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Space data and information transfer systems — Space packet protocol

Systèmes de transfert des données et informations spatiales — Protocole pour données spatiales par paquets

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22646 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 133.0-B-1, September 2003) and was adopted (without modifications except those stated in Clause 2 of this International Standard) by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

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Space data and information transfer systems — Space packet protocol

1 Scope

This International Standard specifies the space packet protocol for transferring space application data over a network involving a ground-to-space or space-to-space communications link.

The scope and field of application are furthermore detailed in subclauses 1.1 and 1.2 of the enclosed CCSDS publication.

2 Requirements

Requirements are the technical recommendations made in the following publication (reproduced on the following pages), which is adopted as an International Standard:

CCSDS 133.0-B-1, September 2003, *Space packet protocol.*

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 133.0-B-1.

Pages i to v

This part is information which is relevant to the CCSDS publication only.

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Add the following information to the references indicated:

[3] Document CCSDS 301.0-B-3, January 2002, is equivalent to ISO 11104:2003.

[4] Document CCSDS 135.0-B-1, January 2002, is equivalent to ISO 22647:—[1)].

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Add the following information to the references indicated:

[B2] Document CCSDS 102.0-B-5, November 2000, is equivalent to ISO 13419:2003.

[B3] Document CCSDS 203.0-B-2, June 2001, is equivalent to ISO 12174:2003.

[B6] Document CCSDS 132.0-B-1, September 2003, is equivalent to ISO 22645:2005.

1) To be published.

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[B7] Document CCSDS 232.0-B-1, September 2003, is equivalent to ISO 22664:2005.

[B8] Document CCSDS 732.0-B-1, September 2003, is equivalent to ISO 22666:2005.

It has been agreed with the Consultative Committee for Space Data Systems that Subcommittee ISO/TC 20/SC 13 will be consulted in the event of any revision or amendment of publication CCSDS 133.0-B-1. To this end, NASA will act as a liaison body between CCSDS and ISO.

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Consultative Committee for Space Data Systems

RECOMMENDATION FOR SPACE DATA SYSTEM STANDARDS

SPACE PACKET PROTOCOL

CCSDS 133.0-B-1

BLUE BOOK

September 2003

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CCSDS RECOMMENDATION FOR SPACE PACKET PROTOCOL

AUTHORITY

Issue:	Blue Book, Issue 1
Date:	September 2003
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This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS Recommendations is detailed in reference [B1], and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

This Recommendation is published and maintained by:

CCSDS Secretariat
Office of Space Communication (Code M-3)
National Aeronautics and Space Administration
Washington, DC 20546, USA

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CCSDS RECOMMENDATION FOR SPACE PACKET PROTOCOL

STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of member space Agencies. The Committee meets periodically to address data systems problems that are common to all participants, and to formulate sound technical solutions to these problems. Inasmuch as participation in the CCSDS is completely voluntary, the results of Committee actions are termed **Recommendations** and are not considered binding on any Agency.

This **Recommendation** is issued by, and represents the consensus of, the CCSDS Plenary body. Agency endorsement of this **Recommendation** is entirely voluntary. Endorsement, however, indicates the following understandings:

– Whenever an Agency establishes a CCSDS-related **standard**, this **standard** will be in accord with the relevant **Recommendation**. Establishing such a **standard** does not preclude other provisions which an Agency may develop.

– Whenever an Agency establishes a CCSDS-related standard, the Agency will provide other CCSDS member Agencies with the following information:

  - The **standard** itself.
  - The anticipated date of initial operational capability.
  - The anticipated duration of operational service.

– Specific service arrangements are made via memoranda of agreement. Neither this Recommendation nor any ensuing standard is a substitute for a memorandum of agreement.

No later than five years from its date of issuance, this **Recommendation** will be reviewed by the CCSDS to determine whether it should: (1) remain in effect without change; (2) be changed to reflect the impact of new technologies, new requirements, or new directions; or, (3) be retired or canceled.

In those instances when a new version of a **Recommendation** is issued, existing CCSDS-related Agency standards and implementations are not negated or deemed to be non-CCSDS compatible. It is the responsibility of each Agency to determine when such standards or implementations are to be modified. Each Agency is, however, strongly encouraged to direct planning for its new standards and implementations towards the later version of the Recommendation.

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CCSDS RECOMMENDATION FOR SPACE PACKET PROTOCOL

FOREWORD

This document is a technical Recommendation for use in developing flight and ground systems for space missions and has been prepared by the Consultative Committee for Space Data Systems (CCSDS). The Space Packet Protocol described herein is intended for missions that are cross-supported between Agencies of the CCSDS.

This Recommendation specifies a communications protocol to be used by space missions to transfer space application data over a network that involves a ground-to-space or space-to-space communications link. This Recommendation was developed by consolidating the specifications of the packet portion of three CCSDS Recommendations, references [B2]-[B4], which define essentially the same protocol and services but in slightly different contexts.

This Recommendation does not change the major technical contents defined in (references [B2]-[B4]), but the presentation of the specification has been changed so that:

a) this protocol can be used to transfer any data over any space link in either direction;

b) all CCSDS space link protocols are specified in a unified manner;

c) the specification matches the Open Systems Interconnection (OSI) Basic Reference Model (references [1] and [2]).

Together with the change in presentation, a few technical specifications in references [B2]-[B4] have been changed in order to unify the specifications in references [B2]-[B4]. Also, some technical terms in references [B2]-[B4] have been changed in order to unify the terminology used in all the CCSDS Recommendations that define space link protocols and to define this protocol as a general communications protocol. These changes are listed in annex C of this Recommendation.

Through the process of normal evolution, it is expected that expansion, deletion or modification to this document may occur. This Recommendation is therefore subject to CCSDS document management and change control procedures, as defined in reference [B1]. Current versions of CCSDS documents are maintained at the CCSDS Web site:

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Questions relating to the contents or status of this document should be addressed to the CCSDS Secretariat at the address indicated on page i.

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– National Aeronautics and Space Administration (NASA)/USA.
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– Russian Space Agency (RSA)/Russian Federation.

Observer Agencies

– Austrian Space Agency (ASA)/Austria.
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DOCUMENT CONTROL

Document	Title and Issue	Date	Status
CCSDS 133.0-B-1	Space Packet Protocol, Issue 1	September 2003	Original Issue

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CCSDS RECOMMENDATION FOR SPACE PACKET PROTOCOL

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CCSDS RECOMMENDATION FOR SPACE PACKET PROTOCOL

1 INTRODUCTION

1.1 PURPOSE

The purpose of this Recommendation is to specify the Space Packet Protocol. Space missions will use this protocol to transfer space application data over a network that involves a ground-to-space or space-to-space communications link.

1.2 SCOPE

This Recommendation defines the Space Packet Protocol in terms of:

a) the services provided to the users of this protocol;

b) the protocol data units employed by the protocol; and

c) the procedures performed by the protocol.

It does not specify:

a) individual implementations or products;

b) the implementation of service interfaces within real systems;

c) the methods or technologies required to perform the procedures; or

d) the management activities required to configure and control the protocol.

1.3 APPLICABILITY

This Recommendation applies to the creation of Agency standards and to future data communications over space links between CCSDS Agencies in cross-support situations. The Recommendation includes comprehensive specification of the services and protocol for inter-Agency cross-support. It is neither a specification of, nor a design for, real systems that may be implemented for existing or future missions.

The Recommendation specified in this document is to be invoked through the normal standards programs of each CCSDS Agency and is applicable to those missions for which cross-support, based on capabilities described in this Recommendation, is anticipated. Where mandatory capabilities are clearly indicated in sections of the Recommendation, they must be implemented when this document is used as a basis for cross-support. Where options are allowed or implied, implementation of these options is subject to specific bilateral cross- support agreements between the Agencies involved.

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1.4 RATIONALE

The CCSDS believes it is important to document the rationale underlying the recommendations chosen, so that future evaluations of proposed changes or improvements will not lose sight of previous decisions.

1.5 DOCUMENT STRUCTURE

This document is divided into five numbered sections and three annexes:

a) section 1 presents the purpose, scope, applicability, and rationale of this Recommendation and lists the conventions, definitions, and references used throughout the Recommendation;

b) section 2 provides an overview of the Space Packet Protocol;

c) section 3 defines the services provided by the protocol entity;

d) section 4 specifies the protocol data units and procedures employed by the protocol entity;

e) section 5 lists the managed parameters associated with this protocol;

f) annex A lists all acronyms used within this document;

g) annex B provides a list of informative references;

h) annex C lists the changes from the older CCSDS Recommendations (references [B2]-[B4]).

1.6 CONVENTIONS AND DEFINITIONS

1.6.1 DEFINITIONS

1.6.1.1 Definitions from the Open Systems Interconnection (OSI) Basic Reference Model

This Recommendation makes use of a number of terms defined in reference [1]. The use of those terms in this Recommendation shall be understood in a generic sense; i.e., in the sense that those terms are generally applicable to any of a variety of technologies that provide for the exchange of information between real systems. Those terms are:

a) blocking;

b) connection;

c) entity;

d) flow control;

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e) peer entities;

f) protocol control information;

g) protocol data unit;

h) real system;

i) segmenting;

j) service;

k) Service Access Point (SAP);

l) SAP address;

m) service data unit.

1.6.1.2 Definitions from OSI Service Definition Conventions

This Recommendation makes use of a number of terms defined in reference [2]. The use of those terms in this Recommendation shall be understood in a generic sense; i.e., in the sense that those terms are generally applicable to any of a variety of technologies that provide for the exchange of information between real systems. Those terms are:

a) indication;

b) primitive;

c) request;

d) service provider;

e) service user.

1.6.1.3 Terms Defined in this Recommendation

For the purposes of this Recommendation, the following definitions also apply. Many other terms that pertain to specific items are defined in the appropriate sections.

asynchronous: not *synchronous* (see below).

delimited: having a known (and finite) length; applies to data in the context of data handling.

Mission Phase: a period of a mission during which specified communications characteristics are fixed. The transition between two consecutive mission phases may cause an interruption of the communications services.

Physical Channel: a stream of bits transferred over a space link in a single direction.

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space link: a communications link between a spacecraft and its associated ground system, or between two spacecraft. A space link consists of one or more Physical Channels in one or both directions.

synchronous: of or pertaining to a sequence of events occurring in a fixed time relationship (within specified tolerance) to another sequence of events.

