A SCADA Implementation using IP based Network with Ring Topology for Path Protection

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Implementing a SCADA System for Ethernet and Serial Port access using an Internet Protocol (IP) based network formed out of point to point 2 Mbps E1 Links connected in a ring fashion

A. A SCADA system implementation for access of Serial Port based devices as well as Ethernet based Devices

Supervisory Control and Data Acquisition (SCADA) systems have been used for a variety of application in Indian Railways. A typical SCADA system consists of a server and several RTUs (Remote Terminal Units), interconnected over copper circuits using analog modems. The protocol is typically Master-Slave type, with the master system at the head end driving a pair of copper wires using a 4-wire analog modem towards multiple slave systems (RTUs) distributed along the track. Each slave system is also connected to a 4-wire analog modem, and drives the other pair of wires, which is multidropped at other slave modems and at the head end. If distances are long, PCM multiplexers are used for carrying analog modem data over E1 channels.

The system generally uses asynchronous communication, and a query-response protocol between the master and slaves. The end application involves the slave RTUs collecting data from sensors or measuring systems locally, and sending it to the master which has the facility to process and display the data.

A major drawback of multidrop analog modems is that signal quality deteriorates rapidly as data travels over the multidrop circuits in upstream and downstream direction. Also, there is no path redundancy, and a single break can render the chain inoperative. Data rates achieved are low – such as 1200 bps for chains exceeding a few slave stations. The scheme is also not able to support modern forms of communication between master and slave such as ethernet based communications using protocols such as TCP or UDP over IP.

CYGNUS provides an IP compatible, high throughput solution for SCADA applications using its CYGNUS 1110 IP Network Access Device (NAX). Like IP routers, multiple NAX units can be interconnected via their WAN ports to form an IP network. This network is capable of transporting not only traditional multidrop serial data but also Ethernet based data between the master and slave RTUs. NAX provides four RS232 ports and four Ethernet ports through which user devices can directly connect to it. A typical scheme using NAX that can replace a multidrop modem network and also simultaneously provide for Etnernet/IP based access for clients and servers is shown in Fig 1.

The figure shows a head end location which has the monitoring station. A serial port based master device and an ethernet based master device at the monitoring station are connected to he NAX unit there. There can even be a single device, such as a PC, performing the role of both types of masters. The NAX device at the central site is connected to another NAX at RTU site 1 using a 2 Mbps E1 Link (a pair of leased line Modems may be required to extend the V.35 WAN port of NAX to a nearby cable hut – these modems can be either copper based G.shdsl modems such as CYGNUS 850 or Optical Fiber based modem such as CYGNUS 855). The NAX at RTU Site 1 is similarly connected to NAX at RTU site 2, and so on; till it reaches the last RTU site. The NAX at the last RTU site is connected back to the NAX at the head-end, thus forming a ring which provides redundancy in the communication path between various NAXs.

