PROTOCOL ANALYSIS FOR NETWORKED ACQUIREMENT SYSTEM

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ABSTRACT

This paper analyzed protocols may be used in each layer in networked telemetry systems, and also presents some deeper researches of the advantages of using synchronous time-division for the physical layer of a networked telemetry system.

KEY WORDS

Networked Acquirement, Sync Transportation, Network Communication, Telemetry System

INTRODUCTION

Since the structure of distributed data acquisition systems have been changing from a Master-Slave architecture towards networked systems, the traditional bus-based data transportation becomes insufficient for the needs of timing, managing and monitoring for the networked systems. A more complicated transportation protocol should be introduced.

The best way to implement transportation protocols for a networked data acquisition system is b y choosing those from the communication industry, which should be tailored and reconstructed to satisfy the following features of an airborne networked data acquisition system:

a) The synchronization of the whole system
b) Needs for real-time transportation
c) Fixed data transportation cycle
d) Maintenance of time-sequence of the acquired data
e) Small-scale with nearly fixed network topology and fixed data transportation route

In addition, the data to be transported in the networked data acquisition system is limited to following types:

a) Computer Generated Data (no needs for keeping time sequence)
b) Timing Information
c) PCM Data
d) Bus Data

e) The analog and discrete data
f) Video, Images and Sounds

Based on these features, we can start to choose the proper protocols beginning by analyzing the network structure of a networked data acquisition system.

NETWORK STRUCTURE ANALYSIS

In the field of communication systems, network architecture is the key factor to determine the system design. The same is true in telemetry transportation networks. Here we will discuss a proper network structure for a networked data acquisition system from the network node characteristics, network layer and network abstraction.

There are five types of network nodes in a networked data acquisition system: control node, data acquisition terminal, data transportation node, data processing center, recording and analyzing node.

a) Control Node
   A network management node is needed to allocate the network bandwidth, to time and manage other nodes in the network. It should only consume a little of the network bandwidth since it only outputs computer generated data and timing information.
b) Data acquisition terminal
   The characteristic of various data acquisition devices (terminals) in the network is that the terminals need mainly uplink bandwidth and a small downlink bandwidth.
c) Data transportation node
   This may include both wireless and wired transmission nodes, which will be responsible for the data flow from one node to another node in the network.
d) Data processing center
   This refers to the data processing service node and recording node in the network, which will occupy a large bandwidth in both directions in a burst mode. This node also supports multiple bidirectional data streams.
e) Recording and analyzing node
   This is the recorder and data analysis node in the network, which has a small data throughput in the uplink direction, and a huge data throughput in the downlink direction. The node should be able to receive multiple data streams at same time.

Based on the characteristics of the network nodes, a layered network architecture would be applicable to a networked data acquisition system. A flat architecture as shown in figure 1 is not chosen because it will treat all the network nodes the same and follow the same data transmission protocols on the physical layer.

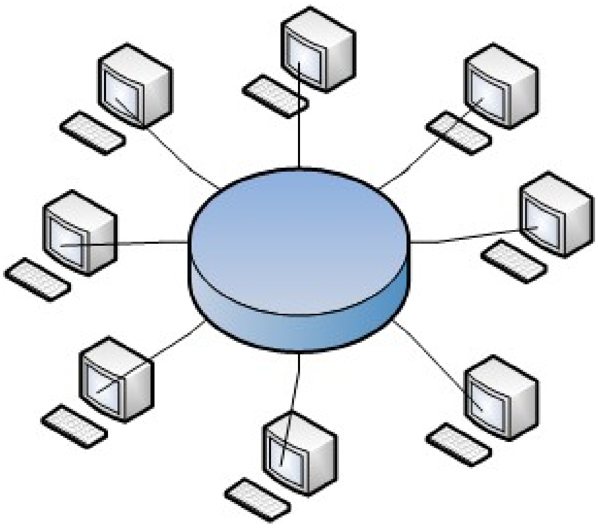

Figure 1. Flat Network Architecture

In contrast, using a layered architecture as shown in figure 2, the network nodes could be treated differently. The network could be separated into a relatively fixed core section and flexible access sections, and different transportation protocols could be applied in each section. In this way, the flexibility could be guaranteed while the stability and the security of the whole network is maintained.

