ASIA/PAC
ATN IDRP Routing Policy
Version 3.1

SUMMARY

This paper is the version 3.1 of the ATN IDRP Routing Policy for the Asia and Pacific region. It maintains the approach developed at the ATNICG/2 meeting in Hong Kong in May 2007. This document however defines a combined ASIA/PAC regional prefix rather than a combined ASIA/PAC/NAM region.

September 2009

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4.1.3 Route Distribution Policies for Routes to Airborne Systems 20Executive Summary

This document provides global policy for Aeronautical Telecommunication Network (ATN) routers operating in the Asia and Pacific Region in support of Air Traffic Services Message Handling Services (ATSMHS) and other ATN services.

Background

The ATN Transition Task Force (ATNTTF) has been assigned a number of tasks to prepare the region for the introduction of the ATN. At the third meeting of the ATNTTF Working Group B meeting held in Bangkok, Thailand on 27 through 30 August 2001, a specific action item was identified to develop documentation on Routing Policy. This document is in response to that action.

Overview

This document presents relevant background information on routing and provides a general discussion of policy-based routing. With this background, policy for routing to ground systems is specified for ATN ground-ground routers in support of inter-regional, intra-regional and local connectivity. This document additionally provides a set of recommended policies for routing to airborne systems. These policies are subject to further development in future versions of this document as the Asia/Pacific ATN Routing architecture evolves to include air-ground routers.

1. INTRODUCTION

The Aeronautical Telecommunication Network Transition Task Force is preparing a series of documents which will govern the introduction of the ATN into the Asia and Pacific region. This document is to be the basis of ATN routing policy for the region.

1.1 OBJECTIVES

The objective of this document is to specify global policy for Aeronautical Telecommunication Network (ATN) routers operating in the Asia and Pacific Region in support of Traffic Service Communications (ATSC) and Aeronautical Industry Service Communications (AINSC).

1.2 SCOPE

The scope of the document includes:

- An introduction to relevant routing concepts;
- An overview of the Inter-domain Routing Protocol (IDRP) and the rational for its use in the ATN
- Routing policy requirements for ATN routers in the Asia and Pacific Region.

1.3 REFERENCES

Reference 1 Manual of Technical Provisions for the ATN (ICAO Doc 9705-AN/956)

Reference 2 Asia/Pacific ATN Routing Architecture

Reference 3 ISO/IEC TR 9575, Information technology – Telecommunications and information exchange between systems – OSI Routeing Framework

Reference 4 ISO/IEC 10747, Information technology – Telecommunications and information exchange between systems – Protocol for Exchange of Inter-domain routeing Information among Intermediate Systems to Support Forwarding of ISO 8473 PDUs.

Reference 5 Asia/Pacific ATN Addressing Plan

1.4 TERMS USED

Backbone Router – A backbone router (in the Asia and Pacific region) is a Class 4 Ground/Ground ATN router which has been designated by the operating state/organization to provide an appropriate level of performance and support the routing policies for inter-regional and intra-regional connectivity, and whose operation as a backbone router has been approved by the ICAO regional office as agreed-to by all other member states/organizations.

***Network Addressing Domain* –** A subset of the global addressing domain consisting of all the NSAP addresses allocated by one or more addressing authorities.

***Network Entity (NE)* –** A functional portion of an internetwork router or host computer that is responsible for the operation of internetwork data transfer, routing information exchange and network layer management protocols.

***Network Entity Title (NET)* –** The global address of a network entity.

***Network Service Access Point (NSAP)* –** Point within the ISO protocol architecture at which global end users may be uniquely addressed on an end-to-end basis.

***Network Service Access Point (NSAP) Address* –** A hierarchically organized global address, supporting international, geographical and telephony-oriented formats by way of an address format identifier located within the protocol header. Although the top level of the NSAP address hierarchy is internationally administered by ISO, subordinate address domains are administered by appropriate local organizations.

***NSAP Address Prefix* –** A portion of the NSAP Address used to identify groups of systems that reside in a given routing domain or confederation. An NSAP prefix may have a length that is either smaller than or the same size as the base NSAP Address.

***Routing Domain (RD)* –** A set of End Systems and Intermediate Systems that operate the same routing policy and that are wholly contained within a single administrative domain.

***Routing Domain Confederation (RDC)* –** A set of routing domains and/or routing domain confederations that have agreed to join together. The formation of a routing domain confederation is done by private arrangement between its members without any need for global coordination.

1.4 ROUTING CONCEPTS

In this document the primary concern is routing through the ATN at the network layer. In order to establish a common framework, certain fundamental concepts are described. See Reference 3 for more detailed information.

The routing process in any network involves a forwarding function and a route maintenance function. Forwarding refers to those actions which result in the actual relaying of network protocol data units (NPDUs) through nodes in the network. From a simplified perspective, forwarding is the process of accepting an incoming NPDU, accessing a routing database to determine the next network node or locally attached system, and sending the NDPU on to that node or system. Route maintenance refers to the update of the routing database. Route maintenance may be static, in which case it is performed through management operations in either an on-line or off-line mode, or it may be dynamic (also known as adaptive routing). Dynamic route maintenance involves the exchange of routing protocol data units (RPDUs). RPDUs may be received from a single source such as a Network Control Center, in which case routing is said to be centralized. Alternatively, RPDUs may be exchanged among the nodes in a network, in which case routing is said to be distributed. See Figure 2-1. In the ATN a distributed adaptive routing procedure is adopted.

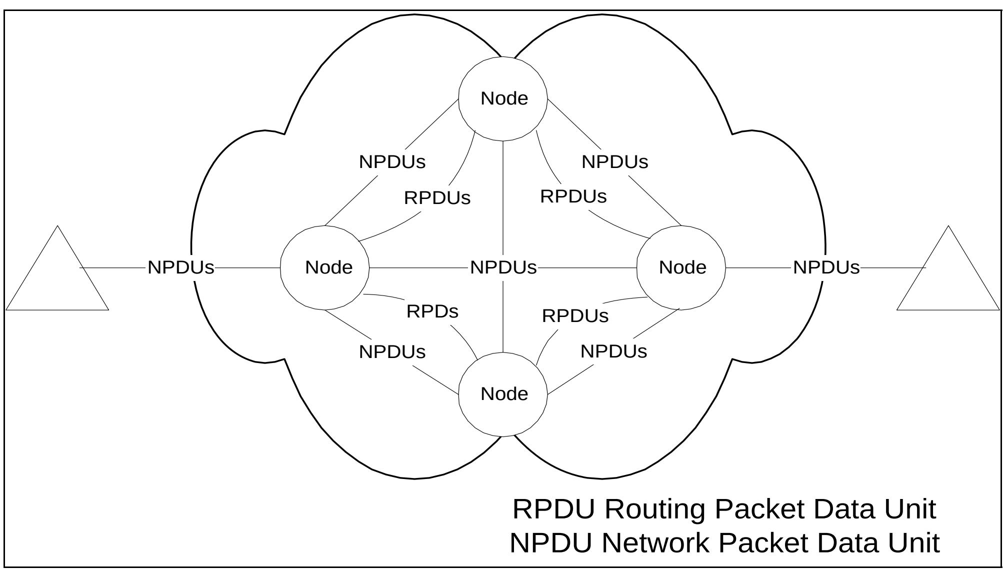

Figure 2-1. Exchange of NPDUs and RPDUs in Generic Network Environment

The route maintenance and forwarding functions under a distributed adaptive routing procedure are depicted generically in Figure 2-2. The routing database is partitioned into a Routing Information Base (RIB), which is the primary concern of the Route Maintenance Function, and a Forwarding Information Base (FIB), which is the primary concern of the Forwarding Function. The Route Maintenance and Forwarding Functions are conceptually connected through a Decision Process. The Decision Process determines:

1. Which routes are accepted into the Routing Information Base,
2. Which routes are placed into the Forwarding Information Base in support of the forwarding function, and
3. Which routes are to be advertised to other nodes in the network.

As will be described in more detail below, the decision process is affected by policy.

