INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA AND PACIFIC OFFICE

ASIA/PAC ATN ROUTING ARCHITECTURE

Second Edition – March 2004

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EXECUTIVE SUMMARY

This document provides technical guidance on the transition to the Aeronautical Telecommunication Network (ATN) for the ground-ground data communications in the ICAO ASIA/PAC Region.

The material presented here is technical in nature. The ATN Transition Plan includes information about the implementation of Regional ATN Routing Architecture as presented in this document.

The routing architecture is based upon the need for a ground-ground infrastructure to eventually replace the existing AFTN infrastructure. For this reason, the routing architecture uses the existing AFTN infrastructure as a guideline for the positioning of ATN equipment.

The routing architecture is designed primarily for the ground-ground environment. It is intended that this architecture will also be suitable as the routing architecture for the introduction of the air-ground communication requirements.

This document was adopted by 12th Meeting of APANPIRG held in 2001 for distribution to States in the ASIA/PAC and adjacent regions.

1. INTRODUCTION

This initial plan provides technical guidance on the routing architecture for the ASIA/PAC Region.

1.1 Terms used

Aeronautical Fixed Telecommunication Network (AFTN): a low-speed network providing the majority of ground-ground data communication services within the ICAO realm. This term is defined in ICAO Annex 10.

Boundary Intermediate Systems (BIS): a router that supports IDRP and routes PDUs to more than one routing domain. This term is defined in ICAO Doc. 9705.

Backbone Boundary Intermediate Systems (BBIS): a router that primarily routes PDUs between routing domains and does not support End Systems.

Note: This definition is similar to that found in ICAO Doc. 9705 and is meant to be consistent with that definition. This definition is made on the assumption that this version of the routing architecture is limited to the ground-ground infrastructure.

End Boundary Intermediate Systems (EBIS): a router that primarily routes PDUs between routing domains and connected End Systems.

End Systems (ES): an ATN system that supports one or more applications and that is a source and/or destination for PDUs.

Inter Regional Boundary Intermediate Systems (IRBIS)*:* a router that routes PDUs between systems (both End Systems and Boundary Intermediate Systems) within the Region with routers outside of the Region. These routers are the entry points into the Region and exit points from the Region for PDUs.

***Network Service Access Point (NSAP)* address**: a 20 octet value that uniquely identifies an interface between the Transport Layer and the Network Layer. In the ATN it provides the address of transport entity providing ATN Internet services.

1.2 Acronyms used

AFTN	-	Aeronautical Fixed Telecommunication Network
BIS	-	Boundary Intermediate Systems
BBIS	-	Backbone Boundary Intermediate Systems
CLNP	-	Connectionless Network Protocol
EBIS	-	End Boundary Intermediate Systems
ES	-	End System
IDRP	-	Inter-Domain Routing Protocol
IS	-	Intermediate System
PDU	-	Protocol Data Unit

2. ROUTING DOMAIN FUNDAMENTALS

The ATN consists of a set of End-Systems (ESs) and a set of Intermediate Systems (ISs). ESs are the source and destination of all data and are where the applications reside. ISs are better known as routers and relay PDUs from one system to another.

The ISs and ESs are organized into *Routing Domains*. Routing Domains are used to define sets of systems (that typically operate together) into clusters. These clusters have two major properties:

- they are controlled by a single organization, and
- a significant amount of the traffic is internal to the cluster.

The single most important characteristic is that they are controlled by a single organization. This characteristic is manifested in technical terms by mutual trust between all routers in a routing domain. Routing protocols are based on the fact that the information exchanged between *intra*-domain routers can be trusted. No special reliability or trust is required to accept information about advertised routes.

The second characteristic, most traffic is internal to a routing domain, is more an artifact of proper network engineering. Routing domains are established through the NSAP addressing conventions established for the ATN in Doc. 9705, Sub-Volume 5. All systems with NSAP addresses defined with the same address prefix are by definition in the same routing domain.

