a gateway between Ethernet and MODBUS Plus. However the cable used to transmit MODBUS Plus is ideal for the transmission Ethernet via SHDSL using the DDW-xxx devices, so an upgrade path is available using the existing cabling infrastructure.

DNP3 (IEC 60870-5)

The DNP3 protocol can be used over serial and Ethernet networks. The Ethernet version of DNP3 is based on standard TCP/IP frames making DNP3 a very straight forward plug and play protocol. The TCP/IP version of the protocol simply encapsulates the DNP serial data frame inside a UDP or TCP IP frame. No special measures are required when handling DNP3 at the L2 (switched) or L3 (routed) level. The DNP 3 protocol is found mostly in the electricity distribution and clean/waste water industries and is usually used for SCADA or data gathering remote location. The MRD-Xxx routers support DNP3 node configuration so that they can report status information directly from the MRD-Xxx to the SCADA or data gathering system.

All Ethernet switches and routers in the Westermo range are compatible with DNP3 over IP. The WeConnect VPN remote access solution is fully compatible with DNP3 and can provide wide area connectivity to DNP3 nodes anywhere there is Internet connectivity.

The asynchronous serial DNP3 protocol is compatible with all devices that support RS-232 or RS485 interfaces, such as the legacy TD modems, ODW fibre converters and RS-232 to 485 converters. All Westermo Ethernet devices with asynchronous serial interfaces such as the Lynx-DSS, MRD-3xx, ADSL-350 and DDW-xxx all support conversion from serial DNP3 to DNP3 IP. This is a direct translation from serial to IP and not a gateway type functionality as in the case of MODBUS TCP/IP to MODBUS RTU.

There are a few derivations of DNP3 specifically designed for a particular industry. WITS (Water Industry Telemetry Standards) has been specifically designed by the UK water supply industry. This protocol can be handled in the same way as standard DNP3 and does not present any issues.

Secure DNP3 has been introduced to add the Cyber security layer to DNP3. However the implantation of secure DNP3 is slow due to the extra computation power required by the RTU/IED and the SCADA system to encrypt the packets. The encrypted packets can be carried over all Westermo Ethernet device in the same way as DNP3.

IEC 61870-5-104 and IEC61870-5-101

The IEC 61870-5-104 and the serial version IEC 61870-5-101 protocols are extensively found in the electricity distribution and rail sector. The IP based IEC-104 version of the protocol is very similar to DNP3 and present no problems when being transported over Westermo devices either local over a LAN or over a wide area infrastructure such as the MRD-Xxx. Like DNP3, IEC-104 can be securely transported over WeConnect and any Westermo device supporting L3 routing functionality.

There are some differences in the IEC-61870 -5-101 data framing and IEC-61870-5-104 so a direct translation or gateway from serial to Ethernet is not directly possible at this time. However most of the major SCADA and TeleControl systems found in the electricity distribution industry support IEC-61870-5-101 over IP. IEC-61870-5-101 over IP is simply the asynchronous serial data encapsulated in a UDP frame and transmitted over the IP infrastructure. This method of transporting IEC61870-5-101 is supported by any Westermo device with serial to IP conversion built in i.e. the MRD-Xxx, ADSL-350 Lynx-DSS, DDW-xxx.

The IEC-61870-5-101 serial protocol is fully compatible with all Westermo serial legacy devices e.g. TD modems, ODW fibre and RS-232 to 485 converters.

Ethernet/IP

The Ethernet/IP protocol was originally created by Allen Bradly, but is now published as an open standard via the ODVA. The Ethernet/IP protocol uses TCP/IP compliant addressing and an extension known as multicast. Multicast is a type of broadcast message, but where the messages are delivered is controlled by the IGMP protocol. Devices that are interested in receiving the multicast broadcast from a device have to register their interest before the multicast messages are forwarded. It is beyond the scope of this document to describe how multicast works at the network level for more information visit the Westermo.com WEB site.

WeOS devices are Ethernet/IP compatible and require no configuration to be used on an Ethernet/IP system. There are a number of IGMP snooping features that can be used to refine the way the multicast messages is controlled within the network. In most cases there is no need to change the IGMP setting. The exception is when using DDW devices due to the reduced bandwidth available. For more advice on configuring IGMP snooping please refer to the WeOS management guide.