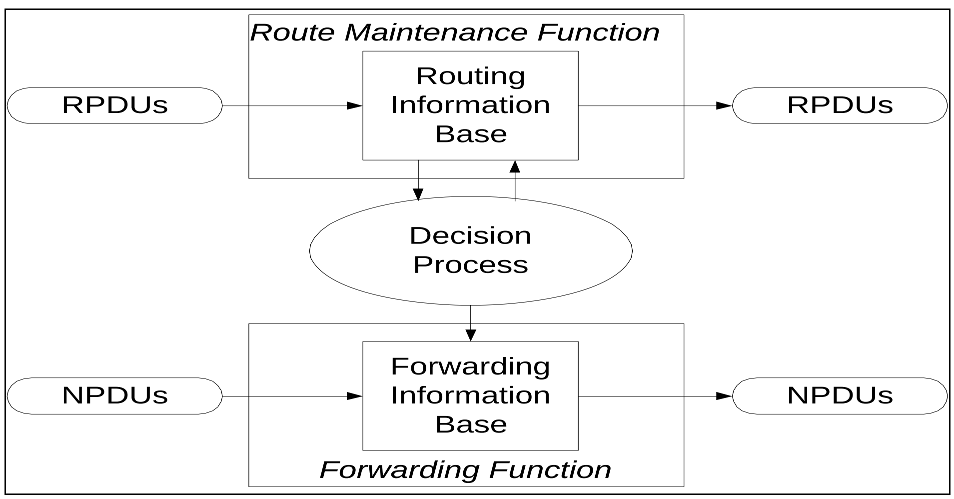

Figure 2-2 Generic Routing Functions

1.5 INTER-DOMAIN ROUTING PROTOCOL (IDRP)

In this section the rational for the use of IDRP in the ATN is summarized. The three general reasons for using IDRP are support for mobility, support for policy-based routing, and support for the secure exchange of routing information.

1.5.1 SUPPORT FOR MOBILITY

A fundamental objective of the ATN is to maintain connectivity from ground-based ATSC and AINSC end systems to their airborne counterparts. This is to be accomplished over multiple subnetworks; that is, over the various VHF Digital Links, over Mode S and over AMSS (Aeronautical Mobile Satellite Service). This objective is essentially a routing problem. If we consider the general approaches to routing, it is immediately obvious that static routing would not work. This is because routes to an aircraft are inherently dynamic; that is, aircraft traverse multiple subnetworks and within each subnetwork they traverse multiple ground stations. Thus we are left with some type of adaptive routing. A centralized approach to adaptive routing has the problem that the central control center where changes would be reported becomes a bottleneck, especially in a global environment. Even if enough capacity could be provided, there are associated timing considerations; that is, a reported change in an aircraft's location must be available to communicating ground systems in real time. There are also administrative considerations with centralized adaptive routing. These considerations include determining which administration (a particular Civil Aviation Authority (CAA), service provider, etc.) would operate the central control center and what the liabilities associated with such an operation would be. Accordingly, since neither static routing nor centralized adaptive routing would be appropriate, we are led to some type of distributed adaptive routing approach as the solution to mobility.

There are two general approaches to distributed adaptive routing. The first is called *link state* routing and the second is called *distance vector* routing. Under link state routing, each change in the network topology (in connectivity to an aircraft in the context of support for mobility) is broadcast to every other node in the network. Upon receipt of each change message, each node updates its image of the network topology and calculates the complete (shortest) path to the destination in the change message. The main problem with this approach is that the number of messages required to report changes in network topology becomes quite large in a global environment. Thus we arrive at a distance vector approach to distributed adaptive routing approach in the ATN. Under distance vector routing, a change in connectivity is propagated (i.e., advertised) to affected ATN routers throughout the network. The RPDU consists of a vector containing a destination prefix and a distance metric, which is generically a measure of the cost associated with the path being advertised to a particular destination.[1] The difference

[1] In the context of the OSI Routeing Framework (Reference 3) IDRP would be classified as a distance vector routing protocol. However, in the technical literature, IDRP is often called *path vector* routing protocol. This is because IDRP can advertise multiple metrics called path attributes associated with a

however (from link state routing) is that not all routers need be affected. In other words, not every router needs to know about every change. Particular changes need only be propagated to a point where a choice of routes is to be made. Beyond that point either an aggregate route may be advertised to other routers or these routers may be configured with a default path to that point. For example, a service provider with a ground-ground router connected to a CAA's ATN router on one side and with connections to multiple service provider air-ground routers on the other side may not need to advertise a new route each time an aircraft connects to a new air-ground router. The service provider ground-ground router may rather only advertise an aggregate route to the ATN router when the aircraft connects with the first air-ground router and withdraw the aggregate route when the aircraft is no longer connected to any air-ground router. At the same time, non-backbone routers belonging to the CAA need not receive routes to individual aircraft but rather may be configured to forward all aircraft NPDUs to the backbone router.

1.5.2 SUPPORT FOR POLICY-BASED ROUTING

1.5.2.1 IDRP Model of Operation

ATN routers execute a particular distributed adaptive routing protocol for route maintenance. The protocol is called IDRP, which stands for Inter-domain Routing Protocol (Reference 4). Figure 2-3 depicts a simplified model of IDRP route maintenance and CLNP forwarding.[2]

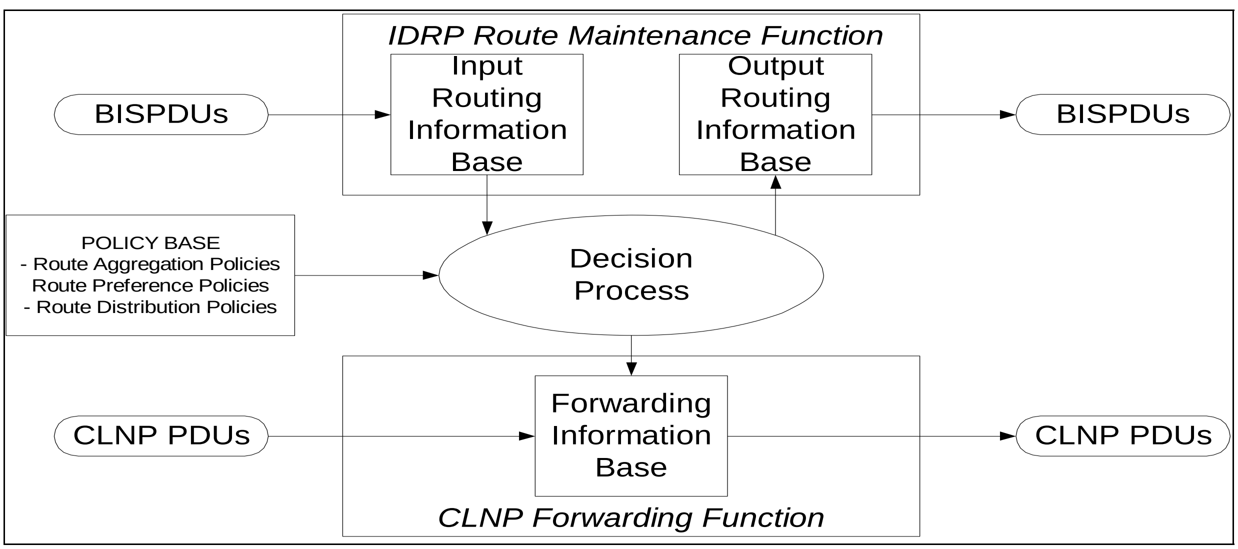

Figure 2-3. IDRP Route Maintenance and CLNP Forwarding

particular route to a destination rather than a single distance metric.

[2] The model of routing components in this document is a simplified form of the IDRP model. The IDRP specification (Reference 4) contains a more detailed model involving the concept of a multiple local RIBs for combinations of path attributes.

In the context of IDRP, an ATN router is a Boundary Intermediate System (BIS), and accordingly the routing PDUs exchanged are called BISPDUs. Similarly, in the context of CLNP (Connectionless Network Protocol: the network protocol used by ATN), the forwarded NPDUs are called CLNP PDUs. As depicted in the figure and described in the following section, the IDRP decision process is conditioned by a policy base.

1.5.2.2 Types of Policy

The IDRP decision process (and thus ATN routing policy) is conditioned by three types of policy concerns.

- *Route Aggregation* policies permit ATN routers to reduce the amount of routing information propagated throughout the ATN.
- *Route Preference* policies determine which routes received in BISBPUs will be installed in the Forwarding Information Base. Route preference policies thus determine which path an ATN router will select to forward CLNP NPDUs on.
- *Route Distribution* policies determine which routes an ATN router will advertise to other ATN routers. Route distribution policies are a key aspect of a domain's transit policy in that they determine which routes will be permitted in a domain. An ATN router will not propagate a route, which it does not wish to support. By selective advertisement of routing information ATN routers control the use of their own resources since other routers cannot choose a route they do not know about.

1.5.3 SUPPORT FOR SECURE EXCHANGE OF ROUTING INFORMATION

A final general advantage of using IDRP in the ATN is that it has a mechanism for the secure exchange of routing information. The mechanism takes advantage of a transport protocol built in to IDRP operation. When an IDRP connection is established (through the exchange of OPEN BISPDUs), the type of security to be applied to subsequent BISPDUs is signaled. In Edition 3 of ICAO Doc. 9705, procedures for performing *Type 2* authentication are specified. With type 2 authentication each ATN router can be assured that the routing updates it receives are from a peer ATN router whose identity has been confirmed using strong (cryptographic) authentication.

