ATNP WG 2 WP /__

AERONAUTICAL TELECOMMUNICATIONS NETWORK PANEL
(ATNP) WORKING GROUP 2

Banff, Canada
16 - 20 October 1995

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WORKING PAPER

IDRP Router Initiation Times With Mode S

SUMMARY

CAASD has used its ATN simulation to estimate router initiation time using Mode S, with and without the Interdomain Routing Protocol (IDRP - ISO/IEC 10747 [1]) on the air/ground link. This simulation of router initiation relies heavily on the analysis done by Ted Signore of CAASD [2]. The paper describes a surprising result: the router initiation time is longer when one router takes on a "passive role," that is, it waits for the remote router to send an IDRP Open rather than sending an IDRP Open immediately upon receipt of an Intermediate System Hello (ISH).

REFERENCES

1. "Information Processing Systems - Telecommunications and Information Exchange between Systems - Protocol for Exchange of Inter-domain Routeing Information among Intermediate Systems to Support Forwarding of ISO 8473 PDUs," ISO/IEC 10747, 18 October 1993.

2. T. L. Signore, "Time Estimates for the IDRP Initiation Sequence," ATNP WG2 WP13, 24 - 28 October 1994.

1.0 Introduction

One of the most important measures of Aeronautical Telecommunications Network (ATN) performance is how long it takes to establish communication between an airborne and a ground router. The Center for Advanced Aviation System Development (CAASD) has used its ATN simulation to estimate this time using Mode S, with and without the Interdomain Routing Protocol (IDRP - ISO/IEC 10747 [1]) on the air/ground link. This paper describes the estimates.

This simulation of router initiation relies heavily on the analysis done by Ted Signore of CAASD. Ted's work in this area is documented in a working paper submitted at the San Diego ATN Panel Working Group 2 meeting [2]. This paper uses the term "router initiation time" as it is used in [2] to denote the time to establish communication between the routers.

The paper describes a surprising result: the router initiation time is longer when one router takes on a "passive role," that is, it waits for the remote router to send an IDRP Open rather than sending an IDRP Open immediately upon receipt of an Intermediate System Hello (ISH).

2.0 Mode S Model

The Mode S model in the simulation assumes each aircraft carries a level 4 transponder which can send and receive 160 bytes in each scan.[1] Of this 160 bytes, a small number of bytes are used by Mode S itself. Multiple messages between a sensor/transponder pair may be multiplexed into a single scan up to the 160 byte limit. The simulation assumes that Mode S utilization is low enough that the delay across Mode S is independent between aircraft. The simulation also assumes that applications do not send messages over a link until the router initiation process is complete; therefore, packets in the router initiation sequence never queue behind application messages. More details on the Mode S model were presented in [3].

3.0 Router Initiation Sequence

Table 1 shows the sequence of messages for router initiation. The "OPEN ACKs" in scan 4 are IDRP OPENs that acknowledge the local router's previously sent OPEN. With the packet sizes estimated in [2], each Intermediate System Hello (ISH) and IDRP packet is small enough to be sent in a single scan, but packets are large enough that none can be multiplexed on Mode S. The sequence assumes that ISO 8208 fast select is not used to

[1] A level 4 transponder must be able to downlink a minimum 40 bytes per scan; it is expected that implementations will be capable of 160 bytes per scan.

transmit ISHs in the Mode S Call Request and Call Accept. If fast select is used, the sequence will take two fewer scans. If multiple UPDATEs must be sent from the ground to the aircraft, router initiation will require additional scans.

Table 1. Active Router Initiation Sequence

Scan	Uplink	Downlink
1	Call Request	
2		Call Accept
3	Intermediate System Hello (ISH)	
4		ISH
5	IDRP OPEN	IDRP OPEN
6	IDRP OPEN ACK	IDRP OPEN ACK
7	IDRP UPDATE	IDRP UPDATE

There are differences of opinion about whether OPENs should be sent in both directions on scans 5 and 6. An IDRP connection can be established by sending an OPEN in one direction on scan 5 and returning a single OPEN ACK on scan 6. [4] describes this sequence, where one router takes on a “passive role” and argues that “This approach will permit the exchange of route initiation data to take place in the shortest timeframe.” Surprisingly, the passive mode actually requires one more Mode S scan than the active mode because the ground router does not enter the IDRP established state until it receives the UPDATE in scan 7 and therefore cannot send an UPDATE until scan 8. Table 2 shows the router initiation sequence with the ground router in the passive role.