2.1 Intra-Domain Routing

Intra-domain routing is the routing of PDUs from the source to destination where both are in the same domain. Intra-domain routing implies one or more ISs capable of routing PDUs across the domain. Examples of intra-domain routing would be CLNP-capable routers exchanging PDUs between two Local Area Networks.

Since the ATN is specified across State boundaries, there are no SARPs developed for intra-domain routing. The choice and configuration of internal routers is a local matter.

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2.2 Inter-Domain Routing

The central definition of routing in the ATN is concerned with inter-domain routing. This is a particularly difficult problem since by the very nature of inter-domain routing, the information received cannot be fully trusted.

Inter-domain routing is based upon the mutual distrust of the received routing information. First, reliability mechanisms must be built-in to ensure the reliable transfer of the information. Second, the received information must be filtered to ensure that it meets the suitability constraints of the received system (in other words, can it be believed.)

After receiving the routing information, the inter-domain router must build routing tables based upon its internal policy about routing its data.

2.3 Types of Routing Domains

There are two basic types of routing domains: end routing domains, and transit routing domains. An end routing domain routes PDUs to and from end-systems within its routing domain. Figure 1 shows an end routing domain.

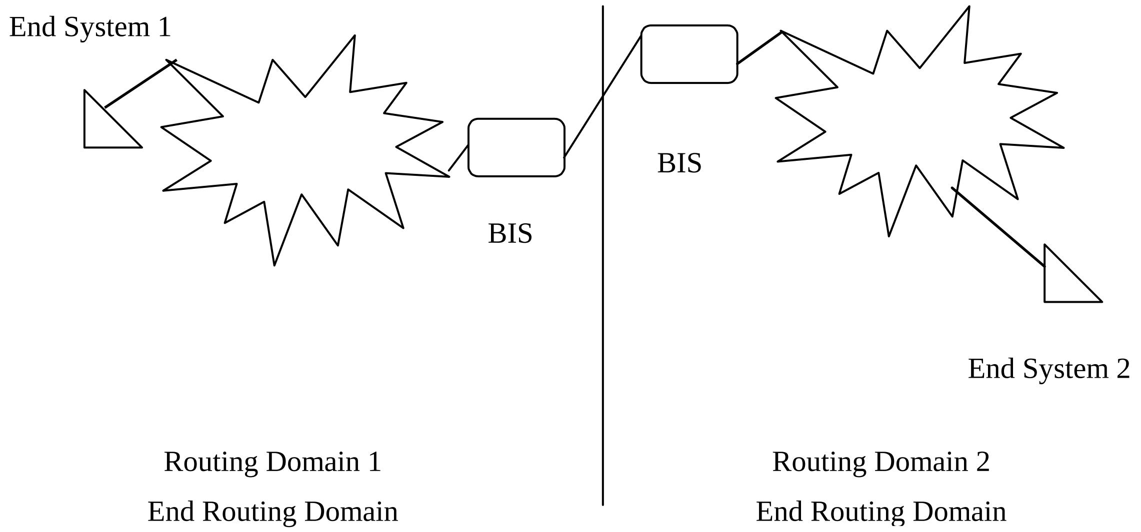

Figure 1 – End Routing Domains

A transit routing domain routes PDUs between two or more routing domains, and may as an option also act as an end routing domain. An example of a transit domain is where a set of backbone routers is configured in their own routing domain with all of the end systems in end routing domains attached to the backbone.

