Creating a Dynamic Serial Edge
For Integrated Industrial Networks

Technical Brief
GarrettCom, Inc.

As industrial networks evolve, Ethernet is becoming the standard technology for new system interfaces and for new core local network infrastructure. However, industrial networks are still far from homogeneous. There is a decades-long accumulation of industrial devices that utilize asynchronous, serial protocols for operational applications such as SCADA (Supervisory Control and Data Acquisition) and for industrial device console interfaces. These serial communications requirements may be met via separate networks distinct from the emerging IP/Ethernet infrastructure. Alternatively, as this document describes, serial devices on the edge of industrial networks can be integrated with the central IP/Ethernet network. This integration enables more universal network access and leverages common investments in a high performance, cost effective and resilient core network infrastructure. This new approach to having network-enabled serial devices represents the Dynamic Serial Edge of industrial networks.

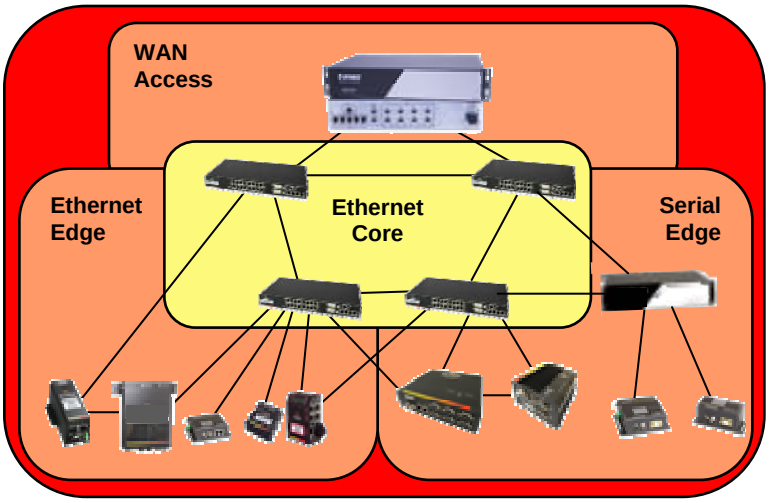
The Strategic, Integrated Industrial Network Architecture

There are many factors encouraging rapid deployment of Ethernet as the core technology for industrial networks. IP/Ethernet provides a broadly supported technology for system interconnection across many system suppliers. It leverages mass market component volumes to create a cost-effective, high-performance network. Ethernet lends itself to fiber-based connectivity that is important in electrically noisy industrial environments. Ethernet also supports ring, dual-star and mesh topologies that are highly resilient against single-point network faults, thus improving system reliability.

A holistic view of the emerging industrial network (as depicted in Figure 1 below) uses Ethernet switches as a universal connectivity medium at the core of the network, and then surrounds this core with edge and access layers for Ethernet devices, serial devices and wide area network connections.

In the Ethernet-edge part of this architecture, some industrial devices connect directly to the core network, generally using integral fiber optics or copper-to-fiber media converters. These are usually single connections, but in some cases dual connectivity is implemented to enhance reliability. Often, Ethernet edge switches are deployed near distributed industrial devices, sometimes serving multiple devices. The edge switches may provide dual-homed connectivity to the core network as well as copper-to-fiber media conversion. This edge architecture provides fiber-based network distribution for signal immunity in harsh environments and resilient connectivity for improved system reliability.

Figure 1
Integrated Industrial Network Architecture



The Wide Area Network (WAN) access element of the architecture provides connection to private facilities or carrier-provided WAN services in order to enable access by remote systems or personnel to industrial devices in the local network. WAN access requires physical layer interfaces to WAN facilities, IP routing for interconnection of different Ethernet networks, and perimeter-security capabilities such as an IP Firewall.

