TELEMETRY DATA DISTRIBUTION UTILIZING A MULTICAST IP NETWORK

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ABSTRACT

The efficient distribution of telemetry data via standard Ethernet networks has become an increasingly important part of telemetry system designs. While there are several methods and architectures to choose from, a solution based on IP multicast transmission provides for a fast and efficient method of distributing data from a single source to multiple clients. This data distribution method allows for increased scalability as data servers are no longer required to service individual client connections, and network bandwidth is minimized with multiple network clients being simultaneously serviced via a single data transmission.

KEYWORDS

IP Multicast, Telemetry Systems, Data Distribution, and Ethernet Networks.

INTRODUCTION

The installation of widespread Ethernet networks, heralded by many as the Internet Age, has provided the telemetry system engineer with more options, solutions, and challenges in acquiring and distributing telemetry data to various geographical locations, organizations, and individuals than ever before. Bandwidth utilization and optimization concerns are no longer confined to the telemetry link, and local system boards and buses, but have been broadened to include the network that connects the various nodes and monitoring stations of today's telemetry systems. Implementation, configuration, and optimization of this network are now as much of a key concern to system designers as their choice of sampling rates, modulation and encoding techniques, and decommutation schemes. Unfortunately, the network requirements of a telemetry ground station are not satisfied by a simple, traditional IP network installation.

TRADITIONAL IP NETWORK COMMUNICATION

Traditional IP network communication consists of simple point to point communications. A single source node on the network talks with a single receiver node. This type of communication does not appeal to a typical telemetry system scenario, which can have one or more source nodes simultaneously talking to many receiver nodes, and is referred to as multipoint communications. The only way to accomplish this with traditional IP communication techniques is to use either a unicast or a broadcast design.

A unicast design (Figure A) requires that the source node send an individual data transmission to each of the interested receiver nodes. While this approach allows for easy implementation and receiver node selectivity, it comes with a high cost. The source node must use more processing time sending individual transmissions to each interested receiver node, while network bandwidth is consumed by the multiple movements of identical data over the network. These two design inefficiencies result in a system architecture that has limited scalability beyond a single source and a small number of interested receivers.

