JPL D-48259

Interplanetary Overlay Network (ION)
Design and Operation

V4.0.1

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DOCUMENT CHANGE LOG

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V4.0.1	11/20/2020		ION 4.0.1 release features.	Skipped V4.0.0.
V3.6.2	11/19/2018		ION 3.6.2 release features.	Skipped V3.6.1.
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V3.1	9/28/2012		ION 3.1 release features.	
V3.0	3/22/2012		Align with ION 3.0 release	
V1.13	10/13/2011		Updates for SourceForge release	
V1.12	6/11/2010		Updates for second open source release (2.2)	
V1.11	12/11/2009		BRS updates, multi-node config.	
V1.10	10/23/2009		Final additions prior to DINET 2 experiment	
V1.9	6/29/2009		Add updates for DINET 2, including CFDP, ionsec.	
V1.8	2/6/2009		Update discussion of Contact Graph Routing; document status msg formats.	
V1.7	12/1/2008		Add documentation for one-way-light-time simulators, BP extension interface.	
V1.6	10/03/2008		Add documentation of sm_SemUnend.	
V1.5	09/20/2008		Revisions requested by JPL SQA.	
V1.4	07/31/2008		Add a section on optimizing an ION-based network; tuning.	
V1.3	07/08/2008		Revised some details of Contact Graph Routing.	
V1.2	05/24/2008		Revised man pages for bptrace, ltprc, bprc.	
V1.1	05/18/2008		Some additional diagrams.	
V1.0	04/28/2008		Initial version of the ION design and ops manual.	

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1 Design

The Interplanetary Overlay Network (ION) software distribution is an implementation of Delay-Tolerant Networking (DTN) architecture as described in Internet RFC 4838. It is designed to enable inexpensive insertion of DTN functionality into embedded systems such as robotic spacecraft. The intent of ION deployment in space flight mission systems is to reduce cost and risk in mission communications by simplifying the construction and operation of automated digital data communication networks spanning space links, planetary surface links, and terrestrial links.

A comprehensive overview of DTN is beyond the scope of this document. Very briefly, though, DTN is a digital communication networking technology that enables data to be conveyed between two communicating entities automatically and reliably even if one or more of the network links in the end-to-end path between those entities is subject to very long signal propagation latency and/or prolonged intervals of unavailability.

The DTN architecture is much like the architecture of the Internet, except that it is one layer higher in the familiar ISO protocol "stack". The DTN analog to the Internet Protocol (IP), called "Bundle Protocol" (BP), is designed to function as an "overlay" network protocol that interconnects "internets" – including both Internet-structured networks and also data paths that utilize only space communication links as defined by the Consultative Committee for Space Data Systems (CCSDS) – in much the same way that IP interconnects "subnets" such as those built on Ethernet, SONET, etc. By implementing the DTN architecture, ION provides communication software configured as a protocol stack that looks like this:

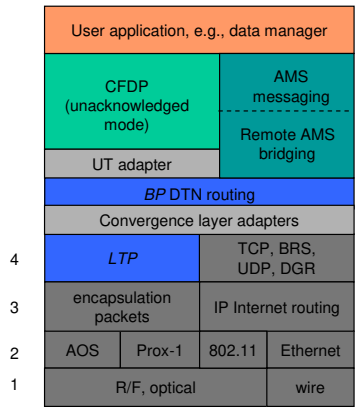


Figure 1 DTN protocol stack

Data traversing a DTN are conveyed in DTN *bundles* – which are functionally analogous to IP packets – between BP *endpoints* which are functionally analogous to sockets. Multiple BP endpoints may be accessed at a single DTN *node* – functionally analogous to a network interface card – and multiple nodes may reside on the same computer just as a

single computer (host or router) in the Internet may have multiple network interface cards.

BP endpoints are identified by Universal Record Identifiers (URIs), which are ASCII text strings of the general form:

scheme_name:*scheme_specific_part*

For example:

dtn://topquark.caltech.edu/mail

But for space flight communications this general textual representation might impose more transmission overhead than missions can afford. For this reason, ION is optimized for networks of endpoints whose IDs conform more narrowly to the following scheme:

ipn:*node_number.service_number*

This enables them to be abbreviated to pairs of unsigned binary integers via a technique called Compressed Bundle Header Encoding (CBHE). CBHE-conformant BP *endpoint IDs* (EIDs) are not only functionally similar to Internet socket addresses but also structurally similar: node numbers are roughly analogous to Internet node numbers (IP addresses), in that they typically identify the flight or ground data system computers on which network software executes, and service numbers are roughly analogous to TCP and UDP port numbers.

More generally, the node numbers in CBHE-conformant BP endpoint IDs are one manifestation of the fundamental ION notion of *network node number*: in the ION architecture there is a natural one-to-one mapping not only between node numbers and BP endpoint node numbers but also between node numbers and:

- LTP engine IDs
- AMS continuum numbers
- CFDP entity numbers

Starting with version 3.1 of ION, this endpoint naming rule is experimentally extended to accommodate *bundle multicast*, i.e., the delivery of copies of a single transmitted bundle to multiple nodes at which interest in that bundle's payload has been expressed. Multicast in ION – "Interplanetary Multicast" (IMC) – is accomplished by simply issuing a bundle whose destination endpoint ID conforms to the following scheme:

imc:*group_number.service_number*

A copy of the bundle will automatically be delivered at every node that has registered in the destination endpoint.

(Note: for now, the operational significance of a given group number must be privately negotiated among ION users. If this multicast mechanism proves useful, IANA may at some point establish a registry for IMC group numbers. **Also note that a new mechanism for bundle multicast is introduced in ION 4.0.1, along with support for Bundle Protocol version 7.** This new mechanism vastly simplifies bundle multicast; chiefly, the **imcadmin** utility is deprecated.)

1.1 Structure and function

The ION distribution comprises the following software packages:

- ici (Interplanetary Communication Infrastructure), a set of general-purpose libraries providing common functionality to the other packages. The ici package includes a security policy component that supports the implementation of security mechanisms at multiple layers of the protocol stack.
- ltp (Licklider Transmission Protocol), a core DTN protocol that provides transmission reliability based on delay-tolerant acknowledgments, timeouts, and retransmissions. The LTP specification is defined in Internet RFC 5326.
- bp (Bundle Protocol), a core DTN protocol that provides delay-tolerant forwarding of data through a network in which continuous end-to-end connectivity is never assured, including support for delay-tolerant dynamic routing. The BP specification is defined in Internet RFC 5050.
- dgr (Datagram Retransmission), an alternative implementation of LTP that is designed for use in the Internet. Equipped with algorithms for TCP-like congestion control, DGR enables data to be transmitted via UDP with reliability comparable to that provided by TCP. The dgr system is provided primarily for the conveyance of Meta-AMS (see below) protocol traffic in an Internet-like environment.
- ams (Asynchronous Message Service), an application-layer service that is not part of the DTN architecture but utilizes underlying DTN protocols. AMS comprises three protocols supporting the distribution of brief messages within a network:
    - The core AAMS (Application AMS) protocol, which does message distribution on both the publish/subscribe model and the client/server model, as required by the application.
    - The MAMS (Meta-AMS) protocol, which distributes control information enabling the operation of the Application AMS protocol.
    - The RAMS (Remote AMS) protocol, which performs aggregated message distribution to end nodes that may be numerous and/or accessible only over very expensive links, using an aggregation tree structure similar to the distribution trees used by Internet multicast technologies.
- cfdp (CCSDS File Delivery Protocol), another application-layer service that is not part of the DTN architecture but utilizes underlying DTN protocols. CFDP performs the segmentation, transmission, reception, reassembly, and delivery of files in a delay-tolerant manner. ION's implementation of CFDP conforms to the "class 1" definition of the protocol in the CFDP standard, utilizing DTN (BP, nominally over LTP) as its "unitdata transport" layer.
- bss (Bundle Streaming Service), a system for efficient data streaming over a delay-tolerant network. The bss package includes (a) a convergence-layer protocol (bssp) that preserves in-order arrival of all data that were never lost en route, yet ensures that all data arrive at the destination eventually, and (b) a library

for building delay-tolerant streaming applications, which enables low-latency presentation of streamed data received in real time while offering rewind/playback capability for the entire stream including late-arriving retransmitted data.

- tc (Trusted Collective), a system for propagating critical yet non-confidential information in a trustworthy manner. tc can be thought of as a delay-tolerant functional analog to the servers in client/server architectures. Multiple applications may make use of the tc system, but currently only one tc application is bundled with ION: dtka (delay-tolerant key administration), which provides delay-tolerant public key infrastructure.

Taken together, the packages included in the ION software distribution constitute a communication capability characterized by the following operational features:

- Reliable conveyance of data over a delay-tolerant network (*dtnet*), i.e., a network in which it might never be possible for any node to have reliable information about the detailed current state of any other node.
- Built on this capability, reliable data streaming, reliable file delivery, and reliable distribution of short messages to multiple recipients (subscribers) residing in such a network.
- Management of traffic through such a network, taking into consideration:
    - requirements for data security
    - scheduled times and durations of communication opportunities
    - fluctuating limits on data storage and transmission resources
    - data rate asymmetry
    - the sizes of application data units
    - and user-specified final destination, priority, and useful lifetime for those data units.
- Facilities for monitoring the performance of the network.
- Robustness against node failure.
- Portability across heterogeneous computing platforms.
- High speed with low overhead.
- Easy integration with heterogeneous underlying communication infrastructure, ranging from Internet to dedicated spacecraft communication links.

1.2 Constraints on the Design

A DTN implementation intended to function in an interplanetary network environment – specifically, aboard interplanetary research spacecraft separated from Earth and from one another by vast distances – must operate successfully within two general classes of design constraints: link constraints and processor constraints.

1.2.1 Link constraints

All communications among interplanetary spacecraft are, obviously, wireless. Less obviously, those wireless links are generally slow and are usually asymmetric.

The electrical power provided to on-board radios is limited and antennae are relatively small, so signals are weak. This limits the speed at which data can be transmitted intelligibly from an interplanetary spacecraft to Earth, usually to some rate on the order of 256 Kbps to 6 Mbps.

The electrical power provided to transmitters on Earth is certainly much greater, but the sensitivity of receivers on spacecraft is again constrained by limited power and antenna mass allowances. Because historically the volume of command traffic that had to be sent to spacecraft was far less than the volume of telemetry the spacecraft were expected to return, spacecraft receivers have historically been engineered for even lower data rates from Earth to the spacecraft, on the order of 1 to 2 Kbps.

As a result, the cost per octet of data transmission or reception is high and the links are heavily subscribed. Economical use of transmission and reception opportunities is therefore important, and transmission is designed to enable useful information to be obtained from brief communication opportunities: units of transmission are typically small, and the immediate delivery of even a small part (carefully delimited) of a large data object may be preferable to deferring delivery of the entire object until all parts have been acquired.

1.2.2 Processor constraints

The computing capability aboard a robotic interplanetary spacecraft is typically quite different from that provided by an engineering workstation on Earth. In part this is due, again, to the limited available electrical power and limited mass allowance within which a flight computer must operate. But these factors are exacerbated by the often intense radiation environment of deep space. In order to minimize errors in computation and storage, flight processors must be radiation-hardened and both dynamic memory and non-volatile storage (typically flash memory) must be radiation-tolerant. The additional engineering required for these adaptations takes time and is not inexpensive, and the market for radiation-hardened spacecraft computers is relatively small; for these reasons, the latest advances in processing technology are typically not available for use on interplanetary spacecraft, so flight computers are invariably slower than their Earth-bound counterparts. As a result, the cost per processing cycle is high and processors are heavily subscribed; economical use of processing resources is very important.

The nature of interplanetary spacecraft operations imposes a further constraint. These spacecraft are wholly robotic and are far beyond the reach of mission technicians; hands-on repairs are out of the question. Therefore the processing performed by the flight computer must be highly reliable, which in turn generally means that it must be highly predictable. Flight software is typically required to meet “hard” real-time processing deadlines, for which purpose it must be run within a hard real-time operating system (RTOS).

One other implication of the requirement for high reliability in flight software is that the dynamic allocation of system memory may be prohibited except in certain well-understood states, such as at system start-up. Unrestrained dynamic allocation of system memory introduces a degree of unpredictability into the overall flight system that can threaten the reliability of the computing environment and jeopardize the health of the vehicle.

1.3 Design Principles

The design of the ION software distribution reflects several core principles that are intended to address these constraints.

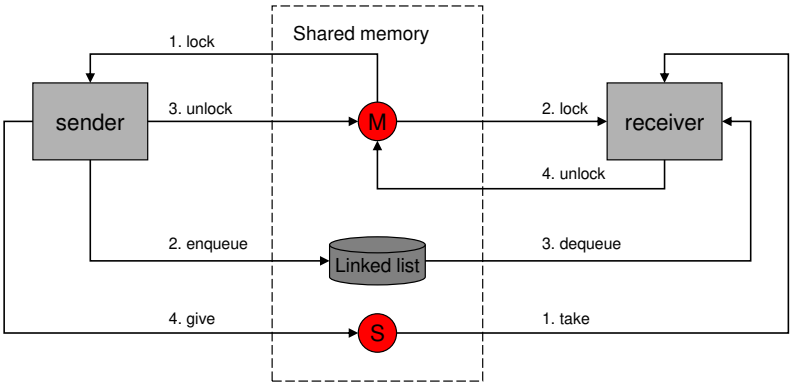


Figure 2 ION inter-task communication

1.3.1 Shared memory

Since ION must run on flight processors, it had to be designed to function successfully within an RTOS. Many real-time operating systems improve processing determinism by omitting the support for protected-memory models that is provided by Unix-like operating systems: all tasks have direct access to all regions of system memory. (In effect, all tasks operate in kernel mode rather than in user mode.) ION therefore had to be designed with no expectation of memory protection.

But universally shared access to all memory can be viewed not only as a hazard but also as an opportunity. Placing a data object in shared memory is an extremely efficient means of passing data from one software task to another.

ION is designed to exploit this opportunity as fully as possible. In particular, virtually all inter-task data interchange in ION follows the model shown in Figure 2:

- The sending task takes a mutual exclusion semaphore (mutex) protecting a linked list in shared memory (either DRAM or non-volatile memory), appends a data item to the list, releases the mutex, and gives a "signal" semaphore associated with the list to announce that the list is now non-empty.
- The receiving task, which is already pended on the linked list's associated signal semaphore, resumes execution when the semaphore is given. It takes the associated mutex, extracts the next data item from the list, releases the mutex, and proceeds to operate on the data item from the sending task.

Semaphore operations are typically extremely fast, as is the storage and retrieval of data in memory, so this inter-task data interchange model is suitably efficient for flight software.

1.3.2 Zero-copy procedures

Given ION's orientation toward the shared memory model, a further strategy for processing efficiency offers itself: if the data item appended to a linked list is merely a pointer to a large data object, rather than a copy, then we can further reduce processing overhead by eliminating the cost of byte-for-byte copying of large objects.

Moreover, in the event that multiple software elements need to access the same large object at the same time, we can provide each such software element with a pointer to the object rather than its own copy (maintaining a count of references to assure that the object is not destroyed until all elements have relinquished their pointers). This serves to reduce somewhat the amount of memory needed for ION operations.

1.3.3 Highly distributed processing

The efficiency of inter-task communications based on shared memory makes it practical to distribute ION processing among multiple relatively simple pipelined tasks rather than localize it in a single, somewhat more complex daemon. This strategy has a number of advantages:

- The simplicity of each task reduces the sizes of the software modules, making them easier to understand and maintain, and thus it can somewhat reduce the incidence of errors.
- The scope of the ION operating stack can be adjusted incrementally at run time, by spawning or terminating instances of configurable software elements, without increasing the size or complexity of any single task and without requiring that the stack as a whole be halted and restarted in a new configuration. In theory, a module could even be upgraded with new functionality and integrated into the stack without interrupting operations.
- The clear interfaces between tasks simplify the implementation of flow control measures to prevent uncontrolled resource consumption.

1.3.4 Portability

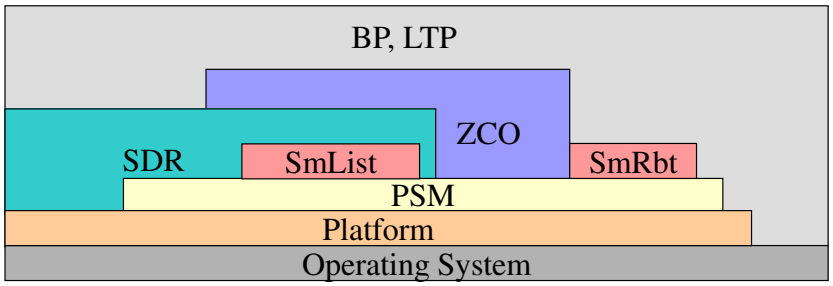
Designs based on these kinds of principles are foreign to many software developers, who may be far more comfortable in development environments supported by protected memory. It is typically much easier, for example, to develop software in a Linux environment than in VxWorks 5.4. However, the Linux environment is not the only one in which ION software must ultimately run.

Consequently, ION has been designed for easy portability. POSIX™ API functions are widely used, and differences in operating system support that are not concealed within the POSIX abstractions are mostly encapsulated in two small modules of platform-sensitive ION code. The bulk of the ION software runs, without any source code modification whatsoever, equally well in Linux™ (Red Hat®, Fedora™, and Ubuntu™,

so far), FreeBSD®, Solaris® 9, Microsoft Windows (the MinGW environment), OS/X®, VxWorks® 5.4, and RTEMS™, on both 32-bit and 64-bit processors. Developers may compile and test ION modules in whatever environment they find most convenient.

1.4 Organizational Overview

Two broad overviews of the organization of ION may be helpful at this point. First, here is a summary view of the main functional dependencies among ION software elements:



BP, LTP	Bundle Protocol and Licklider Transmission Protocol libraries and daemons
ZCO	Zero-copy objects capability: minimize data copying up and down the stack
SDR	Spacecraft Data Recorder: persistent object database in shared memory, using PSM and SmList
SmList	linked lists in shared memory using PSM
SmRbt	red-black trees in shared memory using PSM
PSM	Personal Space Management: memory management within a pre-allocated memory partition
Platform	common access to O.S.: shared memory, system time, IPC mechanisms
Operating System	POSIX thread spawn/destroy, file system, time

Figure 3 ION software functional dependencies

That is, BP and LTP invoke functions provided by the sdr, zco, psm, and platform elements of the ici package, in addition to functions provided by the operating system itself; the zco functions themselves also invoke sdr, psm, and platform functions; and so on.

Second, here is a summary view of the main line of data flow in ION's DTN protocol implementations:

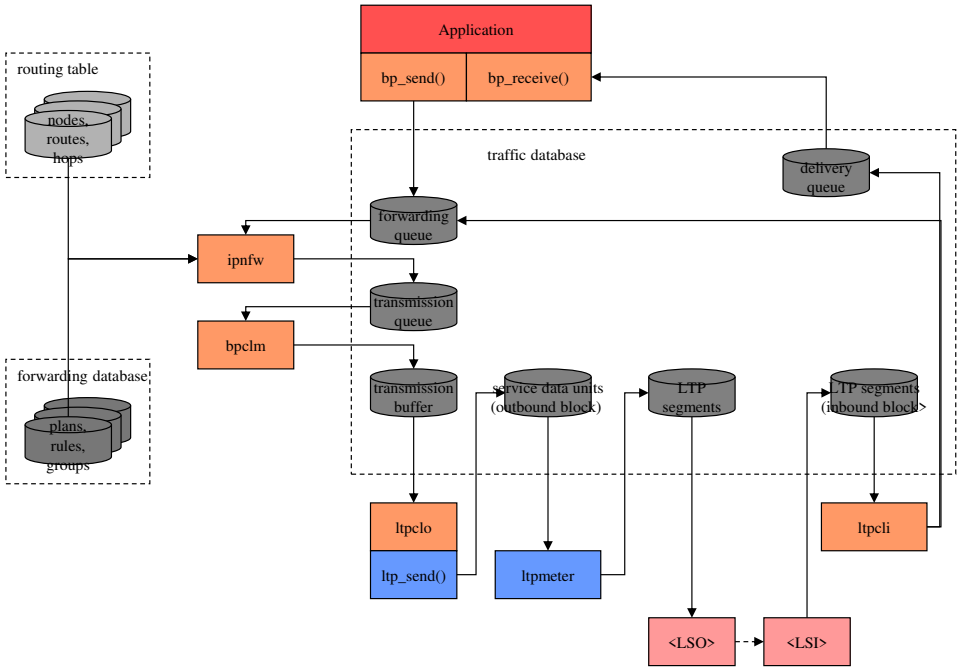


Figure 4 Main line of ION data flow

Note that data objects residing in shared memory, many of them in a nominally non-volatile SDR data store, constitute the central organizing principle of the design. Here as in other diagrams showing data flow in this document:

- Ordered collections of data objects are shown as cylinders.
- Darker greyscale data entities indicate data that are managed in the SDR data store, while lighter greyscale data entities indicate data that are managed in volatile DRAM to improve performance.
- Rectangles indicate processing elements (tasks, processes, threads), sometimes with library references specifically identified.

A few notes on this main line data flow:

- For simplicity, the data flow depicted here is a "loopback" flow in which a single BP "node" is shown sending data to itself (a useful configuration for test purposes). To depict typical operations over a network we would need two instances of this node diagram, such that the <LSO> task of one node is shown sending data to the <LSI> task of the other and vice versa.
- A BP application or application service (such as Remote AMS) that has access to the local BP node – for our purposes, the "sender" – invokes the `bp_send` function to send a unit of application data to a remote counterpart. The destination of the application data unit is expressed as a BP endpoint ID (EID). The application data unit is encapsulated in a bundle and is queued for forwarding.

- The forwarder task identified by the "scheme" portion of the bundle's destination EID removes the bundle from the forwarding queue and computes a route to the destination EID. The first node on the route is termed the "proximate node" for the computed route. The forwarder appends the bundle to the transmission queue for the convergence-layer manager (CLM) daemon that is responsible for transmission to the proximate node.
- The CLM daemon removes the bundle from the transmission queue and imposes rate control, fragments the bundle as necessary, and appends the bundle to the transmission buffer for some underlying "convergence layer" (CL) protocol interface to the proximate node, termed an *outduct*. In the event that multiple outducts are available for transmission to that node (e.g., multiple radio frequency bands), the CLM invokes mission-supplied code to select the appropriate duct. Each outduct is serviced by some CL-specific output task that communicates with the proximate node – in this case, the LTP output task **ltpclo**. (Other CL protocols supported by ION include TCP and UDP.)
- The output task for LTP transmission to the selected proximate node removes the bundle from the transmission buffer and invokes the `ltp_send` function to append it to a *block* that is being assembled for transmission to the proximate node. (Because LTP acknowledgment traffic is issued on a per-block basis, we can limit the amount of acknowledgment traffic on the network by aggregating multiple bundles into a single block rather than transmitting each bundle in its own block.)
- The **ltpmeter** task for the selected proximate node divides the aggregated block into multiple segments and enqueues them for transmission by underlying link-layer transmission software, such as an implementation of the CCSDS AOS protocol.
- Underlying link-layer software at the sending node transmits the segments to its counterpart at the proximate node (the receiver), where they are used to reassemble the transmission block.
- The receiving node's input task for LTP reception extracts the bundles from the reassembled block and dispatches them: each bundle whose final destination is some other node is queued for forwarding, just like bundles created by local applications, while each bundle whose final destination is the local node is queued for delivery to whatever application "opens" the BP endpoint identified by the bundle's final destination endpoint ID. (Note that a multicast bundle may be both queued for forwarding, possibly to multiple neighboring nodes, and also queued for delivery.)
- The destination application or application service at the receiving node opens the appropriate BP endpoint and invokes the `bp_receive` function to remove the bundle from the associated delivery queue and extract the original application data unit, which it can then process.

Finally, note that the data flow shown here represents the sustained operational configuration of a node that has been successfully instantiated on a suitable computer.

The sequence of operations performed to reach this configuration is not shown. That startup sequence will necessarily vary depending on the nature of the computing platform and the supporting link services. Broadly, the first step normally is to run the **ionadmin** utility program to initialize the data management infrastructure required by all elements of ION. Following this initialization, the next steps normally are (a) any necessary initialization of link service protocols, (b) any necessary initialization of convergence-layer protocols (e.g., LTP – the **ltpadmin** utility program), and finally (c) initialization of the Bundle Protocol by means of the **bpadmin** utility program. BP applications should not try to commence operation until BP has been initialized.

1.5 Resource Management in ION

Successful Delay-Tolerant Networking relies on retention of bundle protocol agent state information – including protocol traffic that is awaiting a transmission opportunity – for potentially lengthy intervals. The nature of that state information will fluctuate rapidly as the protocol agent passes through different phases of operation, so efficient management of the storage resources allocated to state information is a key consideration in the design of ION.

Two general classes of storage resources are managed by ION: volatile "working memory" and non-volatile "heap".

1.5.1 Working Memory

ION's "working memory" is a fixed-size pool of shared memory (dynamic RAM) that is allocated from system RAM at the time the bundle protocol agent commences operation. Working memory is used by ION tasks to store temporary data of all kinds: linked lists, red-black trees, transient buffers, volatile databases, etc. All intermediate data products and temporary data structures that ought not to be retained in the event of a system power cycle are written to working memory.

Data structures residing in working memory may be shared among ION tasks or may be created and managed privately by individual ION tasks. The dynamic allocation of working memory to ION tasks is accomplished by the Personal Space Management (PSM) service, described later. All of the working memory for any single ION bundle protocol agent is managed as a single PSM "partition". The size of the partition is specified in the **wmSize** parameter of the ionconfig file supplied at the time ION is initialized.

1.5.2 Heap

ION's "heap" is a fixed-size pool of notionally non-volatile storage that is likewise allocated at the time the bundle protocol agent commences operation. This notionally non-volatile space **may** occupy a fixed-size pool of shared memory (dynamic RAM, which might or might not be battery-backed), or it **may** occupy only a single fixed-size file in the file system, or it may occupy both. In the latter case, all heap data are written both to memory and to the file but are read only from memory; this configuration offers the reliable non-volatility of file storage coupled with the high performance of retrieval from dynamic RAM.

We characterize ION's heap storage as "notionally" non-volatile because the heap may be configured to reside only in memory (or, for that matter, in a file that resides in the file system of a RAM disk). When the heap resides only in memory, its contents are truly non-volatile only if that memory is battery-backed. Otherwise heap storage is in reality as volatile as working memory: heap contents will be lost upon a system power cycle (which may in fact be the preferred behavior for any given deployment of ION). However, the heap should not be thought of as "memory" even when it in fact resides only in DRAM, just as a disk device should not be thought of as "memory" even when it is in fact a RAM disk.

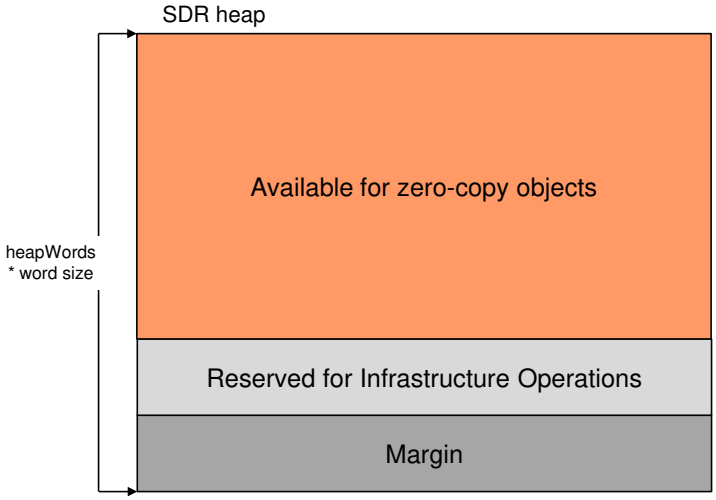


Figure 5 ION heap space use

The ION heap is used for storage of data that (in at least some deployments) would have to be retained in the event of a system power cycle to ensure the correct continued operation of the node. For example, all queues of bundles awaiting route computation, transmission, or delivery reside in the node's heap. So do the non-volatile databases for all of the protocols implemented within ION, together with all of the node's persistent configuration parameters.

The dynamic allocation of heap space to ION tasks is accomplished by the Simple Data Recorder (SDR) service, described later. The entire heap for any single ION bundle protocol agent is managed as a single SDR "data store".

Space within the ION heap is apportioned as shown in Figure 5. The total number of bytes of storage space in the heap is computed as the product of the size of a "word" on the deployment platform (normally the size of a pointer) multiplied by the value of the **heapWords** parameter of the ionconfig file supplied at the time ION is initialized. Of this total, 20% is normally reserved as margin and another 40% is normally reserved for various infrastructure operations. (Both of these percentages are macros that may be overridden at compile time.) The remainder is available for storage of protocol state data in the form of "zero-copy objects", described later. At any given moment, the data encapsulated in a zero-copy object may "belong" to any one of the protocols in the ION stack (AMS, CFDP, BP, LTP), depending on processing state; the available heap space is a single common resource to which all of the protocols share concurrent access.

Because the heap is used to store queues of bundles awaiting processing, blocks of LTP data awaiting transmission or reassembly, etc., the heap for any single ION node must be large enough to contain the maximum volume of such data that the node will be required to retain during operations. Demand for heap space is substantially mitigated if most of the application data units passed to ION for transmission are file-resident, as the file contents themselves need not be copied into the heap. In general, however, computing the optimum ION heap size for a given deployment remains a research topic.

1.6 Package Overviews

1.6.1 Interplanetary Communication Infrastructure (ICI)

The ICI package in ION provides a number of core services that, from ION's point of view, implement what amounts to an extended POSIX-based operating system. ICI services include the following:

1. Platform

The platform system contains operating-system-sensitive code that enables ICI to present a single, consistent programming interface to those common operating system services that multiple ION modules utilize. For example, the platform system implements a standard semaphore abstraction that may invisibly be mapped to underlying POSIX semaphores, SVR4 IPC semaphores, Windows Events, or VxWorks semaphores, depending on which operating system the package is compiled for. The platform system also implements a standard shared-memory abstraction, enabling software running on operating systems both with and without memory protection to participate readily in ION's shared-memory-based computing environment.

2. Personal Space Management (PSM)

Although sound flight software design may prohibit the uncontrolled dynamic management of system memory, private management of assigned, fixed blocks of system memory is standard practice. Often that private management amounts to merely controlling the reuse of fixed-size rows in static tables, but such techniques can be awkward and may not make the most efficient use of available memory. The ICI package provides an alternative, called PSM, which performs high-speed dynamic allocation and recovery of variable-size memory objects within an assigned memory block of fixed size. A given PSM-managed memory block may be either private or shared memory.

3. Memmgr

The static allocation of privately-managed blocks of system memory for different purposes implies the need for multiple memory management regimes, and in some cases a program that interacts with multiple software elements may need to participate in the private shared-memory management regimes of each. ICI's memmgr system enables multiple memory managers – for multiple privately-managed blocks of system memory – to coexist within ION and be concurrently available to ION software elements.

4. Lyst

The lyst system is a comprehensive, powerful, and efficient system for managing doubly-linked lists in private memory. It is the model for a number of other list management systems supported by ICI; as noted earlier, linked lists are heavily used in ION inter-task communication.

5. Llcv

The llcv (Linked-List Condition Variables) system is an inter-thread communication abstraction that integrates POSIX thread condition variables (vice semaphores) with doubly-linked lists in private memory.

6. Smlist

Smlist is another doubly-linked list management service. It differs from lyst in that the lists it manages reside in shared (rather than private) DRAM, so operations on them must be semaphore-protected to prevent race conditions.

7. SmRbt

The SmRbt service provides mechanisms for populating and navigating "red/black trees" (RBTs) residing in shared DRAM. RBTs offer an alternative to linked lists: like linked lists they can be navigated as queues, but locating a single element of an RBT by its "key" value can be much quicker than the equivalent search through an ordered linked list.

8. Simple Data Recorder (SDR)

SDR is a system for managing non-volatile storage, built on exactly the same model as PSM. Put another way, SDR is a small and simple "persistent object" system or "object database" management system. It enables straightforward management of linked lists (and other data structures of arbitrary complexity) in non-volatile storage, notionally within a single file whose size is pre-defined and fixed.

SDR includes a transaction mechanism that protects database integrity by ensuring that the failure of any database operation will cause all other operations undertaken within the same transaction to be backed out. The intent of the system is to assure retention of coherent protocol engine state even in the event of an unplanned flight computer reboot in the midst of communication activity.

9. Sptrace

The sptrace system is an embedded diagnostic facility that monitors the performance of the PSM and SDR space management systems. It can be used, for example, to detect memory "leaks" and other memory management errors.

10. Zco

ION's zco (zero-copy objects) system leverages the SDR system's storage flexibility to enable user application data to be encapsulated in any number of layers of protocol without copying the successively augmented protocol data unit from one layer to the next. It also implements a reference counting system that enables protocol data to be processed safely by multiple software elements concurrently – e.g., a bundle may be both delivered to a local endpoint and, at the same time, queued for forwarding to another node – without requiring that distinct copies of the data be provided to each element.

11. Rfx

The ION rfx (R/F Contacts) system manages lists of scheduled communication opportunities in support of a number of LTP and BP functions.

12. Ionsec

The IONSEC (ION security) system manages information that supports the implementation of security mechanisms in the other packages: security policy rules and computation keys.

1.6.2 Licklider Transmission Protocol (LTP)

The ION implementation of LTP conforms fully to RFC 5326, but it also provides two additional features that enhance functionality without affecting interoperability with other implementations:

- The service data units – nominally bundles – passed to LTP for transmission may be aggregated into larger blocks before segmentation. By controlling block size we can control the volume of acknowledgment traffic generated as blocks are received, for improved accommodation of highly asynchronous data rates.
- The maximum number of transmission sessions that may be concurrently managed by LTP (a protocol control parameter) constitutes a transmission "window" – the basis for a delay-tolerant, non-conversational flow control service over interplanetary links.

In the ION stack, LTP serves effectively the same role that is performed by an LLC protocol (such as IEEE 802.2) in the Internet architecture, providing flow control and retransmission-based reliability between topologically adjacent bundle protocol agents.

All LTP session state is safely retained in the ION heap for rapid recovery from a spacecraft or software fault.

1.6.3 Bundle Protocol (BP)

The ION implementation of BP conforms fully to RFC 5050, including support for the following standard capabilities:

- Prioritization of data flows
- Proactive bundle fragmentation
- Bundle reassembly from fragments
- Flexible status reporting
- Custody transfer, including re-forwarding of custodial bundles upon timeout interval expiration or failure of nominally reliable convergence-layer transmission

The system also provides three additional features that enhance functionality without affecting interoperability with other implementations:

- Rate control provides support for congestion forecasting and avoidance.

- Bundle headers are encoded into compressed form (CBHE, as noted earlier) before issuance, to reduce protocol overhead and improve link utilization.
- Bundles may be "multicast" to all nodes that have registered within a given multicast group endpoint.

In addition, ION BP includes a system for computing dynamic routes through time-varying network topology assembled from scheduled, bounded communication opportunities. This system, called "Contact Graph Routing," is described later in this Guide.

In short, BP serves effectively the same role that is performed by IP in the Internet architecture, providing route computation, forwarding, congestion avoidance, and control over quality of service.

All bundle transmission state is safely retained in the ION heap for rapid recovery from a spacecraft or software fault.

1.6.4 Asynchronous Message Service (AMS)

The ION implementation of the CCSDS AMS standard conforms fully to CCSDS 735.0-B-1. AMS is a data system communications architecture under which the modules of mission systems may be designed as if they were to operate in isolation, each one producing and consuming mission information without explicit awareness of which other modules are currently operating. Communication relationships among such modules are self-configuring; this tends to minimize complexity in the development and operations of modular data systems.

A system built on this model is a "society" of generally autonomous inter-operating modules that may fluctuate freely over time in response to changing mission objectives, modules' functional upgrades, and recovery from individual module failure. The purpose of AMS, then, is to reduce mission cost and risk by providing standard, reusable infrastructure for the exchange of information among data system modules in a manner that is simple to use, highly automated, flexible, robust, scalable, and efficient.

A detailed discussion of AMS is beyond the scope of this Design Guide. For more information, please see the AMS Programmer's Guide.

1.6.5 Datagram Retransmission (DGR)

The DGR package in ION is an alternative implementation of LTP that is designed to operate responsibly – i.e., with built-in congestion control – in the Internet or other IP-based networks. It is provided as a candidate "primary transfer service" in support of AMS operations in an Internet-like (non-delay-tolerant) environment. The DGR design combines LTP's concept of concurrent transmission transactions with congestion control and timeout interval computation algorithms adapted from TCP.

1.6.6 CCSDS File Delivery Protocol (CFDP)

The ION implementation of CFDP conforms fully to Service Class 1 (Unreliable Transfer) of CCSDS 727.0-B-4, including support for the following standard capabilities:

- Segmentation of files on user-specified record boundaries.
- Transmission of file segments in protocol data units that are conveyed by an underlying Unitdata Transfer service, in this case the DTN protocol stack. File data segments may optionally be protected by CRCs. When the DTN protocol stack is configured for reliable data delivery (i.e., with BP custody transfer running over a reliable convergence-layer protocol such as LTP), file delivery is reliable; CFDP need not perform retransmission of lost data itself.
- Reassembly of files from received segments, possibly arriving over a variety of routes through the delay-tolerant network. The integrity of the delivered files is protected by checksums.
- User-specified fault handling procedures.
- Operations (e.g., directory creation, file renaming) on remote file systems.

All CFDP transaction state is safely retained in the ION heap for rapid recovery from a spacecraft or software fault.

1.6.7 Bundle Streaming Service (BSS)

The BSS service provided in ION enables a stream of video, audio, or other continuously generated application data units, transmitted over a delay-tolerant network, to be presented to a destination application in two useful modes concurrently:

- In the order in which the data units were generated, with the least possible end-to-end delivery latency, but possibly with some gaps due to transient data loss or corruption.
- In the order in which the data units were generated, without gaps (i.e., including lost or corrupt data units which were omitted from the real-time presentation but were subsequently retransmitted), but in a non-real-time "playback" mode.

1.6.8 Trusted Collective (TC)

The TC service provided in ION enables critical but non-confidential information (such as public keys, for asymmetric cryptography) to be provided in a delay-tolerant, trustworthy manner. An instance of TC comprises:

- A distributed Authority, the members of which must reach consensus on database content and must collaborate on the proactive distribution of that content.
- Any number of Clients, which:
    - Announce new content to the Authority via authenticated bundle multicast, and/or
    - Receive trustworthy bulletins multicast by the members of the Authority.

1.7 Acronyms

BP	Bundle Protocol

BSP	Bundle Security Protocol
BSS	Bundle Streaming Service
CCSDS	Consultative Committee for Space Data Systems
CFDP	CCSDS File Delivery Protocol
CGR	Contact Graph Routing
CL	convergence layer
CLI	convergence layer input
CLO	convergence layer output
DTKA	Delay-Tolerant Key Administration
DTN	Delay-Tolerant Networking
ICI	Interplanetary Communication Infrastructure
ION	Interplanetary Overlay Network
LSI	link service input
LSO	link service output
LTP	Licklider Transmission Protocol
OWLT	one-way light time
RFC	request for comments
RFX	Radio (R/F) Contacts
RTT	round-trip time
TC	Trusted Collective
TTL	time to live

1.8 Network Operation Concepts

A small number of network operation design elements – fragmentation and reassembly, bandwidth management, and delivery assurance (retransmission) – can potentially be addressed at multiple layers of the protocol stack, possibly in different ways for different reasons. In stack design it's important to allocate this functionality carefully so that the effects at lower layers complement, rather than subvert, the effects imposed at higher layers of the stack. This allocation of functionality is discussed below, together with a discussion of several related key concepts in the ION design.

1.8.1 Fragmentation and Reassembly

To minimize transmission overhead and accommodate asymmetric links (i.e., limited "uplink" data rate from a ground data system to a spacecraft) in an interplanetary

network, we ideally want to send "downlink" data in the largest possible aggregations – coarse-grained transmission.

But to minimize head-of-line blocking (i.e., delay in transmission of a newly presented high-priority item) and minimize data delivery latency by using parallel paths (i.e., to provide fine-grained partial data delivery, and to minimize the impact of unexpected link termination), we want to send "downlink" data in the smallest possible aggregations – fine-grained transmission.

We reconcile these impulses by doing both, but at different layers of the ION protocol stack.

First, at the application service layer (AMS and CFDP) we present relatively small application data units (ADUs) – on the order of 64 KB – to BP for encapsulation in bundles. This establishes an upper bound on head-of-line blocking when bundles are de-queued for transmission, and it provides perforations in the data stream at which forwarding can readily be switched from one link (route) to another, enabling partial data delivery at relatively fine, application-appropriate granularity.

(Alternatively, large application data units may be presented to BP and the resulting large bundles may be proactively fragmented at the time they are presented to the convergence-layer manager. This capability is meant to accommodate environments in which the convergence-layer manager has better information than the application as to the optimal bundle size, such as when the residual capacity of a contact is known to be less than the size of the bundle.)

Then, at the BP/LTP convergence layer adapter lower in the stack, we aggregate these small bundles into *blocks* for presentation to LTP:

> Any continuous sequence of bundles that are to be shipped to the same LTP engine and all require assured delivery may be aggregated into a single block, to reduce overhead and minimize report traffic.
>
> However, this aggregation is constrained by an aggregation size limit rule: aggregation must stop and the block must be transmitted as soon as the sum of the sizes of all bundles aggregated into the block exceeds the block aggregation threshhold value declared for the applicable *span* (the relationship between the local node's LTP engine and the receiving LTP engine) during LTP protocol configuration via **ltpadmin**.

Given a preferred block acknowledgment period – e.g., a preferred acknowledgement traffic rate of one report per second – the nominal block aggregation threshold is notionally computed as the amount of data that can be sent over the link to the receiving LTP engine in a single block acknowledgment period at the planned outbound data rate to that engine.

Taken together, application-level fragmentation (or BP proactive fragmentation) and LTP aggregation place an upper limit on the amount of data that would need to be re-transmitted over a given link at next contact in the event of an unexpected link termination that caused delivery of an entire block to fail. For example, if the data rate is 1 Mbps and the nominal block size is 128 KB (equivalent to 1 second of transmission time), we would prefer to avoid the risk of having wasted five minutes of downlink in

sending a 37.5 MB file that fails on transmission of the last kilobyte, forcing retransmission of the entire 37.5 MB. We therefore divide the file into, say, 1200 bundles of 32 KB each which are aggregated into blocks of 128 KB each: only a single block failed, so only that block (containing just 4 bundles) needs to be retransmitted. The cost of this retransmission is only 1 second of link time rather than 5 minutes. By controlling the cost of convergence-layer protocol failure in this way, we avoid the overhead and complexity of "reactive fragmentation" in the BP implementation.

Finally, within LTP itself we fragment the block as necessary to accommodate the Maximum Transfer Unit (MTU) size of the underlying link service, typically the transfer frame size of the applicable CCSDS link protocol.

1.8.2 Bandwidth Management

The allocation of bandwidth (transmission opportunity) to application data is requested by the application task that's passing data to DTN, but it is necessarily accomplished only at the lowest layer of the stack at which bandwidth allocation decisions can be made – and then always in the context of node policy decisions that have global effect.

The transmission queue interface to a given neighbor in the network is actually three queues of outbound bundles rather than one: one queue for each of the defined levels of priority ("class of service") supported by BP. When an application presents an ADU to BP for encapsulation in a bundle, it indicates its own assessment of the ADU's priority. Upon selection of a proximate forwarding destination node for that bundle, the bundle is appended to whichever of the queues corresponds to the ADU's priority.

Normally the convergence-layer manager (CLM) task servicing a given proximate node extracts bundles in strict priority order from the heads of the three queues. That is, the bundle at the head of the highest-priority non-empty queue is always extracted.

However, if the ION_BANDWIDTH_RESERVED compiler option is selected at the time ION is built, the convergence-layer manager task servicing a given proximate node extracts bundles in interleaved fashion from the heads of the node's three queues:

- Whenever the priority-2 ("express") queue is non-empty, the bundle at the head of that queue is the next one extracted.
- At all other times, bundles from both the priority-1 queue and the priority-0 queue are extracted, but over a given period of time twice as many bytes of priority-1 bundles will be extracted as bytes of priority-0 bundles.

Following insertion of the extracted bundles into transmission buffers, CLO tasks other than **ltpclo** simply segment the buffered bundles as necessary and transmit them using the underlying convergence-layer protocols. In the case of **ltpclo**, the output task aggregates the buffered bundles into blocks as described earlier and a second daemon task named **ltpmeter** waits for aggregated blocks to be completed; **ltpmeter**, rather than the CLO task itself, segments each completed block as necessary and passes the segments to the link service protocol that underlies LTP. Either way, the transmission ordering requested by application tasks is preserved.

1.8.3 Contact Plans

In the Internet, protocol operations can be largely driven by currently effective information that is discovered opportunistically and immediately, at the time it is needed, because the latency in communicating this information over the network is negligible: distances between communicating entities are small and connectivity is continuous. In a DTN-based network, however, ad-hoc information discovery would in many cases take so much time that it could not be completed before the information lost currency and effectiveness. Instead, protocol operations must be largely driven by information that is pre-placed at the network nodes and tagged with the dates and times at which it becomes effective. This information takes the form of *contact plans* that are managed by the R/F Contacts (rfx) services of ION's ici package.

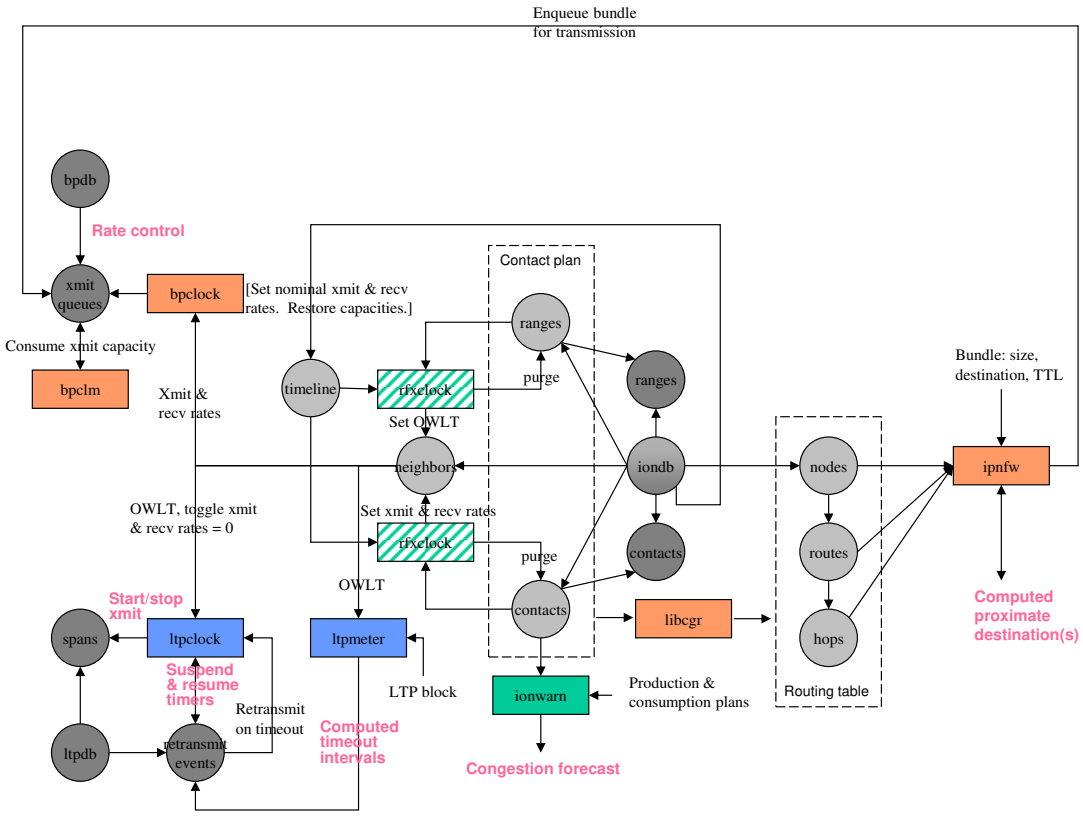


Figure 6 RFX services in ION

The structure of ION's RFX (contact plan) database, the rfx system elements that populate and use that data, and affected portions of the BP and LTP protocol state databases are shown in Figure 6. (For additional details of BP and LTP database management, see the BP/LTP discussion later in this document.)

To clarify the notation of this diagram, which is also used in other database structure diagrams in this document:

- Data objects of defined structure are shown as circles. Dark greyscale indicates notionally non-volatile data retained in "heap" storage, while lighter greyscale indicates volatile data retained in dynamic random access memory.

- Solid arrows connecting circles indicate one-to-many cardinality.
- A dashed arrow between circles indicates a potentially many-to-one reference mapping.
- Arrows from processing elements (rectangles) to data entities indicate data production, while arrows from data entities to processing elements indicate data retrieval.

A *contact* is here defined as an interval during which it is expected that data will be transmitted by DTN node A (the contact's transmitting node) and most or all of the transmitted data will be received by node B (the contact's receiving node). Implicitly, the transmitting mode will utilize some "convergence-layer" protocol underneath the Bundle Protocol to effect this direct transmission of data to the receiving node. Each contact is characterized by its start time, its end time, the identities of the transmitting and receiving nodes, and the rate at which data are expected to be transmitted by the transmitting node throughout the indicated time period.

(Note that a contact is specifically ***not*** an episode of activity on a link. Episodes of activity on different links – e.g., different radio transponders operating on the same spacecraft – may well overlap, but contacts by definition cannot; they are bounded time intervals and as such are innately "tiled". For example, suppose transmission on link X from node A to node B, at data rate RX, begins at time T1 and ends at time T2; also, transmission on link Y from node A to node B, at data rate RY begins at time T3 and ends at time T4. If T1 = T3 and T2 = T4, then there is a single contact from time T1 to time T2 at data rate RX + RY. If T1 < T3 and T2 = T4, then there are two contiguous contacts: one from T1 to T3 at data rate RX, then one from T3 to T2 at data rate RX + RY. If T1 < T3 and T3<T2 < T4, then there are three contiguous contacts: one from T1 to T3 at data rate RX, then one from T3 to T2 at data rate RX + RY, then one from T2 to T4 at data rate RY. And so on.)

A *range interval* is a period of time during which the displacement between two nodes A and B is expected to vary by less than 1 light second from a stated anticipated distance. (We expect this information to be readily computable from the known orbital elements of all nodes.) Each range interval is characterized by its start time, its end time, the identities of the two nodes to which it pertains, and the anticipated approximate distance between those nodes throughout the indicated time period, to the nearest light second.

The *topology timeline* at each node in the network is a time-ordered list of scheduled or anticipated changes in the topology of the network. Entries in this list are of two types:

- Contact entries characterize scheduled contacts.
- Range entries characterize anticipated range intervals.

Each node to which, according to the RFX database, the local node transmits data directly via some convergence-layer protocol at some time is termed a *neighbor* of the local node. Each neighbor is associated with one or more outduct for the applicable BP convergence-layer (CL) protocol adapter(s), so bundles that are to be transmitted directly to this neighbor can simply be queued for transmission by outduct (as discussed in the Bandwidth Management notes above).

At startup, and at any time while the system is running, **ionadmin** inserts and removes Contact and Range entries in the topology timeline of the RFX database. Inserting or removing a Contact or Range entry will cause routing tables to be recomputed for the destination nodes of all subsequently forwarded bundles, as described in the discussion of Contact Graph Routing below.

Once per second, the **rfxclock** task (which appears in multiple locations on the diagram to simplify the geometry) applies all topology timeline events (Contact and Range start, stop, purge) with effective time in the past. Applying a Contact event that cites a neighboring node revises the transmission or reception data rate between the local node and that Neighbor. Applying a Range event that cites a neighboring node revises the OWLT between the local node and that neighbor. Setting data rate or OWLT for a node with which the local node will at some time be in direct communication may entail creation of a Neighbor object.

1.8.4 Route Computation

ION's computation of a route for a given bundle with a given destination endpoint is accomplished by one of several methods, depending on the destination. In every case, the result of successful routing is the insertion of the bundle into an outbound transmission queue (selected according to the bundle's priority) for one or more neighboring nodes.

But before discussing these methods it will be helpful to establish some terminology:

Egress plans

ION can only forward bundles to a neighboring node by queuing them on some explicitly specified transmission queue. Specifications that associate neighboring nodes with outducts are termed *egress plans*. They are retained in ION's unicast forwarding database.

Static routes

ION can be configured to forward to some specified node all bundles that are destined for a given node to which no *dynamic route* can be discovered from an examination of the contact graph, as described later. Static routing is implemented by means of the "exit" mechanism described below.

Unicast

When the destination of a bundle is a single node that is registered within a known "singleton endpoint" (that is, an endpoint that is known to have exactly one member), then transmission of that bundle is termed *unicast*. For this purpose, the destination endpoint ID must be a URI formed in either the "dtn" scheme (e.g., `dtn://bobsmac/mail`) or the "ipn" scheme (e.g., `ipn:913.11`).

Exits

When unicast routes must be computed to nodes for which no contact plan information is known (e.g., the size of the network makes it impractical to distribute all Contact and Range information for all nodes to every node, or the destination nodes don't participate in Contact Graph Routing at all), the job of

computing routes to all nodes may be partitioned among multiple *exit* nodes. Each exit is responsible for managing routing information (for example, a comprehensive contact graph) for some subset of the total network population – a group comprising all nodes whose node numbers fall within the range of node numbers assigned to the exit. A bundle destined for a node for which no dynamic route can be computed from the local node's contact graph may be routed to the exit node for the group within whose range the destination's node number falls. Exits are defined in ION's unicast forwarding database. (Note that the exit implements *static routes* in ION in addition to improving scalability.)

