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Space data and information transfer systems — Bundle protocol specification

Systèmes de transfert des données et informations spatiales — Spécifications du protocole groupé CCSDS

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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ISO 21323 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 734.2-B-1, September 2015) 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*.

STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of its members. 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 **Recommended Standards** and are not considered binding on any Agency.

This **Recommended Standard** is issued by, and represents the consensus of, the CCSDS members. Endorsement of this **Recommendation** is entirely voluntary. Endorsement, however, indicates the following understandings:

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FOREWORD

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CCSDS has processes for identifying patent issues and for securing from the patent holder agreement that all licensing policies are reasonable and non-discriminatory. However, CCSDS does not have a patent law staff, and CCSDS shall not be held responsible for identifying any or all such patent rights.

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

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DOCUMENT CONTROL

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CCSDS 734.2-B-1	CCSDS Bundle Protocol Specification, Recommended Standard, Issue 1	September 2015	Original issue

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1 INTRODUCTION

1.1 PURPOSE

This document defines a Recommended Standard for the CCSDS Bundle Protocol (BP), based on the Bundle Protocol of RFC 5050 (reference [1]), which defines end-to-end protocol, block formats, and abstract service descriptions for the exchange of messages (bundles) that support Delay Tolerant Networking (DTN). BP provides Network Layer service to applications allowing them to utilize BP's capabilities:

– custody-based retransmission;

– ability to cope with intermittent connectivity;

– ability to take advantage of scheduled, predicted, and opportunistic connectivity (in addition to continuous connectivity);

– notional data accountability with built-in status reporting.

1.2 SCOPE

This Recommended Standard is designed to be applicable to any kind of space mission or infrastructure that is communication-resource poor and is subject to long latencies and/or temporary network partitions, regardless of complexity. It is intended that this Recommended Standard become a uniform standard among all CCSDS Agencies. In addition, this specification exists to utilize the underlying service of various internetworking protocols both onboard and in transit between ground and space-based assets.

This Recommended Standard is intended to be applied to all systems that claim conformance to the CCSDS Bundle Protocol. It is agnostic to the choice of underlying transmission protocol in that BP can function over AOS, Space Packet, Proximity-1 Space Link Protocol, and various Internet and ground based protocols.

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. The concept and rationale for the use of a bundle protocol in space links may be found in reference [H1].

1.3 ORGANIZATION OF THIS RECOMMENDED STANDARD

This Recommended Standard is organized as follows:

– Section 2 contains an overview of the Bundle Protocol and the references from which it is derived.

– Section 3 contains the CCSDS modification to RFC 5050.

– Section 4 contains the service descriptions.

– Section 5 contains services BP requires of the system.

– Section 6 contains conformance requirements.
– Annex A contains the Implementation Conformance Statement for the protocol.
– Annex B contains the Convergence Layer Adapters (CLAs).
– Annex C contains the Extended Class of Service specification.
– Annex D contains the Aggregate Custody Signal specification.
– Annex E contains the Delay Tolerant Payload Conditioning specification.
– Annex F contains BP managed information.
– Annex G contains Security, Space Assigned Numbers Authority (SANA), and Patent Considerations.
– Annex H contains Informative References.
– Annex I contains abbreviations and acronyms used in this document.

1.4 DEFINITIONS

1.4.1 DEFINITIONS FROM OPEN SYSTEMS INTERCONNECTION (OSI) SERVICE DEFINITION CONVENTIONS

This Recommended Standard makes use of a number of terms defined in reference [2]. As used in this Recommended Standard those terms are to be interpreted 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:

– indication;
– primitive;
– request;
– response.

1.4.2 DEFINITIONS FROM OSI BASIC REFERENCE MODEL

This Recommended Standard makes use of a number of terms defined in reference [3]. As used in this Recommended Standard those terms are to 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:

– entity;
– Protocol Data Unit (PDU);
– service;
– Service Data Unit (SDU).