2. GENERAL FRAMEWORK FOR ATN IDRP ROUTING POLICY

2.1 ROUTING POLICY GOAL FOR ATN ROUTERS

The ATN infrastructure and each region of the infrastructure must support a consistent set of routing policies to provide paths to ground systems at an inter-regional, intra-regional and local level and paths to airborne systems without an inordinate number of routing protocol updates. Accordingly, the detailed policy requirements and recommendations specified in section 4 are derived from the following general routing policy goal:

a. **Asia and Pacific region ATN routers will provide global shortest path connectivity with a minimal exchange of routing information.**

This general policy goal is intended to meet the objective of minimizing the delay to PDUs traversing the network while ensuring that the exchange of routing information does not significantly degrade the performance of the network for delivery of PDUs.

2.2 NETWORK ORGANIZATION FOR ROUTING TO GROUND SYSTEMS

For ground ATSC and AINSC applications the ATN infrastructure may be partitioned into various levels of organization. See Figure 2-1, which depicts routing domains for three states in the Asia/Pacific region.. Routing domains at the highest level are associated with a particular ICAO region or a group of regions called a "combined region". The Asia/Pacific region is a combined region with an NSAP prefix of 4700278191. Within a region, routing domains are next associated with a particular state or organization. Figure 2-1 depicts three arbitrary states (s1, s2, and s3). Note that in accordance with the regional addressing plan s1, s2, and s3 would actually be a two-byte field with the two ASCII characters assigned to the state or organization. Finally, within a particular state or organization there may be multiple local routing domains. Figure 2-1 depicts one routing domain in states s1 and s2 and three routing domains in state s2. Within this framework ATN ground routers may be characterized and their policy requirements specified according to the type of connectivity they have to adjacent ATN ground routers.

- ATN routers connecting to adjacent routers in another region are said to have "inter-regional" connectivity.
- ATN routers connecting to adjacent routers in another state or organization within a particular region are said to have "intra-regional" connectivity.
- ATN routers connecting to adjacent routers within a particular state or organization are said to have "local" connectivity, i.e. intra-state or intra-organizational connectivity.

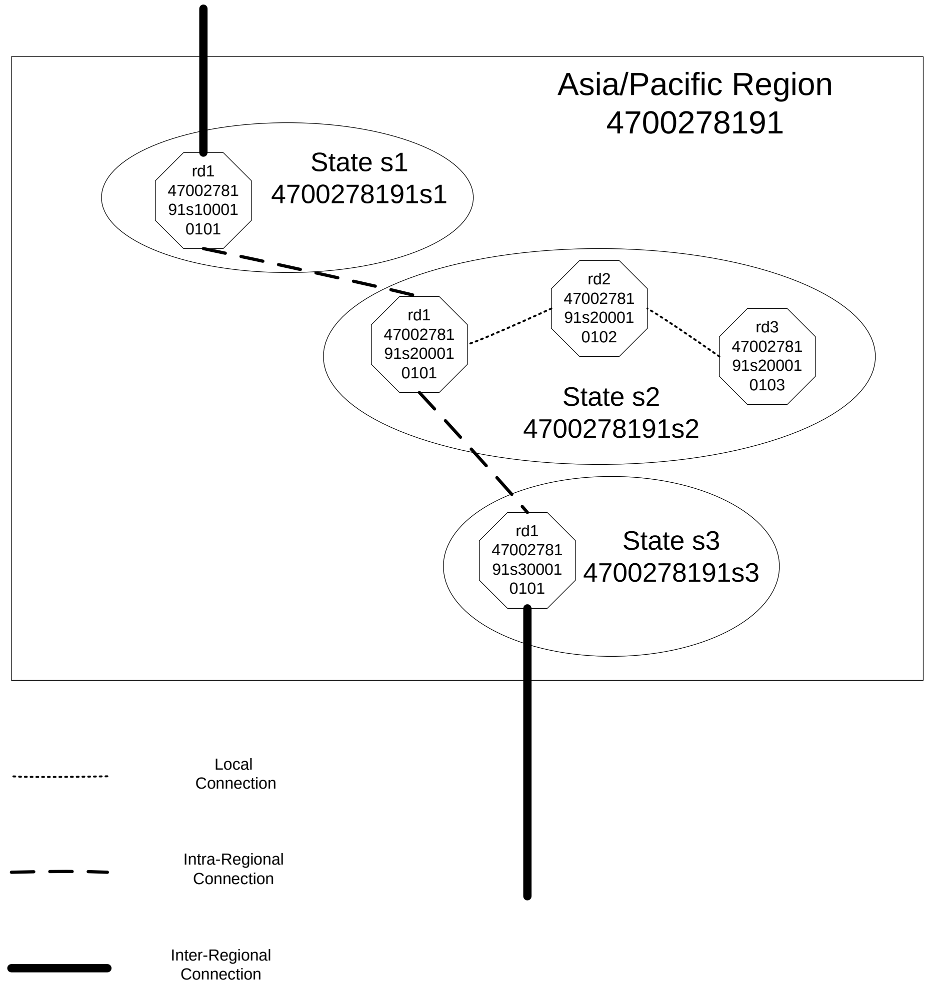

Figure 2-1. Connectivity of Ground Routing Domains

2.3 NETWORK ORGANIZATION FOR ROUTING TO AIRBORNE SYSTEMS

For air-ground ATSC and AINSC applications in the ATN it is useful to distinguish ground state domains from air-ground domains or subnetworks, which may operated by Service Provider organizations. See Figure 2-2. This figure depicts two distinct Air-Ground subnetworks, which are connected to the regional backbone. Note that a state may operate its own Air-Ground subnetwork, in which case the concepts that apply to Service Providers apply to the state-operated subnetwork.

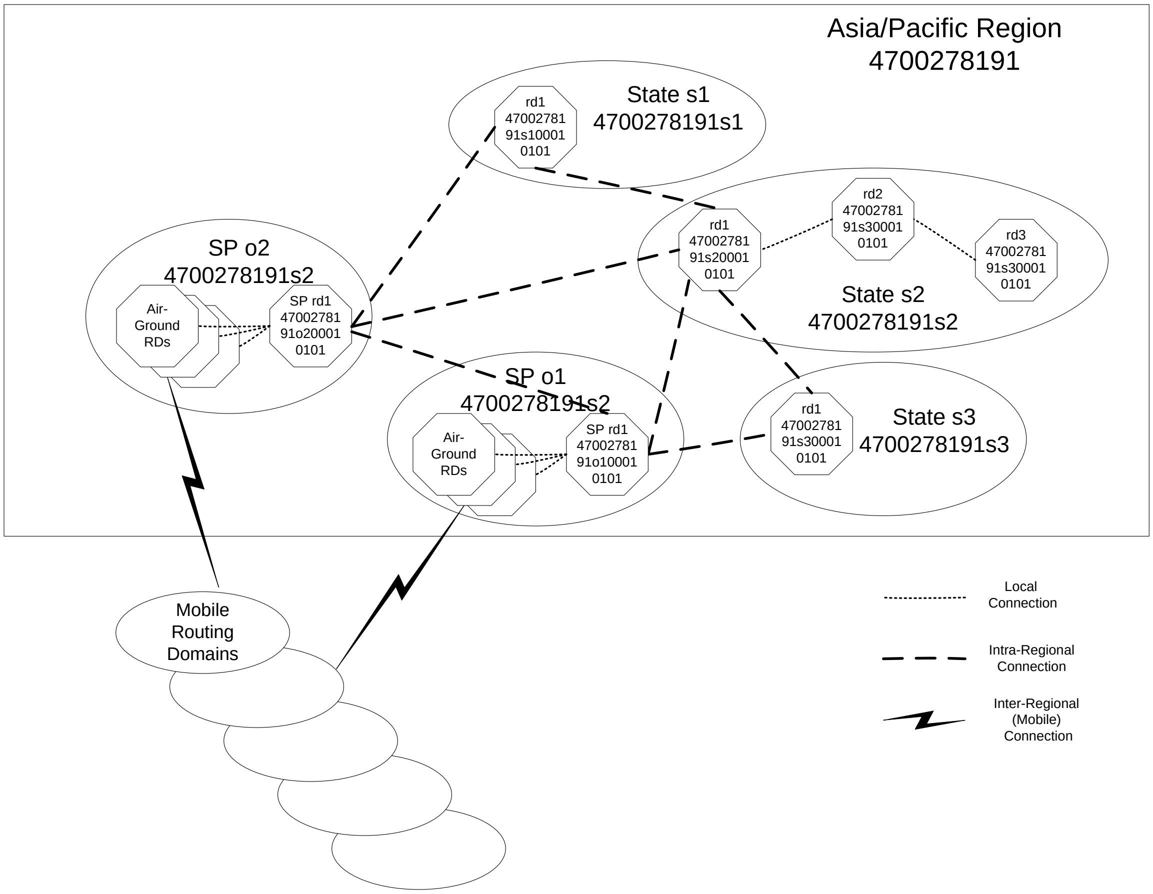

Figure 2-2. Connectivity of Air-Ground Service Providers to Regional Backbone

3. POLICY FOR ROUTES TO GROUND SYSTEMS

The policy requirements for ATN routers in the Asia and Pacific region for routes to ground (i.e., fixed) systems are specified in this section 3. Section 3.1 specifies the general policy for routes to ground systems. Policy requirements are next partitioned into policy for inter-regional routes (section 3.2), policy for intra-regional routes (section 3.3), and policy for local routes (section 3.4) according to the organizational framework described in section 2.2. Within these second-level sections policy requirements are partitioned at a third level according to the types of policy concerns identified in section 1.5.2, that is, policy requirements are partitioned at a third level into aggregation policies, preference policies, and distribution policies. Section 3.5 notes that additional state/organizational local routing policies are permitted.

