APPLICATION OF EMERGING COMMUNICATION TECHNOLOGIES TO THE CREATION OF A "VIRTUAL RANGE"

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ABSTRACT

This paper addresses the creation of a large virtual-range environment whereby multiple, geographically dispersed, test ranges may operate in concert to support test operations. The most significant benefit of the virtual range environment is the time-sharing of costly processing resources. Other benefits include improved reliability and responsiveness of inter-range data transfer. This paper will focus on existing and near-term technology that may be applied to create a virtual-range and will address the technological and economic advantages and disadvantages of TDM vs. ATM approaches.

KEYWORDS

SONET, ATM, Telemetry, Data, Voice, Communications

INTRODUCTION

Test Ranges are increasingly moving towards transmission of data, video, and voice via digital means. This movement has been encouraged by the increasing availability of high-speed digital networks and low-cost high-performance telemetry processors and workstations. These systems however are effectively restricted to local operation because the means to extend these systems beyond the range's borders are throughput limited by present day interfaces, generally consisting of leased DS0 (64 kbps) or DS1 (1.544 Mbps) lines. Occasionally, DS3 (45 Mbps) lines or private microwave circuits are available.

The situation though is improving rapidly as public carriers begin to deploy the Synchronous Optical Network (SONET). SONET will ultimately allow users to communicate at rates in excess of 2 Gbps, with 155 Mbps links to the desktop becoming commonplace. In addition, advances are being made in network protocols, specifically Asynchronous Transfer Mode (ATM), which can significantly improve the bandwidth utilization efficiency of these emerging high-speed networks.

The availability of high-speed inter-range communications will allow the creation of a Virtual Range environment. High-speed data collection, telemetry processors, and workstations, previously bound by the length of their Local Area Networks (LANs) and high-speed bus interfaces, can be effectively shared among geographically diverse users. The net effect will be to significantly increase the capabilities of all of the ranges while at the same time reducing the costs associated with custom processor development by distributing processor usage over a broader population.

This paper describes a SONET network that can be implemented in a realistic test range environment using available or near term technology. Of specific interest to the Test Range community is the support for non-standard data formats commonly found only in telemetry processing applications, along with full motion video and RCC 5 Mbps compressed video. As inter-range service offerings become available, these networks can be interconnected to create the Virtual Range environment.

It is also important to discuss the relationship of SONET to ATM. SONET and ATM are occasionally confused for one another and the relationship between the two is often misunderstood. This paper will attempt to clarify that relationship and address the possible application of ATM within the SONET network described.

THE TEST RANGE OPERATIONAL ENVIRONMENT

Test Range communication requirements may be broadly characterized as "dynamic"; changing frequently to accommodate the unique demands of each test mission supported. Test Ranges also employ a wide variety of non-standard synchronous and asynchronous digital communications formats which are a by-product of the specialized telemetry equipment used during testing.

The Test Range network must be capable of supporting the following types of interfaces:

- o D4 Compatible DS1 with DS0 Channel Access.

- o RS-232C and V.35 interfaces at standard interface rates.

- High speed RS-422 at TlC (3.12 Mbps), T2 (6.3 Mbps), and DS-A (12.6 Mbps) rates.

- RS-422 interface at RCC Video Codec rate of 5 Mbps.

- RS-422 interface at variable rates of 0 bps to 43 Mbps.

- M13 and Wideband DS3 interfaces (45 Mbps).

- Local Area Network interfaces at 10 Mbps (Ethernet) and 100 Mbps (FDDI).

Equipment is often remotely located, unattended, and difficult to reach. Maintenance and support have been further complicated by overall reductions in staffing levels at most range facilities.

A SONET BASED RANGE NETWORK

Ranges are typically spread over very large areas with limited access to remote facilities. As a result, the need for efficient and reliable high capacity data transport is more critical. SONET based networks are well positioned to satisfy range requirements because they offer very high capacity, extensive performance monitoring, automatic protection switching and self healing architecture. SONET also presents a standard interface throughout the network that simplifies network integration in a multi-vendor environment.