1.6.2 NOMENCLATURE

The following conventions apply throughout this Recommendation:

a) the words 'shall' and 'must' imply a binding and verifiable specification;

b) the word 'should' implies an optional, but desirable, specification;

c) the word 'may' implies an optional specification;

d) the words 'is', 'are', and 'will' imply statements of fact.

1.6.3 CONVENTIONS

In this document, the following convention is used to identify each bit in an *N*-bit field. The first bit in the field to be transmitted (i.e., the most left justified when drawing a figure) is defined to be 'Bit 0'; the following bit is defined to be 'Bit 1' and so on up to 'Bit *N*–1'. When the field is used to express a binary value (such as a counter), the Most Significant Bit (MSB) shall be the first transmitted bit of the field, i.e., 'Bit 0' (see figure 1-1).

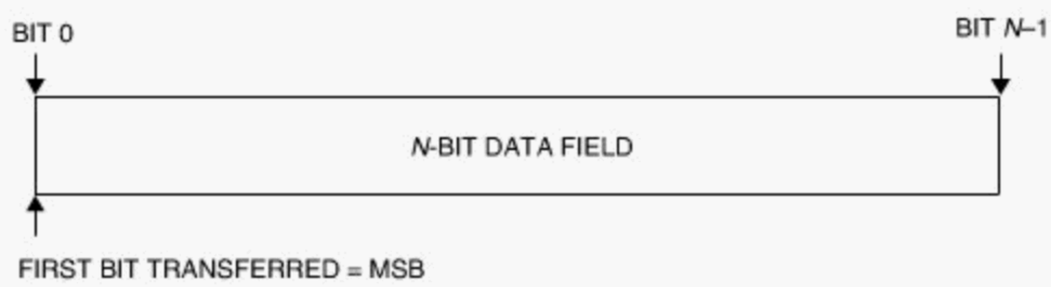

Figure 1-1: Bit Numbering Convention

In accordance with standard data-communications practice, data fields are often grouped into eight-bit 'words' which conform to the above convention. Throughout this Recommendation, such an eight-bit word is called an 'octet'.

The numbering for octets within a data structure starts with zero.

By CCSDS convention, all 'spare' bits shall be permanently set to '0'.

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1.7 REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Recommendation are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS Recommendations.

[1] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1. 2nd ed. Geneva: ISO, 1994.

[2] *Information Technology—Open Systems Interconnection—Basic Reference Model—Conventions for the Definition of OSI Services*. International Standard, ISO/IEC 10731:1994. Geneva: ISO, 1994.

[3] *Time Code Formats*. Recommendation for Space Data Systems Standards, CCSDS 301.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, January 2002.

[4] *Space Link Identifiers*. Recommendation for Space Data System Standards, CCSDS 135.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, January 2002.

NOTE – Informative references are listed in annex B.

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2 OVERVIEW

2.1 CONCEPT OF SPACE PACKET PROTOCOL

2.1.1 ARCHITECTURE

The Space Packet Protocol is designed to meet the requirements of space missions to efficiently transfer space application data of various types and characteristics over a network that involves a ground-to-space or space-to-space communications link (hereafter called space link).

Figure 2-1 illustrates where the Space Packet Protocol is located in the protocol stack. The Space Packet Protocol provides a unidirectional data transfer service from a single source user application to one or more destination user applications through one or more subnetworks. The path from the source user application to the destination user application(s) through the subnetwork(s) is called a Logical Data Path (LDP).

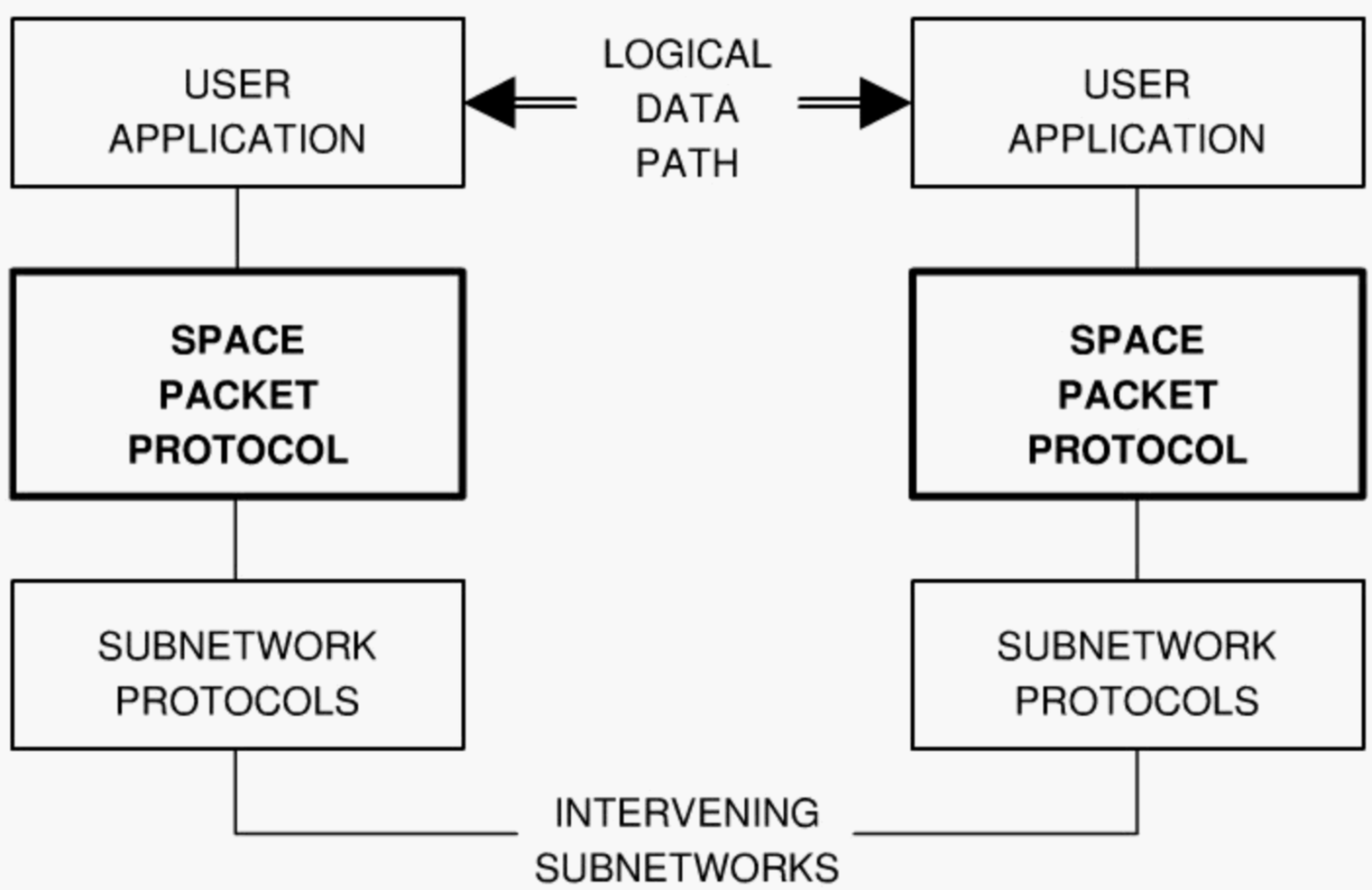

Figure 2-1: Protocol Configuration

As the data traverse the subnetworks of the LDP, they are carried by subnetwork-specific mechanisms using protocols provided by the subnetworks. The selection of protocols used in the subnetworks is determined independently for each subnetwork and may not be the same through the entire LDP.

The LDP is configured by a service of a management system before actual data transfer occurs, and can only be reconfigured through the management system. Every LDP is uniquely identified by a Path Identifier (Path ID). Each LDP consists of a single source end system, one or more destination end systems, one or more subnetworks, and, if multiple

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subnetworks are involved, one or more intermediate systems that interconnect the subnetworks. An LDP involves only one subnetwork only if the source and destination end systems are on the same subnetwork.

Figure 2-2 shows an example of an LDP from a single source user application to a single destination user application. In this example, the source and destination end systems are connected via three subnetworks interconnected by two intermediate systems.

NOTES

1 For typical configurations of LDPs, see reference [B5].

2 In some implementations, the functions of the source or destination Space Packet Protocol entity depicted in figure 2-2 may be performed by the user application itself. In such cases, the portion of the user application that performs the functions described in this Recommendation should be regarded as the Space Packet Protocol entity.