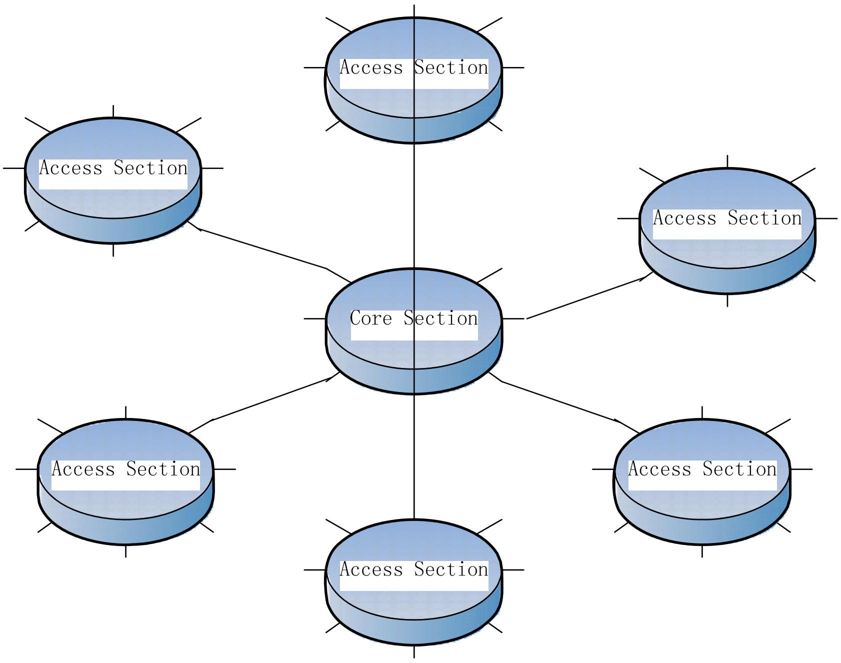

Figure 2. Layered Network Architecture

In a layered architecture, each sub-network could be managed independently. Both the complexity of each sub-network and its management complexity could be reduced by restricting the number of nodes in the sub-network. The malfunction of one sub-network will not affect other sub-networks.

The network of a networked data acquisition system could be divided into two parts, the transportation net and access net. As the core section, the transportation net could be composed of access/transmission devices and access nodes. The access node refers to the input/output devices of the transportation net and external equipment. There are different kinds of access nodes, such as analog acquisition node, the switch quantities acquisition node, the recording service node, PCM input and output nodes etc. The access node interface (ANI) is the interface between the transportation net and the external devices. A standard unique ANI, which would not be restricted to special access media or specified access nodes, could connect different access/transmission devices and access nodes to each other.

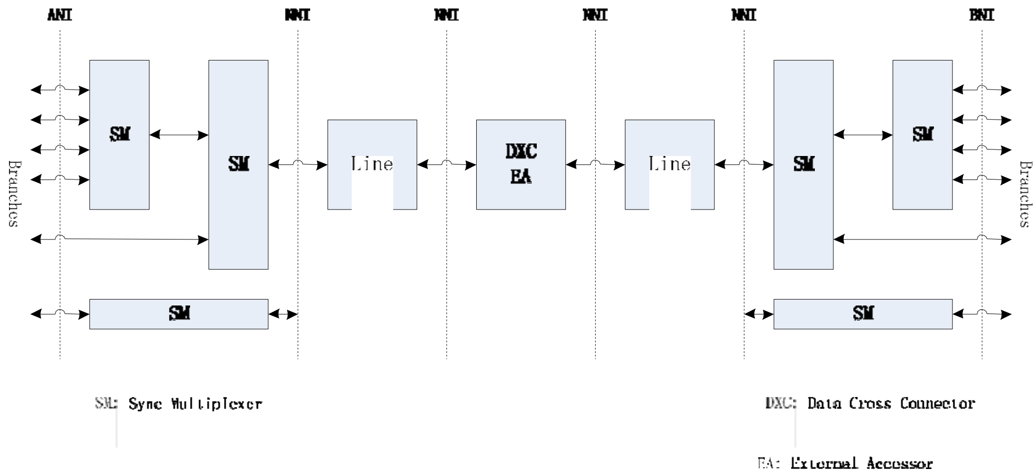

Figure 3. Network Units

PROTOCOLS ANALYSIS

There are various data access protocols which can be running on the transportation net. Figure 4 shows the necessary protocols in each layer of a transportation net for a data acquisition system.

As synchronization and real-time processing are two crucial factors for an airborne data acquisition system, and the best way to improve synchronization of a system is using the communication protocols that have low transmission delay and high synchronization performance. So we recommend SDH (Synchronous Data Hierarchy) [2] as the transport protocol in the physical layer. There are full and complete overhead bytes in SDH, which would provide detailed information for network performance monitoring, and an independent management channel for the network management. In addition, static routing in SDH greatly simplifies the complexity of the system and reduces the data transmission delay in the data acquisition system.