A possible intra-range backbone implemented using SONET equipment is shown in Figure 1. The figure depicts several modes of operation that include point-to-point, add-drop, and protected ring architectures.

A feature of SONET transport systems is the ability to transport high data rate traffic using concatenated STS-N signals (N x 51 Mbps). The network illustrated in Figure 1 can support 100 Mbps data streams along side of traditional DSl/DS0 voice and data traffic. The real value of a SONET intra-range backbone lies in its ability to be interconnected with other ranges via public or private SONET network offerings to create a Virtual Range environment. Operation across ranges then becomes nearly transparent.

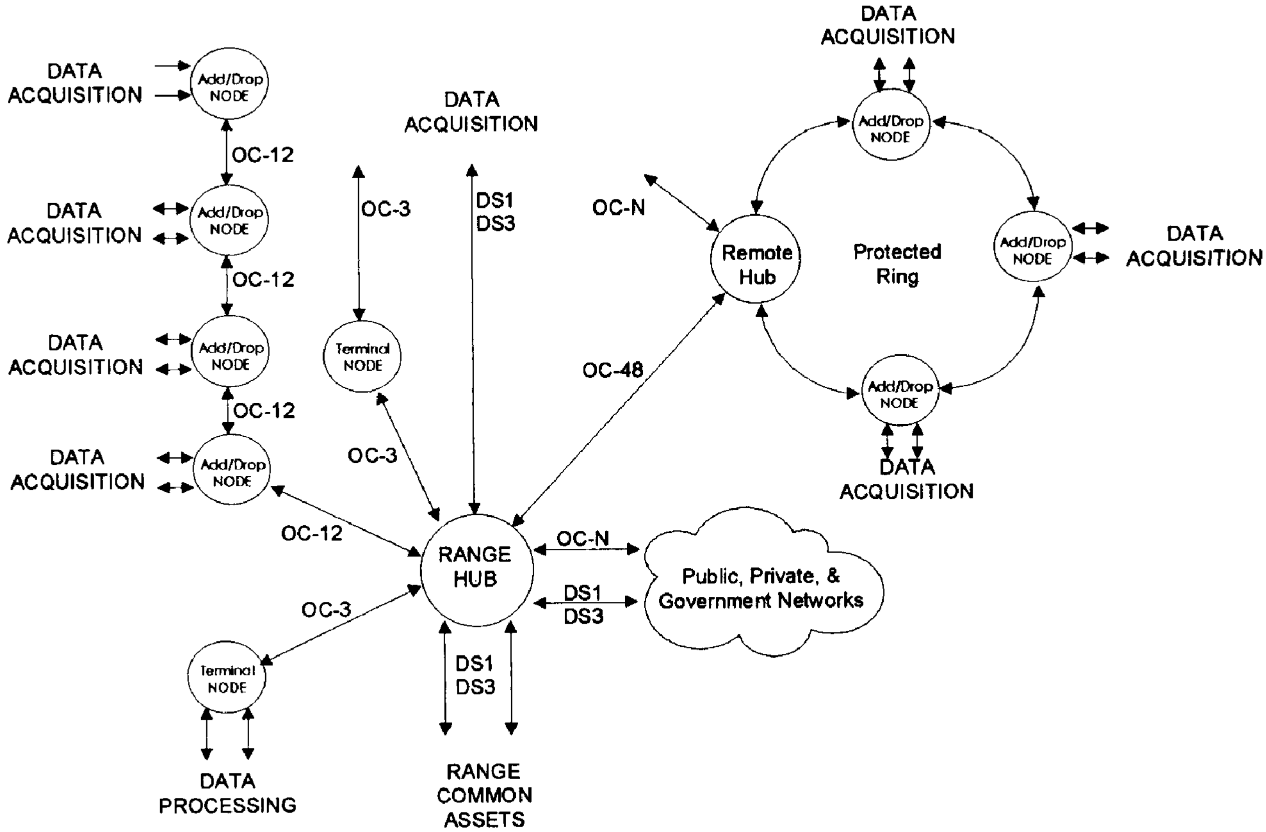

Figure 1. SONET based Intra-Range Communications Backbone

A SONET TERMINAL NODE FOR THE RANGES

The authors have designed a SONET Terminal that represents a unique integration of off-the-shelf products intended for use in test range applications (Figure 2.). The SONET Terminal multiplexes a full-motion video channel (DS3 rate), up to 43.7 Mbps aggregate bandwidth of variable rate telemetry data (8 channels), and up to 28 DSls onto either an OC-3 interface for end-terminal use or an OC-12 interface for Add/Drop applications. Up to four terminals may be supported on a single OC-12 link.

The SONET Terminal incorporates video and data switches that may be remotely controlled via the SONET Embedded Operations Channels (EOCs) to allow user selection of multiple input sources for transport over the SONET backbone. In addition, the Multiplexer supports full Add/Drop control over the DS3 and DSl inputs into the Mux. Ample patch access is provided to facilitate test and special circuit connection. For secure applications, the Terminal can be configured in a TEMPEST qualified enclosure and Type I or II encryption equipment can be installed as required to support transmission of classified or sensitive data.