Note 1. – This section specifies routing policy requirements for backbone routers in the Asia/Pacific region. A backbone router is a Class 4 Ground/Ground ATN router which has been designated by the operating state/organization to provide an appropriate level of performance and support the routing policies for inter-regional and intra-regional connectivity, and whose operation as a backbone router has been approved by the ICAO regional office as agreed-to by all other member states/organizations. This section also contains a number of recommended policies non-backbone routers.

Note 2. – This document and companion documents specify requirements for ATN routers in the "Asia and Pacific region"; however, in order to facilitate shortest path routing across inter-domain boundaries, the Asia and Pacific regions are combined under a single region identifier. See Appendix B for more information on the combined "Asia/Pac region".

3.1 GENERAL POLICY

a) If a backbone router receives multiple routes to an aggregate or specific destination, the route with the shortest path (i.e., lowest value of RD Hop Count) shall be selected.

b) All ATN routers in the Asia and Pacific shall authenticate the identity of peer ATN routers.

Note. – Authentication may be accomplished via IDRP Type 2 Authentication as specified in Edition 3 of ICAO Doc 9705 or via local means via Bilateral Agreement between the responsible organizations.

3.2 POLICY FOR INTER-REGIONAL AGGREGATE ROUTES TO GROUND SYSTEMS

Inter-regional route aggregation permits advertisement of a single aggregate route which identifies all systems in an ICAO region. Aggregation at an inter-regional level refers to aggregating NLRI fields to an NSAP prefix up through the first octet of the ADM field. (Reference 5)

Note. – Although this section specifies policy for inter-regional aggregate routes, the strategy for the Asia and Pacific regions is to combine them under a single region identifier. Therefore, the policy specified in this section will not apply between the Asia and Pacific regions See Appendix B for more information on the combined “Asia/Pac region”. Although the Asia/Pac strategy will result in not advertising inter-regional routes among these regions, this inter-regional policy is still specified since the actual interface to other regions has not yet been determined.

3.2.1 ROUTE AGGREGATION POLICIES FOR INTER-REGIONAL ROUTES

a) Backbone routers with inter-regional connectivity shall be configured with aggregate routes to ground systems for ATSC and AINSC applications at an inter-regional level.

3.2.2 ROUTE PREFERENCE POLICIES FOR INTER-REGIONAL AGGREGATE ROUTES

a) Backbone routers with inter-regional connectivity shall accept inter-regional aggregate routes to ground systems for ATSC and AINSC applications from adjacent ATN routers.

b) **Recommendation. -** Backbone routers with inter-regional connectivity should only accept inter-regional aggregate routes on these connections.

Note 1. - A simple method is to not accept routes with an NSAP prefix longer than the first octet of the ADM field. An alternative is to only accept inter-regional aggregate routes which have been pre-configured (using a so-called access control list).

Note 2. – This policy statement is a recommendation since in the future other routes such as routes to an airline’s “administrative” routing domain may need to be supported.

c) Backbone routers with intra-regional connectivity shall accept inter-regional aggregate routes to ground systems for ATSC and AINSC applications from adjacent ATN routers.

d) Routers with local connectivity (i.e., intra-state or intra-organization) shall accept inter-regional aggregate routes to ground systems for ATSC and AINSC applications from adjacent ATN routers.

3.2.3 ROUTE DISTRIBUTION POLICIES FOR INTER-REGIONAL AGGREGATE ROUTES

a) Backbone routers with inter-regional connectivity shall distribute inter-regional aggregate routes to ground systems for ATSC and AINSC applications to adjacent ATN routers.

b) Backbone routers with intra-regional connectivity shall distribute inter-regional aggregate routes to ground systems for ATSC and AINSC applications to adjacent ATN routers.

c) Routers with local connectivity shall distribute inter-regional aggregate routes to ground systems for ATSC and AINSC applications to adjacent ATN routers.

3.3 POLICY FOR INTRA-REGIONAL AGGREGATE ROUTES TO GROUND SYSTEMS

Intra-regional route aggregation permits advertisement of a single aggregate route which identifies all systems in a particular state or organization of an ICAO region. Aggregation at an intra-regional level refers to aggregating NLRI fields to an NSAP prefix up through the complete ADM field. (Reference 5)

3.3.1 INTRA-REGIONAL ROUTE AGGREGATION POLICIES

a) Backbone routers with intra-regional connectivity shall be configured with aggregate routes to ground systems for ATSC and AINSC applications at an intra-regional level.

3.3.2 INTRA-REGIONAL ROUTE PREFERENCE POLICIES

a) Backbone routers with intra-regional connectivity shall accept intra-regional aggregate routes to ground systems for ATSC and AINSC applications from adjacent ATN routers.

b) **Recommendation.** Backbone routers with intra-regional connectivity should only accept inter-regional or intra-regional aggregate routes on these connections.

c) Routers with local connectivity shall accept intra-regional aggregate routes to ground systems for ATSC and AINSC applications from adjacent ATN routers.

d) **Recommendation.** Non-Backbone routers with local connectivity may accept intra-regional aggregate routes to ground systems for ATSC and AINSC applications from adjacent ATN routers.

Note. – Non-backbone routers that accept intra-regional routes must provide an appropriate level of performance to support the routing policies for intra-regional connectivity. Other alternatives for Non-Backbone transit routers are described in Appendix C.

3.3.3 Intra-Regional Route Distribution Policies

a) Backbone routers with intra-regional connectivity shall distribute intra-regional aggregate routes to ground systems for ATSC and AINSC applications to adjacent ATN routers.

b) Routers with local connectivity shall distribute intra-regional aggregate routes to ground systems for ATSC and AINSC applications to adjacent ATN routers.

c) **Recommendation.** Non-Backbone routers with local connectivity may distribute intra-regional aggregate routes to ground systems for ATSC and AINSC applications to adjacent ATN routers.

Note. – Non-backbone routers that distribute intra-regional routes must provide an appropriate level of performance to support the routing policies for intra-regional connectivity. Other alternatives for Non-Backbone transit routers are described in Appendix C.

3.4 Policy for Aggregate Routes to Ground Systems for Distinct Routing Domains within a State/ Organization

Distinct Routing Domain-level aggregation permits advertisement of a single aggregate route which identifies all systems in a specific routing domain of a particular state or organization of an ICAO region. Aggregation at this level refers to aggregating NLRI fields to an NSAP prefix up through the complete ARS field. (Reference 5) ATN routers connecting to adjacent routers within a particular state or organization, i.e., with intra-state or intra-organizational connectivity, are said to have "local" connectivity.

3.4.1 Distinct Routing Domain Route Aggregation Policies

a) **Recommendation.** ATN routers serving individual routing domains should be configured with aggregate routes to all ground systems for ATSC and AINSC applications.

3.4.2 Distinct Routing Domain Route Preference Policies

a) **Recommendation.** ATN routers with local connectivity should accept state/organizational-level aggregate routes to ground systems for ATSC and AINSC applications from adjacent ATN routers within the same state or organization.

3.4.3 Distinct Routing Domain Route Distribution Policies

a) **Recommendation.** ATN routers with local connectivity should distribute state/organizational-level aggregate routes to ground systems for ATSC and AINSC applications to adjacent ATN routers within the same state or organization.

3.5 LOCAL STATE/ORGANIZATIONAL ROUTING POLICIES

Individual states/organizations may have additional routing policies consistent with the above policies for routes to ground systems. Such policies may include various local preferences or Quality of Service based routing, for example, routing based on line error rates, expense, delay, capacity, and priority.

3.6 CONFIGURATION OF ROUTES TO END ROUTING DOMAINS

The routing policies in sections 3.1 through 3.5 apply to transit routing domains, i.e, routers which connect to two or more other routers. However there are several end routing domains in the Asia/Pacific region where routers are connected to only one other router. In this case the routes may be statically configured in both routers rather than using IDRP dynamic routing procedures. Note however that the router in the transit routing domain must still distribute a route to the end routing domain to other routers. Note further that the distributed route must reflect the actual reachability of the end routing domain. Thus if IDRP is not used to determine reachability to the end routing domain some other local means must be used, for example, detecting whether or not there is an X.25 connection.