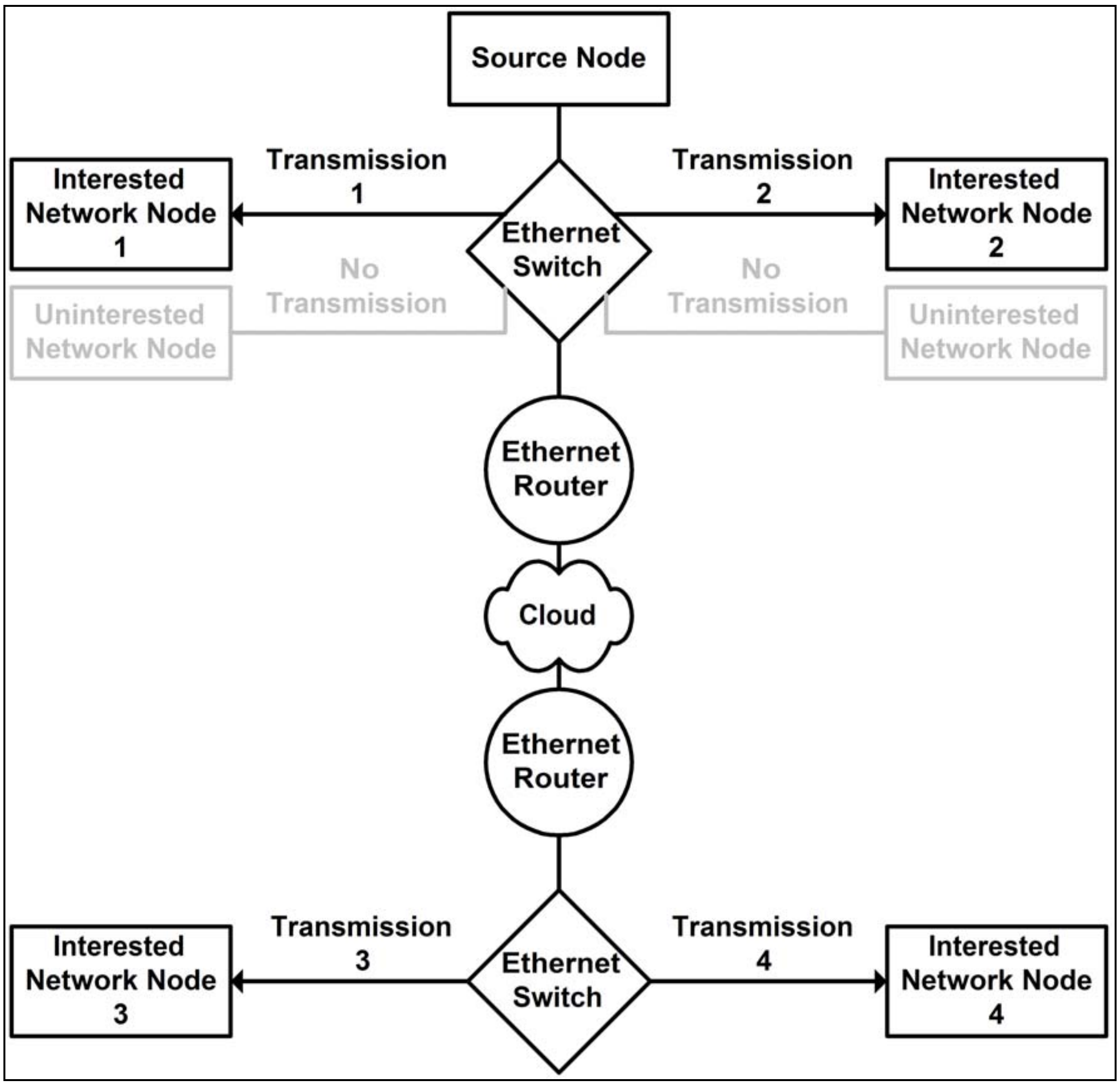

Figure A – Multipoint Unicast Communication Design

The implementation of a broadcast design (Figure B) addresses the two main scalability inefficiencies of the unicast approach while reducing the additional latency induced from multiple sends. This efficiency comes at the cost of interested receiver selectivity. While the source and network perform only a single data transmission, all network nodes receive the transmission whether or not they are interested in the data. Besides the loss of receiver selectivity, there is the additional problem that some interested nodes will not receive any data. This is due to WAN connections being configured to prevent the forwarding of broadcast transmissions, in an effort to protect the network from crippling broadcast storms. The loss of WAN data distribution limits system scalability to small local area network configurations where at least a majority of nodes are interested in the data being distributed.