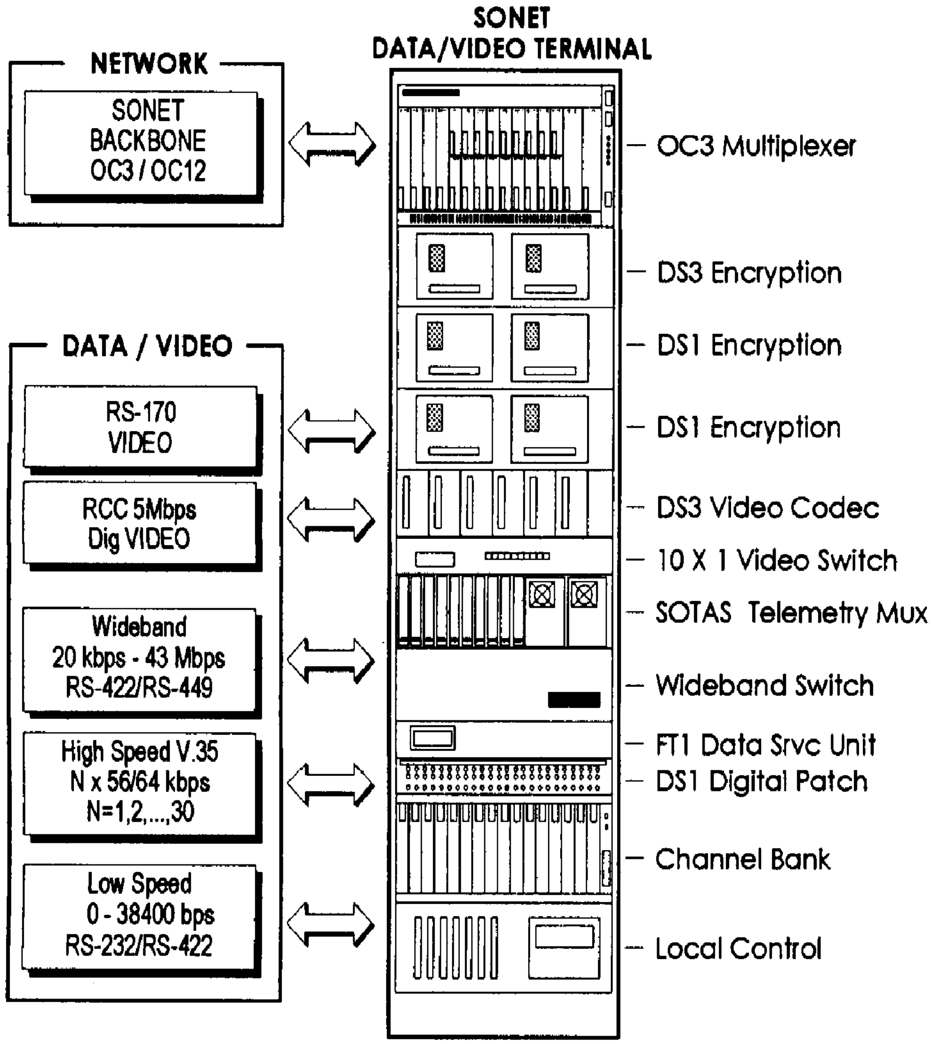

Figure 2. A SONET Based Terminal can be implemented in a single rack of equipment using available off-the-shelf products.

The Terminal as configured here can support:

- o Any one of-up to ten remotely selectable RS-170 Video Inputs.

- o Eight programmable high speed RS-422 inputs with up to 43.7 Mbps aggregate bandwidth. An optional N x 8 wideband digital switch can be used to remotely select from more than eight input channels.

- o Four DS1 inputs (up to 28 available) used as follows:
  - Channel bank with DS0B data ports, 2W FX, and 4W E&M cards.
  - FTl Data Service Unit supporting N x 56/64 kbps (Add/Drop available).
  - DSX interface (straight Tl) via digital patch.

A simple block diagram of the Terminal is provided in Figure 3.