4. POLICY FOR ROUTES TO AIRBORNE SYSTEMS

The policy requirements for ATN routers in the Asia and Pacific region for routes to airborne (i.e., mobile) systems are specified in this section 4. Policy requirements are next partitioned according to the types of policy concerns identified in section 1.5.2; that is, policy requirements are partitioned into aggregation policies, preference policies, and distribution policies.

Note 1. – This initial baseline document only contains recommended policies. This is primarily because the architecture for air-ground ATN routers has not yet been developed. Once more concrete plans for the implementation of airborne applications in the Asia and Pacific region are developed, additional requirements and/or recommendations may be added in future versions of this document.

4.1 POLICY FOR AGGREGATE ROUTES TO AIRBORNE SYSTEMS

Aggregation of routes to airborne (i.e. mobile) systems permits advertisement of aggregate routes to airborne systems rather than advertisement of individual routes to every airborne system. Aggregation of routes to mobile systems may occur at a coarse level to “all mobile” or may occur at an “administrative domain” level of all aircraft belonging to an airline or the General Aviation aircraft of a given country of registration. Aggregation to “all mobile” refers to aggregating NLRI fields to an NSAP prefix up through the VER field where the value of the VER field may be “41” for Mobile AINSC routes or “C1” for Mobile ATSC routes. Aggregation at an administrative domain” level refers to aggregating the NLRI fields to an NSAP prefix up through the ADM field.

4.1.1 ROUTE AGGREGATION POLICIES FOR ROUTES TO AIRBORNE SYSTEMS

b) **Recommendation. -** ATN routers in an Air-Ground subnetwork (e.g., backbone routers for an Air-Ground Service Provider) with intra-regional connectivity (to the regional backbone routers) should be configured with aggregate routes to airborne systems for ATSC and AINSC applications at an “administrative domain” level.

Note –The basic assumption of this recommendation is there may be multiple service providers operating in a region and that an airline will contract with one service provider as the primary provider of air-ground service and optionally contract with a second service provider for back-up service.

c) **Recommendation. -** ATN routers in the regional backbone with local connectivity should be configured with aggregate routes to airborne systems for ATSC and AINSC applications at an “all mobile” level.

4.1.2 ROUTE PREFERENCE POLICIES FOR ROUTES TO AIRBORNE SYSTEMS

a) **Recommendation. -** ATN ground routers in the regional backbone with intra-regional connectivity to ATN routers in an Air-Ground subnetwork should accept aggregate routes to airborne systems for ATSC and AINSC applications from adjacent ATN routers at an “administrative domain” level.

b) **Recommendation. -** ATN ground routers in the regional backbone with intra-regional connectivity to ATN routers in an Air-Ground subnetwork should accept routes to airborne systems for ATSC and AINSC applications from adjacent ATN routers at a “mobile routing domain” level, i.e., accept routes to individual aircraft.

Note. – This policy permits advertisement of routes to individual aircraft for cases where there are multiple Air-Ground subnetworks. It permits routing to the Air-Ground subnetwork with actual connectivity to an aircraft.

c) **Recommendation. -** ATN ground routers with local connectivity to ATN routers should accept aggregate routes to airborne end systems for ATSC and AINSC applications from adjacent ATN routers at an “all mobile” level.

Note. – Non-backbone routers accept routes at an “all mobile” level from backbone routers and from other non-backbone routers.

4.1.3 ROUTE DISTRIBUTION POLICIES FOR ROUTES TO AIRBORNE SYSTEMS

a) **Recommendation. -** ATN ground routers with intra-regional connectivity to ATN routers should distribute aggregate routes to airborne systems for ATSC and AINSC applications at an “administrative domain” level to adjacent ATN ground routers.

b) **Recommendation. -** ATN ground routers with intra-regional connectivity to ATN routers should distribute routes to airborne systems for ATSC and AINSC applications at a “mobile routing domain” level to adjacent ATN ground routers.

c) **Recommendation.** ATN ground routers with local connectivity to ATN routers should distribute aggregate routes to airborne systems for ATSC and AINSC applications at an “all mobile” level to adjacent ATN ground routers.

Appendix A – Scenarios for Distribution of Routes to Ground Systems

This appendix contains example scenarios which illustrate distribution of inter-regional, intra-regional, and routing domain level routes in accordance with the Asia Pacific routing policy. Note that in these examples the Asia and Pacific regions are defined as distinct regions. This is to illustrate the concept of hierarchical distribution of routing information. In practice, the Asia and Pacific regions are grouped together as a combined region with a single address prefix. See Appendix B. Note also that although the scenarios are for ATSC applications, the principles apply also to AINSC applications.**Scenario A-1 Inter-Regional Route Distribution**

Figure A-1 depicts routing policy operation for distribution of inter-regional routes for ATSC applications in the Asia Region.

STEP 1.

Ground-Ground Router A (GG A) in State S1 of the Pacific Region is a backbone router with inter-regional connectivity to the Asia Region. In accordance with 3.1.2.1.a GG A is configured with an aggregate route to ground systems for ATSC applications.

STEP 2.

In accordance with 3.1.2.3.a GG A distributes the aggregate route to adjacent Ground-Ground Router B (GG B) in State S3 of the Asia Region. In accordance with 3.1.2.2.a GG B accepts this route and installs it in its routing database.

STEP 3.

In accordance with 3.1.2.3.b GG B distributes the aggregate route to adjacent Ground-Ground Router C (GG C) in State S2 of the Asia Region. In accordance with 3.1.2.2.c GG B accepts this route and installs it in its routing database.

STEP 4.

In accordance with 3.1.2.3.b GG C distributes the aggregate route to adjacent Ground-Ground Router F (GG F) in State S1 of the Asia Region. In accordance with 3.1.2.2.c GG F accepts this route and installs it in its routing database. In accordance with 3.1.2.3.c GG C distributes the aggregate route to adjacent Ground-Ground Router D (GG D) also in State S2 of the Asia Region. In accordance with 3.1.2.2.d GG D accepts this route and installs it in its routing database.

STEP 5.

In accordance with 3.1.2.3.c GG D distributes the aggregate route to adjacent Ground-Ground Router E (GG E) also in State S2 of the Asia Region. In accordance with 3.1.2.2.d GG E accepts this route and installs it in its routing database.

STEP 6.

In accordance with 3.1.2.3.a GG F distributes the aggregate route to an (unidentified) adjacent Ground-Ground Router in an adjacent Region.

