Aeronautical Telecommunications Network Panel

WG2

ATN Internet Working Group Meeting

Banff, Alberta, Canada

16 - 20 October 1995

Agenda Item

ATN Message Cost

Summary:

This Working Paper provides an outline for the identification of billable bits per message for the exchange of ATN data. It is intended that all Air/Ground, Ground/Ground and Airborne systems within the ATN be analyzed with respect to message size (including overhead). The paper is focused on Network and Transport provisions and protocols with a brief overview of the size of the session, presentation and application layers. It is intended to provide helpful guidance material to States for the completion of an option analysis for decision making.

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1. Introduction

This Working Paper outline is structured to eventually provide detailed estimates on ATN message size (in bits). It will be successful only after data it has been compiled and completely analysed. The end result will be the number of billable bits per message based on data size and overhead of various ATN communication messages. The actual costing information will vary with different providers and, in some cases, is still in the testing phase of development.

The following discussion centers around the different types of communications that are incorporated into the ATN. These methods of communications are divided into three groups:

1. Ground/Ground;
2. Air/Ground; and
3. Airborne.

They can be broken down into functional components that determine the actual message size.

2. Discussion

The events and discussions by the Working Groups of the ATNP and ISO have made important decisions that affect protocols to be used and, in turn, the size of the message to be sent. This paper is designed to present the most recently compiled facts (largely based on Aeronautical Communications Service Provider's tests) on ATN message sizes and scenarios for possible use in cost benefit analysis by the States. The appropriate layers of the ISO seven layer stack predominantly responsible for message transaction, will be represented in this discussion.

The Upper Layers: Session, Presentation and Application layers add to the actual message being sent, and will be dealt with at the Working Group 3 level. However, estimates obtained from service providers have been used in this discussion.

Throughout the discussion the following questions need to be answered:

1. How many bits per message and per connection (for specific ATM requirements i.e. ADS & CPDLC);
2. How many bits per unit time for maintaining a connection and detecting a failure in a timely manner;
3. How many bits are necessary for overhead in the various ATN established protocols; and
4. What provisions exist for sharing the costs of ATC traffic/AOC traffic.

Below is a brief description of the protocols used by the particular layers (Table 2-1).

Layer	Protocol
Application	grouped together using WG3 validated data
Presentation	
Session	
Transport	ISO 8073 (TP4) or ISO 8602 (or both)
Network	CLNP / ISO 8473 / SNAcP * ISO 9542
Data Link	Not Applicable
Physical	Not Applicable

Table 2-1 OSI layers and protocols * recommended use

2.1. Network Layer

This layer provides the means to establish, maintain and terminate network connections between open systems. The following are some of the basic evaluations of the network layer protocols used in the ATN applications. The variance to this standard will be explained in each of the three cases G/G, A/G and airborne. In calculating the overall size of the bits sent over the network layer we must consider the overhead and the fact that protocols will vary.

2.1.1. Message Size

The network layer is composed of an NSAP (ISO 8348/AD2) and three associated parts: CLNP, SNDCF and SNACP. The discussion will include the specific ISO protocols ISO-8208 and ISO-8473 which are used by the ATN. The Data (or message) part of each communication will vary from scenario to scenario. First, a look at the ISO general standard message size from which the ATN stems.

NSAP. The NSAP (address) is usually **20 bytes** long. It identifies the end system to be contacted and includes a TSAP selector.

CLNP. The overhead added by the CLNP is the header of the NPDU DATA packet in the 8473 protocol and the PDUs used for the dynamic routing protocols. This section describes the lengths of NPDU header. The four parts of the CLNP header are:

1. The fixed part (coded with 9 bytes);
2. The address part (coded with 42 bytes);
3. The segmentation part (6 bytes field); and
4. The optional part contains three options: Priority, QOS and security (3 bytes each, security to be determined).

Finally, upon the addition of the different segments of the CLNP NPDU's header the total is **63 bytes** of overhead to which the security field from the options part must be added.