Table 2. Passive Router Initiation Sequence

Scan	Uplink	Downlink
1	Call Request	
2		Call Accept
3	Intermediate System Hello (ISH)	
4		ISH
5		IDRP OPEN
6	IDRP OPEN ACK	
7		IDRP UPDATE
8	IDRP UPDATE	

The ATN Manual now directs that passive router initiation be used; therefore, the results presented below assume a passive router initiation sequence.

Tables 1 and 2 do not show the IDRP KEEPALIVE that must be sent to acknowledge an IDRP UPDATE. This keepalive is not necessary for data transfer and is therefore not shown as part of the router initiation sequence. Even so, because it takes bandwidth on the air/ground link, this keepalive can cause additional delay for an application message sent immediately following router initiation.

4.0 Router Initiation Time

The uplink ISH must wait until the antenna rotates into position to communicate with the aircraft. This time is uniformly distributed from 0 to the scan time. Scans 2 through 8 each take a complete scan time. Thus, the router initiation time, t_{ri} is

7 scans * scan time • t_{ri} • 8 scans * scan time

With a 12 second scan for en route airspace,

84 seconds • t_{ri} • 96 seconds

With a 4.8 second scan for terminal airspace,

33.6 seconds • t_{ri} • 38.4 seconds

Connection establishment times are uniformly distributed between these bounds.

Figure 1 shows connection establishments times recorded in the simulation using a 12 second Mode S scan. Figure 1 shows the relative number of times that the router initiation time fell in each 1 second interval from 0 to 100 seconds. The sample consists of 928 router initiation sequences. As expected, the times all fall between 84 and 96 seconds.

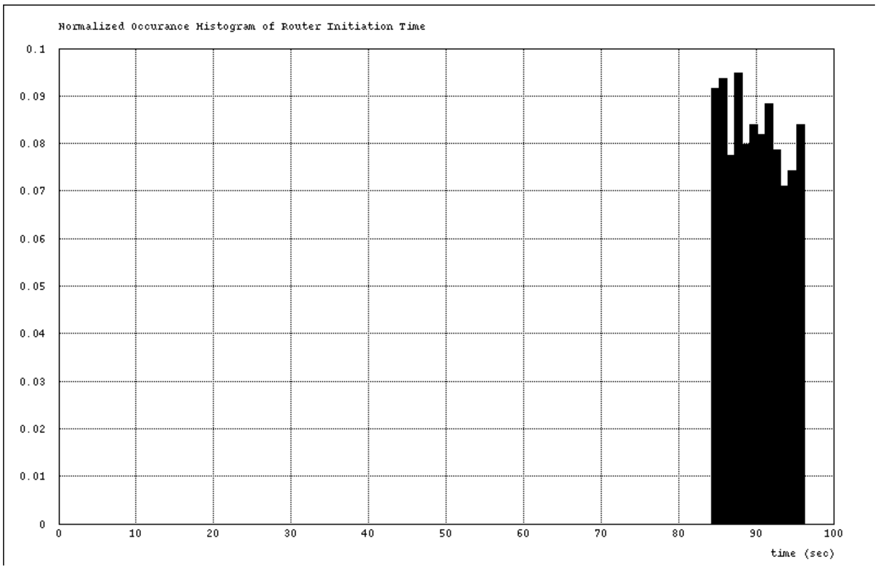

Figure 1. Router Initiation Time in Simulation

5.0 Router Initiation Without IDRP

In CNS/ATM package 1, IDRP will be optional on the air/ground link. Without IDRP, the router initiation sequence will just consist of the ISO 8208 call establishment and an uplink and a downlink ISH. The router initiation time in this case is the time for the antenna to rotate into position to send the uplink ISH plus one full scan time to return the downlink ISH. With a 12 second scan for en route airspace,