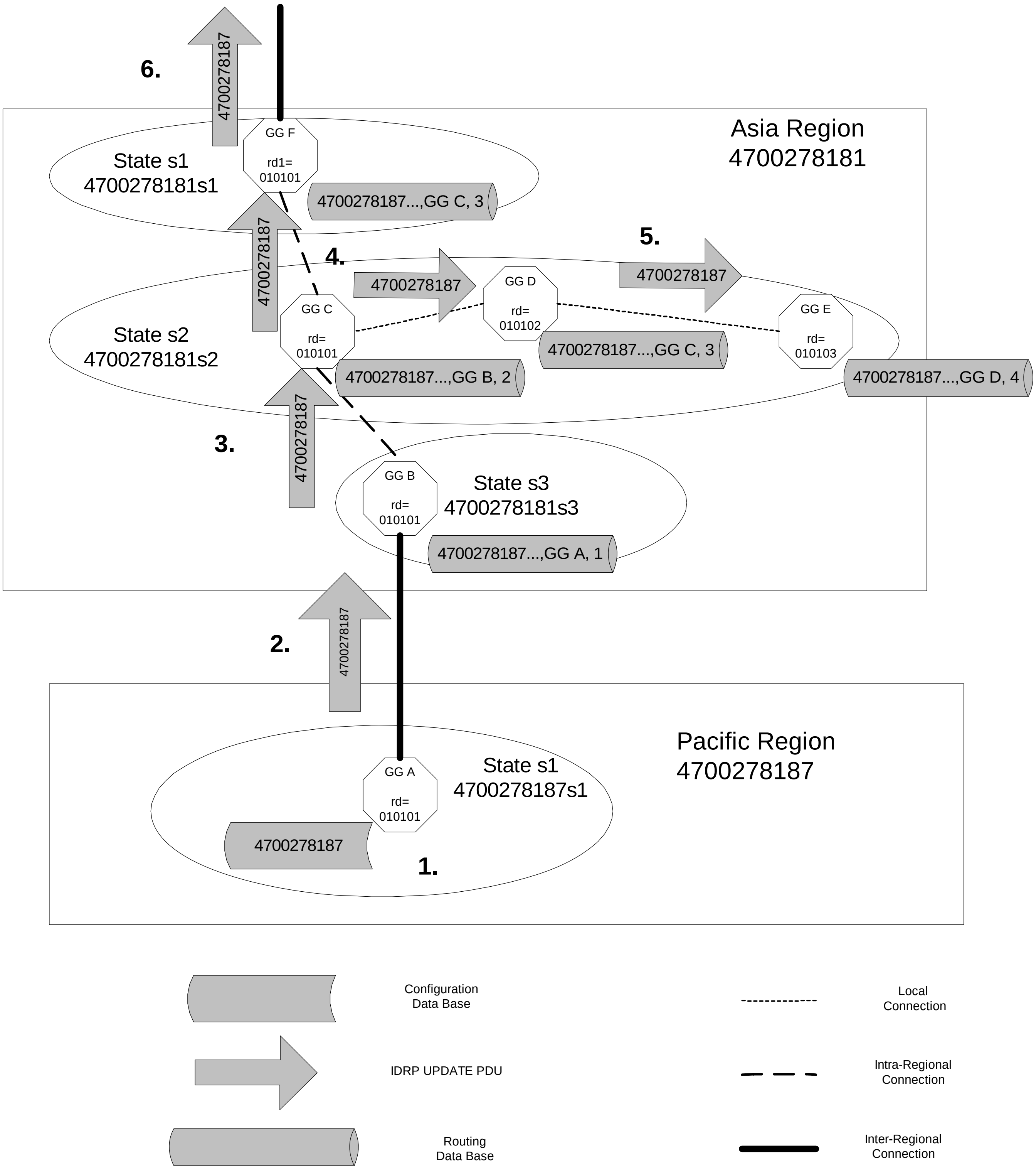

Figure A-1 Inter-Regional Route Distribution

Scenario A-2 Intra-Regional Route Distribution

Figure A-2 depicts routing policy operation for distribution of intra-regional routes for ATSC applications in the Asia Region.

STEP 1.

Ground-Ground Router B (GG B) in State S3 is a backbone router with intra-regional connectivity in the Asia Region. In accordance with 3.1.3.1.a GG B is configured with an aggregate route to ground systems for ATSC applications.

STEP 2.

In accordance with 3.1.3.3.a GG B distributes the aggregate route to adjacent Ground-Ground Router C (GG C) in State S2 of the Asia Region. In accordance with 3.1.3.2.a GG C accepts this route and installs it in its routing database.

STEP 3.

In accordance with 3.1.3.3.a GG C distributes the aggregate route to adjacent Ground-Ground Router F (GG F) in State S1 of the Asia Region. In accordance with 3.1.3.2.a GG B accepts this route and installs it in its routing database. In accordance with 3.1.3.3.b GG C distributes the aggregate route to adjacent Ground-Ground Router D (GG D) also in State S2 of the Asia Region. In accordance with 3.1.3.2.c GG D accepts this route and installs it in its routing database.

STEP 4.

In accordance with 3.1.3.3.b GG D distributes the aggregate route to adjacent Ground-Ground Router D (GG E) also in State S2 of the Asia Region. In accordance with 3.1.3.2.c GG E accepts this route and installs it in its routing database.

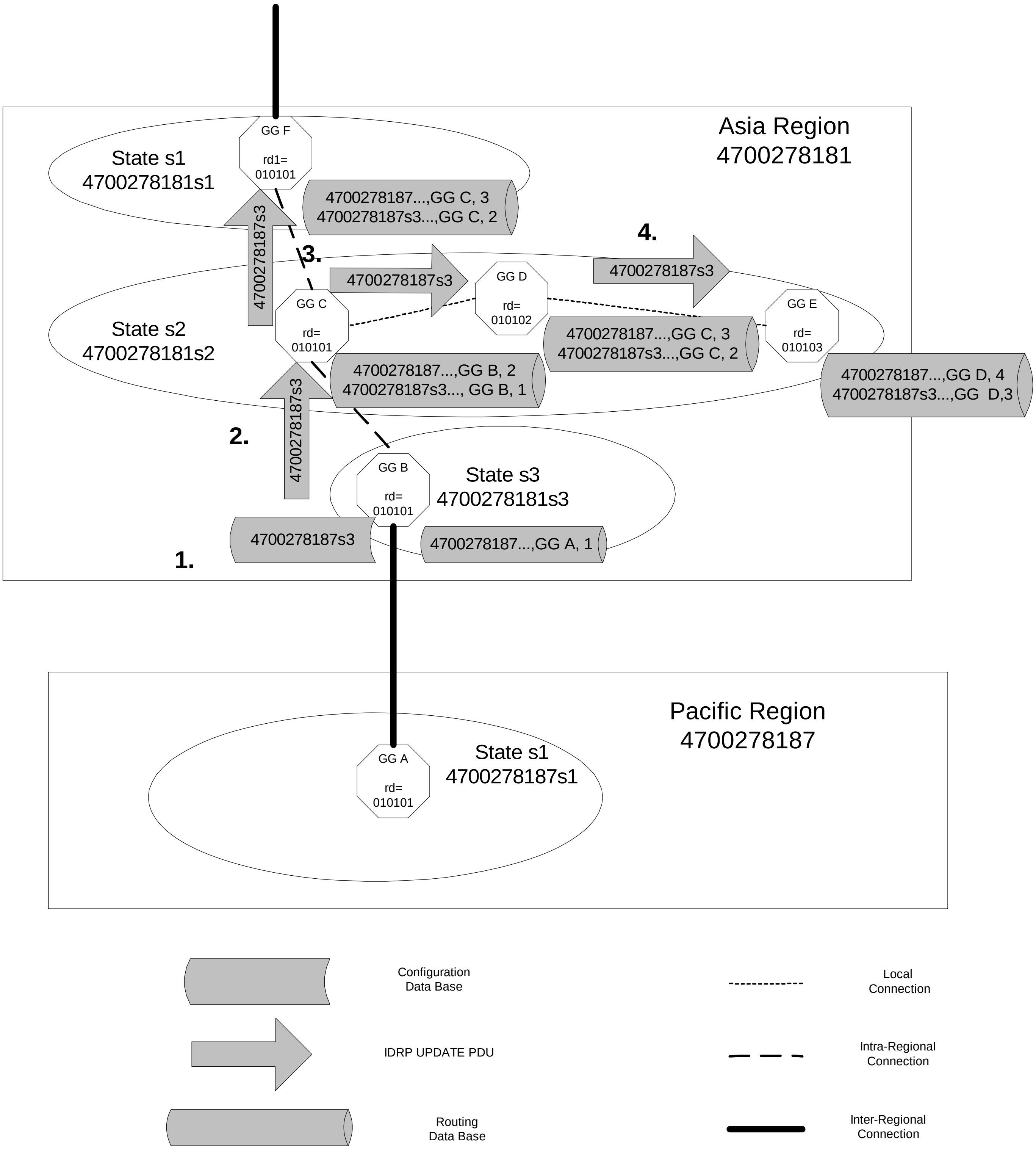

Figure A-2 Intra-Regional Route Distribution

Scenario A-3 Routing Domain Route Distribution

Figure A-3 depicts routing policy operation for distribution of routing domain routes for ATSC applications in the Asia Region.

STEP 1.

Ground-Ground Router E (GG E) in State S2 is a (non-backbone) routing domain level router with local connectivity in the Asia Region. In accordance with 3.1.4.1.a GG E is configured with an aggregate route to ground systems for ATSC applications.

STEP 2.

In accordance with 3.1.4.3.a GG E distributes the aggregate route to adjacent Ground-Ground Router D (GG D) also in State S2 of the Asia Region. In accordance with 3.1.4.2.a GG D accepts this route and installs it in its routing database.

STEP 3.

In accordance with 3.1.4.3.a GG D distributes the aggregate route to adjacent Ground-Ground Router C (GG C) also in State S2 of the Asia Region. In accordance with 3.1.4.2.a GG C accepts this route and installs it in its routing database.

