AERONAUTICAL TELECOMMUNICATIONS NETWORK PANEL

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Transport/Application Frozen Reference Timing Problem

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Summary

Continuing ADS Trials work has raised a problem that requires either changes to ISO/EIC 8073 or in the ICS SARPs or further ICS GM. This paper explains the problem.

1. Summary

This is a specific example of a problem where all parties believe they are following the Transport layer specification (ISO 8073) but it is not possible to establish a CMA Connection. This was encountered during the ADS trials.

If there is a failure of one of the X.25 networks underlying the ATN, or of one of the interconnecting routers, communication between aircraft and the ground using ADS can, under certain conditions, enter a semi-permanent livelock state when the underlying service is restored. This has been traced to a failure of the implemented Transport protocol to restore the transport-level connection between the two systems.

Under these circumstances, the ground-based system remains convinced that the original transport connection was not broken, while the air-based system tries unsuccessfully to set up a new connection.

Whilst it appears that the ISO 8073 Transport protocol specification has not been followed exactly by the implementation (and this is being studied with a view to changing its behaviour under these circumstances), a number of alternative suggestions for solving the problem are also made.

2. Overview

In the ADS network, the communication between the aircraft end-system (ADSU) and the ground end-system (GS) uses Transport Class 4 protocol (ISO 8073) over connectionless network service (CLNS, ISO 8473). Although the network service makes use of underlying connection-oriented X.25 networks it is connectionless end-to-end. If a network error occurs in one of these underlying networks, the data integrity must be resolved by the Transport protocol.

The analysis below uses several timer-related definitions from ISO 8073, as follows:

Symbol	Name	Description	Value in ADS trials network
T1	Local retransmission time	The maximum time a transport process will wait for an acknowledgement before retransmitting a packet	100s
N	Max retransmissions	The number of times a packet will be retransmitted before giving up	3
L	Max round-trip delay	The longest an acknowledgement could possibly take to arrive following transmission unless an underlying network break has occurred. This is used to decide when to release frozen references.	Not known exactly, but > 300s and < 960s
I_L	Local inactivity time	Time after which a system will drop the connection if the other end sends no traffic	960s

3. Problem scenario

The diagram below represents the sequence of messages. The vertical axis is the time axis. The vertical line on the left represents the ADSU, and that on the right the GS. The shaded area in the centre represents the network; the black section is where the network service is unavailable. The arrowed lines between the end-systems are the messages themselves. Timers within the end-systems are shown by vertical arrowed lines. The numbers in circles are reference points, referred to in the following paragraphs.

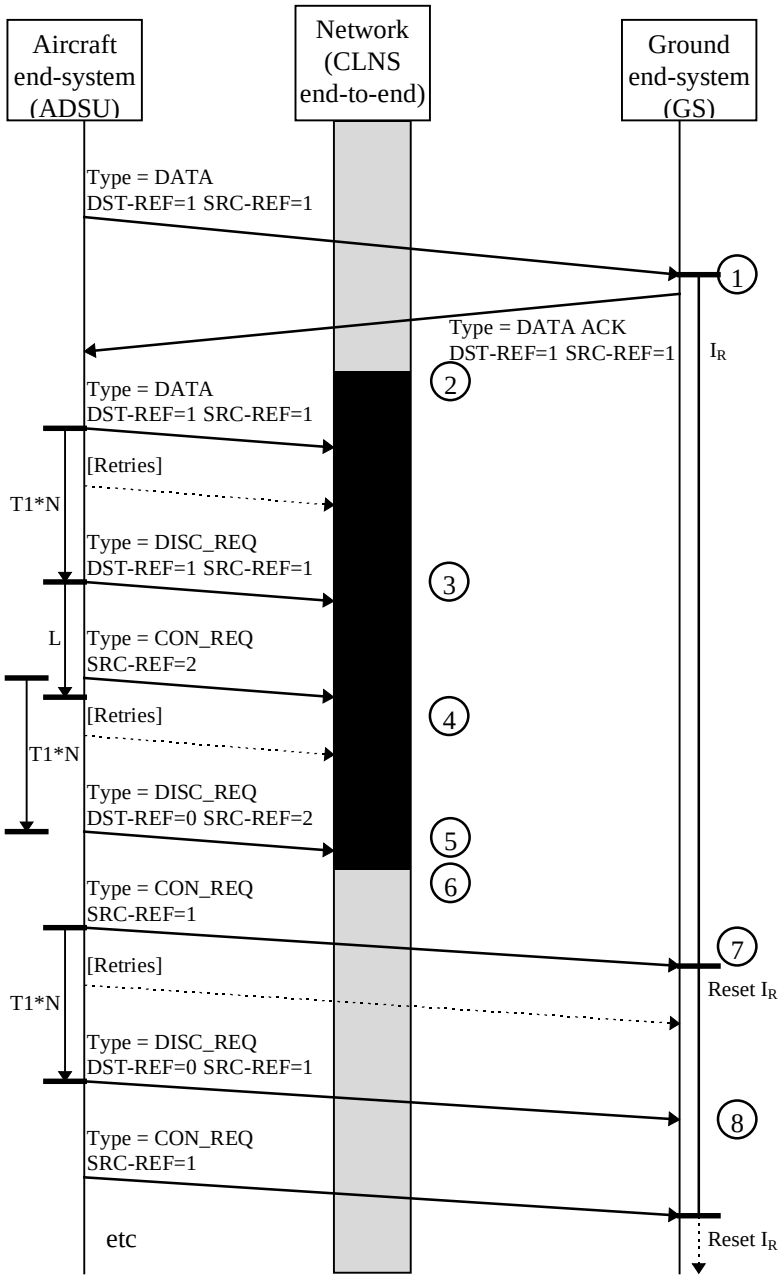
When this problem occurs, a Transport Connection already exists between the ADSU and the GS. The X25 connection disconnects for some reason at (2). The aircraft is the first to see this since it is usually the side with data to send. The ADSU retries the messages *N* times *T1* seconds apart, then disconnects the Transport connection at (3).

