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Mobile Subnetwork Connectivity Reporting Requirements for ICS Package-2

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Summary

The ICAO ADS Panel developed the operational requirements for the ATS data link applications concurrent with the ATNP WG2 development of the ICS SARPs (i.e., Sub-Volume V of Doc 9705). The ADSP has defined very stringent requirements for service availability and continuity of service that probably cannot be satisfied by early (i.e., Package 1) implementations due in part to lack of real-time reporting of mobile subnetwork connection status. This working paper proposes to modify Sub-Volume V to impose more explicit requirements on mobile subnetworks that to claim to support ATSC.

1. BACKGROUND

The ICAO ADS Panel developed the operational requirements for the ATS data link applications concurrent with the ATNP WG2 development of the ICS SARPs (i.e., Sub-Volume V of Doc 9705). The ADSP has defined very stringent requirements for service availability and continuity of service that probably cannot be satisfied by early (i.e., Package 1) implementations due in part to lack of real-time reporting of mobile subnetwork connection status.

2. DISCUSSION

2.1 The ICAO ADS Panel has produced an ICAO Manual of ATS Data Link Applications. In this document the operational requirements for the initial data link applications are defined. The following table and text are excerpted from this document.

Application	Availability	Integrity	Reliability	Continuity
DLIC	99.9%	10^{-6}	99.9%	99.9%
ADS	99.996%	10^{-7}	99.996%	99.996%
CPDLC	99.99%	10^{-7}	99.99%	99.99%
FIS	99.9%	10^{-6}	99.9%	99.9%
AIDC	99.996%	10^{-7}	99.9%	99.9%
ADS-B	99.996%	10^{-7}	99.996%	99.996%

Table 3A-2: Application Specific Performance Requirements

> "Except in catastrophic situations, no single end-to-end outage should exceed 30 seconds (end-to-End availability may be achieved through provision of alternate communications routings where feasible)."

It is important to note the very demanding requirements for continuity of service and service availability for the CPDLC and ADS (contract) applications. As noted in the accompanying text (above) the availability may be achieved through provision of alternate communications routing. Although not explicitly stated, this comment could also be applicable to the requirement for continuity of service.

2.2 In order for the ATN to offer an end-to-end service that satisfies the above stated operational requirements each BIS must have near real-time knowledge of the loss of connectivity over a given subnetwork. The consequence of not having such knowledge could be the forwarding of packets to a subnetwork that will discard the packets because it cannot provide the required connectivity. If such a condition were to persist for any significant period of time then the ability of the ATN ICS to satisfy the operational requirements for availability and continuity of service would be seriously compromised.

2.3 A review of the existing ICS requirements related to the technical mechanisms that will allow a BIS to gain knowledge of the status of mobile subnetwork connectivity has identified the following Doc 9705 Sub-Volume V provisions:

2.3.1 Section 5.2.5.1 defines requirements applicable to any (i.e., fixed or mobile) ATN subnetwork while para. 5.2.5.2 defines additional requirements specific to ATN mobile subnetworks. These provisions are generally of a functional nature and do not explicitly require mobile subnetworks to generate join and leave events. However para. 5.2.5.2.4.1 does require:

“An ATN Mobile Subnetwork shall provide a connection-mode service between SNPAs, with a well-defined start and end to a connection, and with a reliable, sequenced SNSDU transfer over that connection.”

Doc 9705 notes in para. 5.2.5.2.5:

“ATN Mobile Subnetworks may provide a mechanism for detection of change in media connectivity and for the conveyance of this information to connected ATN routers.”

Doc 9705 further requires in para. 5.2.5.2.5.1:

“If a Mobile Subnetwork provides subnetwork connectivity information, the subnetwork shall convey this information to connected subnetwork service users (i.e., connected ATN routers), in order to initiate operation of the internetwork protocols as specified in 5.3.”

Under Doc 9705 para. 5.3.5.2 (i.e., Air/Ground Route Initiation) there are additional requirements levied on mobile subnetworks related to use of Join Events. Specifically, para. 5.3.5.2.1.1 states

”BIS-BIS communications over a Mobile Subnetwork shall be either air-initiated or ground-initiated, with one of these two modes of operation selected for all instances of a given subnetwork type.

Note 1.— Three classes of procedures are distinguished by this specification. These are: (a) Air-Initiated i.e. when the Airborne Router initiates the procedure, (b) Ground-Initiated i.e. when the Air/Ground Router initiates the procedure, and (c) Air or Ground-Initiated i.e. when either the Airborne or the Air/Ground Router may initiate the procedure.