1.4.3 DEFINITIONS FROM RFC 5050

1.4.3.1 Overview

This Recommended Standard makes use of a number of terms defined in reference [1]. Some of the definitions needed for section 2 of this document are reproduced here for convenience.

A graphical representation of a bundle node is given in figure 1-1. A bundle node is any entity that can send and/or receive bundles.

Each bundle node has three conceptual components described in more detail below: a 'bundle protocol agent', a set of zero or more 'convergence layer adapters', and an 'application agent'. The major components are illustrated in figure 1-1 and include the addition of storage for enqueued traffic and a Management Information Base (MIB) element.

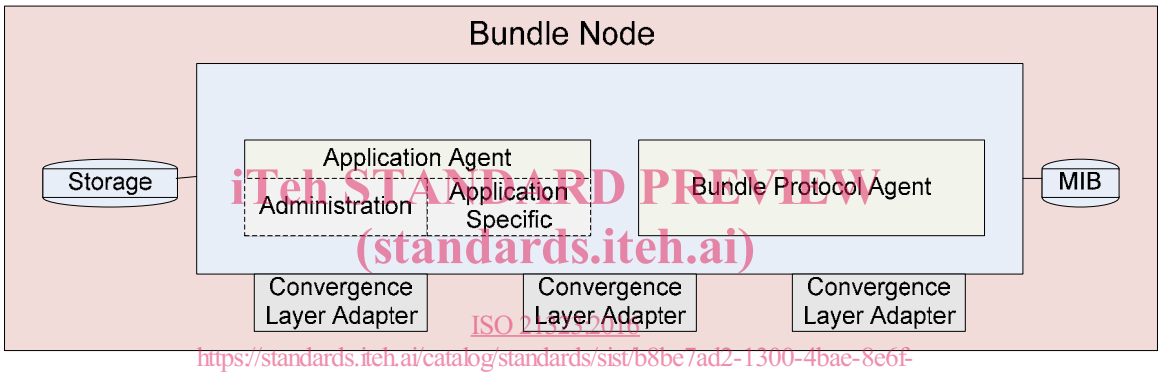

Figure 1-1: Graphical Representation of a Bundle Node

It should be noted that there is *one* application agent per conceptual bundle node. That application may register in multiple endpoints (may provide multiple endpoint identifiers to the bundle protocol agent, requesting delivery of bundles to any of those endpoints).

1.4.3.2 RFC 5050 Terms

bundle: A protocol data unit of the DTN Bundle Protocol.

NOTE – Each bundle comprises a sequence of two or more 'blocks' of protocol data, which serve various purposes. Multiple instances of the same bundle (the same unit of DTN protocol data) might exist concurrently in different parts of a network, possibly in different representations, in the memory local to one or more bundle nodes, and/or in transit between nodes. In the context of the operation of a bundle node, a bundle is an instance of some bundle in the network that is in that node's local memory.

bundle node (also simply 'node' or 'BP node'): Any entity that can send and/or receive bundles.

NOTE – In the most familiar case, a bundle node is instantiated as a single process running on a general-purpose computer, but in general the definition is meant to be broader: a bundle node might alternatively be a thread, an object in an object-oriented operating system, a special-purpose hardware device, etc. Each bundle node has three conceptual components, defined below: a 'bundle protocol agent', a set of zero or more 'convergence layer adapters', and an 'application agent'.

bundle protocol agent, BPA: Node component that offers the BP services and executes the procedures of the Bundle Protocol.

NOTE – The manner in which it does so is an implementation matter. BPA functionality can be coded into individual nodes, as a shared library that is shared by any number of bundle nodes on a single computer, as a daemon whose services are invoked via inter-process or network communication by one or more bundle nodes on one or more computers, or in hardware.

application agent, AA: Node component that utilizes the BP services to effect communication for some purpose.