Multicast

When the destination of a bundle is all nodes that are registered within a known "multicast endpoint" (that is, an endpoint that is not known to have exactly one member), then transmission of that bundle is termed *multicast*. For this purpose (in ION), the destination endpoint ID must be a URI formed in the "imc" scheme (e.g., `imc:913.11`).

Multicast Groups

A *multicast group* is the set of all nodes in the network that are members of a given multicast endpoint. Forwarding a bundle to all members of its destination multicast endpoint is the responsibility of all of the multicast-aware nodes of the network. These nodes are additionally configured to be nodes of a single multicast spanning tree overlaid onto the dtnet. A single multicast tree serves to forward bundles to all multicast groups: each node of the tree manages petitions indicating which of its "relatives" (parent and children) are currently interested in bundles destined for each multicast endpoint, either natively (due to membership in the indicated group) or on behalf of more distant relatives.

1.8.4.1 Unicast

We begin unicast route computation by attempting to compute a dynamic route to the bundle's final destination node. The details of this algorithm are described in the section on ***Contact Graph Routing***, below.

If no dynamic route can be computed, but the final destination node is a "neighboring" node that is directly reachable, then we assume that taking this direct route is the best strategy unless transmission to that neighbor is flagged as "blocked" for network operations purposes.

Otherwise we must look for a static route. If the bundle's destination node number is in one of the ranges of node numbers assigned to exit nodes, then we forward the bundle to the exit node for the smallest such range. (If the exit node is a neighbor and transmission to that neighbor is not blocked, we simply queue the bundle for transmission to that neighbor; otherwise we similarly look up the static route for the exit node until eventually we resolve to some egress plan.)

If we can determine neither a dynamic route nor a static route for this bundle, but the reason for this failure was transmission blockage that might be resolved in the future,

then the bundle is placed in a "limbo" list for future re-forwarding when transmission to some node is "unblocked."

Otherwise, the bundle cannot be forwarded. If custody transfer is requested for the bundle, we send a custody refusal to the bundle's current custodian; in any case, we discard the bundle.

1.8.4.2 Multicast

Multicast route computation is much simpler.

- When an endpoint for the "imc" scheme is added on an ION node – that is, when the node joins that multicast endpoint – BP administrative records noting the node's new interest in the application topic corresponding to the endpoint's group number are multicast to other network nodes as needed, using a "built-in" multicast group of which all nodes of the network are implicitly members. On receipt of such a record, each node notes the sending relative's interest and forwards the record to other nodes as necessary, and so on. (Deletion of endpoints results in similar propagation of cancelling administrative records.)
- A bundle whose destination endpoint cites a multicast group, whether locally sourced or received from another node:
    - Is delivered immediately, if the local node is a member of the indicated endpoint.
    - Is queued for direct transmission to all other nodes in the local "region" of network topology that are members of the multicast group. Passageway nodes forward the bundle as necessary into other regions that are topologically adjacent to the local region.

1.8.5 Delivery Assurance

End-to-end delivery of data can fail in many ways, at different layers of the stack. When delivery fails, we can either accept the communication failure or retransmit the data structure that was transmitted at the stack layer at which the failure was detected. ION is designed to enable retransmission at multiple layers of the stack, depending on the preference of the end user application.

At the lowest stack layer that is visible to ION, the convergence-layer protocol, failure to deliver one or more segments due to segment loss or corruption will trigger segment retransmission if a "reliable" convergence-layer protocol is in use: LTP "red-part" transmission or TCP (including Bundle Relay Service, which is based on TCP)[1].

Segment loss may be detected and signaled via NAK by the receiving entity, or it may only be detected at the sending entity by expiration of a timer prior to reception of an ACK. Timer interval computation is well understood in a TCP environment, but it can be

[1] In ION, reliable convergence-layer protocols (where available) are by default used for every bundle. The application can instead mandate selection of "best-effort" service at the convergence layer by setting the BP_BEST_EFFORT flag in the "extended class of service flags" parameter, but this feature is an ION extension that is not supported by other BP implementations at the time of this writing.

a difficult problem in an environment of scheduled contacts as served by LTP. The round-trip time for an acknowledgment dialogue may be simply twice the one-way light time (OWLT) between sender and receiver at one moment, but it may be hours or days longer at the next moment due to cessation of scheduled contact until a future contact opportunity. To account for this timer interval variability in retransmission, the **ltpclock** task infers the initiation and cessation of LTP transmission, to and from the local node, from changes in the current xmit and recv data rates in the corresponding Neighbor objects. This controls the dequeuing of LTP segments for transmission by underlying link service adapter(s) and it also controls suspension and resumption of timers, removing the effects of contact interruption from the retransmission regime. For a further discussion of this mechanism, see the section below on ***LTP Timeout Intervals***.

Note that the current OWLT in Neighbor objects is also used in the computation of the nominal expiration times of timers and that **ltpclock** is additionally the agent for LTP segment retransmission based on timer expiration.

It is, of course, possible for the nominally reliable convergence-layer protocol to fail altogether: a TCP connection might be abruptly terminated, or an LTP transmission might be canceled due to excessive retransmission activity (again possibly due to an unexpected loss of connectivity). In this event, BP itself detects the CL protocol failure and re-forwards all bundles whose acquisition by the receiving entity is presumed to have been aborted by the failure. This re-forwarding is initiated in different ways for different CL protocols, as implemented in the CL input and output adapter tasks. If immediate re-forwarding is impossible because transmission to all potentially viable neighbors is blocked, the affected bundles are placed in the limbo list for future re-forwarding when transmission to some node is unblocked.

In addition to the implicit forwarding failure detected when a CL protocol fails, the forwarding of a bundle may be explicitly refused by the receiving entity, provided the bundle is flagged for custody transfer service. A receiving node's refusal to take custody of a bundle may have any of a variety of causes: typically the receiving node either (a) has insufficient resources to store and forward the bundle, (b) has no route to the destination, or (c) will have no contact with the next hop on the route before the bundle's TTL has expired. In any case, a "custody refusal signal" (packaged in a bundle) is sent back to the sending node, which must re-forward the bundle in hopes of finding a more suitable route.

Alternatively, failure to receive a custody acceptance signal within some convergence-layer-specified or application-specified time interval may also be taken as an implicit indication of forwarding failure. Here again, when BP detects such a failure it attempts to re-forward the affected bundle, placing the bundle in the limbo list if re-forwarding is currently impossible.

In the worst case, the combined efforts of all the retransmission mechanisms in ION are not enough to ensure delivery of a given bundle, even when custody transfer is requested. In that event, the bundle's "time to live" will eventually expire while the bundle is still in custody at some node: the **bpclock** task will send a bundle status report to the bundle's report-to endpoint, noting the TTL expiration, and destroy the bundle. The report-to endpoint, upon receiving this report, may be able to initiate application-layer

retransmission of the original application data unit in some way. This final retransmission mechanism is wholly application-specific, however.

1.8.6 Rate Control

In the Internet, the rate of transmission at a node can be dynamically negotiated in response to changes in level of activity on the link, to minimize congestion. On deep space links, signal propagation delays (distances) may be too great to enable effective dynamic negotiation of transmission rates. Fortunately, deep space links are operationally reserved for use by designated pairs of communicating entities over pre-planned periods of time at pre-planned rates. Provided there is no congestion inherent in the contact plan, congestion in the network can be avoided merely by adhering to the planned contact periods and data rates. *Rate control* in ION serves this purpose.

While the system is running, transmission and reception of bundles is constrained by the *current capacity* in the *throttle* of each convergence-layer manager. Completed bundle transmission activity reduces the current capacity of the applicable throttle by the capacity consumption computed for that bundle. This reduction may cause the throttle's current capacity to become negative. Once the current capacity of the applicable throttle goes negative, activity is blocked until non-negative capacity has been restored by **bpclock**.

Once per second, the **bpclock** task increases the current capacity of each throttle by one second's worth of traffic at the nominal data rate for transmission to that node, thus enabling some possibly blocked bundle transmission and reception to proceed.

bpclock revises all throttles' nominal data rates once per second in accord with the current data rates in the corresponding Neighbor objects, as adjusted by **rfxclock** per the contact plan.

Note that this means that, for any neighboring node for which there are planned contacts, ION's rate control system will enable data flow only while contacts are active.

1.8.7 Flow Control

A further constraint on rates of data transmission in an ION-based network is LTP flow control. LTP is designed to enable multiple block transmission sessions to be in various stages of completion concurrently, to maximize link utilization: there is no requirement to wait for one session to complete before starting the next one. However, if unchecked this design principle could in theory result in the allocation of all memory in the system to incomplete LTP transmission sessions. To prevent complete storage resource exhaustion, we set a firm upper limit on the total number of outbound blocks that can be concurrently in transit at any given time. These limits are established by **ltpadmin** at node initialization time.

The maximum number of transmission sessions that may be concurrently managed by LTP therefore constitutes a transmission "window" – the basis for a delay-tolerant, non-conversational flow control service over interplanetary links. Once the maximum number of sessions are in flight, no new block transmission session can be initiated – regardless of how much outduct transmission capacity is provided by rate control – until some existing session completes or is canceled.

Note that this consideration emphasizes the importance of configuring the aggregation size limits and session count limits of spans during LTP initialization to be consistent with the maximum data rates scheduled for contacts over those spans.

1.8.8 Storage Management

Congestion in a dtnet is the imbalance between data enqueuing and dequeuing rates that results in exhaustion of queuing (storage) resources at a node, preventing continued operation of the protocols at that node.

In ION, the affected queuing resources are allocated from notionally non-volatile storage space in the SDR data store and/or file system. The design of ION is required to prevent resource exhaustion by simply refusing to enqueue additional data that would cause it.

However, a BP router's refusal to enqueue received data for forwarding could result in costly retransmission, data loss, and/or the "upstream" propagation of resource exhaustion to other nodes. Therefore the ION design additionally attempts to prevent potential resource exhaustion by forecasting levels of queuing resource occupancy and reporting on any congestion that is predicted. Network operators, upon reviewing these forecasts, may revise contact plans to avert the anticipated resource exhaustion.

The non-volatile storage used by ION serves several purposes: it contains queues of bundles awaiting forwarding, transmission, and delivery; it contains LTP transmission and reception sessions, including the blocks of data that are being transmitted and received; it contains queues of LTP segments awaiting radiation; it may contain CFDP transactions in various stages of completion; and it contains protocol operational state information, such as configuration parameters, static routes, the contact graph, etc.

Effective utilization of non-volatile storage is a complex problem. Static pre-allocation of storage resources is in general less efficient (and also more labor-intensive to configure) than storage resource pooling and automatic, adaptive allocation: trying to predict a reasonable maximum size for every data storage structure and then rigidly enforcing that limit typically results in underutilization of storage resources and underperformance of the system as a whole. However, static pre-allocation is mandatory for safety-critical resources, where certainty of resource availability is more important than efficient resource utilization.

The tension between the two approaches is analogous to the tension between circuit switching and packet switching in a network: circuit switching results in underutilization of link resources and underperformance of the network as a whole (some peaks of activity can never be accommodated, even while some resources lie idle much of the time), but dedicated circuits are still required for some kinds of safety-critical communication.

So the ION data management design combines these two approaches (see 1.5 above for additional discussion of this topic):

- A fixed percentage of the total SDR data store heap size (by default, 40%) is statically allocated to the storage of protocol operational state information, which is critical to the operation of ION.

- Another fixed percentage of the total SDR data store heap size (by default, 20%) is statically allocated to "margin", a reserve that helps to insulate node management from errors in resource allocation estimates.
- The remainder of the heap, plus all pre-allocated file system space, is allocated to protocol traffic[2].

The maximum projected occupancy of the node is the result of computing a *congestion forecast* for the node, by adding to the current occupancy all anticipated net increases and decreases from now until some future time, termed the *horizon* for the forecast.

The forecast horizon is indefinite – that is, "forever" – unless explicitly declared by network management via the `ionadmin` utility program. The difference between the horizon and the current time is termed the *interval* of the forecast.

Net occupancy increases and decreases are of four types:

1. Bundles that are originated locally by some application on the node, which are enqueued for forwarding to some other node.
2. Bundles that are received from some other node, which are enqueued either for forwarding to some other node or for local delivery to an application.
3. Bundles that are transmitted to some other node, which are dequeued from some forwarding queue.
4. Bundles that are delivered locally to an application, which are dequeued from some delivery queue.

The type-1 anticipated net increase (total data origination) is computed by multiplying the node's projected rate of local data production, as declared via an **ionadmin** command, by the interval of the forecast. Similarly, the type-4 anticipated net decrease (total data delivery) is computed by multiplying the node's projected rate of local data consumption, as declared via an **ionadmin** command, by the interval of the forecast. Net changes of types 2 and 3 are computed by multiplying inbound and outbound data rates, respectively, by the durations of all periods of planned communication contact that begin and/or end within the interval of the forecast.

Congestion forecasting is performed by the **ionwarn** utility program. **ionwarn** may be run independently at any time; in addition, the **ionadmin** utility program automatically runs **ionwarn** immediately before exiting if it executed any change in the contact plan, the forecast horizon, or the node's projected rates of local data production or consumption. Moreover, the **rfxclock** daemon program also runs **ionwarn** automatically whenever any of the scheduled reconfiguration events it dispatches result in contact state changes that might alter the congestion forecast.

If the final result of the forecast computation – the maximum projected occupancy of the node over the forecast interval – is less than the total protocol traffic allocation, then no congestion is forecast. Otherwise, a congestion forecast status message is logged noting

[2] Note that, in all occupancy figures, ION data management accounts not only for the sizes of the payloads of all queued bundles but also for the sizes of their headers.

the time at which maximum projected occupancy is expected to equal the total protocol traffic allocation.

Congestion control in ION, then, has two components:

> First, ION's congestion detection is anticipatory (via congestion forecasting) rather than reactive as in the Internet.
>
> Anticipatory congestion detection is important because the second component – congestion mitigation – must also be anticipatory: it is the adjustment of communication contact plans by network management, via the propagation of revised schedules for future contacts.

(Congestion mitigation in an ION-based network is likely to remain mostly manual for many years to come, because communication contact planning involves much more than orbital dynamics: science operations plans, thermal and power constraints, etc. It will, however, rely on the automated rate control features of ION, discussed above, which ensure that actual network operations conform to established contact plans.)

Rate control in ION is augmented by *admission control*. ION tracks the sum of the sizes of all zero-copy objects currently residing in the heap and file system at any moment. Whenever any protocol implementation attempts to create or extend a ZCO in such a way that total heap or file occupancy would exceed an upper limit asserted for the node, that attempt is either blocked until ZCO space becomes available or else rejected altogether.

1.8.9 Optimizing an ION-based network

ION is designed to deliver critical data to its final destination with as much certainty as possible (and optionally as soon as possible), but otherwise to try to maximize link utilization. The delivery of critical data is expedited by contact graph routing and bundle prioritization as described elsewhere. Optimizing link utilization, however, is a more complex problem.

If the volume of data traffic offered to the network for transmission is less than the capacity of the network, then all offered data should be successfully delivered[3]. But in that case the users of the network are paying the opportunity cost of whatever portion of the network capacity was not used.

Offering a data traffic volume that is exactly equal to the capacity of the network is in practice infeasible. TCP in the Internet can usually achieve this balance because it exercises end-to-end flow control: essentially, the original source of data is *blocked* from offering a message until notified by the final destination that transmission of this message can be accommodated given the current negotiated data rate over the end-to-end path (as determined by TCP's congestion control mechanisms). In a delay-tolerant network no such end-to-end negotiated data rate may exist, much less be knowable, so such precise control of data flow is impossible.[4]

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[3] Barring data loss or corruption for which the various retransmission mechanisms in ION cannot compensate.

[4] Note that ION may indeed block the offering of a message to the network, but this is local admission control – assuring that the node's local buffer space for queuing outbound bundles is not oversubscribed –

The only alternative: the volume of traffic offered by the data source must be greater than the capacity of the network and the network must automatically discard excess traffic, shedding lower-priority data in preference to high-priority messages on the same path.

ION discards excess traffic proactively when possible and reactively when necessary.

Proactive data triage occurs when ION determines that it cannot compute a route that will deliver a given bundle to its final destination prior to expiration of the bundle's Time To Live (TTL). That is, a bundle may be discarded simply because its TTL is too short, but more commonly it will be discarded because the planned contacts to whichever neighboring node is first on the path to the destination are already fully subscribed: the queue of bundles awaiting transmission to that neighbor is already so long as to consume the entire capacity of all announced opportunities to transmit to it. Proactive data triage causes the bundle to be immediately destroyed as one for which there is "No known route to destination from here."

The determination of the degree to which a contact is subscribed is based not only on the aggregate size of the queued bundles but also on the estimated aggregate size of the overhead imposed by all the convergence-layer (CL) protocol data units – at all layers of the underlying stack – that encapsulate those bundles: packet headers, frame headers, etc. This means that the accuracy of this overhead estimate will affect the aggressiveness of ION's proactive data triage:

- If CL overhead is overestimated, the size of the bundle transmission backlog for planned contacts will be overstated, unnecessarily preventing the enqueuing of additional bundles – a potential under-utilization of available transmission capacity in the network.
- If CL overhead is underestimated, the size of the bundle transmission backlog for planned contacts will be understated, enabling the enqueuing of bundles whose transmission cannot in fact be accomplished by the network within the constraints of the current contact plan. This will eventually result in reactive data triage.

Essentially, all reactive data triage – the destruction of bundles due to TTL expiration prior to successful delivery to the final destination – occurs when the network conveys bundles at lower net rates than were projected during route computation. These performance shortfalls can have a variety of causes:

- As noted above, underestimating CL overhead causes CL overhead to consume a larger fraction of contact capacity than was anticipated, leaving less capacity for bundle transmission.
- Conversely, the total volume of traffic offered may have been accurately estimated but the amount of contact capacity may be less than was promised: a contact might be started late, stopped early, or omitted altogether, or the actual data rate on the link might be less than was advertised.
- Contacts may be more subtly shortened by the configuration of ION itself. If the clocks on nodes are known not to be closely synchronized then a "maximum

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rather than end-to-end flow control. It is always possible for there to be ample local buffer space yet insufficient network capacity to convey the offered data to their final destination, and vice versa.

clock error" of N seconds may be declared, causing reception episodes to be started locally N seconds earlier and stopped N seconds later than scheduled, to avoid missing some transmitted data because it arrived earlier or later than anticipated. But this mechanism also causes transmission episodes to be started N seconds later and stopped N seconds earlier than scheduled, to avoid transmitting to a neighbor before it is ready to receive data, and this contact truncation ensures transmission of fewer bundles than planned.

- Flow control within the convergence layer underlying the bundle protocol may constrain the effective rate of data flow over a link to a rate that's lower than the link's configured maximum data rate. In particular, mis-configuration of the LTP flow control window can leave transmission capacity unused while LTP engines are awaiting acknowledgments.
- Even if all nodes are correctly configured, a high rate of data loss or corruption due to unexpectedly high R/F interference or underestimated acknowledgment round-trip times may cause an unexpectedly high volume of retransmission traffic. This will displace original bundle transmission, reducing the effective "goodput" data rate on the link.
- Finally, custody transfer may propagate operational problems from one part of the network to other nodes. One result of reduced effective transmission rates is the accumulation of bundles for which nodes have taken custody: the custodial nodes can't destroy those bundles and reclaim the storage space they occupy until custody has been accepted by "downstream" nodes, so abbreviated contacts that prevent the flow of custody acceptances can increase local congestion. This reduces nodes' own ability to take custody of bundles transmitted by "upstream" custodians, increasing queue sizes on those nodes, and so on. In short, custody transfer may itself ultimately impose reactive data triage simply by propagating congestion.

Some level of data triage is essential to cost-effective network utilization, and proactive triage is preferable because its effects can be communicated immediately to users, improving user control over the use of the network. Optimizing an ION-based network therefore amounts to managing for a modicum of proactive data triage and as little reactive data triage as possible. It entails the following:

1. Estimating convergence-layer protocol overhead as accurately as possible, erring (if necessary) on the side of optimism – that is, underestimating a little.

   As an example, suppose the local node uses LTP over CCSDS Telemetry to send bundles. The immediate convergence-layer protocol is LTP, but the total overhead per CL "frame" (in this case, per LTP segment) will include not only the size of the LTP header (nominally 5 bytes) but also the size of the encapsulating space packet header (nominally 6 bytes) and the overhead imposed by the outer encapsulating TM frame.

   Suppose each LTP segment is to be wrapped in a single space packet, which is in turn wrapped in a single TM frame, and Reed-Solomon encoding is applied. An efficient TM frame size is 1115 bytes, with an

additional 160 bytes of trailing Reed-Solomon encoding and another 4 bytes of leading pseudo-noise code. The frame would contain a 6-byte TM frame header, a 6-byte space packet header, a 5-byte LTP segment header, and 1098 bytes of some LTP transmission block.

So the number of "payload bytes per frame" in this case would be 1098 and the number of "overhead bytes per frame" would be 4 + 6 + 6 + 5 + 160 = 181. Nominal total transmission overhead on the link would be 181 / 1279 = about 14%.

2. Synchronizing nodes' clocks as accurately as possible, so that timing margins configured to accommodate clock error can be kept as close to zero as possible.
3. Setting the LTP session limit and block size limit as generously as possible (whenever LTP is at the convergence layer), to assure that LTP flow control does not constrain data flow to rates below those supported by BP rate control.
4. Setting ranges (one-way light times) and queuing delays as accurately as possible, to prevent unnecessary retransmission. Err on the side of pessimism – that is, overestimate a little.
5. Communicating changes in configuration – especially contact plans – to all nodes as far in advance of the time they take effect as possible.
6. Providing all nodes with as much storage capacity as possible for queues of bundles awaiting transmission.

1.9 BP/LTP detail – how it works

Although the operation of BP/LTP in ION is complex in some ways, virtually the entire system can be represented in a single diagram. The interactions among all of the concurrent tasks that make up the node – plus a Remote AMS task or CFDP UT-layer task, acting as the application at the top of the stack – are shown below. (The notation is as used earlier but with semaphores added. Semaphores are shown as small circles, with arrows pointing into them signifying that the semaphores are being given and arrows pointing out of them signifying that the semaphores are being taken.)

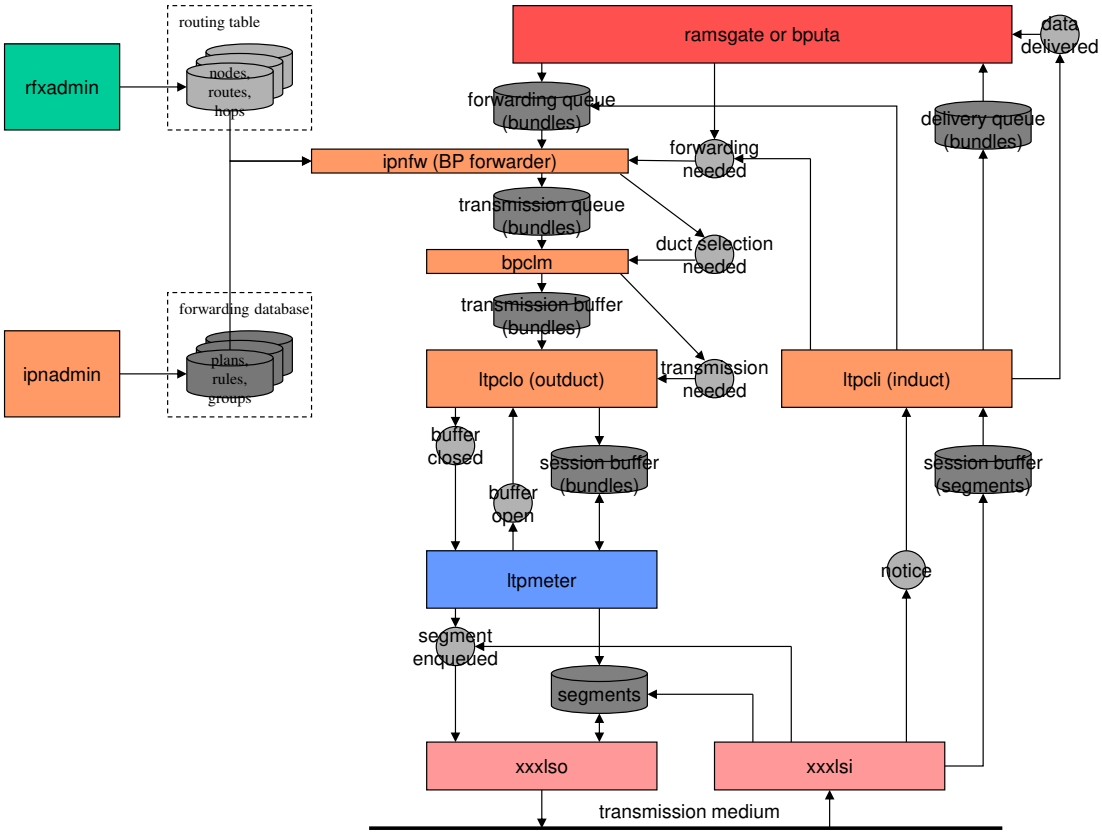


Figure 7 ION node functional overview

Further details of the BP/LTP data structures and flow of control and data appear on the following pages. (For specific details of the operation of the BP and LTP protocols as implemented by the ION tasks, such as the nature of report-initiated retransmission in LTP, please see the protocol specifications. The BP specification is documented in Internet RFC 5050, while the LTP specification is documented in Internet RFC 5326.)

1.9.1 Databases

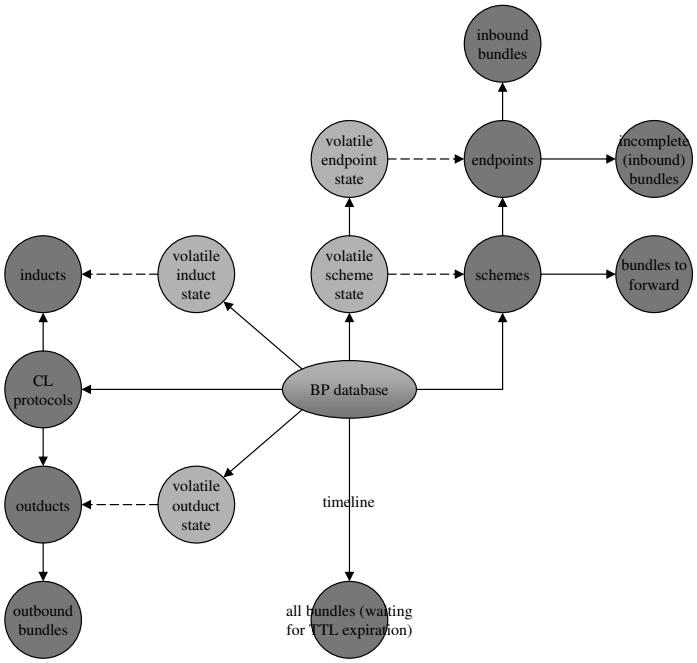


Figure 8 Bundle protocol database

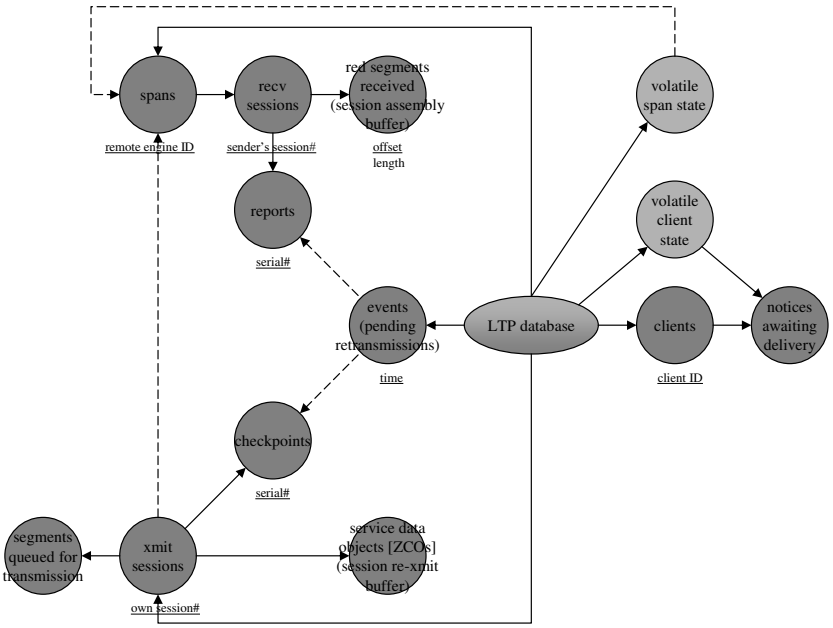
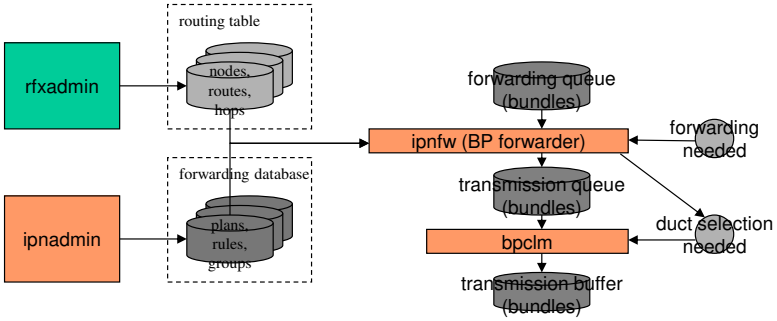


Figure 9 Licklider transmission protocol database

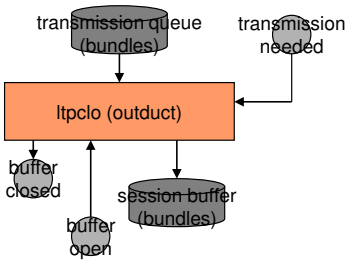
1.9.2 Control and data flow

Bundle Protocol



1. Waits for *forwarding needed* semaphore.
2. Gets bundle from queue.
3. Consults routing table and forwarding table to determine all plausible proximate destinations – routing.
   - A plausible proximate destination is the destination node of the first entry in a contact sequence (a list of concatenated contact periods) ending in a contact period whose destination node is the bundle's destination node and whose start time is less than the bundle's expiration time.
4. Appends bundle to transmission queue (based on priority) for best plausible proximate destination.
5. Gives *duct selection needed* semaphore for that transmission queue.
6. Convergence-layer manager daemon waits for *duct selection needed* semaphore.
7. Gets bundle from queue. Imposes flow control, fragments as needed. Consults mission-provided code (if provided), selects outduct to use for transmission of bundle to this proximate destination.
8. Inserts bundle into transmission buffer for selected outduct.
9. Gives *transmission needed* semaphore for this buffer.

Figure 10 BP forwarder



1. Waits for *buffer open* semaphore (indicating that the link's session buffer has room for the bundle).
2. Waits for *transmission needed* semaphore.
3. Gets bundle from queue, subject to priority.
4. Appends bundle to link's session buffer – aggregation. Buffer size is notionally limited by aggregation size limit, a persistent attribute of the Span object: implicitly, the rate at which we want reports to be transmitted by the destination engine.
5. Gives *buffer closed* semaphore when buffer occupancy reaches the aggregation size limit.

Figure 11 BP convergence layer output

1. Initializes session buffer, gives *buffer open* semaphore.
2. Waits for *buffer closed* semaphore (indicating that the session buffer is ready for transmission).
3. Segments the entire buffer into segments of managed MTU size – fragmentation.
4. Appends all segments to segments queue for immediate transmission.
5. Gives *segment enqueued* semaphore.

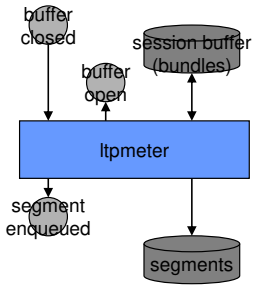


Figure 12 LTP transmission metering

1. Waits for *segment enqueued* semaphore (indicating that there is now something to transmit).
2. Gets segment from queue.
3. Sets retransmission timer if necessary.
4. Transmits the segment using link service protocol.

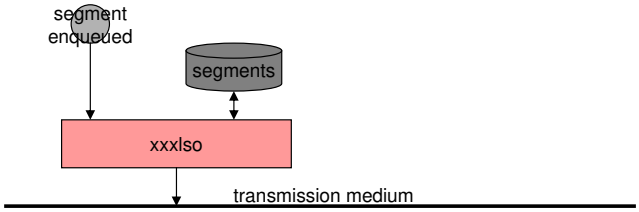


Figure 13 LTP link service output

1. Receives a segment using link service protocol.
2. If data, generates report segment and appends it to queue – reliability. Also inserts data into reception session buffer “red part” and, if that buffer is complete, gives *notice* semaphore to trigger bundle extraction and dispatching by ltpcli.
3. If a report, appends acknowledgement to segments queue.
4. If a report of missing data, recreates lost segments and appends them to queue.
5. Gives *segment enqueued* semaphore.

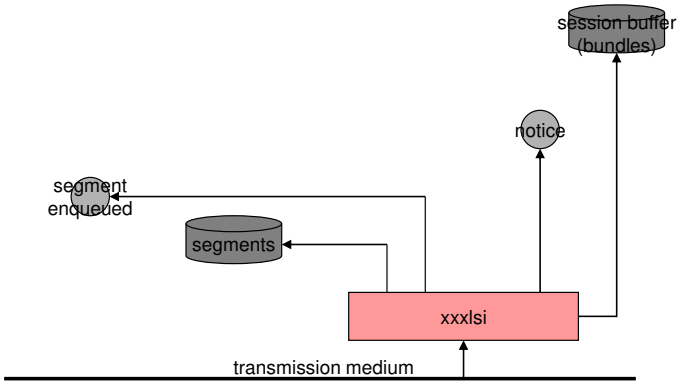


Figure 14 LTP link service input

1.10 Contact Graph Routing (CGR)

CGR is a dynamic routing system that computes routes through a time-varying topology of scheduled communication contacts in a DTN network. It is designed to support operations in a space network based on DTN, but it also could be used in terrestrial applications where operation according to a predefined schedule is preferable to opportunistic communication, as in a low-power sensor network.

The basic strategy of CGR is to take advantage of the fact that, since communication operations are planned in detail, the communication routes between any pair of "bundle agents" in a population of nodes that have all been informed of one another's plans can be inferred from those plans rather than discovered via dialogue (which is impractical over long-one-way-light-time space links).

1.10.1 Contact Plan Messages

CGR relies on accurate contact plan information provided in the form of contact plan messages that currently are only read from **ionrc** files and processed by **ionadmin**, which retains them in a non-volatile contact plan in the RFX database, in ION's SDR data store.

Contact plan messages are of two types: *contact messages* and *range messages*.

Each contact message has the following content:

- The starting UTC time of the interval to which the message pertains.
- The stop time of this interval, again in UTC.
- The Transmitting node number.
- The Receiving node number.
- The planned rate of transmission from node A to node B over this interval, in bytes per second.

Each range message has the following content:

- The starting UTC time of the interval to which the message pertains.
- The stop time of this interval, again in UTC.
- Node number A.
- Node number B.
- The anticipated distance between A and B over this interval, in light seconds.

Note that range messages may be used to declare that the "distance" in light seconds between nodes A and B is **different** in the B→A direction from the distance in the A→B direction. While direct radio communication between A and B will not be subject to such asymmetry, it's possible for connectivity established using other convergence-layer technologies to take different physical paths in different directions, with different signal propagation delays.

1.10.2 Routing Tables

Each node uses Range and Contact messages in the contact plan to build a "routing table" data structure.

The routing table constructed locally by each node in the network is a list of *entry node lists*, one route list for every other node D in the network that is cited in any Contact or Range in the contact plan. Entry node lists are computed as they are needed, and the maximum number of entry node lists resident at a given time is the number of nodes that are cited in any Contacts or Ranges in the contact plan. Each entry in the entry node list for node D is a list of the neighbors of local node X; included with each entry of the entry node list is a list one or more routes to D through the indicated neighbor, termed a *route lis*t.

Each route in the route list for node D identifies a path to destination node D, from the local node, that begins with transmission to one of the local node's neighbors in the network– the initial receiving node for the route, termed the route's *entry node*.

For any given route, the contact from the local node to the entry node constitutes the initial transmission segment of the end-to-end path to the destination node. Additionally noted in each route object are all of the other contacts that constitute the remaining segments of the route's end-to-end path.

Each route object also notes the forwarding *cost* for a bundle that is forwarded along this route. In this version of ION, CGR is configured to deliver bundles as early as possible, so best-case final delivery time is used as the cost of a route. Other metrics might be substituted for final delivery time in other CGR implementations. NOTE, however, that if different metrics are used at different nodes along a bundle's end-to-end path it becomes impossible to prevent routing loops that can result in non-delivery of the data.

Finally, each route object also notes the route's termination time, the time after which the route will become moot due to the termination of the earliest-ending contact in the route.

1.10.3 Key Concepts

Expiration time

Every bundle transmitted via DTN has a time-to-live (TTL), the length of time after which the bundle is subject to destruction if it has not yet been delivered to its destination. The *expiration time* of a bundle is computed as its creation time plus its TTL. When computing the next-hop destination for a bundle that the local bundle agent is required to forward, there is no point in selecting a route that can't get the bundle to its final destination prior to the bundle's expiration time.

OWLT margin

One-way light time (OWLT) – that is, distance – is obviously a factor in delivering a bundle to a node prior to a given time. OWLT can actually change during the time a bundle is en route, but route computation becomes intractably complex if we can't assume an OWLT "safety margin" – a maximum delta by which OWLT between any pair of nodes can change during the time a bundle is in transit between them.

We assume that the maximum rate of change in distance between any two nodes in the network is about 150,000 miles per hour, which is about 40 miles per second. (This was the speed of the Helios spacecraft, the fastest man-made object launched to date.)

At this speed, the distance between any two nodes that are initially separated by a distance of N light seconds will increase by a maximum of 80 miles per second of transit (in the event that they are moving in opposite directions). This will result in data arrival no later than roughly (N + 2Q) seconds after transmission – where the "OWLT margin" value Q is (40 * N) divided by 186,000 – rather than just N seconds after transmission as would be the case if the two nodes were stationary relative to each other. When computing the expected time of arrival of a transmitted bundle we simply use N + 2Q, the most pessimistic case, as the anticipated total in-transit time.

Capacity

The *capacity* of a contact is the product of its data transmission rate (in bytes per second) and its duration (stop time minus start time, in seconds).

Estimated capacity consumption

The size of a bundle is the sum of its payload size and its header size[5], but bundle size is not the only lien on the capacity of a contact. The total estimated volume consumption (or "EVC") for a bundle is the sum of the sizes of the bundle's payload and header and the estimated convergence-layer overhead. For a bundle whose header is of size M and whose payload is of size N, the estimated convergence-layer overhead is defined as 3% of (M+N), or 100 bytes, whichever is larger.**Residual capacity**

The *residual capacity* of a given contact between the local node and one of its neighbors, as computed for a given bundle, is the sum of the capacities of that contact and all prior scheduled contacts between the local node and that neighbor, less the sum of the ECCs of all bundles with priority equal to or higher than the priority of the subject bundle that are currently queued on the outduct for transmission to that neighbor.

Excluded neighbors

A neighboring node C that refuses custody of a bundle destined for some remote node D is termed an *excluded neighbor* for (that is, with respect to computing routes to) D. So long as C remains an excluded neighbor for D, no bundles destined for D will be forwarded to C – except that occasionally (once per lapse of the RTT between the local node and C) a custodial bundle destined for D will be forwarded to C as a "probe bundle". C ceases to be an excluded neighbor for D as soon as it accepts custody of a bundle destined for D.

Critical bundles

[5] The minimum size of an ION bundle header is 26 bytes. Adding extension blocks (such as those that effect the Bundle Security Protocol) will increase this figure.

A Critical bundle is one that absolutely has got to reach its destination and, moreover, has got to reach that destination as soon as is physically possible[6].

For an ordinary non-Critical bundle, the CGR dynamic route computation algorithm uses the routing table to select a single neighboring node to forward the bundle through. It is possible, though, that due to some unforeseen delay the selected neighbor may prove to be a sub-optimal forwarder: the bundle might arrive later than it would have if another neighbor had been selected, or it might not even arrive at all.

For Critical bundles, the CGR dynamic route computation algorithm causes the bundle to be inserted into the outbound transmission queues for transmission to all neighboring nodes that can plausibly forward the bundle to its final destination. The bundle is therefore guaranteed to travel over the most successful route, as well as over all other plausible routes. Note that this may result in multiple copies of a Critical bundle arriving at the final destination.

1.10.4 Dynamic Route Selection Algorithm

Given a bundle whose destination is node D, we proceed as follows.

First, if no contacts in the contact plan identify transmission to node D, then we cannot use CGR to find a route for this bundle; CGR route selection is abandoned.

Next, if the contact plan has been modified in any way since routes were computed for any nodes, we discard all routes for all nodes and authorize route recomputaton. (The contact plan changes may have invalidated any or all of those earlier computations.)

We create an empty list of Proximate Nodes (network neighbors) to send the bundle to.

We create a list of Excluded Nodes, i.e., nodes through which we will not compute a route for this bundle. The list of Excluded Nodes is initially populated with:

- the node from which the bundle was directly received (so that we avoid cycling the bundle between that node and the local node) – unless the Dynamic Route Selection Algorithm is being re-applied due to custody refusal as discussed later;
- all excluded neighbors for the bundle's final destination node.

If all routes computed for node D have been discarded due to contact plan modification, then we must compute a new list of all routes from the local node to D. To do so:

- We construct an abstract contact graph, a directed acyclic graph whose root is a notional contact from the local node to itself and whose other vertices are all other contacts representing transmission "from" some node such that a contact "to" that node already exists in the graph, excluding contacts representing transmission "to" some node such that a contact "from" that node already exists in the graph. A terminal vertex is also included in the graph, constituting a notional contact from node D to itself.

[6] In ION, all bundles are by default non-critical. The application can indicate that data should be sent in a Critical bundle by setting the BP_MINIMUM_LATENCY flag in the "extended class of service" parameter, but this feature is an ION extension that is not supported by other BP implementations at the time of this writing.

- We perform several Dijkstra searches within this graph, one search for each of the local node's neighbors. On each search we find the lowest-cost route that begins at the root of the graph and ends at the terminal vertex. Each time a route is computed, we add it to the list of routes for that route's entry node and then remove from further consideration all contacts from the local node to the entry node of that route.
    - The lowest-cost route computed during a search is the one that is found to have the earliest best-case delivery time, where the best-case delivery time characterizing a route is given by the time at which a bundle would arrive at node D if transmitted at the earliest possible moment of the last contact in the route prior to the terminal vertex.
    - Any contact whose end time is before the earliest possible time that the bundle could arrive at the contact's sending node is ignored.
    - The earliest possible arrival time for the bundle on a given contact is pessimistically computed as the sum of the bundle's earliest possible transmission time plus the range in light seconds from the contact's sending node to its receiving node, plus the applicable one-way light time margin.
    - The earliest possible transmission time for the bundle on a given contact is the start time of the contact or bundle's earliest possible arrival time at the contact's sending node, whichever is later.
- If node D's list of entry nodes (route lists) is still empty, then we cannot use CGR to find a route for this bundle; CGR route selection is abandoned.

We next examine all of the routes that are currently computed for transmission of bundles to node D.

- Any route whose termination time is in the past is deleted from the list, and all contacts in that route whose termination time is in the past are also deleted. But we then run another Dijkstra search to compute the best route through the affected entry node given the remaining contacts; if this search finds a route, the new route is inserted into the appropriate location in the list.
- Any route whose best-case final delivery time is after the bundle's expiration time is ignored, as is any route whose entry node is in the list of Excluded Nodes. Loopback routes are also ignored unless the local node is the bundle's final destination.
- For each route, the aggregate radiation time for this bundle on this route is computed by summing the product of payload size and contact transmission rate over all contacts in the route. Any route for which the sum of best-case delivery time and aggregate radiation time is after the bundle's expiration time is ignored.

For each route that is not ignored, the route's entry node is added to the list of Proximate Nodes for this bundle. Associated with the entry node number in this list entry are the best-case final delivery time of the route, the total number of "hops" in the route's end-to-end path, and the forfeit time for transmission to this node. Forfeit time is the route's

termination time, the time by which the bundle must have been transmitted to this node in order to have any chance of being forwarded on this route.

If, at the end of this procedure, the Proximate Nodes list is empty, then we have been unable to use CGR to find a route for this bundle; CGR route selection is abandoned.

Otherwise:

- If the bundle is flagged as a critical bundle, then a cloned copy of this bundle is enqueued for transmission to every node in the Proximate Nodes list.
- Otherwise, the bundle is enqueued for transmission on the outduct to the most preferred neighbor in the Proximate Nodes list:
    - If one of the nodes in this list is associated with a best-case delivery time that is earlier than that of all other nodes in the list, then it is the most preferred neighbor.
    - Otherwise, if one of the nodes with the earliest best-case delivery time is associated with a smaller hop count than every other node with the same best-case delivery time, then it is the most preferred neighbor.
    - Otherwise, the node with the smallest node number among all nodes with the earliest best-case delivery time and smallest hop count is arbitrarily chosen as the most preferred neighbor.

1.10.5 Exception Handling

Conveyance of a bundle from source to destination through a DTN can fail in a number of ways, many of which are best addressed by means of the Delivery Assurance mechanisms described earlier. Failures in Contact Graph Routing, specifically, occur when the expectations on which routing decisions are based prove to be false. These failures of information fall into two general categories: contact failure and custody refusal.

1) Contact failure

   A scheduled contact between some node and its neighbor on the end-to-end route may be initiated later than the originally scheduled start time, or be terminated earlier than the originally scheduled stop time, or be canceled altogether. Alternatively, the available capacity for a contact might be overestimated due to, for example, diminished link quality resulting in unexpectedly heavy retransmission at the convergence layer. In each of these cases, the anticipated transmission of a given bundle during the affected contact may not occur as planned: the bundle might expire before the contact's start time, or the contact's stop time might be reached before the bundle has been transmitted.

   For a non-Critical bundle, we handle this sort of failure by means of a timeout: if the bundle is not transmitted prior to the forfeit time for the selected Proximate Node, then the bundle is removed from its outbound transmission queue and the Dynamic Route Computation Algorithm is re-applied to the bundle so that an alternate route can be computed.

2) Custody refusal

A node that receives a bundle may find it impossible to forward it, for any of several reasons: it may not have enough storage capacity to hold the bundle, it may be unable to compute a forward route (static, dynamic, or default) for the bundle, etc. Such bundles are simply discarded, but discarding any such bundle that is marked for custody transfer will cause a custody refusal signal to be returned to the bundle's current custodian.

When the affected bundle is non-Critical, the node that receives the custody refusal re-applies the Dynamic Route Computation Algorithm to the bundle so that an alternate route can be computed – except that in this event the node from which the bundle was originally directly received is omitted from the initial list of Excluded Nodes. This enables a bundle that has reached a dead end in the routing tree to be sent back to a point at which an altogether different branch may be selected.

For a Critical bundle no mitigation of either sort of failure is required or indeed possible: the bundle has already been queued for transmission on all plausible routes, so no mechanism that entails re-application of CGR's Dynamic Route Computation Algorithm could improve its prospects for successful delivery to the final destination. However, in some environments it may be advisable to re-apply the Dynamic Route Computation Algorithm to all Critical bundles that are still in local custody whenever a new Contact is added to the contact graph: the new contact may open an additional forwarding opportunity for one or more of those bundles.

1.10.6 Remarks

The CGR routing procedures respond dynamically to the changes in network topology that the nodes are able know about, i.e., those changes that are subject to mission operations control and are known in advance rather than discovered in real time. This dynamic responsiveness in route computation should be significantly more effective and less expensive than static routing, increasing total data return while at the same time reducing mission operations cost and risk.

Note that the non-Critical forwarding load across multiple parallel paths should be balanced automatically:

- Initially all traffic will be forwarded to the node(s) on what is computed to be the best path from source to destination.
- At some point, however, a node on that preferred path may have so much outbound traffic queued up that no contacts scheduled within bundles' lifetimes have any residual capacity. This can cause forwarding to fail, resulting in custody refusal.
- Custody refusal causes the refusing node to be temporarily added to the current custodian's excluded neighbors list for the affected final destination node. If the refusing node is the only one on the path to the destination, then the custodian may end up sending the bundle back to its upstream neighbor. Moreover, that

custodian node too may begin refusing custody of bundles subsequently sent to it, since it can no longer compute a forwarding path.

- The upstream propagation of custody refusals directs bundles over alternate paths that would otherwise be considered suboptimal, balancing the queuing load across the parallel paths.
- Eventually, transmission and/or bundle expiration at the oversubscribed node relieves queue pressure at that node and enables acceptance of custody of a "probe" bundle from the upstream node. This eventually returns the routing fabric to its original configuration.

Although the route computation procedures are relatively complex they are not computationally difficult. The impact on computation resources at the vehicles should be modest.

1.11 LTP Timeout Intervals

Suppose we've got Earth ground station ES that is currently in view of Mars but will be rotating out of view ("Mars-set") at some time T1 and rotating back into view ("Mars-rise") at time T3. Suppose we've also got Mars orbiter MS that is currently out of the shadow of Mars but will move behind Mars at time T2, emerging at time T4. Let's also suppose that ES and MS are 4 light-minutes apart (Mars is at its closest approach to Earth). Finally, for simplicity, let's suppose that both ES and MS want to be communicating at every possible moment (maximum link utilization) but never want to waste any electricity.

Neither ES nor MS wants to be wasting power on either transmitting or receiving at a time when either Earth or Mars will block the signal.

ES will therefore stop transmitting at either T1 or (T2 - 4 minutes), whichever is earlier; call this time T_{et0}. It will stop receiving – that is, power off the receiver – at either T1 or (T2 + 4 minutes), whichever is earlier; call this time T_{er0}. It will resume transmitting at either T3 or (T4 - 4 minutes), whichever is later, and it will resume reception at either T3 or (T4 + 4 minutes), whichever is later; call these times T_{et1} and T_{er1}.

Similarly, MS will stop transmitting at either T2 or (T1 - 4 minutes), whichever is earlier; call this time T_{mt0}. It will stop receiving – that is, power off the receiver – at either T2 or (T1 + 4 minutes), whichever is earlier; call this time T_{mr0}. It will resume transmitting at either T4 or (T3 - 4 minutes), whichever is later, and it will resume reception at either T4 or (T3 + 4 minutes), whichever is later; call these times T_{mt1} and T_{mr1}.

By making sure that we don't transmit when the signal would be blocked, we guarantee that anything that is transmitted will arrive at a time when it can be received. Any reception failure is due to data corruption en route.

So the moment of transmission of an acknowledgment to any message is always equal to the moment the original message was sent plus some imputed outbound queuing delay QO1 at the sending node, plus 4 minutes, plus some imputed inbound and outbound queuing delay QI1 + QO2 at the receiving node. The nominally expected moment of reception of this acknowledgment is that moment of transmission plus 4 minutes, plus some imputed inbound queuing delay QI2 at the original sending node. That is, the timeout interval is 8 minutes + QO1 + QI1 + QO2 + QO2 – *unless* this moment of acknowledgment transmission is during an interval when the receiving node is not transmitting, for whatever reason. In this latter case, we want to suspend the acknowledgment timer during any interval in which we know the remote node will not be transmitting. More precisely, we want to add to the timeout interval the time difference between the moment of message arrival and the earliest moment at which the acknowledgment could be sent, i.e., the moment at which transmission is resumed[7].

[7] If we wanted to be extremely accurate we could also subtract from the timeout interval the imputed inbound queuing delay QI, since inbound queuing would presumably be completed during the interval in which transmission was suspended. But since we're guessing at the queuing delays anyway, this adjustment doesn't make a lot of sense.

So the timeout interval Z computed at ES for a message sent to MS at time T_X is given by:

$$Z = QO1 + 8 + QI1 + ((T_A = T_X + 4) > T_{mt0} \;\&\&\; T_A < T_{mt1}) \;?\; T_{mt1} - T_A : 0) + QI2 + QO2;$$

This can actually be computed in advance (at time T_X) if T1, T2, T3, and T4 are known and are exposed to the protocol engine.

If they are not exposed, then Z must initially be estimated to be (2 * the one-way light time) + QI + QO. The timer for Z must be dynamically suspended at time T_{mt0} in response to a state change as noted by **ltpclock**. Finally, the timer must be resumed at time T_{mt1} (in response to another state change as noted by **ltpclock**), at which moment the correct value for Z can be computed.

1.12 CFDP

The ION implementation of CFDP is very simple, because only Class-1 (Unacknowledged) functionality is implemented: the store-and-forward routing performed by Bundle Protocol makes the CFDP Extended Procedures unnecessary and the inter-node reliability provided by the CL protocol underneath BP – in particular, by LTP – makes the CFDP Acknowledged Procedures unnecessary. All that CFDP is required to do is segment and reassemble files, interact with the underlying Unitdata Transfer layer – BP/LTP – to effect the transmission and reception of file data segments, and handle CFDP metadata including filestore requests. CFDP-ION does all this, including support for cancellation of a file transfer transaction by cancellation of the transmission of the bundles encapsulating the transaction's protocol data units.

Note that all CFDP data transmission is "by reference", via the ZCO system, rather than "by value": the retransmission buffer for a bundle containing CFDP file data is an extent of the original file itself, not a copy retained in the ION database, and data received in bundles containing CFDP PDU is written immediately to the appropriate location in the reconstituted file rather than stored in the ION database. This minimizes the space needed for the database. In general, file transmission via CFDP is the most memory-efficient way to use ION in flight operations.

