WHITEPAPER

Connectivity - An Overview of Connectivity Technologies

DATAMAX®

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Introduction

The definition of connectivity differs depending on the viewpoint of the person answering the question. Effective data communication between a device, such as a printer, and a command driver, such as a host computer, is only one aspect of connectivity. Device flexibility is another aspect, one that is equally important and often overlooked in creating an effective automatic identification and data collection (AIDC) system that can achieve the Return on Investment (ROI) required to justify the system's implementation.

Few workplaces remain static in terms of layout and workflow. Having connectivity options that are flexible to adapt to changing business conditions helps maintain productivity in the face of change.

This White Paper will provide an overview of the types of connectivity options available, their respective benefits and limitations, and their applicability to AIDC systems.

Basic Data Communication Types

There are two basic types of data communication - wired and wireless - with a number of options within each basic type.

> Wired
- Serial
- Parallel
- Twinax/Coax
- USB
- Ethernet

> Wireless
- Communication Modes
- Infrared
- Bluetooth
- Wi-Fi (IEEE 802.11)

Many AIDC devices either have built-in capabilities to support more than one of the above connectivity options or can be upgraded to support additional protocols. This capability makes it possible to select one connectivity option to meet current demands and a different one at a later date as the work environment changes.

Below is a short synopsis of each of the protocols. Table 1 summarizes the performance characteristics and typical applications for each of these protocols.

Wired

Serial

Serial communication is one of the most basic forms of connectivity as well as one of the slowest. There are three types of serial communication in common use: RS232, RS422, and RS485. Data is sent "serially," that is, one bit at a time. It is capable of bi-directional communication between the host and the device.

Serial ports are commonly identified as "COM" ports on most computers.

> RS232 is designed to connect a single device to a single host, typically a PC or mobile computer. Cable length is limited to 50 feet (15.25m). Maximum data communication speed is 20Kbps.
>
> RS422 can be used to connect more than one device to a host, but is more typically used to provide greater data communication speed or to allow greater distance between the host and the device. RS422 can be used in limited multi-drop applications. Maximum cable length is 4,000 feet (1.2km). Maximum data communication speed ranges from 100Kbps to 10Mbps, depending on the cable length.
>
> RS485 offers higher speeds, greater distance, true multi-drop capabilities, and is able to communicate with as many as 32 different devices. Cable length and data communication speeds are the same as RS422.

Parallel

Parallel communication offers higher speed than serial communication and is more typically used to connect a single printer to a PC or workstation. Eight bits of data (one byte) is transferred simultaneously on multiple paths, resulting in faster data transmission. The original (Centronics) parallel ports were capable of only one-way communication (from the computer to the device) with a speed of up to 1.2Mbps. Current IEEE 1284-compliant parallel ports offer bi-directional communication. There are two sub-protocols: EPP (Enhanced Parallel Port), with a speed of up to 8 Mbps and ECP (Enhanced Capability Port), with a speed of up to 16Mbps. Typically, however, IEEE 1284 parallel ports handle about 80Kbps. Cable lengths are limited to 6 feet (1.8m) and require IEEE 1284 cables for bi-directional communication.

Parallel ports are identified as "LPT" ports on most computers.

Twinax/Coax

Twinaxial and Coaxial cables are typically used to connect printers and other peripherals either through a workstation or a router on a network.

Twinax cables consist of two wires side-by-side and are typically used with IBM AS/400 host networks.Coax cables consist of two conductors, one inside the other, and are found on many local area networks and with IBM 3270 terminals.

Data transmission speed depends on the host network. Maximum cable length is 5,000 feet (1.5km).

USB (Universal Serial Bus)

The Universal Serial Bus (USB) is a newer connectivity option, most notable for its ability to allow "hot" connect/disconnect of multiple peripherals to a host. When supported by the host software, USB ports offer an "autodetect" feature that identifies new devices and automatically asks to install the appropriate driver. USB can support up to 127 devices.

The older version of USB (1.1) had data transmission speeds of 1.5-12Mbps. Version 2.0 has data transmission speeds up to 480Mbps. Cable length is a standard 6 feet (1.6m) but can be extended up to 16 feet (4.8m) with no effect on performance.