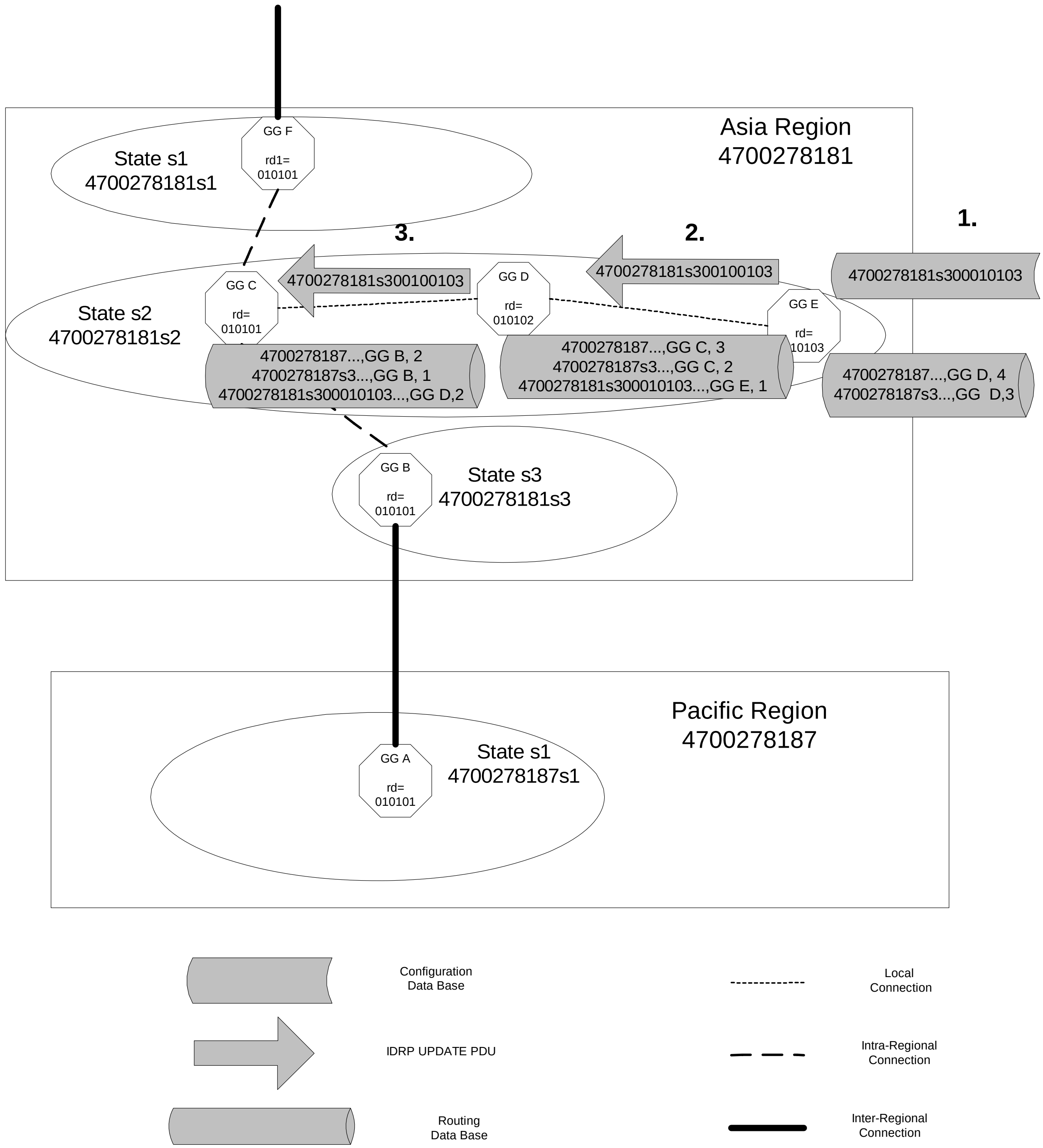

Figure A-3 Routing Domain Route Distribution

APPENDIX B

Routing with a Common Address Prefix for the Asia and Pacific Regions

B-1. Asia/Pacific ATN Routing Policy Goal

Section 2.1 of this document has specified an IDRP Routing policy with the following general routing policy goal:

- Asia and Pacific region ATN routers will provide global shortest path connectivity with a minimal exchange of routing information.

B.2. ATN Hierarchical Address Structure and Routing Prefixes

The ATN uses a hierarchical address structure to reduce the amount of routing information advertises on an inter- and intra-regional basis. The general ATN address structure is depicted in Figure B-1.

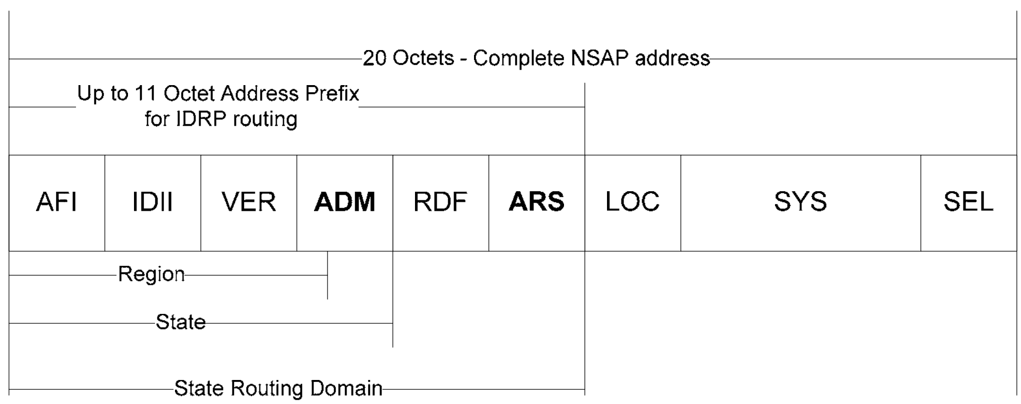

Figure B-1 – ATN NSAP Address Structure

The Asia/Pacific Region the NSAP addressing plan uses the first 5 octets of an NSAP address (up to the 1st octet of the ADM field) to designate an ICAO Region. The first 7 octets of an NSAP address (including the second two octets of the ADM field) designate a states or organizations within a Region. The first 11 octets (including the ARS field) designate individual routing domains within a state or organization.

Given the above generic address allocation the following address prefixes will be advertised in accordance with the Asia/Pacific Routing Policy.

- Routers with inter-regional connectivity will advertise a regional prefix of 5 octets on the inter-regional interface to indicate they can reach all systems in the region,
- Routers with intra-regional connectivity will advertise a prefix of 7 octets on the intra-regional interface to indicate they can reach all systems within the state or organization, and
- Routers with local connectivity will advertise a prefix of 11 octets for individual routing domains in the state or region.

B.3. Consequence of Aggregation on Inter-regional boundaries

Because systems are aggregated under a single address prefix, a router receiving multiple advertisements may not always choose the shortest path.

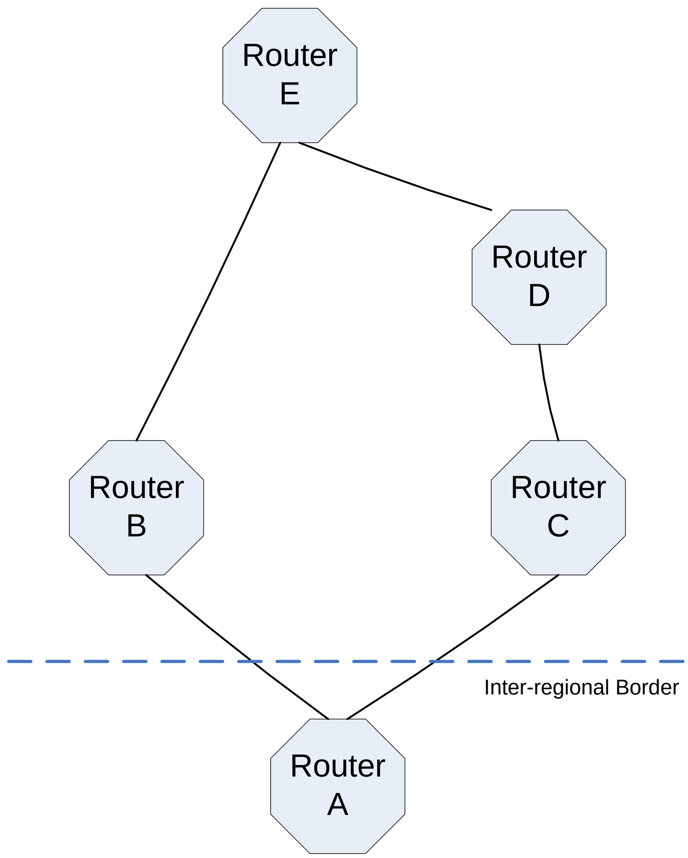

Figure B-2 – Routers with Inter-Regional Connectivity

Figure B-2 depicts Router A connected to two routers (B and C) across an inter-regional boundary. In accordance with the routing policy, routers B and C will advertise the same regional 5 octet prefix indicating that they can reach all systems in the region. In addition Routers B and C will advertise a hop count of 1 since they are one hop away from A. Given two paths of equal length to the same prefix, Router A will select the Router which happens to have the lowest address. However, in order to reach Router D via the shortest path, Router A should select the path via Router C. Similarly to reach Router E via the shortest path, Router A should select the path via Router B.

B.3. General Recommendation to eliminate inter-regional borders

In order to achieve shortest path routing, it is proposed that the inter-regional border be eliminated whenever possible such that Router A belongs to the same region as the other routers. In this case, following the policy, Router A will receive a 7 octet prefix for Routers D and E from both Router B and

Router C but the hop count will be different. Using the hop count Router A can select the shortest path.