Note 2.— Two types of Mobile Subnetworks are also recognised by this specification. These are: (a) those which provide information on the availability of specific Mobile Systems on the subnetwork through the Join Event defined in this section, and (b) those which do not. The latter type are only appropriate to Route Initiation Procedures which are Air-Initiated.

Note 3.— For a given Mobile Subnetwork type, the use of air-initiated or ground-initiated procedures, and the implementation of Join Events is outside of the scope of this specification, and is a matter for the SARPs specified by the relevant ICAO panel.

Note 4.— The interfaces to all Mobile Subnetworks are assumed to be compatible with ISO/IEC 8208. The ISO/IEC 8208 term Data

Terminal Equipment (DTE) is also used in this specification to refer to a system attached to a Mobile Subnetwork."

Doc 9705 defines in para. 5.3.5.2.3.1 the "airborne router procedures for use of an ISO/IEC 8208 Mobile subnetwork that does not provide information on subnetwork connectivity." Doc 9705 then goes on to provide in para. 5.3.5.2.3.2 the "airborne router procedures for use with ISO/IEC 8208 Mobile Subnetwork that does provide connectivity information."

In the case where the mobile subnet does not provide a join event (either air or ground) the following alternative procedure is defined:

5.3.5.2.3.1.1.1 An Airborne Router's IS-SME shall be configured with a list of subnetwork addresses for each supported Mobile Subnetwork that does not provide information on subnetwork connectivity.

5.3.5.2.3.1.1.2 This list shall include the addresses which are necessary to meet the communication needs of the aircraft.

Note.— In the case of the AMSS, the Airborne Router's IS-SME will be configured with a list for each GES that the aircraft may use to communicate. Each such list will include the subnetwork addresses (e.g. DTE addresses) of the Air/Ground routers attached to the GES in question through which communications services may be required.

5.3.5.2.3.1.1.3 An Airborne Router's IS-SME shall continually issue a Call Request to each subnetwork address on each appropriate list with which it does not currently have a subnetwork connection and which is not subject to a back-off period (see 5.3.5.2.3.1.2), in turn.

5.3.5.2.3.1.1.4 The period between each successive Call Request shall be configurable to ensure that the Mobile Subnetwork is not rendered unavailable.

5.3.5.2.3.1.1.5 When a subnetwork connection is successfully established, then the procedures of 5.3.5.2.6 shall be applied to that subnetwork connection. The polling procedure shall continue for the remaining subnetwork addresses on the list, if any.

2.3.2 It can be concluded that Doc 9705 allows a subnetwork to alternatively::

a) generate a Join Event on the aircraft
b) generate a Join Event on the ground
c) generate a Join Event both on the aircraft and on the ground
d) use an alternative to providing support for Join Events

Alternatives a, b, and c will provide an equivalent capability to, in effect, trigger the exchange of routing information between the airborne and air-ground routers. Alternative (d) above however will not provide the equivalent level of service in that for the case of an AMSS subnetwork, the airborne router would need to have prior knowledge of every possible AMSS GES and could fail to establish connections with any new GES or GES with revised network addresses. Also the polling procedure defined as an alternative to the use of Join Events would introduce additional delays in establishment of new routes potentially resulting in reduced service availability and continuity. This could limit the ability of the overall communications service to satisfy the end-to-end requirements for service availability and continuity as established by the ADS Panel. Thus this alternative would be most appropriate for use within a very constrained environment, such as might be the case for operational trials with a static ground subnetwork topology.

2.3.3 Doc 9705 describes in para. 5.3.5.2.13 the requirements for "air/ground route termination." It is noted that there are the following two procedures by which a Leave Event can be generated:

> "The 'Leave Event' is defined to signal when subnetwork connectivity with a remote ATN Router over a Mobile Subnetwork ceases to be available. This event may be generated by (a) the subnetwork itself using mechanisms outside of the scope of this specification, or (b) the SNDCF when it receives a clear indication from the subnetwork reporting either a network or a user initiated call clearing. The Leave Event is always reported to the IS-SME."

Thus a mobile subnetwork using ISO/IEC 8208 protocol, such as AMSS, could either generate a leave event or clear the 8208 call when air/ground connectivity is lost.