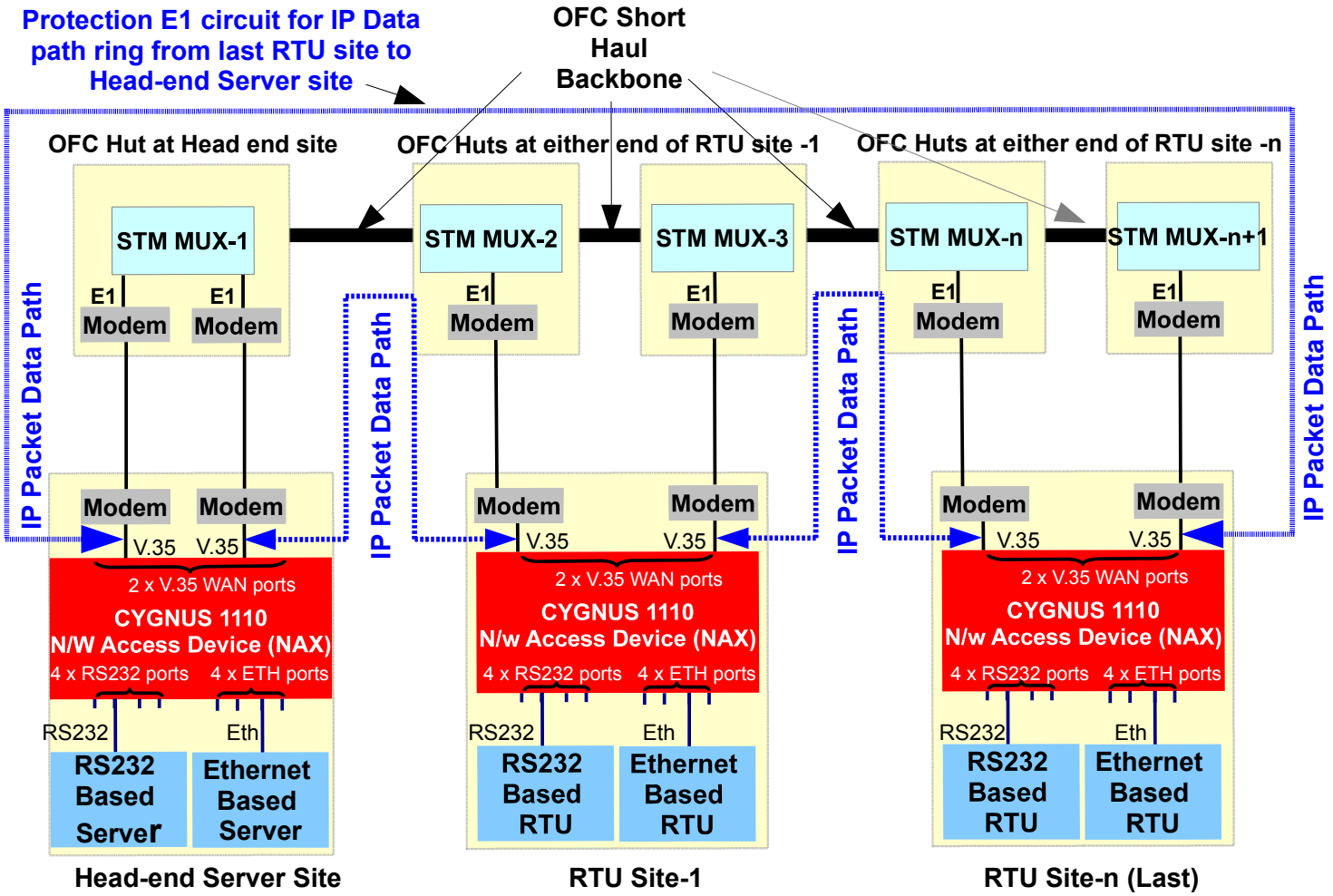

Fig 1: A SCADA System based on Ring protected IP based connectivity scheme of RTUs having RS232 or Ethernet interface for SCADA