B.4. Eliminating Inter-regional borders in the Asia/Pacific Region

Figure B-3 depicts Asia/Pacific Routing topology. The dotted lines are cases where there is inter-regional connectivity in accordance with the NSAP Addressing Plan.

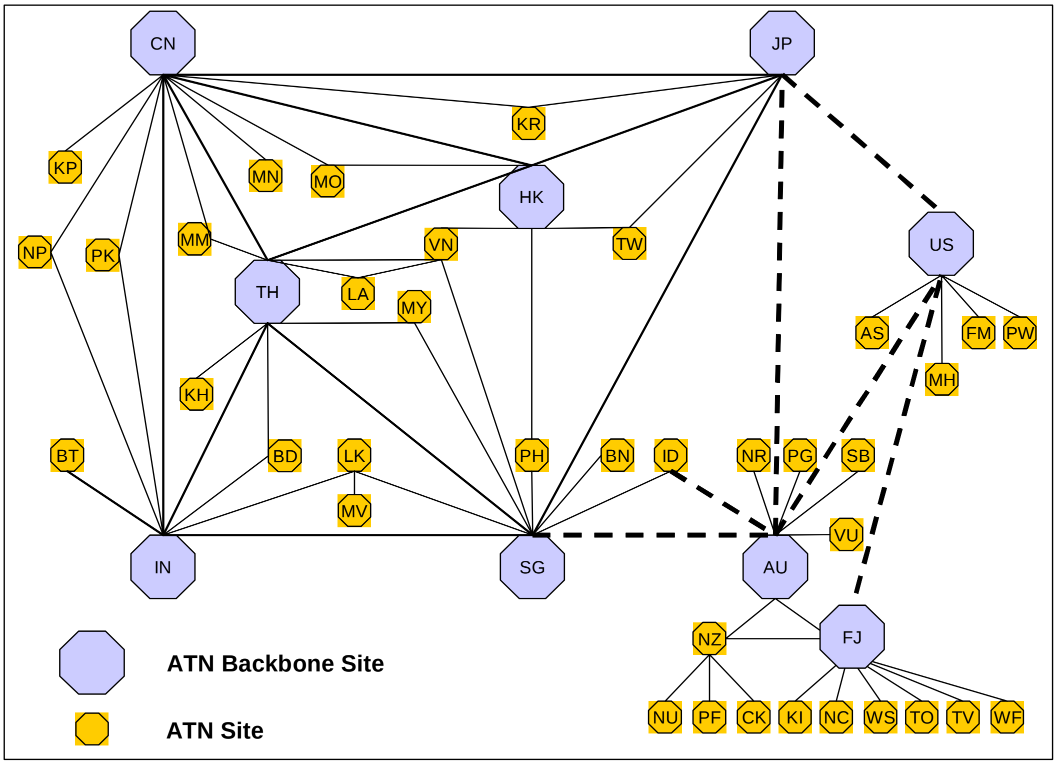

Figure B-3 – Asia, Pacific, and NAM Inter-Regional Connectivity

B.4.1 Eliminating the Asia/Pacific Border

As an example we may consider the case of Australia (AU). From the diagram it can be seen that Autralia (AU) will receive aggregate prefixes from Japan (JP) and Singapore (SG). And so for example to reach China (CN) the desired path would be via Japan (JP) but to reach India the desired path would be via Singapore (SG). This can be accomplished by combining the Asia and Pacific regions into a single "combined region". The effect will generally be that shortest path routing will be achieved across the two regions.

B.4.2 Eliminating the Asia/Pacific to NAM border

If the Asia and Pacific regions are combined but the connections to the US are still inter-regional, then the US will receive the same aggregate prefix from Japan, Australia, and Fiji Consequently, the US may not select the shortest path to routers beyond the interfacing router. In order to avoid this situation, the inter-regional border to the US may also be eliminated by making the US part of a combined Asia and Pacific region for routing purposes. The routing prefix uses the hexadecimal value of '91' in the first octet of the ADM field to signal the combined Asia/Pac region.

APPENDIX C

Non-Backbone Transit Routers

C-1. Introduction

The routing policy in this document distinguishes between backbone and non-backbone routers. See Figure C-1. In the event of a failure of a connection between two backbone routers (A and C), the next shortest path between these routers will be selected. This may result in a path through a non-backbone router being selected.

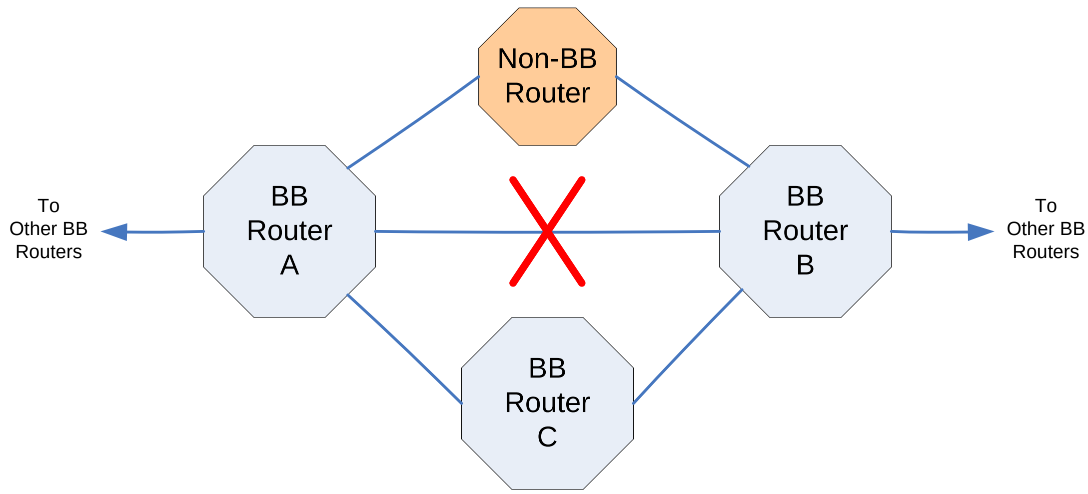

FIGURE C-1: ALTERNATE PATH VIA BACKBONE OR NON-BACKBONE ROUTER

This may occur even if there is an equal hop path through backbone routers (i.e, through router C). This can happen becaue of the way IDRP selects paths. If there is more than one path with the same lowest hop count, IDRP will compare the NET addresses of the adjacent routers on each path as integers and select the “lowest”. In the Asia/Pac region this can occur in several situations. From Figure B-3 it can be seen that the following non-backbone routes could be selected.

Failed Connection	**Alternate Path**
Japan–Hong Kong	alternate path via Taiwan instead of Beijing
Japan–China	alternate path via Republic of Korea instead of Hong Kong
China–India	alternate path via Pakistan instead of Thailand
Thailand–India	alternate path via Bangladesh instead of Beijing or Singapore
India–Singapore	alternate path via Sri Lanka instead of Thailand

In general non-backbone transit routers are not required to to handle intra-domain traffic but they are not precluded from doing so. Recommendation 3.3.3.c specifies that "Non-Backbone routers with local connectivity may distribute intra-regional aggregate routes to ground systems for ATSC and AINSC applications to adjacent ATN routers." This recommendation has an important caveat however. Non-backbone routers that distribute intra-regional routes must provide an appropriate level of performance to support the routing policies for intra-regional connectivity. If a non-backbone router does not have the appropriate level of performance there are several alternatives which may be selected.

C-3. Alternatives

Alternative 1 – Preference for alternate routes via Backbone Routers

When the connection between two backbone routers fails and there are multiple alternate paths available as depicted in Figure C-1, preference should be given to the backbone path, i.e., via backbone router C. If a backbone path is not available and there are multiple non-backbone paths then the link with the greatest capacity (speed) should be selected. This local policy may be summarized as follows:

> *If there are multiple paths with the same lowest hop count, PDUs should be forwarded on the ATN backbone path, if available, otherwise on the link with the greatest speed.*

Alternative 2 – Operate as Transit Router only for directly connected Backbone Routers

A non-backbone transit router may accept routes for the directly connected backbone routers and for other routers in the network; however, it could have a more restrictive policy regarding which routes it will advertise. Specifically a non-backbone transit router could be configured to only distribute routes for directly connected routers. For example, the non-backbone router in Figure C-1 would distribute a route for router A to router B but not other intra-regional routes received from router A. In the other direction, the non-backbone router in Figure C-1 would distribute a route for router B to router A but not other intra-regional routes received from router B. The net result of this approach is that the non-backbone router could be an alternate path only for traffic between the adjacent backbone routers. How this is accomplished is a local matter. One possible method would be to statically configure these routes in the non-backbone router.