Because it still has data to send, the ADSU now attempts to re-establish a Transport connection with the GS, sending a Connection Request (CR) at (4). In doing this, it uses a new connection reference, sent in the SRC-REF field. This is because it is required to wait *L* seconds to re-use the previous reference (set to 1 in this example), so that it can be certain there are no messages in transit using the old value - ie. this reference is *frozen*.

However, the network remains unavailable, and by the time the CR has been retried and timed out at (5), the frozen reference has been released. Now a new CR is sent with the previous SRC-REF value of 1.

Meanwhile the GS has kept the original connection open, assuming that the ADSU simply had no data to send. It would close the connection when the Inactivity Timer I_L expires (16 min). However, the network recovers sooner than this, at (6). The next CR from the ADSU gets through to the GS. This CR carries the same ADSU SRC-REF as the previous Transport Connection. The GS discards the request because it refers to an existing connection, and resets its Inactivity Timer for that connection.

The ADSU goes through its retry sequence and then sends a Disconnection Request (DR) at (8), with the ADSU SRC-REF of 1 and a GS DST-REF of zero (because no Connect Confirm (CC) has been sent from the GS and therefore the value is unknown). The DR is ignored by the GS. This sequence from (6) to (8) is then continuously repeated until the ADSU decides to use a different SRC-REF or an X.25 break of greater than 16 minutes occurs.



4. Analysis

In most respects the Transport processes appear to be operating correctly to ISO 8073. However, it seems likely that it has been misinterpreted in one respect.

Section 6.7.2.4 of the standard describes the procedure for releasing connections when operating over CLNS. In sub-paragraph (c) it says that unless the process is waiting for a CC or a DC, it should send a DC and *consider the transport connection to be released.* It explicitly says that if the DST-REF of the DR is set to zero, this rule is also followed, and the SRC-REF of the DC is then set to zero.

The other section of ISO 8073 to consider is 6.9.2, which specifies how to match a received transport packet (TPDU) with a transport connection (meaning a SRC-REF/DST-REF pair). This section is not explicit on how to treat a DR with a zero-value DST_REF, but it does say

that the SRC_REF field must be used as well when a DR is received. Since the SRC_REF will be unique for a remote NSAP, knowledge of the SRC_REF value alone will be enough to positively identify the connection.

Four cases, (a) to (d), follow, none of which match this case, but they are introduced as following "inability to match the TPDU to an existing transport connection". Since there is no such inability if the previous paragraph is followed, this does not apply.

Therefore it is concluded that the behaviour of the GS is incorrect in not responding to the DR TPDU. It should reply with a DC, in which the SRC_REF is set to zero, as specified in section 6.7.2.4.

5. Conclusion

It is recommended that the ISO 8073 standard be re-examined with a view to the behaviour of the ADS end-system implementation being changed as described above.

Other options, which WG2 should consider, would include

- incrementing the Source Reference for each usage, rather than immediately re-using the reference (i.e. not using the lowest available). This is the best alternative to the recommended solution, since it has no direct effect on the operation of the protocol;

- Setting the local Frozen reference timer value to greater than the remote Inactivity timer. This would go against the intention in ISO 8073 and possibly cause problems in other areas;

- decreasing the value of I_L to no more than (*T1*N*). This would automatically be taken care of by additional ACK packets to make sure the connection was not dropped unintentionally. However, it would ultimately increase expense through extra network usage.
