Phase II – Development of the On-board Aircraft Network

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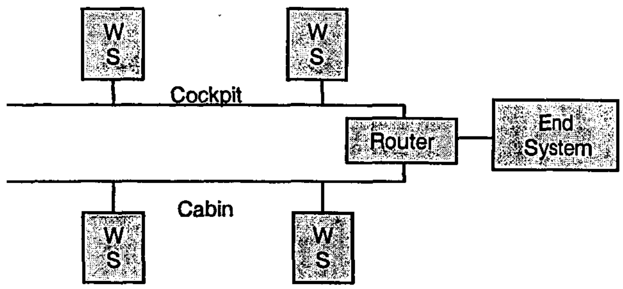
Description of Work

Phase II will focus on the development of the on-board aircraft networking portion of the testbed which includes the subnet and router configuration and investigation of QoS issues. The tesbed configuration will look like the following:



This implementation of the testbed will consist of a workstation, which functions as the end system, connected to a router. The router will service two subnets that provide data to the cockpit and the passenger cabin. During the testing, data will be transferred between the end systems and those on both subnets. QoS issues will be identified and a preliminary scheme will be developed. The router will be configured for the testbed network and initial security studies will be initiated. In addition, architecture studies of both the SITA and Immarsat networks will be conducted.

<u>Testing Objectives</u>

The phase II testing will accomplish the following objectives:

1. Configure the testbed for the aircraft on board configuration.
2. Perform QoS analysis based on the configuration settings in the router and IOS operating system.
3. Perform architectural studies on the SITA and Immarsat Networks to understand the configuration and operation of both systems.

Quality of Service Defined:
Quality of Service is defined as a network's ability to provide consistent performance for a specified service. The purpose of the Weather Information Communications (WINCOMM) Project is to develop advance communications and information for aircraft. This involves improving the time and manner in which weather data is sent to aircraft from the ground. Since the cockpit's communication method will now work on the packet switch network, several Quality of Service issues arise. Data destined for the cockpit needs to have priority over data destined to the cabin. Data priority is an issue where specified network traffic receives preferred treatment over other traffic while traveling to its destination. The goals of Quality of Service include:

1. Dedicated bandwidth
2. Controlled jitter and latency
3. Improved loss characteristics

The testbed for the cockpit/cabin scenario consists of two workstations running both Linux Red Hat 9 and Microsoft Windows Server 2000. One machine emulates the cabin and the other machine emulates the cockpit. Both workstations are connected to a Cisco router through an eight port hub. A front end system is connected to another router through a switch. The two routers are connected for emulation through the serial interfaces. The QoS features on the first router will be used to improve service.

The Cisco's IOS has four aspects of QoS which include classification, marking, policing and shaping, and queuing. Classification is basically separating network traffic into a specified class of service. The separation of classes can be based on an incoming interface, source or destination address, or applications. Marking consists of putting some type of mark on packets that enter or leave the router according to the classification scheme. Policing and shaping is a reaction to the marked packets. This aspect of QoS controls the traffic entering or leaving the router, so that the network conditions are predictable. Finally, queuing controls how and in what order packets are allowed to enter and leave the network.

Cisco IOS offers different types of QoS tools and below are the tools relevant to our application with examples:

Classification – this tool is used to identify and mark flows such as Policy-Based Routing (PBR).
Congestion Management – Examples of these are Priority Queuing (PQ), Weighted Fair Queuing (WFQ), and Class Based Weighted Fair Queuing (CB/WFQ). The manage the network upon congestion
Congestion Avoidance - Congestion avoidance techniques monitor the network traffic loads in order to prevent network congestions. Some examples are Weighted Random Early Detection (WRED), and Committed Access Rate (CAR).

Policy-Based Routing - It was first implemented on Cisco IOS Software Release 11.1. This mechanism forwards/routes data packets based on predefined polices according to

Access Control Lists. Thus classification and marking are the QoS features provided by Policy-Based Routing.
Access Control Lists are used to classify particular traffic by implementing a sequential list of permit and deny conditions. These lists are applied to an interface on the router and can be used to filter data based on applications, protocols, port numbers, and/or IP addresses.
Policy-Based Routing also allows for the marking of the IP precedence bits located in the type of service field of the IP header. The first three bits of the TOS field represent the IP precedence field. Although there are eight possible combinations, only six classes are available.

Priority queuing (PQ): It is implemented in Cisco IOS Software Release 11.1 and above. It ensures that important traffic gets precedence over others. PQ can be prioritized by network protocol, incoming interface, packet size, source/destination address, etc. Packets are categorized in one of four queues – high, medium, normal, or low – based on assigned priority.