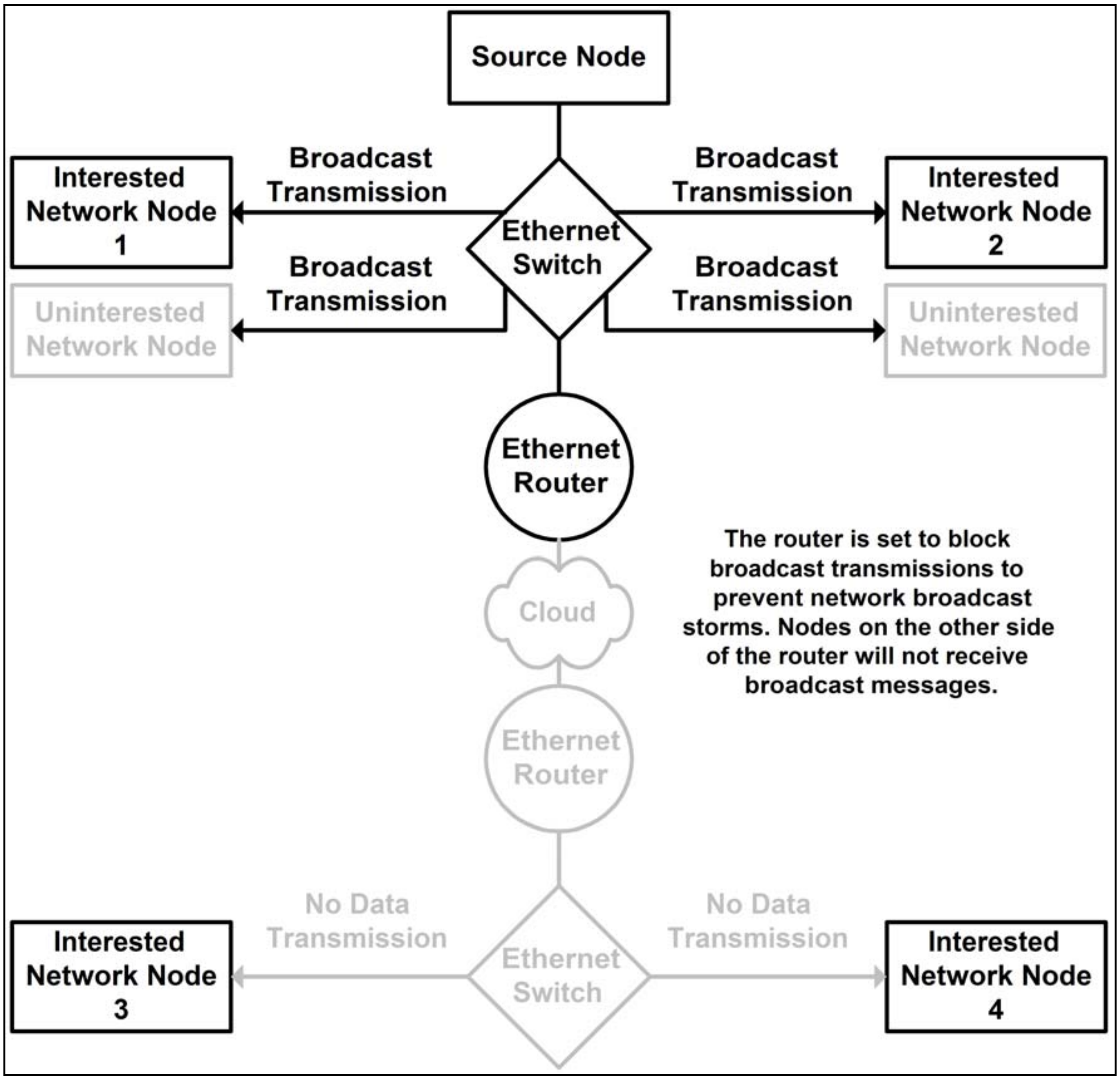

Figure B – Multipoint Broadcast Communication Design

IP MULTICAST NETWORK COMMUNICATION

The increasing need for to efficiently broadcast streams of time-sensitive data to multiple parties and the limitations of traditional IP network communication strategies led to the creation and adoption of better data distribution technologies such as IP multicast. IP multicast technology contains the unicast design advantage of receiver selectivity combined with the efficiency that comes by using the single data transmission approach of the broadcast design.