Ethernet

The most common network star topology found today is Ethernet-based and most commonly utilizes the Transmission Control Protocol/Internet Protocol (TCP/IP).

Communication distance is determined by the transmission media (i.e. copper or fiber) and the configuration of routers and switches on the network. With standard routers and converters, distances of several miles can be achieved although performance does diminish with distance. Speeds of 3Mbps are not atypical at the maximum effective distance. Over fiber optic networks, distances of over 6 miles (10km) are possible, again, with slower speeds. Actual performance and distance is highly dependent on the network configuration.

10baseT Ethernet is the most common. Maximum data communication speed is 10Mbps.

100baseT Ethernet (IEEE 802.3u), also called Fast Ethernet, offers data communication speeds up to 100Mbps.

1000baseT Ethernet (IEEE 802.3ab), also called Gigabit Ethernet, is the newest protocol, and offers data communication speeds up to 1000Mbps. Gigabit Ethernet has been used for years for server-to-server connections and has now migrated down to the PC level.

Wireless

Communication Modes

There are two primary methods for wireless devices to communicate with each other on a network: Infrastructure (Access Point) and Ad-hoc (Peer-to-Peer).

Infrastructure communication utilizes a wireless access point that each device connects to in order to share information. Each of the wireless devices must have a wireless network adapter in order to be connected to the access point. A wired connection can also be configured to work with a wireless network using the infrastructure method. For example, the wired device is connected to the access point using an Ethernet cable and the wireless device communicates with the wired device via the access point.

Ad-hoc communication utilizes a direct connection between the computer and a wireless device. This type of communication is generally limited to a small number of devices because performance decreases after connecting six wireless devices. Each of the wireless devices must have a wireless network adapter in order to be connected to the main computer.

Infrared

Infrared communication is designed for short-range communication between a peripheral and a host computer or network. It is typically used to connect wireless keyboards/mice as well as desktop peripherals. It can also be employed in an Ethernet (EthIR LAN/WAN) configuration.

There are two types of IR: diffuse and direct.

> Diffuse IR allows multiple connections and is less dependent on line-of-sight.
>
> Direct IR is point-to-point and does require line-of-sight. Standards have been developed by IrDA (Infrared Developers Association) for direct IR connections.

Because infrared is light-based, environmental considerations as well as line-of-sight affect achieved range. IrDA devices only claim a range of about 3 feet (1m) but some diffuse IR device manufacturers claim much greater range, similar to that of RF-based systems (depending on placement of the IR base station).

Connected to a serial port, IR provides data communication speeds up to 4Mbps.

Bluetooth

Designed as a short-distance radio frequency (RF) communication standard, sometimes called a Wireless Personal Network (WPAN), Bluetooth is most commonly used to connect computer peripherals such as keyboards/mice or printers and to enable communication between a PC and another device such as a PDA. Because it is RF-based, it does not require line-of-sight between one device and another. Significant concentrations of metal or liquids may significantly reduce its effective range and/or distort the signal.

Bluetooth is designed to provide point-to-point as well as point-to-multipoint connection (called "piconets"). It is designed to enable devices to make their own connections without the need for operator intervention. Connections can be established on an ad hoc basis.

Data communication speed is up to 1Mbps with a maximum range of about 325 feet (100m) although a range of almost 70 feet (20m) may be more typical.

Bluetooth is covered by IEEE 802.15 and operates in the 2.45GHz range of the radio spectrum, the same as some Wi-Fi devices (see below). At present, there are potential conflicts between 2.45GHz Wi-Fi and Bluetooth.

Wi-Fi (IEEE 802.11)
RF-based 802.11 devices, also called Wi-Fi, or Wireless Fidelity, are the most commonly used for Wireless LANs (WLANs).
There are currently three Wi-Fi standards: 802.11(a), 802.11(b), and 802.11(g). There is an ongoing debate over the relative merits of each of the 802.11 methods and no conclusions will be drawn here.

The Wi-Fi designation is achieved by devices that have been tested and certified to conform to Ethernet communications standards and can successfully interoperate with devices from other manufacturers (within each standard classification). All 802.11 products use spread spectrum technology to minimize interference from outside sources.