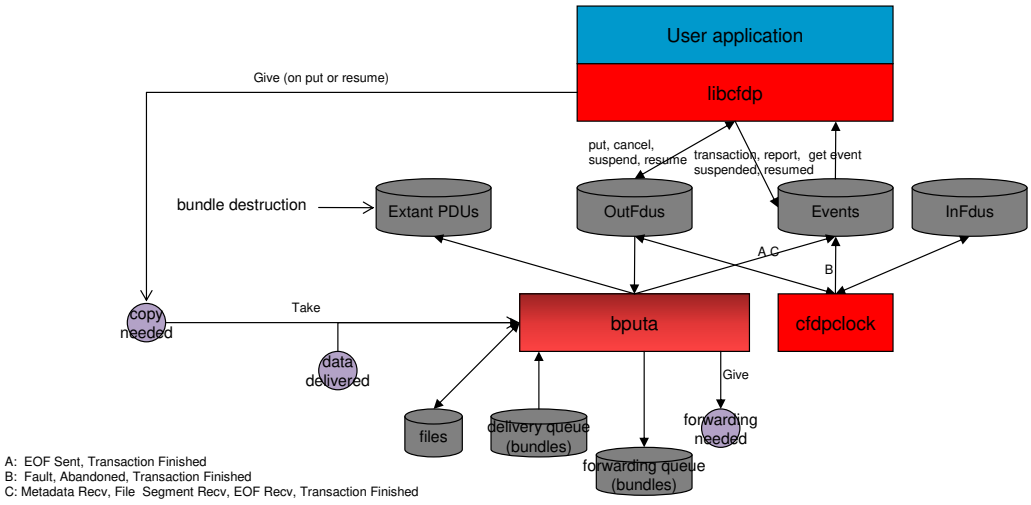


Figure 15 A CFDP-ION entity

1.13 Additional Figures for Manual Pages

1.13.1 list data structures (lyst, sdrlist, smlist)

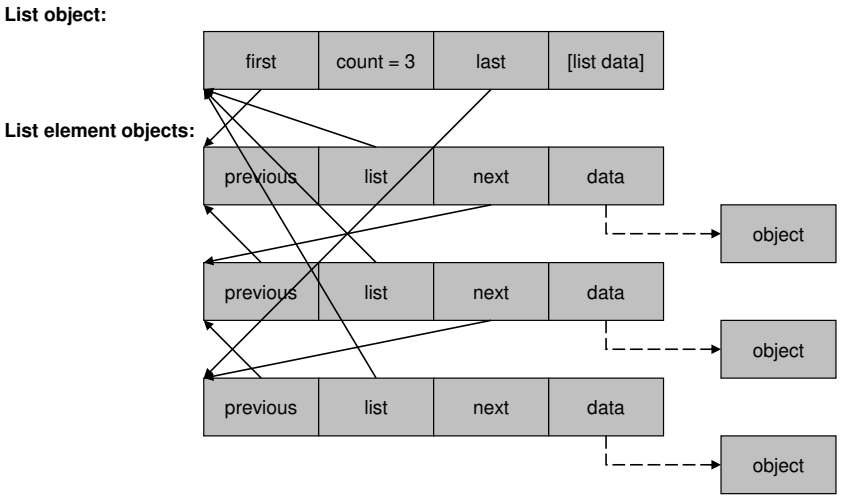


Figure 16 ION list data structures

1.13.2 psm partition structure

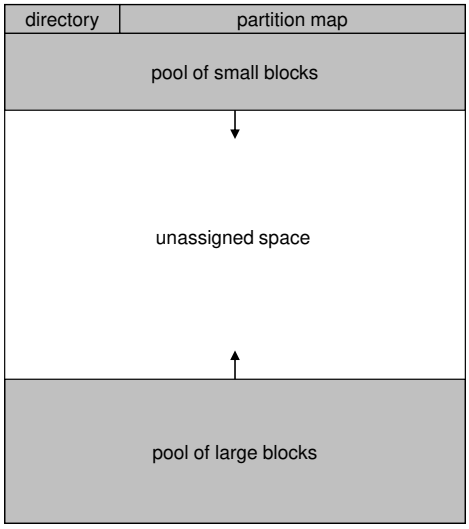


Figure 17 psm partition structure

1.13.3 psm and sdr block structures

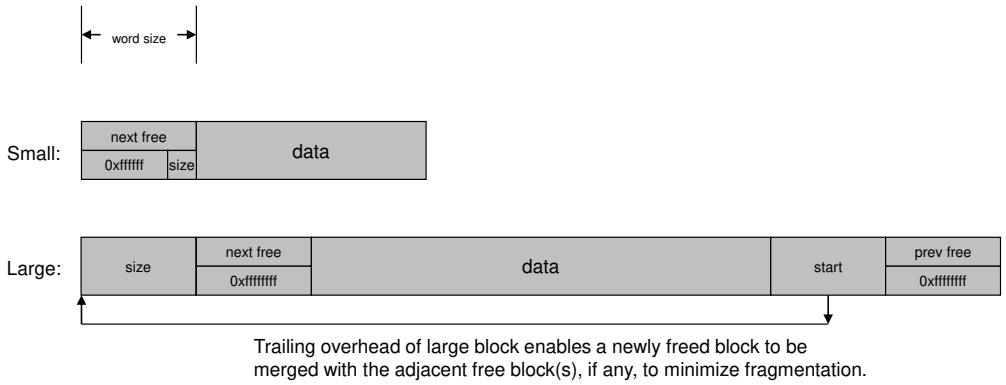


Figure 18 psm and sdr block structures

1.13.4 sdr heap structure

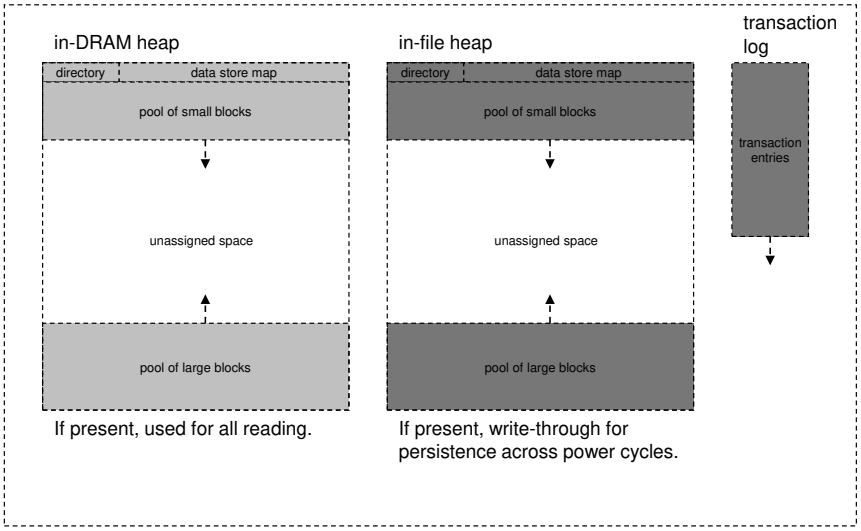


Figure 19 sdr heap structure

2 Operation

The ION source distribution contains a README.TXT file with details on building ION from source. For installations starting with the Sourceforge distribution, the standard sequence of

- ./configure
    - Note: the user needs to clear all errors reported by the configure script before proceeding. The distribution contains a default "Makefile" at the top level of the distribution for developer use. The configure script must complete successfully to produce an updated Makefile.
- make
- sudo make install

will build ION and install it under **/usr/local**.

Users building from a clone of the repository need to use the command

- autoreconf -fi

before starting the installation.

The "Build" instructions shown in the following sections for each package are the instructions for building each package individually, for ION development purposes. The default installation target for the individual package build commands is **/opt.**

One compile-time option is applicable to all ION packages: the platform selection parameters –DVXWORKS and –DRTEMS affect the manner in which most task instantiation functions are compiled. For VXWORKS and RTEMS, these functions are compiled as library functions that must be identified by name in the platform's symbol table, while for Unix-like platforms they are compiled as `main()` functions.

2.1 Interplanetary Communication Infrastructure (ICI)

2.1.1 Compile-time options

Declaring values for the following variables, by setting parameters that are provided to the C compiler (for example, `-DFSWSOURCE` or `-DSM_SEMBASEKEY=0xff13`), will alter the functionality of ION as noted below.

PRIVATE_SYMTAB

This option causes ION to be built for VxWorks 5.4 or RTEMS with reliance on a small private local symbol table that is accessed by means of a function named `sm_FindFunction`. Both the table and the function definition are, by default, provided by the `symtab.c` source file, which is automatically included within the `platform_sm.c` source when this option is set. The table provides the address of the top-level function to be executed when a task for the indicated symbol (name) is to be spawned, together with the priority at which that task is to execute and the amount of stack space to be allocated to that task.

PRIVATE_SYMTAB is defined by default for RTEMS but not for VxWorks 5.4.

Absent this option, ION on VxWorks 5.4 must successfully execute the VxWorks `symFindByName` function in order to spawn a new task. For this purpose the entire VxWorks symbol table for the compiled image must be included in the image, and task priority and stack space allocation must be explicitly specified when tasks are spawned.

FSWLOGGER

This option causes the standard ION logging function, which simply writes all ION status messages to a file named `ion.log` in the current working directory, to be replaced (by `#include`) with code in the source file `fswlogger.c`. A file of this name must be in the inclusion path for the compiler, as defined by `-Ixxxx` compiler option parameters.

FSWCLOCK

This option causes the invocation of the standard `time` function within `getUTCTime` (in `ion.c`) to be replaced (by `#include`) with code in the source file `fswutc.c`, which might for example invoke a mission-specific function to read a value from the spacecraft clock. A file of this name must be in the inclusion path for the compiler.

FSWWDNAME

This option causes the invocation of the standard `getcwd` function within `cfdpInit` (in `libcfdpP.c`) to be replaced (by `#include`) with code in the source file `wdname.c`, which must in some way cause the mission-specific value of current working directory name to be copied into `cfdpdbBuf.workingDirectoryName`. A file of this name must be in the inclusion path for the compiler.

FSWSYMTAB

If the PRIVATE_SYMTAB option is also set, then the FSWSYMTAB option causes the code in source file `mysymtab.c` to be included in `platform_sm.c` in place of the default symbol table access implementation in `symtab.c`. A file named `mysymtab.c` must be in the inclusion path for the compiler.

FSWSOURCE

This option simply causes FSWLOGGER, FSWCLOCK, FSWWDNAME, and FSWSYMTAB all to be set.

GDSLOGGER

This option causes the standard ION logging function, which simply writes all ION status messages to a file named `ion.log` in the current working directory, to be replaced (by `#include`) with code in the source file `gdslogger.c`. A file of this name must be in the inclusion path for the compiler, as defined by `-Ixxxx` compiler option parameters.

GDSSOURCE

This option simply causes GDSLOGGER to be set.

ION_OPS_ALLOC=*xx*

This option specifies the percentage of the total non-volatile storage space allocated to ION that is reserved for protocol operational state information, i.e., is not available for the storage of bundles or LTP segments. The default value is 20.

ION_SDR_MARGIN=*xx*

This option specifies the percentage of the total non-volatile storage space allocated to ION that is reserved simply as margin, for contingency use. The default value is 20.

The sum of ION_OPS_ALLOC and ION_SDR_MARGIN defines the amount of non-volatile storage space that is sequestered at the time ION operations are initiated: for purposes of congestion forecasting and prevention of resource oversubscription, this sum is subtracted from the total size of the SDR "heap" to determine the maximum volume of space available for bundles and LTP segments. Data reception and origination activities fail whenever they would cause the total amount of data store space occupied by bundles and segments to exceed this limit.

USING_SDR_POINTERS

This is an optimization option for the SDR non-volatile data management system: when set, it enables the value of any variable in the SDR data store to be accessed directly by means of a pointer into the dynamic memory that is used as the data store storage medium, rather than by reading the variable into a location in local stack memory. Note that this option must **not** be enabled if the data store is configured for file storage only, i.e., if the SDR_IN_DRAM flag was set to zero at the time the data store was created by calling `sdr_load_profile`. See the ionconfig(5) man page in Appendix A for more information.

NO_SDR_TRACE

This option causes non-volatile storage utilization tracing functions to be omitted from ION when the SDR system is built. It disables a useful debugging option but reduces the size of the executable software.

NO_PSM_TRACE

This option causes memory utilization tracing functions to be omitted from ION when the PSM system is built. It disables a useful debugging option but reduces the size of the executable software.

IN_FLIGHT

This option controls the behavior of ION when an unrecoverable error is encountered.

If it is set, then the status message "Unrecoverable SDR error" is logged and the SDR non-volatile storage management system is globally disabled: the current database access transaction is ended and (provided transaction reversibility is enabled) rolled back, and all ION tasks terminate.

Otherwise, the ION task that encountered the error is simply aborted, causing a core dump to be produced to support debugging.

SM_SEMKEY=0x*XXXX*

This option overrides the default value (0xee01) of the identifying "key" used in creating and locating the global ION shared-memory system mutex.

SVR4_SHM

This option causes ION to be built using svr4 shared memory as the pervasive shared-memory management mechanism. svr4 shared memory is selected by default when ION is built for any platform other than MinGW, VxWorks 5.4, or RTEMS. (For these latter operating systems all memory is shared anyway, due to the absence of a protected-memory mode.)

POSIX1B_SEMAPHORES

This option causes ION to be built using POSIX semaphores as the pervasive semaphore mechanism. POSIX semaphores are selected by default when ION is built for RTEMS but are otherwise not used or supported; this option enables the default to be overridden.

SVR4_SEMAPHORES

This option causes ION to be built using svr4 semaphores as the pervasive semaphore mechanism. svr4 semaphores are selected by default when ION is built for any platform other than MinGW (for which Windows event objects are used), VxWorks 5.4 (for which VxWorks native semaphores are the default choice), or RTEMS (for which POSIX semaphores are the default choice).

SM_SEMBASEKEY=0x*XXXX*

This option overrides the default value (0xee02) of the identifying "key" used in creating and locating the global ION shared-memory semaphore database, in the event that svr4 semaphores are used.

SEMMNI=*xxx*

This option declares to ION the total number of svr4 semaphore sets provided by the operating system, in the event that svr4 semaphores are used. It overrides the default value, which is 10 for Cygwin and 128 otherwise. (Changing this value typically entails rebuilding the O/S kernel.)

SEMMSL=*xxx*

This option declares to ION the maximum number of semaphores in each svr4 semaphore set, in the event that svr4 semaphores are used. It overrides the default value, which is 6 for Cygwin and 250 otherwise. (Changing this value typically entails rebuilding the O/S kernel.)

SEMMNS=*xxx*

This option declares to ION the total number of svr4 semaphores that the operating system can support; the maximum possible value is SEMMNI x SEMMSL. It overrides the default value, which is 60 for Cygwin and 32000 otherwise. (Changing this value typically entails rebuilding the O/S kernel.)

ION_NO_DNS

This option causes the implementation of a number of Internet socket I/O operations to be omitted for ION. This prevents ION software from being able to operate over Internet

connections, but it prevents link errors when ION is loaded on a spacecraft where the operating system does not include support for these functions.

ERRMSGS_BUFSIZE=*xxxx*

This option set the size of the buffer in which ION status messages are constructed prior to logging. The default value is 4 KB.

SPACE_ORDER=*x*

This option declares the word size of the computer on which the compiled ION software will be running: it is the base-2 log of the number of bytes in an address. The default value is 2, i.e., the size of an address is $2^2 = 4$ bytes. For a 64-bit machine, SPACE_ORDER must be declared to be 3, i.e., the size of an address is $2^3 = 8$ bytes.

NO_SDRMGT

This option enables the SDR system to be used as a data access transaction system only, without doing any dynamic management of non-volatile data. With the NO_SDRMGT option set, the SDR system library can (and in fact must) be built from the `sdrxn.c` source file alone.

DOS_PATH_DELIMITER

This option causes ION_PATH_DELIMITER to be set to '\' (backslash), for use in construction path names. The default value of ION_PATH_DELIMITER is '/' (forward slash, as is used in Unix-like operating systems).

2.1.2 Build

To build ICI for a given deployment platform:

1. Decide where you want ION's executables, libraries, header files, etc. to be installed. The ION makefiles all install their build products to subdirectories (named **bin**, **lib**, **include**, **man**, **man/man1**, **man/man3**, **man/man5**) of an ION root directory, which by default is the directory named **/opt**. If you wish to use the default build configuration, be sure that the default directories (**/opt/bin**, etc.) exist; if not, select another ION root directory name – this document will refer to it as **$OPT** – and create the subdirectories as needed. In any case, make sure that you have read, write, and execute permission for all of the ION installation directories and that:
    - The directory **/$OPT/bin** is in your execution path.
    - The directory **/$OPT/lib** is in your $LD_LOADLIB_PATH.
2. Edit the Makefile in **ion/ici**:
    - Make sure PLATFORMS is set to the appropriate platform name, e.g., x86-redhat, sparc-sol9, etc.
    - Set OPT to your ION root directory name, if other than "/opt".
3. Then:

```
cd ion/ici
```

```
make
make install
```

2.1.3 Configure

Three types of files are used to provide the information needed to perform global configuration of the ION protocol stack: the ION system configuration (or **ionconfig**) file, the ION administration command (**ionrc**) file, and the ION security configuration (**ionsecrc**) file. For details, see the man pages for ionconfig(5), ionrc(5), and ionsecrc(5) in Appendix A.

Normally the instantiation of ION on a given computer establishes a single ION node on that computer, for which hard-coded values of wmKey and sdrName (see ionconfig(5)) are used in common by all executables to assure that all elements of the system operate within the same state space. For some purposes, however, it may be desirable to establish multiple ION nodes on a single workstation. (For example, constructing an entire self-contained DTN network on a single machine may simplify some kinds of regression testing.) ION supports this configuration option as follows:

- Multi-node operation on a given computer is enabled if and only if the environment variable ION_NODE_LIST_DIR is defined in the environment of every participating ION process. Moreover, the value assigned to this variable must be the same text string in the environments of all participating ION processes. That value must be the name (preferably, fully qualified) of the directory in which the ION multi-node database file "ion_nodes" will reside.
- The definition of ION_NODE_LIST_DIR makes it possible to establish up to one ION nodes per directory rather than just one ION node on the computer. When **ionadmin** is used to establish a node, the `ionInitialize()` function will get that node's wmKey and sdrName from the .ionconfig file, use them to allocate working memory and create the SDR database, and then write a line to the ion_nodes file noting the nodeNbr, wmKey, sdrName, and wdName for the node it just initialized. wdName is the current working directory in which **ionadmin** was running at the time it called `ionInitialize()`; it is the directory within which the node resides.
- This makes it easy to connect all the node's daemon processes – running within the same current working directory – to the correct working memory partition and SDR database: the `ionAttach()` function simply searches the ion_nodes file for a line whose wdName matches the current working directory of the process that is trying to attach, then uses that line's wmKey and sdrName to link up.
- It is also possible to initiate a process from within a directory other than the one in which the node resides. To do so, define the additional environment variable ION_NODE_WDNAME in the shell from which the new process is to be initiated. When `ionAttach()` is called it will first try to get "current working directory" (for ION attachment purposes **only**) from that environment variable; only if ION_NODE_WDNAME is undefined will it use the actual cwd that it gets from calling igetcwd().

2.1.4 Run

The executable programs used in operation of the ici component of ION include:

- The **ionadmin** system configuration utility and **ionsecadmin** security configuration utility, invoked at node startup time and as needed thereafter.
- The **rfxclock** background daemon, which effects scheduled network configuration events.
- The **sdrmend** system repair utility, invoked as needed.
- The **sdrwatch** and **psmwatch** utilities for resource utilization monitoring, invoked as needed.

Each time it is executed, **ionadmin** computes a new congestion forecast and, if a congestion collapse is predicted, invokes the node's congestion alarm script (if any). **ionadmin** also establishes the node number for the local node and starts/stops the **rfxclock** task, among other functions. For further details, see the man pages for ionadmin(1), ionsecadmin(1), rfxclock(1), sdrmend(1), sdrwatch(1), and psmwatch(1) in Appendix A.

2.1.5 Test

Six test executables are provided to support testing and debugging of the ICI component of ION:

- The **file2sdr** and **sdr2file** programs exercise the SDR system.
- The **psmshell** program exercises the PSM system.
- The **file2sm**, **sm2file**, and **smlistsh** programs exercise the shared-memory linked list system.

For details, see the man pages for file2sdr(1), sdr2file(1), psmshell(1), file2sm(1), sm2file(1), and smlistsh(1) in Appendix A.

2.2 Licklider Transmission Protocol (LTP)

2.2.1 Build

To build LTP:

1. Make sure that the "ici" component of ION has been built for the platform on which you plan to run LTP.
2. Edit the Makefile in **ion/ltp**:
   - As for ici, make sure PLATFORMS is set to the name of platform on which you plan to run LTP.
   - Set OPT to the directory containing the bin, lib, include, etc. directories used for building ici.
3. Then:

```
cd ion/ltp
make
make install
```

2.2.2 Configure

The LTP administration command (**ltprc**) file provides the information needed to configure LTP on a given ION node. For details, see the man page for ltprc(5) in Appendix A.

2.2.3 Run

The executable programs used in operation of the ltp component of ION include:

- The **ltpadmin** protocol configuration utility, invoked at node startup time and as needed thereafter.
- The **ltpclock** background daemon, which effects scheduled LTP events such as segment retransmissions.
- The **ltpmeter** block management daemon, which segments blocks and effects LTP flow control.
- The **udplsi** and **udplso** link service input and output tasks, which handle transmission of LTP segments encapsulated in UDP datagrams (mainly for testing purposes).

ltpadmin starts/stops the **ltpclock** and ltpmeter tasks and, as mandated by configuration, the **udplsi** and **udplso** tasks.

For details, see the man pages for ltpadmin(1), ltpclock(1), ltpmeter(1), udplsi(1), and udplso(1) in Appendix A.

2.2.4 Test

Two test executables are provided to support testing and debugging of the LTP component of ION:

- **ltpdriver** is a continuous source of LTP segments.
- **ltpcounter** is an LTP block receiver that counts blocks as they arrive.

For details, see the man pages for ltpdriver(1) and ltpcounter(1) in Appendix A.

2.3 Bundle Streaming Service Protocol (BSSP)

2.3.1 Build

To build BSSP:

1. Make sure that the "ici" component of ION has been built for the platform on which you plan to run BSSP.
2. Edit the Makefile in **ion/bssp**:
   - As for ici, make sure PLATFORMS is set to the name of platform on which you plan to run BSSP.
   - Set OPT to the directory containing the bin, lib, include, etc. directories used for building ici.
3. Then:

```
cd ion/bssp
make
make install
```

2.3.2 Configure

The BSSP administration command (**bssprc**) file provides the information needed to configure BSSP on a given ION node. For details, see the man page for bssprc(5) in Appendix A.

2.3.3 Run

The executable programs used in operation of the bssp component of ION include:

- The **bsspadmin** protocol configuration utility, invoked at node startup time and as needed thereafter.
- The **bsspclock** background daemon, which effects scheduled BSSP events such as segment retransmissions.
- The **udpbsi** and **udpbso** link service input and output tasks, which handle transmission of BSSP segments encapsulated in UDP datagrams (mainly for testing purposes).

bsspadmin starts/stops the **bsspclock** task and, as mandated by configuration, the **udpbsi** and **udblso** tasks.

For details, see the man pages for bsspadmin(1), bsspclock(1), bsspmeter(1), udpbsi(1), and udpbso(1) in Appendix A.

2.4 Bundle Protocol (BP)

2.4.1 Compile-time options

Declaring values for the following variables, by setting parameters that are provided to the C compiler (for example, `-DION_NOSTATS` or `-DBRSTERM=60`), will alter the functionality of BP as noted below.

TargetFFS

Setting this option adapts BP for use with the TargetFFS flash file system on the VxWorks operating system. TargetFFS apparently locks one or more system semaphores so long as a file is kept open. When a BP task keeps a file open for a sustained interval, subsequent file system access may cause a high-priority non-BP task to attempt to lock the affected semaphore and therefore block; in this event, the priority of the BP task may automatically be elevated by the inversion safety mechanisms of VxWorks. This "priority inheritance" can result in preferential scheduling for the BP task – which does not need it – at the expense of normally higher-priority tasks, and can thereby introduce runtime anomalies. BP tasks should therefore close files immediately after each access when running on a VxWorks platform that uses the TargetFFS flash file system. The TargetFFS compile-time option ensures that they do so.

BRSTERM=*xx*

This option sets the maximum number of seconds by which the current time at the BRS server may exceed the time tag in a BRS authentication message from a client; if this interval is exceeded, the authentication message is presumed to be a replay attack and is rejected. Small values of BRSTERM are safer than large ones, but they require that clocks be more closely synchronized. The default value is 5.

ION_NOSTATS

Setting this option prevents the logging of bundle processing statistics in status messages.

KEEPALIVE_PERIOD=*xx*

This option sets the number of seconds between transmission of keep-alive messages over any TCP or BRS convergence-layer protocol connection. The default value is 15.

ION_BANDWIDTH_RESERVED

Setting this option overrides strict priority order in bundle transmission, which is the default. Instead, bandwidth is shared between the priority-1 and priority-0 queues on a 2:1 ratio whenever there is no priority-2 traffic.

ENABLE_BPACS

This option causes Aggregate Custody Signaling source code to be included in the build. ACS is alternative custody transfer signaling mechanism that sharply reduces the volume of custody acknowledgment traffic.

ENABLE_IMC

This option causes IPN Multicast source code to be included in the build. IMC is discussed in section 1.8.4 above.

2.4.2 Build

To build BP:

1. Make sure that the "ici" and "ltp" and "dgr" components of ION have been built for the platform on which you plan to run BP.
2. Edit the Makefile in **ion/bp**:
   - As for ici, make sure PLATFORMS is set to the name of platform on which you plan to run BP.
   - Set OPT to the directory containing the bin, lib, include, etc. directories used for building ici.
3. Then:

```
cd ion/bp
make
make install
```

2.4.3 Configure

The BP administration command (**bprc**) file provides the information needed to configure generic BP on a given ION node. The IPN scheme administration command (**ipnrc**) file provides information that configures static and default routes for endpoints whose IDs conform to the "ipn" scheme. The DTN scheme administration command (**dtn2rc**) file provides information that configures static and default routes for endpoints whose IDs conform to the "dtn" scheme, as supported by the DTN2 reference implementation. For details, see the man pages for bprc(5), ipnrc(5), and dtn2rc(5) in Appendix A.

2.4.4 Run

The executable programs used in operation of the bp component of ION include:

- The **bpadmin, ipnadmin,** and **dtn2admin** protocol configuration utilities, invoked at node startup time and as needed thereafter.
- The **bpclock** background daemon, which effects scheduled BP events such as TTL expirations and which also implements rate control.
- The **ipnfw** and **dtn2fw** forwarding daemons, which compute routes for bundles addressed to "ipn"-scheme and "dtn"-scheme endpoints, respectively.
- The **ipnadminep** and **dtn2adminep** administrative endpoint daemons, which handle custody acceptances, custody refusals, and status messages.
- The **bpclm** background daemon, which selects convergence-layer outducts by which bundles are transmitted to neighboring nodes.
- The **brsscla** (server) and **brsccla** (client) Bundle Relay Service convergence-layer adapters.

- The **tcpcli** (input) TCP convergence-layer adapter, which includes convergence-layer output functionality in privately managed threads.
- The s**tcpcli** (input) and s**tcpclo** (output) simplified TCP convergence-layer adapters.
- The **udpcli** (input) and **udpclo** (output) UDP convergence-layer adapters.
- The **ltpcli** (input) and **ltpclo** (output) LTP convergence-layer adapters.
- The **dgrcla** Datagram Retransmission convergence-layer adapter.
- The **bpsendfile** utility, which sends a file of arbitrary size, encapsulated in a single bundle, to a specified BP endpoint.
- The **bpstats** utility, which prints a snapshot of currently accumulated BP processing statistics on the local node.
- The **bptrace** utility, which sends a bundle through the network to enable a forwarding trace based on bundle status reports.
- The **lgsend** and **lgagent** utilities, which are used for remote administration of ION nodes.
- The **hmackeys** utility, which can be used to create hash keys suitable for use in bundle authentication blocks and BRS convergence-layer protocol connections.

bpadmin starts/stops the **bpclock** task and, as mandated by configuration, the **ipnfw**, **dtn2fw**, **ipnadminep**, **dtn2adminep**, bpclm, **brsscla**, **brsccla**, tcpcli, s**tcpcli**, s**tcpclo**, **udpcli**, **udpclo**, **ltpcli**, **ltpclo**, and **dgrcla** tasks.

For details, see the man pages for bpadmin(1),ipnadmin(1), dtn2admin(1), bpclock(1), bpclm(1), ipnfw(1), dtn2fw(1), ipnadminep(1), dtn2adminep(1), brsscla(1), brsccla(1),tcpcli(1), stcpcli(1), stcpclo(1), udpcli(1), udpclo(1), ltpcli(1), ltpclo(1), dgrcla(1), bpsendfile(1), bpstats(1), bptrace(1), lgsend(1), lgagent(1), and hmackeys(1) in Appendix A.

2.4.5 Test

Five test executables are provided to support testing and debugging of the BP component of ION:

- **bpdriver** is a continuous source of bundles.
- **bpcounter** is a bundle receiver that counts bundles as they arrive.
- **bpecho** is a bundle receiver that sends an “echo” acknowledgment bundle back to bpdriver upon reception of each bundle.
- **bpsource** is a simple console-like application for interactively sending text strings in bundles to a specified DTN endpoint, nominally a **bpsink** task.
- **bpsink** is a simple console-like application for receiving bundles and printing their contents.

For details, see the man pages for bpdriver(1), bpcounter(1), bpecho(1), bpsource(1), and bpsink(1) in Appendix A.

2.5 Datagram Retransmission (DGR)

2.5.1 Build

To build DGR:

1. Make sure that the "ici" component of ION has been built for the platform on which you plan to run DGR.
2. Edit the Makefile in **ion/dgr**:
   - As for ici, make sure PLATFORMS is set to the name of platform on which you plan to run DGR.
   - Set OPT to the directory containing the bin, lib, include, etc. directories used for building ici.
3. Then:

```
cd ion/dgr
make
make install
```

2.5.2 Configure

No additional configuration files are required for the operation of the DGR component of ION.

2.5.3 Run

No runtime executables are required for the operation of the DGR component of ION.

2.5.4 Test

Two test executables are provided to support testing and debugging of the DGR component of ION:

- **file2dgr** repeatedly reads a file of text lines and sends copies of those text lines via DGR to **dgr2file**, which writes them to a copy of the original file.

For details, see the man pages for file2dgr(1) and dgr2file(1) in Appendix A.

2.6 Asynchronous Message Service (AMS)

2.6.1 Compile-time options

Note that, by default, the syntax by which AMS MIB information is presented to AMS is as documented in the "amsrc" man page. Alternatively it is possible to use an XML-based syntax as documented in the "amsxml" man page. To use the XML-based syntax instead, be sure that the "expat" XML interpretation system is installed and pass the argument "--with-expat" to "./configure" when building ION.

Defining the following macros, by setting parameters that are provided to the C compiler (for example, DAMS_INDUSTRIAL), will alter the functionality of AMS as noted below.

AMS_INDUSTRIAL

Setting this option adapts AMS to an "industrial" rather than safety-critical model for memory management. By default, the memory acquired for message transmission and reception buffers in AMS is allocated from limited ION working memory, which is fixed at ION start-up time; this limits the rate at which AMS messages may be originated and acquired. When –DAMS_INDUSTRIAL is set at compile time, the memory acquired for message transmission and reception buffers in AMS is allocated from system memory, using the familiar malloc() and free() functions; this enables much higher message traffic rates on machines with abundant system memory.

2.6.2 Build

To build AMS:

1. Make sure that the "bp" component of ION has been built for the platform on which you plan to run AMS.
2. Edit the Makefile in **ion/cfdp**:
   - Just as for bp, make sure PLATFORMS is set to the name of platform on which you plan to run AMS.
   - Set OPT to the directory containing the bin, lib, include, etc. directories used for building bp.
3. Then:

```
cd ion/ams
make
make install
```

2.6.3 Configure

There is no central configuration of AMS; each AMS entity (configuration server, registrar, or application module) is individually configured at the time its initial MIB is loaded at startup. For details of MIB file syntax, see the man pages for amsrc(5) and amsxml(5) in Appendix A.

2.6.4 Run

The executable programs used in operation of the AMS component of ION include:

- The **amsd** background daemon, which serves as configuration server and/or as the registrar for a single application cell.
- The **ramsgate** application module, which serves as the Remote AMS gateway for a single message space.
- The **amsstop** utility, which terminates all AMS operation throughout a single message space.
- The **amsmib** utility, which announces supplementary MIB information to selected subsets of AMS entities without interrupting the operation of the message space.

For details, see the man pages for amsd(1), ramsgate(1), amsstop(1), and amsmib(1) in Appendix A.

2.6.5 Test

Seven test executables are provided to support testing and debugging of the AMS component of ION:

- **amsbenchs** is a continuous source of messages.
- **amsbenchr** is a message receiver that calculates bundle transmission performance statistics.
- **amshello** is an extremely simple AMS "hello, world" demo program – a self-contained distributed application in a single source file of about seventy lines.
- **amsshell** is a simple console-like application for interactively publishing, sending, and announcing text strings in messages.
- **amslog** is a simple console-like application for receiving messages and piping their contents to stdout.
- **amslogprt** is a pipeline program that simply prints AMS message contents piped to it from amslog.
- **amspubsub** is a pair of functions for rudimentary testing of AMS functionality in a VxWorks environment.

For details, see the man pages for amsbenchs(1), amsbenchr(1), amshello(1), amsshell(1), amslog(1), amslogprt(1), amspub(1), and amssub(1) in Appendix A.

For further operational details of the AMS system, please see sections 4 and 5 of the AMS Programmer's Guide.

2.7 CCSDS File Delivery Protocol (CFDP)

2.7.1 Compile-time options

Defining the following macro, by setting a parameter that is provided to the C compiler (i.e., `-DTargetFFS`), will alter the functionality of CFDP as noted below.

TargetFFS

Setting this option adapts CFDP for use with the TargetFFS flash file system on the VxWorks operating system. TargetFFS apparently locks one or more system semaphores so long as a file is kept open. When a CFDP task keeps a file open for a sustained interval, subsequent file system access may cause a high-priority non-CFDP task to attempt to lock the affected semaphore and therefore block; in this event, the priority of the CFDP task may automatically be elevated by the inversion safety mechanisms of VxWorks. This "priority inheritance" can result in preferential scheduling for the CFDP task – which does not need it – at the expense of normally higher-priority tasks, and can thereby introduce runtime anomalies. CFDP tasks should therefore close files immediately after each access when running on a VxWorks platform that uses the TargetFFS flash file system. The TargetFFS compile-time option assures that they do so.

2.7.2 Build

To build CFDP:

1. Make sure that the "bp" component of ION has been built for the platform on which you plan to run CFDP.
2. Edit the Makefile in **ion/cfdp**:
   - Just as for bp, make sure PLATFORMS is set to the name of platform on which you plan to run CFDP.
   - Set OPT to the directory containing the bin, lib, include, etc. directories used for building bp.
3. Then:

```
cd ion/cfdp
make
make install
```

2.7.3 Configure

The CFDP administration command (**cfdprc**) file provides the information needed to configure CFDP on a given ION node. For details, see the man page for cfdprc(5) in Appendix A.

2.7.4 Run

The executable programs used in operation of the CFDP component of ION include:

- The **cfdpadmin** protocol configuration utility, invoked at node startup time and as needed thereafter.
- The **cfdpclock** background daemon, which effects scheduled CFDP events such as check timer expirations. The **cfdpclock** task also effects CFDP transaction cancellations, by canceling the bundles encapsulating the transaction's protocol data units.
- The **bputa** UT-layer input/output task, which handles transmission of CFDP PDUs encapsulated in bundles.

cfdpadmin starts/stops the **cfdpclock** task and, as mandated by configuration, the **bputa** task.

For details, see the man pages for cfdpadmin(1), cfdpclock(1), and bputa(1) in Appendix A.

2.7.5 Test

A single executable, **cfdptest**, is provided to support testing and debugging of the DGR component of ION. For details, see the man page for cfdptest(1) in Appendix A.

2.8 Bundle Streaming Service (BSS)

2.8.1 Compile-time options

Defining the following macro, by setting a parameter that is provided to the C compiler (e.g., –DWINDOW=10000), will alter the functionality of BSS as noted below.

WINDOW=*xx*

Setting this option changes maximum number of seconds by which the BSS database for a BSS application may be "rewound" for replay. The default value is 86400 seconds, which is 24 hours.

2.8.2 Build

To build BSS:

- Make sure that the "bp" component of ION has been built for the platform on which you plan to run BSS.
- Edit the Makefile in **ion/bss**:
- As for ici, make sure PLATFORMS is set to the name of platform on which you plan to run BSS.
- Set OPT to the directory containing the bin, lib, include, etc. directories used for building ici.
- Then:

```
cd ion/bss
make
make install
```

2.8.3 Configure

No additional configuration files are required for the operation of the BSS component of ION.

2.8.4 Run

No runtime executables are required for the operation of the BSS component of ION.

2.8.5 Test

Four test executables are provided to support testing and debugging of the BSS component of ION:

- **bssdriver** sends a stream of data to **bsscounter** for non-interactive testing.
- **bssStreamingApp** sends a stream of data to **bssrecv** for graphical, interactive testing.

For details, see the man pages for bssdriver(1), bsscounter(1), bssStreamingApp(1), and bssrecv(1) in Appendix A.

Executables (man section 1)

amsbenchr
amsbenchs
amsd
amshello
amslog
amslogprt
amsmib
amspub
amsshell
amsstop
amssub
ramsgate
bibeadmin
bibeclo
bpadmin
bpcancel
bpchat
bpclm
bpclock
bpcounter
bpdriver
bpecho
bping
bplist
bpnmtest
bprecvfile
bpsecadmin
bpsendfile
bpsink
bpsource
bpstats
bpstats2
bptrace
bptransit
brsccla
brsscla
cgrfetch
dccpcli
dccpclo
dgrcli
dgrclo
dtn2admin
dtn2adminep
dtn2fw
hmackeys
imcfw
ipnadmin
ipnadminep
ipnd
ipnfw
lgagent
lgsend
ltpcli
ltpclo
stcpcli
stcpclo
tcpcli
tcpclo
udpcli
udpclo
bssStreamingApp
bssrecv
bsspadmin
udpbso
bpcp
bpcpd
bputa
cfdpadmin
cfdpclock
cfdptest
dtpcadmin
dtpcclock
dtpcd
dtpcreceive
dtpcsend
file2sdr
file2sm
ionadmin
ionlog
ionsecadmin
ionunlock
ionxnowner
owltsim
owlttb
psmshell
psmwatch
rfxclock
sdr2file
sdrmend
sdrwatch
sm2file
smlistsh
smrbtsh
dccplsi
dccplso
ltpadmin
ltpclock
ltpcounter
ltpdriver
ltpmeter
ltpsecadmin

udplsi
udplso
nm_agent
nm_mgr
dtka
dtkaadmin
tcaadmin
tcaboot
tcacompile
tcapublish
tcarecv
tcc
tccadmin
dtpcrc
ionconfig
ionrc
ionsecrc
ltprc
dtkarc
tcarc
tccrc

Libraries (man section 3)

ams
bp
bpextensions
bss
bssp
cfdp
dgr
dtpc
ion
ioncbor
ioncrc
llcv
lyst
memmgr
platform
psm
sdr
sdrhash
sdrlist
sdrstring
sdrtable
smlist
smrbt
zco
ltp
tc

Configuration files (man section 5)

amsrc
amsxml
petition_log
biberc
bprc
bpsecrc
dtn2rc
ipnrc
lgfile
bssprc
cfdprc

NAME

amsbenchr − Asynchronous Message Service (AMS) benchmarking meter

SYNOPSIS

amsbenchr

DESCRIPTION

amsbenchr is a test program that simply subscribes to subject ‘‘bench’’ and receives messages published by **amsbenchs** until all messages in the test − as indicated by the count of remaining messages, in in the first four bytes of each message − have been received. Then it stops receiving messages, calculates and prints performance statistics, and terminates.

amsbenchr will register as an application module in the root unit of the venture identified by application name ‘‘amsdemo’’ and authority name ‘‘test’’. A configuration server for the local continuum and a registrar for the root unit of that venture (which may both be instantiated in a single **amsd** daemon task) must be running in order for **amsbenchr** to commence operations.

EXIT STATUS

−1 **amsbenchr** failed, for reasons noted in the ion.log file.

‘‘0’’
amsbenchr terminated normally.

FILES

A MIB initialization file with the applicable default name (see **amsrc** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

amsbenchr can’t register.
amsbenchr failed to register, for reasons noted in the ion.log file.

amsbenchr: subject ’bench’ is unknown.
amsbenchr can’t subscribe to test messages; probably an error in the MIB initialization file.

amsbenchr can’t subscribe.
amsbenchr failed to subscribe, for reasons noted in the ion.log file.

amsbenchr can’t get event.
amsbenchr failed to receive a message, for reasons noted in the ion.log file.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amsrc (5)

NAME

amsbenchs − Asynchronous Message Service (AMS) benchmarking driver

SYNOPSIS

amsbenchs *count size*

DESCRIPTION

amsbenchs is a test program that simply publishes *count* messages of *size* bytes each on subject ‘‘bench’’, then waits while all published messages are transmitted, terminating when the user uses ^C to interrupt the program. The remaining number of messages to be published in the test is written into the first four octets of each message.

amsbenchs will register as an application module in the root unit of the venture identified by application name ‘‘amsdemo’’ and authority name ‘‘test’’. A configuration server for the local continuum and a registrar for the root unit of that venture (which may both be instantiated in a single **amsd** daemon task) must be running in order for **amsbenchs** to commence operations.

EXIT STATUS

−1 **amsbenchs** failed, for reasons noted in the ion.log file.

‘‘0’’
: **amsbenchs** terminated normally.

FILES

A MIB initialization file with the applicable default name (see **amsrc** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

No memory for amsbenchs.
: Insufficient available memory for a message content buffer of the indicated size.

amsbenchs can’t register.
: **amsbenchs** failed to register, for reasons noted in the ion.log file.

amsbenchs can’t set event manager.
: **amsbenchs** failed to start its background event management thread, for reasons noted in the ion.log file.

amsbenchs: subject ’bench’ is unknown.
: **amsbenchs** can’t publish test messages; probably an error in the MIB initialization file.

amsbenchs can’t publish message.
: **amsbenchs** failed to publish, for reasons noted in the ion.log file.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amsrc (5)

NAME

amsd − AMS configuration server and/or registrar daemon

SYNOPSIS

amsd { @ | *MIB_source_name* } { . | @ | *config_server_endpoint_spec* } [*application_name authority_name registrar_unit_name*]

DESCRIPTION

amsd is a background ‘‘daemon’’ task that functions as an AMS ‘‘configuration server’’ in the local continuum, as an AMS ‘‘registrar’’ in a specified cell, or both.

If *MIB_source_name* is specified, it must name a MIB initialization file in the correct format for **amsd**, either **amsrc** (5) or **amsxml** (5), depending on whether or not −DNOEXPAT was set at compile time. Otherwise @ is required; in this case, the built-in default MIB is loaded.

If this **amsd** task is **NOT** to run as a configuration server then the second command-line argument must be a ’.’ character. Otherwise the second command-line argument must be either ’@’ or *config_server_endpoint_spec*. If ’@’ then the endpoint specification for this configuration server is automatically computed as the default endpoint specification for the primary transport service as noted in the MIB: "*hostname*:2357".

If an AMS module is **NOT** to be run in a background thread for this daemon (enabling shutdown by **amsstop** (1) and/or runtime MIB update by **amsmib** (1)), then either the last three command-line arguments must be omitted or else the ‘‘amsd’’ role must not be defined in the MIB loaded for this daemon. Otherwise the *application_name* and *authority_name* arguments are required and the ‘‘amsd’’ role must be defined in the MIB.

If this **amsd** task is **NOT** to run as a registrar then the last command-line argument must be omitted. Otherwise the last three command-line arguments are required and they must identify a unit in an AMS venture for the indicated application and authority that is known to operate in the local continuum, as noted in the MIB. Note that the unit name for the ‘‘root unit’’ of a venture is the zero-length string "".

EXIT STATUS

‘‘0’’
: **amsd** terminated without error.

−1
: **amsd** terminated due to an anomaly as noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and restart **amsd**.

FILES

If *MIB source name* is specified, then a file of this name must be present. Otherwise a MIB initialization file with the applicable default name (see **amsrc** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

amsd can’t load MIB.
: MIB initialization file was missing, unreadable, or invalid.

amsd can’t start CS.
: Configuration server initialization failed for reasons noted in ion.log file.

amsd can’t start RS.
: Registrar initialization failed for reasons noted in ion.log file.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amsmib (1), **amsstop** (1), **amsrc** (5), **amsxml** (5)

NAME

amshello − Asynchronous Message Service (AMS) demo program for UNIX

SYNOPSIS

amshello

DESCRIPTION

amshello is a sample program designed to demonstrate that an entire (very simple) distributed AMS application can be written in just a few lines of C code. When started, **amshello** forks a second process and initiates transmission of a ‘‘Hello’’ text message from one process to the other, after which both processes unregister and terminate.

The **amshello** processes will register as application modules in the root unit of the venture identified by application name ‘‘amsdemo’’ and authority name ‘‘test’’. A configuration server for the local continuum and a registrar for the root unit of that venture (which may both be instantiated in a single **amsd** daemon task) must be running in order for the **amshello** processes to run.

EXIT STATUS

‘‘0’’

amshello terminated normally.

FILES

A MIB initialization file with the applicable default name (see **amsrc** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

No diagnostics apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amsrc (5)

NAME

amslog − Asynchronous Message Service (AMS) test message receiver

SYNOPSIS

amslog *unit_name role_name application_name authority_name [{ s | i }]*

DESCRIPTION

amslog is a message reception program designed to test AMS functionality.

When **amslog** is started, it registers as an application module in the unit identified by *unit_name* of the venture identified by *application_name* and *authority_name*; the role in which it registers must be indicated in *role_name*. A configuration server for the local continuum and a registrar for the indicated unit of the indicated venture (which may both be instantiated in a single **amsd** daemon task) must be running in order for **amslog** to run.

amslog runs as two threads: a background thread that receives AMS messages and logs them to standard output, together with a foreground thread that acquires operating parameters in lines of console input to control the flow of messages to the background thread.

When the first character of a line of input from stdin to the **amslog** foreground thread is '.' (period), **amslog** immediately terminates. Otherwise, the first character of each line of input from stdin must be either '+' indicating assertion of interest in a message subject or '−' indicating cessation of interest in a subject. In each case, the name of the subject in question must begin in the second character of the input line. Note that "everything" is a valid subject name.

By default, **amslog** runs in "subscribe" mode: when interest in a message subject is asserted, **amslog** subscribes to that subject; when interest in a message subject is rescinded, **amslog** unsubscribes to that subject. This behavior can be overridden by providing a third command-line argument to **amslog** − a "mode" indicator. When mode is 'i', **amslog** runs in "invite" mode. In "invite" mode, when interest in a message subject is asserted, **amslog** invites messages on that subject; when interest in a message subject is rescinded, **amslog** cancels its invitation for messages on that subject.

The "domain" of a subscription or invitation can optionally be specified immediately after the subject name, on the same line of console input:

> Domain continuum name may be specified, or the place-holder domain continuum name "_" may be specified to indicate "all continua".
>
> If domain continuum name ("_" or otherwise) is specified, then domain unit name may be specified or the place-holder domain unit name "_" may be specified to indicate "the root unit" (i.e., the entire venture).
>
> If domain unit name ("_" or otherwise) is specified, then domain role name may be specified.

When **amslog** runs in VxWorks or RTEMS, the subject and content of each message are simply written to standard output in a text line for display on the console. When **amslog** runs in a UNIX environment, the subject name length (a binary integer), subject name (ASCII text), content length (a binary integer), and content (ASCII text) are written to standard output for redirection either to a file or to a pipe to **amslogprt**.

Whenever a received message is flagged as a Query, **amslog** returns a reply message whose content is the string "Got " followed by the first 128 bytes of the content of the Query message, enclosed in single quote marks and followed by a period.

EXIT STATUS

−1 **amslog** terminated with an error as noted in the ion.log file.

"0"
: **amslog** terminated normally.

FILES

A MIB initialization file with the applicable default name (see **amsrc** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

amslog can't register.

amslog failed to register, for reasons noted in the ion.log file.

amslog can't set event manager.

amslog failed to start its background thread, for reasons noted in the ion.log file.

amslog can't read from stdin

amslog foreground thread failed to read console input, for reasons noted in the ion.log file.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amsshell (1), **amslogprt** (1), **amsrc** (5)

NAME

amslogprt − UNIX utility program for printing AMS log messages from amslog

SYNOPSIS

amslogprt

DESCRIPTION

amslogprt simply reads AMS activity log messages from standard input (nominally written by **amslog** and prints them. When the content of a logged message is judged not to be an ASCII text string, the content is printed in hexadecimal.

amslogprt terminates at the end of input.

EXIT STATUS

"0"

amslogprt terminated normally.

FILES

No files are needed by amslogprt.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

None.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amsrc (5)

NAME

amsmib − Asynchronous Message Service (AMS) MIB update utility

SYNOPSIS

amsmib *application_name authority_name role_name continuum_name unit_name file_name*

DESCRIPTION

amsmib is a utility program that announces relatively brief Management Information Base (MIB) updates to a select population of AMS modules. Because **amsd** processes may run AAMS modules in background threads, and because a single MIB is shared in common among all threads of any process, **amsmib** may update the MIBs used by registrars and/or configuration servers as well.

MIB updates can only be propagated to modules for which the subject ''amsmib'' was defined in the MIB initialization files cited at module registration time. All ION AMS modules implicitly invite messages on subject ''amsmib'' (from all modules registered in role ''amsmib'' in all continua of the same venture) at registration time if subject ''amsmib'' and role ''amsmib'' are defined in the MIB.

amsmib registers in the root cell of the message space identified by *application_name* and *authority_name*, within the local continuum. It registers in the role ''amsmib''; if this role is not defined in the (initial) MIB loaded by **amsmib** at registration time, then registration fails and **amsmib** terminates.

amsmib then reads into a memory buffer up to 4095 bytes of MIB update text from the file identified by *file_name*. The MIB update text must conform to **amsxml** (5) or **amsrc** (5) syntax, depending on whether or not the intended recipient modules were compiled with the −DNOEXPAT option.

amsmib then ''announces'' (see **ams_announce()** in **ams** (3)) the contents of the memory buffer to all modules of this same venture (identified by *application_name* and *authority_name*) that registered in the indicated role, in the indicated unit of the indicated continuum. If *continuum_name* is "" then the message will be sent to modules in all continua. If *role_name* is "" then all modules will be eligible to receive the message, regardless of the role in which they registered. If *unit_name* is "" (the root unit) then all modules will be eligible to receive the message, regardless of the unit in which they registered.

Upon reception of the announced message, each destination module will apply all of the MIB updates in the content of the message, in exactly the same way that its original MIB was loaded from the MIB initialization file when the module started running.

If multiple modules are running in the same memory space (e.g., in different threads of the same process, or in different tasks on the same VxWorks target) then the updates will be applied multiple times, because all modules in the same memory space share a single MIB. MIB updates are idempotent, so this is harmless (though some diagnostics may be printed).

Moreover, an **amsd** daemon will have a relevant ''MIB update'' module running in a background thread if *application_name* and *authority_name* were cited on the command line that started the daemon (provided the role ''amsd'' was defined in the initial MIB loaded at the time **amsd** began running). The MIB exposed to the configuration server and/or registrar running in that daemon will likewise be updated upon reception of the announced message.

The name of the subject of the announced mib update message is ''amsmib''; if this subject is not defined in the (initial) MIB loaded by **amsmib** then the message cannot be announced. Nor can any potential recipient module receive the message if subject ''amsmib'' is not defined in that module's MIB.

EXIT STATUS

''0''

amsmib terminated normally.

''1''

An anomalous exit status, indicating that **amsmib** failed to register.

FILES

A MIB initialization file with the applicable default name (see **amsrc** (5) and **amsxml** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

amsmib subject undefined.
: The **amsmib** utility was unable to announce the MIB update message.

amsmib domain role unknown.
: The **amsmib** utility was unable to announce the MIB update message.

amsmib domain continuum unknown.
: The **amsmib** utility was unable to announce the MIB update message.

amsmib domain unit unknown.
: The **amsmib** utility was unable to announce the MIB update message.

amsmib can't open MIB file.
: The **amsmib** utility was unable to construct the MIB update message.

MIB file length > 4096.
: The MIB update text file was too long to fit into the **amsmib** message buffer.

Can't seek to end of MIB file.
: I/O error in processing the MIB update text file.

Can't read MIB file.
: I/O error in processing the MIB update text file.

amsmib can't announce 'amsmib' message.
: The **amsmib** utility was unable to announce the MIB update message, for reasons noted in the log file.

amsmib can't register.
: The **amsmib** utility failed to register, for reasons noted in the log file.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amsd (1), **ams** (3), **amsrc** (5), **amsxml** (5)

NAME

amspub − Asynchronous Message Service (AMS) test driver for VxWorks

SYNOPSIS

amspub "*application_name*“, ”*authority_name*“, ”*subject_name*“, ”*message_text*"

DESCRIPTION

amspub is a message publication program designed to test AMS functionality in a VxWorks environment. When an **amspub** task is started, it registers as an application module in the root unit of the venture identified by *application_name* and *authority_name*, looks up the subject number for *subject_name*, publishes a single message with content *message_text* on that subject, unregisters, and terminates.

A configuration server for the local continuum and a registrar for the root unit of the indicated venture (which may both be instantiated in a single **amsd** daemon task) must be running in order for **amspub** to run.

EXIT STATUS

−1 **amspub** terminated with an error as noted in the ion.log file.

“0”
amspub terminated normally.

FILES

The **amspub** source code is in the amspubsub.c source file.