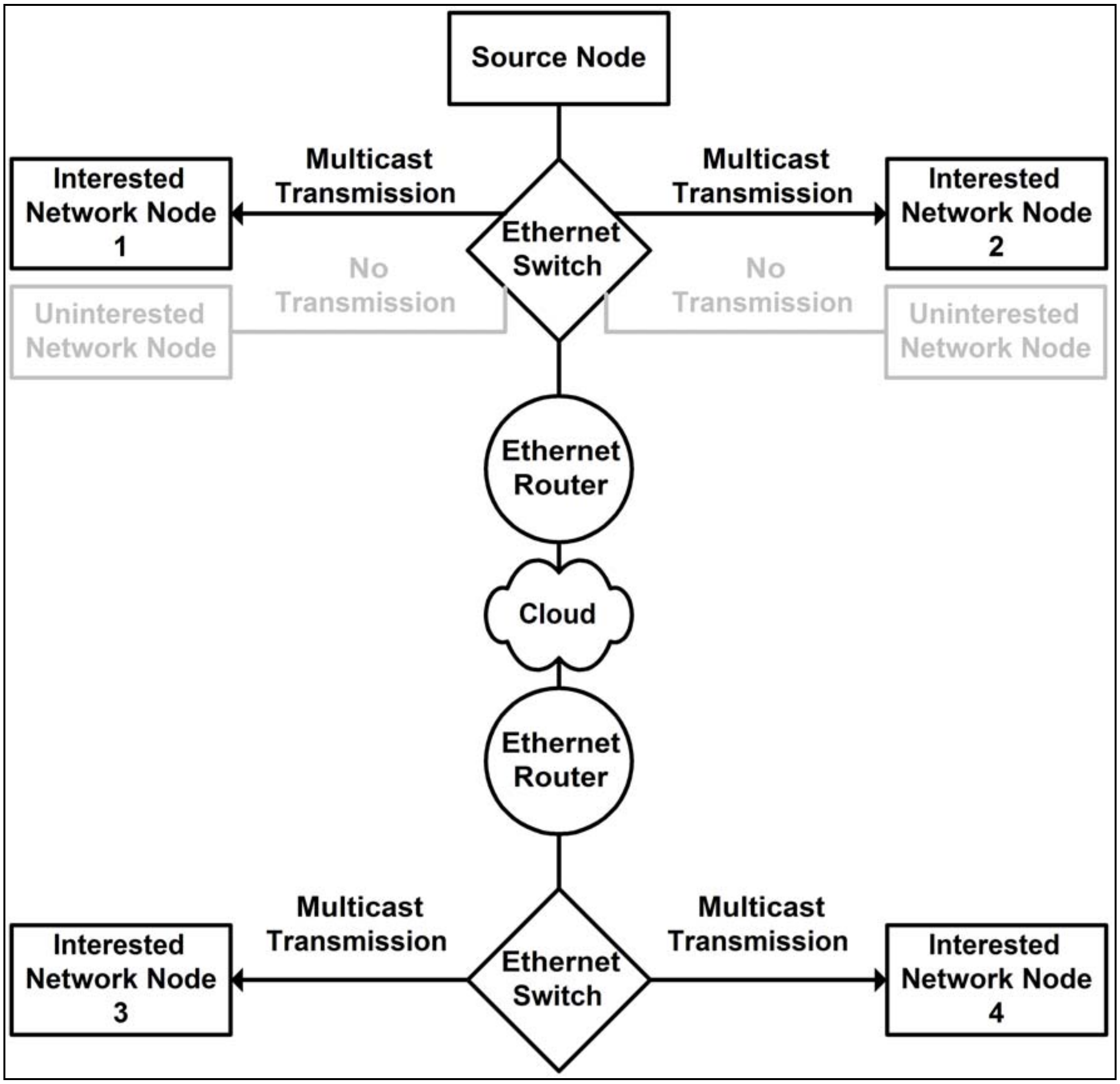

Figure C – Multicast Communication Design

The multicast communication design is based on a group concept. Each multicast group represents a number of receivers that are interested in receiving the specified data stream. In order to receive data a network node simply joins the multicast group. The multicast group has no physical or geographical limits and is simply represented by what is known as a multicast IP address.

Multicast IP addresses are defined by the Internet Assigned Numbers Authority (IANA) as being the IPv4 Class D range, which translates to the IP address range of 224.0.0.0 to 239.255.255.255. Of particular interest to telemetry system designers, are the address ranges of 224.0.1.0 to 238.255.255.255 and addresses in the 239.0.0.0/8 range.

The 224.0.1.0 to 238.255.255.255 multicast address range is commonly referred to as the “globally scoped address range”. Globally scoped addresses are used when an application needs to multicast data between various organizations or over the Internet. These addresses are controlled and assigned by the IANA.

The 239.0.0.0/8 range of multicast addresses is referred to as "administratively scoped" or "addresses of limited scope." These addresses may be used by any organization or individual but will be confined to the local or wide area network and thus cannot be forwarded outside of their respective domains. This is done by implementing the appropriate data filters on the network routers along the LAN/WAN edges.