The performance of 802.11 devices decreases with distance in order to ensure accurate data communication. In "quiet" RF environments, data communication rates can remain higher than in "noisy" ones.

All 802.11 devices communicate with an access point that is typically a node on a network. Achieved data communication speed is therefore dependent on both wireless and wired network performance.

802.11 (a) operates in the 5GHz range. 802.11(a) specifies orthogonal frequency division multiplexing as a means to avoid interference. Many reports suggest that (a) is preferable for high concentration applications. Data communication rates range from a high of 54Mbps close to the access point to as low as 3Mbps at the edge of its range, approximately 165 feet (50m).

802.11(b) operates at 2.45GHz and employs direct sequence spread spectrum to avoid interference. It offers data communication speeds of up to 11Mbps close to the access point, falling off to 1Mbps at the edge of its range, approximately 410 feet (124m). 802.11(b) operates at the same frequency as Bluetooth and may cause interference with, or be subject to interference by, Bluetooth communications.

802.11(g) operates at 2.45GHz and employs orthogonal frequency division multiplexing and a form of direct sequence spread spectrum that is backwardly compatible with 802.11(b) devices. Like 802.11(a), it offers data communication speeds of 54Mbps close to the access point, falling off to 6Mbps at the edge of its range, approximately 300 feet (91m).

Note: The ranges listed above are for open area installations. With typical indoor installations, communication ranges are considerably lower and dependent on environment, antenna configuration, and antenna placement.

Table 1: Summary of Data Communication Capabilities

Protocol	Max. Speed	Max. Distance	Typical Applications
RS232 (Serial) RS422 (Serial) RS485 (Serial)	20Kbps 10Mbps 10Mbps	50' (15.25m) 4,000' (1.2km) 4,000' (1.2km)	Connecting keyboard, mouse or single peripheral to PC or workstation Connect a single peripheral to a PC or workstation Connecting one or more peripherals to a PC or workstation
EPP (Parallel) ECP (Parallel)	8Mbps 16Mbps	6' (1.8m)	Connecting a single peripheral to PC or workstation
Twinax	Network dependent	5,000' (1.5km)	Connecting networked peripherals to AS/400
Coax	Network dependent	5,000' (1.5km)	Connecting networked peripherals to LAN and 3270 workstations
USB 1.1 USB 2.0	12Mbps 480Mbps	16' (4.8m)	Connecting multiple peripherals to a PC;connecting keyboard/mouse to PC
Ethernet 10baseT Ethernet 100baseT Ethernet 1000baseT	10Mbps 100Mbps 1000Mbps	9,800' (3 km) (copper) 32,800' (10 km) (fiber) 100m (copper)	Networking multiple servers, PCs and peripherals
Bluetooth	1Mbps	325' (100m)	Networking one or more devices and/or peripherals
Infrared (IR)	4Mbps	3' (1m) or more	Communication between a PC, PDA and/or peripheral devices
Wi-Fi 802.11(a) Wi-Fi 802.11(b) Wi-Fi 802.11(g)	3Mbps - 54Mbps 1Mbps - 11Mbps 6Mbps - 54Mbps	165' (50m) 410' (124m) 300' (91m)	Wireless LAN, connecting PCs and peripherals to network

Table Notes:
For consistency, speeds typically reported in bytes/second have been converted to bits/second.
Data communication speed is reported at its maximum capacity; actual thruput may be half the stated speed.

Typical AIDC Applications (Wired)

Serial

Typically, bar code scanners can be connected via serial communications to a dedicated PC or workstation. Bar code scanners may be connected to the keyboard port using a "wedge" reader. Bar code printers may be connected via a serial (COM) port but it is more typical to take advantage of the higher data communication speed of a parallel (LPT) port.

Parallel

Many bar code printers are connected to a dedicated PC or workstation using parallel (LPT) ports.

Twinax/Coax

Bar code printers can be added to Twinax/Coax networks when equipped with the proper interface option. In some applications, this is the only option because of the network configuration.

USB

It is becoming more common to find bar code scanners and printers equipped with USB connectivity options because of the ease of setup and high data communication speeds.