A MIB initialization file with the applicable default name (see **amsrc** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

amspub can’t register.
amspub failed to register, for reasons noted in the ion.log file.

amspub: subject is unknown
amspub can’t publish test messages on the specified subject; possibly an error in the MIB initialization file.

amspub can’t publish message.
amspub failed to publish, for reasons noted in the ion.log file.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amssub (1), **amsrc** (5)

NAME

amsshell − Asynchronous Message Service (AMS) test message sender (UNIX)

SYNOPSIS

amsshell *unit_name role_name application_name authority_name [{ p | s | q | a }]*

DESCRIPTION

amsshell is a message issuance program designed to test AMS functionality.

When **amsshell** is started, it registers as an application module in the unit identified by *unit_name* of the venture identified by *application_name* and *authority_name*; the role in which it registers must be indicated in *role_name*. A configuration server for the local continuum and a registrar for the indicated unit of the indicated venture (which may both be instantiated in a single **amsd** daemon task) must be running in order for **amsshell** to run.

amsshell runs as two threads: a background thread that receives watches for AMS configuration events (including shutdown), together with a foreground thread that acquires operating parameters and message content in lines of console input to control the issuance of messages.

The first character of each line of input from stdin to the **amsshell** indicates the significance of that line:

= Sets the name of the subject on which all messages are to be issued, until superseded by another ''='' line. The subject name must begin at the second character of this line. Optionally, subject name may be followed by a single ' ' (space) character and then the text of the first message to be issued on this subject, which is to be issued immediately.

r Sets the number of the role constraining the domain of message issuance. The role number must begin at the second character of this line.

c Sets the number of the continuum constraining the domain of message issuance. The continuum number must begin at the second character of this line.

u Sets the number of the unit constraining the domain of message issuance. The unit number must begin at the second character of this line.

m Sets the number of the module to which subsequent messages are to be issued. The module number must begin at the second character of this line.

. Terminates **amsshell**.

When the first character of a line of input from stdin is none of the above, the entire line is taken to be the text of a message that is to be issued immediately, on the previously specified subject, to the previously specified module (if applicable), and subject to the previously specified domain (if applicable).

By default, **amsshell** runs in ''publish'' mode: when a message is to be issued, it is simply published. This behavior can be overridden by providing a fifth command-line argument to **amsshell** − a ''mode'' indicator. The supported modes are as follows:

p This is ''publish'' mode. Every message is published.

s This is ''send'' mode. Every message is sent privately to the application module identified by the specified module, unit, and continuum numbers.

q This is ''query'' mode. Every message is sent privately to the application module identified by the specified module, unit, and continuum numbers, and **amsshell** then waits for a reply message before continuing.

a This is ''announce'' mode. Every message is announced to all modules in the domain established by the previously specified role, unit, and continuum numbers.

EXIT STATUS

−1 **amsshell** terminated with an error as noted in the ion.log file.

''0''

amsshell terminated normally.

FILES

A MIB initialization file with the applicable default name (see **amsrc** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

amsshell can't register.

amsshell failed to register, for reasons noted in the ion.log file.

amsshell can't set event manager.

amsshell failed to start its background thread, for reasons noted in the ion.log file.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amslog (1), **amsrc** (5)

NAME

ams stop − Asynchronous Message Service (AMS) message space shutdown utility

SYNOPSIS

amsstop *application_name authority_name*

DESCRIPTION

amsstop is a utility program that terminates the operation of all registrars and all application modules running in the message space which is that portion of the indicated AMS venture that is operating in the local continuum. If one of the **amsd** tasks that are functioning as registrars for this venture is also functioning as the configuration server for the local continuum, then that configuration server is also terminated.

application_name and *authority_name* must identify an AMS venture that is known to operate in the local continuum, as noted in the MIB for the **amsstop** application module.

A message space can only be shut down by **amsstop** if the subject ‘‘amsstop’’ is defined in the MIBs of all modules in the message spaces.

EXIT STATUS

‘‘0’’

amsstop terminated normally.

‘‘1’’

An anomalous exit status, indicating that **amsstop** was unable to register and therefore failed to shut down its message space, for reasons noted in the ion.log file.

FILES

A MIB initialization file with the applicable default name (see **amsrc** (5) and **amsxml** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

amsstop can’t register.

This message indicates that **amsstop** was unable to register, possibly because the ‘‘amsstop’’ role is not defined in the MIB initialization file.

amsstop subject undefined.

This message indicates that **amsstop** was unable to stop the message space because the ‘‘amsstop’’ subject is not defined in the MIB initialization file.

amsstop can’t publish ’amsstop’ message.

This message indicates that **amsstop** was unable to publish a message on subject ’amsstop’ for reasons noted in the **ion.log** log file.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amsrc (5)

NAME

amssub − Asynchronous Message Service (AMS) test message receiver for VxWorks

SYNOPSIS

amssub "*application_name*“, ”*authority_name*“, ”*subject_name*"

DESCRIPTION

amssub is a message reception program designed to test AMS functionality in a VxWorks environment. When an **amssub** task is started, it registers as an application module in the root unit of the venture identified by *application_name* and *authority_name*, looks up the subject number for *subject_name*, subscribes to that subject, and begins receiving and printing messages on that subject until terminated by **amsstop**.

A configuration server for the local continuum and a registrar for the root unit of the indicated venture (which may both be instantiated in a single **amsd** daemon task) must be running in order for **amssub** to run.

EXIT STATUS

−1 **amssub** terminated with an error as noted in the ion.log file.

“0”
amssub terminated normally.

FILES

The **amssub** source code is in the amspubsub.c source file.

A MIB initialization file with the applicable default name (see **amsrc** (5)) must be present.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

amssub can’t register.
amssub failed to register, for reasons noted in the ion.log file.

amssub: subject is unknown
amssub can’t subscribe to messages on the specified subject; possibly an error in the MIB initialization file.

amssub can’t subscribe.
amssub failed to subscribe, for reasons noted in the ion.log file.

amssub can’t get event.
amssub failed to receive message, for reasons noted in the ion.log file.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amspub (1), **amsrc** (5)

NAME

ramsgate – Remote AMS gateway daemon

SYNOPSIS

ramsgate *application_name authority_name* [*bundles_TTL*]

DESCRIPTION

ramsgate is a background ''daemon'' task that functions as a Remote AMS gateway. *application_name* and *authority_name* must identify an AMS venture that is known to operate in the local continuum, as noted in the MIB for the **ramsgate** application module.

ramsgate will register as an application module in the root unit of the indicated venture, so a configuration server for the local continuum and a registrar for the root unit of the indicated venture (which may both be instantiated in a single **amsd** daemon task) must be running in order for **ramsgate** to commence operations.

ramsgate with communicate with other RAMS gateway modules in other continua by means of the RAMS network protocol noted in the RAMS gateway endpoint ID for the local continuum, as identified (explicitly or implicitly) in the MIB.

If the RAMS network protocol is ''bp'' (i.e., the DTN Bundle Protocol), then an ION Bundle Protocol node must be operating on the local computer and that node must be registered in the BP endpoint identified by the RAMS gateway endpoint ID for the local continuum. Moreover, in this case the value of *bundles_TTL* – if specified – will be taken as the lifetime in seconds that is to be declared for all ''bundles'' issued by **ramsgate**; *bundles_TTL* defaults to 86400 seconds (one day) if omitted.

EXIT STATUS

''0''

ramsgate terminated normally.

''1''

ramsgate failed, for reasons noted in the ion.log file; the task terminated.

FILES

A MIB initialization file with the applicable default name (see **amsrc** (5)) must be present.

ramsgate records all ''petitions'' (requests for data on behalf of AMS modules in other continua) in a file named ''petition.log''. At startup, the **ramsgate** daemon automatically reads and processes all petitions in the petition.log file just as if they were received in real time. **Note** that this means that you can cause petitions to be, in effect, ''pre-received'' by simply editing this file prior to startup. This can be an especially effective way to configure a RAMS network in which long signal propagation times would otherwise retard real-time petitioning and thus delay the onset of fully functional message exchange.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

ramsgate can't run.

RAMS gateway functionality failed, for reasons noted in the ion.log file.

BUGS

Note that the AMS design principle of receiving messages immediately and enqueuing them for eventual ingestion by the application module – rather than imposing application-layer flow control on AMS message traffic – enables high performance but makes **ramsgate** vulnerable to message spikes. Since production and transmission of bundles is typically slower than AMS message reception over TCP service, the ION working memory and/or heap space available for AMS event insertion and/or bundle production can be quickly exhausted if a high rate of application message production is sustained for a long enough time. Mechanisms for defending against this sort of failure are under study, but for now the best mitigations are simply to (a) build with compiler option –DAMS_INDUSTRIAL=1, (b) allocate as much space as possible to ION working memory and SDR heap (see **ionconfig** (5)) and (c) limit the rate of AMS message issuance.

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

amsrc (5), **petition_log** (5)

NAME

bibeadmin − bundle−in−bundle encapsulation database administration interface

SYNOPSIS

bibeadmin [*commands_filename*]

DESCRIPTION

bibeadmin configures the local ION node's database of parameters governing the forwarding of BIBE PDUs to specified remote nodes.

bibeadmin operates in response to BIBE configuration commands found in the file *commands_filename*, if provided; if not, **bibeadmin** prints a simple prompt (:) so that the user may type commands directly into standard input.

The format of commands for *commands_filename* can be queried from **bibeadmin** with the 'h' or '?' commands at the prompt. The commands are documented in **biberc** (5).

EXIT STATUS

"0" Successful completion of BIBE administration.
"1" Unsuccessful completion of BIBE administration, due to inability to attach to the Bundle Protocol system or to initialize the BIBE database.

EXAMPLES

bibeadmin
Enter interactive BIBE configuration command entry mode.

bibeadmin host1.biberc
Execute all configuration commands in *host1.biberc*, then terminate immediately.

FILES

See **biberc** (5) for details of the BIBE configuration commands.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the biberc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **bibeadmin**. Otherwise **bibeadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the logfile ion.log:

bibeadmin can't attach to BP.
Bundle Protocol has not been initialized on this computer. You need to run **bpadmin** (1) first.

bibeadmin can't initialize routing database.
There is no SDR data store for *bibeadmin* to use. Please run **ionadmin** (1) to start the local ION node.

Can't open command file...
The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **bibeadmin** to fail but are noted in the **ion.log** log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename* file. Please see **biberc** (5) for details.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bibeclo (1), **biberc** (5)

NAME

bibeclo − BP convergence layer output task using bundle−in−bundle encapsulation

SYNOPSIS

bibeclo *peer_EID destination_EID*

DESCRIPTION

bibeclo is a background ‘‘daemon’’ task that extracts bundles from the queues of bundles destined for *destination_EID* that are ready for transmission via bundle-in-bundle encapsulation (BIBE) to *peer_EID*, encapsulates them in BP administrative records of (non-standard) record type 7 (BP_BIBE_PDU), and sends those administrative records in encapsulating bundles destined for *peer_EID*. The forwarding of encapsulated bundles for which custodial acknowledgment is requested causes **bibeclo** to post custodial re-forwarding timers to the node’s timeline. Parameters governing the forwarding of BIBE PDUs to *peer_EID* are stipulated in the corresponding BIBE convergence-layer adapter (**bcla**) structure residing in the BIBE database, as managed by **bibeadmin**.

The receiving node is expected to process received BIBE PDUs by simply dispatching the encapsulated bundles − whose destination is the node identified by *destination_EID* − as if they had been received from neighboring nodes in the normal course of operations; BIBE PDUs for which custodial acknowledgment was requested cause the received bundles to be noted in custody signals that are being aggregated by the receiving node.

bibeclo additionally sends aggregated custody signals in BP administrative records of (non-standard) record type 8 (BP_BIBE_SIGNAL) as the deadlines for custody signal transmission arrive.

Note that the reception and processing of both encapsulated bundles and custody signals is performed by the scheme-specific administration endpoint daemon(s) at the receiving nodes. Reception of a custody signal terminates the custodial re-forwarding timers for all bundles acknowledged in that signal; the re-forwarding of bundles upon custodial re-forwarding timer expiration is initiated by the **bpclock** daemon.

bibeclo is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **bibeclo** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the BIBE convergence layer protocol.

EXIT STATUS

“0”

bibeclo terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **bibeclo**.

“1”

bibeclo terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **bibeclo**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

bibeclo can’t attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No such bibe outduct.

No BIBE outduct with duct name *destination_EID* exists. Use **bpadmin** to stop the BIBE convergence-layer protocol, add the outduct, and then restart the BIBE protocol.

No such bcla.
: No bcla structure for the node identified by *peer_EID* has been added to the BP database. Use **bpadmin** to stop the BIBE convergence-layer protocol, use **bibeadmin** to add the bcla, and then use **bpadmin** to restart the BIBE protocol.

CLO task is already started for this duct.
: Redundant initiation of **bibeclo**.

Can't dequeue bundle.
: BIBE outduct closed deleted or other system error. Check ION log; correct the problem and restart BIBE.

[i] bibeclo outduct closed.
: Nominal shutdown message.

Can't prepend header; CLO stopping.
: System error. Check ION log; correct the problem and restart BIBE.

Can't destroy old ZCO; CLO stopping.
: System error. Check ION log; correct the problem and restart BIBE.

Can't get outbound space for BPDU.
: System error. Check ION log; correct the problem and restart BIBE.

Can't send encapsulated bundle.
: System error. Check ION log; correct the problem and restart BIBE.

Can't track bundle.
: System error. Check ION log; correct the problem and restart BIBE.

[!] Encapsulated bundle not sent.
: Malformed bundle issuance request, which might be a software error. Contact technical support.

Can't release ZCO; CLO stopping.
: System error. Check ION log; correct the problem and restart BIBE.

[i] bibeclo duct has ended.
: Nominal shutdown message.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

biberc (5), **bibeadmin** (1)

NAME

bpadmin – ION Bundle Protocol (BP) administration interface

SYNOPSIS

bpadmin [*commands_filename* | . | !]

DESCRIPTION

bpadmin configures, starts, manages, and stops bundle protocol operations for the local ION node.

It operates in response to BP configuration commands found in the file *commands_filename*, if provided; if not, **bpadmin** prints a simple prompt (:) so that the user may type commands directly into standard input. If *commands_filename* is a period (.), the effect is the same as if a command file containing the single command 'x' were passed to **bpadmin** — that is, the ION node's *bpclock* task, forwarder tasks, and convergence layer adapter tasks are stopped. If *commands_filename* is an exclamation point (!), that effect is reversed: the ION node's *bpclock* task, forwarder tasks, and convergence layer adapter tasks are restarted.

The format of commands for *commands_filename* can be queried from **bpadmin** with the 'h' or '?' commands at the prompt. The commands are documented in **bprc** (5).

EXIT STATUS

"0" Successful completion of BP administration.

EXAMPLES

bpadmin
: Enter interactive BP configuration command entry mode.

bpadmin host1.bp
: Execute all configuration commands in *host1.bp*, then terminate immediately.

bpadmin .
: Stop all bundle protocol operations on the local node.

FILES

See **bprc** (5) for details of the BP configuration commands.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the bprc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **bpadmin**. Otherwise **bpadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the logfile ion.log:

ION can't set custodian EID information.
: The *custodial_endpoint_id* specified in the BP initialization ('1') command is malformed. Remember that the format for this argument is ipn:*element_number*.0 and that the final 0 is required, as custodial/administration service is always service 0. Additional detail for this error is provided if one of the following other errors is present:

  Malformed EID.

  Malformed custodian EID.

bpadmin can't attach to ION.
: There is no SDR data store for *bpadmin* to use. You should run **ionadmin** (1) first, to set up an SDR data store for ION.

Can't open command file...
: The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **bpadmin** to fail but are noted in the **ion.log** log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename* file. Please see **bprc** (5)

for details.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ionadmin (1), **bprc** (5), **ipnadmin** (1), **ipnrc** (5), **dtnadmin** (1), **dtnrc** (5)

NAME

bpcancel − Bundle Protocol (BP) bundle cancellation utility

SYNOPSIS

bpcancel *source_EID creation_seconds* [*creation_count* [*fragment_offset* [*fragment_length*]]]

DESCRIPTION

bpcancel attempts to locate the bundle identified by the command-line parameter values and cancel transmission of this bundle. Bundles for which multiple copies have been queued for transmission can't be canceled, because one or more of those copies might already have been transmitted. Transmission of a bundle that has never been cloned and that is still in local bundle storage is cancelled by simulation of an immediate time-to-live expiration.

EXIT STATUS

"0"

bpcancel has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can't attach to BP.

bpadmin has not yet initialized BP operations.

bpcancel failed finding bundle.

The attempt to locate the subject bundle failed due to some serious system error. It will probably be necessary to terminate and re-initialize the local ION node.

bpcancel failed destroying bundle.

Probably an unrecoverable database error, in which case the local ION node must be terminated and re-initialized.

bpcancel failed.

Probably an unrecoverable database error, in which case the local ION node must be terminated and re-initialized.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bplist (1)

NAME

bpchat – Bundle Protocol chat test program

SYNOPSIS

bpchat *sourceEID destEID* [ct]

DESCRIPTION

bpchat uses Bundle Protocol to send input text in bundles, and display the payload of received bundles as output. It is similar to the **talk** utility, but operates over the Bundle Protocol. It operates like a combination of the **bpsource** and **bpsink** utilities in one program (unlike **bpsource**, **bpchat** emits bundles with a *sourceEID*).

If the *sourceEID* and *destEID* are both **bpchat** applications, then two users can chat with each other over the Bundle Protocol: lines that one user types on the keyboard will be transported over the network in bundles and displayed on the screen of the other user (and the reverse).

bpchat terminates upon receiving the SIGQUIT signal, i.e., ^C from the keyboard.

EXIT STATUS

"0"

bpchat has terminated normally. Any problems encountered during operation will be noted in the **ion.log** log file.

"1"

bpchat has terminated due to a BP transmit or reception failure. Details should be noted in the **ion.log** log file.

OPTIONS

[ct] If the string "ct" is appended as the last argument, then bundles will be sent with custody transfer requested.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **bpchat** are written to the ION log file *ion.log*.

Can't attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

Can't open own endpoint.

Another application has already opened *ownEndpointId*. Terminate that application and rerun.

bpchat bundle reception failed.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

No space for ZCO extent.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can't create ZCO.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bpchat can't send echo bundle.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

bpecho (1), **bpsource** (1), **bpsink** (1), **bp** (3)

NAME

bpclm – DTN bundle protocol convergence layer management daemon

SYNOPSIS

bpclm *neighboring_node_ID*

DESCRIPTION

bpclm is a background ‘‘daemon’’ task that manages the transmission of bundles to a single designated neighboring node (as constrained by an ‘‘egress plan’’ data structure for that node) by one or more convergence-layer (CL) adapter output daemons (via buffer structures called ‘‘outducts’’).

bpclm is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **bpclm** can also be spawned and terminated in response to commands that START and STOP the corresponding node’s egress plan.

EXIT STATUS

“0”

bpclm terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart the egress plan for this node.

“1”

bpclm terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart the egress plan for this node.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

bpclm can’t attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No egress plan for this node

No egress plan for the node identified by *neighboring_node_ID* has been added to the BP database. Use **bpadmin** to add and start the plan.

bpclm task is already started for this node

Redundant initiation of **bpclm**.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5)

NAME

bpclock – Bundle Protocol (BP) daemon task for managing scheduled events

SYNOPSIS

bpclock

DESCRIPTION

bpclock is a background ‘‘daemon’’ task that periodically performs scheduled Bundle Protocol activities. It is spawned automatically by **bpadmin** in response to the ’s’ command that starts operation of Bundle Protocol on the local ION node, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command.

Once per second, **bpclock** takes the following action:

First it (a) destroys all bundles whose TTLs have expired, (b) enqueues for re-forwarding all bundles that were expected to have been transmitted (by convergence-layer output tasks) by now but are still stuck in their assigned transmission queues, and (c) enqueues for re-forwarding all bundles for which custody has not yet been taken that were expected to have been received and acknowledged by now (as noted by invocation of the **bpMemo()** function by some convergence-layer adapter that had CL-specific insight into the appropriate interval to wait for custody acceptance).

Then **bpclock** adjusts the transmission and reception ‘‘throttles’’ that control rates of LTP transmission to and reception from neighboring nodes, in response to data rate changes as noted in the RFX database by **rfxclock**.

bpclock then checks for bundle origination activity that has been blocked due to insufficient allocated space for BP traffic in the ION data store: if space for bundle origination is now available, **bpclock** gives the bundle production throttle semaphore to unblock that activity.

Finally, **bpclock** applies rate control to all convergence-layer protocol inducts and outducts:

For each induct, **bpclock** increases the current capacity of the duct by the applicable nominal data reception rate. If the revised current capacity is greater than zero, **bpclock** gives the throttle’s semaphore to unblock data acquisition (which correspondingly reduces the current capacity of the duct) by the associated convergence layer input task.

For each outduct, **bpclock** increases the current capacity of the duct by the applicable nominal data transmission rate. If the revised current capacity is greater than zero, **bpclock** gives the throttle’s semaphore to unblock data transmission (which correspondingly reduces the current capacity of the duct) by the associated convergence layer output task.

EXIT STATUS

‘‘0’’

bpclock terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **bpclock**.

‘‘1’’

bpclock was unable to attach to Bundle Protocol operations, probably because **bpadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

bpclock can’t attach to BP.

bpadmin has not yet initialized BP operations.

Can't dispatch events.
An unrecoverable database error was encountered. **bpclock** terminates.

Can't adjust throttles.
An unrecoverable database error was encountered. **bpclock** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **rfxclock** (1)

NAME

bpcounter − Bundle Protocol reception test program

SYNOPSIS

bpcounter *ownEndpointId* [*maxCount*]

DESCRIPTION

bpcounter uses Bundle Protocol to receive application data units from a remote **bpdriver** application task. When the total number of application data units it has received exceeds *maxCount*, it terminates and prints its reception count. If *maxCount* is omitted, the default limit is 2 billion application data units.

EXIT STATUS

"0"

bpcounter has terminated. Any problems encountered during operation will be noted in the **ion.log** log file.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **bpcounter** are written to the ION log file *ion.log*.

Can't attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

Can't open own endpoint.

Another application has already opened *ownEndpointId*. Terminate that application and rerun.

bpcounter bundle reception failed.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bpdriver** (1), **bpecho** (1), **bp** (3)

NAME

bpdriver – Bundle Protocol transmission test program

SYNOPSIS

bpdriver *nbrOfCycles ownEndpointId destinationEndpointId* [*length*] [t*TTL*] [i*Injection Rate*]

DESCRIPTION

bpdriver uses Bundle Protocol to send *nbrOfCycles* application data units of length indicated by *length*, to a counterpart application task that has opened the BP endpoint identified by *destinationEndpointId*.

If omitted, *length* defaults to 60000.

TTL indicates the number of seconds the bundles may remain in the network, undelivered, before they are automatically destroyed. If omitted, *TTL* defaults to 300 seconds.

bpdriver normally runs in ''echo'' mode: after sending each bundle it waits for an acknowledgment bundle before sending the next one. For this purpose, the counterpart application task should be **bpecho**.

Alternatively **bpdriver** can run in ''streaming'' mode, i.e., without expecting or receiving acknowledgments. Streaming mode is enabled when *length* is specified as a negative number, in which case the additive inverse of *length* is used as the effective value of *length*. For this purpose, the counterpart application task should be **bpcounter**.

If the effective value of *length* is 1, the sizes of the transmitted service data units will be randomly selected multiples of 1024 in the range 1024 to 62464.

Injection Rate specifies in bits-per-second the equivalent, average rate at which bpdriver will send bundles into the network. A negative or 0 rate value will turn off injection rate control. By default, bpdriver will inject bundle as fast as it can be handled by ION unless a positive value for *injection rate* is provided.

bpdriver normally runs with custody transfer disabled. To request custody transfer for all bundles sent by **bpdriver**, specify *nbrOfCycles* as a negative number; the additive inverse of *nbrOfCycles* will be used as its effective value in this case.

When all copies of the file have been sent, **bpdriver** prints a performance report.

EXIT STATUS

''0''

bpdriver has terminated. Any problems encountered during operation will be noted in the **ion.log** log file.

FILES

The service data units transmitted by **bpdriver** are sequences of text obtained from a file in the current working directory named ''bpdriverAduFile'', which **bpdriver** creates automatically.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **bpdriver** are written to the ION log file *ion.log*.

Can't attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

Can't open own endpoint.

Another application has already opened *ownEndpointId*. Terminate that application and rerun.

Can't create ADU file

Operating system error. Check errtext, correct problem, and rerun.

Error writing to ADU file

Operating system error. Check errtext, correct problem, and rerun.

bpdriver can't create file ref.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bpdriver can't create ZCO.
: ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bpdriver can't send message
: Bundle Protocol service to the remote endpoint has been stopped.

bpdriver reception failed
: **bpdriver** is in ''echo'' mode, and Bundle Protocol delivery service has been stopped.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bpcounter** (1), **bpecho** (1), **bp** (3)

NAME

bpecho − Bundle Protocol reception test program

SYNOPSIS

bpecho *ownEndpointId*

DESCRIPTION

bpecho uses Bundle Protocol to receive application data units from a remote **bpdriver** application task. In response to each received application data unit it sends back an ‘‘echo’’ application data unit of length 2, the NULL-terminated string ‘‘x’’.

bpecho terminates upon receiving the SIGQUIT signal, i.e., ^C from the keyboard.

EXIT STATUS

‘‘0’’

bpecho has terminated normally. Any problems encountered during operation will be noted in the **ion.log** log file.

‘‘1’’

bpecho has terminated due to a BP reception failure. Details should be noted in the **ion.log** log file.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **bpecho** are written to the ION log file *ion.log*.

Can’t attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

Can’t open own endpoint.

Another application has already opened *ownEndpointId*. Terminate that application and rerun.

bpecho bundle reception failed.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

No space for ZCO extent.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can’t create ZCO.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bpecho can’t send echo bundle.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bpdriver** (1), **bpcounter** (1), **bp** (3)

NAME

bping − Send and receive Bundle Protocol echo bundles.

SYNOPSIS

bping [**−c** *count*] [**−i** *interval*] [**−p** *priority*] [**−q** *wait*] [**−r** *flags*] [**−t** *ttl*] *srcEID destEID* [*reporttoEID*]

DESCRIPTION

bping sends bundles from *srcEID* to *destEID*. If the *destEID* echoes the bundles back (for instance, it is a **bpecho** endpoint), **bping** will print the round-trip time. When complete, bping will print statistics before exiting. It is very similar to **ping**, except it works with the bundle protocol.

bping terminates when one of the following happens: it receives the SIGINT signal (Ctrl+C), it receives responses to all of the bundles it sent, or it has sent all *count* of its bundles and waited *wait* seconds.

When **bping** is executed in a VxWorks or RTEMS environment, its runtime arguments are presented positionally rather than by keyword, in this order: count, interval, priority, wait, flags, TTL, verbosity (a Boolean, defaulting to zero), source EID, destination EID, report-to EID.

Source EID and destination EID are always required.

EXIT STATUS

These exit statuses are taken from **ping**.

"0"
: **bping** has terminated normally, and received responses to all the packets it sent.

"1"
: **bping** has terminated normally, but it did not receive responses to all the packets it sent.

"2"
: **bping** has terminated due to an error. Details should be noted in the **ion.log** log file.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **bping** are written to the ION log file *ion.log* and printed to standard error. Diagnostic messages that don't cause **bping** to terminate indicate a failure parsing an echo response bundle. This means that *destEID* isn't an echo endpoint: it's responding with some other bundle message of an unexpected format.

Can't attach to BP.
: **bpadmin** has not yet initialized Bundle Protocol operations.

Can't open own endpoint.
: Another application has already opened *ownEndpointId*. Terminate that application and rerun.

bping bundle reception failed.
: BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

No space for ZCO extent.
: ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can't create ZCO.
: ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bping can't send echo bundle.
: BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpecho (1), **bptrace** (1), **bpadmin** (1), **bp** (3), **ping** (8)

NAME

bplist − Bundle Protocol (BP) utility for listing queued bundles

SYNOPSIS

bplist [{count | detail} [*destination_EID*[/*priority*]]]

DESCRIPTION

bplist is a utility program that reports on bundles that currently reside in the local node, as identified by entries in the local bundle agent's ''timeline'' list.

Either a count of bundles or a detailed list of bundles (noting primary block information together with hex and ASCII dumps of the payload and all extension blocks, in expiration-time sequence) may be requested.

Either all bundles or just a subset of bundles − restricted to bundles for a single destination endpoint, or to bundles of a given level of priority that are all destined for some specified endpoint − may be included in the report.

By default, **bplist** prints a detailed list of all bundles residing in the local node.

EXIT STATUS

''0''

bplist terminated, for reasons noted in the **ion.log** file.

''1''

bplist was unable to attach to Bundle Protocol operations, probably because **bpadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can't attach to BP.

bpadmin has not yet initialized BP operations.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpclock (1)

NAME

bpnmtest – Bundle Protocol (BP) network management statistics test

SYNOPSIS

bpnmtest

DESCRIPTION

bpnmtest simply prints to stdout messages containing the current values of all BP network management tallies, then terminates.

EXIT STATUS

"0"

bpnmtest has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can't attach to BP.

bpadmin has not yet initialized BP operations.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

NAME

bprecvfile − Bundle Protocol (BP) file reception utility

SYNOPSIS

bprecvfile *own_endpoint_ID* [*max_files*]

DESCRIPTION

bprecvfile is intended to serve as the counterpart to **bpsendfile**. It uses **bp_receive()** to receive bundles containing file content. The content of each bundle is simply written to a file named ''testfileN'' where N is the total number of bundles received since the program began running.

If a *max_files* value of N (where N > 0) is provided, the program will terminate automatically upon completing its Nth file reception. Otherwise it will run indefinitely; use ^C to terminate the program.

EXIT STATUS

''0''

bprecvfile has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can't attach to BP.

bpadmin has not yet initialized BP operations.

Can't open own endpoint.

Another BP application task currently has *own_endpoint_ID* open for bundle origination and reception. Try again after that task has terminated. If no such task exists, it may have crashed while still holding the endpoint open; the easiest workaround is to select a different source endpoint.

bprecvfile bundle reception failed.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bprecvfile: can't open test file

File system error. **bprecvfile** terminates.

bprecvfile: can't receive bundle content.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bprecvfile: can't write to test file

File system error. **bprecvfile** terminates.

bprecvfile cannot continue.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bprecvfile: can't handle bundle delivery.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpsendfile (1), **bp** (3)

NAME

bpsecadmin – BP security policy administration interface

SYNOPSIS

bpsecadmin [*commands_filename*]

DESCRIPTION

bpsecadmin configures and manages BP security policy on the local computer.

It configures and manages BP security policy on the local computer in response to BP configuration commands found in *commands_filename*, if provided; if not, **bpsecadmin** prints a simple prompt (:) so that the user may type commands directly into standard input.

The format of commands for *commands_filename* can be queried from **bpsecadmin** by entering the command 'h' or '?' at the prompt. The commands are documented in **bpsecrc** (5).

EXIT STATUS

"0"

Successful completion of BP security policy administration.

EXAMPLES

bpsecadmin

Enter interactive ION security policy administration command entry mode.

bpsecadmin host1.bpsecrc

Execute all configuration commands in *host1.bpsecrc*, then terminate immediately.

FILES

Status and diagnostic messages from **bpsecadmin** and from other software that utilizes the ION node are nominally written to a log file in the current working directory within which **bpsecadmin** was run. The log file is typically named **ion.log**.

See also **bpsecrc** (5).

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the ionrc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **bpsecadmin**. Otherwise **bpsecadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the log file:

Can't open command file...

The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **bpsecadmin** to fail but are noted in the log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename*. Please see **bpsecrc** (5) for details.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

bpsecrc (5)

NAME

bpsendfile − Bundle Protocol (BP) file transmission utility

SYNOPSIS

bpsendfile *own_endpoint_ID destination_endpoint_ID file_name* [*class_of_service* [*time_to_live (seconds)*]]

DESCRIPTION

bpsendfile uses **bp_send**() to issue a single bundle to a designated destination endpoint, containing the contents of the file identified by *file_name*, then terminates. The bundle is sent with no custody transfer requested. When *class_of_service* is omitted, the bundle is sent at standard priority; for details of the *class_of_service* parameter, see **bptrace** (1). *time_to_live*, if not specified, defaults to 300 seconds (5 minutes). **NOTE** that *time_to_live* is specified **AFTER** *class_of_service*, rather than before it as in **bptrace** (1).

EXIT STATUS

"0"

bpsendfile has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can't attach to BP.

bpadmin has not yet initialized BP operations.

Can't open own endpoint.

Another BP application task currently has *own_endpoint_ID* open for bundle origination and reception. Try again after that task has terminated. If no such task exists, it may have crashed while still holding the endpoint open; the easiest workaround is to select a different source endpoint.

Can't stat the file

Operating system error. Check errtext, correct problem, and rerun.

bpsendfile can't create file ref.

Probably an unrecoverable database error, in which case the local ION node must be terminated and re-initialized.

bpsendfile can't create ZCO.

Probably an unrecoverable database error, in which case the local ION node must be terminated and re-initialized.

bpsendfile can't send file in bundle.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bprecvfile (1), **bp** (3)

NAME

bpsink – Bundle Protocol reception test program

SYNOPSIS

bpsink *ownEndpointId*

DESCRIPTION

bpsink uses Bundle Protocol to receive application data units from a remote **bpsource** application task. For each application data unit it receives, it prints the ADU's length and — if length is less than 80 — its text.

bpsink terminates upon receiving the SIGQUIT signal, i.e., ^C from the keyboard.

EXIT STATUS

"0"

bpsink has terminated. Any problems encountered during operation will be noted in the **ion.log** log file.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **bpsink** are written to the ION log file *ion.log*.

Can't attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

Can't open own endpoint.

Another application has already opened *ownEndpointId*. Terminate that application and rerun.

bpsink bundle reception failed.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can't receive payload.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can't handle delivery.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bpsource** (1), **bp** (3)

NAME

bpsource − Bundle Protocol transmission test shell

SYNOPSIS

bpsource *destinationEndpointId* ["*text*"] [−t*TTL*]

DESCRIPTION

When *text* is supplied, **bpsource** simply uses Bundle Protocol to send *text* to a counterpart **bpsink** application task that has opened the BP endpoint identified by *destinationEndpointId*, then terminates.

Otherwise, **bpsource** offers the user an interactive ''shell'' for testing Bundle Protocol data transmission. **bpsource** prints a prompt string ('': '') to stdout, accepts a string of text from stdin, uses Bundle Protocol to send the string to a counterpart **bpsink** application task that has opened the BP endpoint identified by *destinationEndpointId*, then prints another prompt string and so on. To terminate the program, enter a string consisting of a single exclamation point (!) character.

TTL indicates the number of seconds the bundles may remain in the network, undelivered, before they are automatically destroyed. If omitted, *TTL* defaults to 300 seconds.

The source endpoint ID for each bundle sent by **bpsource** is the null endpoint ID, i.e., the bundles are anonymous. All bundles are sent standard priority with no custody transfer and no status reports requested.

EXIT STATUS

''0''

bpsource has terminated. Any problems encountered during operation will be noted in the **ion.log** log file.

FILES

The service data units transmitted by **bpsource** are sequences of text obtained from a file in the current working directory named ''bpsourceAduFile'', which **bpsource** creates automatically.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **bpsource** are written to the ION log file *ion.log*.

Can't attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

bpsource fgets failed

Operating system error. Check errtext, correct problem, and rerun.

No space for ZCO extent.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can't create ZCO extent.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bpsource can't send ADU

Bundle Protocol service to the remote endpoint has been stopped.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bpsink** (1), **bp** (3)

NAME

bpstats − Bundle Protocol (BP) processing statistics query utility

SYNOPSIS

bpstats

DESCRIPTION

bpstats simply logs messages containing the current values of all BP processing statistics accumulators, then terminates.

EXIT STATUS

"0"

bpstats has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

bpstats can't attach to BP.

bpadmin has not yet initialized BP operations.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ion (3)

NAME

bpstats2 – Bundle Protocol (BP) processing statistics query utility via bundles

SYNOPSIS

bpstats2 *sourceEID* [*default destEID*] [ct]

DESCRIPTION

bpstats2 creates bundles containing the current values of all BP processing statistics accumulators. It creates these bundles when:

- an interrogation bundle is delivered to *sourceEID*: the contents of the bundle are discarded, a new statistics bundle is generated and sent to the source of the interrogation bundle. The format of the interrogation bundle is irrelevant.
- a SIGUSR1 signal is delivered to the **bpstats2** application: a new statistics bundle is generated and sent to *default destEID*.

EXIT STATUS

"0"

bpstats2 has terminated. Any problems encountered during operation will be noted in the **ion.log** log file.

"1"

bpstats2 failed to start up or receive bundles. Diagnose the issue reported in the **ion.log** file and try again.

OPTIONS

[ct] If the string "ct" is appended as the last argument, then statistics bundles will be sent with custody transfer requested.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

bpstats2 can't **bp_attach**().

bpadmin has not yet initialized BP operations.

bpstats2 can't open own endpoint.

Another BP application has opened that endpoint; close it and try again.

No space for ZCO extent.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can't create ZCO extent.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

bpstats2 can't send stats bundle.

Bundle Protocol service to the remote endpoint has been stopped.

Can't send stats: bad dest EID (dest EID)

The destination EID printed is an invalid destination EID. The destination EID may be specified in *default destEID* or the source EID of the interrogation bundle. Ensure that *default destEID* is an EID that is valid for ION, and that the interrogator is a source EID that is also a valid destination EID. Note that "dtn:none" is not a valid destination EID, but is a valid source EID.

NOTES

A very simple interrogator is **bpchat** which can repeatedly interrogate **bpstats2** by just striking the enter key.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpstats (1), **bpchat** (1)

NAME

bptrace − Bundle Protocol (BP) network trace utility

SYNOPSIS

bptrace *own_endpoint_ID destination_endpoint_ID report−to_endpoint_ID TTL class_of_service* "*trace_text*" [*status_report_flags*]

DESCRIPTION

bptrace uses **bp_send()** to issue a single bundle to a designated destination endpoint, with status reporting options enabled as selected by the user, then terminates. The status reports returned as the bundle makes its way through the network provide a view of the operation of the network as currently configured.

TTL indicates the number of seconds the trace bundle may remain in the network, undelivered, before it is automatically destroyed.

class_of_service is *custody-requested.priority*[.*ordinal*[.*unreliable.critical*[.*data-label*]]], where *custody-requested* must be 0 or 1 (Boolean), *priority* must be 0 (bulk) or 1 (standard) or 2 (expedited), *ordinal* must be 0−254, *unreliable* must be 0 or 1 (Boolean), *critical* must also be 0 or 1 (Boolean), and *data-label* may be any unsigned integer. *custody-requested* is passed in with the bundle transmission request, but if set to 1 it serves only to request the use of reliable convergence-layer protocols; this will have the effect of enabling custody transfer whenever the applicable convergence-layer protocol is bundle-in-bundle encapsulation (BIBE). *ordinal* is ignored if *priority* is not 2. Setting *class_of_service* to ''0.2.254'' or ''1.2.254'' gives a bundle the highest possible priority. Setting *unreliable* to 1 causes BP to forego convergence-layer retransmission in the event of data loss. Setting *critical* to 1 causes contact graph routing to forward the bundle on all plausible routes rather than just the ''best'' route it computes; this may result in multiple copies of the bundle arriving at the destination endpoint, but when used in conjunction with priority 2.254 it ensures that the bundle will be delivered as soon as physically possible.

trace_text can be any string of ASCII text; alternatively, if we want to send a file, it can be ''@'' followed by the name of the file.

status_report_flags must be a sequence of status report flags, separated by commas, with no embedded whitespace. Each status report flag must be one of the following: rcv, fwd, dlv, del.

EXIT STATUS

''0''

bptrace has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

bptrace can't attach to BP.

bpadmin has not yet initialized BP operations.

bptrace can't open own endpoint.

Another BP application task currently has *own_endpoint_ID* open for bundle origination and reception. Try again after that task has terminated. If no such task exists, it may have crashed while still holding the endpoint open; the easiest workaround is to select a different source endpoint.

No space for bptrace text.

Probably an unrecoverable database error, in which case the local ION node must be terminated and re-initialized.

bptrace can't create ZCO.

Probably an unrecoverable database error, in which case the local ION node must be terminated and re-initialized.

bptrace can't send message.

BP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bp (3)

NAME

bptransit – Bundle Protocol (BP) daemon task for forwarding received bundles

SYNOPSIS

bptransit

DESCRIPTION

bptransit is a background ‘‘daemon’’ task that is responsible for presenting to ION’s forwarding daemons any bundles that were received from other nodes (i.e., bundles whose payloads reside in Inbound ZCO space) and are destined for yet other nodes. In doing so, it migrates these bundles from Inbound buffer space to Outbound buffer space on the same prioritized basis as the insertion of locally sourced outbound bundles.

Management of the bptransit daemon is automatic. It is spawned automatically by **bpadmin** in response to the ’s’ command that starts operation of Bundle Protocol on the local ION node, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command.

Whenever a received bundle is determined to have a destination other than the local node, a pointer to that bundle is appended to one of two queues of ‘‘in-transit’’ bundles, one for bundles whose forwarding is provisional (depending on the availability of Outbound ZCO buffer space; bundles in this queue are potentially subject to congestion loss) and one for bundles whose forwarding is confirmed. Bundles received via convergence-layer adapters that can sustain flow control, such as STCP, are appended to the ‘‘confirmed’’ queue, while those from CLAs that cannot sustain flow control (such as LTP) are appended to the ‘‘provisional’’ queue.

bptransit comprises two threads, one for each in-transit queue. The confirmed in-transit thread dequeues bundles from the ‘‘confirmed’’ queue and moves them from Inbound to Outbound ZCO buffer space, blocking (if necessary) until space becomes available. The provisional in-transit queue dequeues bundles from the ‘‘provisional’’ queue and moves them from Inbound to Outbound ZCO buffer space if Outbound space is available, discarding (‘‘abandoning’’) them if it is not.

EXIT STATUS

‘‘0’’

bptransit terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **bptransit**.

‘‘1’’

bptransit was unable to attach to Bundle Protocol operations, probably because **bpadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

bptransit can’t attach to BP.

bpadmin has not yet initialized BP operations.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

bpadmin (1)

NAME

brsccla – BRSC–based BP convergence layer adapter (input and output) task

SYNOPSIS

brsccla *server_hostname*[:*server_port_nbr*]*_own_node_nbr*

DESCRIPTION

BRSC is the ‘‘client’’ side of the Bundle Relay Service (BRS) convergence layer protocol for BP. It is complemented by BRSS, the ‘‘server’’ side of the BRS convergence layer protocol for BP. BRS clients send bundles directly only to the server, regardless of their final destinations, and the server forwards them to other clients as necessary.

brsccla is a background ‘‘daemon’’ task comprising three threads: one that connects to the BRS server, spawns the other threads, and then handles BRSC protocol output by transmitting bundles over the connected socket to the BRS server; one that simply sends periodic ‘‘keepalive’’ messages over the connected socket to the server (to assure that local inactivity doesn't cause the connection to be lost); and one that handles BRSC protocol input from the connected server.

The output thread connects to the server's TCP socket at *server_hostname* and *server_port_nbr*, sends over the connected socket the client's *own_node_nbr* (in SDNV representation) followed by a 32–bit time tag and a 160–bit HMAC–SHA1 digest of that time tag, to authenticate itself; checks the authenticity of the 160–bit countersign returned by the server; spawns the keepalive and receiver threads; and then begins extracting bundles from the queues of bundles ready for transmission via BRSC and transmitting those bundles over the connected socket to the server. Each transmitted bundle is preceded by its length, a 32–bit unsigned integer in network byte order. The default value for *server_port_nbr*, if omitted, is 80.

The reception thread receives bundles over the connected socket and passes them to the bundle protocol agent on the local ION node. Each bundle received on the connection is preceded by its length, a 32–bit unsigned integer in network byte order.

The keepalive thread simply sends a ‘‘bundle length’’ value of zero (a 32–bit unsigned integer in network byte order) to the server once every 15 seconds.

brsccla is spawned automatically by **bpadmin** in response to the 's' (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an 'x' (STOP) command. **brsccla** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the BRSC convergence layer protocol.

EXIT STATUS

‘‘0’’

brsccla terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart the BRSC protocol.

‘‘1’’

brsccla terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart the BRSC protocol.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

brsccla can't attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No such brsc induct.

No BRSC induct with duct name matching *server_hostname*, *own_node_nbr*, and *server_port_nbr* has been added to the BP database. Use **bpadmin** to stop the BRSC convergence-layer protocol, add the

induct, and then restart the BRSC protocol.

CLI task is already started for this duct.
: Redundant initiation of **brsccla**.

No such brsc outduct.
: No BRSC outduct with duct name matching *server_hostname*, *own_node_nbr*, and *server_port_nbr* has been added to the BP database. Use **bpadmin** to stop the BRSC convergence-layer protocol, add the outduct, and then restart the BRSC protocol.

Can't connect to server.
: Operating system error. Check errtext, correct problem, and restart BRSC.

Can't register with server.
: Configuration error. Authentication has failed, probably because (a) the client and server are using different HMAC/SHA1 keys or (b) the clocks of the client and server differ by more than 5 seconds. Update security policy database(s), as necessary, and assure that the clocks are synchronized.

brsccla can't create receiver thread
: Operating system error. Check errtext, correct problem, and restart BRSC.

brsccla can't create keepalive thread
: Operating system error. Check errtext, correct problem, and restart BRSC.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **brsscla** (1)

NAME

brsscla − BRSS−based BP convergence layer adapter (input and output) task

SYNOPSIS

brsscla *local_hostname*[:*local_port_nbr*]

DESCRIPTION

BRSS is the ‘‘server’’ side of the Bundle Relay Service (BRS) convergence layer protocol for BP. It is complemented by BRSC, the ‘‘client’’ side of the BRS convergence layer protocol for BP.

brsscla is a background ‘‘daemon’’ task that spawns 2*N threads: one that handles BRSS client connections and spawns sockets for continued data interchange with connected clients; one that handles BRSS protocol output by transmitting over those spawned sockets to the associated clients; and two thread for each spawned socket, an input thread to handle BRSS protocol input from the associated connected client and an output thread to forward BRSS protocol output to the associated connected client.

The connection thread simply accepts connections on a TCP socket bound to *local_hostname* and *local_port_nbr* and spawns reception threads. The default value for *local_port_nbr*, if omitted, is 80.

Each reception thread receives over the socket connection the node number of the connecting client (in SDNV representation), followed by a 32−bit time tag and a 160−bit HMAC−SHA1 digest of that time tag. The receiving thread checks the time tag, requiring that it differ from the current time by no more than BRSTERM (default value 5) seconds. It then recomputes the digest value using the HMAC−SHA1 key named "*node_number*.brs" as recorded in the ION security database (see **ionsecrc** (5)), requiring that the supplied and computed digests be identical. If all registration conditions are met, the receiving thread sends the client a countersign — a similarly computed HMAC−SHA1 digest, for the time tag that is 1 second later than the provided time tag — to assure the client of its own authenticity, then commences receiving bundles over the connected socket. Each bundle received on the connection is preceded by its length, a 32−bit unsigned integer in network byte order. The received bundles are passed to the bundle protocol agent on the local ION node.

Each output thread extracts bundles from the queues of bundles ready for transmission via BRSS to the corresponding connected client and transmits the bundles over the socket to that client. Each transmitted bundle is preceded by its length, a 32−bit unsigned integer in network byte order.

brsscla is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **brsscla** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the BRSS convergence layer protocol.

EXIT STATUS

‘‘0’’

brsscla terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart the BRSS protocol.

‘‘1’’

brsscla terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart the BRSS protocol.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

brsscla can’t attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No such brss induct.
: No BRSS induct with duct name matching *local_hostname* and *local_port_nbr* has been added to the BP database. Use **bpadmin** to stop the BRSS convergence-layer protocol, add the induct, and then restart the BRSS protocol.

CLI task is already started for this duct.
: Redundant initiation of **brsscla**.

Can't get IP address for host
: Operating system error. Check errtext, correct problem, and restart BRSS.

Can't open TCP socket
: Operating system error — unable to open TCP socket for accepting connections. Check errtext, correct problem, and restart BRSS.

Can't initialize socket (note: must be root for port 80)
: Operating system error. Check errtext, correct problem, and restart BRSS.

brsscla can't create sender thread
: Operating system error. Check errtext, correct problem, and restart BRSS.

brsscla can't create access thread
: Operating system error. Check errtext, correct problem, and restart BRSS.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **brsccla** (1)

NAME

cgrfetch − Visualize CGR simulations

SYNOPSIS

cgrfetch [*OPTIONS*] *DEST-NODE*

DESCRIPTION

cgrfetch uses CGR to simulate sending a bundle from the local node to *DEST-NODE*. It traces the execution of CGR to generate graphs of the routes that were considered and the routes that were ultimately chosen to forward along. No bundle is sent during the simulation.

A JSON representation of the simulation is output to *OUTPUT-FILE*. The representation includes parameters of the simulation and a structure for each considered route, which in turn includes calculated parameters for the route and an image of the contact graph.

The **dot** (1) tool from the Graphviz package is used to generate the contact graph images and is required for **cgrfetch** (1). The **base64** (1) tool from coreutils is used to embed the images in the JSON and is also required.

Note that a trace of the route computation logic performed by CGR is printed to stderr; there is currently no cgrfetch option for redirecting this output to a file.

OPTIONS

DEST-NODE
: The final destination to route to. To be useful, it should be a node that exists in the contact plan.

−q Disable trace message output.

−j Disable JSON output.

−m Use a minimum-latency extended COS for the bundle. This ends up sending the bundle to all proximate nodes.

−t DISPATCH-OFFSET
: Request a dispatch time of *DISPATCH-OFFSET* seconds from the time the command is run (default: 0).

−e EXPIRATION-OFFSET
: Set the bundle expiration time to *EXPIRATION-OFFSET* seconds from the time the command is run (default: 3600).

−s BUNDLE-SIZE
: Set the bundle payload size to *BUNDLE-SIZE* bytes (default: 0).

−o OUTPUT-FILE
: Send JSON to *OUTPUT-FILE* (default: stdout).

−d PROTO:NAME
: Use *PROTO* as the outduct protocol and *NAME* as the outduct name (default: udp:*). Use **list** to list all available outducts.

EXAMPLES

cgrfetch 8
: Simulate CGR with destination node 8 and dispatch time equal to the current time.

cgrfetch 8 −t 60
: Do the same with a dispatch time 60 seconds in the future.

cgrfetch −d list
: List all available outducts.

SEE ALSO

dot (1), **base64** (1)

NAME

dccpcli – DCCP–based BP convergence layer input task

SYNOPSIS

dccpcli *local_hostname*[:*local_port_nbr*]

DESCRIPTION

dccpcli is a background ''daemon'' task that receives DCCP datagrams via a DCCP socket bound to *local_hostname* and *local_port_nbr*, extracts bundles from those datagrams, and passes them to the bundle protocol agent on the local ION node.

If not specified, port number defaults to 4556.

Note that **dccpcli** has no fragmentation support at all. Therefore, the largest bundle that can be sent via this convergence layer is limited to just under the link's MTU (typically 1500 bytes).

The convergence layer input task is spawned automatically by **bpadmin** in response to the 's' (START) command that starts operation of the Bundle Protocol; the text of the command that is used to spawn the task must be provided at the time the ''dccp'' convergence layer protocol is added to the BP database. The convergence layer input task is terminated by **bpadmin** in response to an 'x' (STOP) command. **dccpcli** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the DCCP convergence layer protocol.

EXIT STATUS

''0''

dccpcli terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **dccpcli**.

''1''

dccpcli terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **dccpcli**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

dccpcli can't attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No such dccp duct.

No DCCP induct matching *local_hostname* and *local_port_nbr* has been added to the BP database. Use **bpadmin** to stop the DCCP convergence-layer protocol, add the induct, and then restart the DCCP protocol.

CLI task is already started for this duct.

Redundant initiation of **dccpcli**.

dccpcli can't get IP address for host.

Operating system error. Check errtext, correct problem, and restart **dccpcli**.

CLI can't open DCCP socket. This probably means DCCP is not supported on your system.

Operating system error. This probably means that you are not using an operating system that supports DCCP. Make sure that you are using a current Linux kernel and that the DCCP modules are being compiled. Check errtext, correct problem, and restart **dccpcli**.

CLI can't initialize socket.

Operating system error. Check errtext, correct problem, and restart **dccpcli**.

dccpcli can't get acquisition work area.
ION system error. Check errtext, correct problem, and restart **dccpcli**.

dccpcli can't create new thread.
Operating system error. Check errtext, correct problem, and restart **dccpcli**.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **dccpclo** (1)

NAME

dccpclo – DCCP–based BP convergence layer output task

SYNOPSIS

dccpclo *remote_hostname*[:*remote_port_nbr*]

DESCRIPTION

dccpclo is a background ‘‘daemon’’ task that connects to a remote node’s DCCP socket at *remote_hostname* and *remote_port_nbr*. It then begins extracting bundles from the queues of bundles ready for transmission via DCCP to this remote bundle protocol agent and transmitting those bundles as DCCP datagrams to the remote host.

If not specified, *remote_port_nbr* defaults to 4556.

Note that **dccpclo** has no fragmentation support at all. Therefore, the largest bundle that can be sent via this convergence layer is limited to just under the link’s MTU (typically 1500 bytes).

dccpclo is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **dccpclo** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the DCCP convergence layer protocol.

EXIT STATUS

‘‘0’’

dccpclo terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **dccpclo**.

‘‘1’’

dccpclo terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **dccpclo**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

dccpclo can’t attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No memory for DCCP buffer in dccpclo.

ION system error. Check errtext, correct problem, and restart **dccpclo**.

No such dccp duct.

No DCCP outduct matching *local_hostname* and *local_port_nbr* has been added to the BP database. Use **bpadmin** to stop the DCCP convergence-layer protocol, add the outduct, and then restart **dccpclo**.

CLO task is already started for this duct.

Redundant initiation of **dccpclo**.

dccpclo can’t get IP address for host.