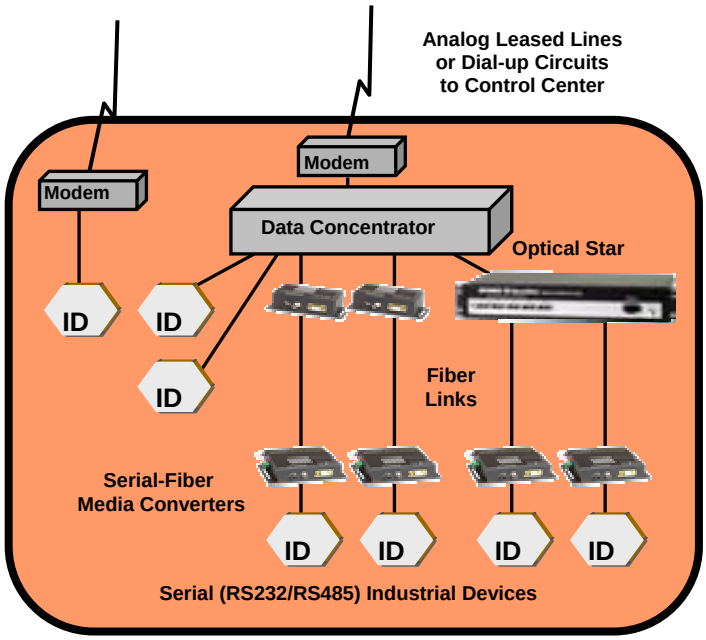
The Serial Edge of the industrial architecture has historically been implemented as a separate network. In some cases the Ethernet and Serial domains share a common WAN access element, but as yet, most do not share a local Ethernet infrastructure. The transition to an integrated Dynamic Serial Edge is further described below.

Traditional Serial Edge Connectivity

There are numerous serial devices in industrial environments. Early systems used vendor-specific proprietary serial protocols for industrial applications. More recently, many systems have standardized on serial-mode DNP and Modbus protocols. In addition, most industrial devices utilize serial-mode console interfaces for device provisioning and administration.

Over the years, relatively static, dedicated networks have been developed for connecting these serial devices and interfaces to central data collectors and/or to basic remote access facilities (see Figure 2). Devices are generally connected over dedicated copper or fiber cabling, sometimes using serial-mode copper-to-fiber media converters for signal immunity. Some local serial networks support star configurations and multicast serial protocols to enable data concentrators to communicate to several devices over a single port. Devices may be connected to dedicated modem connections for remote access, or some limited shared WAN access may be provided by a local data concentrator for both an operational data interface, such as SCADA, and separately for serial console access.

Figure 2
Traditional "Static" Serial Edge Network



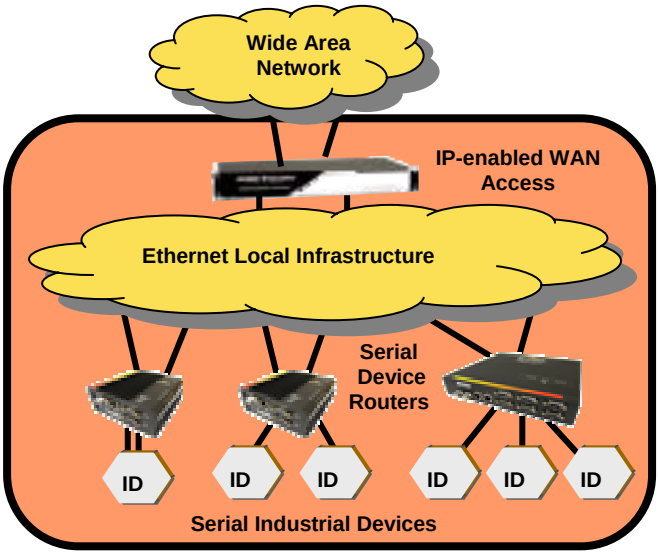
These static serial edge networks rely on dedicated connections for each application. Adding new industrial devices or new systems means adding new dedicated connections. Console access to devices is also highly restricted, inhibiting efficient access by remote technical personnel. Connections are hard-wired with no resiliency against faults and no remote management of network elements.