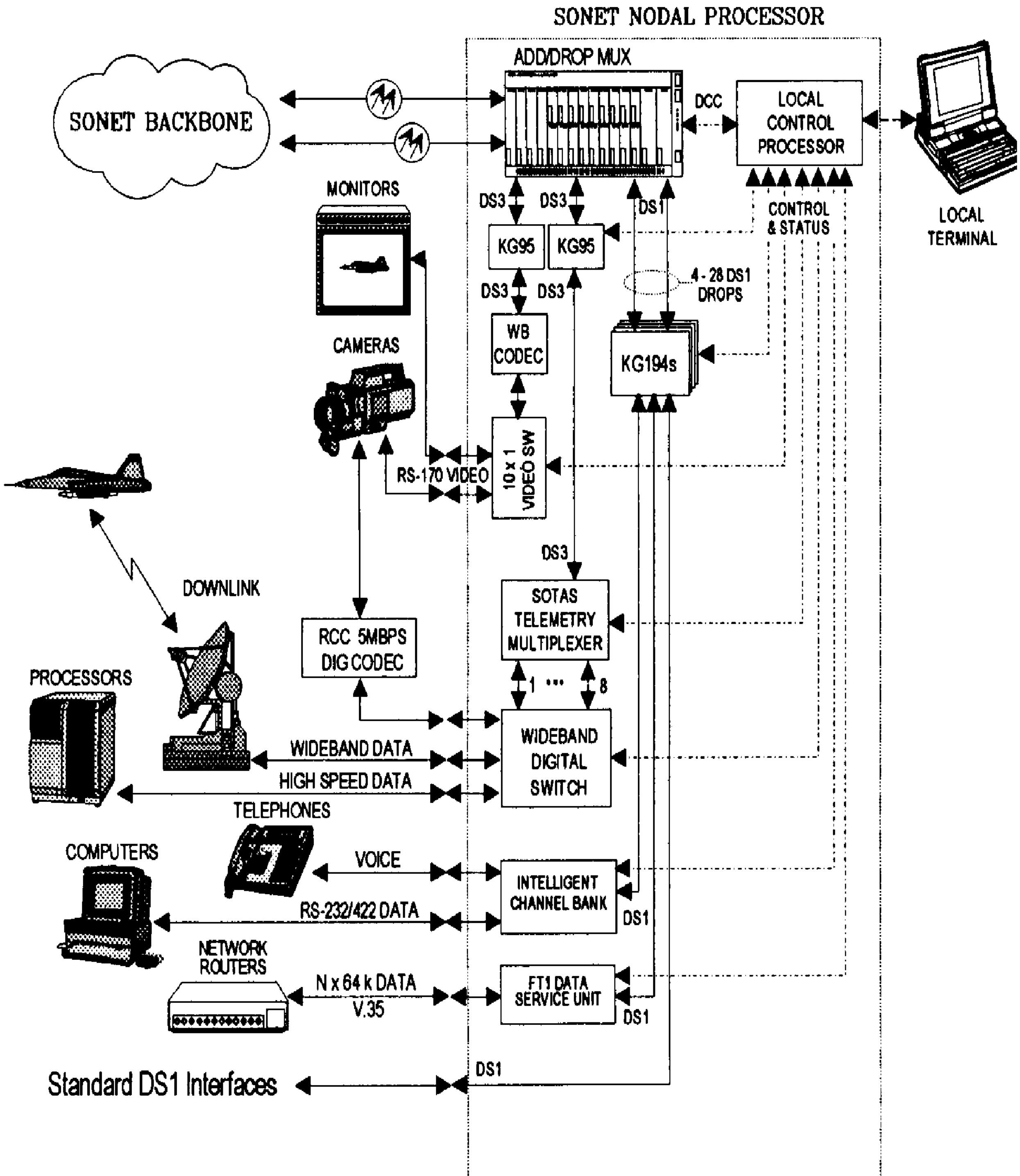

Figure 3. The SONET Terminal interfaces to a wide variety of standard and non-standard devices.

The configuration of the Node is a function of how the available bandwidth (150 Mbps) is to be used. In both the OC-3 and OC-12 versions, one to three DS3s (or equivalent DS1 capacity) may be added or dropped. Alternate configurations include:

- o Replacing the RS-170 Video Codec with a second Telemetry Multiplexer.
- o Providing a straight DS3 termination for external equipment.
- o Changing the mix of DS1s and DS3s supported.

Other changes could include:

- o Use commercial encryption equipment or no encryption equipment at all.
- o Incorporate network routers into the Node.
- o Provide additional switching capability.

The standard nature of the equipment and associated interfaces make it relatively easy to support a variety of network equipment. An additional feature of the Node shown in Figure 4. is the incorporation of a Local Control Processor. This processor takes advantage of the Embedded Operations Channel (EOC) found in the SONET frame overhead to provide an integrated remote control and monitoring capability without need for an external control network.

A SONET HUB