NOTE – The AA has an application-specific element and administrative element. The application-specific element of an AA constructs, as defined in section 5 of RFC 5050, requests transmission of, accepts delivery of, and processes application-specific application data units; the only interface between the BPA and the application-specific element of the AA is the BP service interface. The administrative element of an AA constructs and requests transmission of administrative records as defined in section 6 of RFC 5050. It accepts delivery of and processes any custody signals that the node receives. In addition to the BP service interface, there is a (conceptual) private control interface between the BPA and the administrative element of the AA that enables each to direct the other to take action under specific circumstances. For a node that serves simply as a 'router' in the overlay network, the AA may have no application-specific element at all. The application-specific elements of other nodes' AAs may perform arbitrarily complex application functions, perhaps even offering multiplexed DTN communication services to a number of other applications. As with the BPA, the way AA performs its functions is wholly an implementation matter; in particular, the administrative element of an AA might be built into the library or daemon or hardware that implements the BPA, and the application-specific element of an AA might be implemented either in software or in hardware.

convergence layer adapter, CLA: Adapter that sends and receives bundles on behalf of the BPA.

NOTE – A CLA enables the BPA to interact with an underlying data transport mechanism such as a link or network to send and receive bundles. The manner in which a CLA sends and receives bundles is an implementation matter and is unique to the underlying transport mechanism. Therefore the BPA may utilize CLAs from a number of different underlying transport mechanisms subject to the routing of traffic.

1.5 REFERENCES

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

[1] K. Scott and S. Burleigh. *Bundle Protocol Specification*. RFC 5050. Reston, Virginia: ISOC, November 2007.

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

[4] S. Burleigh. *Compressed Bundle Header Encoding (CBHE)*. RFC 6260. Reston, Virginia: ISOC, May 2011.

[5] Space Assigned Numbers Authority (SANA). http://sanaregistry.org/.

[6] *Licklider Transmission Protocol (LTP) for CCSDS*. Issue 1. Recommendation for Space Data System Standards (Blue Book), CCSDS 734.1-B-1. Washington, D.C.: CCSDS, May 2015.

[7] L. Eggert and G. Fairhurst. *Unicast UDP Usage Guidelines for Application Designers*. RFC 5405. Reston, Virginia: ISOC, November 2008.

[8] *Encapsulation Service*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 133.1-B-2. Washington, D.C.: CCSDS, October 2009.

[9] M. Ramadas, S. Burleigh, and S. Farrell. *Licklider Transmission Protocol—Specification*. RFC 5326. Reston, Virginia: ISOC, September 2008.

[10] M. Blanchet. *Delay-Tolerant Networking Bundle Protocol IANA Registries*. RFC 6255. Reston, Virginia: ISOC, May 2011.

2 OVERVIEW

2.1 GENERAL

Delay Tolerant Networking is an end-to-end network service providing communications in and/or through environments characterized by one or more of the following:

– intermittent connectivity;

– variable delays, which may be large and irregular;

– high bit error rates;

– asymmetric and simplex links.

One core element of DTN is the BP. BP provides end-to-end network services, operating above the data transport services provided by links or networks accessed via the CLAs, and forming a store-and-forward network. Key capabilities of the Bundle Protocol include:

– ability to cope with intermittent connectivity;

– ability to take advantage of scheduled and opportunistic connectivity (in addition to 'always up' connectivity);

– custody transfer;

– hop-by-hop security (authentication of transmitting entity);

– end-to-end security (confidentiality, integrity) for data;

– late binding of names to addresses.

Reference [H1] contains descriptions of these capabilities and rationale for the DTN architecture.

The Bundle Protocol uses the 'native' local protocols for communications within a given network. The interface between the Bundle Protocol and a specific lower-layer protocol suite is known as a convergence layer. Figure 2-1 shows an example configuration with the Bundle Protocol and a convergence layer adaptor running above a transport protocol (intended to be interpreted in the context of the Internet stack) on the left, and running directly over a Data Link Layer on the right. The 'CL B' on the right could, for example, be the interface to the Licklider Transmission Protocol with the 'Link B1' representing LTP running over one of the CCSDS Data Link Layer protocols. Alternatively BP could be used to connect together two internets that may exist, such as an on-orbit (or lunar) network and a ground network.