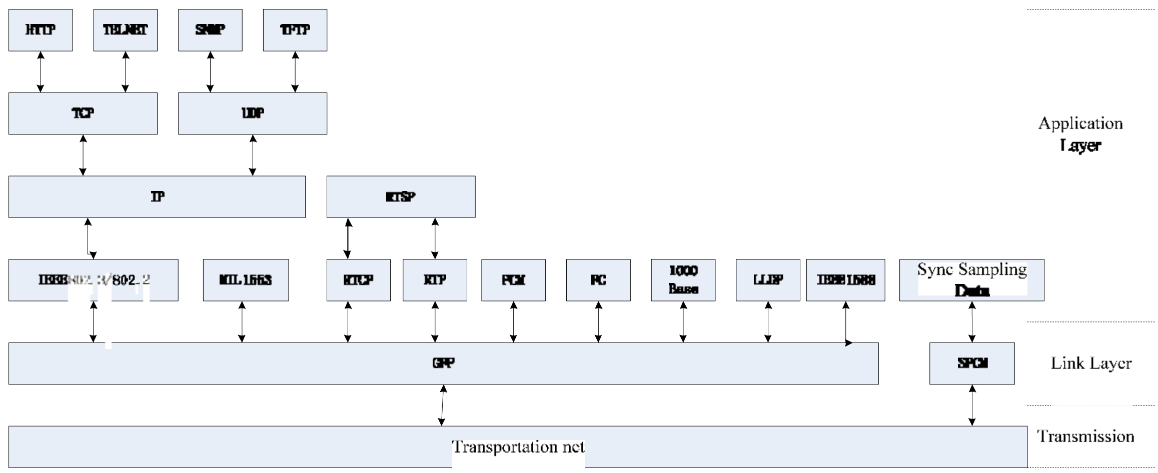

Figure 4 Data Communication Protocols on Each Layer

It is not necessary to realize the whole set of transmission protocols in SDH when we apply SDH to the airborne networked data acquisition system. It could be tailored and simplified in following ways which are not required in the telemetry area:

a) Discard the redundant protection function
b) Optimize the overhead processing
c) Simplify the multiplexing path
d) Select the appropriate timing level

According to a sync relationship with the system clock, the data transportation service can be divided into a synchronous data service and an asynchronous data service. Different transmission protocol will be used for each. Generic framing procedure (GFP) will be used for the asynchronous data service while a synchronized PCM format [2] that complies with IRIG 106 chapter 4 [1], will be used for the synchronous data service (as shown in Figure 4).

GFP provides a general schema for signal adaptation to the transportation network. The client signal could include the protocol data unit PDU (such as Ethernet) or continuous bit flow (such as Fiber Channel, MIL-STD-1553B data flow, etc.).

A synchronous PCM protocol that complies with Chapter 4 of IRIG-106, could be applied to transport synchronously sampled data using the system clock. In addition to complying with Chapter 4 of IRIG-106, the PCM frame should synchronize with SDH transmission net, and the frame length should be in accordance with the SDH transmission network frame format.

The composition of the network and data exchange are completed in the transmission layer when using SDH as the transport layer protocol, so that the application layer protocol could be greatly simplified for an airborne data acquisition system. In fact, the required protocols in the application layer include the data service protocol, network management protocol, and timing protocol.

For data that comes from heterogeneous system protocols, such as STD-MIL1553 protocol, Arinc429 protocol, FC protocol and various types of Ethernet protocols, could be transmitted transparently through the GFP link to the transmission network.

The analog quantities switching parameters could be directly put into the synchronous PCM frames and sent through the transmission network. The RTP, RTCP, RTSP protocol could be used to transport video data streams.

The network management channel of the system could be based on the TCP/UDP, so the system should support IEEE802.2/802.3, IP, TCP and UDP protocols. TFTP and SNMP are two required network management protocols. HTTP and TELNET protocol might be adopted. In addition, we suggest LLDP protocol be used for automatic network topology discovery capability.

IEEE1588 protocol [3] could be used for system timing, but it could be optimized and simplified by combining with the synchronous characteristics of SDH transmission network.

CONCLUSION

To construct a networked data acquisition system, the most significant task is to design the data communication network for the system and choosing the right protocols for it.

It would be better to choose a mature synchronous transmission network with simplification and modification in accordance with the characteristics of the data transportation for airborne data acquisition. The suggested protocols for data transportation for each network layer would be a simplified SDH for the transport layer, GFP and synchronized PCM for data link layer, while TCP/UDP, TFTP, SNMP, LLDP and IEEE1588 are used for the application layer.

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