Introducing the Dynamic Serial Edge

The primary strategic objective for the serial edge of industrial networks is to network-enable serial devices so that remote systems and personnel can more readily and more securely access these devices over a common IP/Ethernet infrastructure. Cost effectiveness is also important. The new generation of the serial edge should leverage the emerging Ethernet infrastructure to take advantage of the ubiquity, performance, fiber connectivity and resiliency offered by the emerging Ethernet core architecture.

A new Dynamic Serial Edge (see Figure 3 below) is created by the deployment of intelligent Serial-IP networking devices adjacent to distributed industrial serial devices in order to provide Serial-IP/Ethernet connectivity into the common local core network. Primary examples of such networking devices are the GarrettCom Magnum DX40 and Magnum DX800 Serial Device Routers. These devices can be widely distributed within even the harshest industrial environments and will connect serial industrial devices directly to the IP/Ethernet infrastructure. In some cases, multiple serial connections may be attached to the same industrial device. For example, multiple serial connections enable both an operational data interface such as SCADA and separately provide for serial console access.

Figure 3
Dynamic Serial Edge Network



Magnum DX Serial Device Routers are typically dual-connected to the Ethernet core over fiber media, and will support various network topologies that provide resilient connectivity in differing industrial applications. One common topology is dual-connected into two different Ethernet backbone rings (as in Figure 4) for use in architectures such as large power substations with strict IEC 61850 designs that require redundant core networks. Another topology is a resilient Ethernet-based edge collector ring connecting several dispersed serial edge devices (as in Figure 5) that may be cost-effective in highly distributed applications such as pipelines, tunnels and wind farms.

Figure 4
Dual-ported Dynamic Serial Edge Topology

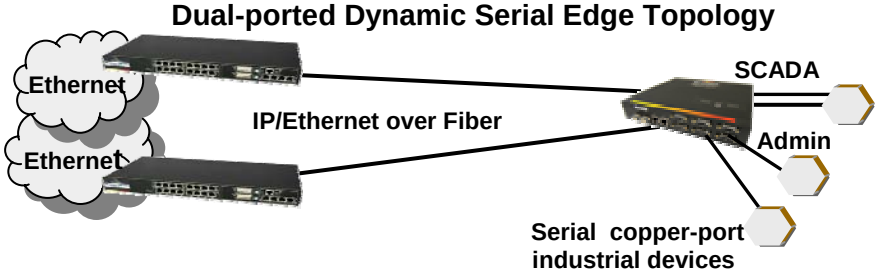
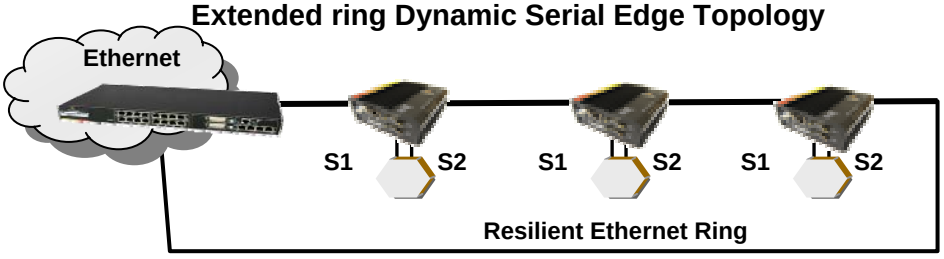