The Hub provides a central switching and distribution point for the Range. Ideally, the Hub should be able to interface directly to the SONET backbone at the OC-N rate while maintaining visibility and access to the lowest level of data transported through the system. (Direct fiber interfaces however are not available as of this writing. Typical availability dates for direct OC-N interfaces range from mid 1993 to mid 1995.) The investment in hub multiplexer hardware is not lost though because the equipment can be reused in a terminal capacity as optical interfaces become available.

There are several switching systems that are well positioned to provide the needed SONET based DS3 and DSl switching fabric now and provide direct optical interfaces in the near future. A hub design that incorporates both Wideband (DS3/DS1) and Broadband (DS3/DS3) SONET Digital Cross-connect System is shown in Figure 4. It is important to recognize the need for both Wideband and Broadband systems to support the data transport requirements of the network. A Wideband matrix is required to support lower speed tributary switching at the DS1, DSlC, and DS2 rates. A Broadband matrix is required to support clear-channel DS3 and STS-N Synchronous Payload Envelope (SPE) switching.

Narrowband DS 1/ 0 switching is readily supported via a small 1/0 DCS. Features and characteristics of the major brands vary slightly and most support digital conferencing and broadcast modes of operation. Subrate (DS0B) digital cross-connects for low speed data (<9600 baud) should also be supported in the DS1/0 switch.