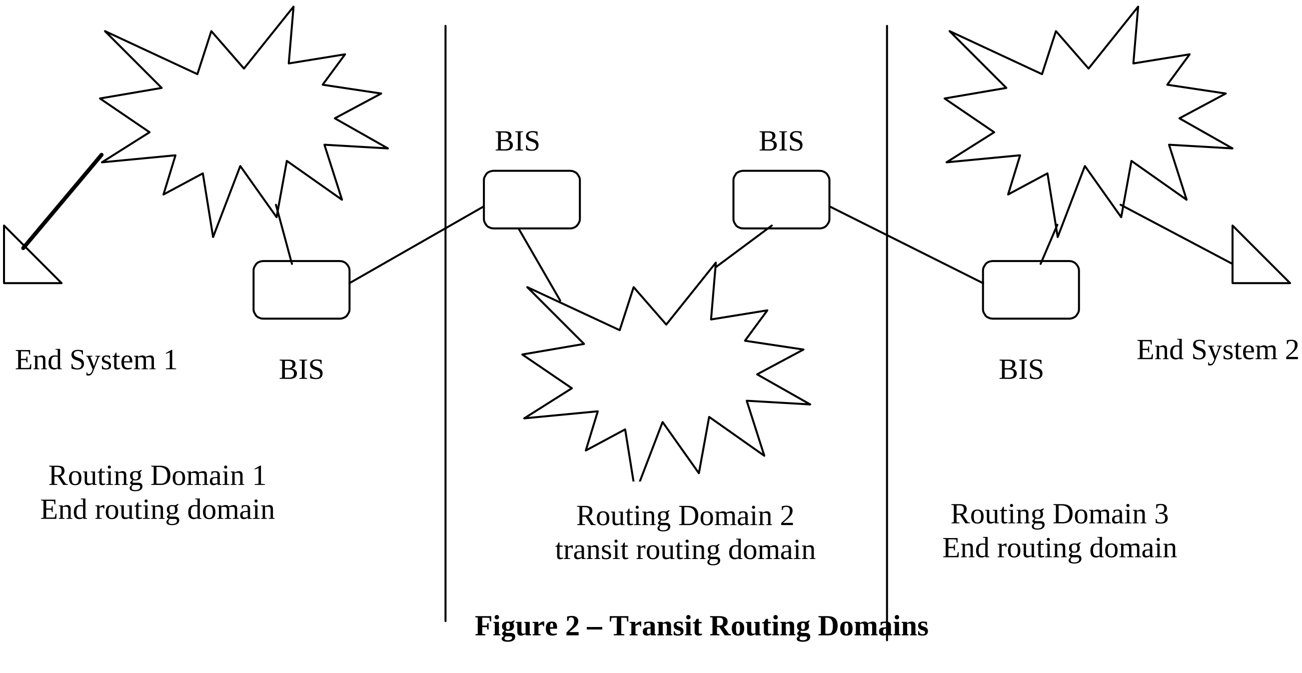

Figure 2 – Transit Routing Domains

Note: A transit routing domain may or may not be part of the backbone. That is, a transit routing domain may consist of BISs none of which are backbone routers.

2.4 Routing Domain Construction

Based on the above, a routing domain consists of at least one inter-domain router.

Note: There must be at least one BIS. There is no requirement for any other equipment.

Routing domains are elements of the physical structure of the ATN.

3. ROUTER FUNDAMENTALS

All routers discussed within this document are ICAO Doc. 9705 compliant Boundary Intermediate Systems (BISs).

Note: Individual States may elect to use other routers that do not comply with the ATN IDRP requirements as found in ICAO Doc. 9705 within the limits of their own States. These router are internal State issues and outside the scope of this document.

3.1 Boundary Intermediate System Overview

Boundary Intermediate Systems comprise the interfaces between networks, and in particular, between different routing domains. The term “Boundary Intermediate System” can often be replaced with the more common term “router”.

An important consideration in developing the routing architecture is the different roles that routers take within the ATN environment.

3.2 Router Types

There will be two primary types of BISs employed within the Region:

- Backbone BISs (BBISs), and
- End BISs (EBISs).

Note: A third type of BIS is supported within this routing architecture but since its use is subject primarily to bi-lateral agreements between States and Organizations, it is not fully described here. This third type of BIS is non-BBIS that acts as a transit router between two RDs but is not part of the Regional backbone.

3.2.1 Backbone BISs

A BBIS is a router that primarily routes PDUs between routing domains. These routers are typically higher performance routers that aid in the efficient flow of data between domains. BBISs may have End-Systems connected to them, but often are limited to only router-to-router connections.