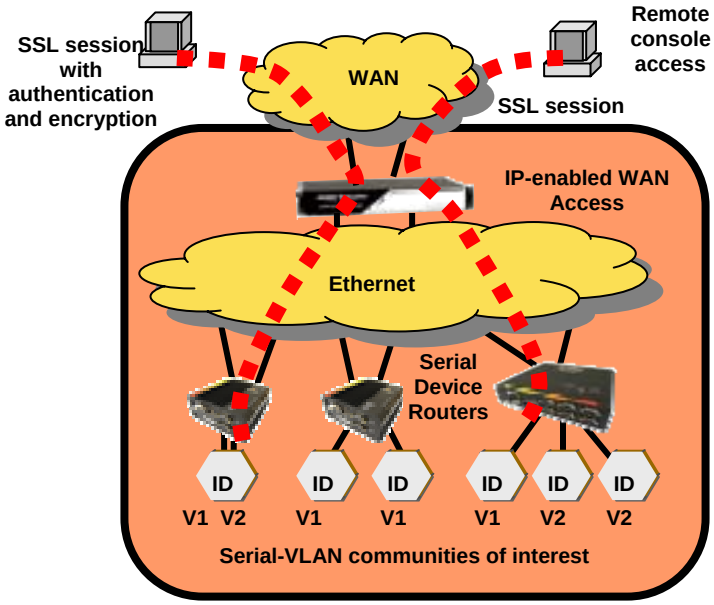
Figure 5
Extended ring Dynamic Serial Edge Topology



Security Features of the Dynamic Serial Edge

An important aspect of the Dynamic Serial Edge is cyber security. Cyber security becomes more urgent when remote access is expanded to include serial devices. In some industries, such as electric power transmission, remote access brings regulatory obligations for cyber security protection of critical infrastructure. Many strategic networks will already have some degree of perimeter security via a WAN-access firewall function; however, rigorous port security for industrial devices requires authentication and encryption of serial connections by remote systems and personnel on an end-to-end basis, extending locally to the serial port itself. Serial Device Routers support Secure Socket Layer (SSL) sessions from remote systems and PC-based remote personnel with authentication that is specific to individual serial ports. They also perform high-performance, hardware-assisted encryption of traffic all the way to the edge of the local network. Serial Device Routers include an additional capability for associating serial ports into closed communities of interest. This feature uses Ethernet 802.1Q VLAN technology, with serial ports individually assignable to different VLANs (Virtual Local Area Networks).