Ethernet/IP is routable over a WeOS L3 network using static multicast routing. It is more likely that a system using Ethernet/IP will use the unicast or peer to peer version of the protocol. The WeOS Firewall can also be used to filter multicast or unicast Ethernet/IP. The full range of cyber-security features can be used with Ethernet/IP. The only exception are with systems that are using Ethernet/IP motion or safety as they are sensitive to delays.
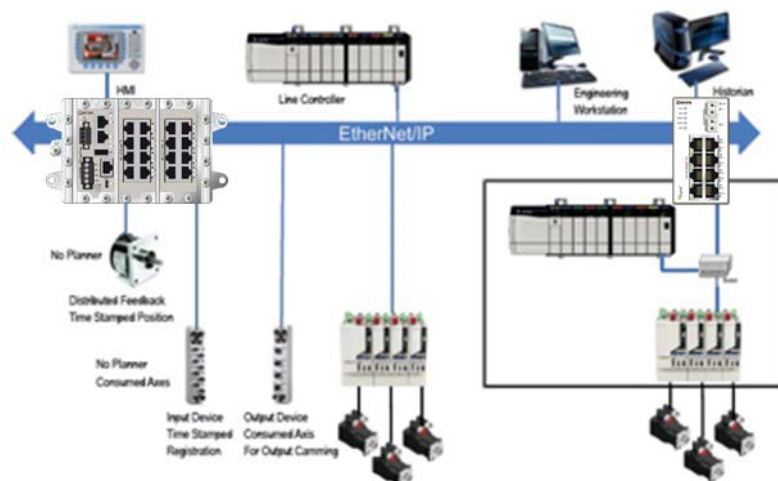
Legacy Allan Bradly (AB) protocols and communications busses

Within the family of AB protocols are DH+, DF1 and DH-485.

The DH+ bus used a twin axial cable to communicate up 6000 feet, approx. 1200m, at speeds up to 64kbs. Westermo no longer have any devices that can be used to extend or convert DH+. Hoverer the cable can be used by the DDW range of devices, so an upgrade path is available using the excising cabling infrastructure. The cable is not ideal as it is not twisted, but the cable is of a very high quality and does have a foil screen built into the cable. Tests have shown the cable is able to reliably carry SHDSL signals over existing installation up to the full 6000 feet range of the original specification for DH+. Care should be taken and each installations should be tested case by case, due to the cable not being twisted. If the cable is being reused for SHDSL ensure that foil screen it is grounded at one end **only**.

The AB DF1 serial protocol can communicate via any Westermo device with an RS-232 serial interface i.e. TD modems, ODW fibre converters, MRD, ADSL-350, any WeOS device with a serial interface and WeConnect are all capable of converting and carrying DF1.

The DH-485 bus uses standard twisted pair RS-485 cabling. The cable is ideal for the transmission of Ethernet via SHDSL using the DDW-xxx devices so an upgrade path is available using the excising cabling infrastructure.

Profinet

Profinet is divided into different levels depending on its application and the type of information being sent over the network. Profinet IRT is currently not supported by Westermo switches as it requires hardware support to ensure that IRT data is always sent through the network at precisely the same time interval or time slot.

The more common implementation of Profinet RT and NRT can be sent over a standard L2 switched network with minimal configuration. The Profinet data is a mixture of broadcast and unicast frames. All the Profinet data can be contained within a VLAN to stop the Profinet broadcast data from leaking out of ports on the whole network. Typically Profinet at the Automation and control level, is a L2 protocol and cannot be directly routed. Profinet via TCP/IP is compatible with L3 routing so can be passed over VPN's or through firewalls.