A slightly modified version of the Network layer being discussed is the X.25. It is connection-oriented and used by several service providers. In the past, it has been noted that the X.25 standard does not map well onto the OSI Reference model and it includes some transport layer functionality's (end-to-end). However, it had emerged before the model was recommended and has been modified since. X.25 has a similar structure to the ISO protocol ISO-8208 which will be discussed. In order to calculate the size of a packet, the default values are used unless the X.25 parameters are negotiated (using the X.25 facilities field). The default values are:

- Maximum packet size of 128 octets;
- Window size of 2; and
- 3 bit sequence numbers.

Although X.25 is primarily a network function, because it spills over onto the transport layer we will discuss it's message size here. The PDU's used in the X.25 service and their associated values are:

- CR/CC TPDU is 20 bytes;
- Data packets add 3 bytes (normal) or 4 bytes (extended);
- Receive ready or receive not ready is 3 bytes (normal) and 4 bytes (extended);
- Interrupt request/confirmation 3 bytes each;
- CLEAR PDU 23 bytes; and
- Reset 5 bytes.

The values are the basic PDU calculations for the X.25 (ISO 8208) subnetworks. The extended format is used when many DATA packets must be sent or received during a connection.

TOTAL = 57 bytes using the "normal" calculation.

2.2. Transport Layer

The transport layer is used to optimize the use of the available network service and provide end-to-end significance. This section describes the lengths of the protocols TPDU, the size of the DATA TPDU's header (in class 4), and the assumptions used to calculate these lengths.

2.2.1. Message Size

The overhead induced by the TP4 (Transport Protocol Class 4) protocol comes from the TPDUs used for the management of the protocol, CR,CC,DR,DC,AK and the header added to the DATA TPDU, DT and ED.

Overhead for TPDU: The overhead consists of 3 parts

1. The Length Indicator (LI) field;
2. The fixed part; and,
3. The variable part.

The fixed part and the variable part are significant within each TPDU. The LI field contains the TPDU's length excluding the LI length itself.

The fixed part: The DATA TPDU's header size depends on whether the TPDU-NR(which is the sequence number of TPDU sent) has a normal format or an extended format. The extended format is recommended when a permanent or long connection is established: the number of TPDUs sent in this case can reach a value which cannot be stored in the normal format. Indeed, for some TPDUs, the fixed part depends of the choice of an extended format or a normal format.

The variable part: Some parameters are additional information of variable length. These fields are not mandatory for the ATN and are not used in our calculations . Other parameters are required or allowed by the ATN but in this case, the length of each field is known. The following is an attempt to calculate the TP4's header size in two cases: 1. only with the parameters required by the ATN manual (minimal length of overhead), with known optional parameters (maximum length of the overhead).

The summary of PDU header sizes for the Transport layer (ISO 8073) is as follows:

- Connection Request/Connection Confirm - 22 bytes each;
- Disconnect Request - 11 bytes;
- Disconnect Confirm - 10 bytes;
- AK - 5 bytes (min), 14 bytes (max);
- DATA - 5 bytes (min), 12 bytes (max);
- Expedited Data - 5 bytes (min), 12 bytes (max);
- Expedited Data Acknowledgment - 5 bytes (min), 12 bytes (max);

2.3. Upper Layers

As an estimate, the entire upper layer protocol establishment for connection requires **98 octets**. The upper layers are described briefly to explain their bit usage per layer.

2.3.1. The Session layer

The Session Layer provides numerous services to the ATN communications. It contributes a set of tools (functional units) that can be negotiated, a set of rules for operation and a method of navigating amongst these rules. The layer is based on the use of "tokens" for control.

2.3.2. The Presentation Layer

Most of the Presentation Layer is provided outside of the actual layer. It provides a way of representing the data which includes semantics and data representation. Using an ASN.1 example with Basic Encoding rules, the basic length of the encoded message is **12 Octets.**

2.3.3. The Application Layer

The Application Layer is where things concerning users take place. This includes electronic mail, file transfers, remote login and directory services. The X.400 message handling system supports the old TELEX message system is also the subject of ISO 10021-Series standards.

3. ATN Applications Overview

With the different types of communications explained, the breakdown in message size and eventually costing becomes easier to “swallow”. The particular ISO protocols related to the ATN are as in Table 3-1. The 3 subnetworks use some of the same ISO protocols.
The following is a brief overview of the protocols used in the Air/Ground, Ground/Ground and Airborne environments (Table 2-2).

