B&B ELECTRONICS

PRODUCT INFORMATION

Modbus: Using Legacy Code to Solve Modern Challenges

Overview

In December 1990, a world-renowned economist named Paul Zane Pilzer published a book titled "Unlimited Wealth." Among other things, the book looked at the ever-increasing role technology played in the business world and made a number of projections about how technology would dominate business as time went on.

During that discussion he coined a phrase – "The Technology Gap", defined as the gap between what is currently invented and available, and what is actually being used in the market. As the speed of technological inventions increased, the gap would widen and cause a number of difficulties for business – particularly for industries like manufacturing that relied heavily on technology.

A dangerous – and expensive – gap exists between current technologies and those actually being implemented.

The challenge would be for companies to find a way to quickly – or even permanently – span the "technology gap" so that they did not consume vast resources on staying current within a whirlwind of new developments and technologies.

Today's Technology Gap

Consider how the "technology gap" plays out within the industrial and manufacturing sector. A production piece of equipment is purchased in the mid 1990's. It has a 20-year functional lifespan and is designed to communicate with the computers and PLC's of the day.

Yet, within 5-years, CPU's, networks, interfaces, software, DAQ components, and other technologies have taken a massive leap ahead and changed – in some cases, even down to the way they connect and communicate (ie, the advent of wireless systems, USB, etc…). Suddenly a "technology gap" exists between the production hardware and the operational controllers and communication lines.

Closing the Gap

The challenge lies in retaining legacy equipment while keeping pace with cutting-edge technologies.

In this scenario, it is readily apparent that, in order to stay competitive in the market, the manufacturer has a significant need to upgrade their operational, control, and communication components – but not necessarily their production equipment. The problem is that, in many respects, the elements are no longer designed to interact on friendly terms.

Fortunately, there is a sturdy bridge, which, at least for t the time being, appears to present a permanent solution to the "technology gap" issue being faced by the industrial sector.

The "Bridge" relies on two layers to ensure its strength:

- Software layer, consisting of Modbus and its various forms
- Hardware layer, consisting of RS-232 and RS-485 – the physical layers of Modbus

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The Modbus protocol, combined with RS-232 and RS-485 connections, form the working bridge to span the "Gap".

For the time being, we'll focus in on the Modbus software layer.

Introduction to Modbus: The Technology Gap Bridge

In late 1979, long before Mr. Pilzer was theorizing on the speed of technological developments, Modicon, a small company out of California, had its engineers develop a communication protocol that allowed programmable logic controllers (PLC's) to effectively communicate with factory and industrial equipment.

The Modbus protocol had several distinct advantages:

- First, it is thin, simple, and effective. It requires very little by way of hardware to run it – thus saving valuable space and allowing for smaller, less expensive electronic components.
- It is fairly simple to learn and program into new and existing hardware – thus significantly reducing development and programming time for manufacturers and end users. This feature allows a Modbus system to be implemented and up and running within days – not months. Today, many Modbus modules are actually plug-and-play, making installation virtually instantaneous
- Modbus typically utilizes RS-232 and RS-485 to physically connect to PLC's, I/O, and other hardware – connection ports that remain the standard on today's industrial equipment.
- Modbus is designed to move raw data, regardless of form or function. This gives vendors enormous flexibility in development on their end, and greatly minimizes data format restrictions.
- One final aspect of Modbus makes it very attractive: it is free. Early on, Modicon opened the protocol to everyone and anyone who wanted it.

Even given these benefits, the success of Modbus, and its virtually universal acceptance as the de facto industrial communication protocol, is somewhat of a wonder. Today, it is reported that there are well over 7 million Modbus nodes in North America and Europe alone, with thousands of different types of devices utilizing it.

There are over 7 million Modbus nodes in North America and Europe alone. Additionally, thousands of diverse electronic components support and use Modbus.

The far reach of Modbus has added yet another benefit to its utilization: Interoperability. The simplicity of Modbus and the way it packages information, enables it to effectively communicate with virtually any piece of industrial equipment or operating system on the market today.

Three Transmission Modes

Over the years, Modbus has taken three primary variations or ways in which it can package information. These three transmission modes are:

1. **ASCII** (American Standard Code for Information Interchange) – The original transmission mode has several advantages, the strongest of which is that all data is sent and received in a format that humans can read. This relieved the end user of the need of complex software converters and somewhat reduced resources.

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by Modbus is

The drawback to this mode is what's referred to as "bloat ware" because it takes up a lot data space and is, compared to its binary counterpart, less efficient.