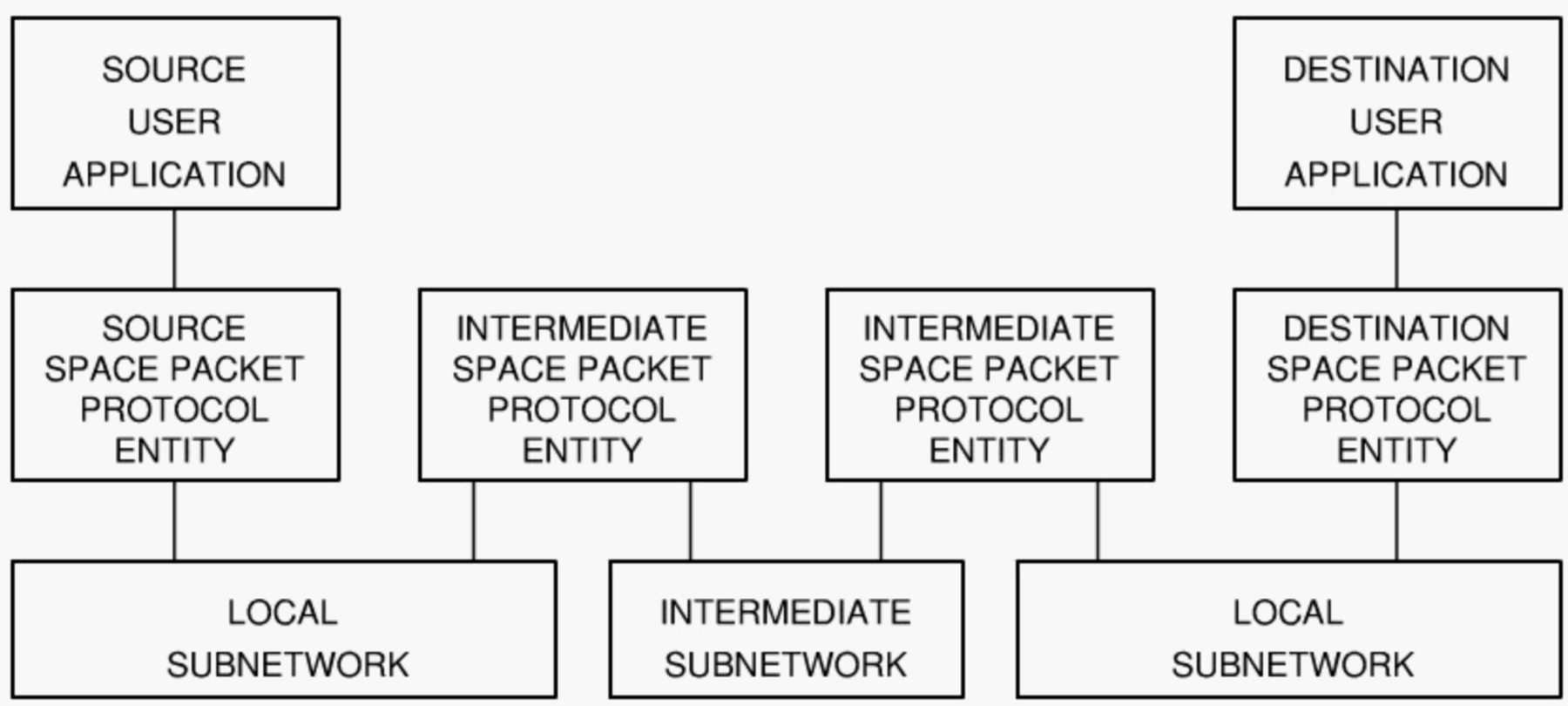

Figure 2-2: Example of a Logical Data Path

2.1.2 PROTOCOL FEATURES

The Space Packet Protocol provides the users with services to transfer space application data through an LDP. The major function performed by this protocol is the routing of application data along the LDP through underlying subnetworks.

The protocol data units employed by this protocol are Space Packets (unless otherwise stated, the term 'Packet' in this document refers to the Space Packet). They are variable in length (or may be fixed at the discretion of the user) and are transmitted at variable intervals. Aside from a header that identifies the Packet, the internal data content of Space Packets is completely under the control of the user application. Each user application can define the organization and content of Packets independently of other user applications and with a

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minimum of constraints imposed by the transmission mechanisms of the underlying subnetworks.

The Space Packet Protocol entity at the source end system either generates Space Packets from service data units supplied by the source user application, or validates Space Packets provided as service data units by the source user application. At the source and intermediate systems, the Space Packet Protocol entity examines the Path ID of incoming Space Packets and routes them through appropriate subnetworks using the mechanisms provided by the subnetworks. Routing information (i.e., mapping from Path IDs to subnetwork addresses) is provided to the Space Packet Protocol entities by management. If there are multiple destinations for an LDP, multicasting of Space Packets may be performed by one or more Space Packet Protocol entities at the source end system and/or intermediate system(s).

2.1.3 ADDRESSING

Each LDP is uniquely identified by a Path ID. A Path ID consists of an Application Process Identifier (APID) and an optional APID Qualifier.

An APID Qualifier identifies a naming domain for APIDs and APIDs are unique only in a single naming domain. An APID naming domain usually corresponds to a spacecraft (or an element of a constellation of cooperating space vehicles). Each space project shall establish APID naming domains to be used in their project. The assignment of APIDs to LDPs within a naming domain is controlled by the space project that owns the naming domain. If a system (or a subnetwork) handles only Space Packets associated with a single naming domain, the APID Qualifier need not be used in the system (or the subnetwork).

While the APID is contained in the Packet Primary Header of the Space Packet, the APID Qualifier does not appear in the data structure defined by the Space Packet Protocol. The value of the APID Qualifier is usually carried by a protocol (or protocols) of the underlying subnetworks.

If Space Packets are transferred over a space-to-ground or space-to-space communications link with one of the Space Data Link Protocols (references [B6]-[B8]), the Master Channel Identifier (MCID), carried by the Space Data Link Protocol and defined therein, shall be used as the APID Qualifier.

2.1.4 PROTOCOL DESCRIPTION

The Space Packet Protocol is described in terms of:

a) the services provided to the users;

b) the protocol data units; and

c) the procedures performed by the protocol.

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The service definitions are given in the form of primitives, which present an abstract model of the logical exchange of data and control information between the protocol entity and the service user. The definitions of primitives are independent of specific implementation approaches.

The procedure specifications define the procedures performed by protocol entities for the transfer of information between peer entities. The definitions of procedures are independent of specific implementation methods or technologies.

This protocol specification also specifies the requirements for the services provided by the underlying subnetworks.

2.2 OVERVIEW OF SERVICES

2.2.1 COMMON FEATURES OF SERVICES

The Space Packet Protocol provides users with data transfer services. The point at which a service is provided by a protocol entity to a user is called an SAP (see reference [1]). A Service Access Point of the Space Packet Protocol is identified by a Path ID and each service user is also identified by a Path ID.

Service data units submitted to a SAP are processed in the order of submission. No processing order is maintained for service data units submitted to different SAPs.

NOTE – Implementations may be required to perform flow control at a SAP between the service user and the service provider. However, CCSDS does not recommend a scheme for flow control between the user and the provider.

The followings are features common to the services defined by this Recommendation:

a) Pre-configured Services. The user can send or receive data only through a pre-configured LDP established by management.

b) Unidirectional (one way) Services. One end of an LDP can send, but not receive, data through the LDP, while the other end can receive, but not send.

c) Asynchronous Services. There are no predefined timing rules for the transfer of service data units supplied by the service user. The user may request data transfer at any time it desires, but there may be restrictions imposed by the provider on the data generation rate.

d) Unconfirmed Services: the sending user does not receive confirmation from the receiving end that data has been received.

e) Incomplete Services. The services do not guarantee completeness, nor do they provide a retransmission mechanism.

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f) Non–sequence Preserving Services. The sequence of service data units supplied by the sending user may not be preserved through the LDP.

NOTE – This protocol may be used for sending data from user A to user B and from user B to user A, but two LDPs, one for each direction, should be used in such cases.

The end-to-end quality-of-service provided to service users will vary according to the individual qualities-of-service provided by the various subnetworks along the LDP. The Space Packet Protocol does not provide any mechanisms for guaranteeing a particular quality-of-service; it is the responsibility of implementing organizations to ensure that the end-to-end performance of a particular service instance meets the requirements of its users.

2.2.2 SUMMARY OF SERVICES

2.2.2.1 General

The Space Packet Protocol provides two services: Packet Service and Octet String Service. Table 2-1 summarizes these services.

Table 2-1: Summary of Services Provided by Space Packet Protocol

Service	Service Data Unit	SAP Address
Packet	Space Packet	Path ID
Octet String	Octet String	Path ID

Each source or destination SAP of an LDP has an associated type of service, either Packet or Octet String. The service type need not be preserved from end to end of the LDP; i.e., asymmetric services may be provided. For instance, an invocation of the Octet String Service at the source end system may (at the user's request) result in an instance of the Packet Service at the destination end system(s) of the same LDP.

NOTE – As explained in 2.1.2, the protocol data unit is the Space Packet for both service types. In the case of the Packet Service, the same Space Packet is used both as the service data unit and as the protocol data unit.

2.2.2.2 Packet Service

The Packet Service transfers Space Packets, pre-formatted by the service user, intact through the LDP. The service user must generate Space Packets according to the specification given in subsection 4.1 of this Recommendation. Space Packets supplied by the service user are transferred by the service provider without further formatting.

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2.2.2.3 Octet String Service

The Octet String service transfers delimited strings of octets supplied by the service user through the LDP. The service provider transfers the strings of octets by formatting them into Space Packets.

2.3 OVERVIEW OF FUNCTIONS

2.3.1 GENERAL FUNCTIONS

The Space Packet Protocol transfers service data units, supplied by sending users, encapsulated in a sequence of protocol data units known as Space Packets, using services of underlying subnetworks. The Space Packets have variable lengths and are transferred through subnetworks asynchronously.

The protocol entity performs the following protocol functions:

a) generation (or validation) and processing of protocol control information included in the header to perform data identification;

b) routing of protocol data units through a series of underlying subnetworks;

c) multiplexing/demultiplexing in order for various service users (i.e., various LDPs) to share a logical connection provided by an underlying subnetwork.

The protocol entity does not perform the following protocol functions:

a) connection establishment and release;

b) segmenting and blocking of service data units;

c) retransmission of missing service data units;

d) flow control.

2.3.2 INTERNAL ORGANIZATION OF PROTOCOL ENTITY

Figures 2-3, 2-4, and 2-5 show the internal organization of the protocol entity of the sending, intermediate, and receiving systems, respectively. In figure 2-3, data flow from top to bottom of the figure. In figure 2-4, data flow between top and bottom in both directions. In figure 2-5, data flow from bottom to top.

These figures identify data-handling functions performed by the protocol entity. The purpose of these figures is to show logical relationships among the functions of the protocol entity. The figures are not intended to imply any hardware or software configuration in a real system. Depending on the services actually used for a real system, not all of the functions may be present in the protocol entity.