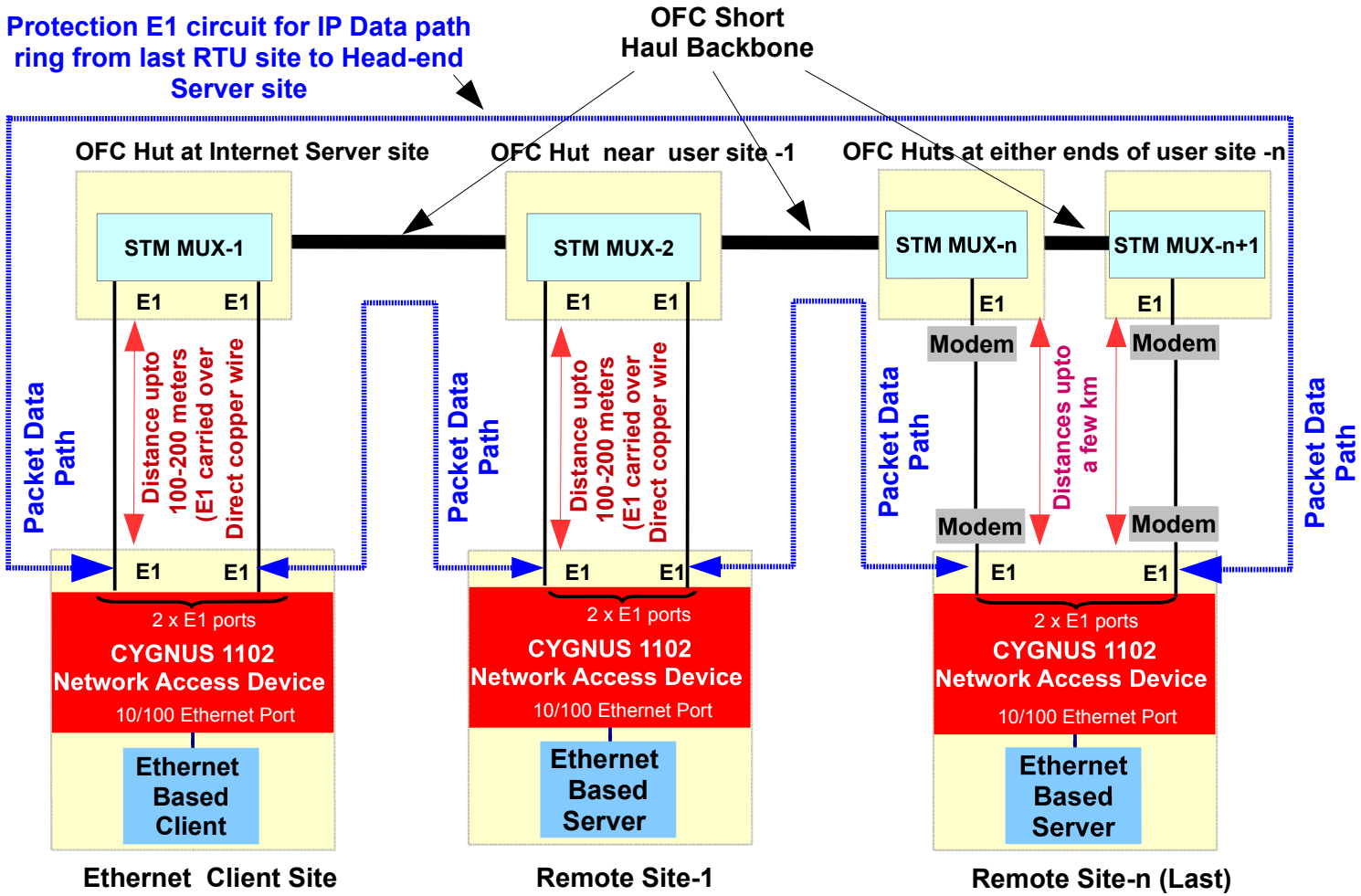

Fig 2. A Ring-protected Ethernet Based Access scheme over E1 links

Note 1: Client and Remote site - 1 connected to a single Cable hut as distance is small
Note 2: Remote site - n is connected to different cable huts as distance is larger, and separately laid cables from internet client site to different cable huts with G.shdsl or Fiber modems ensures better uptime on possible cable faults

The system simultaneously operates in two ways. In serial mode, the master device at the head end sends its data using asynchronous communication. This data is encapsulated by the NAX at the head end in the form of UDP-IP packets. A copy of each such packet is sent to all NAX devices and is delivered to the RTUs via serial ports of the NAX units there. All RTUs receive each packet from the head end, but only the RTU whose address matches with the address mentioned in the packet from the master responds. Other RTUs ignore the packet. Serial data sent by the RTU in response to the master's packet is received by the NAX unit to which it is connected, which encapsulates it in a UDP-IP packet and sends it to the NAX unit at the head end. There the data from the RTU is delivered to the master device through a serial port. This completes “poll-response” cycle between the master and a slave.

Handling of ethernet data, is straight forward. The network is configured in such a way that every NAX's ethernet port represents a block of IP addresses. The network routes data from the master station at the head end to any ethernet based RTU that is connected to a NAX unit at any location, and vice-versa. The protocols that can be employed are either Modbus protocol or any proprietary protocol between the master and slaves.

B. A system implementation for accessing only Ethernet Based Devices

A simpler systems can be implemented if the application is only ethernet-based access. This is shown in Fig 2. Here another CYGNUS product – CYGNUS 1102 Network Access Device is used. It is similar to CYGNUS 1110, but does not have RS232 user ports. It is modular in design and supports direct connection to E1 interface on its WAN port.

A network of CYGNUS 1102 units can be formed using 2 Mbps links, similar to the network of CYGNUS 1110 units described above. The CYGNUS 1102 network can provide the throughput needed to do routine jobs of control, monitoring and access. It can even be used as a distributed Internet access system for downstream stations provided the bandwidth required is not very high.