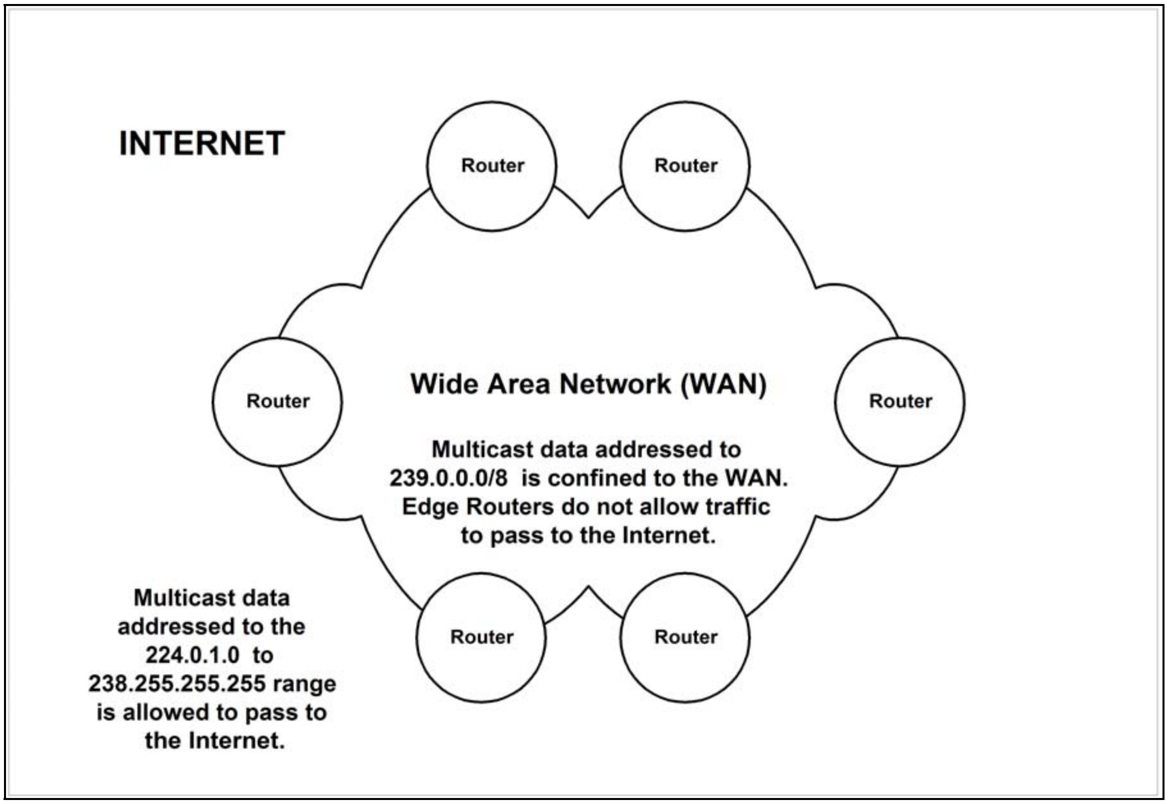

Figure D – Scope of Multicast IP Ranges

Source nodes required to send data with the desired multicast scope simply insert the multicast IP address of the desired group into the destination field of a standard unicast IP data packet. This packet will then be routed to all joined group members based on the scope of the multicast IP address.

Implementing a Multicast Design for Telemetry Data Distribution

In situations where a single PCM downlink is going to be distributed and recorded, the multicast network configuration is fairly straight forward. The data acquisition system becomes the multicast source node and simply multicasts the telemetry data out to a single multicast address. All interested receiver nodes simply join the designated multicast group.