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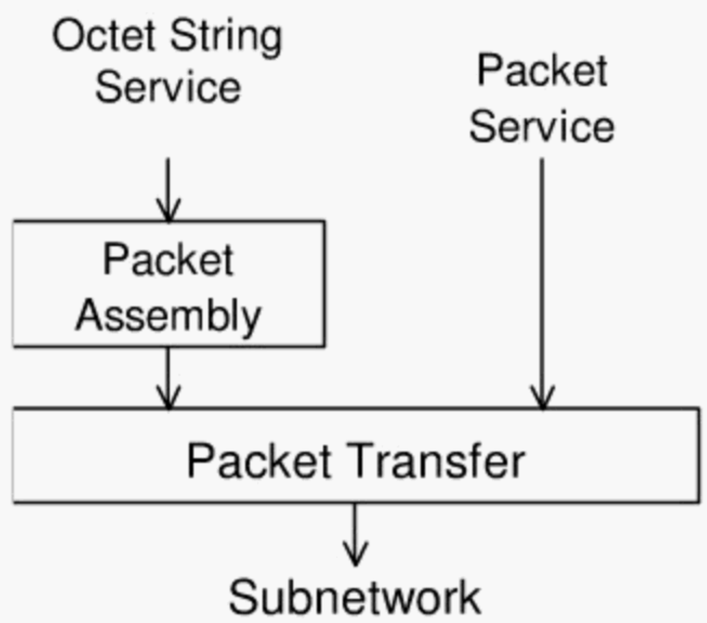

Figure 2-3: Internal Organization of Protocol Entity (Sending End)

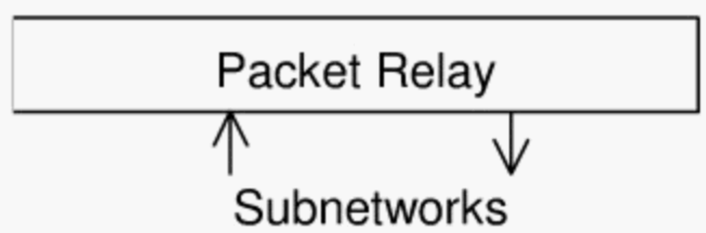

Figure 2-4: Internal Organization of Protocol Entity (Intermediate System)

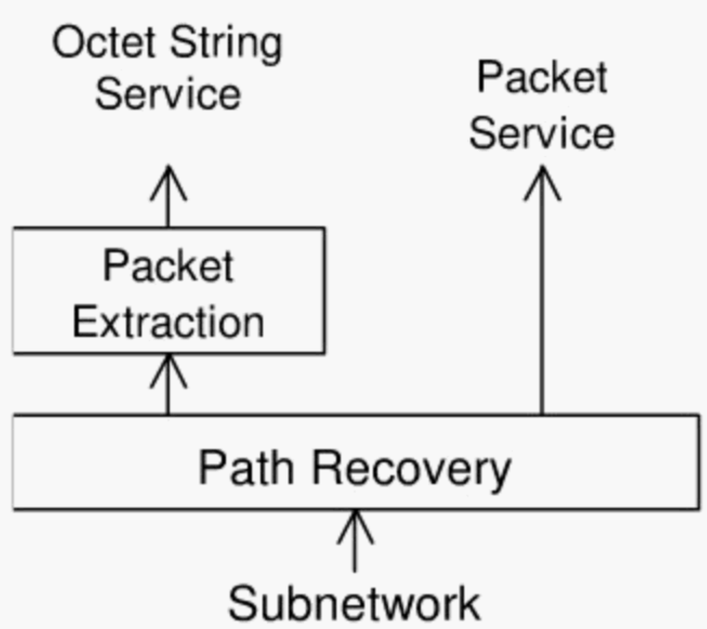

Figure 2-5: Internal Organization of Protocol Entity (Receiving End)

2.4 SERVICES ASSUMED FROM SUBNETWORKS

2.4.1 SERVICES ASSUMED FROM SUBNETWORKS

As described in 2.1.1, the Space Packet Protocol uses services provided by the underlying subnetworks. It is intended that the Space Packet Protocol be capable of operating over services derived from a wide variety of real subnetworks and data links. Therefore, in order to simplify the specifications of the protocol, its operation is defined with respect to an abstract underlying service rather than any particular real subnetwork service.

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It is assumed in this specification that the underlying subnetworks provide the following capabilities to the Space Packet Protocol:

a) addressing and routing capability in the subnetwork to be used for establishing LDPs;

b) capability for associating an APID Qualifier (see 2.1.3) with each Space Packet that traverses the subnetwork (if necessary).

2.4.2 PERFORMANCE REQUIREMENTS TO SUBNETWORKS

The performance of the underlying subnetworks shall be chosen according to the following criteria:

a) the probability of misidentifying the APID and other values in the Packet header shall be less than a mission-specified value;

b) the probability of loss of Space Packets by the subnetworks shall be less than a mission-specified value.

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3 SERVICE DEFINITION

3.1 OVERVIEW

This section provides service definition in the form of primitives, which present an abstract model of the logical exchange of data and control information between the protocol entity and the service user. The definitions of primitives are independent of specific implementation approaches.

The parameters of the primitives are specified in an abstract sense and specify the information to be made available to the user of the primitive. The way in which a specific implementation makes this information available is not constrained by this specification. In addition to the parameters specified in this section, an implementation may provide other parameters to the service user (e.g., parameters for controlling the service, monitoring performance, facilitating diagnosis, etc.).

3.2 SOURCE DATA

3.2.1 SOURCE DATA OVERVIEW

This subsection describes the service data units that are transferred from sending users to receiving users by the Space Packet Protocol.

The service data units transferred by the Space Packet Protocol are:

a) Space Packet;

b) Octet String.

3.2.2 SPACE PACKET

3.2.2.1 The Space Packet shall be a variable-length, delimited, octet-aligned data unit defined in section 4 of this Recommendation. It shall consist of at least 7 and at most 65542 octets, but individual project organizations may establish the maximum length used for their projects, taking into account the maximum service data unit size in all subnetworks traversed by the LDP.

3.2.2.2 Space Packets shall be transferred through the LDP with the Packet Service.

3.2.3 OCTET STRING

3.2.3.1 The Octet String shall be a variable-length, delimited, octet-aligned data unit whose content and format are unknown to the Space Packet Protocol. It shall consist of at least 1 and at most 65536 octets, but individual project organizations may establish the maximum

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length used for their projects, taking into account the maximum service data unit size in all subnetworks traversed by the LDP.

3.2.3.2 The Octet String may contain a Packet Secondary Header defined in 4.1.3.2 of this Recommendation.

3.2.3.3 Octet Strings shall be transferred through the LDP with the Octet String Service.

3.3 PACKET SERVICE

3.3.1 OVERVIEW OF PACKET SERVICE

The Packet Service shall transfer Space Packets, pre-formatted by the service user, intact through the LDP. The service user must generate Space Packets according to the specification given in section 4 of this Recommendation. Space Packets supplied by the service user shall be transferred by the service provider without further formatting.

3.3.2 PACKET SERVICE PARAMETERS

3.3.2.1 Space Packet

The Space Packet parameter shall be the service data unit transferred by the Packet Service.

NOTE – For restrictions on the Space Packets transferred by the Packet Service, see 3.2.2.

3.3.2.2 APID

The APID is a mandatory parameter and must be used in conjunction with the APID Qualifier (if used) to uniquely identify the LDP.

3.3.2.3 APID Qualifier

The APID Qualifier is an optional parameter that is associated with the APID of the Space Packet; it may be used to identify the naming domain of the APID. This information, when used, shall be transferred through the LDP using a service provided by underlying subnetworks.

3.3.2.4 QoS Requirement

The QoS Requirement is an optional parameter that indicates the quality-of-service requirement of each Space Packet. If one of the underlying subnetworks supports multiple levels of quality-of-service, then this parameter shall be used to select an appropriate quality-of-service level.

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NOTE – If the Telecommand (TC) Space Data Link Protocol (reference [B7]) is used as one of the protocols of the underlying subnetworks, the user can specify with this parameter whether the Type-A or Type-B service should be applied to the transfer of each Space Packet.

3.3.3 PACKET SERVICE PRIMITIVES

3.3.3.1 General

The service primitives associated with this service are:

a) PACKET.request;

b) PACKET.indication.

3.3.3.2 PACKET.request

3.3.3.2.1 Function

At the sending end, the Packet Service user shall pass a PACKET.request primitive to the service provider to request that a Packet be transferred to the user at the receiving end through the specified LDP.

NOTE – The PACKET.request primitive is the service request primitive for the Packet Service.

3.3.3.2.2 Semantics

The PACKET.request primitive shall provide parameters as follows:

PACKET.request	(Space Packet, APID, APID Qualifier (optional), QoS Requirement (optional))

3.3.3.2.3 When Generated

The PACKET.request primitive shall be passed to the service provider to request it to send the Space Packet.

3.3.3.2.4 Effect On Receipt

Receipt of the PACKET.request primitive shall cause the service provider to transfer the Space Packet.

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3.3.3.2.5 Additional Comments

The PACKET.request primitive shall be used to transfer Space Packets through the LDP identified with the APID and the optional APID Qualifier.

3.3.3.3 PACKET.indication

3.3.3.3.1 Function

At the receiving end, the service provider shall pass a PACKET.indication to the Packet Service user to deliver a Packet.

NOTE – The PACKET.indication primitive is the service indication primitive for the Packet Service.

3.3.3.3.2 Semantics

The PACKET.indication primitive shall provide parameters as follows:

```
PACKET.indication          (Space Packet,
                           APID,
                           APID Qualifier (optional))
```

3.3.3.3.3 When Generated

The PACKET.indication primitive shall be passed from the service provider to the Packet Service user at the receiving end to deliver a Space Packet.

3.3.3.3.4 Effect On Receipt

The effect of receipt of the PACKET.indication primitive by the Packet Service user is undefined.

3.3.3.3.5 Additional Comments

The PACKET.indication primitive shall be used to deliver Space Packets to the Packet Service user identified with the APID and the APID Qualifier.

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3.4 OCTET STRING SERVICE

3.4.1 OVERVIEW OF OCTET STRING SERVICE

The Octet String service shall transfer delimited strings of octets supplied by the service user through the LDP. The service provider shall transfer the strings of octets by formatting them into Space Packets.

3.4.2 OCTET STRING SERVICE PARAMETERS

3.4.2.1 Octet String

The Octet String parameter shall be the service data unit transferred by the Octet String Service.

NOTE – For restrictions on the Octet Strings transferred by the Octet String Service, see 3.2.3.

3.4.2.2 APID

The APID is a mandatory parameter and must be used in conjunction with the APID Qualifier (if used) to uniquely identify the LDP.

3.4.2.3 APID Qualifier

The APID Qualifier is an optional parameter that is associated with the APID of the Space Packet generated from the Octet String; it may be used to identify the naming domain of the APID. This information, when used, shall be transferred through the LDP using a service provided by underlying subnetworks.

3.4.2.4 Secondary Header Indicator

The Packet Primary Header shall contain a Secondary Header Flag that indicates the presence or absence of a Packet Secondary Header. The service user in the source end system shall signal whether or not a Packet Secondary Header is contained at the start of the Octet String by passing the Secondary Header Indicator parameter to the service provider. The service provider shall use the value of this parameter to set the value of the Secondary Header Flag in the Packet Primary Header.

NOTE – The Secondary Header is a feature of the Space Packet which allows additional types of information that may be useful to the user application (e.g., a time code) to be included.

