AERONAUTICAL TELECOMMUNICATIONS NETWORK PANEL

Working Group 2

Brussels 22-26 April 1996

COTP Timers Analysis in the ATN/AMSS Computer Model

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SUMMARY

This paper presents the status of an ongoing study of COTP timer values through simulation results. The simulation effort uses a high-fidelity ATN/AMSS Computer Model developed by the U.S. Federal Aviation Administration (FAA). The work reported herein is part of an effort to select optimal set of COTP timer values valid for all the air/ground subnetworks used in the ATN.

1. Introduction

This paper presents simulation results as part of a Federal Aviation Administration (FAA) effort concerning COTP timers analysis and selection for the ATN. The goal of the effort is to determine if there is an optimal set of timer values that provide normal operation for all subnetworks used within the ATN. Here, we present and discuss recent results obtained by computer simulation of ATN with AMSS as the air/ground subnetwork. We further describe future work planned towards the harmonization of the timer values selection across all subnetworks.

2. ATN/AMSS Simulation Architecture

The ATN/AMSS model was developed using the Optimized Network Engineering Tool (OPNET) jointly between Mayflower Communications Company Inc. and the MITRE Corporation under the sponsorship of FAA. The principles of the International Organizations for Standardization (ISO) Open System Interconnection (OSI) architecture are used as the basis for development of ATN, and the complete functionality of the AMSS data communication service is encompassed.

3. Simulation Scenarios

3.1 Previous Approach to Selection of Timer Values

In our previous work, described in [1], we made the following assumptions which affected the selection of COTP timers:

- Timers are configurable per established Transport Connection, i.e., per different priority (Urgent, Flight Safety, Other safety, and Normal),
- Timers are configurable per direction (uplink and downlink), i.e., different transit delays are assumed in the from-aircraft and to-aircraft direction,
- Timers are configurable per AMSS channel bit rate (we executed simulations for 600 and 10,500 bps).

Under these assumptions, the following criteria were satisfied during simulation runs:

- Normal operation of Transport Protocol was provided, e.g., no excessive number of COTP connection releases occurred,
- Desired load on the AMSS channels was maintained (P and T channel at 60-70%, R channel at 10-12%),
- SATCOM/Oceanic traffic profile was used [2],
- No variation of oceanic traffic was used.

Computer resource limitation required that the anticipated traffic of each AES during oceanic flight be multiplied by a factor (called "traffic factor") in order to simulate the existence of multiple aircraft to attain the desired AMSS channel loading. For example, to achieve an AMSS P-channel load of 65%, a total of 720 AES were required to be logged on to one GES and were simulated using 90 AES with a traffic factor of 8.

3.2 Reevaluation of Acknowledgement Timer Values

Mayflower reevaluated the assumptions and criteria for timers selection in response to the task to evaluate whether it is possible to select one set of COTP timer values, regardless of the air/ground subnetwork for CNS/ATM-1 Package SARPs, and to the decision that the Application layer should not be concerned with the setting of Transport layer timers. The effort presented in the following attempts to select a unique value for the Acknowledgment timer, regardless of the priority, direction, and channel rate in the AMSS, while still providing normal operation of Transport Protocol, and maintaining desired load on the AMSS channels as previous simulations. In addition, our desire is to achieve equivalent performance as per the previously selected optimized timer values (Tables 1 and 2). Extensive simulation runs were performed for a wide range of timer values, from 10 to 1000 seconds, using the ATN/AMSS Computer Model.

4. Results and Analysis

For the scenario given in 3.1, selected Acknowledgement and Retransmission timer values are shown in Table 1 and Table 2, respectively.

	Priority Group			
	Urgent	**Flight Safety**	**Other Safety**	**Normal**
600 bps, AC/Ground	40/70	50/80	60/90	70/100
10,500 bps AC/Ground	160/280	200/320	240/360	280/400

Table 1. Acknowledgement Timer Values which exhibited optimal performance

	Priority Group			
	Urgent	**Flight Safety**	**Other Safety**	**Normal**
600 bps, AC/Ground	290/310	310/340	390/420	480/510
10,500 bps AC/Ground	190/310	230/350	280/400	330/450

Table 2. Retransmission Timer Values which exhibited optimal performance

For the given traffic profile, in the network of 90 AES with each of them generating 8 times the expected traffic per AES, we observed that fast acknowledgement causes large delays, particularly in the uplink direction for flight safety messages. This is attributed to the flow control mechanism in the Satellite Subnetwork layer, which causes excessive queuing delays for uplink data TPDUs due to the presence of acknowledgement packets of the ADS downlink messages. Furthermore, since the aircraft AK TPDUs are also delayed, this causes unnecessary retransmissions from the aircraft Transport entity, which overloads the AMSS downlink T-channel. The overload is prevented by selecting larger acknowledgement times, thus acknowledging multiple data TPDUs with one AK TPDU.