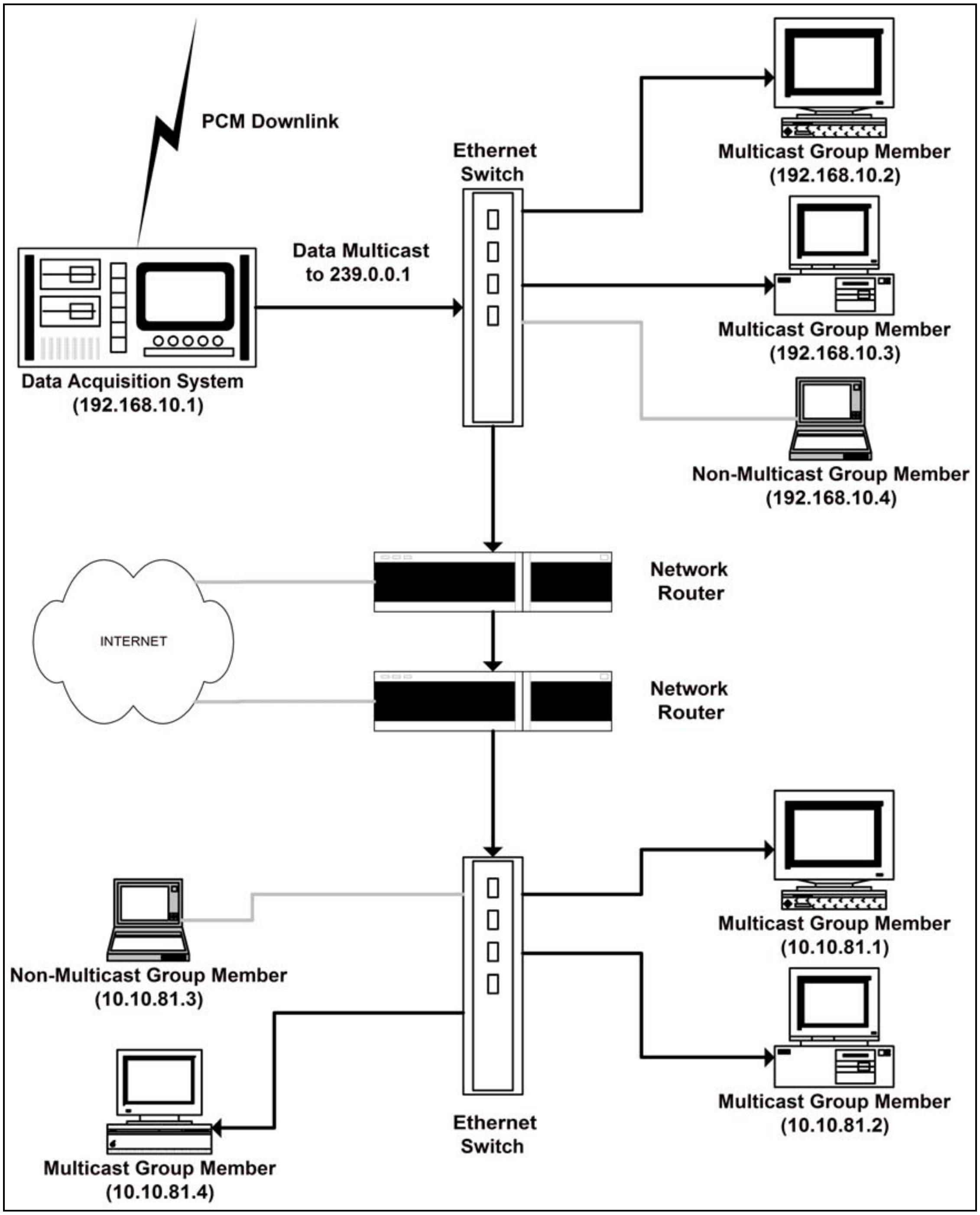

Figure E – Single PCM Stream Multicast Distribution Design

Since the various display nodes may be interested in different data sets, and quite possibly be performing different engineering unit (EU) conversions, the most efficient system architecture is to multicast the raw decommutated frame aligned data. Sending the raw data allows for a single uniform multicast design, that leverages the distributed processing power available as each node performs its own EU conversions and data processing. Applying this same distributed computing design philosophy to a multi-stream scenario results in an easily scalable system architecture for multi-stream applications.

In most multi-stream applications there are both multiple multicast sources and multiple remote receiver nodes. The benefits of a distributed computing approach on the receiving node side have been discussed, but significant benefits can be derived on the source node side as well. By breaking each PCM stream into its own telemetry unit provides for a distributed and modular telemetry system that is easy to implement, adapt, upgrade, and identify. Each modular telemetry unit would be responsible for recording and distributing a single PCM stream. If all of the receiver nodes are interested in the data from all of the multicast sources then a single multicast address can be used as shown in Figure F. The individual data stream is easily identifiable by the IP address of the source node.