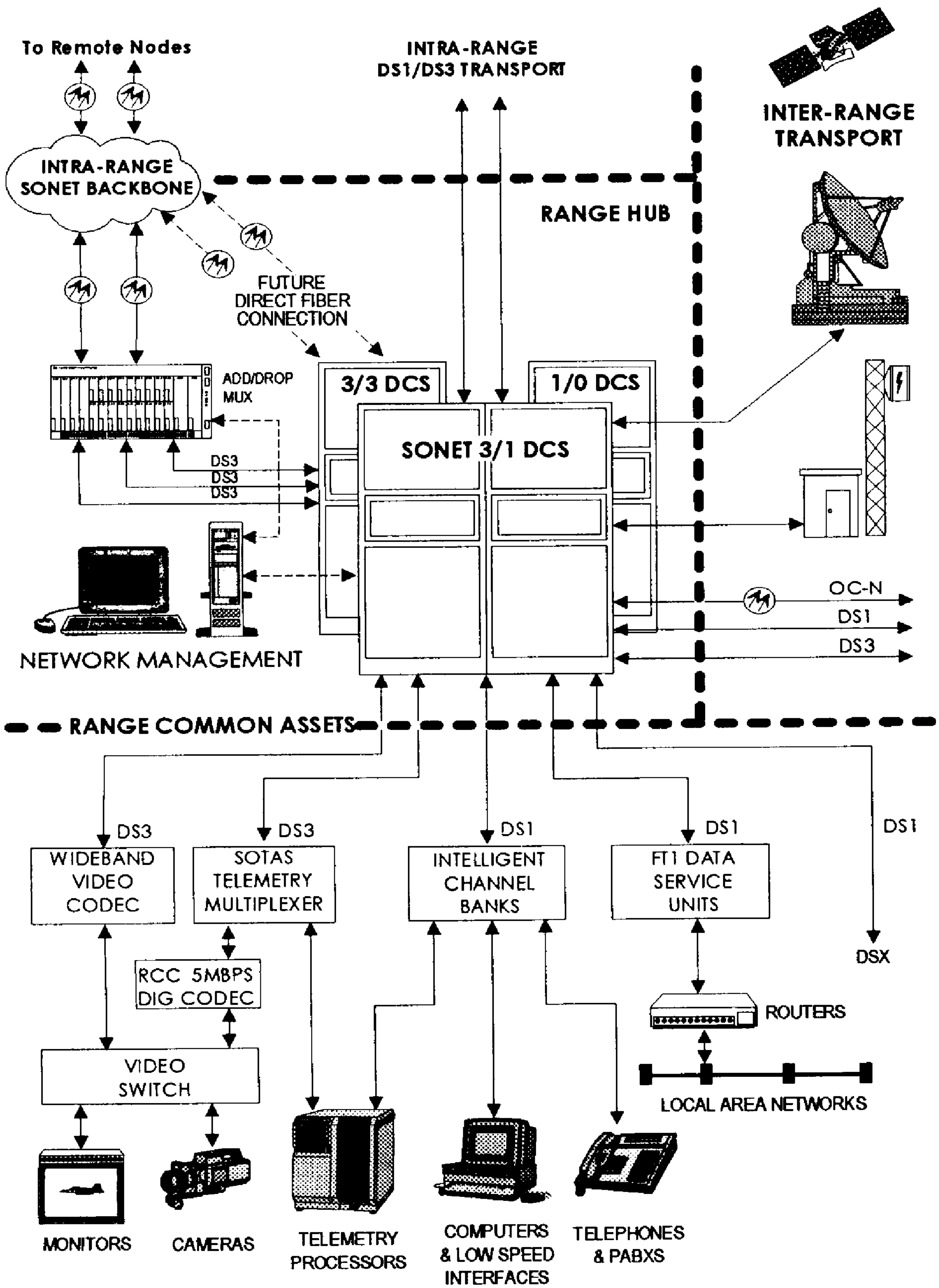

Figure 4. The SONET based hub design will support direct interfaces to the SONET backbone as well as hub based common assets and inter-range transport media.