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3.4.2.5 Quality of Service (QoS) Requirement

The QoS Requirement is an optional parameter that indicates the quality-of-service requirement of each Space Packet. If one of the underlying subnetworks supports multiple levels of quality-of-service, this parameter is used to select an appropriate quality-of-service level.

NOTE – If the TC Space Data Link Protocol (reference [B7]) is used as one of the protocols of the underlying subnetworks, the user can specify with this parameter whether the Type-A or Type-B service should be applied to the transfer of each Space Packet.

3.4.2.6 Data Loss Indicator

The Data Loss Indicator parameter shall be used to alert the user in a destination end system that one or more Octet Strings have been lost during transmission, as evidenced by a discontinuity in the Packet Sequence Count. This is an optional parameter, the presence or absence of which is implementation-specific. If Data Loss Indicators are to be generated by a particular implementation then they must be declared at design time and be used consistently by all parties involved in the implementation.

3.4.3 OCTET STRING SERVICE PRIMITIVES

3.4.3.1 General

The service primitives associated with this service are:

a) OCTET_STRING.request;

b) OCTET_STRING.indication.

3.4.3.2 OCTET_STRING.request

3.4.3.2.1 Function

At the sending end, the Octet String Service user shall pass an OCTET_STRING.request primitive to the service provider to request that an Octet String be transferred to the user at the receiving end through the specified LDP.

NOTE – The OCTET_STRING.request primitive is the service request primitive for the Octet String Service.

3.4.3.2.2 Semantics

The OCTET_STRING.request primitive shall provide parameters as follows:

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OCTET_STRING.request (Octet String,
APID,
APID Qualifier (optional),
Secondary Header Indicator,
QoS Requirement (optional))

3.4.3.2.3 When Generated

The OCTET_STRING.request primitive shall be passed to the service provider to request it to send the Octet String.

3.4.3.2.4 Effect On Receipt

Receipt of the OCTET_STRING.request primitive shall cause the service provider to transfer the Octet String.

3.4.3.2.5 Additional Comments

The OCTET_STRING.request primitive shall be used to transfer Octet Strings through the LDP identified with the APID and the APID Qualifier.

3.4.3.3 OCTET_STRING.indication

3.4.3.3.1 Function

At the receiving end, the service provider shall pass an OCTET_STRING.indication to the Octet String Service user to deliver an Octet String.

NOTE – The OCTET_STRING.indication primitive is the service indication primitive for the Octet String Service.

3.4.3.3.2 Semantics

The OCTET_STRING.indication primitive shall provide parameters as follows:

OCTET_STRING.indication (Octet String,
APID,
APID Qualifier (optional),
Secondary Header Indicator,
Data Loss Indicator (optional))

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3.4.3.3.3 When Generated

The OCTET_STRING.indication primitive shall be passed from the service provider to the Octet String Service user at the receiving end to deliver an Octet String.

3.4.3.3.4 Effect On Receipt

The effect of receipt of the OCTET_STRING.indication primitive by the Octet String Service user is undefined.

3.4.3.3.5 Additional Comments

The OCTET_STRING.indication primitive shall be used to deliver Octet Strings to the Octet String Service user identified with the APID and the APID Qualifier.

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4 PROTOCOL SPECIFICATION

4.1 PROTOCOL DATA UNIT

4.1.1 SPACE PACKET

NOTE – The protocol data unit of the Space Packet Protocol is the Space Packet. In this Recommendation, the Space Packet is also called the Packet.

4.1.1.1 A Space Packet shall encompass the major fields, positioned contiguously, in the following sequence:

a) Packet Primary Header (6 octets, mandatory);

b) Packet Data Field (from 1 to 65536 octets, mandatory).

4.1.1.2 A Space Packet shall consist of at least 7 and at most 65542 octets.

NOTES

1 The maximum Packet length allowed by a particular spacecraft or ground implementation may be less than the maximum specified here.

2 A Space Packet that contains Idle Data in its Packet Data Field is called an Idle Packet.

3 Idle Packets are generated by the Telemetry (TM) and Advanced Orbiting Systems (AOS) Space Data Link Protocols (references [B6] and [B8], respectively) when needed to maintain synchronization of the data transport processes.

4.1.1.3 The structural components of the Space Packet are shown in figure 4-1.

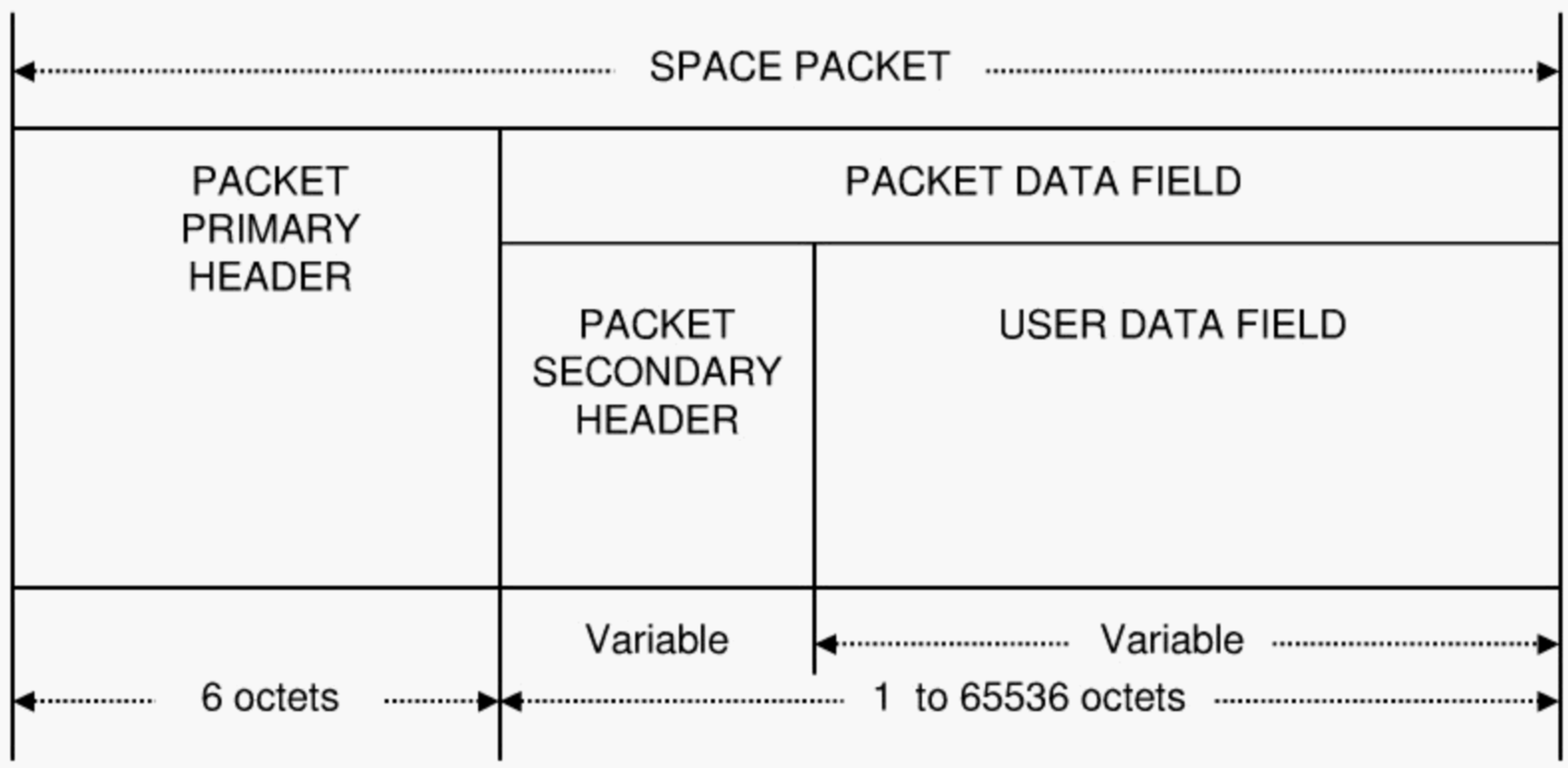

Figure 4-1: Space Packet Structural Components

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4.1.2 PACKET PRIMARY HEADER

4.1.2.1 General

The Packet Primary Header is mandatory and shall consist of four fields, positioned contiguously, in the following sequence:

a) Packet Version Number (3 bits, mandatory);

b) Packet Identification Field (13 bits, mandatory);

c) Packet Sequence Control Field (16 bits, mandatory);

d) Packet Data Length (16 bits, mandatory).

The format of the Packet Primary Header is shown in figure 4-2.