Protocol	Ground/Ground	Air/Ground	Airborne
TP4 with no optional parameter	in use	in use	--
TP4 with optional parameter	in use	in use	--
ISO - 8208	X.25	Satellite AVPAC / VDL	--
ISO 8648			
ISO - 8473	in use	in use	
ISO - 9542 (Routing Protocol)	--	Airborne & A/G router	Airborne & A/G router
ISO 8602 (CL)			
ISO 8073 (CO)			
ISO 10747	IDRP	--	--

Table 2-2 Protocols and environments

3.1. Ground/Ground Subnetworks

The costs incurred by a G/G subnetwork are normally calculated by a few variables:

- the number of successful calls;
- the amount of data transferred; and

- the time spent on a particular call.

These guidelines will be a basis for the total G/G message cost of the ATN. All monetary calculations should be based on some assumptions regarding how ATN applications will use the service offered by the ATN internetwork. The communications systems of concern with regards to ATN G/G communications are:

1. AFTN - World Wide Store and forward communications between ATS providers;
2. ARINC Data network service (ADNS);
3. SITA - large airline oriented packet switch network, migration to X.25 based Mega Transport Network; and
4. Airline Private Networks.

The AFTN and SITA networks are a widely used form of G/G communications. The G/G evaluation will be based on the basic X.25 service due to the fact that no specific options have been stated in the CNS/ATM package 1 SARPs. The size of typical messages for this system have been established and tested.

3.2 Air/Ground Subnetworks

The A/G communication system are difficult to analyze at this particular phase of the ATN. Many of the uses are still undergoing investigation and testing. However, the A/G capabilities that can be implemented due to their durability are:

1. Gatelink - for aircraft parked on the ground - (100Mbps, infrared or hard-wire);
2. HF - voice backup for oceanic aircraft - HF data link is being tested;
3. Satellite - (AMSS, VDL) voice and data available world wide;
4. SSR Mode S; and
5. VHF - voice in busy airspace - ACARS.

3.3 Airborne Subnetworks

The airborne subnetworks permit the transfer of data between applications inside the aircraft. The types of communications are:

1. ARINC 429
2. ARINC 629
3. ARINC 636
4. ARINC 646
5. ARINC 659

The protocols (network, transport, session and presentation) that control these communications systems will be discussed.

4. Summary

The following table will compile the results of the size of messages created by the protocol.

Protocol	total bytes
ISO - 8473 n/w	X
ISO 8648 n/w	X
ISO - 8208	X
TP4 with no optional parameter	X
TP4 with optional parameter	X
ISO 8602 (CL) trpt	X
ISO 8073 (CO) trpt	X
ISO - 9542 (Routing Protocol)	X
ISO 10747	X

5. Scenarios and Assumptions

The following are examples (as provided by SITA) for two different scenarios. Additional scenarios will be required to cover all aspects of ATN communications.

Examples

For all examples in this chapter we consider a one hour period for all calculations. And for each TPDU DT sent by transport layer, a TPDU AK is received.

Example 1:
We have a 3 minute connection every five minutes. Data are sent every 30 seconds and we suppose that the TSDU DT are shorter than 1024 bytes (TPDU DT sent by transport layer) so that all TSDU DT can be forwarded without segmentation.
In one hour, there are 12 connections and 6 TSDU DT received by the transport layer. With the TPDU size calculated in the previous section, we have two scenarios for this example, without optional fields or with all optional fields. As the data are sent during a long connection, we choose the normal format for TPDU-NR.

In this example:

The shortest overhead is 1380 bytes
The longest overhead is 4260 bytes (with all optional fields)

Example 2

We have a continuous connection. All other suppositions are identical with the first example, but because the connection is maintained for a long time, we assume that the extended format is used for the TPDU-NR

In this case, there are 120 TSDU DT received by the transport layer:

The shortest overhead is 2160 bytes
The longest overhead is 4800 bytes (with all optional fields)

6. Recommendations

1. It is requested that the meeting determine if the calculation of billable bits is a value added function provided to the States.

2. If this information is determined necessary, it is proposed that representatives provide the available information on:

a) Actual data size for the various ATN communications systems;
b) Possible costs for usage;
c) Information related to ongoing or recently completed tests; and
d) Miscellaneous information related to this topic.