Operating system error. Check errtext, correct problem, and restart **dccpclo**.

dccpclo can’t create thread.

Operating system error. Check errtext, correct problem, and restart **dccpclo**.

CLO can’t open DCCP socket. This probably means DCCP is not supported on your system.

Operating system error. This probably means that you are not using an operating system that supports DCCP. Make sure that you are using a current Linux kernel and that the DCCP modules are being compiled. Check errtext, correct problem, and restart **dccpclo**.

CLO can't initialize socket.
: Operating system error. Check errtext, correct problem, and restart **dccpclo**.

CLO **send()** error on socket.
: Operating system error. Check errtext, correct problem, and restart **dccpclo**.

Bundle is too big for DCCP CLO.
: Configuration error: bundles that are too large for DCCP transmission (i.e., larger than the MTU of the link or 65535 bytes — whichever is smaller) are being enqueued for **dccpclo**. Change routing or use smaller bundles.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **dccpcli** (1)

NAME

dgrcli − DGR−based BP convergence layer reception task

SYNOPSIS

dgrcli *local_hostname*[:*local_port_nbr*]

DESCRIPTION

dgrcli is a background ‘‘daemon’’ task that handles DGR convergence layer protocol input.

The daemon receives DGR messages via a UDP socket bound to *local_hostname* and *local_port_nbr*, extracts bundles from those messages, and passes them to the bundle protocol agent on the local ION node. (*local_port_nbr* defaults to 1113 if not specified.)

dgrcli is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **dgrcli** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the DGR convergence layer protocol.

EXIT STATUS

“0”

dgrcli terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **dgrcli**.

“1”

dgrcli terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **dgrcli**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

dgrcli can’t attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No such dgr induct.

No DGR induct with duct name matching *local_hostname* and *local_port_nbr* has been added to the BP database. Use **bpadmin** to stop the DGR convergence-layer protocol, add the induct, and then restart the DGR protocol.

CLI task is already started for this engine.

Redundant initiation of **dgrcli**.

Can’t get IP address for host

Operating system error. Check errtext, correct problem, and restart DGR.

dgrcli can’t open DGR service access point.

DGR system error. Check prior messages in **ion.log** log file, correct problem, and then stop and restart the DGR protocol.

dgrcli can’t create receiver thread

Operating system error. Check errtext, correct problem, and restart DGR.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5)

NAME

dgrclo – DGR–based BP convergence layer transmission task

SYNOPSIS

dgrclo *remote_hostname*[:*remote_port_nbr*]

DESCRIPTION

dgrclo is a background ‘‘daemon’’ task that spawns two threads, one that handles DGR convergence layer protocol input (positive and negative acknowledgments) and a second that handles DGR convergence layer protocol output.

The output thread extracts bundles from the queues of bundles ready for transmission via DGR to a remote bundle protocol agent, encapsulates them in DGR messages, and uses a randomly configured local UDP socket to send those messages to the remote UDP socket bound to *remote_hostname* and *remote_port_nbr*. (*local_port_nbr* defaults to 1113 if not specified.)

The input thread receives DGR messages via the same local UDP socket and uses them to manage DGR retransmission of transmitted datagrams.

dgrclo is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **dgrclo** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the DGR convergence layer protocol.

EXIT STATUS

‘‘0’’

dgrclo terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **dgrclo**.

‘‘1’’

dgrclo terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **dgrclo**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

dgrclo can’t attach to BP.
: **bpadmin** has not yet initialized Bundle Protocol operations.

CLI task is already started for this engine.
: Redundant initiation of **dgrclo**.

No such dgr outduct.
: No DGR outduct with duct name matching *remote_hostname* and *remote_port_nbr* has been added to the BP database. Use **bpadmin** to stop the DGR convergence-layer protocol, add the outduct, and then restart the DGR protocol.

dgrclo can’t open DGR service access point.
: DGR system error. Check prior messages in **ion.log** log file, correct problem, and then stop and restart the DGR protocol.

dgrclo can’t create sender thread
: Operating system error. Check errtext, correct problem, and restart DGR.

dgrclo can’t create receiver thread
: Operating system error. Check errtext, correct problem, and restart DGR.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5)

NAME

dtn2admin – baseline "dtn" scheme administration interface

SYNOPSIS

dtn2admin [*commands_filename*]

DESCRIPTION

dtn2admin configures the local ION node's routing of bundles to endpoints whose IDs conform to the *dtn* endpoint ID scheme. Endpoint IDs in the *dtn* scheme are strings of the form "dtn://*node_name*/[[~]*demux_token*]", where *node_name* identifies a BP node (often this is the DNS name of the computer on which the node resides) and *demux_token* normally identifies a specific application processing point. When and only when the terminating demux string (everything after the final '/') does NOT begin with '~', the endpoint ID identifies a singleton endpoint; when the terminating demux string is omitted, the endpoint ID constitutes a node ID. Although the *dtn* endpoint ID scheme imposes more transmission overhead than the *ipn* scheme, ION provides support for *dtn* endpoint IDs to enable interoperation with other implementations of Bundle Protocol.

dtn2admin operates in response to "dtn" scheme configuration commands found in the file *commands_filename*, if provided; if not, **dtn2admin** prints a simple prompt (:) so that the user may type commands directly into standard input.

The format of commands for *commands_filename* can be queried from **dtn2admin** with the 'h' or '?' commands at the prompt. The commands are documented in **dtn2rc** (5).

EXIT STATUS

"0" Successful completion of "dtn" scheme administration.
"1" Unsuccessful completion of "dtn" scheme administration, due to inability to attach to the Bundle Protocol system or to initialize the "dtn" scheme.

EXAMPLES

dtn2admin
Enter interactive "dtn" scheme configuration command entry mode.

dtn2admin host1.dtn2rc
Execute all configuration commands in *host1.dtn2rc*, then terminate immediately.

FILES

See **dtn2rc** (5) for details of the DTN scheme configuration commands.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the dtn2rc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **dtn2admin**. Otherwise **dtn2admin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the logfile ion.log:

dtn2admin can't attach to BP.
Bundle Protocol has not been initialized on this computer. You need to run **bpadmin** (1) first.

dtn2admin can't initialize routing database.
There is no SDR data store for *dtn2admin* to use. Please run **ionadmin** (1) to start the local ION node.

Can't open command file...
The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **dtn2admin** to fail but are noted in the **ion.log** log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename* file. Please see **dtn2rc** (5) for details.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

dtn2rc (5)

NAME

dtn2adminep – administrative endpoint task for the "dtn" scheme

SYNOPSIS

dtn2adminep

DESCRIPTION

dtn2adminep is a background ‘‘daemon’’ task that receives and processes administrative bundles (minimally, all bundle status reports) that are sent to the ‘‘dtn’’−scheme administrative endpoint on the local ION node, if and only if such an endpoint was established by **bpadmin**. It is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of Bundle Protocol on the local ION node, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **dtn2adminep** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the ‘‘dtn’’ scheme.

dtn2adminep responds to bundle status reports by logging ASCII text messages describing the reported activity.

EXIT STATUS

‘‘0’’

dtn2adminep terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **dtn2adminep**.

‘‘1’’

dtn2adminep was unable to attach to Bundle Protocol operations or was unable to load the ‘‘dtn’’ scheme database, probably because **bpadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

dtn2adminep can’t attach to BP.

bpadmin has not yet initialized BP operations.

dtn2adminep can’t load routing database.

dtn2admin has not yet initialized the ‘‘dtn’’ scheme.

dtn2adminep can’t get admin EID.

dtn2admin has not yet initialized the ‘‘dtn’’ scheme.

dtn2adminep crashed.

An unrecoverable database error was encountered. **dtn2adminep** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **dtn2admin** (1).

NAME

dtn2fw − bundle route computation task for the "dtn" scheme

SYNOPSIS

dtn2fw

DESCRIPTION

dtn2fw is a background ‘‘daemon’’ task that pops bundles from the queue of bundle destined for ‘‘dtn’’−scheme endpoints, computes proximate destinations for those bundles, and appends those bundles to the appropriate queues of bundles pending transmission to those computed proximate destinations.

For each possible proximate destination (that is, neighboring node) there is a separate queue for each possible level of bundle priority: 0, 1, 2. Each outbound bundle is appended to the queue matching the bundle's designated priority.

Proximate destination computation is affected by static routes as configured by **dtn2admin** (1).

dtn2fw is spawned automatically by **bpadmin** in response to the 's' (START) command that starts operation of Bundle Protocol on the local ION node, and it is terminated by **bpadmin** in response to an 'x' (STOP) command. **dtn2fw** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the ‘‘dtn’’ scheme.

EXIT STATUS

‘‘0’’

dtn2fw terminated, for reasons noted in the **ion.log** log file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **dtn2fw**.

‘‘1’’

dtn2fw could not commence operations, for reasons noted in the **ion.log** log file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **dtn2fw**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

dtn2fw can't attach to BP.

bpadmin has not yet initialized BP operations.

dtn2fw can't load routing database.

dtn2admin has not yet initialized the ‘‘dtn’’ scheme.

Can't create lists for route computation.

An unrecoverable database error was encountered. **dtn2fw** terminates.

'dtn' scheme is unknown.

The ‘‘dtn’’ scheme was not added when **bpadmin** initialized BP operations. Use **bpadmin** to add and start the scheme.

Can't take forwarder semaphore.

ION system error. **dtn2fw** terminates.

Can't enqueue bundle.

An unrecoverable database error was encountered. **dtn2fw** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **dtn2admin** (1), **bprc** (5), **dtn2rc** (5).

NAME

hmackeys − utility program for generating good HMAC−SHA1 keys

SYNOPSIS

hmackeys [*keynames_filename*]

DESCRIPTION

hmackeys writes files containing randomized 160−bit key values suitable for use by HMAC−SHA1 in support of Bundle Authentication Block processing, Bundle Relay Service connections, or other functions for which symmetric hash computation is applicable. One file is written for each key name presented to *hmackeys*; the content of each file is 20 consecutive randomly selected 8−bit integer values, and the name given to each file is simply "*keyname*.hmk".

hmackeys operates in response to the key names found in the file *keynames_filename*, one name per file text line, if provided; if not, **hmackeys** prints a simple prompt (:) so that the user may type key names directly into standard input.

When the program is run in interactive mode, either enter 'q' or press ^C to terminate.

EXIT STATUS

''0'' Completion of key generation.

EXAMPLES

hmackeys

Enter interactive HMAC/SHA1 key generation mode.

hmackeys host1.keynames

Create a key file for each key name in *host1.keynames*, then terminate immediately.

FILES

No other files are used in the operation of *hmackeys*.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the logfile ion.log:

Can't open keynames file...

The *keynames_filename* specified in the command line doesn't exist.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

brsscla (1), **ionsecadmin** (1)

NAME

imcfw – bundle route computation task for the IMC scheme

SYNOPSIS

imcfw

DESCRIPTION

imcfw is a background ‘‘daemon’’ task that pops bundles from the queue of bundle destined for IMC-scheme (Interplanetary Multicast) endpoints, determines which ‘‘relatives’’ on the IMC multicast tree to forward the bundles to, and appends those bundles to the appropriate queues of bundles pending transmission to those proximate destinations.

For each possible proximate destination (that is, neighboring node) there is a separate queue for each possible level of bundle priority: 0, 1, 2. Each outbound bundle is appended to the queue matching the bundle's designated priority.

Proximate destination computation is determined by multicast group membership as resulting from nodes' registration in multicast endpoints (accomplished simply by adding the appropriate endpoint as discussed in **bprc** (5).

imcfw is spawned automatically by **bpadmin** in response to the 's' (START) command that starts operation of Bundle Protocol on the local ION node, and it is terminated by **bpadmin** in response to an 'x' (STOP) command. **imcfw** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the IMC scheme.

EXIT STATUS

“0”

imcfw terminated, for reasons noted in the **ion.log** log file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **imcfw**.

“1”

imcfw could not commence operations, for reasons noted in the **ion.log** log file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **imcfw**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

imcfw can't attach to BP.

bpadmin has not yet initialized BP operations.

imcfw can't load routing database.

ipnadmin has not yet initialized the IPN scheme.

Can't create lists for route computation.

An unrecoverable database error was encountered. **imcfw** terminates.

'imc' scheme is unknown.

The IMC scheme was not added when **bpadmin** initialized BP operations. Use **bpadmin** to add and start the scheme.

Can't take forwarder semaphore.

ION system error. **imcfw** terminates.

Can't exclude sender from routes.

An unrecoverable database error was encountered. **imcfw** terminates.

Can't enqueue bundle.

An unrecoverable database error was encountered. **imcfw** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5)

NAME

ipnadmin – Interplanetary Internet (IPN) scheme administration interface

SYNOPSIS

ipnadmin [*commands_filename*]

DESCRIPTION

ipnadmin configures the local ION node's routing of bundles to endpoints whose IDs conform to the *ipn* endpoint ID scheme. Every endpoint ID in the *ipn* scheme is a string of the form "ipn:*node_number.service_number*" where *node_number* is a CBHE ''node number'' and *service_number* identifies a specific application processing point. When *service_number* is zero, the endpoint ID constitutes a node ID. All endpoint IDs formed in the *ipn* scheme identify singleton endpoints.

ipnadmin operates in response to IPN scheme configuration commands found in the file *commands_filename*, if provided; if not, **ipnadmin** prints a simple prompt (:) so that the user may type commands directly into standard input.

The format of commands for *commands_filename* can be queried from **ipnadmin** with the 'h' or '?' commands at the prompt. The commands are documented in **ipnrc** (5).

EXIT STATUS

''0'' Successful completion of IPN scheme administration.

''1'' Unsuccessful completion of IPN scheme administration, due to inability to attach to the Bundle Protocol system or to initialize the IPN scheme.

EXAMPLES

ipnadmin

Enter interactive IPN scheme configuration command entry mode.

ipnadmin host1.ipnrc

Execute all configuration commands in *host1.ipnrc*, then terminate immediately.

FILES

See **ipnrc** (5) for details of the IPN scheme configuration commands.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the ipnrc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **ipnadmin**. Otherwise **ipnadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the logfile ion.log:

ipnadmin can't attach to BP.

Bundle Protocol has not been initialized on this computer. You need to run **bpadmin** (1) first.

ipnadmin can't initialize routing database.

There is no SDR data store for *ipnadmin* to use. Please run **ionadmin** (1) to start the local ION node.

Can't open command file...

The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **ipnadmin** to fail but are noted in the **ion.log** log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename* file. Please see **ipnrc** (5) for details.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

ipnrc (5)

NAME

ipnadminep – administrative endpoint task for the IPN scheme

SYNOPSIS

ipnadminep

DESCRIPTION

ipnadminep is a background ‘‘daemon’’ task that receives and processes administrative bundles (nominally, all bundle status reports) that are sent to the IPN-scheme administrative endpoint on the local ION node, if and only if such an endpoint was established by **bpadmin**. It is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of Bundle Protocol on the local ION node, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **ipnadminep** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the IPN scheme.

ipnadminep responds to bundle status reports by logging ASCII text messages describing the reported activity.

EXIT STATUS

‘‘0’’

ipnadminep terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **ipnadminep**.

‘‘1’’

ipnadminep was unable to attach to Bundle Protocol operations or was unable to load the IPN scheme database, probably because **bpadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

ipnadminep can’t attach to BP.

bpadmin has not yet initialized BP operations.

ipnadminep can’t load routing database.

ipnadmin has not yet initialized the IPN scheme.

ipnadminep crashed.

An unrecoverable database error was encountered. **ipnadminep** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **ipnadmin** (1), **bprc** (5)

NAME

ipnd – ION IPND module

DESCRIPTION

The **ipnd** daemon is the ION implementation of DTN IP Neighbor Discovery. This module allows the node to send and receive beacon messages using unicast, multicast or broadcast IP addresses. Beacons are used for the discovery of neighbors and may be used to advertise services that are present and available on nodes, such as routing algorithms or CLAs.

ION IPND module is configured using a *.rc configuration file. The name of the configuration file must be passed as the sole command-line argument to **ipnd** when the daemon is started. Commands are interpreted line by line, with exactly one command per line. The formats and effects of the ION **ipnd** management commands are described below.

USAGE

ipnd *config_file_name*

COMMANDS

1 The **initialize** command. This must be the first command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by ipnd to be logged into ion.log. Setting echo to 0 disables this behavior. Default is 1.

m eid *eid*
Local eid. This command sets the advertised BP endpoint ID by which the node will identify itself in beacon messages.

m announce period { 1 | 0 }
Announce period control. Setting to 1 causes all beacons messages sent to contain beacon period. Setting to 0 disables this behavior. Default is 1.

m announce eid { 1 | 0 }
Announce eid control. Setting to 1 causes all beacons messages sent to contain source eid. Setting to 0 disables this behavior. This should be always set to 1. Default is 1.

m interval unicast *interval*
Unicast interval. This command sets the beacon messages period on unicast transmissions. Time interval is expressed in seconds. Default is 5.

m interval multicast *interval*
Multicast interval. This command sets the beacon messages period on multicast transmissions. Time interval is expressed in seconds. Default is 7.

m interval broadcast *interval*
Broadcastcast interval. This command sets the beacon messages period on broadcast transmissions. Time interval is expressed in seconds. Default is 11.

m multicast ttl *ttl*
Multicast ttl. This command sets the multicast outgoing beacon messages' time to live, in seconds. Default is 255.

m svcdef *id name child_name*:*child_type ...*
Service definition. This command specifies definitions of ''services'', which are dynamically defined beacon message data structures indicating the capabilities of the beacon message sender. *id* is a service-identifying number in the range 128–255. *name* is the name of the service type that is being defined. The definition of the structure of the service is a sequence of elements, each of which is a *name***:***type* pair. Each *child_type* must be the name of a standard or previously defined service type. Infinite recursion is supported.

a svcadv *name child_name*:*child_value ...*
Service advertising command. This command defines which services will be advertised and with which values. All types of formats for values are supported (e.g. 999, 0345 (octal), 0x999 (hex), −1e−9, 0.32, etc.). For a service that contains only a single element, it is not necessary to provide that element's name. E.g. it is enough to write Booleans:true instead of Booleans:BooleanValues:B:true, as BooleanValues is the only child of Booleans and B is the only child of BooleanValues.

a listen *IP_address*
Listen socket specification command. This command asserts, in the form *IP_address*, the IP address of the socket at which the IPND daemon is to listen for incoming beacons; a default port number is used. The address can be an unicast, a multicast or a broadcast address. If a multicast address is provided all the configured unicast addresses will listen for multicast packets in that group. If a broadcast address is provided all the unicast addresses will listen for broadcasted packets.

a destination *destination_socket_spec*
Destination socket specification command. This command asserts the specification for a socket to which the IPND daemon is to send beacons. It can be an unicast, a multicast or a broadcast address.

s The **start** command. This command starts the IPND daemon for the local ION node.

EXAMPLES

m scvdef 128 FooRouter Seed:SeedVal BaseWeight:WeightVal RootHash:bytes

Defines a new service called FooRouter comprising 3 elements. SeedVal and WeightVal are user defined services that must be already defined.

m svcdef 129 SeedVal Value:fixed16

m svcdef 130 WeightVal Value:fixed16

m svcdef 128 FooRouter Seed:SeedVal BaseWeight:WeightVal RootHash:bytes

m svcdef 150 FixedValuesList F16:fixed16 F32:fixed32 F64:fixed64

m svcdef 131 VariableValuesList U64:uint64 S64:sint64

m svcdef 132 BooleanValues B:boolean

m svcdef 133 FloatValuesList F:float D:double

m svcdef 135 IntegersList FixedValues:FixedValuesList VariableValues:VariableValuesList

m svcdef 136 NumbersList Integers:IntegersList Floats:FloatValuesList

m svcdef 140 HugeService CLAv4:CLA−TCP−v4 Booleans:BooleanValues Numbers:NumbersList FR:FooRouter

a svcadv HugeService CLAv4:IP:10.1.0.10 CLAv4:Port:4444 Booleans:true FR:Seed:0x5432 FR:BaseWeight:13 FR:RootHash:BEEF Numbers:Integers:FixedValues:F16:0x16 Numbers:Integers:FixedValues:F32:0x32 Numbers:Integers:FixedValues:F64:0x1234567890ABCDEF Numbers:Floats:F:0.32 Numbers:Floats:D:−1e−6 Numbers:Integers:VariableValues:U64:18446744073704783380 Numbers:Integers:VariableValues:S64:−4611686018422619668

This shows how to define multiple nested services and how to advertise them.

SEE ALSO

ion (3)

NAME

ipnfw – bundle route computation task for the IPN scheme

SYNOPSIS

ipnfw

DESCRIPTION

ipnfw is a background ‘‘daemon’’ task that pops bundles from the queue of bundle destined for IPN-scheme endpoints, computes proximate destinations for those bundles, and appends those bundles to the appropriate queues of bundles pending transmission to those computed proximate destinations.

For each possible proximate destination (that is, neighboring node) there is a separate queue for each possible level of bundle priority: 0, 1, 2. Each outbound bundle is appended to the queue matching the bundle's designated priority.

Proximate destination computation is affected by static and default routes as configured by **ipnadmin** (1) and by contact graphs as managed by **ionadmin** (1) and **rfxclock** (1).

ipnfw is spawned automatically by **bpadmin** in response to the 's' (START) command that starts operation of Bundle Protocol on the local ION node, and it is terminated by **bpadmin** in response to an 'x' (STOP) command. **ipnfw** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the IPN scheme.

EXIT STATUS

‘‘0’’

ipnfw terminated, for reasons noted in the **ion.log** log file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **ipnfw**.

‘‘1’’

ipnfw could not commence operations, for reasons noted in the **ion.log** log file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **ipnfw**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

ipnfw can't attach to BP.

bpadmin has not yet initialized BP operations.

ipnfw can't load routing database.

ipnadmin has not yet initialized the IPN scheme.

Can't create lists for route computation.

An unrecoverable database error was encountered. **ipnfw** terminates.

'ipn' scheme is unknown.

The IPN scheme was not added when **bpadmin** initialized BP operations. Use **bpadmin** to add and start the scheme.

Can't take forwarder semaphore.

ION system error. **ipnfw** terminates.

Can't exclude sender from routes.

An unrecoverable database error was encountered. **ipnfw** terminates.

Can't enqueue bundle.

An unrecoverable database error was encountered. **ipnfw** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **ipnadmin** (1), **bprc** (5), **ipnrc** (5)

NAME

lgagent – ION Load/Go remote agent program

SYNOPSIS

lgagent *own_endpoint_ID*

DESCRIPTION

ION Load/Go is a system for management of an ION-based network, enabling the execution of ION administrative programs at remote nodes. The system comprises two programs, **lgsend** and **lgagent**.

The **lgagent** task on a given node opens the indicated ION endpoint for bundle reception, receives the extracted payloads of Load/Go bundles sent to it by **lgsend** as run on one or more remote nodes, and processes those payloads, which are the text of Load/Go source files.

Load/Go source file content is limited to newline-terminated lines of ASCII characters. More specifically, the text of any Load/Go source file is a sequence of *line sets* of two types: *file capsules* and *directives*. Any Load/Go source file may contain any number of file capsules and any number of directives, freely intermingled in any order, but the typical structure of a Load/Go source file is simply a single file capsule followed by a single directive.

When **lgagent** identifies a file capsule, it copies all of the capsule's text lines to a new file that it creates in the current working directory. When **lgagent** identifies a directive, it executes the directive by passing the text of the directive to the **pseudoshell()** function (see **platform** (3)). **lgagent** processes the line sets of a Load/Go source file in the order in which they appear in the file, so the text of a directive may reference a file that was created as the result of processing a prior file capsule in the same source file.

EXIT STATUS

"0"

Load/Go remote agent processing has terminated.

FILES

lgfile contains the Load/Go file capsules and directives that are to be processed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

lgagent: can't attach to BP.

Bundle Protocol is not running on this computer. Run **bpadmin** (1) to start BP.

lgagent: can't open own endpoint.

own_endpoint_ID is not a declared endpoint on the local ION node. Run **bpadmin** (1) to add it.

lgagent: bundle reception failed.

ION system problem. Investigate and correct before restarting.

lgagent cannot continue.

lgagent processing problem. See earlier diagnostic messages for details. Investigate and correct before restarting.

lgagent: no space for bundle content.

ION system problem: have exhausted available SDR data store reserves.

lgagent: can't receive bundle content.

ION system problem: have exhausted available SDR data store reserves.

lgagent: can't handle bundle delivery.

ION system problem. Investigate and correct before restarting.

lgagent: pseudoshell failed.

Error in directive line, usually an attempt to execute a non-existent administration program (e.g., a misspelled program name). Terminates processing of source file content.

A variety of other diagnostics noting source file parsing problems may also be reported. These errors are non-fatal but they terminate the processing of the source file content from the most recently received bundle.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

lgsend (1), **lgfile** (5)

NAME

lgsend – ION Load/Go command program

SYNOPSIS

lgsend *command_file_name own_endpoint_ID destination_endpoint_ID*

DESCRIPTION

ION Load/Go is a system for management of an ION-based network, enabling the execution of ION administrative programs at remote nodes. The system comprises two programs, **lgsend** and **lgagent**.

The **lgsend** program reads a Load/Go source file from a local file system, encapsulates the text of that source file in a bundle, and sends the bundle to an **lgagent** task that is waiting for data at a designated DTN endpoint on the remote node.

To do so, it first reads all lines of the Load/Go source file identified by *command_file_name* into a temporary buffer in ION's SDR data store, concatenating the lines of the file and retaining all newline characters. Then it invokes the **bp_send()** function to create and send a bundle whose payload is this temporary buffer, whose destination is *destination_endpoint_ID*, and whose source endpoint ID is *own_endpoint_ID*. Then it terminates.

EXIT STATUS

"0"
: Load/Go file transmission succeeded.

"1"
: Load/Go file transmission failed. Examine **ion.log** to determine the cause of the failure, then re-run.

FILES

lgfile contains the Load/Go file capsules and directive that are to be sent to the remote node.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

lgsend: can't attach to BP.
: Bundle Protocol is not running on this computer. Run **bpadmin** (1) to start BP.

lgsend: can't open own endpoint.
: *own_endpoint_ID* is not a declared endpoint on the local ION node. Run **bpadmin** (1) to add it.

lgsend: can't open file of LG commands: *error description*
: *command_file_name* doesn't identify a file that can be opened. Correct spelling of file name or file's access permissions.

lgsend: can't get size of LG command file: *error description*
: Operating system problem. Investigate and correct before rerunning.

lgsend: LG cmd file size > 64000.
: Load/Go command file is too large. Split it into multiple files if possible.

lgsend: no space for application data unit.
: ION system problem: have exhausted available SDR data store reserves.

lgsend: fgets failed: *error description*
: Operating system problem. Investigate and correct before rerunning.

lgsend: can't create application data unit.
: ION system problem: have exhausted available SDR data store reserves.

lgsend: can't send bundle.
: ION system problem. Investigate and correct before rerunning.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

lgagent (1), **lgfile** (5)

NAME

ltpcli − LTP−based BP convergence layer input task

SYNOPSIS

ltpcli *local_node_nbr*

DESCRIPTION

ltpcli is a background ‘‘daemon’’ task that receives LTP data transmission blocks, extracts bundles from the received blocks, and passes them to the bundle protocol agent on the local ION node.

ltpcli is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol; the text of the command that is used to spawn the task must be provided at the time the ‘‘ltp’’ convergence layer protocol is added to the BP database. The convergence layer input task is terminated by **bpadmin** in response to an ’x’ (STOP) command. **ltpcli** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the LTP convergence layer protocol.

EXIT STATUS

‘‘0’’

ltpcli terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **ltpcli**.

‘‘1’’

ltpcli terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **ltpcli**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

ltpcli can’t attach to BP.
bpadmin has not yet initialized Bundle Protocol operations.

No such ltp duct.
No LTP induct matching *local_node_nbr* has been added to the BP database. Use **bpadmin** to stop the LTP convergence-layer protocol, add the induct, and then restart the LTP protocol.

CLI task is already started for this duct.
Redundant initiation of **ltpcli**.

ltpcli can’t initialize LTP.
ltpadmin has not yet initialized LTP operations.

ltpcli can’t open client access.
Another task has already opened the client service for BP over LTP.

ltpcli can’t create receiver thread
Operating system error. Check errtext, correct problem, and restart LTP.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **ltpadmin** (1), **ltprc** (5), **ltpclo** (1)

NAME

ltpclo − LTP−based BP convergence layer adapter output task

SYNOPSIS

ltpclo *remote_node_nbr*

DESCRIPTION

ltpclo is a background ‘‘daemon’’ task that extracts bundles from the queues of segments ready for transmission via LTP to the remote bundle protocol agent identified by *remote_node_nbr* and passes them to the local LTP engine for aggregation, segmentation, and transmission to the remote node.

ltpclo is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **ltpclo** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the LTP convergence layer protocol.

EXIT STATUS

“0”

ltpclo terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart the BRSC protocol.

“1”

ltpclo terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart the BRSC protocol.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

ltpclo can’t attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No such ltp duct.

No LTP outduct with duct name matching *remote_node_nbr* has been added to the BP database. Use **bpadmin** to stop the LTP convergence-layer protocol, add the outduct, and then restart the LTP protocol.

CLO task is already started for this duct.

Redundant initiation of **ltpclo**.

ltpclo can’t initialize LTP.

ltpadmin has not yet initialized LTP operations.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **ltpadmin** (1), **ltprc** (5), **ltpcli** (1)

NAME

sstcpcli – DTN simple TCP convergence layer input task

SYNOPSIS

stcpcli *local_hostname*[:*local_port_nbr*]

DESCRIPTION

stcpcli is a background ‘‘daemon’’ task comprising 1 + N threads: one that handles TCP connections from remote **stcpclo** tasks, spawning sockets for data reception from those tasks, plus one input thread for each spawned socket to handle data reception over that socket.

The connection thread simply accepts connections on a TCP socket bound to *local_hostname* and *local_port_nbr* and spawns reception threads. The default value for *local_port_nbr*, if omitted, is 4556.

Each reception thread receives bundles over the associated connected socket. Each bundle received on the connection is preceded by a 32−bit unsigned integer in network byte order indicating the length of the bundle. The received bundles are passed to the bundle protocol agent on the local ION node.

stcpcli is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol; the text of the command that is used to spawn the task must be provided at the time the ‘‘stcp’’ convergence layer protocol is added to the BP database. The convergence layer input task is terminated by **bpadmin** in response to an ’x’ (STOP) command. **stcpcli** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the STCP convergence layer protocol.

EXIT STATUS

‘‘0’’

stcpcli terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **stcpcli**.

‘‘1’’

stcpcli terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **stcpcli**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

stcpcli can’t attach to BP.
: **bpadmin** has not yet initialized Bundle Protocol operations.

No such stcp duct.
: No STCP induct matching *local_hostname* and *local_port_nbr* has been added to the BP database. Use **bpadmin** to stop the STCP convergence-layer protocol, add the induct, and then restart the STCP protocol.

CLI task is already started for this duct.
: Redundant initiation of **stcpcli**.

Can’t get IP address for host
: Operating system error. Check errtext, correct problem, and restart STCP.

Can’t open TCP socket
: Operating system error. Check errtext, correct problem, and restart STCP.

Can’t initialize socket
: Operating system error. Check errtext, correct problem, and restart STCP.

stcpcli can't create access thread
Operating system error. Check errtext, correct problem, and restart STCP.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **stcpclo** (1)

NAME

stcpclo − DTN simple TCP convergence layer adapter output task

SYNOPSIS

stcpclo *remote_hostname*[:*remote_port_nbr*]

DESCRIPTION

stcpclo is a background ‘‘daemon’’ task that connects to a remote node’s TCP socket at *remote_hostname* and *remote_port_nbr*. It then begins extracting bundles from the queues of bundles ready for transmission via TCP to this remote bundle protocol agent and transmitting those bundles over the connected socket to that node. Each transmitted bundle is preceded by a 32−bit integer in network byte order indicating the length of the bundle.

If not specified, *remote_port_nbr* defaults to 4556.

stcpclo is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **stcpclo** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the STCP convergence layer protocol.

EXIT STATUS

‘‘0’’

stcpclo terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart the STCP protocol.

‘‘1’’

stcpclo terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart the STCP protocol.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

stcpclo can’t attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No such stcp duct.

No STCP outduct with duct name matching *remote_hostname* and *remote_port_nbr* has been added to the BP database. Use **bpadmin** to stop the STCP convergence-layer protocol, add the outduct, and then restart the STCP protocol.

CLO task is already started for this duct.

Redundant initiation of **stcpclo**.

Can’t get IP address for host

Operating system error. Check errtext, correct problem, and restart STCP.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **stcpcli** (1)

NAME

tcpcli − DTN TCPCL−compliant convergence layer input task

SYNOPSIS

tcpcli *local_hostname*[:*local_port_nbr*]

DESCRIPTION

tcpcli is a background ‘‘daemon’’ task comprising 3 + 2*N threads: an executive thread; a clock thread that periodically attempts to connect to remote TCPCL entities as identified by the tcp outducts enumerated in the **bprc** (5) file (each of which must specify the *hostname*[:*port_nbr*] to connect to); a thread that handles TCP connections from remote TCPCL entities, spawning sockets for data reception from those tasks; plus one input thread and one output thread for each connection, to handle data reception and transmission over that socket.

The connection thread simply accepts connections on a TCP socket bound to *local_hostname* and *local_port_nbr* and spawns reception threads. The default value for *local_port_nbr*, if omitted, is 4556.

Each time a connection is established, the entities will first exchange contact headers, because connection parameters need to be negotiated. **tcpcli** records the acknowledgement flags, reactive fragmentation flag, and negative acknowledgements flag in the contact header it receives from its peer TCPCL entity.

Each reception thread receives bundles over the associated connected socket. Each bundle received on the connection is preceded by message type, fragmentation flags, and size represented as an SDNV. The received bundles are passed to the bundle protocol agent on the local ION node.

Similarly, each transmission thread obtains outbound bundles from the local ION node, encapsulates them as noted above, and transmits them over the associated connected socket.

tcpcli is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol; the text of the command that is used to spawn the task must be provided at the time the ‘‘tcp’’ convergence layer protocol is added to the BP database. The convergence layer input task is terminated by **bpadmin** in response to an ’x’ (STOP) command. **tcpcli** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the TCP convergence layer protocol.

EXIT STATUS

“0”

tcpcli terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **tcpcli**.

“1”

tcpcli terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **tcpcli**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

tcpcli can’t attach to BP.

bpadmin has not yet initialized Bundle Protocol operations.

No such tcp duct.

No TCP induct matching *local_hostname* and *local_port_nbr* has been added to the BP database. Use **bpadmin** to stop the TCP convergence-layer protocol, add the induct, and then restart the TCP protocol.

CLI task is already started for this duct.
Redundant initiation of **tcpcli**.

Can't get IP address for host
Operating system error. Check errtext, correct problem, and restart TCP.

Can't open TCP socket
Operating system error. Check errtext, correct problem, and restart TCP.

Can't initialize socket
Operating system error. Check errtext, correct problem, and restart TCP.

tcpcli can't create access thread
Operating system error. Check errtext, correct problem, and restart TCP.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5)

NAME

tcpclo − TCPCL−compliant convergence layer adapter output task [DEPRECATED]

SYNOPSIS

tcpclo

DESCRIPTION

tcpclo is deprecated. The outducts for the ‘‘tcp’’ convergence-layer adapter are now drained by threads managed within tcpcli.

EXIT STATUS

‘‘0’’

tcpclo terminated normally.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

No diagnostics apply.

SEE ALSO

tcpcli (1)

NAME

udpcli − UDP−based BP convergence layer input task

SYNOPSIS

udpcli *local_hostname*[:*local_port_nbr*]

DESCRIPTION

udpcli is a background ‘‘daemon’’ task that receives UDP datagrams via a UDP socket bound to *local_hostname* and *local_port_nbr*, extracts bundles from those datagrams, and passes them to the bundle protocol agent on the local ION node.

If not specified, port number defaults to 4556.

The convergence layer input task is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol; the text of the command that is used to spawn the task must be provided at the time the ‘‘udp’’ convergence layer protocol is added to the BP database. The convergence layer input task is terminated by **bpadmin** in response to an ’x’ (STOP) command. **udpcli** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the UDP convergence layer protocol.

EXIT STATUS

‘‘0’’

udpcli terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **udpcli**.

‘‘1’’

udpcli terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **udpcli**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

udpcli can’t attach to BP.
: **bpadmin** has not yet initialized Bundle Protocol operations.

No such udp duct.
: No UDP induct matching *local_hostname* and *local_port_nbr* has been added to the BP database. Use **bpadmin** to stop the UDP convergence-layer protocol, add the induct, and then restart the UDP protocol.

CLI task is already started for this duct.
: Redundant initiation of **udpcli**.

Can’t get IP address for host
: Operating system error. Check errtext, correct problem, and restart UDP.

Can’t open UDP socket
: Operating system error. Check errtext, correct problem, and restart UDP.

Can’t initialize socket
: Operating system error. Check errtext, correct problem, and restart UDP.

udpcli can’t create receiver thread
: Operating system error. Check errtext, correct problem, and restart UDP.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **udpclo** (1)

NAME

udpclo − UDP−based BP convergence layer output task

SYNOPSIS

udpclo *remote_hostname*[:*remote_port_nbr*]

DESCRIPTION

udpclo is a background ‘‘daemon’’ task that extracts bundles from the queues of bundles ready for transmission via UDP to a remote node’s UDP socket at *remote_hostname* and *remote_port_nbr*, encapsulates those bundles in UDP datagrams, and sends those datagrams to that remote UDP socket.

udpclo is spawned automatically by **bpadmin** in response to the ’s’ (START) command that starts operation of the Bundle Protocol, and it is terminated by **bpadmin** in response to an ’x’ (STOP) command. **udpclo** can also be spawned and terminated in response to START and STOP commands that pertain specifically to the UDP convergence layer protocol.

EXIT STATUS

“0”

udpclo terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bpadmin** to restart **udpclo**.

“1”

udpclo terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bpadmin** to restart **udpclo**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

udpclo can’t attach to BP.
bpadmin has not yet initialized Bundle Protocol operations.

No memory for UDP buffer in udpclo.
ION system error. Check errtext, correct problem, and restart UDP.

No such udp duct.
No UDP outduct with duct name *remote_hostname*[:<remote_port_nbr>] has been added to the BP database. Use **bpadmin** to stop the UDP convergence-layer protocol, add the outduct, and then restart the UDP protocol.

CLO task is already started for this engine.
Redundant initiation of **udpclo**.

CLO can’t open UDP socket
Operating system error. Check errtext, correct problem, and restart **udpclo**.

CLO **write()** error on socket
Operating system error. Check errtext, correct problem, and restart **udpclo**.

Bundle is too big for UDP CLA.
Configuration error: bundles that are too large for UDP transmission (i.e., larger than 65535 bytes) are being enqueued for **udpclo**. Change routing.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpadmin (1), **bprc** (5), **udpcli** (1)

NAME

bssStreamingApp − Bundle Streaming Service transmission test program

SYNOPSIS

bssStreamingApp *own_endpoint_ID destination_endpoint_ID* [*class_of_service*]

DESCRIPTION

bssStreamingApp uses BSS to send streaming data over BP from *own_endpoint_ID* to bssrecv listening at *destination_endpoint_ID*. *class_of_service* is as specified for **bptrace** (1); if omitted, bundles are sent at BP's standard priority (1).

The bundles issued by **bssStreamingApp** all have 65000−byte payloads, where the ASCII representation of a positive integer (increasing monotonically from 0, by 1, throughout the operation of the program) appears at the start of each payload. All bundles are sent with custody transfer requested, with time-to-live set to 1 day. The application meters output by sleeping for 12800 microseconds after issuing each bundle.

Use CTRL-C to terminate the program.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bssrecv (1), **bss** (3)

NAME

bssrecv – Bundle Streaming Service reception test program

SYNOPSIS

bssrecv

DESCRIPTION

bssrecv uses BSS to acquire streaming data from **bssStreamingApp**.

bssrecv is a menu-driven interactive test program, run from the operating system shell prompt. The program enables the user to begin and end a session of BSS data acquisition from **bssStreamingApp**, displaying the data as it arrives in real time; to replay data acquired during the current session; and to replay data acquired during a prior session.

The user must provide values for three parameters in order to initiate the acquisition or replay of data from **bssStreamingApp**:

BSS database name
: All data acquired by the BSS session thread will be written to a BSS "database" comprising three files: table, list, and data. The name of the database is the root name that is common to the three files, e.g., *db3*.tbl, *db3*.lst, *db3*.dat would be the three files making up the *db3* BSS database.

path name
: All three files of the selected BSS database must reside in the same directory of the file system; the path name of that directory is required.

endpoint ID
: In order to acquire streaming data issued by **bssStreamingApp**, the **bssrecv** session thread must open the BP endpoint to which that data is directed. For this purpose, the ID of that endpoint is needed.

bssrecv offers the following menu options:

1. Open BSS Receiver in playback mode
   bssrecv prompts the user for the three parameter values noted above, then opens the indicated BSS database for replay of the data in that database.

2. Start BSS receiving thread
   bssrecv prompts the user for the three parameter values noted above, then starts a background session thread to acquire data into the indicated database. Each bundle that is acquired is passed to a display function that prints a single line consisting of N consecutive '*' characters, where N is computed as the data number at the start of the bundle's payload data, modulo 150. Note that the database is **not** open for replay at this time.

3. Run BSS receiver thread
   bssrecv prompts the user for the three parameter values noted above, then starts a background session thread to acquire data into the indicated database (displaying the data as described for option 2 above) and also opens the database for replay.

4. Close current playback session
   bssrecv closes the indicated BSS database, terminating replay access.

5. Stop BSS receiving thread
   bssrecv terminates the current background session thread. Replay access to the BSS database, if currently open, is **not** terminated.

6. Stop BSS Receiver
   bssrecv terminates the current background session thread. Replay access to the BSS database, if currently open, is also terminated.

7. Replay session
   bssrecv prompts the user for the start and end times bounding the reception interval that is to be replayed, then displays all data within that interval in both forward and reverse time order. The display function performed for this purpose is the same one that is exercised during real-time

acquisition of streaming data.

8. Exit
bssrecv terminates.

EXIT STATUS

"0"
bssrecv has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bssStreamingApp (1), **bss** (3)

NAME

bsspadmin − Bundle Streaming Service Protocol (BSSP) administration interface

SYNOPSIS

bsspadmin [*commands_filename* | .]

DESCRIPTION

bsspadmin configures, starts, manages, and stops BSSP operations for the local ION node.

It operates in response to BSSP configuration commands found in the file *commands_filename*, if provided; if not, **bsspadmin** prints a simple prompt (:) so that the user may type commands directly into standard input. If *commands_filename* is a period (.), the effect is the same as if a command file containing the single command 'x' were passed to **bsspadmin** — that is, the ION node's *bsspclock* task and link service adapter tasks are stopped.

The format of commands for *commands_filename* can be queried from **bsspadmin** with the 'h' or '?' commands at the prompt. The commands are documented in **bssprc** (5).

EXIT STATUS

0 Successful completion of BSSP administration.

EXAMPLES

bsspadmin
: Enter interactive BSSP configuration command entry mode.

bsspadmin host1.bssp
: Execute all configuration commands in *host1.bssp*, then terminate immediately.

bsspadmin .
: Stop all BSSP operations on the local node.

FILES

See **bssprc** (5) for details of the BSSP configuration commands.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the bssprc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **bsspadmin**. Otherwise **bsspadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the logfile ion.log:

bsspadmin can't attach to ION.
: There is no SDR data store for *bsspadmin* to use. You should run **ionadmin** (1) first, to set up an SDR data store for ION.

Can't open command file...
: The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **bsspadmin** to fail but are noted in the **ion.log** log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename* file. Please see **bssprc** (5) for details.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bssprc (5)

NAME

udpbso − UDP−based best−effort link service output task for BSSP

SYNOPSIS

udpbso {*remote_engine_hostname* | @}[:*remote_port_nbr*] *txbps remote_engine_nbr*

DESCRIPTION

udpbso is a background ‘‘daemon’’ task that extracts BSSP PDUs from the queue of PDUs bound for the indicated remote BSSP engine, encapsulates them in UDP datagrams, and sends those datagrams to the indicated UDP port on the indicated host. If not specified, port number defaults to 6001.

UDP congestion can be controlled by setting udpbso’s rate of UDP datagram transmission *txbps* (transmission rate in bits per second) to the value that is supported by the underlying network.

Each ‘‘span’’ of BSSP data interchange between the local BSSP engine and a neighboring BSSP engine requires its own best-effort and reliable link service output tasks. All link service output tasks are spawned automatically by **bsspadmin** in response to the ’s’ command that starts operation of the BSSP protocol, and they are all terminated by **bsspadmin** in response to an ’x’ (STOP) command.

EXIT STATUS

‘‘0’’

udpbso terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **bsspadmin** to restart **udpbso**.

‘‘1’’

udpbso terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **bsspadmin** to restart **udpbso**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

udpbso can’t initialize BSSP.

bsspadmin has not yet initialized BSSP protocol operations.

No such engine in database.

remote_engine_nbr is invalid, or the applicable span has not yet been added to the BSSP database by **bsspadmin**.

BE-BSO task is already started for this engine.

Redundant initiation of **udpbso**.

BE-BSO can’t open UDP socket

Operating system error. Check errtext, correct problem, and restart **udpbso**.

BE-BSO can’t bind UDP socket

Operating system error. Check errtext, correct problem, and restart **udpbso**.

Segment is too big for UDP BSO.

Configuration error: PDUs that are too large for UDP transmission (i.e., larger than 65535 bytes) are being enqueued for **udpbso**. Use **bsspadmin** to change maximum block size for this span.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ABSO

bsspadmin (1), **tcpbso** (1), **udpbsi** (1)

NAME

bpcp − A remote copy utility for delay tolerant networks utilizing NASA JPL's Interplanetary Overlay Network (ION)

SYNOPSIS

bpcp [−dqr | −v] [−L *bundle_lifetime*] [−C *custody_on/off*] [−S *class_of_service*] [*host1*:]*file1* ... [*host2*:]*file2*

DESCRIPTION

bpcp copies files between hosts utilizing NASA JPL's Interplanetary Overlay Network (ION) to provide a delay tolerant network. File copies from local to remote, remote to local, or remote to remote are permitted. **bpcp** depends on ION to do any authentication or encryption of file transfers. All covergence layers over which **bpcp** runs MUST be reliable.

The options are permitted as follows:

−d Debug output. Repeat for increased verbosity.
−q Quiet. Do not output status messages.
−r Recursive.
−v Display version information.
−L *bundle_lifetime*
Bundle lifetime in seconds. Default is 86400 seconds (1 day).

−C *BP_custody*
Acceptable values are ON/OFF,YES/NO,1/0. Default is OFF.

−S *class_of_service*
Bundle Protocol Class of Service for this transfer. Available options are:

0 Bulk Priority
1 Standard Priority
2 Expedited Priority

Default is Standard Priority.

bpcp utilizes CFDP to preform the actual file transfers. This has several important implications. First, ION's CFDP implementation requires that reliable convergence layers be used to transfer the data. Second, file permissions are not transferred. Files will be made executable on copy. Third, symbolic links are ignored for local to remote transfers and their target is copied for remote transfers. Fourth, all hosts must be specified using ION's IPN naming scheme.

In order to preform remote to local transfers or remote to remote transfers, **bpcpd** must be running on the remote hosts. However, **bpcp** should NOT be run simultaneously with **bpcpd** or **cfdptest**.

EXIT STATUS

"0"
bpcp terminated normally.

"1"
bpcp terminated abnormally. Check console and the **ion.log** file for error messages.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpcpd (1), **ion** (3), **cfdptest** (1)

NAME

bpcpd − ION Delay Tolerant Networking remote file copy daemon

SYNOPSIS

bpcpd [−d | −v]

DESCRIPTION

bpcpd is the daemon for **bpcp**. Together these programs copy files between hosts utilizing NASA JPL's Interplanetary Overlay Network (ION) to provide a delay tolerant network.

The options are permitted as follows:

−d Debug output. Repeat for increased verbosity.

−v Display version information.

bpcpd must be running in order to copy files from this host to another host (i.e. remote to local). Copies in the other direction (local to remote) do not require **bpcpd**. Further, **bpcpd** should NOT be run simultaneously with **bpcp** or **cfdptest**.

EXIT STATUS

"0"

bpcpd terminated normally.

"1"

bpcpd terminated abnormally. Check console and the **ion.log** file for error messages.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

bpcp (1), **ion** (3), **cfdptest** (1)

NAME

bputa − BP−based CFDP UT−layer adapter

SYNOPSIS

bputa

DESCRIPTION

bputa is a background ‘‘daemon’’ task that sends and receives CFDP PDUs encapsulated in DTN bundles.

The task is spawned automatically by **cfdpadmin** in response to the ’s’ command that starts operation of the CFDP protocol; the text of the command that is used to spawn the task must be provided as a parameter to the ’s’ command. The UT-layer daemon is terminated by **cfdpadmin** in response to an ’x’ (STOP) command.

EXIT STATUS

‘‘0’’

bputa terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **cfdpadmin** to restart **bputa**.

‘‘1’’

bputa terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **cfdpadmin** to restart **bputa**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

CFDP can’t attach to BP.
bpadmin has not yet initialized BP protocol operations.

CFDP can’t open own endpoint.
Most likely another bputa task is already running. Use **cfdpadmin** to stop CFDP and restart.

CFDP can’t get Bundle Protocol SAP.
Most likely a BP configuration problem. Use **bpadmin** to stop BP and restart.

bputa can’t attach to CFDP.
cfdpadmin has not yet initialized CFDP protocol operations.

bputa can’t dequeue outbound CFDP PDU; terminating.
Possible system error. Check ion.log for additional diagnostic messages.

bputa can’t send PDU in bundle; terminating.
Possible system error. Check ion.log for additional diagnostic messages.

bputa can’t track PDU; terminating.
Possible system error. Check ion.log for additional diagnostic messages.

bputa bundle reception failed.
Possible system error; reception thread terminates. Check ion.log for additional diagnostic messages.

bputa can’t receive bundle ADU.
Possible system error; reception thread terminates. Check ion.log for additional diagnostic messages.

bputa can’t handle bundle delivery.
Possible system error; reception thread terminates. Check ion.log for additional diagnostic messages.

bputa can’t handle inbound PDU.
Possible system error; reception thread terminates. Check ion.log for additional diagnostic messages.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

cfdpadmin (1), **bpadmin** (1)

NAME

cfdpadmin – ION's CCSDS File Delivery Protocol (CFDP) administration interface

SYNOPSIS

cfdpadmin [*commands_filename* | . | !]

DESCRIPTION

cfdpadmin configures, starts, manages, and stops CFDP operations for the local ION node.

It operates in response to CFDP configuration commands found in the file *commands_filename*, if provided; if not, **cfdpadmin** prints a simple prompt (:) so that the user may type commands directly into standard input. If *commands_filename* is a period (.), the effect is the same as if a command file containing the single command 'x' were passed to **cfdpadmin** — that is, the ION node's *cfdpclock* task and UT layer service task (nominally *bputa*) are stopped. If *commands_filename* is an exclamation point (!), that effect is reversed: the ION node's *cfdpclock* task and UT layer service task (nominally *bputa*) are restarted.

The format of commands for *commands_filename* can be queried from **cfdpadmin** with the 'h' or '?' commands at the prompt. The commands are documented in **cfdprc** (5).

EXIT STATUS

"0"

Successful completion of CFDP administration.

EXAMPLES

cfdpadmin

Enter interactive CFDP configuration command entry mode.

cfdpadmin host1.cfdprc

Execute all configuration commands in *host1.cfdprc*, then terminate immediately.

cfdpadmin .

Stop all CFDP operations on the local node.

FILES

See **cfdprc** (5) for details of the CFDP configuration commands.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the cfdprc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **cfdpadmin**. Otherwise **cfdpadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the logfile ion.log:

cfdpadmin can't attach to ION.

There is no SDR data store for *cfdpadmin* to use. You should run **ionadmin** (1) first, to set up an SDR data store for ION.

Can't open command file...

The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **cfdpadmin** to fail but are noted in the **ion.log** log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename* file. Please see **cfdprc** (5) for details.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

cfdprc (5)

NAME

cfdpclock − CFDP daemon task for managing scheduled events

SYNOPSIS

cfdpclock

DESCRIPTION

cfdpclock is a background ‘‘daemon’’ task that periodically performs scheduled CFDP activities. It is spawned automatically by **cfdpadmin** in response to the ’s’ command that starts operation of the CFDP protocol, and it is terminated by **cfdpadmin** in response to an ’x’ (STOP) command.

Once per second, **cfdpclock** takes the following action:

First it scans all inbound file delivery units (FDUs). For each one whose check timeout deadline has passed, it increments the check timeout count and resets the check timeout deadline. For each one whose check timeout count exceeds the limit configured for this node, it invokes the Check Limit Reached fault handling procedure.

Then it scans all outbound FDUs. For each one that has been Canceled, it cancels all extant PDU bundles and sets transmission progress to the size of the file, simulating the completion of transmission. It destroys each outbound FDU whose transmission is completed.

EXIT STATUS

‘‘0’’

cfdpclock terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **cfdpadmin** to restart **cfdpclock**.

‘‘1’’

cfdpclock was unable to attach to CFDP protocol operations, probably because **cfdpadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

cfdpclock can’t initialize CFDP.

cfdpadmin has not yet initialized CFDP protocol operations.

Can’t dispatch events.

An unrecoverable database error was encountered. **cfdpclock** terminates.

Can’t manage links.

An unrecoverable database error was encountered. **cfdpclock** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

cfdpadmin (1)

NAME

cfdptest – CFDP test shell for ION

SYNOPSIS

cfdptest [*commands_filename*]

DESCRIPTION

cfdptest provides a mechanism for testing CFDP file transmission. It can be used in either scripted or interactive mode. All bundles containing CFDP PDUs are sent with custody transfer requested and with all bundle status reporting disabled.