A good explanation of all the aspects related to Profinet can be found at;

http://www.automation.com/pdf_articles/profinet/pi_white_paper_profinet_it_en_v1_0.pdf

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61850 Protocols

IEC-61850 defines a number of protocols that are used for different purposes within a substation environment. The three main protocols are;

- GOOSE   Generic Object Oriented Substation Events
- SV or SMV   Sample value
- MMS   Manufacturing Message Specification

GOOSE and SV are MAC or Ethernet layer messages that are treated as broadcast messages by the switches in the network. This is intentional as multiple devices in the substation will need to receive and act upon the same message from a sensor. The GOOSE and SV protocols make extensive use of VLANs to separate the traffic to specific groups of devices. The GOOSE and SV protocols are compatible with L2 WeOS based switches and functionality.

The MMS protocol is a standard TCP/IP i.e. all messages have a source and destination IP address based protocol for communication between the substation SCADA and the Various devices at the field level. Westermo WeOS, MRD and WeConnect are compatible with MMS.

Foundation Fieldbus

Foundation Fieldbus has two main variants FF-H1 and FF-HSE. Currently Westermo does not offer any products directly compatible with FF-H1. However the FF-H1 cabling is ideal for the transmission of Ethernet via SHDSL using the DDW-xxx devices, so an upgrade path is available using the excising cabling infrastructure.

FF-HSE uses standard TCP, UDP and Multicast messaging for communications between nodes or from the nodes to the SCADA/DCS. The FF-HSE protocol does not need any special handling apart from ensuring that IGMP is enabled for systems using Multicast messaging. Device utilising FF-HSE can us DHCP to obtain an IP address. The Westermo WeOS operating system has extensive support for DHCP including Option 82 to always ensure that a device receives the same IP address when connect to a nominated physical port on the WeOS device. FF-HSE was designed to operate on L2 switched networks, but since it uses standard IP data frames it is potentially routable, but not considered an ideal solution.

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HART and HART-IP

The HART fieldbus is based on FSK (frequency shift keying) with the option of also support a 4-20ma signal on the same cable. HART is extensively used in the process control industry for gathering data from large numbers of sensors throughout a plant such as valves and actuators. Currently Westermo does not offer any products directly compatible with the HART protocol. However the HART cabling is ideal for the transmission of Ethernet via SHDSL using the DDW-xxx devices, so an upgrade path is available using the excising cabling infrastructure.

A system using HART as the main fieldbus communications protocol will often include HART Multiplexers (see topology diagram below) as part of the system topology. The HART Multiplexers gather together multiple HART physical field busses and present them as one connection to the DCS or SCADA system. The HART Multiplexer ether uses an RS-232/485 or Ethernet interface. The serial Hart multiplexer serial output can be converted to Ethernet using an EDW-1xx or a WeOS device equipped with a serial interface such as a Lynx-DSS or DDW-142.

The HART-IP protocol uses standard TCP-IP framing so the protocol is compatible with any managed Westermo WeOS device or unmanaged switch. No special handling is required.
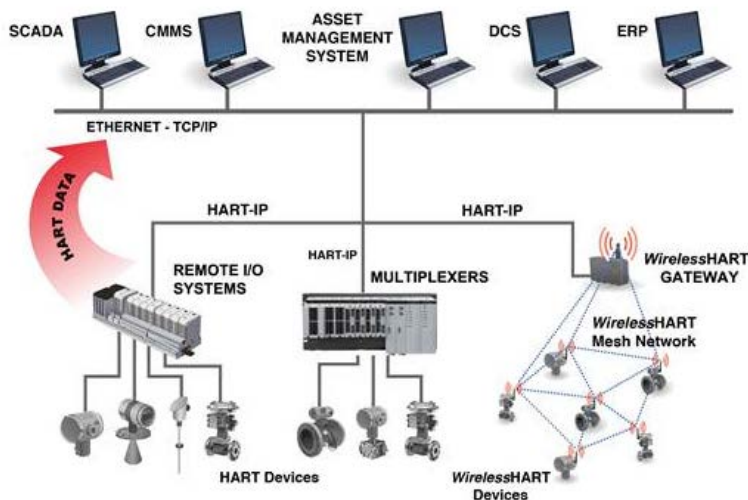
For more information on HART visit;

http://en.hartcomm.org/index.html

Summery table protocol of compatibility

Protocols	Compatible with WeOS	Routable (L3)	Compatible with WeConnect		
Modbus/IP	Yes	Yes	Yes		
DNP3-IP	Yes	Yes	Yes		
61870-5-104	Yes	Yes	Yes		
Ethernet/IP	Yes	Yes [2]	Yes [2]		
GOOSE	Yes	No	No		
SV (SMV)	Yes	No	No		
MMS	Yes	Yes	Yes		
Profinet	Yes [1]	Yes [3]	Yes [3]		
FF-HSE	Yes	Not Idea[4]	No Ideal[4]		
HART-IP	Yes	Not Ideal[4]	Not Ideal[4]		