36 seconds • t_{ri} • 48 seconds

With a 4.8 second scan for terminal airspace,

14.4 seconds • t_{ri} • 19.2 seconds

Table 3 summaries the maximum router initiation time with and without IDRP on the air/ground link. Obviously, much less time is required if IDRP is not used. The reader is reminded that these times will be two scans shorter if ISO 8208 fast select is used to send the ISHs in the Call Request and Call Accept packets. The times could be one scan shorter if both routers send an IDRP Open upon receipt of an ISH.

Table 3. Summary of Mode S Router Initiation Times

	Terminal Sensor (sec)	En Route Sensor (sec)
Without IDRP	[14.4, 19.2]	[36, 48]
With IDRP	[33.6, 38.4]	[84, 96]

6.0 Operational Impacts

Router initiation occurs at the start of each flight and each time an aircraft enters a new cell. In this context, a cell is defined as a region of airspace covered by all the Mode S sensors connected to a single ground ATN router. Router initiation must also take place when the connection is dropped because of a failure or because the aircraft was temporarily out of coverage.

With Mode S, router initiation will take a significant length of time. Applications will not be able to use the link until router initiation is complete. Operationally, the impact of this delay at airspace boundaries depends on whether there is enough overlapping subnetwork coverage to establish a new connection before the old one is lost and depends on the type of transponder used. With a level 4 transponder, the sensor must reserve the transponder to transfer data. During the reservation, no other sensor can communicate with that transponder. With reservations, sending packets for router initiation will preclude the aircraft from communicating via the existing connection with the sensor in the cell the aircraft is leaving. Thus, with a level 4 transponder, applications will experience a communications gap equal to the router initiation time when an aircraft crosses a cell boundary. Since cell boundaries and airspace boundaries are similar, this communications gap occurs at a time when the demand for data link communication is expected to be relatively high. With a level 5 transponder (as defined in the draft Standards and Recommended Practices), reservations are not required, so the aircraft may be able to communicate via the previous sensor while performing router initiation via the sensor in the next cell.

7.0 Recommendations

Because the router initiation time is significantly shorter without IDRP, a superficial analysis might conclude that the ATN should be designed without IDRP on the air/ground link. CNS/ATM package 1 makes this type of operation an option. This is only a partial solution, because without IDRP on the air/ground link the aircraft has no way of knowing which ground systems are reachable through a given air/ground connection. The best solution is to be able to exchange this information more efficiently than can be done with IDRP. CAASD has proposed such a solution, called the Routing Initiation and Policy (RIP) process, described in [5]. The router initiation time with RIP is the same as the non-use-of-IDRP solution in package 1.

8.0 Future Work

CAASD plans to integrate a VHF subnetwork model into the ATN simulation. At that time, router initiation times with VHF will be estimated. With VHF, aircraft must change frequencies at some cell boundary crossings. When frequency changes occur data link communication with the aircraft will be lost while the new IDRP connection is established.

9.0 References

1. "Information Processing Systems - Telecommunications and Information Exchange between Systems - Protocol for Exchange of Inter-domain Routeing Information among Intermediate Systems to Support Forwarding of ISO 8473 PDUs," ISO/IEC 10747, 18 October 1993.

2. T. L. Signore, "Time Estimates for the IDRP Initiation Sequence," ATNP WG2 WP13, 24 - 28 October 1994.

3. "U.S. Simulation Capabilities For Aeronautical Telecommunications Network Validation," Working Paper presented U. S. at SICASP 5, 1 - 19 November 1993.

4. T. Whyman, "Proposed Guidance Material in Support of Route Initiation," ATNP WG2 WP68, 18 January 1995.

5. "CNS/ATM-1 Package Policy Implementation Definition," WG2/WP-72, January 1995.

10.0 Acknowledgments

The author would like to give due credit to Brian Hung, David Millner, and Ed Dillon of The MITRE Corporation for contributions to the development of the ATN simulation. Without their work, these experiments could not have been performed.