The first group of experiments described in 3.2. led to the selection of COTP Acknowledgement time of about 5 minutes (300 sec). The selection was again driven by a traffic profile and multiple acknowledgement in the uplink direction. Since there are not that many acknowledgements transferred in the downlink direction, we were able to set much lower acknowledgement times at the aircraft COTP. The set of simulation runs was performed for single timer values, different at the aircraft and the ground, to reflect possible scenarios when AES and GES operate on different channel rates, or use timer sets specific to different air/ground subnetworks. From these runs, we selected 50 seconds for the aircraft COTP Acknowledgement while still keeping the ground COTP Acknowledgement time at 300 seconds.

5. Preliminary Results

In all previous simulation runs one of the required conditions was to achieve operational load on AMSS P and T channels of 60-70%. This was the main reason for introducing traffic factor in the network of 90 AES. However, it is reasonable to anticipate that the SATCOM oceanic traffic will not have more than 300 AES logged on to one GES and operating at one P channel at a time. Therefore, ongoing work is focused towards analyzing an ATN network that consists of up to 300 AES that generate nominal traffic. We believe that this scenario will generate results much closer to the real conditions. Timer values used in latest simulation runs are presented in Table 3.

Preliminary results of the latest simulations with acknowledgement times as low as 20 seconds, show that the mechanism of reference number assignment takes over the flow control in the Satellite Subnetwork, incurring delayed acknowledgements in the uplink direction, and then a large number of retransmissions from the aircraft’s TP. This is expected, since the available 15 reference numbers per AMSS priority have to be distributed over a larger number of logged on AESs. Reference numbers are assigned per priority per aircraft. To mitigate this problem the need to acknowledge multiple data TPDUs of the same priority from the same AES with one AK TPDU is still desirable. However, in order to acknowledge multiple TPDUs, the acknowledgment timer has to be very large, on the order of 1000 seconds (more than 16 minutes) since the traffic per aircraft is infrequent. This by far exceeds values for other subnetworks.

Symbol for Component	Definition	Value
MLR	Max NSDU life, local to remote	180
MRL	Max NSDU life, remote to local	180
ELR	Max transit delay, local to remote	95
ERL	Max transit delay, remote to local	95
AL	AK time, local	20
AR	AK time, remote	20
IL	Inactivity time, local	3000
IR	Inactivity time, remote	3000
N	Number of transmissions	3
x	Local processing time	1
Computed Values		
T1	Retransmission time (ELR+ERL+AR+x)	211
R	Persistence time (T1*(N-1)+x)	423
L	MLR+MRL+R+AR	803
W	Window time (IR-ELR)/(N-1)	1452.5

Note: All times are in seconds

Table 3. Timer values used in most recent simulations

6. Ongoing Effort and Future Work

The search continues to find a set of timer values that provides adequate performance of ATN over all subnetworks. As far as AMSS subnetwork is considered, such solution might impact the capacity, in terms of number of aircraft that could be logged on. Another possible solution could be to reconsider the use of COTP for ADS and thus eliminate the problem with COTP acknowledgements of ADS messages. Further, in order to harmonize the timer values setting among all subnetworks the overall solution might have to implement a dynamic algorithm for updating retransmission timers based on measured round trip delays [3]. A preliminary analysis has been performed and a dynamic algorithm implementation into the existing ATN model has been proposed.

References

[1] Mayflower Communications Co. Inc., “Evaluation of ATN/AMSS End-to-end Performance by Computer Simulation”, ICAO ATNP WG1, Banff, Canada, 1995.

[2] RTCA, “SATCOM/HFDL Traffic Model”, SC165, WG3-WP308

[3] V.Jacobson, “Congestion Avoidance and Control”, SIGCOMM ‘88, Computer Communications Review, vol. 18, no.4, pp.314-329, Sept. 1988.