(1) RT Profinet only IRT requires specialised switches

(2) Ethernet/IP peer to Peer is recommended when routing between zones or subnets.

(3) When used in peer to peer mode

(4) Protocol is best suited to L2 switched networks

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Summery table of Serial to IP, Gate way and cable reuse

Serial/Legacy	Gateway support	Reuse cable for SHDSL	Serial to IP encapsulation
Modbus RTU/ASCII	Yes	Yes	Yes
Modbus Plus	No	Yes	No
FIP-IO	No	Yes	No
DNP Serial	Yes *	Yes	Yes
DH+	No	Yes **	No
DF1	No	No (RS-232)	Yes
DH-485	No	Yes	No recommended
FF-H1	No	Yes	No
HART	No	Yes	No
HART Multiplexer	No	N/A	Yes

* DNP3 serial to DNP-IP standard support in MRD/ADSL-350

** Requires testing cases by case. Cable is non twisted but does have an 85% screen to compensate

Protocols not listed

The above protocols are a small proportion of the protocols available in the industrial space but they represent around 80% of the installations. If there is an enquiry about a specific protocol not listed in this document then contact the Network Applications Team (NAT) nat@westermo.com and we will investigate the protocol and give an indication of its compatibility with Westermo Ethernet products.

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Running multiple protocols

The VLAN segregation in WeOS devices allows for multiple protocols to be carried over the same network. The example below shows a system running multiple protocols over the same Ethernet backbone. WeOS allows for the configuration of different Quality of Service (QoS) by port, VLAN or IP (ToS) to ensure the most sensitive data is prioritized on the network. The network below is an actual example where multiple protocols coexist on the same infrastructure without any interference, packet leaking or timing issues.
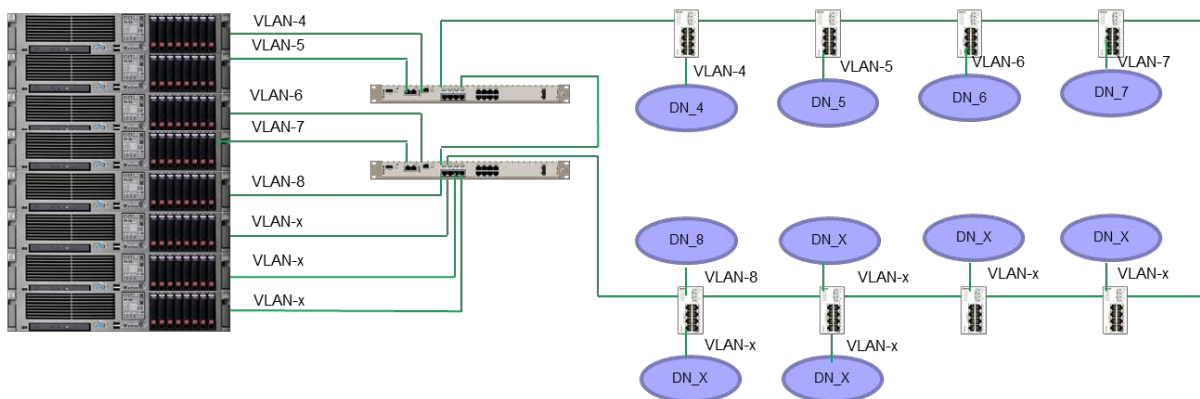
Each DN_x is a different protocol running in a VLAN
In this application all the protocols listed below are running simultaneously over a Gig/b FRNT ring with no loss of performance or timing;

PROFINET
GOOSE
MMS
IAC
MODBUS

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