The ASCII mode also utilizes the cyclic redundancy check (CRC) method to verify that information is sent and received without errors. CRC tends to be more time consuming and less effective than the longitudinal redundancy check (LRC) method that is more widely used.

2. **RTU** (Remote Terminal Unit) – As computer technology grew, so did the world of binary communications – or sending data using only 1's and 0's. In response, a second Modbus transmission mode was developed – RTU.

   RTU is compact, faster, and utilizes LRC to verify the accuracy of transmissions. Because of this, it is more widely used today than the ASCII mode.

   TCP/IP (Transmission Control Protocol/Internet Protocol) – As will be shown in a minute, TCP/IP mode allows the most flexibility, fastest data transmission speeds, most powerful communication arrays, and highest level of accuracy and reliability.

3. Modbus TCP/IP essentially allows data generated following the Modbus protocol to be packaged within the TCP/IP protocol. Because TCP/IP is the standard communication protocol for the Internet, Ethernet networks, and intranet structures, this mode allows for unlimited communication and interoperability options while still using legacy Modbus.

Modbus Network Configuration Considerations

Here are just a few technical details to consider when establishing a Modbus network:

- **Master-Slave** – Modbus is a master-slave technology. This means that only one device on the network can act as master, while the others act as slaves.
- **Single, Multi, or Network** – Modbus supports single, direct connections, or multi-drop connections, or network configurations.
- **Polling** – Modbus does not "report by exception" but rather relies on schedule polling to acquire data. Depending on the volume of data being transmitted and the frequency at which information is needed, this could consume large levels of bandwidth – a consideration in some industrial environments.
- **Node Limits** – Modbus is limited to 254 connections per master unit/system. The exception to this is when TCP/IP mode is utilized because it makes the ratio between master and device virtually unlimited.
- **Contiguous Transmission** – Modbus demands contiguous data transmission as time and data gaps are translated into starts and stops of whole data sections. This requires that all devices on the network be able to buffer data and prevent gaps in transmission.

Modbus is a master-slave protocol and is limited to 254 connections per master.

An Easy Solution to Modbus' Own Technology Gap

There is, however, one area where Modbus is not interoperable: With itself. When looking for converters, repeaters, or other components to utilize within a Modbus environment, it is essential that all components on a given network utilize the same transmission mode.

Configuration Warning: ASCII mode is NOT compatible with RTU mode. All components must be set for the same transmission mode.

For example, a Modbus converter configured with ASCII will not communicate with an RTU element on the network. Likewise RTU components will not speak with ASCII systems.

TCP/IP elements are the exception to this, in that they will speak to either, but require some type of Ethernet component to unwrap the TCP/IP packaging from around the Modbus formatted data, before it is delivered to the Modbus system or component.

Servers and converters allow different transmission modes to co-exist on the same network.

Given Modbus' inability to communicate with itself in different transmission modes, several manufacturers have developed Modbus servers that seamlessly manage traffic from all three modes and convert between ASCII/RTU and TCP/IP. (For an example of this type of module and how it is configured see Modbus Serial Server model MES1A and MES1B).

Before leaving the subject of incompatibility, it should be noted that one other scenario could create complications. Consider the situation when two pieces of equipment operate with the same Modbus transmission mode (ie ASCII or RTU), but have different physical layers (ie one has RS-232 and the other RS-485).

Even though the transmission mode is the same, these two pieces of equipment are physically incompatible. This situation is readily solved with a wide array of converters that allow you to seamlessly flow from an RS-232 connection to an RS-485, and back again. (For examples, see Serial Converters).

Filling The Gap: Economic Advantages of Modbus

The real power behind Modbus is not in its ability to transmit data, but rather in its ability to fill the technology gap. In turn, this translates into a number of solid economical advantages that appear to be timeless. What this means is that, regardless of where technology goes in the future, Modbus will continue to be an economical and advantageous communication protocol to incorporate.

Here are just a few of the ways Modbus can be used to provide economic advantages for manufacturing and industrial companies:

The Modbus protocol can save companies substantial resources and money because of its flexibility and stability.

- **Retention of Legacy Equipment** – Because Modbus encapsulates and moves raw data, it can facilitate communications between your legacy equipment and the constant changing world of CPU's, processors, modules, wireless systems, PCL's and other cutting-edge technologies.

  The economic advantages here should be obvious: New technologies can be incorporated and enjoyed without incurring the enormous costs of changing out functioning and productive equipment.

