Abstract
Telemetry recorders have historically been used as standalone systems with each user responsible for operation and data interpretation on that system. Utilizing the latest peer-to-peer networking technologies, telemetry recorders can now be linked to provide instantaneous communication between systems. This fully distributed, network-based architecture can be used for command and control of multiple recorders, as well as message passing between them. A centralized server is no longer required, resulting in considerable logistical and cost savings. The peer-to-peer communication topology can efficiently connect telemetry recorder “islands of information”.

Keywords
recorder, peer-to-peer, networking, data recording, strip-chart

Introduction
Telemetry recorders have been used for many decades to visually indicate and record real-time parameters for flight test, rocket and missile testing, and satellite telemetry. Historically, these were called strip-chart recorders as they used a direct-writing method of recording waveforms to a moving piece of paper. The latest generation telemetry recorders have evolved beyond their strip-chart roots to become display and recording workstations in which the user can visualize and record data in many different ways. As telemetry recorders have advanced over many generations, communications to and from these systems has become increasingly important to any telemetry facility.

A Brief History of Telemetry Recorder Communications
The earliest telemetry recorders did not have any communications capabilities. These recorders were designed to record analog signals onto paper with pre-printed grids and relied on the user controlling the recorder locally as well as documenting almost all of the test information by writing on the chart. This included both pre-test information such as parameter names, values, test name, date and time as well as real-time information such as status changes, events and points of interest.
The early need for recorder communication was driven by two factors: setup and control. Multi-recorder telemetry facilities needed a way to set up the recorders before a test was started. Analog settings, chart settings, annotation buffers and system information were all configurable settings ideally performed by a host system. In addition, these facilities required the ability to remotely control the recorders in order to automate the recording process. The ability to control functions such as start/stop of recording, chart speed, page marks and chart layouts was important for real-time recording.

One of the first telemetry recorder interfaces was the ubiquitous RS232 serial port. Using an 8-bit serial data, the RS232 port was ideal for setup and control of the telemetry recorder. Since RS232 was limited to a length of 50 feet by specification, other serial interfaces such as RS422 were also used for communication with telemetry recorders. For multiple recorder systems, however, serial interfaces such as RS232 or RS422 were not optimal solutions.

The IEEE-488 (GPIB) interface was also used in early generation recorders. This 8-bit parallel interface could connect up to 15 devices, which lent itself well to multiple recorder environments. The main drawback to IEEE-488 was the maximum total cable length of 20m, with only 4m between any two devices.

While both RS232 and GPIB are still in use today, the latest telemetry recorders utilize an Ethernet interface (10/100 BaseT) for command and control of the system. This interface offers a number of advantages such as high bandwidth, standard protocols, and inexpensive implementation. With twisted pair wiring, recorders can be placed with distances up to 100m. For the first time, telemetry recorders could be efficiently networked together.

**Bridging the Islands of Information**

One of the capabilities that has been missing on telemetry recorders is the ability to communicate from one recorder to another. Although many of the communication methods mentioned above are bidirectional, they all operate through a host system. The users at different telemetry recorders can not communicate to other users within the recorder interface itself. Thus, each individual telemetry recorder is an island of information.

Bridging these islands during real-time recording is desired by the telemetry community for the following applications:

1. Simultaneously controlling several recorders within a workgroup
2. Marking multiple units during an event or other points of interest
3. Messaging between recorder users

The latest generation of telemetry recorders, with their Ethernet interfaces, offer an efficient platform for peer-to-peer networking that can address these requirements.
The term “peer-to-peer” (P2P) refers to a class of systems and applications that employ distributed resources to perform a critical function in a decentralized manner. This network topology differs from the client-server topology in that there is no central server coordinating the communication between client systems. As seen in figure 1, each peer system can communicate directly to all other systems.

In general computing, P2P is becoming widely embraced for many network-based applications. One benefit of P2P networking is reduced infrastructure costs. Since a central server is not required, P2P simplifies the physical layer of a given network. Another benefit is that a P2P network offers improved scalability over a client-server network. It allows for spontaneous communication between small groups that can be created on the fly. Additionally, it can reduce the bandwidth on a network as peers can direct messages between each other. Some of the specific capabilities of P2P in general networking are:

- P2P allows instant communication between peer systems through applications such as instant messaging.
- P2P is very efficient for file sharing.
- P2P enables work collaboration with multiple users.
- P2P offers distributed computing power for large computational jobs.

Many of these P2P capabilities can be applied to the telemetry community. The latest telemetry recorders incorporate this P2P technology by using the Microsoft DirectPlay API. This technology was originally intended for P2P gaming sessions, but works very well for multiple recorder communication. Utilizing the Microsoft DirectPlay transport protocol, these recorder networks can derive the benefits from this gaming technology including reliable delivery of messages, congestion control, message prioritization and message timeouts.
With a P2P topology, each of the recorders is set up with a lobby client application, whose purpose is to communicate directly with other lobby clients on the same LAN subnet. A typical telemetry recorder configuration is shown in figure 2.

![Diagram of P2P configuration](image)

**Figure 2: Telemetry recorders in P2P configuration**

As seen in figure 2, one of the recorders is also designated as a host for the P2P session. The host is responsible for adding or deleting other recorders for a given session. It is important to note that this host role is not that of a central server, but rather one of logistics. In fact, the connection can be such that host migration can occur without the loss of a particular session.

A good example of a telemetry recorder P2P application being used today is called highlight marking. During a flight test, for example, an engineer watching a recorder will often want to mark a specific point when a planned maneuver is performed, or if something unexpected happens. Using a touch-panel interface on the recorder, the engineer can make this highlight mark and add annotation. With the P2P connection, any other recorder that is defined as being part of the workgroup will also receive and record this highlight mark. In this manner, one flight test engineer can mark several recorders at any given point in time.

Another application for recorder P2P is workgroup control. During a test, it is often required that multiple recording systems needs to be started or stopped at the same point in time. These commands can be sent as a P2P messages, allowing a single user to coordinate and control multiple systems in a telemetry facility without the need for a host server.
The needs of the users of multiplayer network games are not incongruous with the needs of telemetry recorder users. One application currently being considered for telemetry recorders is P2P instant messaging, where any user in the workgroup can communicate instantly with another. Another capability of the DirectPlay API is voice communication, which could also be applied to telemetry recorder users. A future enhancement would be to allow this voice communication to occur over the P2P network for different users at different workstations. This could eliminate the requirement of a voice-only line between recorder installations.

**Conclusion**

The telemetry recorder has traditionally been an important but standalone piece of instrumentation for telemetry applications. The latest P2P technologies directly address many of the communication requirements of these recorder users. Recorder-to-recorder communication, multiple unit control and user communication are three areas where P2P can be utilized to serve the needs of telemetry facilities. By applying existing P2P standards and protocols already in use, the networked telemetry recorder no longer needs to be an island of information.

**References**