There is no need for additional Node SONET multiplexers at the Hub thus reducing the overall hardware investment required in the system. Access to common assets located at the Hub occurs via direct DS3 and DS1 interfaces to the Hub DCS.

ATM SWITCHING SUPPORT

SONET and ATM are often confused with each other because the ATM protocol was intended to operate over SONET networks, with OC-3 as the principal interface. They are in fact independent; SONET defines a transmission medium whereas ATM defines a transmission protocol. A SONET signal may carry both ATM traffic and Time Division Multiplexed (TDM) traffic simultaneously and ATM traffic is not restricted to SONET signals. Most of the ATM equipment available today operates at DS3 rates.

The SONET network described in this paper will fully support the ATM protocol. As ATM products become both available and cost effective, they may be directly layered into the network. It is not likely though that ATM will displace the Wideband and Broadband cross-connect systems for many years. The rationale for this assertion is largely economic; based not so much on the initial cost of the ATM switches, which will certainly come down in the next few years, but on the nature of the traffic carried by the network.

ATM is very attractive to high volume carriers with a broad distribution of voice and data traffic. ATM allows the low density distributed nature of voice to be combined with the high-density bursty nature of data in an efficient ***revenue enhancing*** manner. A public service provider can justify the added expense of large ATM switches in terms of-the additional revenue generated by the resultant increase in trunk capacity.

The cost/performance increases attributed to ATM however rely heavily upon a high volume of traffic with a proper mix of traffic types. ATM for example offers no performance increase on a trunk with excess bandwidth. With a minimum bandwidth of 45 Mbps and a design bandwidth of 155 Mbps the potential for excess bandwidth within the range network is fairly high. ATM also does little to enhance high-speed continuous duty cycle data streams, which can operate more efficiently in a TDM environment.

The net result is that ATM does not represent the final solution to range communication requirements for several reasons:

- Range communications are mission dependent and deterministic.
- The Range has control of the network and can predict traffic loading.

- o The Range network is not a revenue generating entity.
- o There is a high percentage of continuous duty cycle data streams.

ATM however can be deployed using small switches and access nodes to support Voice traffic, LAN traffic, and file transfer. As mentioned earlier, the ATM network can be overlaid on top of the SONET network and employed to the extent that realistic improvements in service can be obtained. The need remains however for primary support of Telemetry Data transfer, which is most effectively carried out in a cross-connect environment from both a cost and performance standpoint.

CONCLUSION

The transition to SONET is critical to the range community because the SONET backbone provides the foundation for interconnecting the ranges via SONET on a nationwide basis. A local SONET network implementation is the first step towards creating a "Virtual Range" where users, equipment, and resources are geographically dispersed across the country.

The SONET Node and Hub implementation described in this application note provides:

- o Off-the-shelf system components.
- o Broadcast quality full-motion video.
- o Supports protected ring architecture.
- o Remote control via SONET EOC.
- o Direct interfaces to Hub switch.
- o Integrated network management.
- o Digital conferencing & Broadcast.
- o Transition Platform to B-ISDN / ATM
- o 0 bps -- 43 Mbps flexible data inputs.
- o EIA standard data rates.
- o Matrix switches for Video and Data.
- o Standard DS3/DSl network interfaces.
- o Automatic circuit restoration.
- o DS3/l/0 and Subrate data switching.
- o Ready for LAN & FDDI support.

This paper also recommends the implementation and use of SONET Wideband and Broadband Cross-connect Systems as cost effective, reliable, and practical alternatives to ATM only solutions. ATM should be considered as a component of a SONET network and not as a replacement for SONET switching systems.