Within the context of the ASIA/PAC, BBISs can be further subdivided into Regional BBISs, and Inter-Regional BBISs. Regional BBISs are backbone routers that only connect to routers within the Region. Inter-regional Backbone BBISs are those backbone routers that connect to BBISs in other Regions.

Note: A single, high-performance router may act as both a Regional BBIS and an Inter-Regional BBIS based upon meeting the requirements for performance and reliability.

Note: For completeness of the routing architecture, it must be mentioned that the routers out-side of the Region to which Inter-Regional Backbone BISs attach are, in fact, Inter-Regional Backbone BISs in the other Region.

Note: The interconnections of backbone BISs typically require higher capacity communication lines based on the consolidation of traffic through those backbone routers. Even though the architecture takes into account existing AFTN infrastructure facilities, the need to upgrade the communication facilities as traffic through the backbone increases may be necessary.

Note: It is possible for some States to provide transit routing from its routing domain(s) to the routing domains of other States using BISs that are not backbone routers. For the purposes of this routing architecture, it is not possible to distinguish between these transit routing domain routers and BBISs.

3.2.2 End BISs

End BISs are connected to one or more BBISs and provide routing services to a single routing domain. Further, End BISs do not act as a transit router for passing PDUs between other routing domains.

4. ASIA/PAC ROUTING ARCHITECTURE

The ASIA/PAC routing architecture is based upon several concepts:

1. From a routing domain point of view, the Region can be considered an “autonomous” area, that is, there is a difference between routers located within the Region and outside the Region.

2. Routing domains and confederations of routing domains may be applied to areas within the Region.

3. States will make their own implementation and transition decisions.

The routing architecture can be divided into several distinct parts:

- the definition of the backbone routing structure for passing information between routing domains within the Region;
- the definition of the routing structure between routing domains not on the backbone;
- the definition of the routing structure for use in end-routing domains; and
- the definition of the routing structure for passing information from this Region to other Regions.

The first component is the definition of the backbone routing structure that supports the exchange of data within the Region. This part defines the interconnection of the major communication facilities in the Region and how they cooperate to link all of the systems in the Region.

The second component is the definition of the structure that allows end routing domains to exchange data across the backbone to another end routing domain. This part defines how the end routing domains connect through the backbone.

The third component defines the routing structure that is used within an end routing domain. This part defines how the individual routing domains may be used to pass data.

The fourth part is needed to define how data will be routed between the systems within the Region with those systems outside the Region. More importantly, the structure describes how all global ATN systems are accessible from systems in the Region.

4.1 ASIA/PAC Backbone

The definition of a Regional Backbone is based upon the efficiencies that may be realized by concentrating ATN traffic at major communication centers and using the economy of scale in passing this information between major communication centers.

The rationale for defining Regional Backbone sites is based upon existing major AFTN center sites and on the flow of both AFTN traffic and possible future air-ground ATN traffic.

The ASIA/PAC is comprised of a large number of countries spread over a wide geographic area. Within the Region there are existing main AFTN communication centers that can be used to simplify the definition of backbone architecture.

However, it must be understood that the expected growth in communication traffic over the ATN could quickly exceed the capabilities of the existing communication infrastructure. Planning for the increased traffic loads will be needed as soon as ATN traffic begins to flow.

The architecture and communication requirements define a routing plan that incorporates alternate routing and communication paths so that no single router or communication failure can isolate major parts of the Region.

The eighth (8) BBIS sites defined in Table 4.1-1 are based on the expected traffic flows. A current AFTN centre site identified as a potential backbone router site. This site is listed first and in bold text as follows:

ATN Backbone router site	State
1	JAPAN (Tokyo)
2	CHINA (Beijing)
3	HONG KONG, CHINA (Hong Kong)
4	SINGAPORE
5	THAILAND (Bangkok)
6	INDIA (Mumbai)
7	AUSTRALIA (Brisbane)
8	FIJI (Nadi)

Table 4.1-1 – Definition of ASIA/PACal Backbone Sites

At each ATN Backbone router site, there should be at least one BBIS. States committing to operate backbone routers are presented in the table above.