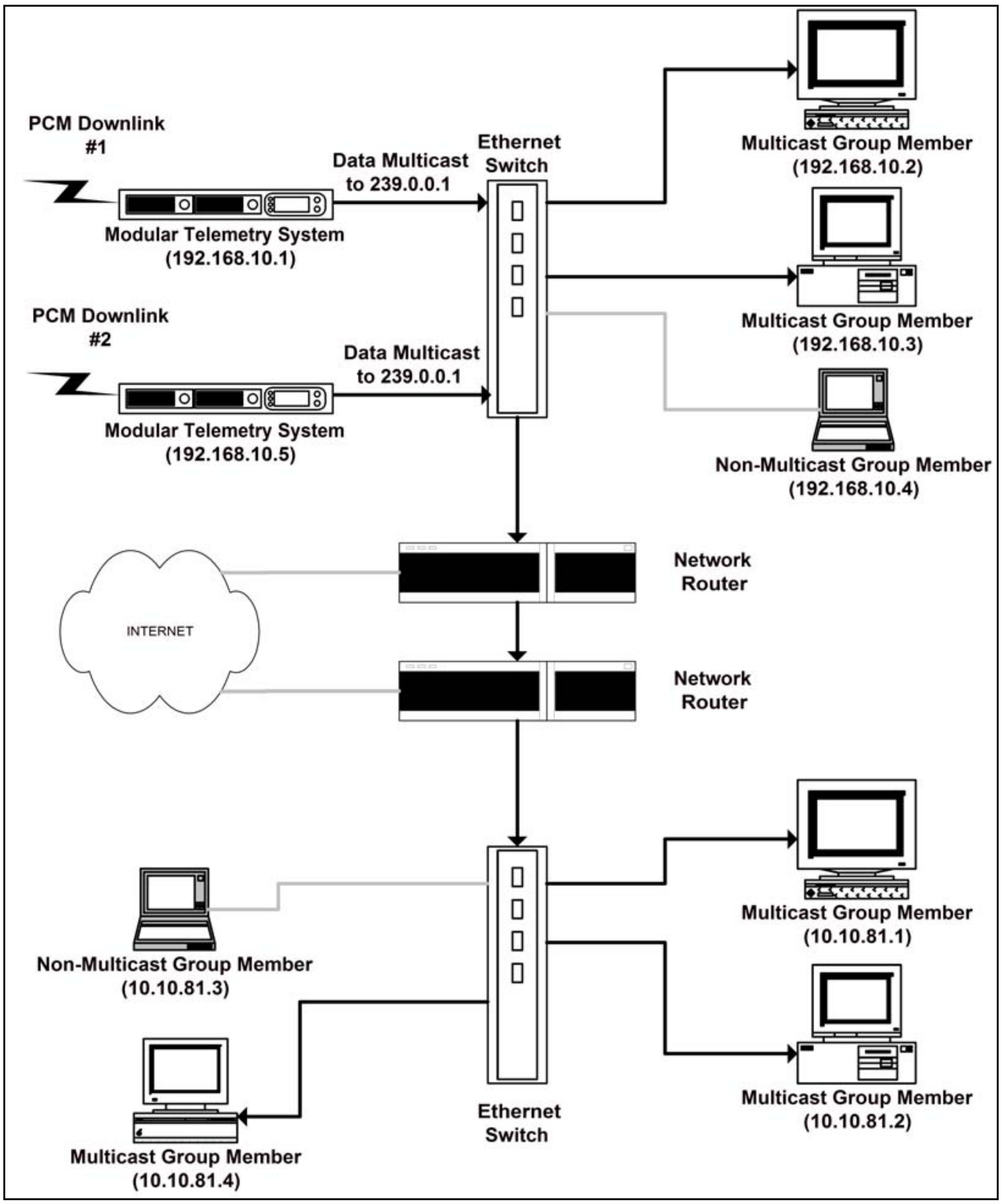

Figure F: Multi-source Single Multicast Address Implementation

If some receiver nodes are interested in data from only one of the sources while other receiver nodes are interested in data from several of the sources then some multicast architecture modification can be performed to ease processing time and network bandwidth. In this scenario, each PCM data acquisition node sends its data to a separate multicast address. Receiver nodes then join those multicast groups of interest to them. Individual stream data is easily identified by the multicast IP address as well as the IP address of the source node.