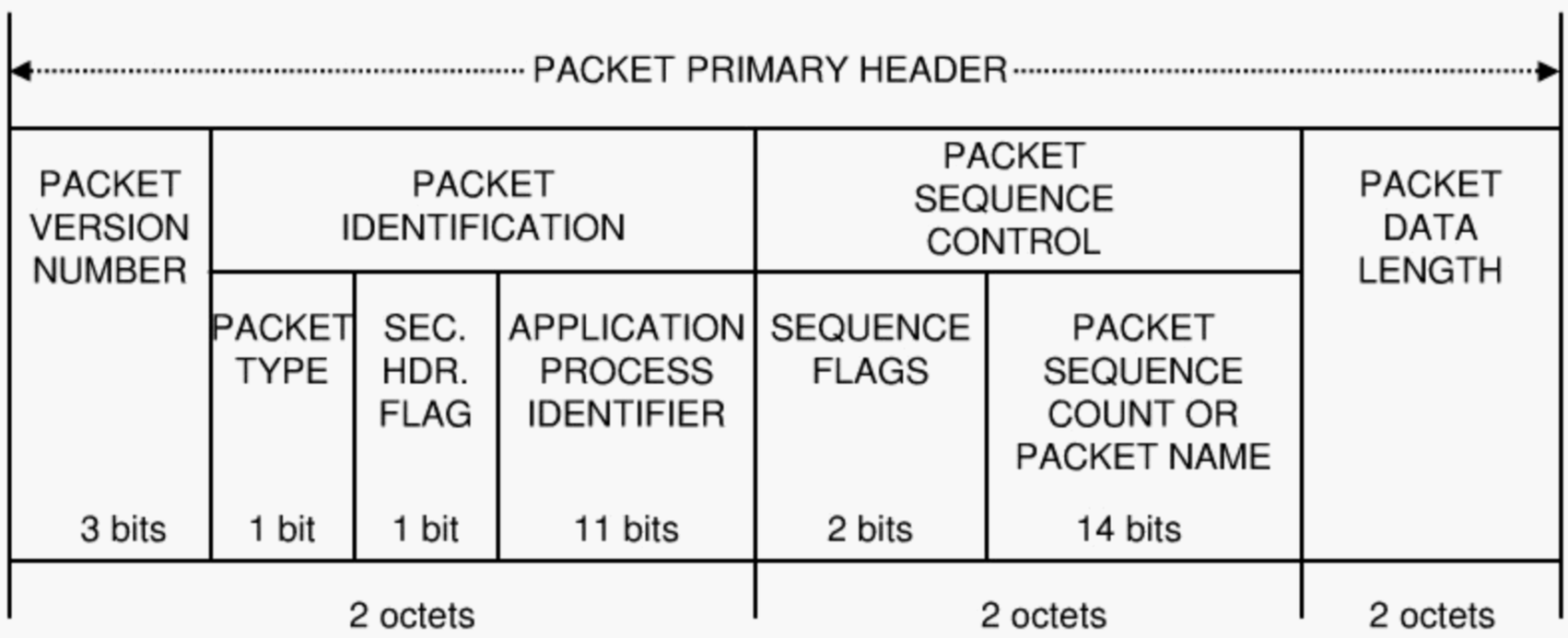

Figure 4-2: Packet Primary Header

4.1.2.2 Packet Version Number

4.1.2.2.1 Bits 0–2 of the Packet Primary Header shall contain the (binary encoded) Packet Version Number.

4.1.2.2.2 This 3-bit field shall identify the data unit as a Space Packet defined by this Recommendation; it shall be set to '000'.

NOTE – The Version Number is used to reserve the possibility of introducing other packet structures. This Recommendation defines Version 1 CCSDS Packet whose binary encoded Version Number is '000'.

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4.1.2.3 Packet Identification Field

4.1.2.3.1 General

4.1.2.3.1.1 Bits 3–15 of the Packet Primary Header shall contain the Packet Identification Field.

4.1.2.3.1.2 This 13-bit field shall be sub-divided into three sub-fields as follows:

a) Packet Type (1 bit, mandatory);

b) Secondary Header Flag (1 bit, mandatory);

c) Application Process Identifier (11 bits, mandatory).

4.1.2.3.2 Packet Type

4.1.2.3.2.1 Bit 3 of the Packet Primary Header shall contain the Packet Type.

4.1.2.3.2.2 The Packet Type shall be used to distinguish Packets used for telemetry (or reporting) from Packets used for telecommand (or requesting).

4.1.2.3.2.3 For a telemetry (or reporting) Packet, this bit shall be set to '0'; for a telecommand (or requesting) Packet, this bit shall be set to '1'.

NOTE – Usually, telemetry Packets are associated with one direction of a space link and telecommand Packets with the other direction. However, the exact definition of 'telemetry Packets' and 'telecommand Packets' should be established by the project that uses this protocol.

4.1.2.3.3 Secondary Header Flag

4.1.2.3.3.1 Bit 4 of the Packet Primary Header shall contain the Secondary Header Flag.

4.1.2.3.3.2 The Secondary Header Flag shall indicate the presence or absence of the Packet Secondary Header within this Space Packet. It shall be '1' if a Packet Secondary Header is present; it shall be '0' if a Packet Secondary Header is not present.

4.1.2.3.3.3 The Secondary Header Flag shall be static with respect to the Path ID throughout a Mission Phase.

4.1.2.3.3.4 The Secondary Header Flag shall be set to '0' for Idle Packets.

4.1.2.3.4 Application Process Identifier

4.1.2.3.4.1 Bits 5–15 of the Packet Primary Header shall contain the APID.

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4.1.2.3.4.2 The APID (possibly in conjunction with the optional APID Qualifier that identifies the naming domain for the APID) shall provide the naming mechanism for the LDP.

NOTE – The APID is unique only within its naming domain. For the discussion of naming domains, see 2.1.3 of this Recommendation.

4.1.2.3.4.3 For Idle Packets the APID shall be '11111111111', i.e., 'all ones'.

Some APIDs may be reserved by CCSDS for transferring some specific data units over space links. The user shall not use these reserved APIDs.

NOTES

1 There are no restrictions on the selection of APIDs except for the reserved APIDs (including the APID for Idle Packets) stated above. In particular, APIDs are not required to be numbered consecutively.

2 For a list of reserved APIDs, see reference [4].

4.1.2.4 Packet Sequence Control Field

4.1.2.4.1 General

4.1.2.4.1.1 Bits 16–31 of the Packet Primary Header shall contain the Packet Sequence Control Field.

4.1.2.4.1.2 This 16-bit field shall be sub-divided into two sub-fields as follows:

a) Sequence Flags (2 bits, mandatory);

b) Packet Sequence Count or Packet Name (14 bits, mandatory).

4.1.2.4.2 Sequence Flags

4.1.2.4.2.1 Bits 16–17 of the Packet Primary Header shall contain the Sequence Flags.

NOTE – The Sequence Flags are not part of the Space Packet Protocol. However, the Sequence Flags may be used by the user of the Packet Service to indicate that the User Data contained within the Space Packet is a segment of a larger set of application data.

4.1.2.4.2.2 The Sequence Flags shall be set as follows:

a) '00' if the Space Packet contains a continuation segment of User Data;

b) '01' if the Space Packet contains the first segment of User Data;

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c) '10' if the Space Packet contains the last segment of User Data;

d) '11' if the Space Packet contains unsegmented User Data.

4.1.2.4.2.3 If the Octet String service is invoked at any point within the LDP, the Sequence Flags must always be set to '11', since segmentation is not allowed within the Octet String service.

4.1.2.4.3 Packet Sequence Count or Packet Name

4.1.2.4.3.1 Bits 18–31 of the Packet Primary Header shall contain the Packet Sequence Count or the Packet Name.

4.1.2.4.3.2 For a Packet with the Packet Type set to '0' (i.e., a telemetry Packet), this field shall contain the Packet Sequence Count. For a Packet with the Packet Type set to '1' (i.e., a telecommand Packet), this field shall contain either the Packet Sequence Count or Packet Name.

4.1.2.4.3.3 The Packet Sequence Count shall provide the sequential binary count of each Space Packet generated by the user application identified by the APID.

4.1.2.4.3.4 The Packet Sequence Count shall be continuous (modulo-16384). A re-setting of the Packet Sequence Count before reaching 16383 shall not take place unless it is unavoidable.

Idle Packets shall not be required to increment the Packet Sequence Count.

NOTES

1 The purpose of the Packet Sequence Count is to order each Packet with other Packets generated by the same user application, even though their order may be disturbed during transport from the sending user to the receiving user.

2 If the Packet Sequence Count is re-set because of an unavoidable re-initialization of a process, the completeness of a sequence of Packets cannot be determined.

3 The Packet Sequence Count may be used in conjunction with a Time Code (see 4.1.3.2.2; its insertion is, however, not mandatory) to provide unambiguous ordering; it is therefore essential that the resolution of the time code is sufficient for this code to increment at least once between successive recyclings of the Packet Sequence Count.

4 The Packet Name allows a particular Packet to be identified with respect to others occurring within the same communications session. There are no restrictions on binary encoding of the Packet Name. That is, the Packet Name can be any 14-bit binary pattern.

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4.1.2.5 Packet Data Length

4.1.2.5.1.1 Bits 32–47 of the Packet Primary Header shall contain the Packet Data Length.

4.1.2.5.1.2 This 16-bit field shall contain a length count *C* that equals one fewer than the length (in octets) of the Packet Data Field.

4.1.2.5.1.3 The length count *C* shall be expressed as:

$$C = (\text{Total Number of Octets in the Packet Data Field}) - 1$$

4.1.3 PACKET DATA FIELD

4.1.3.1 General

4.1.3.1.1 The Packet Data Field is mandatory and shall consist of at least one of the following two fields, positioned contiguously, in the following sequence:

a) Packet Secondary Header (variable length);

b) User Data Field (variable length).

4.1.3.1.2 The Packet Data Field shall contain at least one octet.

4.1.3.2 Packet Secondary Header

4.1.3.2.1 General

4.1.3.2.1.1 If present, the Packet Secondary Header shall follow, without gap, the Packet Primary Header.

4.1.3.2.1.2 The Packet Secondary Header shall be mandatory if no User Data Field is present in the Packet; otherwise it is optional. The presence or absence of a Packet Secondary Header shall be signaled by the Secondary Header Flag within the Packet Identification Field (see 4.1.2.3.3).

4.1.3.2.1.3 If present, the Packet Secondary Header shall consist of an integral number of octets.

4.1.3.2.1.4 The contents of the Packet Secondary Header shall be specified by the source end user for each Path ID, and reported to the destination end user(s) by management.

NOTE – The Packet Secondary Header is not allowed for Idle Packets (see 4.1.2.3.3).

4.1.3.2.1.5 If present, the Packet Secondary Header shall consist of either:

a) a Time Code Field (variable length) only;

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b) an Ancillary Data Field (variable length) only; or

c) a Time Code Field followed by an Ancillary Data Field.

4.1.3.2.1.6 The chosen option shall remain static for a specific Path ID throughout all Mission Phases.

4.1.3.2.1.7 The format of the Packet Secondary Header is shown in figure 4-3.

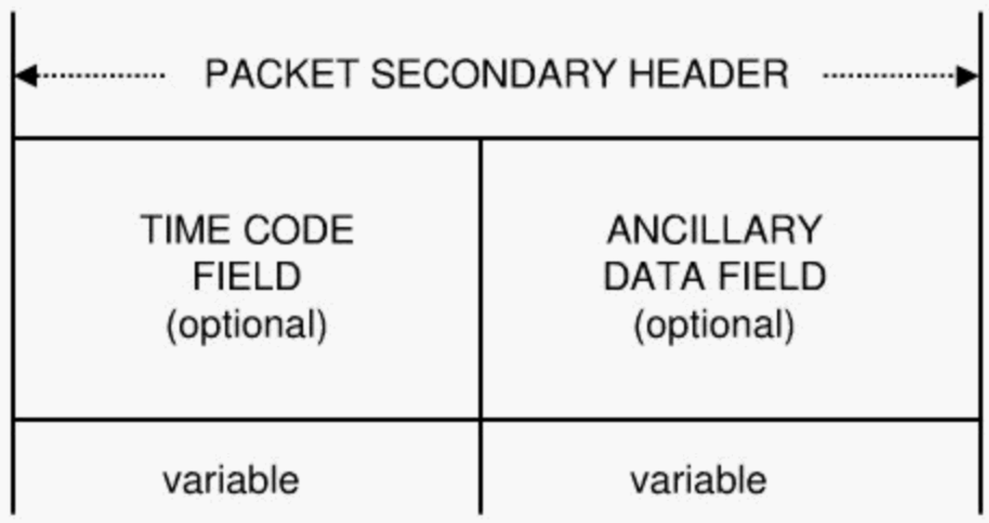

Figure 4-3: Packet Secondary Header

NOTE – The purpose of the Packet Secondary Header is to allow (but not require) a CCSDS-defined means for consistently placing ancillary data (time, internal data field format, spacecraft position/attitude, etc.) in the same location within a Space Packet.