Doc 9705 also defines the following additional mechanism to allow a router to detect the case where air/ground connectivity has in fact been lost, but the mobile subnet has neither issued a Leave Event nor cleared the subnetwork connection:

> "5.3.5.2.13.2 When a Mobile Subnetwork does not provide a network generated Clear Indication (e.g. to indicate that an aircraft has left the range of the Mobile Subnetwork, or when some other communication failure occurs, etc.), an ATN Router shall maintain a "watchdog" timer for each affected subnetwork connection and clear each such subnetwork connection once activity has ceased for a configurable period.
>
> 5.3.5.2.13.3 When such a "watchdog" timer expires, this shall be reported as a "Leave Event" for that subnetwork connection."

Note that the use of the watchdog timer mechanism can be considered a means of detecting a failure within the subnetwork, and is not to be considered as a primary means of monitoring the status of subnetwork connectivity.

2.3.4 Doc 9705 requires mobile subnetworks to either issue Leave Events or to clear subnetwork connections when that mobile subnetwork can no longer provide connectivity between the local and remote ATN routers (i.e., between the peer airborne and the air-ground routers). From the wording of para. 5.3.5.2.13.2 it appears the lack of either a leave event or the clearing of a connection is an error condition and not an acceptable normal mode of operation for a mobile subnetwork. Unlike the requirement for the Join Event, this requirement applies equally to both the ground and airborne cases. In order for both the airborne and the air-ground routers to be able to make a valid routing decision they must know when a mobile subnetwork can no longer provide connectivity to the peer router. Otherwise, the overall service availability and continuity will be compromised since this could result in the router continuing to send packets to a subnetwork that no longer provides the needed connectivity while there is in fact another subnetwork available that does offer the desired connectivity.

Thus mobile subnetworks are required to generate either a Leave Event or a 'call clear' (e.g. resulting in ISO 8208 a 'clear indication' at the router) to both the airborne and the air-ground routers. Of these two alternatives the use of Leave Events is preferred as it may result in a more timely update of the router's internal routing information data base.

However, Doc 9705 does not specify any latency requirement for how fast a mobile subnetwork must detect the loss of connectivity and either issue the Leave Event or clear the call. As a result mobile subnetwork implementations may not report the loss of connectivity within a meaningful period of time. This could result in a serious compromise to the quality of the overall ATN service.

2.4 The intent of the following ADSP requirement is ambiguous:

> *Except in catastrophic situations, no single end-to-end outage should exceed 30 seconds (end-to-End availability may be achieved through provision of alternate communications routings where feasible).*

If the above operational requirement were to be applied to each connection then only mobile subnetworks with very low transit delays could be used for ATSC. This could inherently rule out such mobile subnetworks as AMSS and HFDL from being used on the primary communications path. However, if the above operational requirement is intended to apply to the overall service from a given ATS facility, rather than on a connection-by-connection basis, then it may be achievable but may require an increased role for systems management.

3. RECOMMENDATIONS

It is recommended that WG2 develop changes to the Doc 9705 Sub-Volume V to place more meaningful requirements for the reporting of connectivity status for those mobile subnetworks claiming to support air traffic service communications (ATSC).

3.1 Specifically, mobile subnetworks supporting the ATSC traffic type would be required to:

a) issue Join Events to the air-ground BIS, to the airborne BIS or to both
b) issue a Join Event within a specified time limit after establishing connectivity between ground and airborne subnetwork elements (e.g., between subnetwork DCEs). See WG2/WP-485 for further discussion and recommendations on this topic.
c) issue Leave Events to both the air-ground BIS and to the airborne BIS
d) issue a Leave Event with a maximum latency dependent on the advertised ATSC traffic class for the cases shown in the following table. In this context latency is considered to be the time from when the subnetwork is no longer capable of transferring data packets over an existing connection until the time the Leave Event is actually issued.

ATSC Traffic Class	Max. Leave Event Latency in the Absence of Internet Traffic (seconds)	Max. Leave Event Latency in the Presence of Internet Traffic* (seconds)
A	reserved	reserved
B	27.0	18.0
C	43.2	28.8
D	81	54
E	108	72
F	162	108
G	300	240
H	600	400

* In this case the arrival of an data packet from a BIS may be the event that results in the mobile subnetwork detecting that subnetwork connectivity is no longer available.

Note - The above strawman values were arrived at by taking the 95% probability ATN end-to-end transit delays, as defined in Sub-Volume I, for each ATSC traffic class and using a multiplier of 6 for the case in the absence of internet traffic and a multiplier of 4 for the case were internet

traffic is present. In the former case this could result in a subnetwork requirement for internal keep-alive exchanges to monitor the status of the connection and in the latter case this could place requirements on internal acknowledgements and the number of retries before the Leave Event is issued. The maximum latency values shown would allow the opportunity for at least two delivery attempts by the subnetwork before declaring that the connection is lost.