When scripted with *commands_filename*, **cfdptest** operates in response to CFDP management commands contained in the provided commands file. Each line of text in the file is interpreted as a single command comprising several tokens: a one-character command code and, in most cases, one or more command arguments of one or more characters. The commands configure and initiate CFDP file transmission operations.

If no file is specified, **cfdptest** instead offers the user an interactive ''shell'' for command entry. **cfdptest** prints a prompt string (": ") to stdout, accepts strings of text from stdin, and interprets each string as a command.

The supported **cfdptest** commands (whether interactive or scripted) are as follows:

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

h An alternate form of the **help** command.

z [<number of seconds to pause>]
The **pause** command. When **cfdptest** is running in interactive mode, this command causes the console input processing thread to pause the indicated number of seconds (defaulting to 1) before processing the next command. This is provided for use in test scripting.

d <destination CFDP entity ID number>
The **destination** command. This command establishes the CFDP entity to which the next file transmission operation will be directed. CFDP entity numbers in ION are, by convention, the same as BP node numbers.

f <source file path name>
The **from** command. This command identifies the file that will be transmitted when the next file transmission operation is commanded.

t <destination file path name>
The **to** command. This command provides the name for the file that will be created at the receiving entity when the next file transmission operation is commanded.

l <lifetime in seconds>
The **time-to-live** command. This command establishes the time-to-live for all subsequently issued bundles containing CFDP PDUs. If not specified, the default value 86400 (1 day) is used.

p <priority>
The **priority** command. This command establishes the priority (class of service) for all subsequently issued bundles containing CFDP PDUs. Valid values are 0, 1, and 2. If not specified, priority is 1.

o <ordinal>
The **ordinal** command. This command establishes the ''ordinal'' (sub-priority within priority 2) for all subsequently issued bundles containing CFDP PDUs. Valid values are 0–254. If not specified, ordinal is 0.

m <mode>
The **mode** command. This command establishes the transmission mode (''best-effort'' or assured) for all subsequently issued bundles containing CFDP PDUs. Valid values are 0 (assured, reliable, with reliability provided by a reliable DTN convergence layer protocol), 1 (best-effort, unreliable), and 2

(assured, reliable, but with reliability provided by BP custody transfer). If not specified, transmission mode is 0.

a <latency in seconds>
The **closure latency** command. This command establishes the transaction closure latency for all subsequent file transmission operations. When it is set to zero, the file transmission is ''open loop'' and the CFDP transaction at the sending entity finishes when the EOF is sent. Otherwise, the receiving CFDP entity is being asked to send a ''Finished'' PDU back to the sending CFDP entity when the transaction finishes at the receiving entity. Normally the transaction finishes at the sending entity only when that Finished PDU is received. However, when *closure latency* seconds elapse following transmission of the EOF PDU prior to receipt of the Finished PDU, the transaction finishes immediately with a Check Timer fault.

n { 0 | 1 }
The **segment metadata** command. This command controls the insertion of sample segment metadata — a string representation of the current time — in every file data segment PDU. A value of 1 enables segment metadata insertion, while a value of 0 disables it.

g <srrflags>
The **srrflags** command. This command establishes the BP status reporting that will be requested for all subsequently issued bundles containing CFDP PDUs. *srrflags* must be a status reporting flags string as defined for **bptrace** (1): a sequence of status report flags, separated by commas, with no embedded whitespace. Each status report flag must be one of the following: rcv, ct, fwd, dlv, del.

c <criticality>
The **criticality** command. This command establishes the criticality for all subsequently issued bundles containing CFDP PDUs. Valid values are 0 (not critical) and 1 (critical). If not specified, criticality is 0.

r <action code nbr> <first path name> <second path name>
The **filestore request** command. This command adds a filestore request to the metadata that will be issued when the next file transmission operation is commanded. Action code numbers are:

0 = create file
1 = delete file
2 = rename file
3 = append file
4 = replace file
5 = create directory
6 = remove directory
7 = deny file
8 = deny directory

u '<message text>'
The **user message** command. This command adds a user message to the metadata that will be issued when the next file transmission operation is commanded.

& The **send** command. This command initiates file transmission as configured by the most recent preceding **d**, **f**, **t**, and **a** commands.

| The **get** command. This command causes a request for file transmission to the local node, subject to the parameters provided by the most recent preceding **f**, **t**, and **a** commands, to be sent to the entity identified by the most recent preceding **d** command.

NOTE that 'get' in CFDP is implemented very differently from 'send'. The 'send' operation is a native element of the CFDP protocol. The 'get' operation is implemented by sending to the responding entity a standardized sequence of message-to-user messages in a Metadata PDU – the *user application* at the responding entity receives those messages and initiates a 'send' to accomplish transmission of the file. This means that 'send' can succeed even if no user application is running at the remote node, but 'get' cannot.

^ The **cancel** command. This command cancels the most recently initiated file transmission.

% The **suspend** command. This command suspends the most recently initiated file transmission.

$ The **resume** command. This command resumes the most recently initiated file transmission.

The **report** command. This command reports on the most recently initiated file transmission.

q The **quit** command. Terminates the cfdptest program.

cfdptest in interactive mode also spawns a CFDP event handling thread. The event thread receives CFDP service indications and simply prints lines of text to stdout to announce them.

NOTE that when **cfdptest** runs in scripted mode it does **not** spawn an event handling thread, which makes it possible for the CFDP events queue to grow indefinitely unless some other task consumes and reports on the events. One simple solution is to run an interactive **cfdptest** task in background, simply to keep the event queue cleared, while scripted non-interactive **cfdptest** tasks are run in the foreground.

EXIT STATUS

"0"

cfdptest has terminated. Any problems encountered during operation will be noted in the **ion.log** log file.

FILES

See above for details on valid *commands_filename* commands.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **cfdptest** are written to the ION log file *ion.log*.

Can't open command file...
The file identified by *commands_filename* doesn't exist.

cfdptest can't initialize CFDP.
cfdpadmin has not yet initialized CFDP operations.

Can't put FDU.
The attempt to initiate file transmission failed. See the ION log for additional diagnostic messages from the CFDP library.

Failed getting CFDP event.
The attempt to retrieve a CFDP service indication failed. See the ION log for additional diagnostic messages from the CFDP library.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

cfdpadmin (1), **cfdp** (3)

NAME

dtpcadmin − Delay−Tolerant Payload Conditioning (DTPC) administration interface

SYNOPSIS

dtpcadmin [*commands_filename* | .]

DESCRIPTION

dtpcadmin configures, starts, manages, and stops DTPC operations for the local ION node.

It operates in response to DTPC configuration commands found in the file *commands_filename*, if provided; if not, **dtpcadmin** prints a simple prompt (:) so that the user may type commands directly into standard input. If *commands_filename* is a period (.), the effect is the same as if a command file containing the single command 'x' were passed to **dtpcadmin** — that is, the ION node's *dtpcclock* task and *dtpcd* task are stopped.

The format of commands for *commands_filename* can be queried from **dtpcadmin** with the 'h' or '?' commands at the prompt. The commands are documented in **dtpcrc** (5).

EXIT STATUS

0 Successful completion of DTPC administration.

EXAMPLES

dtpcadmin
: Enter interactive DTPC configuration command entry mode.

dtpcadmin host1.dtpc
: Execute all configuration commands in *host1.dtpc*, then terminate immediately.

dtpcadmin .
: Stop all DTPC operations on the local node.

FILES

See **dtpcrc** (5) for details of the DTPC configuration commands.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the dtpcrc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **dtpcadmin**. Otherwise **dtpcadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the logfile ion.log:

dtpcadmin can't attach to ION.
: There is no SDR data store for *dtpcadmin* to use. You should run **ionadmin** (1) first, to set up an SDR data store for ION.

Can't open command file...
: The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **dtpcadmin** to fail but are noted in the **ion.log** log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename* file. Please see **dtpcrc** (5) for details.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

dtpcrc (5)

NAME

dtpcclock – DTPC daemon task for managing scheduled events

SYNOPSIS

dtpcclock

DESCRIPTION

dtpcclock is a background ‘‘daemon’’ task that periodically performs scheduled DTPC activities. It is spawned automatically by **dtpcadmin** in response to the ’s’ command that starts operation of the DTPC protocol, and it is terminated by **dtpcadmin** in response to an ’x’ (STOP) command.

Once per second, **dtpcclock** takes the following action:

First it executes all DTPC events scheduled to occur at any time up to the current moment:

DTPC ADUs for which an expected positive acknowledgment has not yet arrived are retransmitted.

Received DTPC ADUs whose time to live has elapsed are deleted.

Then **dtpcclock** increases the ages of all DTPC ADUs pending transmission and initiates transmission of each such ADU whose age now equals or exceeds its aggregation time limit.

EXIT STATUS

`0` **dtpcclock** terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **dtpcadmin** to restart **dtpcclock**.

`1` **dtpcclock** was unable to attach to DTPC protocol operations, probably because **dtpcadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

dtpcclock can’t initialize DTPC.
: **dtpcadmin** has not yet initialized DTPC protocol operations.

Can’t send finished adu.
: An unrecoverable database error was encountered. **dtpcclock** terminates.

Can’t stop aggregation for adu.
: An unrecoverable database error was encountered. **dtpcclock** terminates.

Could not scan outbound Adus
: An unrecoverable database error was encountered. **dtpcclock** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

dtpcadmin (1)

NAME

dtpcd − DTPC daemon task for receiving and processing DTPC ADUs in bundles

SYNOPSIS

dtpcd

DESCRIPTION

dtpcd is a background ‘‘daemon’’ task that manages the reception and processing of DTPC protocol data units. It receives the payloads of bundles destined for the ‘‘ipn’’−scheme endpoint whose node number is the number of the local node and whose service number is the DTPC_RECV_SVC_NBR (129 as of the time of this writeng).

DTPC protocol data units are of two types: application data units (ADUs, i.e., aggregations of application data items) and acknowledgments. Each acknowledgment is interpreted as authorization to release the buffer space occupied by the node’s local copy of the acknowledged ADU. Each ADU is parsed into its constituent application data items, which are then delivered to the applications awaiting them, and when required a DTPC end-to-end acknowledgment PDU is returned to the DTPC PDU sender.

EXIT STATUS

`0` **dtpcd** terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **dtpcadmin** to restart **dtpcd**.

`1` **dtpcd** terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **dtpcadmin** to restart **dtpcd**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

DTPC can’t open own ’send’ endpoint.
: Bundle protocol agent has not been started. See **ion** (3).

dtpcd can’t attach to DTPC.
: **dtpcadmin** has not yet initialized DTPC protocol operations.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

dtpcadmin (1), **ion** (3)

NAME

dtpcreceive − Delay−Tolerant Payload Conditioning reception test program

SYNOPSIS

dtpcreceive *topic_ID*

DESCRIPTION

dtpcreceive uses DTPC to acquire application data items on topic *topic_ID* sent by **dtpcsend**. Upon termination it prints the total number of application data items received and the mean rate of application data transmission.

Use CTRL-C to terminate the program.

EXIT STATUS

0 **dtpcreceive** has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

dtpcsend (1), **dtpc** (3)

NAME

dtpcsend − Delay−Tolerant Payload Conditioning transmission test program

SYNOPSIS

dtpcsend *nbr_of_cycles rate payload_size topic_ID profile_ID destination_endpoint*

DESCRIPTION

dtpcsend uses DTPC to send *nbr_of_cycles* application data items of *payload_size* bytes each on topic *topic_ID* to *destination_endpoint* using transmission profile *profile_ID* at *rate* bits per second.

rate must be between 1000 and 200 million bits per second.

payload_size must be between 2 and 1 million bytes. To use application data item sizes chosen at random from the range 1 to 65536, specify *payload_size* = 1.

NOTE that **dtpcsend** invokes an elision function that removes from the outbound DTPC aggregate ADU all records that are of the same size as the first record in that aggregation. This means that specifying any payload size other than 1 that is less than the configured DTPC aggregation size limit will cause DTPC to issue ADUs only when the aggregation time limit is exceeded, and each such ADU will always contain only a single record.

Use CTRL-C to terminate the program.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

dtpcreceive (1), **dtpc** (3)

NAME

file2sdr − SDR data ingestion test program

SYNOPSIS

file2sdr *configFlags fileName*

DESCRIPTION

file2sdr stress-tests SDR data ingestion by repeatedly writing all text lines of the file named *fileName* to one of a series of non-volatile linked lists created in a test SDR data store named "testsdr*configFlags*". By incorporating the data store configuration into the name (e.g., ''testsdr14") we make it relatively easy to perform comparative testing on SDR data stores that are identical aside from their configuration settings.

The operation of **file2sdr** is cyclical: a new linked list is created each time the program finishes copying the file's text lines and starts over again. If you use ^C to terminate **file2sdr** and then restart it, the program resumes operation at the point where it left off.

After writing each line to the current linked list, **file2sdr** gives a semaphore to indicate that the list is now non-empty. This is mainly for the benefit of the complementary test program **sdr2file** (1).

At the end of each cycle **file2sdr** appends a final EOF line to the current linked list, containing the text "*** End of the file ***", and prints a brief performance report:

```
Processing I<lineCount> lines per second.
```

EXIT STATUS

"0"

file2sdr has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **file2sdr** are written to the ION log file *ion.log*.

Can't use sdr.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can't create semaphore.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

SDR transaction failed.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can't open input file

Operating system error. Check errtext, correct problem, and rerun.

Can't reopen input file

Operating system error. Check errtext, correct problem, and rerun.

Can't read from input file

Operating system error. Check errtext, correct problem, and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

sdr2file (1), **sdr** (3)

NAME

file2sm − shared−memory linked list data ingestion test program

SYNOPSIS

file2sm *fileName*

DESCRIPTION

file2sm stress-tests shared-memory linked list data ingestion by repeatedly writing all text lines of the file named *fileName* to a shared-memory linked list that is the root object of a PSM partition named ‘‘file2sm’’.

After writing each line to the linked list, **file2sm** gives a semaphore to indicate that the list is now non-empty. This is mainly for the benefit of the complementary test program **sm2file** (1).

The operation of **file2sm** is cyclical. After copying all text lines of the source file to the linked list, **file2sm** appends an EOF line to the linked list, containing the text ‘‘*** End of the file ***’’, and prints a brief performance report:

```
Processing I<lineCount> lines per second.
```

Then it reopens the source file and starts appending the file’s text lines to the linked list again.

EXIT STATUS

‘‘0’’
: **file2sm** has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Can’t attach to shared memory
: Operating system error. Check errtext, correct problem, and rerun.

Can’t manage shared memory.
: PSM error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can’t create shared memory list.
: smlist error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can’t create semaphore.
: ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

Can’t open input file
: Operating system error. Check errtext, correct problem, and rerun.

Can’t reopen input file
: Operating system error. Check errtext, correct problem, and rerun.

Can’t read from input file
: Operating system error. Check errtext, correct problem, and rerun.

Ran out of memory.
: Nominal behavior. **sm2file** is not extracting data from the linked list quickly enough to prevent it from growing to consume all memory allocated to the test partition.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

sm2file (1), **smlist** (3), **psm** (3)

NAME

ionadmin – ION node administration interface

SYNOPSIS

ionadmin [*commands_filename* | . | !]

DESCRIPTION

ionadmin configures, starts, manages, and stops the ION node on the local computer.

It configures the node and sets (and reports on) global operational settings for the DTN protocol stack on the local computer in response to ION configuration commands found in *commands_filename*, if provided; if not, **ionadmin** prints a simple prompt (:) so that the user may type commands directly into standard input. If *commands_filename* is a period (.), the effect is the same as if a command file containing the single command 'x' were passed to **ionadmin** — that is, the ION node's *rfxclock* task is stopped. If *commands_filename* is an exclamation point (!), that effect is reversed: the ION node's *rfxclock* task is restarted.

The format of commands for *commands_filename* can be queried from **ionadmin** by entering the command 'h' or '?' at the prompt. The commands are documented in **ionrc** (5).

Note that *ionadmin* always computes a congestion forecast immediately before exiting. The result of this forecast — maximum projected occupancy of the DTN protocol traffic allocation in ION's SDR database — is retained for application flow control purposes: if maximum projected occupancy is the entire protocol traffic allocation, then a message to this effect is logged and no new bundle origination by any application will be accepted until a subsequent forecast that predicts no congestion is computed. (Congestion forecasts are constrained by *horizon* times, which can be established by commands issued to *ionadmin*. One way to re-enable data origination temporarily while long-term traffic imbalances are being addressed is to declare a congestion forecast horizon in the near future, before congestion would occur if no adjustments were made.)

EXIT STATUS

"0"

Successful completion of ION node administration.

EXAMPLES

ionadmin

Enter interactive ION configuration command entry mode.

ionadmin host1.ion

Execute all configuration commands in *host1.ion*, then terminate immediately.

FILES

Status and diagnostic messages from **ionadmin** and from other software that utilizes the ION node are nominally written to a log file in the current working directory within which **ionadmin** was run. The log file is typically named **ion.log**.

See also **ionconfig** (5) and **ionrc** (5).

ENVIRONMENT

Environment variables ION_NODE_LIST_DIR and ION_NODE_WDNAME can be used to enable the operation of multiple ION nodes on a single workstation computer. See section 2.1.3 of the ION Design and Operations Guide for details.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the ionrc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **ionadmin**. Otherwise **ionadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the log file:

Can't open command file...
: The *commands_filename* specified in the command line doesn't exist.

ionadmin SDR definition failed.
: A node initialization command was executed, but an SDR database already exists for the indicated node. It is likely that an ION node is already running on this computer or that destruction of a previously started the previous ION node was incomplete. For most ION installations, incomplete node destruction can be repaired by (a) killing all ION processes that are still running and then (b) using **ipcrm** to remove all SVr4 IPC objects owned by ION.

ionadmin can't get SDR parms.
: A node initialization command was executed, but the *ion_config_filename* passed to that command contains improperly formatted commands. Please see **ionconfig** (5) for further details.

Various errors that don't cause **ionadmin** to fail but are noted in the log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename*. Please see **ionrc** (5) for details.

BUGS

If the *ion_config_filename* parameter passed to a node initialization command refers to a nonexistent filename, then **ionadmin** uses default values are used rather than reporting an error in the command line argument.

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ionrc (5), **ionconfig** (5)

NAME

ionlog – utility for redirecting stdin to the ION log file

SYNOPSIS

ionlog

DESCRIPTION

The **ionlog** program simply reads lines of text from stdin and uses writeMemo to copy them into the ion.log file. It terminates when it reaches EOF in stdin.

EXIT STATUS

"0"

ionlog has terminated successfully.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

ionlog unable to attach to ION.

Probable operations error: ION appears not to be initialized, in which case there is no point in running **ionlog**.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

amslogprt (1)

NAME

ionsecadmin – ION global security database management interface

SYNOPSIS

ionsecadmin [*commands_filename*]

DESCRIPTION

ionsecadmin configures and manages the ION security database on the local computer.

It configures and manages the ION security database on the local computer in response to ION configuration commands found in *commands_filename*, if provided; if not, **ionsecadmin** prints a simple prompt (:) so that the user may type commands directly into standard input.

The format of commands for *commands_filename* can be queried from **ionsecadmin** by entering the command 'h' or '?' at the prompt. The commands are documented in **ionsecrc** (5).

EXIT STATUS

"0"

Successful completion of ION security database administration.

EXAMPLES

ionsecadmin

Enter interactive ION security policy administration command entry mode.

ionsecadmin host1.ionsecrc

Execute all configuration commands in *host1.ionsecrc*, then terminate immediately.

FILES

Status and diagnostic messages from **ionsecadmin** and from other software that utilizes the ION node are nominally written to a log file in the current working directory within which **ionsecadmin** was run. The log file is typically named **ion.log**.

See also **ionsecrc** (5).

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the ionrc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **ionsecadmin**. Otherwise **ionsecadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the log file:

Can't open command file...

The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **ionsecadmin** to fail but are noted in the log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename*. Please see **ionsecrc** (5) for details.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

ionsecrc (5)

NAME

ionunlock − utility for unlocking a locked ION node

SYNOPSIS

ionunlock [*sdr_name*]

DESCRIPTION

The **ionunlock** program is designed to be run when some ION thread has terminated while it is the owner of the node's system mutex, i.e., while in the midst of an SDR transaction. IT MUST NEVER BE RUN AT ANY OTHER TIME as it will totally corrupt a node that is not locked up. The program simply declares itself to be the owner of the incomplete transaction and cancels it, enabling the rest of the system to resume operations.

If omitted, *sdr_name* defaults to ''ion''.

EXIT STATUS

''0''

ionunlock has terminated successfully.

''1''

ionunlock has terminated unsuccessfully. See diagnostic messages in the **ion.log** log file for details.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can't initialize the SDR system.

Probable operations error: ION appears not to be initialized, in which case there is no point in running **ionunlock**.

Can't start using SDR.

ION system error. See earlier diagnostic messages posted to **ion.log** for details. In this event it is unlikely that **ionunlock** can be run successfully, and it is also unlikely that it would have any effect if it did run successfully.

ionunlock unnecessary; exiting.

Either the indicated SDR is not initialized or it is not currently stuck in a transaction.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ionxnowner (1), **sdrmend** (1), **sdr** (3)

NAME

ionxnowner – report on which threads are initiating SDR transactions

SYNOPSIS

ionxnowner [*interval* [*count* [*echo*]]]

DESCRIPTION

For *count* interations (defaulting to 1), **ionxnowner** prints the process ID and thread ID of the thread that currently ‘‘owns’’ the local node’s SDR data store (i.e., started the current transaction), then sleeps *interval* seconds (minimum 1). If the optional *echo* parameter is set to 1, then the transaction owner message is logged as well as printed to the console.

EXIT STATUS

‘‘0’’

ionxnowner has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can’t attach to ION.

ION system error. See earlier diagnostic messages posted to ion.log for details.

Can’t access SDR.

ION system error. See earlier diagnostic messages posted to ion.log for details.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ionunlock (1), **sdr** (3), **psmwatch** (1)

NAME

owltsim − one−way light time transmission delay simulator

SYNOPSIS

owltsim *config_filename* [−v]

DESCRIPTION

owltsim delays delivery of data between pairs of ION nodes by specified lengths of time, simulating the signal propagation delay imposed by distance between the nodes.

Its operation is configured by delay simulation configuration lines in the file identified by *config_filename*. A pair of threads is created for each line in the file: one that receives UDP datagrams on a specified port and queues them in a linked list, and a second that later removes queued datagrams from the linked list and sends them on to a specified UDP port on a specified network host.

Each configuration line must be of the following form:

to from my_port# dest_host dest_port# owlt modulus

to identifies the receiving node.
: This parameter is purely informational, intended to make **owltsim**'s printed messages more helpful to the user.

from identifies the sending node.
: A value of '*' may be used to indicate ''all nodes''. Again, this parameter is purely informational, intended to make **owltsim**'s printed messages more helpful to the user.

my_port# identifies **owltsim**'s receiving port for this traffic.
dest_host is a hostname identifying the computer to which **owltsim** will transmit this traffic.
dest_port# identifies the port to which **owltsim** will transmit this traffic.
owlt specifies the number of seconds to wait before forwarding each received datagram.
modulus controls the artificial random data loss imposed on this traffic by **owltsim**.
: A value of '0' specifies ''no imposed data loss''. Any modulus value N > 0 causes **owltsim** to randomly drop (i.e., not transmit upon expiration of the delay interval) one out of every N packets. Any modulus value N < 0 causes **owltsim** to deterministically drop every (0 − N)th packet.

The optional **−v** (''verbose'') parameter causes **owltsim** to print a message whenever it receives, sends, or drops (due to artificial random data loss) a datagram.

Note that error conditions may cause one delay simulation (a pair of threads) to terminate without terminating any others.

owltsim is designed to run indefinitely. To terminate the program, just use control-C to kill it.

EXIT STATUS

''0'' Nominal termination.
''1'' Termination due to an error condition, as noted in printed messages.

EXAMPLES

Here is a sample owltsim configuration file:

2 7 5502 ptl07.jpl.nasa.gov 5001 75 0
7 2 5507 ptl02.jpl.nasa.gov 5001 75 16

This file indicates that **owltsim** will receive on port 5502 the ION traffic from node 2 that is destined for node 7, which will receive it at port 5001 on the computer named ptl07.jpl.nasa.gov; 75 seconds of delay (simulating a distance of 75 light seconds) will be imposed on this transmission activity, and **owltsim** will not simulate any random data loss.

In the reverse direction, **owltsim** will receive on port 5507 the ION traffic from node 7 that is destined for node 2, which will receive it at port 5001 on the computer named ptl02.jpl.nasa.gov; 75 seconds of delay will again be imposed on this transmission activity, and **owltsim** will randomly discard (i.e., not transmit upon expiration of the transmission delay interval) one datagram out of every 16 received at this port.

FILES

Not applicable.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be printed to stdout:

owltsim can't open configuration file
: The program terminates.

owltsim failed on fscanf
: Failure on reading the configuration file. The program terminates.

owltsim stopped malformed config file line *line_number*.
: Failure on parsing the configuration file. The program terminates.

owltsim can't spawn receiver thread
: The program terminates.

owltsim out of memory.
: The program terminates.

owltsim can't open reception socket
: The program terminates.

owltsim can't initialize reception socket
: The program terminates.

owltsim can't open transmission socket
: The program terminates.

owltsim can't initialize transmission socket
: The program terminates.

owltsim can't spawn timer thread
: The program terminates.

owltsim can't acquire datagram
: Datagram transmission failed. This causes the threads for the affected delay simulation to terminate, without terminating any other threads.

owltsim failed on send
: Datagram transmission failed. This causes the threads for the affected delay simulation to terminate, without terminating any other threads.

at *time* owltsim LOST a dg of length *length* from *sending node* destined for *receiving node* due to ECONNREFUSED.
: This is an informational message. Due to an apparent bug in Internet protocol implementation, transmission of a datagram on a connected UDP socket occasionally fails. **owltsim** does not attempt to retransmit the affected datagram.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

udplsi (1), **udplso** (1)

NAME

owlttb − one−way light time transmission delay simulator

SYNOPSIS

owlttb *own_uplink_port# own_downlink_port# dest_uplink_IP_address dest_uplink_port# dest_downlink_IP_address dest_downlink_port# owlt_sec.* [−v]

DESCRIPTION

owlttb delays delivery of data between an NTTI and a NetAcquire box (or two, one for uplink and one for downlink) by a specified length of time, simulating the signal propagation delay imposed by distance between the nodes.

Its operation is configured by the command-line parameters, except that the delay interval itself may be changed while the program is running. **owlttb** offers a command prompt (:), and when a new value of one-way light time is entered at this prompt the new delay interval takes effect immediately.

own_uplink_port# identifies the port on **owlttb** accepts the NTTI's TCP connection for uplink traffic (i.e., data destined for the NetAcquire box).
own_downlink_port# identifies the port on **owlttb** accepts the NTTI's TCP connection for downlink traffic (i.e., data issued by the NetAcquire box).
dest_uplink_IP_address is the IP address (a dotted string) identifying the NetAcquire box to which **owlttb** will transmit uplink traffic.
dest_uplink_port# identifies the TCP port to which **owlttb** will connect in order to transmit uplink traffic to NetAcquire.
dest_downlink_IP_address is the IP address (a dotted string) identifying the NetAcquire box from which **owlttb** will receive downlink traffic.
dest_downlink_port# identifies the TCP port to which **owlttb** will connect in order to receive downlink traffic from NetAcquire.
owlt specifies the number of seconds to wait before forwarding each received segment of TCP traffic.

The optional **−v** (''verbose'') parameter causes **owlttb** to print a message whenever it receives, sends, or discards (due to absence of a connected downlink client) a segment of TCP traffic.

owlttb is designed to run indefinitely. To terminate the program, just use control-C to kill it or enter ''q'' at the prompt.

EXIT STATUS

''0'' Nominal termination.
''1'' Termination due to an error condition, as noted in printed messages.

EXAMPLES

Here is a sample owlttb command:

owlttb 2901 2902 137.7.8.19 10001 137.7.8.19 10002 75

This command indicates that **owlttb** will accept an uplink traffic connection on port 2901, forwarding the received uplink traffic to port 10001 on the NetAcquire box at 137.7.8.19, and it will accept a downlink traffic connection on port 2902, delivering over that connection all downlink traffic that it receives from connecting to port 10002 on the NetAcquire box at 137.7.8.19. 75 seconds of delay (simulating a distance of 75 light seconds) will be imposed on this transmission activity.

FILES

Not applicable.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be printed to stdout:

owlttb can't spawn uplink thread
The program terminates.

owlttb can't spawn uplink sender thread
: The program terminates.

owlttb can't spawn downlink thread
: The program terminates.

owlttb can't spawn downlink receiver thread
: The program terminates.

owlttb can't spawn downlink sender thread
: The program terminates.

owlttb fgets failed
: The program terminates.

owlttb out of memory.
: The program terminates.

owlttb lost uplink client.
: This is an informational message. The NTTI may reconnect at any time.

owlttb lost downlink client
: This is an informational message. The NTTI may reconnect at any time.

owlttb can't open TCP socket to NetAcquire
: The program terminates.

owlttb can't connect TCP socket to NetAcquire
: The program terminates.

owlttb **write()** error on socket
: The program terminates if it was writing to NetAcquire; otherwise it simply recognizes that the client NTTI has disconnected.

owlttb **read()** error on socket
: The program terminates.

owlttb can't open uplink dialup socket
: The program terminates.

owlttb can't initialize uplink dialup socket
: The program terminates.

owlttb can't open downlink dialup socket
: The program terminates.

owlttb can't initialize downlink dialup socket
: The program terminates.

owlttb **accept()** failed
: The program terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

NAME

psmshell – PSM memory management test shell

SYNOPSIS

psmshell *partition_size*

DESCRIPTION

psmshell allocates a region of *partition_size* bytes of system memory, places it under PSM management, and offers the user an interactive ‘‘shell’’ for testing various PSM management functions.

psmshell prints a prompt string (‘‘: ’’) to stdout, accepts a command from stdin, executes the command (possibly printing a diagnostic message), then prints another prompt string and so on.

The locations of objects allocated from the PSM-managed region of memory are referred to as ‘‘cells’’ in psmshell operations. That is, when an object is to be allocated, a cell number in the range 0–99 must be specified as the notional ‘‘handle’’ for that object, for use in future commands.

The following commands are supported:

h The **help** command. Causes **psmshell** to print a summary of available commands. Same effect as the **?** command.

? Another **help** command. Causes **psmshell** to print a summary of available commands. Same effect as the **h** command.

m *cell_nbr size*
The **malloc** command. Allocates a large-pool object of the indicated size and associates that object with *cell_nbr*.

z *cell_nbr size*
The **zalloc** command. Allocates a small-pool object of the indicated size and associates that object with *cell_nbr*.

p *cell_nbr*
The **print** command. Prints the address (i.e., the offset within the managed block of memory) of the object associated with *cell_nbr*.

f *cell_nbr*
The **free** command. Frees the object associated with *cell_nbr*, returning the space formerly occupied by that object to the appropriate free block list.

u The **usage** command. Prints a partition usage report, as per **psm_report** (3).

q The **quit** command. Frees the allocated system memory in the managed block and terminates **psmshell**.

EXIT STATUS

‘‘0’’
psmshell has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

IPC initialization failed.
ION system error. Investigate, correct problem, and try again.

psmshell: can’t allocate space; quitting.
Insufficient available system memory for selected partition size.

psmshell: can’t allocate test variables; quitting.
Insufficient available system memory for selected partition size.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

psm (3)

NAME

psmwatch – PSM memory partition activity monitor

SYNOPSIS

psmwatch *shared_memory_key memory_size partition_name interval count* [verbose]

DESCRIPTION

For *count* interations, **psmwatch** sleeps *interval* seconds and then invokes the **psm_print_trace()** function (see **psm** (3)) to report on PSM dynamic memory management activity in the PSM-managed shared memory partition identified by *shared_memory_key* during that interval. If the optional **verbose** parameter is specified, the printed PSM activity trace will be verbose as described in **psm** (3).

To prevent confusion, the specified *memory_size* and *partition_name* are compared to those declared when this shared memory partition was initially managed; if they don't match, **psmwatch** immediately terminates.

If *interval* is zero, **psmwatch** merely prints a current usage summary for the indicated shared-memory partition and terminates.

psmwatch is helpful for detecting and diagnosing memory leaks. For debugging the ION protocol stack:

shared_memory_key
: Normally "65281", but might be overridden by the value of wmKey in the .ionconfig file used to configure the node under study.

memory_size
: As given by the value of wmKey in the .ionconfig file used to configure the node under study. If this value is not stated in the .ionconfig file, the default value is "5000000".

partition_name
: Always "ionwm".

EXIT STATUS

"0"
: **psmwatch** has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can't attach to psm.
: ION system error. One possible cause is that ION has not yet been initialized on the local computer; run **ionadmin** (1) to correct this.

Can't start trace.
: Insufficient ION working memory to contain trace information. Reinitialize ION with more memory.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

psm (3), **sdrwatch** (1)

NAME

rfxclock – ION daemon task for managing scheduled events

SYNOPSIS

rfxclock

DESCRIPTION

rfxclock is a background ‘‘daemon’’ task that periodically applies scheduled changes in node connectivity and range to the ION node’s database. It is spawned automatically by **ionadmin** in response to the ’s’ command that starts operation of the ION node infrastructure, and it is terminated by **ionadmin** in response to an ’x’ (STOP) command.

Once per second, **rfxclock** takes the following action:

For each neighboring node that has been refusing custody of bundles sent to it to be forwarded to some destination node, to which no such bundle has been sent for at least N seconds (where N is twice the one-way light time from the local node to this neighbor), **rfxclock** turns on a *probeIsDue* flag authorizing transmission of the next such bundle in hopes of learning that this neighbor is now able to accept custody.

Then **rfxclock** purges the database of all range and contact information that is no longer applicable, based on the stop times of the records.

Finally, **rfxclock** applies to the database all range and contact information that is currently applicable, i.e., those records whose start times are before the current time and whose stop times are in the future.

EXIT STATUS

‘‘0’’

rfxclock terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **ionadmin** to restart **rfxclock**.

‘‘1’’

rfxclock was unable to attach to the local ION node, probably because **ionadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

rfxclock can’t attach to ION.

ionadmin has not yet initialized the ION database.

Can’t apply ranges.

An unrecoverable database error was encountered. **rfxclock** terminates.

Can’t apply contacts.

An unrecoverable database error was encountered. **rfxclock** terminates.

Can’t purge ranges.

An unrecoverable database error was encountered. **rfxclock** terminates.

Can’t purge contacts.

An unrecoverable database error was encountered. **rfxclock** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ionadmin (1)

NAME

sdr2file − SDR data extraction test program

SYNOPSIS

sdr2file *configFlags*

DESCRIPTION

sdr2file stress-tests SDR data extraction by retrieving and deleting all text file lines inserted into a test SDR data store named "testsdr*configFlags*" by the complementary test program **file2sdr** (1).

The operation of **sdr2file** echoes the cyclical operation of **file2sdr**: each linked list created by **file2sdr** is used to create in the current working directory a copy of **file2sdr**'s original source text file. The name of each file written by **sdr2file** is file_copy_*cycleNbr*, where *cycleNbr* identifies the linked list from which the file's text lines were obtained.

sdr2file may catch up with the data ingestion activity of **file2sdr**, in which case it blocks (taking the **file2sdr** test semaphore) until the linked list it is currently draining is no longer empty.

EXIT STATUS

"0"
: **sdr2file** has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Can't use sdr.
: ION system error. Check for diagnostics in the ION log file *ion.log*.

Can't create semaphore.
: ION system error. Check for diagnostics in the ION log file *ion.log*.

SDR transaction failed.
: ION system error. Check for diagnostics in the ION log file *ion.log*.

Can't open output file
: Operating system error. Check errtext, correct problem, and rerun.

can't write to output file
: Operating system error. Check errtext, correct problem, and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

file2sdr (1), **sdr** (3)

NAME

sdrmend − SDR corruption repair utility

SYNOPSIS

sdrmend *sdr_name config_flags heap_words heap_key path_name* [*restartCmd restartLatency*]

DESCRIPTION

The **sdrmend** program simply invokes the **sdr_reload_profile()** function (see **sdr** (3)) to effect necessary repairs in a potentially corrupt SDR, e.g., due to the demise of a program that had an SDR transaction in progress at the moment it crashed.

Note that **sdrmend** need not be run to repair ION's data store in the event of a hardware reboot: restarting ION will automatically reload the data store's profile. **sdrmend** is needed only when it is desired to repair the data store without requiring all ION software to terminate and restart.

EXIT STATUS

"0"

sdrmend has terminated successfully.

"1"

sdrmend has terminated unsuccessfully. See diagnostic messages in the **ion.log** log file for details.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can't initialize the SDR system.

Probable operations error: ION appears not to be initialized, in which case there is no point in running **sdrmend**.

Can't reload profile for SDR.

ION system error. See earlier diagnostic messages posted to **ion.log** for details. In this event it is unlikely that **sdrmend** can be run successfully, and it is also unlikely that it would have any effect if it did run successfully.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ionunlock (1), **sdr** (3), **ionadmin** (1)

NAME

sdrwatch − SDR non−volatile data store activity monitor

SYNOPSIS

sdrwatch *sdr_name* [−t | −s | −r | −z] [*interval* [*count* [verbose]]]

DESCRIPTION

For *count* interations (defaulting to 1), **sdrwatch** sleeps *interval* seconds and then performs the SDR operation indicated by the specified mode: 's' to print statistics, 'r' to reset statistics, 'z' to print ZCO space utilization, 't' (the default) to call the **sdr_print_trace()** function (see **sdr** (3)) to report on SDR data storage management activity in the SDR data store identified by *sdr_name* during that interval. If the optional **verbose** parameter is specified, the printed SDR activity trace will be verbose as described in **sdr** (3).

If *interval* is zero, **sdrwatch** just performs the indicated operation once (for 't', it merely prints a current usage summary for the indicated data store) and terminates.

sdrwatch is helpful for detecting and diagnosing storage space leaks. For debugging the ION protocol stack, *sdr_name* is normally ''ion'' but might be overridden by the value of sdrName in the .ionconfig file used to configure the node under study.

EXIT STATUS

''0''

sdrwatch has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

Can't attach to sdr.

ION system error. One possible cause is that ION has not yet been initialized on the local computer; run **ionadmin** (1) to correct this.

Can't start trace.

Insufficient ION working memory to contain trace information. Reinitialize ION with more memory.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

sdr (3), **psmwatch** (1)

NAME

sm2file − shared−memory linked list data extraction test program

SYNOPSIS

sm2file

DESCRIPTION

sm2file stress-tests shared-memory linked list data extraction by retrieving and deleting all text file lines inserted into a shared-memory linked list that is the root object of a PSM partition named ‘‘file2sm’’.

The operation of **sm2file** echoes the cyclical operation of **file2sm**: the EOF lines inserted into the linked list by **file2sm** punctuate the writing of files that are copies of **file2sm**'s original source text file. The name of each file written by **sm2file** is file_copy_*cycleNbr*, where *cycleNbr* is, in effect, the count of EOF lines encountered in the linked list up to the point at which the writing of this file began.

sm2file may catch up with the data ingestion activity of **file2sm**, in which case it blocks (taking the **file2sm** test semaphore) until the linked list is no longer empty.

EXIT STATUS

‘‘0’’
: **sm2file** has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

can’t attach to shared memory
: Operating system error. Check errtext, correct problem, and rerun.

Can’t manage shared memory.
: PSM error. Check for earlier diagnostics describing the cause of the error; correct problem and rerun.

Can’t create shared memory list.
: PSM error. Check for earlier diagnostics describing the cause of the error; correct problem and rerun.

Can’t create semaphore.
: ION system error. Check for earlier diagnostics describing the cause of the error; correct problem and rerun.

Can’t open output file
: Operating system error. Check errtext, correct problem, and rerun.

can’t write to output file
: Operating system error. Check errtext, correct problem, and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

file2sm (1), **smlist** (3), **psm** (3)

NAME

smlistsh − shared−memory linked list test shell

SYNOPSIS

smlistsh *partition_size*

DESCRIPTION

smlistsh attaches to a region of system memory (allocating it if necessary, and placing it under PSM management as necessary) and offers the user an interactive ‘‘shell’’ for testing various shared-memory linked list management functions.

smlistsh prints a prompt string (‘‘: ’’) to stdout, accepts a command from stdin, executes the command (possibly printing a diagnostic message), then prints another prompt string and so on.

The following commands are supported:

h The **help** command. Causes **smlistsh** to print a summary of available commands. Same effect as the **?** command.

? Another **help** command. Causes **smlistsh** to print a summary of available commands. Same effect as the **h** command.

k The **key** command. Computes and prints an unused shared-memory key, for possible use in attaching to a shared-memory region.

+ *key_value size*
The **attach** command. Attaches **smlistsh** to a region of shared memory. *key_value* identifies an existing shared-memory region, in the event that you want to attach to an existing shared-memory region (possibly created by another **smlistsh** process running on the same computer). To create and attach to a new shared-memory region that other processes can attach to, use a *key_value* as returned by the **key** command and supply the *size* of the new region. If you want to create and attach to a new shared-memory region that is for strictly private use, use −1 as key and supply the *size* of the new region.

− The **detach** command. Detaches **smlistsh** from the region of shared memory it is currently using, but does not free any memory.

n The **new** command. Creates a new shared-memory list to operate on, within the currently attached shared-memory region. Prints the address of the list.

s *list_address*
The **share** command. Selects an existing shared-memory list to operate on, within the currently attached shared-memory region.

a *element_value*
The **append** command. Appends a new list element, containing *element_value*, to the list on which **smlistsh** is currently operating.

p *element_value*
The **prepend** command. Prepends a new list element, containing *element_value*, to the list on which **smlistsh** is currently operating.

w The **walk** command. Prints the addresses and contents of all elements of the list on which **smlistsh** is currently operating.

f *element_value*
The **find** command. Finds the list element that contains *element_value*, within the list on which **smlistsh** is currently operating, and prints the address of that list element.

d *element_address*
The **delete** command. Deletes the list element located at *element_address*.

r The **report** command. Prints a partition usage report, as per **psm_report** (3).

q The **quit** command. Detaches **smlistsh** from the region of shared memory it is currently using (without freeing any memory) and terminates **smlistsh**.

EXIT STATUS

"0"

smlistsh has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

No diagnostics apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

smlist (3)

NAME

smrbtsh − shared−memory red−black tree test shell

SYNOPSIS

smrbtsh [*command_file_name*]

DESCRIPTION

smrbtsh allocates a region of shared system memory, attaches to that region, places it under PSM management, creates a temporary ‘‘test’’ red-black tree in that memory region, and executes a series of shared-memory red-black tree commands that exercise various tree access and management functions.

If *command_file_name* is provided, then the commands in the indicated file are executed and the program then terminates. Upon termination, the shared memory region allocated to **smrbtsh** is detached and destroyed.

Otherwise, **smrbtsh** offers the user an interactive ‘‘shell’’ for testing the smrbt functions in a conversational manner: **smrbtsh** prints a prompt string (‘‘: ’’) to stdout, accepts a command from stdin, executes the command (possibly printing a diagnostic message), then prints another prompt string and so on. Upon execution of the ’q’ command, the program terminates.

The following commands are supported:

h The **help** command. Causes **smrbtsh** to print a summary of available commands. Same effect as the **?** command.

? Another **help** command. Causes **smrbtsh** to print a summary of available commands. Same effect as the **h** command.

s [*seed_value*]
The **seed** command. Seeds random data value generator, which is used to generate node values when the **r** command is used. If *seed_value* is omitted, uses current time (as returned by **time** (1)) as seed value.

r [*count*]
The **random** command. Inserts *count* new nodes into the red-black tree, using randomly selected unsigned long integers as the data values of the nodes; *count* defaults to 1 if omitted.

i *data_value*
The **insert** command. Inserts a single new node into the red-black tree, using *data_value* as the data value of the node.

f *data_value*
The **find** command. Finds the rbt node whose value is *data_value*, within the red-black tree, and prints the address of that node. If the node is not found, prints address zero and prints the address of the successor node in the tree.

d *data_value*
The **delete** command. Deletes the rbt node whose data value is *data_value*.

p The **print** command. Prints the red-black tree, using indentation to indicate descent along paths of the tree.

Note: this function is supported only if the **smrbt** library was built with compilation flag −DSMRBT_DEBUG=1.

k The **check** command. Examines the red-black tree, noting the first violation of red-black structure rules, if any.

Note: this function is supported only if the **smrbt** library was built with compilation flag −DSMRBT_DEBUG=1.

l The **list** command. Lists all nodes in the red-black tree in traversal order, noting any nodes whose data values are not in ascending numerical order.

q The **quit** command. Detaches **smrbtsh** from the region of shared memory it is currently using, destroys that shared memory region, and terminates **smrbtsh**.

EXIT STATUS

"0"

smrbtsh has terminated.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

No diagnostics apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

smrbt (3)

NAME

dccplsi − DCCP−based LTP link service input task

SYNOPSIS

dccplsi {*local_hostname* | @}[:*local_port_nbr*]

DESCRIPTION

dccplsi is a background ‘‘daemon’’ task that receives DCCP datagrams via a DCCP socket bound to *local_hostname* and *local_port_nbr*, extracts LTP segments from those datagrams, and passes them to the local LTP engine. Host name ‘‘@’’ signifies that the host name returned by **hostname** (1) is to be used as the socket's host name. If not specified, port number defaults to 1113.

The link service input task is spawned automatically by **ltpadmin** in response to the 's' command that starts operation of the LTP protocol; the text of the command that is used to spawn the task must be provided as a parameter to the 's' command. The link service input task is terminated by **ltpadmin** in response to an 'x' (STOP) command.

EXIT STATUS

‘‘0’’

dccplsi terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **ltpadmin** to restart **dccplsi**.

‘‘1’’

dccplsi terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **ltpadmin** to restart **dccplsi**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

dccplsi can't initialize LTP.

ltpadmin has not yet initialized LTP protocol operations.

LSI task is already started.

Redundant initiation of **dccplsi**.

LSI can't open DCCP socket. This probably means DCCP is not supported on your system.

Operating system error. This probably means that you are not using an operating system that supports DCCP. Make sure that you are using a current Linux kernel and that the DCCP modules are being compiled. Check errtext, correct problem, and restart **dccplsi**.

LSI can't initialize socket.

Operating system error. Check errtext, correct problem, and restart **dccplsi**.

LSI can't create listener thread.

Operating system error. Check errtext, correct problem, and restart **dccplsi**.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ltpadmin (1), **dccplso** (1), **owltsim** (1)

NAME

dccplso – DCCP–based LTP link service output task

SYNOPSIS

dccplso {*remote_engine_hostname* | @}[:*remote_port_nbr*] *remote_engine_nbr*

DESCRIPTION

dccplso is a background ‘‘daemon’’ task that extracts LTP segments from the queue of segments bound for the indicated remote LTP engine, encapsulates them in DCCP datagrams, and sends those datagrams to the indicated DCCP port on the indicated host. If not specified, port number defaults to 1113.

Each ‘‘span’’ of LTP data interchange between the local LTP engine and a neighboring LTP engine requires its own link service output task, such as **dccplso**. All link service output tasks are spawned automatically by **ltpadmin** in response to the ’s’ command that starts operation of the LTP protocol, and they are all terminated by **ltpadmin** in response to an ’x’ (STOP) command.

EXIT STATUS

‘‘0’’

dccplso terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **ltpadmin** to restart **dccplso**.

‘‘1’’

dccplso terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **ltpadmin** to restart **dccplso**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

dccplso can’t initialize LTP.
ltpadmin has not yet initialized LTP protocol operations.

No such engine in database.
remote_engine_nbr is invalid, or the applicable span has not yet been added to the LTP database by **ltpadmin**.

LSO task is already started for this engine.
Redundant initiation of **dccplso**.

LSO can’t create idle thread.
Operating system error. Check errtext, correct problem, and restart **dccplso**.

LSO can’t open DCCP socket. This probably means DCCP is not supported on your system.
Operating system error. This probably means that you are not using an operating system that supports DCCP. Make sure that you are using a current Linux kernel and that the DCCP modules are being compiled. Check errtext, correct problem, and restart **dccplso**.

LSO can’t connect DCCP socket.
Remote host’s **dccplsi** isn’t listening or has terminated. Restart **dccplsi** on the remote host and then restart **dccplso**.

Segment is too big for DCCP LSO.
Configuration error: segments that are too large for DCCP transmission (i.e., larger than 65535 bytes) are being enqueued for **dccplso**. Use **ltpadmin** to change maximum segment size for this span.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

ltpadmin (1), **ltpmeter** (1), **dccplsi** (1), **owltsim** (1)

NAME

ltpadmin – ION Licklider Transmission Protocol (LTP) administration interface

SYNOPSIS

ltpadmin [*commands_filename* | . | !]

DESCRIPTION

ltpadmin configures, starts, manages, and stops LTP operations for the local ION node.

It operates in response to LTP configuration commands found in the file *commands_filename*, if provided; if not, **ltpadmin** prints a simple prompt (:) so that the user may type commands directly into standard input. If *commands_filename* is a period (.), the effect is the same as if a command file containing the single command 'x' were passed to **ltpadmin** — that is, the ION node's *ltpclock* task, *ltpmeter* tasks, and link service adapter tasks are stopped. If *commands_filename* is an exclamation point (!), that effect is reversed: the ION node's *ltpclock* task, *ltpmeter* tasks, and link service adapter tasks are restarted.

The format of commands for *commands_filename* can be queried from **ltpadmin** with the 'h' or '?' commands at the prompt. The commands are documented in **ltprc** (5).

EXIT STATUS

"0" Successful completion of LTP administration.

EXAMPLES

ltpadmin
: Enter interactive LTP configuration command entry mode.

ltpadmin host1.ltp
: Execute all configuration commands in *host1.ltp*, then terminate immediately.

ltpadmin .
: Stop all LTP operations on the local node.

FILES

See **ltprc** (5) for details of the LTP configuration commands.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the ltprc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **ltpadmin**. Otherwise **ltpadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the logfile ion.log:

ltpadmin can't attach to ION.
: There is no SDR data store for *ltpadmin* to use. You should run **ionadmin** (1) first, to set up an SDR data store for ION.

Can't open command file...
: The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **ltpadmin** to fail but are noted in the **ion.log** log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename* file. Please see **ltprc** (5) for details.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

ltpmeter (1), **ltprc** (5)

NAME

ltpclock – LTP daemon task for managing scheduled events

SYNOPSIS

ltpclock

DESCRIPTION

ltpclock is a background ‘‘daemon’’ task that periodically performs scheduled LTP activities. It is spawned automatically by **ltpadmin** in response to the ’s’ command that starts operation of the LTP protocol, and it is terminated by **ltpadmin** in response to an ’x’ (STOP) command.

Once per second, **ltpclock** takes the following action:

First it manages the current state of all links (‘‘spans’’). In particular, it checks the age of the currently buffered session block for each span and, if that age exceeds the span’s configured aggregation time limit, gives the ‘‘buffer full’’ semaphore for that span to initiate block segmentation and transmission by **ltpmeter**.

In so doing, it also infers link state changes (‘‘link cues’’) from data rate changes as noted in the RFX database by **rfxclock**:

If the rate of transmission to a neighbor was zero but is now non-zero, then transmission to that neighbor is unblocked. The applicable ‘‘buffer empty’’ semaphore is given if no outbound block is being constructed (enabling start of a new transmission session) and the ‘‘segments ready’’ semaphore is given if the outbound segment queue is non-empty (enabling transmission of segments by the link service output task).

If the rate of transmission to a neighbor was non-zero but is now zero, then transmission to that neighbor is blocked — i.e., the semaphores triggering transmission will no longer be given.

If the imputed rate of transmission from a neighbor was non-zero but is now zero, then all timers affecting segment retransmission to that neighbor are suspended. This has the effect of extending the interval of each affected timer by the length of time that the timers remain suspended.

If the imputed rate of transmission from a neighbor was zero but is now non-zero, then all timers affecting segment retransmission to that neighbor are resumed.

Then **ltpclock** retransmits all unacknowledged checkpoint segments, report segments, and cancellation segments whose computed timeout intervals have expired.

EXIT STATUS

‘‘0’’

ltpclock terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **ltpadmin** to restart **ltpclock**.

‘‘1’’

ltpclock was unable to attach to LTP protocol operations, probably because **ltpadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

ltpclock can’t initialize LTP.

ltpadmin has not yet initialized LTP protocol operations.

Can’t dispatch events.

An unrecoverable database error was encountered. **ltpclock** terminates.

Can't manage links.

An unrecoverable database error was encountered. **ltpclock** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ltpadmin (1), **ltpmeter** (1), **rfxclock** (1)

NAME

ltpcounter – LTP reception test program

SYNOPSIS

ltpcounter *client_ID* [*max_nbr_of_bytes*]

DESCRIPTION

ltpcounter uses LTP to receive service data units flagged with client service number *client_ID* from a remote **ltpdriver** client service process. When the total number of bytes of client service data it has received exceeds *max_nbr_of_bytes*, it terminates and prints reception and cancellation statistics. If *max_nbr_of_bytes* is omitted, the default limit is 2 billion bytes.

While receiving data, **ltpcounter** prints a 'v' character every 5 seconds to indicate that it is still alive.

EXIT STATUS

"0"

ltpcounter has terminated. Any problems encountered during operation will be noted in the **ion.log** log file.

"1"

ltpcounter was unable to start, because it could not attach to the LTP protocol on the local node or could not open access to client service *clientId*.

In the former case, run **ltpadmin** to start LTP and try again.

In the latter case, some other client service task has already opened access to client service *clientId*. If no such task is currently running (e.g., it crashed while holding the client service open), use **ltpadmin** to stop and restart the LTP protocol.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **ltpcounter** are written to the ION log file *ion.log*.

ltpcounter can't initialize LTP.

ltpadmin has not yet initialized LTP protocol operations.

ltpcounter can't open client access.