4.1.3.2.2 Time Code Field

4.1.3.2.2.1 If present, the Time Code Field shall consist of an integral number of octets.

4.1.3.2.2.2 The Time Code Field shall consist of one of the CCSDS segmented binary or unsegmented binary time codes specified in reference [3].

NOTE – The time codes defined in reference [3] consist of an optional P-Field (Preamble Field), which identifies the time code and its characteristics and a mandatory T-Field (Time Field). Examples of time codes are CCSDS Unsegmented Time Code and CCSDS Day Segmented Time Code. Examples of characteristics are ambiguity period, epoch, length, and resolution.

4.1.3.2.2.3 The time code selected shall be fixed for a given Path ID throughout all Mission Phases.

4.1.3.2.2.4 If the characteristics of the chosen time code are fixed for a particular Path ID, the corresponding P-field (as described in reference [3]) need not be present. If the characteristics are allowed to change for a Path ID, the P-field shall be present so as to identify the changes.

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4.1.3.2.2.5 The presence or absence of the P-field in the Time Code Field shall be fixed for a particular Path ID throughout all Mission Phases. If present, it shall immediately precede the T-field that is defined in reference [3].

4.1.3.2.3 Ancillary Data Field

If present, the Ancillary Data Field shall consist of an integral number of octets.

NOTE – The content and format of the data contained in the Ancillary Data Field are not specified in this Recommendation. The Ancillary Data Field may contain any ancillary information necessary for the interpretation of the information contained within the User Data Field of the Space Packet.

4.1.3.3 User Data Field

4.1.3.3.1 If present, the User Data Field shall follow, without gap, either the Packet Secondary Header (if a Packet Secondary Header is present) or the Packet Primary Header (if a Packet Secondary Header is not present).

4.1.3.3.2 The User Data Field shall be mandatory if a Packet Secondary Header is not present; otherwise it is optional.

4.1.3.3.3 If present, the User Data Field shall consist of an integral number of octets.

4.1.3.3.4 If the Packet is not an Idle Packet, then the User Data Field shall contain application data supplied by the sending user. If the Packet is an Idle Packet, the User Data Field shall contain Idle Data.

NOTE – The bit pattern of Idle Data is not specified in this Recommendation.

4.2 PROTOCOL PROCEDURES AT THE SENDING END

4.2.1 OVERVIEW

This subsection describes procedures at the sending end associated with each of the functions shown in figure 4-4. In this figure, data flow from top to bottom of the figure. This figure identifies data-handling functions performed by the protocol entity at the sending end and shows logical relationships among these functions. This figure is not intended to imply any hardware or software configuration in a real system. Depending on the services actually used for a real system, not all of the functions may be present in the protocol entity. The procedures described in this subsection are defined in an abstract sense and are not intended to imply any particular implementation approach of a protocol entity.

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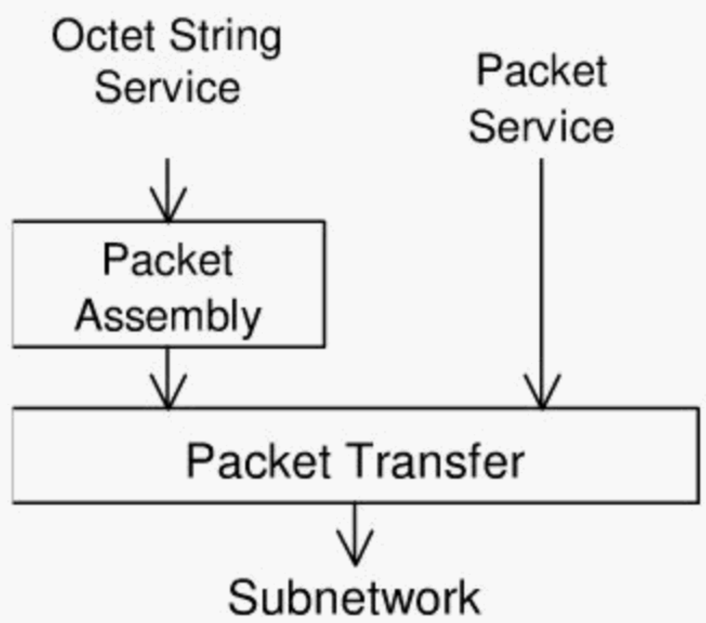

Figure 4-4: Internal Organization of Protocol Entity (Sending End)

4.2.2 PACKET ASSEMBLY FUNCTION

4.2.2.1 The Packet Assembly Function shall be used to generate Space Packets from Octet Strings.

NOTE – There is an instance of the Packet Assembly Function for each Path ID that accepts service data units with the Octet String Service.

4.2.2.2 The Packet Assembly Function receives Octet Strings from the Octet String Service user and shall build Space Packets by generating the Packet Primary Header.

4.2.2.3 The Secondary Header Indicator parameter shall be generated by the service user to indicate the presence or absence of a Packet Secondary Header at the start of Octet Strings.

4.2.2.4 The Packet Assembly Function shall translate the parameter by setting the Secondary Header Flag in the Packet Primary Header to a corresponding value. A sequence counter is maintained and shall be used to generate the Packet Sequence Count in the Packet Primary Header.

4.2.3 PACKET TRANSFER FUNCTION

4.2.3.1 The Packet Transfer Function shall be used to transfer Space Packets to the next protocol entity in the LDP using services of the underlying subnetwork.

NOTE – There is an instance of the Packet Transfer Function in each sending end system.

4.2.3.2 If necessary, the Packet Transfer Function shall multiplex Space Packets received from the instances of the Packet Assembly Function and the Packet Service users, and shall put the Space Packets into a queue, in an appropriate order that is set by management. The algorithm to be used to order the Space Packets is not specified by CCSDS, but shall be defined by project organizations considering factors such as priority, release rate, etc.

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4.2.3.3 The Packet Transfer Function, then, shall examine the Path ID of each Packet in the queue to identify the next protocol entity in the LDP of the Packet and shall transfer the Packet using a service of the underlying subnetwork. The Packet Transfer Function may transfer the Packet to multiple protocol entities which are not necessarily on the same subnetwork; i.e., it may perform a multicast function.

4.3 PROTOCOL PROCEDURES AT AN INTERMEDIATE SYSTEM

4.3.1 OVERVIEW

This subsection describes procedures at an intermediate system associated with the function shown in figure 4-5. The procedures described in this subsection are defined in an abstract sense and are not intended to imply any particular implementation approach of a protocol entity.

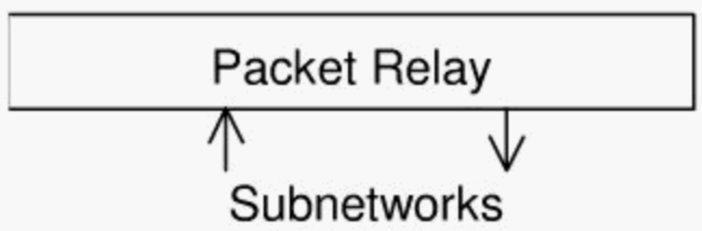

Figure 4-5: Internal Organization of Protocol Entity (Intermediate System)

4.3.2 PACKET RELAY FUNCTION

4.3.2.1 The Packet Relay Function shall be used to relay Space Packets to the next protocol entity in the LDP of each Packet using services of the underlying subnetwork.

NOTE – There is an instance of the Packet Relay Function in each intermediate system.

4.3.2.2 The Packet Relay Function shall receive Space Packets from the underlying subnetworks and shall put the Packets into a queue in an appropriate order that is set by management. The algorithm to be used to order the Space Packets is not specified by CCSDS, but shall be defined by project organizations considering factors such as priority, release rate, etc.

4.3.2.3 The Packet Relay Function, then, shall examine the Path ID of each Packet in the queue to identify the next Packet Protocol Entity in the LDP of the Packet, and shall transfer the Packet using a service of the underlying subnetwork.

4.3.2.4 If the optional APID Qualifier is used, the APID Qualifier of each received Packet shall be retrieved by a service of the subnetwork that carried the Packet. If the APID Qualifier is not used, the Path ID is derived directly from the APID of the Packet.

4.3.2.5 The Packet Relay Function may transfer the Packet to multiple protocol entities, which are not necessarily on the same subnetwork; i.e., it may perform a multicast function.

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4.3.2.6 The Packet Relay Function may temporarily store Packets, using a storage service provided by the Intermediate System, before they are transferred to the next Packet Protocol Entity, in case immediate transfer is impossible or impractical for some reason. The procedures for temporary storage of Packets are not specified by this Recommendation.

4.4 PROTOCOL PROCEDURES AT THE RECEIVING END

4.4.1 OVERVIEW

This subsection describes procedures at the receiving end associated with each of the functions shown in figure 4-6. In this figure, data flow from bottom to top of the figure. This figure identifies data-handling functions performed by the protocol entity at the receiving end and shows logical relationships among these functions. This figure is not intended to imply any hardware or software configuration in a real system. Depending on the services actually used for a real system, not all of the functions may be present in the protocol entity. The procedures described in this subsection are defined in an abstract sense and are not intended to imply any particular implementation approach of a protocol entity.