Figure 6
Extended Cyber Security Protection over a Dynamic Serial Edge Network



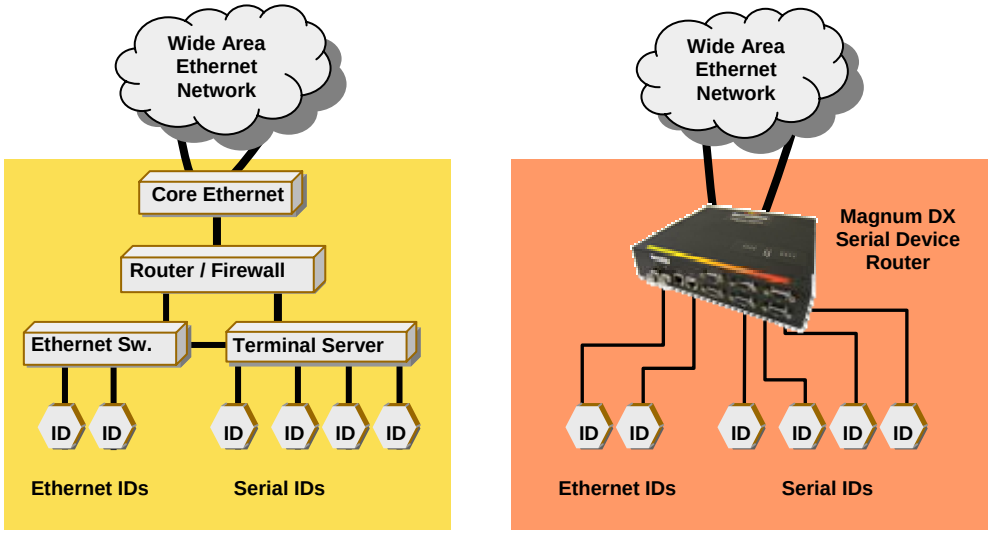
Serial Device Routers vs. Other Devices

Besides Serial Device Routers, there are other networking devices that can connect a serial industrial device to an IP/Ethernet network, such as Terminal Servers, Serial Device Servers, or Console Servers – all essentially the same thing. Like a Serial Device Router, traditional Terminal Servers, Serial Device Servers, or Console Servers provide the basic function of Serial-to-TCP/IP protocol encapsulation and connectivity to an Ethernet network. However, a Serial Device Router does much more.

A Serial Device Router is a combination of multiple network functions in a single product (see Figure 7). A Serial Device Router integrates the functions of a Terminal Server, an Ethernet Switch and an IP Router with a firewall. New per-VLAN routing technology also allows the

Serial Device Router to operate as multiple virtual Ethernet switches and/or multiple virtual terminal servers at the same time.

Figure 7
Multi-function Integration in a Serial Device Router



The multi-function properties of the Serial Device Router considerably enhance resiliency and security at the industrial network edge. In addition to features directly applicable to the edge of local Ethernet networks, the multi-functional nature of a Serial Device Router enables it to play many roles in industrial networks. These include acting as a perimeter security appliance for remote locations, or as a Layer-3 (IP protocol) gateway between different Ethernet network domains.

The table below summarizes key attributes that set the Serial Device Router apart from more basic IP-serial devices such as Terminal Servers. Magnum DX Serial Device Routers also are engineered to demanding power substation equipment specifications for extreme temperatures, electrical surge and immunity, and physical packaging. This enables reliable deployment in many applications where general purpose devices such as commercial-grade terminal servers will not operate.

Network Capabilities	Serial Device Router	Terminal Server
Serial-IP device services	**Yes**	**Yes**
Resiliency features		
Ethernet up-links	**Dual**	**Single**
Fiber Ethernet options	**Yes**	**No**
Resilient ring / mesh / RSTP	**Yes**	**No**
Dynamic IP Routing	**Yes**	**No**
Security features		
Serial port SSL	**Yes**	**No**
Hardware assisted encryption	**Yes**	**No**
“Serial-VLAN” support	**Yes**	**No**
Security perimeter (IP Firewall)	**Yes**	**No**

Achieving Business Objectives

Creating a Dynamic Serial Edge, as enabled by Magnum DX Serial Device Routers, meets many critical business objectives of industrial network designers and planners.

- The Dynamic Serial Edge protects existing investment in industrial equipment where there are serial communications interfaces by network-enabling these serial devices for access by remote systems and personnel.

- Network reliability, and thus associated operational system and process reliability, is improved by increased resiliency of local network connections, use of electrical-noise resistant fiber optic connectivity, and availability of extremely hardened and reliable networking devices.

- Cyber security is extended to the edge of the industrial network for serial devices using serial port SSL and unique Serial-VLAN facilities, facilitating compliance with cyber security standards and further increasing network reliability.

- Deployment of additional industrial devices and systems is made more cost-effective by leveraging the emerging Ethernet core network in industrial environments, and by building for long-term project life cycles with open standards technology.

Summary

The Dynamic Serial Edge is an important component of an overall integrated industrial network architecture. As the transition to Ethernet-at-the-core for substation and factory-floor networks has evolved, serial edge devices have generally been left apart in a static and separate edge network. The new Dynamic Serial Edge, as enabled by products such as GarrettCom's Magnum DX40 and DX800 Serial Device Routers, changes that.

New and evolving applications requirements, such as comprehensive cyber security mandates and heightened concerns for overall system reliability, require new views of the target industrial network architecture. An integrated approach to the design and planning of multi-protocol industrial networks is now available. The Dynamic Serial Edge facilitates the transition to the next generation of Integrated Industrial Networks.

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