Another task has opened access to service client *clientId* and has not yet relinquished it.

Can't get LTP notice.

LTP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ltpadmin (1), **ltpdriver** (1), **ltp** (3)

NAME

ltpdriver – LTP transmission test program

SYNOPSIS

ltpdriver *remoteEngineNbr clientId nbrOfCycles greenLength* [*totalLength*]

DESCRIPTION

ltpdriver uses LTP to send *nbrOfCycles* service data units of length indicated by *totalLength*, of which the trailing *greenLength* bytes are sent unreliably, to the **ltpcounter** client service process for client service number *clientId* attached to the remote LTP engine identified by *remoteEngineNbr*. If omitted, *length* defaults to 60000. If *length* is 1, the sizes of the transmitted service data units will be randomly selected multiples of 1024 in the range 1024 to 62464.

Whenever the size of the transmitted service data unit is less than or equal to *greenLength*, the entire SDU is sent unreliably.

When all copies of the file have been sent, **ltpdriver** prints a performance report.

EXIT STATUS

"0"

ltpdriver has terminated. Any problems encountered during operation will be noted in the **ion.log** log file.

"1"

ltpdriver was unable to start, because it could not attach to the LTP protocol on the local node. Run **ltpadmin** to start LTP, then try again.

FILES

The service data units transmitted by **ltpdriver** are sequences of text obtained from a file in the current working directory named ''ltpdriverAduFile'', which **ltpdriver** creates automatically.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Diagnostic messages produced by **ltpdriver** are written to the ION log file *ion.log*.

ltpdriver can't initialize LTP.

ltpadmin has not yet initialized LTP protocol operations.

Can't create ADU file

Operating system error. Check errtext, correct problem, and rerun.

Error writing to ADU file

Operating system error. Check errtext, correct problem, and rerun.

ltpdriver can't create file ref.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

ltpdriver can't create ZCO.

ION system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

ltpdriver can't send message.

LTP span to the remote engine has been stopped.

ltp_send failed.

LTP system error. Check for earlier diagnostic messages describing the cause of the error; correct problem and rerun.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ltpadmin (1), **ltpcounter** (1), **ltp** (3)

NAME

ltpmeter – LTP daemon task for aggregating and segmenting transmission blocks

SYNOPSIS

ltpmeter *remote_engine_nbr*

DESCRIPTION

ltpmeter is a background ‘‘daemon’’ task that manages the presentation of LTP segments to link service output tasks. Each ‘‘span’’ of LTP data interchange between the local LTP engine and a neighboring LTP engine requires its own **ltpmeter** task. All **ltpmeter** tasks are spawned automatically by **ltpadmin** in response to the ’s’ command that starts operation of the LTP protocol, and they are all terminated by **ltpadmin** in response to an ’x’ (STOP) command.

ltpmeter waits until its span’s current transmission block (the data to be transmitted during the transmission session that is currently being constructed) is ready for transmission, then divides the data in the span’s block buffer into segments and enqueues the segments for transmission by the span’s link service output task (giving the segments semaphore to unblock the link service output task as necessary), then reinitializes the span’s block buffer and starts another session (giving the ‘‘buffer empty’’ semaphore to unblock the client service task — nominally **ltpclo**, the LTP convergence layer output task for Bundle Protocol — as necessary).

ltpmeter determines that the current transmission block is ready for transmission by waiting until either (a) the aggregate size of all service data units in the block’s buffer exceeds the aggregation size limit for this span or (b) the length of time that the first service data unit in the block’s buffer has been awaiting transmission exceeds the aggregation time limit for this span. The ‘‘buffer full’’ semaphore is given when ION (either the **ltp_send()** function or the **ltpclock** daemon) determines that one of these conditions is true; **ltpmeter** simply waits for this semaphore to be given.

The initiation of a new session may also be blocked: the total number of transmission sessions that the local LTP engine may have open at a single time is limited (this is LTP flow control), and while the engine is at this limit no new sessions can be started. Availability of a session from the session pool is signaled by the ‘‘session’’ semaphore, which is given whenever a session is completed or canceled.

EXIT STATUS

‘‘0’’

ltpmeter terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **ltpadmin** to restart **ltpmeter**.

‘‘1’’

ltpmeter terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **ltpadmin** to restart **ltpmeter**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

ltpmeter can’t initialize LTP.

ltpadmin has not yet initialized LTP protocol operations.

No such engine in database.

remote_engine_nbr is invalid, or the applicable span has not yet been added to the LTP database by **ltpadmin**.

ltpmeter task is already started for this engine.

Redundant initiation of **ltpmeter**.

ltpmeter can't start new session.
An unrecoverable database error was encountered. **ltpmeter** terminates.

Can't take bufClosedSemaphore.
An unrecoverable database error was encountered. **ltpmeter** terminates.

Can't create extents list.
An unrecoverable database error was encountered. **ltpmeter** terminates.

Can't post ExportSessionStart notice.
An unrecoverable database error was encountered. **ltpmeter** terminates.

Can't finish session.
An unrecoverable database error was encountered. **ltpmeter** terminates.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ltpadmin (1), **ltpclock** (1)

NAME

ltpsecadmin – LTP security policy administration interface

SYNOPSIS

ltpsecadmin [*commands_filename*]

DESCRIPTION

ltpsecadmin configures and manages LTP security policy on the local computer.

It configures and manages LTP security policy on the local computer in response to LTP configuration commands found in *commands_filename*, if provided; if not, **ltpsecadmin** prints a simple prompt (:) so that the user may type commands directly into standard input.

The format of commands for *commands_filename* can be queried from **ltpsecadmin** by entering the command 'h' or '?' at the prompt. The commands are documented in **ltpsecrc** (5).

EXIT STATUS

"0"

Successful completion of LTP security policy administration.

EXAMPLES

ltpsecadmin

Enter interactive LTP security policy administration command entry mode.

ltpsecadmin host1.ltpsecrc

Execute all configuration commands in *host1.ltpsecrc*, then terminate immediately.

FILES

Status and diagnostic messages from **ltpsecadmin** and from other software that utilizes the ION node are nominally written to a log file in the current working directory within which **ltpsecadmin** was run. The log file is typically named **ion.log**.

See also **ltpsecrc** (5).

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the ionrc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **ltpsecadmin**. Otherwise **ltpsecadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the log file:

Can't open command file...

The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **ltpsecadmin** to fail but are noted in the log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename*. Please see **ltpsecrc** (5) for details.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

ltpsecrc (5)

NAME

udplsi − UDP−based LTP link service input task

SYNOPSIS

udplsi {*local_hostname* | @}[:*local_port_nbr*]

DESCRIPTION

udplsi is a background ‘‘daemon’’ task that receives UDP datagrams via a UDP socket bound to *local_hostname* and *local_port_nbr*, extracts LTP segments from those datagrams, and passes them to the local LTP engine. Host name ‘‘@’’ signifies that the host name returned by **hostname** (1) is to be used as the socket's host name. If not specified, port number defaults to 1113.

The link service input task is spawned automatically by **ltpadmin** in response to the 's' command that starts operation of the LTP protocol; the text of the command that is used to spawn the task must be provided as a parameter to the 's' command. The link service input task is terminated by **ltpadmin** in response to an 'x' (STOP) command.

EXIT STATUS

‘‘0’’

udplsi terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **ltpadmin** to restart **udplsi**.

‘‘1’’

udplsi terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **ltpadmin** to restart **udplsi**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

udplsi can't initialize LTP.

ltpadmin has not yet initialized LTP protocol operations.

LSI task is already started.

Redundant initiation of **udplsi**.

LSI can't open UDP socket

Operating system error. Check errtext, correct problem, and restart **udplsi**.

LSI can't initialize socket

Operating system error. Check errtext, correct problem, and restart **udplsi**.

LSI can't create receiver thread

Operating system error. Check errtext, correct problem, and restart **udplsi**.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ltpadmin (1), **udplso** (1), **owltsim** (1)

NAME

udplso − UDP−based LTP link service output task

SYNOPSIS

udplso {*remote_engine_hostname* | @}[:*remote_port_nbr*] *remote_engine_nbr*

DESCRIPTION

udplso is a background ‘‘daemon’’ task that extracts LTP segments from the queue of segments bound for the indicated remote LTP engine, encapsulates them in UDP datagrams, and sends those datagrams to the indicated UDP port on the indicated host. If not specified, port number defaults to 1113.

Each ‘‘span’’ of LTP data interchange between the local LTP engine and a neighboring LTP engine requires its own link service output task, such as **udplso**. All link service output tasks are spawned automatically by **ltpadmin** in response to the ’s’ command that starts operation of the LTP protocol, and they are all terminated by **ltpadmin** in response to an ’x’ (STOP) command.

EXIT STATUS

‘‘0’’

udplso terminated normally, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **ltpadmin** to restart **udplso**.

‘‘1’’

udplso terminated abnormally, for reasons noted in the **ion.log** file. Investigate and solve the problem identified in the log file, then use **ltpadmin** to restart **udplso**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

udplso can’t initialize LTP.
ltpadmin has not yet initialized LTP protocol operations.

No such engine in database.
remote_engine_nbr is invalid, or the applicable span has not yet been added to the LTP database by **ltpadmin**.

LSO task is already started for this engine.
Redundant initiation of **udplso**.

LSO can’t open UDP socket
Operating system error. Check errtext, correct problem, and restart **udplso**.

LSO can’t connect UDP socket
Operating system error. Check errtext, correct problem, and restart **udplso**.

Segment is too big for UDP LSO.
Configuration error: segments that are too large for UDP transmission (i.e., larger than 65535 bytes) are being enqueued for **udplso**. Use **ltpadmin** to change maximum segment size for this span.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

ltpadmin (1), **ltpmeter** (1), **udplsi** (1), **owltsim** (1)

NAME

nm_agent – Network Management Agent implementing the Asynchronous Management Protocol (AMP)

SYNOPSIS

nm_agent <agent eid> *manager eid*

DESCRIPTION

Starts the network management agent listening on *agent eid* and communicating with a remote manager at *manager eid*

SEE ALSO

Asynchronous Management Protocol <https://datatracker.ietf.org/doc/draft-birrane-dtn-amp/>

nm_mgr (1)

NAME

nm_mgr – Network Management server implementing the Asynchronous Management Protocol (AMP)

SYNOPSIS

nm_mgr [*options*] *manager eid*

The following options may be specified to customize behavior. Use ''nm_mgr --help'' for full usage information:

-A Startup directly in the alternative Automator UI mode. This mode is designed to provide a consistent line-based interface suitable for automated scripting. Type ? when active for usage details.

-l If specified, enable file-based logging of Manager Activity on startup. This can be toggled at any time from the main menu of the UI.

If logging is not enabled, the following arguments have no affect until enabled in UI.

-d Log each agent to a different directory.

-L #
Specify maximum number of entries (reports+tables) per file before rotating.

-D DIR
NM logs will be placed in this directory.

-r Log all received reports to file in text format (as shown in UI).

-t Log all received tables to file in text format (as shown in UI).

-T Log all transmitted message as ASCII-encoded CBOR HEX strings.

-R Log all received messages as ASCII-encoded CBOR HEX strings.

DESCRIPTION

Starts the **nm_mgr** application listening on *mgr eid* for messages from **nm_agent** clients. Specify ''--help'' for full usage information.

An agent will automatically attempt to register with it's configured manager on startup. Agents may also be added manually through the managers UI.

The manager provides a text based UI as its primary interface. The UI provides capabilities to list, register, or delete agents. It can view received reports and tables, and be used to send commands (ARIs) to registered agents.

An experimental REST API is available if built with the configuration option ''--enable-rest''. The default configuration will be accessible at http://localhost:8089/nm/api.

SEE ALSO

Asynchronous Management Protocol <https://datatracker.ietf.org/doc/draft-birrane-dtn-amp/>

nm_agent (1)

NAME

dtka − Delay−Tolerant Key Administration (DTKA) daemon

SYNOPSIS

dtka

dtka is a delay-tolerant public key infrastructure (PKI) system, built on the Trusted Collective (TC) application framework. Each DTKA daemon generates public/private key pairs and uses the TC framework to distribute public keys securely and to receive the public keys generated and distributed by other DTKA daemons. For an overview of TC, see the **tc** (3) manual page.

DESCRIPTION

The DTKA system provides a trustworthy mechanism for delay-tolerant distribution of public keys, enabling ION's BP and LTP implementations to utilize asymmetric cryptography to ensure the integrity and/or confidentiality of data exchange as necessary. (Discussion of asymmetric cryptography is beyond the scope of this manual page.)

A central principle of DTKA is that keys have **effective times** which condition their applicability. For example, the public key that must be used to encrypt a bundle payload destined for a given node is the public key (asserted by that node) whose associated effective time is greatest among all of that node's public keys whose associated effective times are less than or equal to the creation time of the bundle. Effective times enable keys to be distributed far in advance of the times at which they will be used, which is what makes DTKA delay-tolerant: when the time arrives at which a node needs a given key, the key is already in place.

The **dtka** daemon is responsible for periodically generating, on behalf of a given DTN node, public/private key pairs that will be effective at times in the future.

The first public key generated by a given DTN node's **dtka** daemon is distributed by means of an application-specific DTKA initialization procedure. The procedure may be an out-of-band mechanism by which the initializing node's public key is generated and submitted to the DTKA **authority** while the user node is under the physical control of the DTKA authority's administrator. Alternatively, the initializing node's public key may be submitted to the DTKA authority by some other DTN node whose **dtka** daemon is known to the DTKA authority and is trusted, in which case that node utilizes the TC framework on behalf of the initializing node.

Each subsequently generated public key is signed in the node's applicable private key and is submitted directly to the DTKA authority by means of the TC framework.

Public key revocations, generated by the DTKA authority's administrator, are submitted in the same way as assertions of new public keys.

NOTE that dtka utilizes functions provided by cryptography software that is not distributed with ION. To indicate that this supporting software has been installed, set the compiler flag −DCRYPTO_SOFTWARE_INSTALLED when compiling this program. Absent that flag setting at compile time, the dtka daemon's **generateKeyPair()** function does nothing.

EXIT STATUS

"0"

dtka terminated, for reasons noted in the **ion.log** file.

"1"

dtka was unable to attach to TC client functionality, possibly because **tcc** is not running.

FILES

The **dtkaadmin** utility is used to configure the operation of the dtka daemon; see the **dtkarc** (5) man page for details.

ENVIRONMENT

No environment variables apply.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

dtkaadmin (1), **dtkarc** (5), **tc** (3), **tcc** (1), **tccadmin** (1), **tccrc** (5)

NAME

dtkaadmin – DTKA user function administration interface

SYNOPSIS

dtkaadmin [*commands_filename*]

DESCRIPTION

dtkaadmin configures and manages the DTKA administration database for the local ION node, enabling the node to utilize the services of the Trusted Collective for Delay-Tolerant Key Administration.

It configures and manages that database in response to DTKA configuration commands found in *commands_filename*, if provided; if not, **dtkaadmin** prints a simple prompt (:) so that the user may type commands directly into standard input.

The format of commands for *commands_filename* can be queried from **dtkaadmin** by entering the command 'h' or '?' at the prompt. The commands are documented in **dtkarc** (5).

EXIT STATUS

"0"

Successful completion of DTKA configuration.

EXAMPLES

dtkaadmin

Enter interactive DTKA configuration command entry mode.

dtkaadmin host1.karc

Execute all configuration commands in *host1.karc*, then terminate immediately.

FILES

Status and diagnostic messages from **dtkaadmin** and from other software that utilizes the ION node are nominally written to a log file in the current working directory within which **dtkaadmin** was run. The log file is typically named **ion.log**.

See also **dtkarc** (5).

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the dtkarc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **dtkaadmin**. Otherwise **dtkaadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the log file:

Can't open command file...

The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **dtkaadmin** to fail but are noted in the log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename*. Please see **dtkarc** (5) for details.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

dtka (1), **dtkarc** (5)

NAME

tcaadmin − Trusted Collective (TC) authority administration interface

SYNOPSIS

tcaadmin *blocks_group_number* [*commands_filename*]

DESCRIPTION

tcaadmin configures and manages the Trusted Collective authority databases for TC applications on the local ION node, enabling the node to function as a member of one or more collective authorities.

The first command-line argument to **tcaadmin** is *blocksGroupNumber*, which identifies the specific TC application to which all commands submitted to this instance of **tcaadmin** will apply. A TC application is uniquely identified by the group number of the Bundle Protocol multicast group comprising all nodes hosting TC clients that subscribe to TC ''blocks'' published for that application.

tcaadmin configures and manages a TC authority database in response to authority configuration commands found in *commands_filename*, if provided; if not, **tcaadmin** prints a simple prompt (:) so that the user may type commands directly into standard input.

The format of commands for *commands_filename* can be queried from **tcaadmin** by entering the command 'h' or '?' at the prompt. The commands are documented in **tcarc** (5).

EXIT STATUS

''0''

Successful completion of TC authority administration.

EXAMPLES

tcaadmin 203

Enter interactive TC authority administration command entry mode for application 203.

tcaadmin 203 host1.tcarc

Apply the application−203 configuration commands in *host1.tcarc*, then terminate immediately.

FILES

Status and diagnostic messages from **tcaadmin** and from other software that utilizes the ION node are nominally written to a log file in the current working directory within which **tcaadmin** was run. The log file is typically named **ion.log**.

See also **tcarc** (5).

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the tcarc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **tcaadmin**. Otherwise **tcaadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the log file:

Can't open command file...

The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **tcaadmin** to fail but are noted in the log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename*. Please see **tcarc** (5) for details.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

tcacompile (1), **tcapublish** (1), **tcarecv** (1), **tcarc** (5)

NAME

tcaboot − Trusted Collective (TC) authority initialization utility

SYNOPSIS

tcaboot *multicast_group_number_for_TC_bulletins multicast_group_number_for_TC_records number_of_authorities_in_collective K R* [*delay*]

DESCRIPTION

tcaboot writes a TC authority administration command file that initializes a TC authority database. The file, named ‘‘boot.tcarc’’, is written to the current working directory. It simply contains two authority configuration commands that initialize the TC authority database for the TC application and then set the initial bulletin compilation time for this authority to the current ctime plus *delay* seconds. If omitted, *delay* defaults to 5. The other command-line arguments for **tcaboot** are discussed in the descriptions of application initialization commands for **tcaadmin**; see the **tcarc** (5) manual page for details.

EXIT STATUS

‘‘0’’

Successful generation of TC authority initialization file.

EXAMPLES

tcaboot 210 209 6 50 .2

Writes a boot.tcarc file that initializes the local node’s TC authority database as indicated and sets the next bulletin compilation time to the current time plus 5 seconds.

tcaboot 210 209 6 50 .2 90

Writes a boot.tcarc file that initializes the local node’s TC authority database as indicated and sets the next bulletin compilation time to the current time plus 90 seconds.

FILES

No files apply.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the log file:

Can’t open cmd file

tcaboot is unable to create a file named boot.tcarc for the indicated reason, a system error.

Can’t write to cmd file

tcaboot is unable to write to boot.tcarc for the indicated reason, a system error.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

tcaadmin (1), **tcarc** (5)

NAME

tcacompile − Trusted Collective daemon task for compiling critical information bulletins

SYNOPSIS

tcacompile *blocks_group_number*

DESCRIPTION

tcacompile is a background ‘‘daemon’’ task that periodically generates new proposed bulletins of recent critical information records and multicasts those bulletins to all nodes in the collective authority for the TC application identified by *blocks_group_number*. It is spawned automatically by **tcaadmin** in response to the ’s’ command that starts operation of the TC authority function for this application on the local node, and it is terminated by **tcaadmin** in response to an ’x’ (STOP) command.

EXIT STATUS

“0”

tcacompile terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **tcaadmin** to restart **tcacompile**.

“1”

tcacompile was unable to attach to TC authority operations, probably because **tcaadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

tcacompile can’t attach to tca system.

tcaadmin has not yet initialized the authority database for this TC application.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

tcaadmin (1), **tc** (3), **tcarc** (5)

NAME

tcapublish − Trusted Collective authority task that publishes consensus critical information bulletins

SYNOPSIS

tcapublish *blocks_group_number*

DESCRIPTION

tcapublish is a background task that completes the processing of a single iteration of the bulletin publication cycle for the collective authority function of the TC application identified by *blocks_group_number* on the local node. To do so, it receives proposed bulletins multicast by **tcacompile** daemons, resolves differences among the received bulletins to arrive at a consensus bulletin, computes a hash for the consensus bulletin, erasure-codes the consensus bulletin, and multicasts that subset of the resulting code blocks that is allocated to the local node according to the local node's assigned position in the authority array of the application's collective authority. It is spawned automatically by the local node's **tcacompile** daemon for the indicated application, at the time that daemon publishes its own proposed bulletin for this iteration of the bulletin compilation cycle; it terminates immediately after it has finished publishing code blocks.

EXIT STATUS

"0"

tcapublish terminated, for reasons noted in the **ion.log** file.

"1"

tcapublish was unable to attach to TC authority operations, probably because **tcaadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

tcapublish can't attach to DTKA.

tcaadmin has not yet initialized the authority database for this TC application.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

tcaadmin (1), **tc** (3), **tcauthrc** (5)

NAME

tcarecv – Trusted Collective daemon task for receiving newly generated records of critical information

SYNOPSIS

tcarecv *blocks_group_number*

DESCRIPTION

tcarecv is a background "daemon" task that receives new critical information records multicast by user nodes of the TC application identified by *blocks_group_number*. It records those assertions in a database for future processing by **tcacompile**. It is spawned automatically by **tcaadmin** in response to the 's' command that starts operation of the TC authority function for this application on the local node, and it is terminated by **tcaadmin** in response to an 'x' (STOP) command.

EXIT STATUS

"0"

tcarecv terminated, for reasons noted in the **ion.log** file. If this termination was not commanded, investigate and solve the problem identified in the log file and use **tcaadmin** to restart **tcarecv**.

"1"

tcarecv was unable to attach to DTKA operations, probably because **tcaadmin** has not yet been run.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

tcarecv can't attach to DTKA.

tcaadmin has not yet initialized the authority database for this TC application.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

tcaadmin (1), **tc** (3), **tcarc** (5)

NAME

tcc − Trusted Collective client daemon task for handling bulletins from a collective authority

SYNOPSIS

tcc *blocks_group_number*

DESCRIPTION

tcc is a background ‘‘daemon’’ task that receives code blocks multicast by the authority nodes of the collective authority for the TC application identified by *blocks_group_number*. It reassembles bulletins from compatible code blocks and delivers those bulletins to the application’s user function on the local node.

EXIT STATUS

“0”

tcc terminated, for reasons noted in the **ion.log** file.

“1”

tcc was unable to attach to TC client operations, possibly because the TC client database for this application has not yet been initialized by **tcaadmin**.

FILES

No configuration files are needed.

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

The following diagnostics may be issued to the **ion.log** log file:

tcc can’t attach to tcc system.

tcaadmin has not yet initialized the TC client database for this application.

BUGS

Report bugs to <ion−dtn−support@lists.sourceforge.net>

SEE ALSO

tcaadmin (1), **tcarc** (5)

NAME

tccadmin – DTKA node administration interface

SYNOPSIS

tccadmin *blocks_group_number* [*commands_filename*]

DESCRIPTION

tccadmin configures and manages the Trusted Collecive client databases for TC applications on the local ION node, enabling the node to utilize the services of one or more collective authorities.

The first command-line argument to **tccadmin** is *blocksGroupNumber*, which identifies the specific TC application to which all commands submitted to this instance of **tccadmin** will apply. A TC application is uniquely identified by the group number of the Bundle Protocol multicast group comprising all nodes hosting TC clients that subscribe to TC ''blocks'' published for that application.

tccadmin configures and manages a TC client database in response to client configuration commands found in *commands_filename*, if provided; if not, **tccadmin** prints a simple prompt (:) so that the user may type commands directly into standard input.

The format of commands for *commands_filename* can be queried from **tccadmin** by entering the command 'h' or '?' at the prompt. The commands are documented in **tccrc** (5).

EXIT STATUS

''0''

Successful completion of TC client administration.

EXAMPLES

tccadmin

Enter interactive TC client administration command entry mode.

tccadmin host1.karc

Execute all configuration commands in *host1.karc*, then terminate immediately.

FILES

Status and diagnostic messages from **tccadmin** and from other software that utilizes the ION node are nominally written to a log file in the current working directory within which **tccadmin** was run. The log file is typically named **ion.log**.

See also **tccrc** (5).

ENVIRONMENT

No environment variables apply.

DIAGNOSTICS

Note: all ION administration utilities expect source file input to be lines of ASCII text that are NL-delimited. If you edit the tccrc file on a Windows machine, be sure to **use dos2unix to convert it to Unix text format** before presenting it to **tccadmin**. Otherwise **tccadmin** will detect syntax errors and will not function satisfactorily.

The following diagnostics may be issued to the log file:

Can't open command file...

The *commands_filename* specified in the command line doesn't exist.

Various errors that don't cause **tccadmin** to fail but are noted in the log file may be caused by improperly formatted commands given at the prompt or in the *commands_filename*. Please see **tccrc** (5) for details.

BUGS

Report bugs to <ion–dtn–support@lists.sourceforge.net>

SEE ALSO

tcc (1), **tccrc** (5)

NAME

ams – CCSDS Asynchronous Message Service(AMS) communications library

SYNOPSIS

```
#include "ams.h"

typedef void                (*AmsMsgHandler)(AmsModule module,
                                void *userData,
                                AmsEvent *eventRef,
                                int continuumNbr,
                                int unitNbr,
                                int moduleNbr,
                                int subjectNbr,
                                int contentLength,
                                char *content,
                                int context,
                                AmsMsgType msgType,
                                int priority,
                                unsigned char flowLabel);

typedef void                (*AmsRegistrationHandler)(AmsModule module,
                                void *userData,
                                AmsEvent *eventRef,
                                int unitNbr,
                                int moduleNbr,
                                int roleNbr);

typedef void                (*AmsUnregistrationHandler)(AmsModule module,
                                void *userData,
                                AmsEvent *eventRef,
                                int unitNbr,
                                int moduleNbr);

typedef void                (*AmsInvitationHandler)(AmsModule module,
                                void *userData,
                                AmsEvent *eventRef,
                                int unitNbr,
                                int moduleNbr,
                                int domainRoleNbr,
                                int domainContinuumNbr,
                                int domainUnitNbr,
                                int subjectNbr,
                                int priority,
                                unsigned char flowLabel,
                                AmsSequence sequence,
                                AmsDiligence diligence);

typedef void                (*AmsDisinvitationHandler)(AmsModule module,
                                void *userData,
                                AmsEvent *eventRef,
                                int unitNbr,
                                int moduleNbr,
                                int domainRoleNbr,
                                int domainContinuumNbr,
                                int domainUnitNbr,
```

```
                                        int subjectNbr);

        typedef void                (*AmsSubscriptionHandler)(AmsModule module,
                                        void *userData,
                                        AmsEvent *eventRef,
                                        int unitNbr,
                                        int moduleNbr,
                                        int domainRoleNbr,
                                        int domainContinuumNbr,
                                        int domainUnitNbr,
                                        int subjectNbr,
                                        int priority,
                                        unsigned char flowLabel,
                                        AmsSequence sequence,
                                        AmsDiligence diligence);

        typedef void                (*AmsUnsubscriptionHandler)(AmsModule module,
                                        void *userData,
                                        AmsEvent *eventRef,
                                        int unitNbr,
                                        int moduleNbr,
                                        int domainRoleNbr,
                                        int domainContinuumNbr,
                                        int domainUnitNbr,
                                        int subjectNbr);

        typedef void                (*AmsUserEventHandler)(AmsModule module,
                                        void *userData,
                                        AmsEvent *eventRef,
                                        int code,
                                        int dataLength,
                                        char *data);

        typedef void                (*AmsMgtErrHandler)(void *userData,
                                        AmsEvent *eventRef);

        typedef struct
        {
            AmsMsgHandler                   msgHandler;
            void                            *msgHandlerUserData;
            AmsRegistrationHandler          registrationHandler;
            void                            *registrationHandlerUserData;
            AmsUnregistrationHandler        unregistrationHandler;
            void                            *unregistrationHandlerUserData;
            AmsInvitationHandler            invitationHandler;
            void                            *invitationHandlerUserData;
            AmsDisinvitationHandler         disinvitationHandler;
            void                            *disinvitationHandlerUserData;
            AmsSubscriptionHandler          subscriptionHandler;
            void                            *subscriptionHandlerUserData;
            AmsUnsubscriptionHandler        unsubscriptionHandler;
            void                            *unsubscriptionHandlerUserData;
            AmsUserEventHandler             userEventHandler;
            void                            *userEventHandlerUserData;
```

```
    AmsMgtErrHandler                errHandler;
    void                            *errHandlerUserData;
} AmsEventMgt;

typedef enum
{
    AmsArrivalOrder = 0,
    AmsTransmissionOrder
} AmsSequence;

typedef enum
{
    AmsBestEffort = 0,
    AmsAssured
} AmsDiligence;

typedef enum
{
    AmsRegistrationState,
    AmsInvitationState,
    AmsSubscriptionState
} AmsStateType;

typedef enum
{
    AmsStateBegins = 1,
    AmsStateEnds
} AmsChangeType;

typedef enum
{
    AmsMsgUnary = 0,
    AmsMsgQuery,
    AmsMsgReply,
    AmsMsgNone
} AmsMsgType;

[see description for available functions]
```

DESCRIPTION

The ams library provides functions enabling application software to use AMS to send and receive brief messages, up to 65000 bytes in length. It conforms to AMS Blue Book, including support for Remote AMS (RAMS).

In the ION implementation of RAMS, the "RAMS network protocol" may be either the DTN Bundle Protocol (RFC 5050) or — mainly for testing purposes — the User Datagram Protocol (RFC 768). BP is the default. When BP is used as the RAMS network protocol, endpoints are by default assumed to conform to the "ipn" endpoint identifier scheme with **node number** set to the AMS **continuum number** and **service number** set to the AMS **venture number**.

Note that RAMS functionality is enabled by instantiating a **ramsgate** daemon, which is simply an AMS application program that acts as a gateway between the local AMS message space and the RAMS network.

AMS differs from other ION packages in that there is no utilization of non-volatile storage (aside from the BP functionality in RAMS, if applicable). Since there is no non-volatile AMS database, there is no AMS administration program and there are no library functions for attaching to or detaching from such a database. AMS is instantiated by commencing operation of the AMS real-time daemon **amsd**; once **amsd** is

running, AMS application programs (''modules'') can be started. All management of AMS operational state is performed automatically in real time.

However, **amsd** and the AMS application programs all require access to a common store of configuration data at startup in order to load their Management Information Bases. This configuration data must reside in a readable file, which may take either of two forms: a file of XML statements conforming to the scheme described in the **amsxml** (5) man page, or a file of simple but less powerful configuration statements as described in the **amsrc** (5) man page. The **amsxml** alternative requires that the **expat** XML parsing system be installed; the **amsrc** alternative was developed to simplify deployment of AMS in environments in which **expat** is not readily supported. Selection of the configuration file format is a compile-time decision, implemented by setting (or not setting) the −DNOEXPAT compiler option.

The path name of the applicable configuration file may be passed as a command-line parameter to **amsd** and as a registration function parameter by any AMS application program. Note, though, that **ramsgate** and the AMS test and utility programs included in ION always assume that the configuration file resides in the current working directory and that it is named ''mib.amsrc'' if AMS was built with −DNOEXPAT, ''amsmib.xml'' otherwise.

The transport services that are made available to AMS communicating entities are declared by the transportServiceLoaders array in the libams.c source file. This array is fixed at compile time. The order of preference of the transport services in the array is hard-coded, but the inclusion or omission of individual transport services is controlled by setting compiler options. The ''udp'' transport service — nominally the most preferred because it imposes the least processing and transmission overhead — is included by setting the −DUDPTS option. The ''dgr'' service is included by setting the −DDGRTS option. The ''vmq'' (VxWorks message queue) service, supported only on VxWorks, is included by setting the −DVMQTS option. The ''tcp'' transport service — selected only when its quality of service is required — is included by setting the −DTCPTS option.

The operating state of any single AMS application program is managed in an opaque AmsModule object. This object is returned when the application begins AMS operations (that is, registers) and must be provided as an argument to most AMS functions.

int ams_register(char *mibSource, char *tsorder, char *applicationName, char *authorityName, char *unitName, char *roleName, AmsModule *module)

Registers the application within a cell (identified by *unitName*) of a message space that is that portion of the venture identified by *applicationName* and *authorityName* that runs within the local AMS continuum. *roleName* identifies the role that this application will perform in this venture. The operating state of the registered application is returned in *module*.

The application module's identifying parameters are validated against the configuration information in the applicable Management Information Base, which is automatically loaded from the file whose pathname is provided in *mibSource*. If *mibSource* is the zero-length string ("") then the default configuration file name is used as noted above. If *mibSource* is NULL then a rudimentary hard-coded default MIB, useful for basic testing purposes, is loaded. This default MIB defines a single venture for application ''amsdemo'' and authority ''test'', using only the ''dgr'' transport service, with the configuration server residing on the local host machine; subject ''text'' and roles ''shell'', ''log'', ''pitch'', and ''catch'' are defined.

The *tsorder* argument is normally NULL. If non-NULL it must be a NULL-terminated string of ASCII numeric digits '0' through '9' identifying an alternative transport service preference order that overrides the standard transport service preference order defined by the hard-coded array of transportServiceLoaders in the libams.c source file. Each character of the *tsorder* string must represent the index position of one of the transport services within the array. For example, if services ''udp'', ''dgr'', ''vmq'', and ''tcp'' are all available in the array, a *tsorder* string of ''32'' would indicate that this application will only communicate using the tcp and vmq services; services 0 (udp) and 1 (dgr) will not be used, and tcp is preferred to vmq when both are candidate services for transmission of a given message.

Returns 0 on success. On any error, sets *module* to NULL and returns −1.

int ams_unregister(AmsModule module)

Reverses the operation of **ams_unregister()**, destroying *module*. Returns 0 on success, −1 on any error.

int ams_invite(AmsModule module, int roleNbr, int continuumNbr, int unitNbr, int subjectNbr, int priority, unsigned char flowLabel, AmsSequence sequence, AmsDiligence diligence)

Announces this module's agreement to receive messages on the subject identified by *subjectNbr*.

The invitation is extended only to modules registered in the role identified by *roleNbr* (where 0 indicates ''all roles''), operating in the continuum identifed by *continuumNbr* (where 0 indicates ''all continua''), and registered within the unit identified by *unitNbr* (where 0 indicates the venture's root unit) or any of that unit's subunits. These parameters define the ''domain'' of the invitation.

Such messages should be sent at the priority indicated by *priority* with flow label as indicated by *flowLabel* and with quality of service as indicated by *sequence* and *diligence*. *priority* must be an integer in the range 1−15, where priority 1 indicates the greatest urgency. Flow labels are passed through to transport services and are opaque to AMS itself; in the absence of defined flow labels, a value of 0 is typically used. These parameters define the ''class of service'' of the invitation.

Returns 0 on success, −1 on any error.

int ams_disinvite(AmsModule module, int roleNbr, int continuumNbr, int unitNbr, int subjectNbr)

Rescinds the invitation characterized by the indicated subject and domain. Returns 0 on success, −1 on any error.

int ams_subscribe(AmsModule module, int roleNbr, int continuumNbr, int unitNbr, int subjectNbr, int priority, unsigned char flowLabel, AmsSequence sequence, AmsDiligence diligence)

Announces this module's subscription to messages on the indicated subject, constrained by the indicated domain, and transmitted subject to the indicated class of service. Note that subscriptions differ from invitations in that reception of these messages is actively solicited, not just permitted.

Returns 0 on success, −1 on any error.

int ams_unsubscribe(AmsModule module, int roleNbr, int continuumNbr, int unitNbr, int subjectNbr)

Cancels the subscription characterized by the indicated subject and domain. Returns 0 on success, −1 on any error.

int ams_publish(AmsModule module, int subjectNbr, int priority, unsigned char flowLabel, int contentLength, char *content, int context)

Publishes *contentLength* bytes of data starting at *content* as the content of a message that is sent to all modules whose subscriptions to *subjectNbr* are characterized by a domain that includes this module. *priority* and *flowLabel*, if non-zero, override class of service as requested in the subscriptions. *context* is an opaque ''hint'' to the receiving modules; its use is application-specific.

Returns 0 on success, −1 on any error.

int ams_send(AmsModule module, int continuumNbr, int unitNbr, int moduleNbr, int subjectNbr, int priority, unsigned char flowLabel, int contentLength, char *content, int context)

Sends *contentLength* bytes of data starting at *content* as the content of a message that is transmitted privately to the module in the continuum identified by *continuumNbr* (where 0 indicates ''the local continuum'') that is identified by *unitNbr* and *moduleNbr* — provided that *module* is in the domain of one of that module's invitations on *subjectNbr*. *priority* and *flowLabel*, if non-zero, override class of service as requested in the invitation. *context* is an opaque ''hint'' to the receiving module; its use is application-specific.

Returns 0 on success, −1 on any error.

int ams_query(AmsModule module, int continuumNbr, int unitNbr, int moduleNbr, int subjectNbr, int priority, unsigned char flowLabel, int contentLength, char *content, int context, int term, AmsEvent *event)

Sends a message exactly is described above for **ams_send()**, but additionally suspends the delivery and processing of newly received messages until either (a) a ''reply'' message sent in response to this message is received or (b) the time interval indicated by *term*, in seconds, expires. The event (reply or

timeout) that ends the suspension of processing is provided in *event* (as if from **ams_get_event()** when the function returns.

If *term* is AMS_BLOCKING then the timeout interval is indefinite; only reception of a reply message enables the function to return. If *term* is AMS_POLL then the function returns immediately, without waiting for a reply message.

Returns 0 on success, −1 on any error.

int ams_reply(AmsModule module, AmsEvent msg, int subjectNbr, int priority, unsigned char flowLabel, int contentLength, char *content)

Sends a message exactly is described above for **ams_send()**, except that the destination of the message is the sender of the message identified by *msg* and the ''context'' value included in the message is the context that was provided in *msg*. This message is identified as a ''reply'' message that will end the processing suspension resulting from transmission of *msg* if that message was issued by means of **ams_query()** rather than **ams_send()**.

Returns 0 on success, −1 on any error.

int ams_announce(AmsModule module, int roleNbr, int continuumNbr, int unitNbr, int subjectNbr, int priority, unsigned char flowLabel, int contentLength, char *content, int context)

Sends a message exactly is described above for **ams_send()**, except that one copy of the message is sent to every module in the domain of this function (role, continuum, unit) whose invitation for messages on this subject is itself characterized by a domain that includes the the sending module, rather than to any specific module.

Returns 0 on success, −1 on any error.

int ams_get_event(AmsModule module, int term, AmsEvent *event)

Returns in *event* the next event in the queue of AMS events pending delivery to this module. If the event queue is empty at the time this function is called, processing is suspended until either an event is queued or the time interval indicated by *term*, in seconds, expires. See **ams_query()** above for the semantics of *term*. When the function returns on expiration of *term*, an event of type TIMEOUT_EVT is returned in *event*. Otherwise the event will be of type AMS_MSG_EVT (indicating arrival of a message), NOTICE_EVT (indicating a change in the configuration of the message space), or USER_DEFINED_EVT (indicating that application code posted an event).

The nature of the event returned by **ams_get_event()** can be determined by passing *event* to **ams_get_event_type()** as described below. Event type can then be used to determine whether the information content of the event must be obtained by calling **ams_parse_msg()**, **ams_parse_notice()**, or **ams_parse_user_event()**.

In any case, the memory occupied by *event* must be released after the event object is no longer needed. The **ams_recycle_event()** function is invoked for this purpose.

Returns 0 on success, −1 on any error.

int ams_get_event_type(AmsEvent event)

Returns the event type of *event*, or −1 on any error.

int ams_parse_msg(AmsEvent event, int *continuumNbr, int *unitNbr, int *moduleNbr, int *subjectNbr, int *contentLength, char **content, int *context, AmsMsgType *msgType, int *priority, unsigned char *flowLabel);

Extracts all relevant information pertaining to the AMS message encapsulated in *event*, populating the indicated fields. Must only be called when the event type of *event* is known to be AMS_MSG_EVT.

Returns 0 on success, −1 on any error.

int ams_parse_notice(AmsEvent event, AmsStateType *state, AmsChangeType *change, int *unitNbr, int *moduleNbr, int *roleNbr, int *domainContinuumNbr, int *domainUnitNbr, int *subjectNbr, int *priority, unsigned char *flowLabel, AmsSequence *sequence, AmsDiligence *diligence)

Extracts all relevant information pertaining to the AMS configuration change notice encapsulated in

event, populating the relevant fields. Must only be called when the event type of *event* is known to be NOTICE_EVT.

Note that different fields will be populated depending on the nature of the notice in *event*. *state* will be set to AmsRegistrationState, AmsInvitationState, or AmsSubscription state depending on whether the notice pertains to a change in module registration, a change in invitations, or a change in subscriptions. *change* will be set to AmsStateBegins or AmsStateEnds depending on whether the notice pertains to the initiation or termination of a registration, invitation, or subscription.

Returns 0 on success, −1 on any error.

int ams_post_user_event(AmsModule module, int userEventCode, int userEventDataLength, char *userEventData, int priority)

Posts a ‘‘user event’’ whose content is the *userEventDataLength* bytes of data starting at *userEventData*. *userEventCode* is an application-specific value that is opaque to AMS. *priority* determines the event's position in the queue of events pending delivery to this module; it may be any integer in the range 0−15, where 0 indicates the greatest urgency. (Note that user events can be delivered ahead of all message reception events if necessary.)

Returns 0 on success, −1 on any error.

int ams_parse_user_event(AmsEvent event, int *code, int *dataLength, char **data)

Extracts all relevant information pertaining to the user event encapsulated in *event*, populating the indicated fields. Must only be called when the event type of *event* is known to be USER_DEFINED_EVT.

Returns 0 on success, −1 on any error.

int ams_recycle_event(AmsEvent event)

Releases all memory occupied by *event*. Returns 0 on success, −1 on any error.

int ams_set_event_mgr(AmsModule module, AmsEventMgt *rules)

Starts a background thread that processes events queued for this module, handling each event in the manner indicated by *rules*. Returns 0 on success, −1 on any error.

void ams_remove_event_mgr(AmsModule module)

Terminates the background thread established to process events queued for this module. Returns 0 on success, −1 on any error.

int ams_get_module_nbr(AmsModule module)

Returns the module number assigned to this module upon registration, or −1 on any error.

int ams_get_unit_nbr(AmsModule module)

Returns the unit number assigned to the unit within which this module registered, or −1 on any error.

Lyst ams_list_msgspaces(AmsModule module)

Returns a dynamically allocated linked list of all message spaces identified in the MIB for this module, or −1 on any error. See **lyst** (3) for operations that can be performed on the returned linked list.

int **ams_get_continuum_nbr()**

Returns the continuum number assigned to the continuum within which this module operates, or −1 on any error.

int ams_rams_net_is_tree(AmsModule module)

Returns 1 if the RAMS net for the venture in which this module is registered is configured as a tree, 0 if that RAMS net is configured as a mesh, −1 on any error.

int ams_continuum_is_neighbor(int continuumNbr)

Returns 1 if *continuumNbr* identifies a continuum whose RAMS gateways are immediate neighbors (within the applicable RAMS networks) of the RAMS gateways in the local continuum. Returns 0 otherwise.

char *ams_get_role_name(AmsModule module, int unitNbr, int moduleNbr)
: Returns the name of the role in which the module identified by *unitNbr* and *moduleNbr* registered, or NULL on any error.

int ams_subunit_of(AmsModule module, int argUnitNbr, int refUnitNbr)
: Returns 1 if *argUnitNbr* identifies a unit that is wholly contained within the unit identified by *refUnitNbr*, in the venture within which this module is registered. Returns 0 otherwise.

int ams_lookup_unit_nbr(AmsModule module, char *unitName)
: Returns the number assigned to the unit identified by *unitName*, in the venture within which this module is registered, or −1 on any error.

int ams_lookup_role_nbr(AmsModule module, char *roleName)
: Returns the number assigned to the role identified by *roleName*, in the venture within which this module is registered, or −1 on any error.

int ams_lookup_subject_nbr(AmsModule module, char *subjectName)
: Returns the number assigned to the subject identified by *subjectName*, in the venture within which this module is registered, or −1 on any error.

int ams_lookup_continuum_nbr(AmsModule module, char *continuumName)
: Returns the number of the continuum identified by *continuumName*, or −1 on any error.

char *ams_lookup_unit_name(AmsModule module, int unitNbr)
: Returns the name of the unit identified by *unitNbr*, in the venture within which this module is registered, or −1 on any error.

char *ams_lookup_role_name(AmsModule module, int roleNbr)
: Returns the name of the role identified by *roleNbr*, in the venture within which this module is registered, or −1 on any error.

char *ams_lookup_subject_name(AmsModule module, int subjectNbr)
: Returns the name of the subject identified by *subjectNbr*, in the venture within which this module is registered, or −1 on any error.

char *ams_lookup_continuum_name(AmsModule module, int continuumNbr)
: Returns the name of the continuum identified by *continuumNbr*, or −1 on any error.

SEE ALSO

amsd (1), **ramsgate** (1), **amsxml** (5), **amsrc** (5)

NAME

bp − Bundle Protocol communications library

SYNOPSIS

```
#include "bp.h"

[see description for available functions]
```

DESCRIPTION

The bp library provides functions enabling application software to use Bundle Protocol to send and receive information over a delay-tolerant network. It conforms to the Bundle Protocol specification as documented in Internet RFC 5050.

int bp_attach( )

Attaches the application to BP functionality on the local computer. Returns 0 on success, −1 on any error.

Note that all ION libraries and applications draw memory dynamically, as needed, from a shared pool of ION working memory. The size of the pool is established when ION node functionality is initialized by **ionadmin** (1). This is a precondition for initializing BP functionality by running **bpadmin** (1), which in turn is required in order for **bp_attach()** to succeed.

Sdr bp_get_sdr( )

Returns handle for the SDR data store used for BP, to enable creation and interrogation of bundle payloads (application data units).

void bp_detach( )

Terminates all access to BP functionality on the local computer.

int bp_open(char *eid, BpSAP *ionsapPtr)

Opens the application's access to the BP endpoint identified by *eid*, so that the application can take delivery of bundles destined for the indicated endpoint. This SAP can also be used for sending bundles whose source is the indicated endpoint; all bundles sent via this SAP will be subject to immediate destruction upon transmission, i.e., no bundle addresses will be returned by **bp_send()** for use in tracking, suspending/resuming, or cancelling transmission of these bundles. On success, places a value in **ionsapPtr* that can be supplied to future bp function invocations and returns 0. Returns −1 on any error.

int bp_open_source(char *eid, BpSAP *ionsapPtr, detain)

Opens the application's access to the BP endpoint identified by *eid*, so that the application can send bundles whose source is the indicated endpoint. If and only if the value of *detain* is non-zero, citing this SAP in an invocation of **bp_send()** will cause the address of the newly issued bundle to be returned for use in tracking, suspending/resuming, or cancelling transmission of this bundle. **USE THIS FEATURE WITH GREAT CARE:** such a bundle will continue to occupy storage resources until it is explicitly released by an invocation of **bp_release()** or until its time to live expires, so bundle detention increases the risk of resource exhaustion. (If the value of *detain* is zero, all bundles sent via this SAP will be subject to immediate destruction upon transmission.) On success, places a value in **ionsapPtr* that can be supplied to future bp function invocations and returns 0. Returns −1 on any error.

int bp_send(BpSAP sap, char *destEid, char *reportToEid, int lifespan, int classOfService, BpCustodySwitch custodySwitch, unsigned char srrFlags, int ackRequested, BpAncillaryData *ancillaryData, Object adu, Object *newBundle)

Sends a bundle to the endpoint identified by *destEid*, from the source endpoint as provided to the **bp_open()** call that returned *sap*. When *sap* is NULL, the transmitted bundle is anonymous, i.e., the source of the bundle is not identified. This is legal, but anonymous bundles cannot be uniquely identified; status reporting therefore cannot be requested for an anonymous bundle.

reportToEid identifies the endpoint to which any status reports pertaining to this bundle will be sent; if NULL, defaults to the source endpoint.

lifespan is the maximum number of seconds that the bundle can remain in-transit (undelivered) in the network prior to automatic deletion.

classOfService is simply priority for now: BP_BULK_PRIORITY, BP_STD_PRIORITY, or BP_EXPEDITED_PRIORITY. If class-of-service flags are defined in a future version of Bundle Protocol, those flags would be OR'd with priority.

custodySwitch indicates whether or not custody transfer is requested for this bundle and, if so, whether or not the source node itself is required to be the initial custodian. The valid values are SourceCustodyRequired, SourceCustodyOptional, NoCustodyRequired. Note that custody transfer can take effect only for segments of the end-to-end path that are traversed using the Bundle-in-Bundle Encapsulation protocol at the ''convergence layer''; however, requesting custody transfer is interpreted by ION as a request to use ''reliable'' convergence-layer protocols over all segments of the end-to-end path, whether implemented by custody transfer or not.

srrFlags, if non-zero, is the logical OR of the status reporting behaviors requested for this bundle: BP_RECEIVED_RPT, BP_FORWARDED_RPT, BP_DELIVERED_RPT, BP_DELETED_RPT.

ackRequested is a Boolean parameter indicating whether or not the recipient application should be notified that the source application requests some sort of application-specific end-to-end acknowledgment upon receipt of the bundle.

ancillaryData, if not NULL, is used to populate the Extended Class Of Service block for this bundle. The block's *ordinal* value is used to provide fine-grained ordering within ''expedited'' traffic: ordinal values from 0 (the default) to 254 (used to designate the most urgent traffic) are valid, with 255 reserved for custody signals. Note that the insertion of application-specific extension blocks into the bundle, in addition to the canonical extension blocks inserted automatically per the **bpextensions.c** file, may be requested by listing those blocks in the *extensions* variable of the *ancillaryData* block. The value of the block's *flags* is the logical OR of the applicable extended class-of-service flags:

BP_MINIMUM_LATENCY designates the bundle as ''critical'' for the purposes of Contact Graph Routing.

BP_BEST_EFFORT signifies that non-reliable convergence-layer protocols, as available, may be used to transmit the bundle. Notably, the bundle may be sent as ''green'' data rather than ''red'' data when issued via LTP.

BP_DATA_LABEL_PRESENT signifies whether or not the value of *dataLabel* in *ancillaryData* must be encoded into the ECOS block when the bundle is transmitted.

adu is the ''application data unit'' that will be conveyed as the payload of the new bundle. *adu* must be a ''zero-copy object'' (ZCO). To ensure orderly access to transmission buffer space for all applications, *adu* must be created by invoking **ionCreateZco()**, which may be configured either to block so long as insufficient ZCO storage space is available for creation of the requested ZCO or to fail immediately if insufficient ZCO storage space is available.

The function returns 1 on success, 0 on user error, −1 on any system error. If 0 is returned, then an invalid argument value was passed to **bp_send()**; a message to this effect will have been written to the log file. If 1 is returned, then either the destination of the bundle was ''dtn:none'' (the bit bucket) or the ADU has been accepted and queued for transmission in a bundle. In the latter case, if and only if *sap* was a reference to a BpSAP returned by an invocation of **bp_open_source()** that had a non-zero value in the *detain* parameter, then *newBundle* must be non-NULL and the address of the newly created bundle within the ION database is placed in *newBundle*. This address can be used to track, suspend/resume, or cancel transmission of the bundle.

int bp_track(Object bundle, Object trackingElt)

Adds *trackingElt* to the list of ''tracking'' references in *bundle*. *trackingElt* must be the address of an SDR list element — whose data is the address of this same bundle — within some list of bundles that is privately managed by the application. Upon destruction of the bundle this list element will automatically be deleted, thus removing the bundle from the application's privately managed list of

bundles. This enables the application to keep track of bundles that it is operating on without risk of inadvertently de-referencing the address of a nonexistent bundle.

void bp_untrack(Object bundle, Object trackingElt)
Removes *trackingElt* from the list of ''tracking'' references in *bundle*, if it is in that list. Does not delete *trackingElt* itself.

int bp_suspend(Object bundle)
Suspends transmission of *bundle*. Has no effect if bundle is ''critical'' (i.e., has got extended class of service BP_MINIMUM_LATENCY flag set) or if the bundle is already suspended. Otherwise, reverses the enqueuing of the bundle to its selected transmission outduct and places it in the ''limbo'' queue until the suspension is lifted by calling bp_resume. Returns 0 on success, −1 on any error.

int bp_resume(Object bundle)
Terminates suspension of transmission of *bundle*. Has no effect if bundle is ''critical'' (i.e., has got extended class of service BP_MINIMUM_LATENCY flag set) or is not suspended. Otherwise, removes the bundle from the ''limbo'' queue and queues it for route re-computation and re-queuing. Returns 0 on success, −1 on any error.

int bp_cancel(Object bundle)
Cancels transmission of *bundle*. If the indicated bundle is currently queued for forwarding, transmission, or retransmission, it is removed from the relevant queue and destroyed exactly as if its Time To Live had expired. Returns 0 on success, −1 on any error.

int bp_release(Object bundle)
Releases a detained bundle for destruction when all retention constraints have been removed. After a detained bundle has been released, the application can no longer track, suspend/resume, or cancel its transmission. Returns 0 on success, −1 on any error.

int bp_receive(BpSAP sap, BpDelivery *dlvBuffer, int timeoutSeconds)
Receives a bundle, or reports on some failure of bundle reception activity.

The ''result'' field of the dlvBuffer structure will be used to indicate the outcome of the data reception activity.

If at least one bundle destined for the endpoint for which this SAP is opened has not yet been delivered to the SAP, then the payload of the oldest such bundle will be returned in *dlvBuffer*−>*adu* and *dlvBuffer*−>*result* will be set to BpPayloadPresent. If there is no such bundle, **bp_receive()** blocks for up to *timeoutSeconds* while waiting for one to arrive.