4.1.1 ASIA/PAC Backbone

Summarizing the information presented above, the ASIA/PAC Backbone network will consist of at least one BBIS router at each of the backbone sites identified above. Examples of locations for these routers are:

Bangkok, Beijing, Brisbane, Hong Kong, Nadi, Singapore and Tokyo. The actual location of the routers will be based upon implementation schedules and the choices of States.

4.1.2 ASIA/PAC Backbone Router Requirements

The definition of BBIS and the location of these routers may be affected by the requirements for backbone routers. A backbone router must meet several performance and reliability requirements:

- Availability;
- Reliability;
- Capacity; and
- Alternative routing

4.1.2.1 Availability

A backbone router must provide a high-level of availability (24 hours a day, 7 days a week.)

4.1.2.2 Reliability

A backbone router must be a very reliable system that may require either redundant hardware or more than one router per site.

4.1.2.3 Capacity

As a communication concentrator site, backbone routers must be capable of supporting significantly more traffic than other ATN routers.

4.1.2.4 Alternative Routing

Based upon the need for continuity of service, backbone routers will require multiple communication links with a minimum of two and preferably three or more other backbone routers to guarantee alternate routing paths in case of link or router failure.

4.1.3 Routing Policies

States providing Regional BBISs must be capable of supporting routing policies that allow for Regional transit traffic and for dynamic re-routing of traffic based upon loading or link/router failures.

4.2 Inter-Regional Backbone

The second component of the ASIA/PAC Routing Architecture is the definition and potential location of Inter-Regional Backbone Routers. The manner in which this architecture was developed was to ensure that the use of the existing communication infrastructure is possible to the greatest degree. The use of the existing communication infrastructure should reduce the overall cost of transitioning to the ATN.

To re-state from the previous section, the Inter-Regional BBISs provide communication from routers within the ASIA/PAC to routers in other regions. These Inter-Regional BBISs provide vital communications across regions and therefore need to have redundant communication paths and high availability. (Note: This can be accomplished through multiple routers at different locations.)

Based upon the current AFTN circuit environment, the following States have been identified as potential sites for Inter-Regional BBISs. The States currently have circuits with States outside of the ASIA/PAC are found in Table 4.2-1 below.

State	Region
Australia	Africa, North America, South America
China	Europe
Fiji	North America
India	Africa, Middle East
Japan	Europe, North America
Singapore	Europe, Middle East
Thailand	Europe

Table 4.2-1 States with Circuits to Other ICAO Inter-Regional Backbone

For the transition to the ATN, connectivity to the other Regions should be a priority. This is especially important as other Regions begin the transition to the ATN and begin deploying ATN BISs.

4.2.1 Long Term Implementation

Note: Information is needed on States Plan in implementing ATN.

The transition to a fully implemented ATN requires that connectivity amongst the IACO Regions be robust. That is, there is the need to ensure alternate paths and reliable communication. Table 4.2-1 presents a minimal Inter-Regional Backbone that provides a minimum of 2 circuits to other ICAO Regions that communicate directly with the ASIA/PAC. For the long-term implementation of ATN, it would be advisable to have 3 circuits to each Region. The addition of circuits to Africa and Middle East should be considered.

4.2.2 Initial Implementation

Note: Information is needed on States Plan in implementing ATN.

The initial implementation of the ATN, outside of the ASIA/PAC, will most likely be in North America and Europe. Therefore, initial transition planning may focus on those locations.

For connecting to North America, there should be a minimum of two (2) Inter-Regional BBISs. The location of these Inter-Regional BBISs may be located at the centres where the AFTN centres are already existing. For example, the following locations would be candidates for such routers:

Tokyo (RJAA), and Brisbane (YBBB).

Note: The locations presented above are examples of possible router sites. The selection of actual locations will be based on implementation schedules and circuit availabilities.

Note: For additional reliability, a third Inter-Regional BBIS would be preferred. The location of this router may be Nandi (based on current AFTN routing) or some other circuit connection to North America may be used.