Ethernet

Ethernet is becoming one of the most important connectivity options. Virtually all AIDC products can be implemented as nodes on a company intranet and may even be accessed through an Internet connection. This can be a considerable asset in enabling a remote database (whether the company's or a customer's) to initiate the printing of bar code shipping labels or other pertinent materials.

Typical AIDC Applications (Wireless)

Infrared

Infrared is not widely used for AIDC in the U.S., although there have been notable applications in Europe in the late 1980s and early 1990s. As a result of the differences in RF regulations between countries, infrared was seen as the only wireless technology that could be deployed enterprise-wide regardless of the country in which it was implemented. Infrared was used to enable communication between portable data collection terminals and occasionally printers. Data transmission rates were relatively slow but data communication demands were also relatively low. With the development of a more consistent European-wide regulatory environment and increasing bandwidth demands for modern data collection systems, most wireless communications in Europe are now RF-based.

Bluetooth

Although Bluetooth is widely implemented on a number of PDAs, notebooks and desktop devices, it is not yet commonly used for AIDC products. Bluetooth has been considered by some to be a possible replacement for infrared communications.

Wi-Fi (IEEE 802.11)

Printers, scanners, mobile computers and other AIDC devices are increasingly capable of accepting a Wi-Fi radio card. WLANs are becoming more popular because they enable virtually unrestricted flexibility in work area layout.

Additional Considerations

Wired interfaces are currently the most common connection for host and peripheral devices. In many cases, wired is the most cost-effective approach since for serial, parallel and USB, a simple cable is all that is required. In other instances, an existing Ethernet backbone makes connectivity relatively easy. However, any significant changes in the workplace may require major changes in network wiring. These adaptations can become a cost issue.

Wireless networks, although initially more expensive than wired connectivity, may be a more cost-effective solution for new installations. Costs for wireless networks tend to be one-time costs and, with proper planning, can be reconfigured without incurring a substantial additional expense.

Selecting a connectivity option for an AIDC device depends on whether the device is to be a stand-alone (point-to-point) connection or networked, as well as the amount of data to be communicated.

For networked devices, consideration must also be given to:

> existing network configuration,
> specific network requirements/limitations (e.g. coax),
> distance/wiring requirements,
> future plans.

Conclusions

Connectivity options have evolved from the simple serial interface to high-speed Ethernet and Wi-Fi wireless. Each of these options has been developed to address business case requirements.

It should be noted, however, that some of these connectivity options may have outlived their true usefulness and may have been superseded by more recent developments.

Selecting the proper connectivity option(s) for your AIDC device will make current and future implementations go much more smoothly.

Datamax and Connectivity

Datamax understands the importance of corporate data distribution and that hardware integration is a vital component of creating a truly communicative operating environment. Like any printer, a Datamax printer must receive information in order to achieve its investment goal, which is to increase efficiencies and reduce costs in an organization's operations. There is an increased demand for bar code printing solutions to be able to communicate and operate with enterprise applications. Datamax DMXConnect meets this demand by enabling a Datamax printer to be integrated seamlessly into an enterprise network by offering a variety of wired and wireless solutions. Table 2 summarizes the connectivity options available for the various Datamax products.

Table 2: Summary of Datamax Connectivity Options

Printers	Standard Connectivity	Optional Connectivity
E-Class	Serial, Parallel, USB	Ethernet
M-Class	Serial, Parallel, USB	Ethernet
I-Class	Serial, Parallel	USB, Twinax/Coax, Ethernet, Wi-Fi
W-Class	Serial, Parallel	USB, Twinax/Coax, Ethernet, Wi-Fi
S-Class	Serial, Parallel	Ethernet
A-Class	Serial, Parallel, USB	Ethernet, Twinax/Coax, Wi-Fi

Please visit www.datamaxcorp.com for more information on Datamax products and solutions.

Datamax specializes in the design, manufacture, and marketing of products for bar code and RFID labeling including thermal demand printers, label, ticket and tag materials, and thermal transfer ribbons. Headquartered in Orlando, Florida, Datamax has sales representative offices in Singapore, China, and Harlow, England, as well as label converting and preprinting facilities in Robinson, Illinois. Datamax markets its products exclusively through a network of resellers in more than 100 countries worldwide.

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