Weighted Fair Queuing:
Weighted Fair Queuing is implemented to overcome the limitations of the first in first out (FIFO) queuing. WFQ is implemented in Cisco IOS Software Release 11.1.
Weighted Fair Queuing separates traffic based on source and destination network or MAC address, protocol, source and destination port, and socket numbers of a particular session. The classification scheme allows network traffic to be distributed in conversation like schemes based on fair queues. Data is placed in queues based the time it takes for the last bit of each packet to arrive.

Class Based Weighted Fair Queuing improves WFQ by allowing user defined classes of traffic. Traffic can be classified based on matching protocols, access control lists, and/or input interfaces. Bandwidth, weight, and maximum packet limit are administered to class during congestion periods.

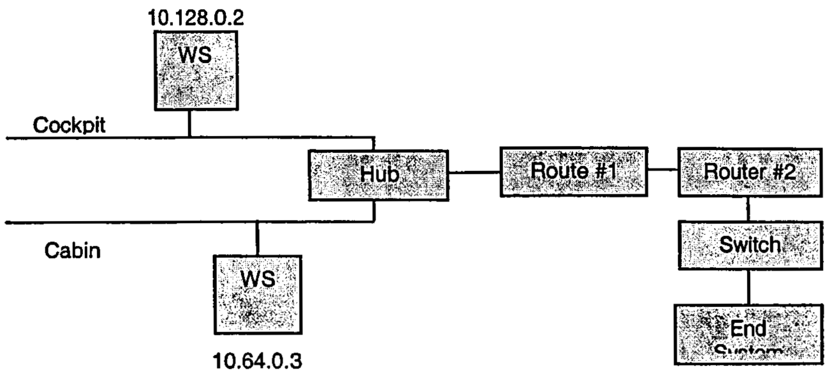
Weighted Random Early Detection
WRED algorithm is designed to avoid congestion before it becomes a problem. It combines the RED algorithm with IP precedence to provide preferential traffic handling for high priority packets. WRED can be configured to discard lower priority traffic when the interface begins to get congested.

Committed Access Rate:
Committed Access Rate is available in Cisco IOS Software Release 12.1. CAR performs two QoS functions.
Packet classification is accomplished by separating traffic based on physical ports, source or destination IP or MAC address, application port, or the IP protocol type as specified in the Access Control List. After the data is classified, it is marked using the IP precedence bits.
CAR also has the ability to police and shape data. This is accomplished by managing the bandwidth for a given class of traffic through rate limiting. Traffic that falls between

specified rates is transmitted. While the other data is either dropped or placed in a different priority category.

Implementation and Architectures:

The current architecture for the aircraft IP network testbed is shown in the following diagram.



The routers used in this diagram are 2500 series routers with one Ethernet port each. The two routers are connected via the serial interfaces.
All of the tools available for QoS will work with this existing architecture. However, some of the features in these tools will only work under different configurations and architectures.

Priority Queueing:

Implementing the priority queueing tool in the existing architecture can be accomplished via an access list and a priority list. Creating the appropriate access list and matching it with a priority list will classify the network traffic into the necessary priority queue. Only one priority list can be assigned to a specified interface.
Priority queueing also has the ability to assign priorities based on the interface packets are entering. If the cockpit and cabin have a dedicated interface for incoming traffic, the data entering the router can be classified into one priority queues. This means explicitly declaring that packets entering the interface assigned to the cockpit be place into the high priority queue. This also means using a router with more than one Ethernet interface.

Committed Access Rate:

Implementing the committed access rate tool in the existing architecture can be accomplished by using the appropriate access list and by specifying a rate limit. Once the policy is matched with an access list the transmission rate for cockpit or cabin data can be specified.
CAR also has the ability to identify packets based on the IP precedence bits in the IP header. However, this requires QoS implementation on the source end of this scenario.

Once the bits are marked and sent through the network, the aircraft's router can use CAR to specify a rate limit for the cockpit and/or cabin.

Policy-Based Routing:
Policy-Based Routing allows for the setting of IP precedence, IP next-hop, and interface after matching the appropriate access list. The IP precedence bits can be used to declare priority and this tool can be used on the current architecture.

Weighted Fair Queuing:
Weighted Fair Queuing along with Class Based WFQ are IP precedence aware. Using this feature within this tool is the best implementation for QoS. However, configurations must be implemented on the source end of this scenario as well. Thi tool will work with the current architecture.

Notes / Reccomendations:
Using routers with more than one Ethernet interface would be very beneficial to this scenario. The schemes and configurations will be more intricate allowing for the best implementation of QoS.
Access Control Lists are normally used as security features. Therefore, when using this tool to implement QoS the list must be configured carefully. If the list permits only one class of traffic all other traffic will be implicitly denied.
IP precedence and Differentiated Services Code Point both take advantage of the QoS solutions within the IP header. Both use the type of service field to mark precedence bits. These tools often times require cooperation throughout all of the networks in which the data packets are traveling.