For connecting to Africa or the Middle East, an Inter-Regional BBISs may be located at the location of the existing AFTN centre, Mumbai. However, this router would not be needed until such time as ATN traffic is destined for that Region and the location of the router would be determined at that time.

One Inter-Regional BBIS (for example, one located at RJAA) should serve as a routing gateway to the North American Region.

A second Inter-Regional BBIS (for example, one located at YBBB) should serve as a routing gateway to the North American Region.

Note: Future work is still required for the definition of policy descriptions for the backbone architecture.

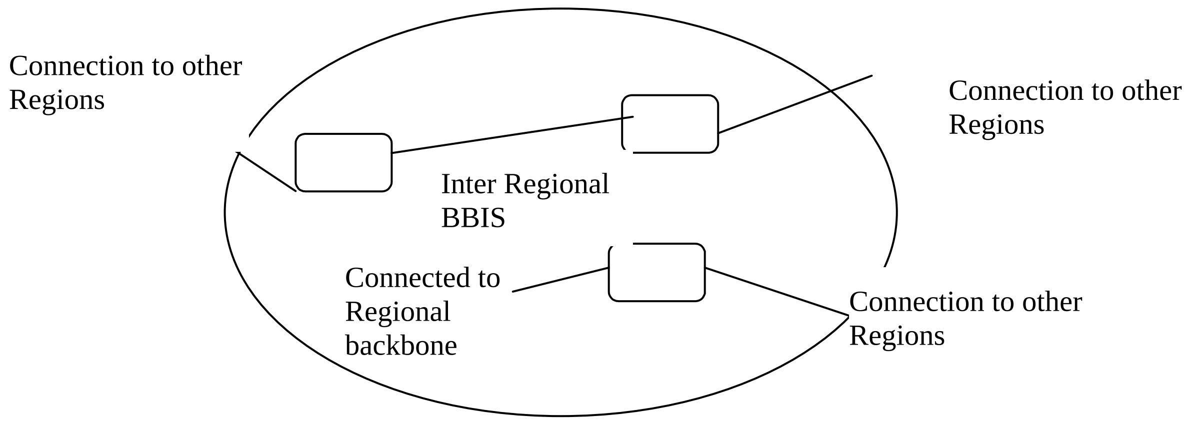

Figure 3 – Inter-Regional Backbone Routers

4.2.3 Transition Issues

The transition issues relating to the regional routing architecture is found in the ATN Transition Plan,

4.3 End BISs

It is assumed that naming and addressing (and routing domain definition) will be done on a Regional basis. Further, that for areas within the Region that may utilize an End BIS serving more than one State, the naming structure will be based on the Regional NSAP format defined in Doc. 9705. Further, States may choose to either implement the Regional (or Sub-Regional) NSAP format or the State NSAP format based on whether it installs a BIS.

5. ROUTING DOMAINS

Each State is expected to have one or more routing domains. Where a State chooses not to implement an ATN BIS, it may choose to incorporate its systems into a routing domain of another State.

The ASIA/PAC ATN Backbone will consist of routers from the selected States. Each of these routers will be part of its State's routing domain. Note: This means that the backbone will not be configured with its own routing domain. Routing to the backbone and between backbone routers will be controlled through IDRP routing policies.

Each State will be responsible for the designation of routing policies for its End Systems and End BISs. Individual States will also be responsible for establishing routing policies for routing to its designated BBIS.

The use of routing confederations is for further study.

6. ATN TRANSITION

Based upon the previous sections, the implementation of the ATN within the ASIA/PAC may require considerable planning for the transition of the AFTN.

6.1 Initial Regional Implementations

The very beginning of ATN implementation will be bilateral testing between States. For this scenario, each State will need at a minimum:

- an ATN router,
- a means for managing the router,
- an ATN application, and
- a circuit connecting the States.

States involved in bilateral ATN trials should consider the use of the trial infrastructure in expanding the ATN throughout the Region.