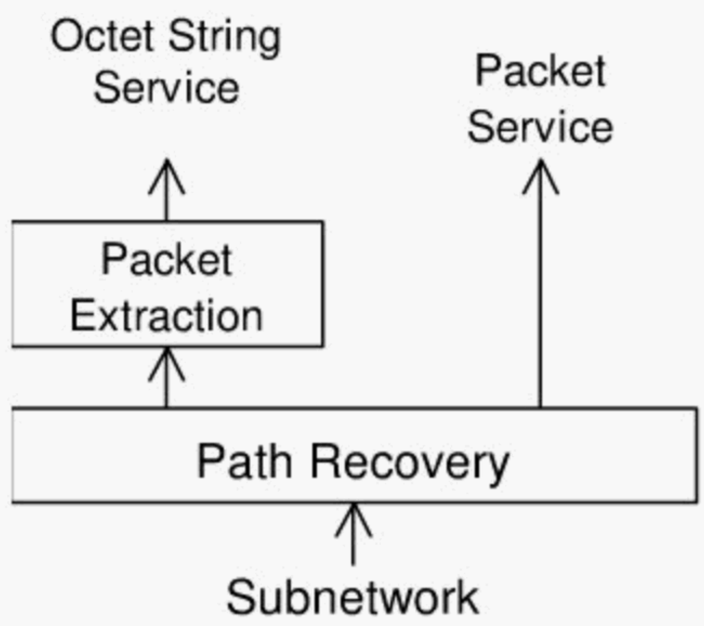

Figure 4-6: Internal Organization of Protocol Entity (Receiving End)

4.4.2 PACKET EXTRACTION FUNCTION

4.4.2.1 The Packet Extraction Function shall be used to extract service data units from Space Packets.

NOTE – There is an instance of the Packet Extraction Function for each Path ID that delivers service data units with the Octet String Service.

4.4.2.2 The Packet Extraction Function shall receive Space Packets from the Path Recovery Function and shall extract Octet Strings by stripping the Packet Primary Header. The Secondary Header Indicator parameter shall be generated by the Packet Extraction Function to indicate the presence of a Packet Secondary Header at the start of the Octet Strings. The Packet Extraction Function checks the continuity of the Packet Sequence Count

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to determine if one or more Packets have been lost during transmission and shall generate the optional Data Loss Indicator parameter accordingly.

4.4.3 PATH RECOVERY FUNCTION

4.4.3.1 The Path Recovery Function shall be used to receive and demultiplex Space Packets received from the underlying subnetwork.

NOTE – There is an instance of the Path Recovery Function in each receiving end system.

4.4.3.2 The Path Recovery Function shall receive Space Packets from the underlying subnetwork and shall demultiplex, if necessary, the received Packets on the basis of the Path ID of each Packet.

4.4.3.3 If the optional APID Qualifier is used, then the APID Qualifier of each received Packet shall be retrieved by a service of the subnetwork. If the APID Qualifier is not used, then the Path ID shall be derived directly from the APID of the Packet.

4.4.3.4 If the receiving user of the Path ID uses the Packet Service, the received Packets shall be delivered intact to the user identified by the Path ID. If the receiving user of the Path ID uses the Octet String Service, then the received Packets shall be delivered to the user through the Packet Extraction Function.

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5 MANAGED PARAMETERS

5.1 OVERVIEW OF MANAGED PARAMETERS

In order to conserve bandwidth on the space link(s) included in the LDPs, some parameters associated with the Space Packet Protocol are handled by management rather than by in-line protocol mechanisms. The managed parameters are those which tend to be static for long periods of time and whose change generally signifies a major reconfiguration of the protocol entities associated with a particular mission. Through the use of a management system, management conveys the required information to the protocol entities.

In this section, the managed parameters used by the Space Packet Protocol are listed. These parameters are defined in an abstract sense and are not intended to imply any particular implementation of a management system.

Managed parameters used by the Space Packet Protocol are classified into two categories: protocol configuration parameters and routing parameters.

5.2 PROTOCOL CONFIGURATION PARAMETERS

Table 5-1 lists the protocol configuration parameters. These parameters shall be used by each Space Packet Protocol entity.

Table 5-1: Protocol Configuration Parameters

Managed Parameter	Allowed Values
Maximum Packet Length (octets)	Integer
Packet Type of Outgoing Packets (Used only by sending systems)	0, 1
Packet Multiplexing Scheme (Used only by sending and intermediate systems)	Mission Specific
Service Type (This parameter is specified for each Path ID at the sending and receiving ends of the LDP)	Packet Service, Octet String Service

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5.3 ROUTING PARAMETERS

Table 5-2 lists the routing parameters. These parameters shall be specified for each Path ID at the sending end system and the intermediate system(s) of the LDP.

Table 5-2: Routing Parameters

Managed Parameter	Allowed Values
Subnetwork Identifier of the next Space Packet Protocol entity in the LDP	Mission Specific
Subnetwork Address of the next Space Packet Protocol entity in the LDP	Subnetwork Specific
APID Qualifier of the LDP (if used)	Mission Specific

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ANNEX A

ACRONYMS

(This annex **is not** part of the Recommendation)

APID	Application Process Identifier
ARQ	Automatic Repeat Request
CCSDS	Consultative Committee for Space Data Systems
CLCW	Communications Link Control Word
COP	Communications Operation Procedure
FARM	Frame Acceptance and Reporting Mechanism
FDU	Frame Data Unit
FOP	Frame Operation Procedure
GMAP ID	Global Multiplexer Access Point Identifier
GVCID	Global Virtual Channel Identifier
MAP ID	Multiplexer Access Point Identifier
MAP	Multiplexer Access Point
MAPA	Multiplexer Access Point Access
MAPP	Multiplexer Access Point Packet
MC	Master Channel
MCF	Master Channel Frame
MCID	Master Channel Identifier
MSB	Most Significant Bit
OSI	Open Systems Interconnection
PVN	Packet Version Number
QoS	Quality of Service
SAP	Service Access Point

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SCID	Spacecraft Identifier
SDU	Service Data Unit
TC	Telecommand
TFVN	Transfer Frame Version Number
VC	Virtual Channel
VCA	Virtual Channel Access
VCF	Virtual Channel Frame
VCID	Virtual Channel Identifier
VCP	Virtual Channel Packet

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ANNEX B

INFORMATIVE REFERENCES

(This annex **is not** part of the Recommendation)

[B1] *Procedures Manual for the Consultative Committee for Space Data Systems*. CCSDS A00.0-Y-8. Yellow Book. Issue 8. Washington, D.C.: CCSDS, July 2002.

[B2] *Packet Telemetry*. Recommendation for Space Data System Standards, CCSDS 102.0-B-5. Blue Book. Issue 5. Washington, D.C.: CCSDS, November 2000.

[B3] *Telecommand Part 3—Data Management Service*. Recommendation for Space Data System Standards, CCSDS 203.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, June 2001.

[B4] *Advanced Orbiting Systems, Networks and Data Links: Architectural Specification*. Recommendation for Space Data Systems Standards, CCSDS 701.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, June 2001.

[B5] *Overview of Space Link Protocols*. Report Concerning Space Data System Standards, CCSDS 130.0-G-1. Green Book. Issue 1. Washington, D.C.: CCSDS, June 2001.

[B6] *TM Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 132.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.

[B7] *TC Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 232.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.

[B8] *AOS Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 732.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.

NOTE – Normative references are listed in 1.7.

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ANNEX C

CHANGES FROM REFERENCES [B2]-[B4]

(This annex **is not** part of the Recommendation)

C1 GENERAL

This Recommendation is developed from the specification of the packet portion of references [B2]-[B4], but a few technical specifications in these references have been changed in order to unify the specifications in references [B2]-[B4]. These technical changes are described in C2. Also, some technical terms in references [B2]-[B4] have been changed in order to unify the terminology used in all the CCSDS Recommendations that define space link protocols and to define this protocol as a general communications protocol. These terminology changes are listed in C3.

C2 TECHNICAL CHANGES

C2.1 QUALITY OF SERVICE REQUIREMENT

An underlying protocol used to support this protocol may provide multiple levels of quality-of-service (for example, the TC Space Data Link Protocol defined in reference [B7] provides two levels of quality of service: Type-A and Type-B). In order for the user to specify the quality of service to be applied to each Space Packet in such a case, a parameter called the QoS Requirement is added in the service request primitives defined in reference [B4].

C2.2 PACKET TYPE

In reference [B4] the Type field of the Packet is not used. However, in order to unify the packet specifications of references [B2]-[B4], the Type field must be used in this Recommendation. However, the exact definition of the values of this field shall be established by the project (see 4.1.2.3.2 of this Recommendation).

C2.3 FIRST BIT IN THE PACKET SECONDARY HEADER

The rule on the usage of the first bit in the Secondary Header specified in reference [B3] (in the second paragraph of 5.2.2) has been deleted in order to unify the packet specifications of references [B2]-[B4].

C2.4 TIME CODE IN THE PACKET SECONDARY HEADER

In reference [B4] a CCSDS time code specified in reference [3] is preferred as the time code used in the Packet Secondary Header, while it is mandatory in reference [B2]. In order to unify the packet specifications and to guarantee interoperability of packets, a CCSDS time code is mandatory in this Recommendation.

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C3 TERMINOLOGY CHANGES

Tables C-1, C-2, and C-3 list the terms that have been changed from references [B2], [B3] and [B4], respectively.

Table C-1: Terms That Have Been Changed from Reference [B2]

Terms Used in Reference [B2]	Terms Used in This Recommendation
Grouping Flags	Sequence Flags
Packet Secondary Header Data Field	Ancillary Data Field
Packet Secondary Header Flag	Secondary Header Flag
Source Data	User Data
Source Sequence Count	Packet Sequence Count
Type Indicator	Packet Type
Version Number	Packet Version Number

Table C-2: Terms That Have Been Changed from Reference [B3]

Terms Used in Reference [B3]	Terms Used in This Recommendation
Application Data	User Data
Packet Length	Packet Data Length
Packetization Layer	(No longer used)
Primary Header	Packet Primary Header
Secondary Header	Packet Secondary Header
Type	Packet Type
Version Number	Packet Version Number

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Table C-3: Terms That Have Been Changed from Reference [B4]

Terms Used in Reference [B4]	Terms Used in This Recommendation
CCSDS Packet	Space Packet
CP_PDU	Space Packet
CP_SDU	Space Packet or Octet String
O_SDU	Octet String
P_SDU	Space Packet
Packet Length	Packet Data Length
Path Layer	(No longer used)
Primary Header	Packet Primary Header
Secondary Header	Packet Secondary Header
Transfer Function	Packet Transfer Function or Packet Relay Function
Type	Packet Type
Version Number	Packet Version Number

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