- **Integration of New Equipment and Systems** – Just as Modbus allows for the retention of legacy equipment, it also provides unlimited flexibility in moving forward with new equipment and technologies. With Modbus TCP/IP and today's advanced Modbus plug-and-play modules, such as wireless systems, servers, and converters, new technologies can be installed, configured and brought online within hours.

  This ensures ongoing productivity, equipment remaining current and up-to-date, low installation costs, and rapid repair/replacement of damaged or out dated devices. It also allows greater flexibility in purchasing new equipment, without the fear of running into compatibility issues.

Modbus TCP/IP brings legacy equipment into the Internet age and erases geographical barriers and network configuration limitations.

- **Distance and Remote Access** – The introduction of Modbus TCP/IP and Modbus wireless systems eliminates the need of having control units physically close to all nodes and devices.

  Through TCP/IP, data and systems can be monitored and controlled through any Internet connection, anywhere in the world. This frees up managers, engineers, and executives to travel as needed and perform their functions from virtually any location. Additionally, it gives companies the power to centrally control geographically diverse operations, creating a solid economics of scale that can save countless dollars in purchasing duplicate systems performing the same functions.

  Wireless Modbus can eliminate wiring headaches, greatly simplify installation, reconfiguration, and repairs, and extend your reach to over 20 miles. The savings in not running physical wires can drastically overshadow the cost of converting to a wireless version of Modbus. (For more info on the power and possibilities of wireless, see "Industrial Wireless: Solving Wiring Issues by Unplugging"and Zlinx Wireless Modbus.)

- **Free Protocol** – And, of course, it goes without saying that because Modbus is a free and open standard, it lowers the cost of development and implementation on all ends. This means no licensing fees, upgrade fees, or proprietary data to incur ongoing costs.

Overview of Modbus Converters and Modules

Various modules, converters and components greatly expand the scope and reach of Modbus and increase the economic advantages to utilizing it.

Because Modbus is so widely utilized in the industrial world, anything short of a general overview of the different types of converters, modules and components available is impossible. However, a quick summary may be helpful:

- **Converters** – Modbus converters come in two different types. First, sometimes it is necessary to move data from one transmission mode to another. This regularly occurs when going from RTU/ASCII to TCP/IP, and sometimes, though less frequently, it is necessary to move from ASCII to RTU and back. Converters facilitate this kind of data movement.

  The second type of Modbus converters you will find is in the connection world. While RS-232 and RS-485 remain the standard connection ports in the industrial world, some PCL's and computers have switched to USB ports. At other times, it is necessary to connect one piece of equipment with RS-232 to another with RS-485. Connection converters facilitate this, while preserving the data structure and remaining compatible with Modbus. B&B offers a number of Modbus compatible protocol converters. Our most popular serial models are the 485DRCi, 485LDRC9, and 4WSD9OTB. USB Converters are available in Panel, Inline, and DIN Rail Mounts. (For more details on USB converters see "USB Converters – Essential Components for Today's Industrial Connections".

- **Servers** – Modbus servers are, in a way, converters, but possess the added ability to manage and direct traffic. Servers typically can be DIN rail mounted or cabinet mounted, and typically serve as a conjunction point between TCP/IP and ASCII/RTU traffic. In all cases they facilitate management at a distance and simplify the setup of a Modbus network.

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- **Wireless** – Modbus wireless components simply remove the wiring between Modbus connections and extend the scope and reach of industrial companies.

- **Modules and Sensors**– Modbus enabled modules come in every shape, size and functionality imaginable. Voltage sensors, thermo couplers, optosensors, relays, and many, many more.

Summary

Because the Modbus protocol is so widely used, extremely adaptable in its applications, and timeless in its usability, it serves as the perfect technology gap bridge between legacy hardware, equipment, and modules, and today's cutting edge technologies.

In a way, it acts as a safeguard against the "technology gap". An investment in industrial equipment from 10 years ago… or the purchases being made this month… will not be wasted due to rapidly advancing technologies. This fact should give companies an added layer of confidence in moving forward.

Final Technical Note

B&B is here to help with all your Modbus questions. Simply give us a call.

At B&B Electronics, we recognize that the process of configuring and deploying new and existing systems can be confusing, time consuming, expensive, and often times very frustrating. Because of this we continue to offer complimentary consultation services. Have a question? Simply pick up the phone and contact one of our Application Engineers at (815) 433-5100. Additionally, you can log onto our website at www.bb-elec.com and ask questions via our live chat. Our team is happy to help point you in the right direction.

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