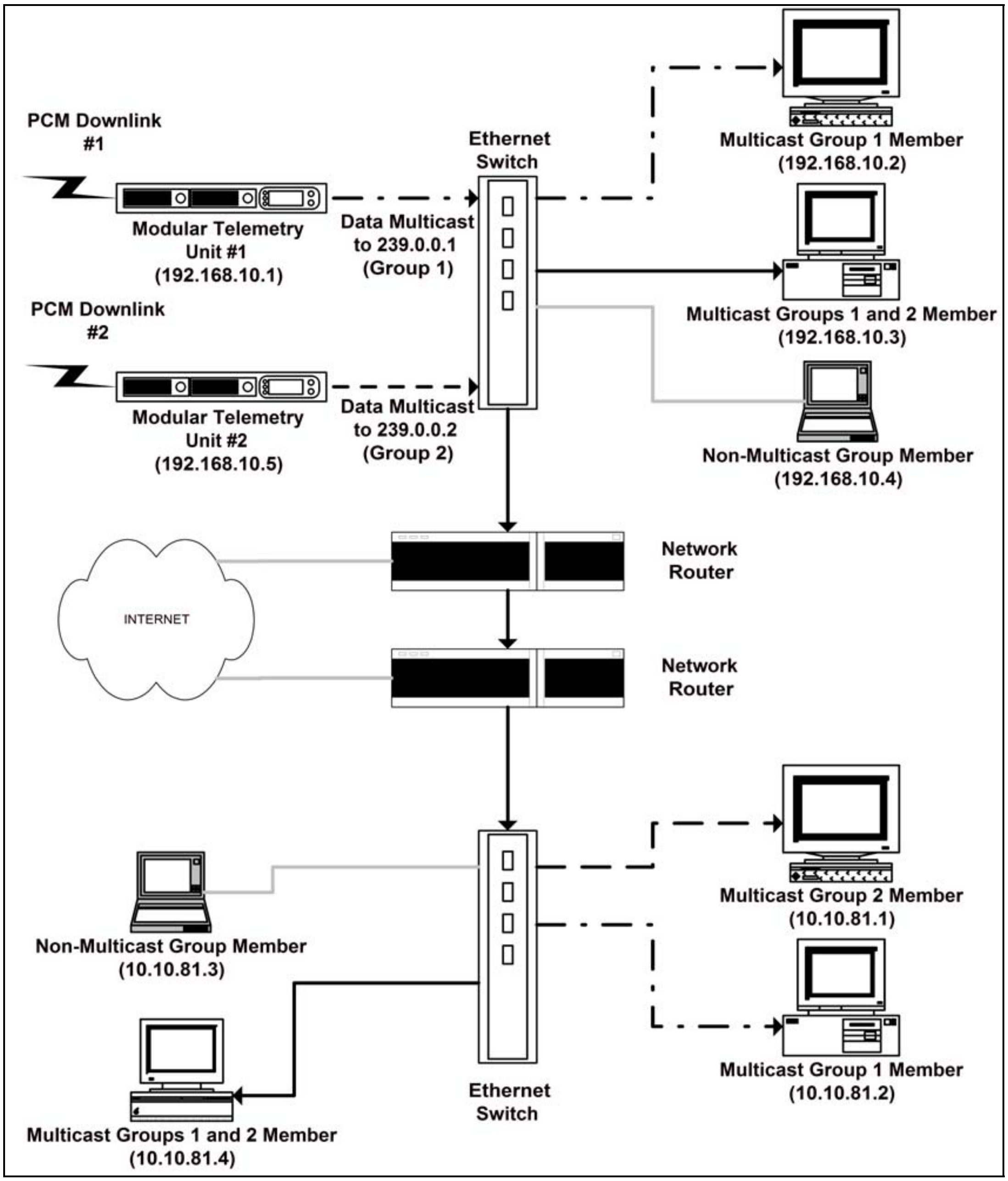

Figure G: Multi-source Multiple Multicast Address Implementation

Conclusion

From complex multiple stream scenarios to the simple distribution of a single PCM stream, IP multicast offers a scalable and easily implemented telemetry data distribution solution. Combining the best features of the unicast and broadcast approaches provide an efficient network distribution technique that allows for receiver node selectivity, without compromising network bandwidth utilization. When this distribution approach is leveraged with a distributed system architecture on the source and receiver sides, the additional benefits of a modular, scalable, robust telemetry system can be realized.

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