If *timeoutSeconds* is BP_POLL (i.e., zero) and no bundle is awaiting delivery, or if *timeoutSeconds* is greater than zero but no bundle arrives before *timeoutSeconds* have elapsed, then *dlvBuffer*−>*result* will be set to BpReceptionTimedOut. If *timeoutSeconds* is BP_BLOCKING (i.e., −1) then **bp_receive()** blocks until either a bundle arrives or the function is interrupted by an invocation of **bp_interrupt()**.

dlvBuffer−>*result* will be set to BpReceptionInterrupted in the event that the calling process received and handled some signal other than SIGALRM while waiting for a bundle.

dlvBuffer−>*result* will be set to BpEndpointStopped in the event that the operation of the indicated endpoint has been terminated.

The application data unit delivered in the data delivery structure, if any, will be a ''zero-copy object'' reference. Use zco reception functions (see **zco** (3)) to read the content of the application data unit.

Be sure to call **bp_release_delivery()** after every successful invocation of **bp_receive()**.

The function returns 0 on success, −1 on any error.

void bp_interrupt(BpSAP sap)
Interrupts a **bp_receive()** invocation that is currently blocked. This function is designed to be called from a signal handler; for this purpose, *sap* may need to be obtained from a static variable.

void bp_release_delivery(BpDelivery *dlvBuffer, int releaseAdu)
Releases resources allocated to the indicated delivery. *releaseAdu* is a Boolean parameter: if non-zero, the ADU ZCO reference in *dlvBuffer* (if any) is destroyed, causing the ZCO itself to be destroyed if no other references to it remain.

void bp_close(BpSAP sap)
Terminates the application's access to the BP endpoint identified by the *eid* cited by the indicated service access point. The application relinquishes its ability to take delivery of bundles destined for the indicated endpoint and to send bundles whose source is the indicated endpoint.

SEE ALSO

bpadmin (1), **lgsend** (1), **lgagent** (1), **bpextensions** (3), **bprc** (5), **lgfile** (5)

NAME

bpextensions – interface for adding extensions to Bundle Protocol

SYNOPSIS

```
#include "bpextensions.c"
```

DESCRIPTION

ION's interface for extending the Bundle Protocol enables the definition of external functions that insert *extension* blocks into outbound bundles (either before or after the payload block), parse and record extension blocks in inbound bundles, and modify extension blocks at key points in bundle processing. All extension-block handling is statically linked into ION at build time, but the addition of an extension never requires that any standard ION source code be modified.

Standard structures for recording extension blocks — both in transient storage [memory] during bundle acquisition (AcqExtBlock) and in persistent storage [the ION database] during subsequent bundle processing (ExtensionBlock) — are defined in the *bei.h* header file. In each case, the extension block structure comprises a block *type* code, block processing *flags*, possibly a list of *EID references*, an array of *bytes* (the serialized form of the block, for transmission), the *length* of that array, optionally an extension-specific opaque *object* whose structure is designed to characterize the block in a manner that's convenient for the extension processing functions, and the *size* of that object.

The definition of each extension is asserted in an ExtensionDef structure, also as defined in the *bei.h* header file. Each ExtensionDef must supply:

The name of the extension. (Used in some diagnostic messages.)

The extension's block type code.

A pointer to an **offer** function.

A pointer to a function to be called when **forwarding** a bundle containing this sort of block.

A pointer to a function to be called when **taking custody** of a bundle containing this sort of block.

A pointer to a function to be called when **enqueuing** for transmission a bundle containing this sort of block.

A pointer to a function to be called when a convergence-layer adapter **dequeues** a bundle containing this sort of block, before serializing it.

A pointer to a function to be called immediately before a convergence-layer adapter **transmits** a bundle containing this sort of block, after the bundle has been serialized.

A pointer to a **release** function.

A pointer to a **copy** function.

A pointer to an **acquire** function.

A pointer to a **review** function.

A pointer to a **decrypt** function.

A pointer to a **parse** function.

A pointer to a **check** function.

A pointer to a **record** function.

A pointer to a **clear** function.

All extension definitions must be coded into an array of ExtensionDef structures named *extensionDefs*.

An array of ExtensionSpec structures named *extensionSpecs* is also required. Each ExtensionSpec provides the specification for producing an outbound extension block: block definition (identified by block type number), three discriminator tags whose semantics are block-type-specific, and CRC type indicating what type of CRC must be used to protect this extension block. The order of appearance of extension

specifications in the extensionSpecs array determines the order in which extension blocks will be inserted into locally sourced bundles.

The standard extensionDefs array — which is empty — is in the *noextensions.c* prototype source file. The procedure for extending the Bundle Protocol in ION is as follows:

1. Specify −DBP_EXTENDED in the Makefile's compiler command line when building the libbpP.c library module.

2. Create a copy of the prototype extensions file, named ''bpextensions.c'', in a directory that is made visible to the Makefile's libbpP.c compilation command line (by a −I parameter).

3. In the ''external function declarations'' area of ''bpextensions.c'', add ''extern'' function declarations identifying the functions that will implement your extension (or extensions).

4. Add one or more ExtensionDef structure initialization lines to the extensionDefs array, referencing those declared functions.

5. Add one or more ExtensionSpec structure initialization lines to the extensionSpecs array, referencing those extension definitions.

6. Develop the implementations of the extension implementation functions in one or more new source code files.

7. Add the object file or files for the new extension implementation source file (or files) to the Makefile's command line for linking libbpP.so.

The function pointers supplied in each ExtensionDef must conform to the following specifications. NOTE that any function that modifies the *bytes* member of an ExtensionBlock or AckExtBlock **must** set the corresponding *length* to the new length of the *bytes* array, if changed.

int (*BpExtBlkOfferFn)(ExtensionBlock *blk, Bundle *bundle)
: Populates all fields of the indicated ExtensionBlock structure for inclusion in the indicated outbound bundle. This function is automatically called when a new bundle is locally sourced or upon acquisition of a remotely sourced bundle that does not contain an extension block of this type. The values of the extension block are typically expected to be a function of the state of the bundle, but this is extension-specific. If it is not appropriate to offer an extension block of this type as part of this bundle, then the *size*, *length*, *object*, and *bytes* members of *blk* must all be set to zero. If it is appropriate to offer such a block but no internal object representing the state of the block is needed, the *object* and *size* members of *blk* must be set to zero. The *type*, *blkProcFlags*, and *dataLength* members of *blk* must be populated by the implementation of the ''offer'' function, but the *length* and *bytes* members are typically populated by calling the BP library function **serializeExtBlk()**, which must be passed the block to be serialized (with *type*, *blkProcFlags* and *dataLength* already set), a Lyst of EID references (two list elements — offsets — per EID reference, if applicable; otherwise NULL), and a pointer to the extension-specific block data. The block's *bytes* array and *object* (if present) must occupy space allocated from the ION database heap. Return zero on success, −1 on any system failure.

int (*BpExtBlkProcessFn)(ExtensionBlock *blk, Bundle *bundle, void *context)
: Performs some extension-specific transformation of the data encapsulated in *blk* based on the state of *bundle*. The transformation to be performed will typically vary depending on whether the identified function is the one that is automatically invoked upon forwarding the bundle, upon taking custody of the bundle, upon enqueuing the bundle for transmission, upon removing the bundle from the transmission queue, or upon transmitting the serialized bundle. The *context* argument may supply useful supplemental information; in particular, the context provided to the ON_DEQUEUE function will comprise the name of the protocol for the duct from which the bundle has been dequeued, together with the EID of the neighboring node endpoint to which the bundle will be directly transmitted when serialized. The block-specific data in *blk* is located within *bytes* immediately after the header of the extension block; the length of the block's header is the difference between *length* and *dataLength*. Whenever the block's *blkProcFlags*, EID extensions, and/or block-specific data are altered, the **serializeExtBlk()** function should be called again to recalculate the size of the extension block and rebuild the *bytes* array. Return zero on success, −1 on any system failure.

void (*BpExtBlkReleaseFn)(ExtensionBlock *blk)
Releases all ION database space occupied by the *object* member of *blk*. This function is automatically called when a bundle is destroyed. Note that incorrect implementation of this function may result in a database space leak.

int (*BpExtBlkCopyFn)(ExtensionBlock *newblk, ExtensionBlock *oldblk)
Copies the *object* member of *oldblk* to ION database heap space and places the address of that new non-volatile object in the *object* member of *newblk*, also sets *size* in *newblk*. This function is automatically called when two copies of a bundle are needed, e.g., in the event that it must both be delivered to a local client and also fowarded to another node. Return zero on success, −1 on any system failure.

int (*BpAcqExtBlkAcquireFn)(AcqExtBlock *acqblk, AcqWorkArea *work)
Populates the indicated AcqExtBlock structure with *size* and *object* for retention as part of the indicated inbound bundle. (The *type*, *blkProcFlags*, EID references (if any), *dataLength*, *length*, and *bytes* values of the structure are pre-populated with data as extracted from the serialized bundle.) This function is only to be provided for extension blocks that are never encrypted; a extension block that may be encrypted should have a BpAcqExtBlkParseFn callback instead. The function is automatically called when an extension block of this type is encountered in the course of parsing and acquiring a bundle for local delivery and/or forwarding. If no internal object representing the state of the block is needed, the *object* member of *acqblk* must be set to NULL and the *size* member must be set to zero. If an *object* is needed for this block, it must occupy space that is allocated from ION working memory using **MTAKE** and its *size* must be indicated in *blk*. Return zero if the block is malformed (this will cause the bundle to be discarded), 1 if the block is successfully parsed, −1 on any system failure.

int (*BpAcqExtBlkReviewFn)(AcqWorkArea *work)
Reviews the extension blocks that have been acquired for this bundle, checking to make sure that all blocks of this type that are required by policy are present. Returns 0 if any blocks are missing, 1 if all required blocks are present, −1 on any system failure.

int (*BpAcqExtBlkDecryptFn)(AcqExtBlock *acqblk, AcqWorkArea *work)
Decrypts some other extension block that has been acquired but not yet parsed, nominally using encapsulated ciphersuite information. Return zero if the block is malformed (this will cause the bundle to be discarded), 1 if no error in decryption was encountered, −1 on any system failure.

int (*BpAcqExtBlkParseFn)(AcqExtBlock *acqblk, AcqWorkArea *work)
Populates the indicated AcqExtBlock structure with *size* and *object* for retention as part of the indicated inbound bundle. (The *type*, *blkProcFlags*, EID references (if any), *dataLength*, *length*, and *bytes* values of the structure are pre-populated with data as extracted from the serialized bundle.) This function is provided for extension blocks that may be encrypted; a extension block that can never be encrypted should have a BpAcqExtBlkAcquireFn callback instead. The function is automatically called when an extension block of this type is encountered in the course of parsing and acquiring a bundle for local delivery and/or forwarding. If no internal object representing the state of the block is needed, the *object* member of *acqblk* must be set to NULL and the *size* member must be set to zero. If an *object* is needed for this block, it must occupy space that is allocated from ION working memory using **MTAKE** and its *size* must be indicated in *blk*. Return zero if the block is malformed (this will cause the bundle to be discarded), 1 if the block is successfully parsed, −1 on any system failure.

int (*BpAcqExtBlkCheckFn)(AcqExtBlock *acqblk, AcqWorkArea *work)
Examines the bundle in *work* to determine whether or not it is authentic, in the context of the indicated extension block. Return 1 if the block is determined to be inauthentic (this will cause the bundle to be discarded), zero if no inauthenticity is detected, −1 on any system failure.

int (*BpExtBlkRecordFn)(ExtensionBlock *blk, AcqExtBlock *acqblk)
Copies the *object* member of *acqblk* to ION database heap space and places the address of that non-volatile object in the *object* member of *blk*; also sets *size* in *blk*. This function is automatically called when an acquired bundle is accepted for forwarding and/or delivery. Return zero on success, −1 on any system failure.

void (*BpAcqExtBlkClearFn)(AcqExtBlock *acqblk)
Uses **MRELEASE** to release all ION working memory occupied by the *object* member of *acqblk*. This function is automatically called when acquisition of a bundle is completed, whether or not the bundle is accepted. Note that incorrect implementation of this function may result in a working memory leak.

UTILITY FUNCTIONS FOR EXTENSION PROCESSING

void discardExtensionBlock(AcqExtBlock *blk)
Deletes this block from the bundle acquisition work area prior to the recording of the bundle in the ION database.

void scratchExtensionBlock(ExtensionBlock *blk)
Deletes this block from the bundle after the bundle has been recorded in the ION database.

Object findExtensionBlock(Bundle *bundle, unsigned int type, unsigned char tag1, unsigned char tag2, unsigned char tag3)
On success, returns the address of the ExtensionBlock in *bundle* for the indicated *type* and tag values. If no such extension block exists, returns zero.

int serializeExtBlk(ExtensionBlock *blk, char *blockData)
Constructs a BPv7−conformant serialized representation of this extension block in blk−>bytes. Returns 0 on success, −1 on an unrecoverable system error.

void suppressExtensionBlock(ExtensionBlock *blk)
Causes *blk* to be omitted when the bundle to which it is attached is serialized for transmission. This suppression remains in effect until it is reversed by **restoreExtensionBlock()**;

void restoreExtensionBlock(ExtensionBlock *blk)
Reverses the effect of **suppressExtensionBlock()**, enabling the block to be included when the bundle to which it is attached is serialized.

SEE ALSO

bp (3)

NAME

bss − Bundle Streaming Service library

SYNOPSIS

```
#include "bss.h"

typedef int (*RTBHandler)(time_t time, unsigned long count, char *buffer, int

[see description for available functions]
```

DESCRIPTION

The BSS library supports the streaming of data over delay-tolerant networking (DTN) bundles. The intent of the library is to enable applications that pass streaming data received in transmission time order (i.e., without time regressions) to an application-specific ‘‘display’’ function — notionally for immediate real-time display — but to store **all** received data (including out-of-order data) in a private database for playback under user control. The reception and real-time display of in-order data is performed by a background thread, leaving the application’s main (foreground) thread free to respond to user commands controlling playback or other application-specific functions.

The application-specific ‘‘display’’ function invoked by the background thread must conform to the RTBHandler type definition. It must return 0 on success, −1 on any error that should terminate the background thread. Only on return from this function will the background thread proceed to acquire the next BSS payload.

All data acquired by the BSS background thread is written to a BSS database comprising three files: table, list, and data. The name of the database is the root name that is common to the three files, e.g., *db3*.tbl, *db3*.lst, *db3*.dat would be the three files making up the *db3* BSS database. All three files of the selected BSS database must reside in the same directory of the file system.

Several replay navigation functions in the BSS library require that the application provide a navigation state structure of type bssNav as defined in the bss.h header file. The application is not reponsible for populating this structure; it’s strictly for the private use of the BSS library.

int bssOpen(char *bssName, char *path, char *eid)

Opens access to a BSS database, to enable data playback. *bssName* identifies the specific BSS database that is to be opened. *path* identifies the directory in which the database resides. *eid* is ignored. On any failure, returns −1. On success, returns zero.

int bssStart(char *bssName, char *path, char *eid, char *buffer, int bufLen, RTBHandler handler)

Starts a BSS data acquisition background thread. *bssName* identifies the BSS database into which data will be acquired. *path* identifies the directory in which that database resides. *eid* is used to open the BP endpoint at which the delivered BSS bundle payload contents will be acquired. *buffer* identifies a data acquisition buffer, which must be provided by the application, and *bufLen* indicates the length of that buffer; received bundle payloads in excess of this length will be discarded.

handler identifies the display function to which each in-order bundle payload will be passed. The *time* and *count* parameters passed to this function identify the received bundle, indicating the bundle’s creation timestamp time (in seconds) and counter value. The *buffer* and *bufLength* parameters indicate the location into which the bundle’s payload was acquired and the length of the acquired payload. *handler* must return −1 on any unrecoverable system error, 0 otherwise. A return value of −1 from *handler* will terminate the BSS data acquisition background thread.

On any failure, returns −1. On success, returns zero.

int bssRun(char *bssName, char *path, char *eid, char *buffer, int bufLen, RTBHandler handler)

A convenience function that performs both **bssOpen()** and **bssStart()**. On any failure, returns −1. On success, returns zero.

void **bssClose()**

Terminates data playback access to the most recently opened BSS database.

void **bssStop()**
Terminates the most recently initiated BSS data acquisition background thread.

void **bssExit()**
A convenience function that performs both **bssClose()** and **bssStop()**.

long bssRead(bssNav nav, char *data, int dataLen)
Copies the data at the current playback position in the database, as indicated by *nav*, into *data*; if the length of the data is in excess of *dataLen* then an error condition is asserted (i.e., −1 is returned). Note that **bssRead()** cannot be successfully called until *nav* has been populated, nominally by a preceding call to **bssSeek()**, **bssNext()**, or **bssPrev()**. Returns the length of data read, or −1 on any error.

long bssSeek(bssNav *nav, time_t time, time_t *curTime, unsigned long *count)
Sets the current playback position in the database, in *nav*, to the data received in the bundle with the earliest creation time that was greater than or equal to *time*. Populates *nav* and also returns the creation time and bundle ID count of that bundle in *curTime* and *count*. Returns the length of data at this location, or −1 on any error.

long bssSeek_read(bssNav *nav, time_t time, time_t *curTime, unsigned long *count, char *data, int dataLen)
A convenience function that performs **bssSeek()** followed by an immediate **bssRead()** to return the data at the new playback position. Returns the length of data read, or −1 on any error.

long bssNext(bssNav *nav, time_t *curTime, unsigned long *count)
Sets the playback position in the database, in *nav*, to the data received in the bundle with the earliest creation time and ID count greater than that of the bundle at the current playback position. Populates *nav* and also returns the creation time and bundle ID count of that bundle in *curTime* and *count*. Returns the length of data at this location (if any), −2 on reaching end of list, or −1 on any error.

long bssNext_read(bssNav *nav, time_t *curTime, unsigned long *count, char *data, int dataLen)
A convenience function that performs **bssNext()** followed by an immediate **bssRead()** to return the data at the new playback position. Returns the length of data read, −2 on reaching end of list, or −1 on any error.

long bssPrev(bssNav *nav, time_t *curTime, unsigned long *count)
Sets the playback position in the database, in *nav*, to the data received in the bundle with the latest creation time and ID count earlier than that of the bundle at the current playback position. Populates *nav* and also returns the creation time and bundle ID count of that bundle in *curTime* and *count*. Returns the length of data at this location (if any), −2 on reaching end of list, or −1 on any error.

long bssPrev_read(bssNav *nav, time_t *curTime, unsigned long *count, char *data, int dataLen)
A convenience function that performs **bssPrev()** followed by an immediate **bssRead()** to return the data at the new playback position. Returns the length of data read, −2 on reaching end of list, or −1 on any error.

SEE ALSO

bp (3)

NAME

bssp – Bundle Streaming Service Protocol (BSSP) communications library

SYNOPSIS

```
#include "bssp.h"

typedef enum
{
    BsspNoNotice = 0,
    BsspXmitSuccess,
    BsspXmitFailure,
    BsspRecvSuccess
} BsspNoticeType;

[see description for available functions]
```

DESCRIPTION

The bssp library provides functions enabling application software to use BSSP to send and receive streaming data in bundles.

BSSP is designed to forward streaming data in original transmission order wherever possible but to retransmit data as necessary to ensure that the entire stream is available for playback eventually. To this end, BSSP uses not one but two underlying ‘‘link service’’ channels: (a) an unreliable ‘‘best efforts’’ channel, for data items that are successfully received upon initial transmission over every extent of the end-to-end path, and (b) a ‘‘reliable’’ channel, for data items that were lost at some point, had to be retransmitted, and therefore are now out of order. The BSS library at the destination node supports immediate ‘‘real-time’’ display of all data received on the ‘‘best efforts’’ channel in transmission order, together with database retention of all data eventually received on the ‘‘reliable’’ channel.

The BSSP notion of **engine ID** corresponds closely to the Internet notion of a host, and in ION engine IDs are normally indistinguishable from node numbers including the node numbers in Bundle Protocol endpoint IDs conforming to the ‘‘ipn’’ scheme.

The BSSP notion of **client ID** corresponds closely to the Internet notion of ‘‘protocol number’’ as used in the Internet Protocol. It enables data from multiple applications — clients — to be multiplexed over a single reliable link. However, for ION operations we normally use BSSP exclusively for the transmission of Bundle Protocol data, identified by client ID = 1.

int **bssp_attach()**
: Attaches the application to BSSP functionality on the lcoal computer. Returns 0 on success, −1 on any error.

void **bssp_detach()**
: Terminates all access to BSSP functionality on the local computer.

int **bssp_engine_is_started()**
: Returns 1 if the local BSSP engine has been started and not yet stopped, 0 otherwise.

int bssp_send(uvast destinationEngineId, unsigned int clientId, Object clientServiceData, int inOrder, BsspSessionId *sessionId)
: Sends a client service data unit to the application that is waiting for data tagged with the indicated *clientId* as received at the remote BSSP engine identified by *destinationEngineId*.

  clientServiceData must be a ‘‘zero-copy object’’ reference as returned by **ionCreateZco()**. Note that BSSP will privately make and destroy its own reference to the client service data object; the application is free to destroy its reference at any time.

  inOrder is a Boolean value indicating whether or not the service data item that is being sent is ‘‘in order’’, i.e., was originally transmitted after all items that have previously been sent to this destination by this local BSSP engine: 0 if no (meaning that the item must be transmitted using the ‘‘reliable’’ channel), 1 if yes (meaning that the item must be transmitted using the ‘‘best-efforts’’ channel.

On success, the function populates **sessionId* with the source engine ID and the ''session number'' assigned to transmission of this client service data unit and returns zero. The session number may be used to link future BSSP processing events to the affected client service data. **bssp_send()** returns −1 on any error.

int bssp_open(unsigned int clientId)
Establishes the application's exclusive access to received service data units tagged with the indicated BSSP client service data ID. At any time, only a single application task is permitted to receive service data units for any single client service data ID.

Returns 0 on success, −1 on any error (e.g., the indicated client service is already being held open by some other application task).

int bssp_get_notice(unsigned int clientId, BsspNoticeType *type, BsspSessionId *sessionId, unsigned char *reasonCode, unsigned int *dataLength, Object *data)
Receives notices of BSSP processing events pertaining to the flow of service data units tagged with the indicated client service ID. The nature of each event is indicated by **type*. Additional parameters characterizing the event are returned in **sessionId*, **reasonCode*, **dataLength*, and **data* as relevant.

The value returned in **data* is always a zero-copy object; use the zco_* functions defined in ''zco.h'' to retrieve the content of that object.

When the notice is an BsspRecvSuccess, the ZCO returned in **data* contains the content of a single BSSP block.

The cancellation of an export session results in delivery of a BsspXmitFailure notice. In this case, the ZCO returned in *data is a service data unit ZCO that had previously been passed to **bssp_send()**.

bssp_get_notice() always blocks indefinitely until an BSSP processing event is delivered.

Returns zero on success, −1 on any error.

void bssp_interrupt(unsigned int clientId)
Interrupts an **bssp_get_notice()** invocation. This function is designed to be called from a signal handler; for this purpose, *clientId* may need to be obtained from a static variable.

void bssp_release_data(Object data)
Releases the resources allocated to hold *data*, which must be a **received** client service data unit ZCO.

void bssp_close(unsigned int clientId)
Terminates the application's exclusive access to received service data units tagged with the indicated client service data ID.

SEE ALSO

bsspadmin (1), **bssprc** (5), **zco** (3)

NAME

cfdp – CCSDS File Delivery Protocol (CFDP) communications library

SYNOPSIS

```
#include "cfdp.h"

typedef enum
{
    CksumTypeUnknown = -1,
    ModularChecksum = 0,
    CRC32CChecksum = 2,
    NullChecksum = 15
} CfdpCksumType;

typedef int (*CfdpReaderFn)(int fd, unsigned int *checksum, CfdpCksumType ckT

typedef int (*CfdpMetadataFn)(uvast fileOffset, unsigned int recordOffset, un

typedef enum
{
    CfdpCreateFile = 0,
    CfdpDeleteFile,
    CfdpRenameFile,
    CfdpAppendFile,
    CfdpReplaceFile,
    CfdpCreateDirectory,
    CfdpRemoveDirectory,
    CfdpDenyFile,
    CfdpDenyDirectory
} CfdpAction;

typedef enum
{
    CfdpNoEvent = 0,
    CfdpTransactionInd,
    CfdpEofSentInd,
    CfdpTransactionFinishedInd,
    CfdpMetadataRecvInd,
    CfdpFileSegmentRecvInd,
    CfdpEofRecvInd,
    CfdpSuspendedInd,
    CfdpResumedInd,
    CfdpReportInd,
    CfdpFaultInd,
    CfdpAbandonedInd
} CfdpEventType;

typedef struct
{
    char            *sourceFileName;
    char            *destFileName;
    MetadataList    messagesToUser;
    MetadataList    filestoreRequests;
    CfdpHandler     *faultHandlers;
    int             unacknowledged;
```

```
    unsigned int    flowLabelLength;
    unsigned char   *flowLabel;
    int             recordBoundsRespected;
    int             closureRequested;
} CfdpProxyTask;

typedef struct
{
    char            *directoryName;
    char            *destFileName;
} CfdpDirListTask;

[see description for available functions]
```

DESCRIPTION

The cfdp library provides functions enabling application software to use CFDP to send and receive files. It conforms to the Class 1 (Unacknowledged) service class defined in the CFDP Blue Book and includes implementations of several standard CFDP user operations.

In the ION implementation of CFDP, the CFDP notion of **entity ID** is taken to be identical to the BP (CBHE) notion of DTN **node number**.

CFDP entity and transaction numbers may be up to 64 bits in length. For portability to 32−bit machines, these numbers are stored in the CFDP state machine as structures of type CfdpNumber.

To simplify the interface between CFDP the user application without risking storage leaks, the CFDP-ION API uses MetadataList objects. A MetadataList is a specially formatted SDR list of user messages, filestore requests, or filestore responses. During the time that a MetadataList is pending processing via the CFDP API, but is not yet (or is no longer) reachable from any FDU object, a pointer to the list is appended to one of the lists of MetadataList objects in the CFDP non-volatile database. This assures that any unplanned termination of the CFDP daemons won't leave any SDR lists unreachable — and therefore un-recyclable — due to the absence of references to those lists. Restarting CFDP automatically purges any unused MetadataLists from the CFDP database. The ''user data'' variable of the MetadataList itself is used to implement this feature: while the list is reachable only from the database root, its user data variable points to the database root list from which it is referenced; while the list is attached to a File Delivery Unit, its user data is null.

By default, CFDP transmits the data in a source file in segments of fixed size. The user application can override this behavior at the time transmission of a file is requested, by supplying a file reader callback function that reads the file — one byte at a time — until it detects the end of a ''record'' that has application significance. Each time CFDP calls the reader function, the function must return the length of one such record (which must be no greater than 65535).

When CFDP is used to transmit a file, a 32−bit checksum must be provided in the ''EOF'' PDU to enable the receiver of the file to assure that it was not corrupted in transit. When an application-specific file reader function is supplied, that function is responsible for updating the computed checksum as it reads each byte of the file; a CFDP library function is provided for this purpose. Two types of file checksums are supported: a simple modular checksum or a 32−bit CRC. The checksum type must be passed through to the CFDP checksum computation function, so it must be provided by (and thus to) the file reader function.

Per-segment metadata may be provided by the user application. To enable this, upon formation of each file data segment, CFDP will invoke the user-provided per-segment metadata composition callback function (if any), a function conforming to the CfdpMetadataFn type definition. The callback will be passed the offset of the segment within the file, the segment's offset within the current record (as applicable), the length of the segment, an open file descriptor for the source file (in case the data must be read in order to construct the metadata), and a 63−byte buffer in which to place the new metadata. The callback function must return the length of metadata to attach to the file data segment PDU (may be zero) or −1 in the event of a general system failure.

The return value for each CFDP ''request'' function (put, cancel, suspend, resume, report) is a reference number that enables ''events'' obtained by calling **cfdp_get_event()** to be matched to the requests that caused them. Events with reference number set to zero are events that were caused by autonomous CFDP activity, e.g., the reception of a file data segment.

int **cfdp_attach()**
: Attaches the application to CFDP functionality on the local computer. Returns 0 on success, −1 on any error.

int **cfdp_entity_is_started()**
: Returns 1 if the local CFDP entity has been started and not yet stopped, 0 otherwise.

void **cfdp_detach()**
: Terminates all access to CFDP functionality on the local computer.

void cfdp_compress_number(CfdpNumber *toNbr, uvast from)
: Converts an unsigned **vast** number into a CfdpNumber structure, e.g., for use when invoking the **cfdp_put()** function.

void cfdp_decompress_number(uvast toNbr, CfdpNumber *from)
: Converts a numeric value in a CfdpNumber structure to an unsigned **vast** integer.

void cfdp_update_checksum(unsigned char octet, uvast *offset, unsigned int *checksum, CfdpCksumType ckType)
: For use by an application-specific file reader callback function, which must pass to **cfdp_update_checksum()** the value of each byte (octet) it reads. *offset* must be *octet*'s displacement in bytes from the start of the file. The *checksum* pointer is provided to the reader function by CFDP.

MetadataList **cfdp_create_usrmsg_list()**
: Creates a non-volatile linked list, suitable for containing messages-to-user that are to be presented to **cfdp_put()**.

int cfdp_add_usrmsg(MetadataList list, unsigned char *text, int length)
: Appends the indicated message-to-user to *list*.

int cfdp_get_usrmsg(MetadataList list, unsigned char *textBuf, int *length)
: Removes from *list* the first of the remaining messages-to-user contained in the list and delivers its text and length. When the last message in the list is delivered, destroys the list.

void cfdp_destroy_usrmsg_list(MetadataList *list)
: Removes and destroys all messages-to-user in *list* and destroys the list.

MetadataList **cfdp_create_fsreq_list()**
: Creates a non-volatile linked list, suitable for containing filestore requests that are to be presented to **cfdp_put()**.

int cfdp_add_fsreq(MetadataList list, CfdpAction action, char *firstFileName, char *seconfdFIleName)
: Appends the indicated filestore request to *list*.

int cfdp_get_fsreq(MetadataList list, CfdpAction *action, char *firstFileNameBuf, char *secondFileNameBuf)
: Removes from *list* the first of the remaining filestore requests contained in the list and delivers its action code and file names. When the last request in the list is delivered, destroys the list.

void cfdp_destroy_fsreq_list(MetadataList *list)
: Removes and destroys all filestore requests in *list* and destroys the list.

int cfdp_get_fsresp(MetadataList list, CfdpAction *action, int *status, char *firstFileNameBuf, char *secondFileNameBuf, char *messageBuf)
: Removes from *list* the first of the remaining filestore responses contained in the list and delivers its action code, status, file names, and message. When the last response in the list is delivered, destroys the list.

void cfdp_destroy_fsresp_list(MetadataList *list)
Removes and destroys all filestore responses in *list* and destroys the list.

int cfdp_read_space_packets(int fd, unsigned int *checksum)
This is a standard ‘‘reader’’ function that segments the source file on CCSDS space packet boundaries. Multiple small packets may be aggregated into a single file data segment.

int cfdp_read_text_lines(int fd, unsigned int *checksum)
This is a standard ‘‘reader’’ function that segments a source file of text lines on line boundaries.

int cfdp_put(CfdpNumber *destinationEntityNbr, unsigned int utParmsLength, unsigned char *utParms, char *sourceFileName, char *destFileName, CfdpReaderFn readerFn, CfdpMetadataFn metadataFn, CfdpHandler *faultHandlers, unsigned int flowLabelLength, unsigned char *flowLabel, unsigned int closureLatency, MetadataList messagesToUser, MetadataList filestoreRequests, CfdpTransactionId *transactionId)
Sends the file identified by *sourceFileName* to the CFDP entity identified by *destinationEntityNbr*. *destinationFileName* is used to indicate the name by which the file will be catalogued upon arrival at its final destination; if NULL, the destination file name defaults to *sourceFileName*. If *sourceFileName* is NULL, it is assumed that the application is requesting transmission of metadata only (as discussed below) and *destinationFileName* is ignored. Note that both *sourceFileName* and *destinationFileName* are interpreted as path names, i.e., directory paths may be indicated in either or both. The syntax of path names is opaque to CFDP; the syntax of *sourceFileName* must conform to the path naming syntax of the source entity’s file system and the syntax of *destinationFileName* must conform to the path naming syntax of the destination entity’s file system.

The byte array identified by *utParms*, if non-NULL, is interpreted as transmission control information that is to be passed on to the UT layer. The nominal UT layer for ION’s CFDP being Bundle Protocol, the *utParms* array is normally a pointer to a structure of type BpUtParms; see the *bp* man page for a discussion of the parameters in that structure.

closureLatency is the length of time following transmission of the EOF PDU within which a responding Transaction Finish PDU is expected. If no Finish PDU is requested, this parameter value should be zero.

messagesToUser and *filestoreRequests*, where non-zero, must be the addresses of non-volatile linked lists (that is, linked lists in ION’s SDR database) of CfdpMsgToUser and CfdpFilestoreRequest objects identifying metadata that are intended to accompany the transmitted file. Note that this metadata may accompany a file of zero length (as when *sourceFileName* is NULL as noted above) — a transmission of metadata only.

On success, the function populates **transactionID* with the source entity ID and the transaction number assigned to this transmission and returns the request number identifying this ‘‘put’’ request. The transaction ID may be used to suspend, resume, cancel, or request a report on the progress of this transmission. **cfdp_put()** returns −1 on any error.

int cfdp_cancel(CfdpTransactionId *transactionId)
Cancels transmission or reception of the indicated transaction. Note that, since the ION implementation of CFDP is Unacknowledged, cancellation of a file transmission may have little effect. Returns request number on success, −1 on any error.

int cfdp_suspend(CfdpTransactionId *transactionId)
Suspends transmission of the indicated transaction. Note that, since the ION implementation of CFDP is Unacknowledged, suspension of a file transmission may have little effect. Returns request number on success, −1 on any error.

int cfdp_resume(CfdpTransactionId *transactionId)
Resumes transmission of the indicated transaction. Note that, since the ION implementation of CFDP is Unacknowledged, resumption of a file transmission may have little effect. Returns request number on success, −1 on any error.

int cfdp_report(CfdpTransactionId *transactionId)

Requests issuance of a report on the transmission or reception progress of the indicated transaction. The report takes the form of a character string that is returned in a CfdpEvent structure; use **cfdp_get_event()** to receive the event (which may be matched to the request by request number). Returns request number on success, 0 if transaction is unknown, −1 on any error.

int cfdp_get_event(CfdpEventType *type, time_t *time, int *reqNbr, CfdpTransactionId *transactionId, char *sourceFileNameBuf, char *destFileNameBuf, uvast *fileSize, MetadataList *messagesToUser, uvast *offset, unsigned int *length, CfdpCondition *condition, uvast *progress, CfdpFileStatus *fileStatus, CfdpDeliveryCode *deliveryCode, CfdpTransactionId *originatingTransactionId, char *statusReportBuf, MetadataList *filestoreResponses);

Populates return value fields with data from the oldest CFDP event not yet delivered to the application.

cfdp_get_event() always blocks indefinitely until an CFDP processing event is delivered or the function is interrupted by an invocation of **cfdp_interrupt()**.

On application error, returns zero but sets errno to EINVAL. Returns −1 on system failure, zero otherwise.

void **cfdp_interrupt()**

Interrupts an **cfdp_get_event()** invocation. This function is designed to be called from a signal handler.

int cfdp_rput(CfdpNumber *respondentEntityNbr, unsigned int utParmsLength, unsigned char *utParms, char *sourceFileName, char *destFileName, CfdpReaderFn readerFn, CfdpHandler *faultHandlers, unsigned int flowLabelLength, unsigned char *flowLabel, unsigned int closureLatency, MetadataList messagesToUser, MetadataList filestoreRequests, CfdpNumber *beneficiaryEntityNbr, CfdpProxyTask *proxyTask, CfdpTransactionId *transactionId)

Sends to the indicated respondent entity a ‘‘proxy’’ request to perform a file transmission. The transmission is to be subject to the configuration values in *proxyTask* and the destination of the file is to be the entity identified by *beneficiaryEntityNbr*.

int cfdp_rput_cancel(CfdpNumber *respondentEntityNbr, unsigned int utParmsLength, unsigned char *utParms, char *sourceFileName, char *destFileName, CfdpReaderFn readerFn, CfdpHandler *faultHandlers, unsigned int flowLabelLength, unsigned char *flowLabel, unsigned int closureLatency, MetadataList messagesToUser, MetadataList filestoreRequests, CfdpTransactionId *rputTransactionId, CfdpTransactionId *transactionId)

Sends to the indicated respondent entity a request to cancel a prior ‘‘proxy’’ file transmission request as identified by *rputTransactionId*, which is the value of *transactionId* that was returned by that earlier proxy transmission request.

int cfdp_get(CfdpNumber *respondentEntityNbr, unsigned int utParmsLength, unsigned char *utParms, char *sourceFileName, char *destFileName, CfdpReaderFn readerFn, CfdpHandler *faultHandlers, unsigned int flowLabelLength, unsigned char *flowLabel, unsigned int closureLatency, MetadataList messagesToUser, MetadataList filestoreRequests, CfdpProxyTask *proxyTask, CfdpTransactionId *transactionId)

Same as **cfdp_rput** except that *beneficiaryEntityNbr* is omitted; the local entity is the implicit beneficiary of the request.

int cfdp_rls(CfdpNumber *respondentEntityNbr, unsigned int utParmsLength, unsigned char *utParms, char *sourceFileName, char *destFileName, CfdpReaderFn readerFn, CfdpHandler *faultHandlers, unsigned int flowLabelLength, unsigned char *flowLabel, unsigned int closureLatency, MetadataList messagesToUser, MetadataList filestoreRequests, CfdpDirListTask *dirListTask, CfdpTransactionId *transactionId)

Sends to the indicated respondent entity a request to prepare a directory listing, save that listing in a file, and send it to the local entity. The request is subject to the configuration values in *dirListTask*.

int cfdp_preview(CfdpTransactionId *transactionId, uvast offset, unsigned int length, char *buffer);

This function is provided to enable the application to get an advance look at the content of a file that CFDP has not yet fully received. Reads *length* bytes starting at *offset* bytes from the start of the file

that is the destination file of the transaction identified by *transactionID*, into *buffer*. On user error (transaction is nonexistent or is outbound, or offset is beyond the end of file) returns 0. On system failure, returns −1. Otherwise returns number of bytes read.

int cfdp_map(CfdpTransactionId *transactionId, unsigned int *extentCount, CfdpExtent *extentsArray);
This function is provided to enable the application to report on the portions of a partially-received file that have been received and written. Lists the received continuous data extents in the destination file of the transaction identified by *transactionID*. The extents (offset and length) are returned in the elements of *extentsArray*; the number of extents returned in the array is the total number of continuous extents received so far, or *extentCount*, whichever is less. The total number of extents received so far is returned as the new value of *extentCount*. On system failure, returns −1. Otherwise returns 0.

SEE ALSO

cfdpadmin (1), **cfdprc** (5)

NAME

dgr – Datagram Retransmission system library

SYNOPSIS

```
#include "dgr.h"

[see description for available functions]
```

DESCRIPTION

The DGR library is an alternative implementation of a subset of LTP, intended for use over UDP/IP in the Internet; unlike ION's canonical LTP implementation it includes a congestion control mechanism that interprets LTP block transmission failure as an indication of network congestion (not data corruption) and reduces data transmission rate in response.

As such, DGR differs from many reliable-UDP systems in two main ways:

```
It uses adaptive timeout interval computation techniques
borrowed from TCP to try to avoid introducing congestion
into the network.

It borrows the concurrent-session model of transmission
from LTP (and ultimately from CFDP), rather than waiting
for one datagram to be acknowledged before sending the next,
to improve bandwidth utilization.
```

At this time DGR is interoperable with other implementations of LTP only when each block it receives is transmitted in a single LTP data segment encapsulated in a single UDP datagram. More complex LTP behavior may be implemented in the future.

int dgr_open(uvast ownEngineId, unsigned int clientSvcId, unsigned short ownPortNbr, unsigned int ownIpAddress, char *memmgrName, Dgr *dgr, DgrRC *rc)

Establishes the application's access to DGR communication service.

ownEngineId is the sending LTP engine ID that will characterize segments issued by this DGR service access point. In order to prevent erroneous system behavior, never assign the same LTP engine ID to any two interoperating DGR SAPs.

clientSvcId identifies the LTP client service to which all LTP segments issued by this DGR service access point will be directed.

ownPortNbr is the port number to use for DGR service. If zero, a system-assigned UDP port number is used.

ownIpAddress is the Internet address of the network interface to use for DGR service. If zero, this argument defaults to the address of the interface identified by the local machine's host name.

memmgrName is the name of the memory manager (see **memmgr**(3)) to use for dynamic memory management in DGR. If NULL, defaults to the standard system **malloc()** and **free()** functions.

dgr is the location in which to store the service access pointer that must be supplied on subsequent DGR function invocations.

rc is the location in which to store the DGR return code resulting from the attempt to open this service access point (always DgrOpened).

On any failure, returns −1. On success, returns zero.

void dgr_getsockname(Dgr dgr, unsigned short *portNbr, unsigned int *ipAddress)

States the port number and IP address of the UDP socket used for this DGR service access point.

void dgr_close(Dgr dgr)

Reverses **dgr_open**(), releasing resources where possible.

int dgr_send(Dgr dgr, unsigned short toPortNbr, unsigned int toIpAddress, int notificationFlags, char *content, int length, DgrRC *rc)

Sends the indicated content, of length as indicated, to the remote DGR service access point identified by *toPortNbr* and *toIpAddress*. The message will be retransmitted as necessary until either it is acknowledged or DGR determines that it cannot be delivered.

notificationFlags, if non-zero, is the logical OR of the notification behaviors requested for this datagram. Available behaviors are DGR_NOTE_FAILED (a notice of datagram delivery failure will issued if delivery of the datagram fails) and DGR_NOTE_ACKED (a notice of datagram delivery success will be issued if delivery of the datagram succeeds). Notices are issued via **dgr_receive()** that is, the thread that calls **dgr_receive()** on this DGR service access point will receive these notices interspersed with inbound datagram contents.

length of content must be greater than zero and may be as great as 65535, but lengths greater than 8192 may not be supported by the local underlying UDP implementation; to minimize the chance of data loss when transmitting over the internet, length should not exceed 512.

rc is the location in which to store the DGR return code resulting from the attempt to send the content.

On any failure, returns −1 and sets **rc* to DgrFailed. On success, returns zero.

int dgr_receive(Dgr dgr, unsigned short *fromPortNbr, unsigned int *fromIpAddress, char *content, int *length, int *errnbr, int timeoutSeconds, DgrRC *rc)

Delivers the oldest undelivered DGR event queued for delivery.

DGR events are of two type: (a) messages received from a remote DGR service access point and (b) notices of previously sent messages that DGR has determined either have been or cannot be delivered, as requested in the *notificationFlags* parameters provided to the **dgr_send()** calls that sent those messages.

In the former case, **dgr_receive()** will place the content of the inbound message in *content*, its length in *length*, and the IP address and port number of the sender in *fromIpAddress* and *fromPortNbr*, and it will set **rc* to DgrDatagramReceived and return zero.

In the latter case, **dgr_receive()** will place the content of the affected **outbound** message in *content* and its length in *length* and return zero. If the event being reported is a delivery success, then DgrDatagramAcknowledged will be placed in **rc*. Otherwise, DgrDatagramNotAcknowledged will be placed in **rc* and the relevant errno (if any) will be placed in **errnbr*.

The *content* buffer should be at least 65535 bytes in length to enable delivery of the content of the received or delivered/undeliverable message.

timeoutSeconds controls blocking behavior. If *timeoutSeconds* is DGR_BLOCKING (i.e., −1), **dgr_receive()** will not return until (a) there is either an inbound message to deliver or an outbound message delivery result to report, or (b) the function is interrupted by means of **dgr_interrupt()**. If *timeoutSeconds* is DGR_POLL (i.e., zero), **dgr_receive()** returns immediately; if there is currently no inbound message to deliver and no outbound message delivery result to report, the function sets **rc* to DgrTimedOut and returns zero. For any other positive value of *timeoutSeconds*, **dgr_receive()** returns after the indicated number of seconds have lapsed (in which case the returned value of **rc* is DgrTimedOut), or when there is a message to deliver or a delivery result to report, or when the function is interrupted by means of **dgr_interrupt()**, whichever occurs first. When the function returns due to interruption by **dgr_interrupt()**, the value placed in **rc* is DgrInterrupted instead of DgrDatagramReceived.

rc is the location in which to store the DGR return code resulting from the attempt to receive content.

On any I/O error or other unrecoverable system error, returns −1. Otherwise always returns zero, placing DgrFailed in **rc* and writing a failure message in the event of an operating error.

void dgr_interrupt(Dgr dgr)

Interrupts a **dgr_receive()** invocation that is currently blocked. Designed to be called from a signal handler; for this purpose, *dgr* may need to be obtained from a static variable.

SEE ALSO

ltp (3), **file2dgr** (1), **dgr2file** (1)

NAME

dtpc − Delay−Tolerant Payload Conditioning (DTPC) communications library

SYNOPSIS

```
#include "dtpc.h"

[see description for available functions]
```

DESCRIPTION

The dtpc library provides functions enabling application software to use Delay-Tolerant Payload Conditioning (DTPC) when exchanging information over a delay-tolerant network. DTPC is an application service protocol, running in a layer immediately above Bundle Protocol, that offers delay-tolerant support for several end-to-end services to applications that may require them. These services include delivery of application data items in transmission (rather than reception) order; detection of reception gaps in the sequence of transmitted application data items, with end-to-end negative acknowledgment of the missing data; end-to-end positive acknowledgment of successfully received data; end-to-end retransmission of missing data, driven either by negative acknowledgment or timer expiration; suppression of duplicate application data items; aggregation of small application data items into large bundle payloads, to reduce bundle protocol overhead; and application-controlled elision of redundant data items in aggregated payloads, to improve link utiliization.

int dptc_attach( )

Attaches the application to DTPC functionality on the local computer. Returns 0 on success, −1 on any error.

void dptc_detach( )

Terminates all access to DTPC functionality on the local computer.

int dtpc_entity_is_started( )

Returns 1 if the local DTPC entity has been started and not yet stopped, 0 otherwise.

int dtpc_open(unsigned int topicID, DtpcElisionFn elisionFn, DtpcSAP *dtpcsapPtr)

Establishes the application as the sole authorized client for posting and receiving application data items on topic *topicID* within the local BP node. On success, the service access point for posting and receiving such data items is placed in **dtpcsapPtr*, the elision callback function *elisionFn* (if not NULL) is associated with this topic, and 0 is returned. Returns −1 on any error.

int dtpc_send(unsigned int profileID, DtpcSAP sap, char *destEid, unsigned int maxRtx, unsigned int aggrSizeLimit, unsigned int aggrTimeLimit, int lifespan, BpAncillaryData *ancillaryData, unsigned char srrFlags, BpCustodySwitch custodySwitch, char *reportToEid, int classOfService, Object item, unsigned int length)

Inserts an application data item into an outbound DTPC application data unit destined for *destEid*.

Transmission of that outbound ADU will be subject to the profile identified by *profileID*, as asserted by **dtpcadmin** (1), if *profileID* is non-zero. In that case, *maxRtx*, *aggrSizeLimit*, *aggrTimeLimit*, *lifespan*, *ancillaryData*, *srrFlags*, *custodySwitch*, *reportToEid*, and *classOfService* are ignored.

If *profileID* is zero then the profile asserted by **dtpcadmin** (1) that matches *maxRtx*, *aggrSizeLimit*, *aggrTimeLimit*, *lifespan*, *ancillaryData*, *srrFlags*, *custodySwitch*, *reportToEid*, and *classOfService* will govern transmission of the ADU, unless no such profile has been asserted, in which case **dtpc_send()** returns 0 indicating user error.

maxRtx is the maximum number of times any single DTPC ADU transmitted subject to the indicated profile may be retransmitted by the DTPC entity. If *maxRtx* is zero, then the DTPC transport service features (in-order delivery, end-to-end acknowledgment, etc.) are disabled for this profile.

aggrSizeLimit is the size threshold for concluding aggregation of an outbound ADU and requesting transmission of that ADU. If *aggrSizeLimit* is zero, then the DTPC transmission optimization features (aggregation and elision) are disabled for this profile.

aggrTimeLimit is the time threshold for concluding aggregation of an outbound ADU and requesting

transmission of that ADU. If *aggrTimeLimit* is zero, then the DTPC transmission optimization features (aggregation and elision) are disabled for this profile.

lifespan, *ancillaryData*, *srrFlags*, *custodySwitch*, *reportToEid*, and *classOfService* are as defined for bp_send (see **bp** (3)).

item must be an object allocated within ION's SDR ''heap'', and *length* must be the length of that object. The item will be inserted into the outbound ADU's list of data items posted for the topic associated with *sap*, and the elision callback function declared for *sap* (if any, and if the applicable profile does not disable transmission optimization features) will be invoked immediately after insertion of the application data item but before DTPC makes any decision on whether or not to initiate transmission of the outbound ADU.

The function returns 1 on success, 0 on any user application error, −1 on any system error.

int dtpc_receive(DtpcSAP sap, DtpcDelivery *dlvBuffer, int timeoutSeconds)
Receives a single DTPC application data item, or reports on some failure of DTPC reception activity.

The ''result'' field of the dlvBuffer structure will be used to indicate the outcome of the data reception activity.

If at least one application data item on the topic associated with *sap* has not yet been delivered to the SAP, then the payload of the oldest such item will be returned in *dlvBuffer*−>*item* and *dlvBuffer*−>*result* will be set to PayloadPresent. If there is no such item, **dtpc_receive()** blocks for up to *timeoutSeconds* while waiting for one to arrive.

If *timeoutSeconds* is DTPC_POLL (i.e., zero) and no application data item is awaiting delivery, or if *timeoutSeconds* is greater than zero but no item arrives before *timeoutSeconds* have elapsed, then *dlvBuffer*−>*result* will be set to ReceptionTimedOut. If *timeoutSeconds* is DTPC_BLOCKING (i.e., −1) then **bp_receive()** blocks until either an item arrives or the function is interrupted by an invocation of **dtpc_interrupt()**.

dlvBuffer−>*result* will be set to ReceptionInterrupted in the event that the calling process received and handled some signal other than SIGALRM while waiting for a bundle.

dlvBuffer−>*result* will be set to DtpcServiceStopped in the event that DTPC service has been terminated on the local node.

The application data item delivered in the DTPC delivery structure, if any, will be an object allocated within ION's SDR ''heap''; the length of that object will likewise be provided in the DtpcDelivery structure.

Be sure to call **dtpc_release_delivery()** after every successful invocation of **dtpc_receive()**.

The function returns 0 on success, −1 on any error.

void dtpc_interrupt(DtpcSAP sap)
Interrupts a **dtpc_receive()** invocation that is currently blocked. This function is designed to be called from a signal handler; for this purpose, *sap* may need to be obtained from a static variable.

void dtpc_release_delivery(DtpcDelivery *dlvBuffer)
Releases resources allocated to the indicated DTPC delivery.

void dtpc_close(DtpcSAP sap)
Removes the application as the sole authorized client for posting and receiving application data items on the topic indicated in *sap* within the local BP node. The application relinquishes its ability to send and receive application data items on the indicated topic.

SEE ALSO

dtpcadmin (1), **dtpcrc** (5), **bp** (3)

NAME

ion – Interplanetary Overlay Network common definitions and functions

SYNOPSIS

```
#include "ion.h"

[see description for available functions]
```

DESCRIPTION

The Interplanetary Overlay Network (ION) software distribution is an implementation of Delay-Tolerant Networking (DTN) architecture as described in Internet RFC 4838. It is designed to enable inexpensive insertion of DTN functionality into embedded systems such as robotic spacecraft. The intent of ION deployment in space flight mission systems is to reduce cost and risk in mission communications by simplifying the construction and operation of automated digital data communication networks spanning space links, planetary surface links, and terrestrial links.

The ION distribution comprises the following software packages:

ici (Interplanetary Communication Infrastructure), a set of general-purpose libraries providing common functionality to the other packages.

ltp (Licklider Transmission Protocol), a core DTN protocol that provides transmission reliability based on delay-tolerant acknowledgments, timeouts, and retransmissions.

dgr (Datagram Retransmission), a library that enables data to be transmitted via UDP with reliability comparable to that provided by TCP. DGR is an alternative implementation of LTP, designed for use within an internet.

bssp (Bundle Streaming Service Protocol), a protocol that supports delay-tolerant data streaming. BSSP delivers data in transmission order with minimum latency but possibly with omissions, for immediate display, and at the same time it delivers the same data reliably in background so that the streamed data can be ‘‘rewound’’ for possibly improved presentation.

bp (Bundle Protocol), a core DTN protocol that provides delay-tolerant forwarding of data through a network in which continuous end-to-end connectivity is never assured, including support for delay-tolerant dynamic routing. The Bundle Protocol (BP) specification is defined in Internet RFC 5050.

ams (Asynchronous Message Service), *cfdp* (CCSDS File Delivery Protocol), *dtpc* (Delay-Tolerant Payload Conditioning), and *bss* (Bundle Streaming Service), application-layer services that are not part of the DTN architecture but utilize underlying DTN protocols.

Taken together, the packages included in the ION software distribution constitute a communication capability characterized by the following operational features:

Reliable conveyance of data over a DTN, i.e., a network in which it might never be possible for any node to have reliable information about the detailed current state of any other node.

Built on this capability, reliable distribution of short messages to multiple recipients (subscribers) residing in such a network.

Management of traffic through such a network.

Facilities for monitoring the performance of the network.

Robustness against node failure.

Portability across heterogeneous computing platforms.

High speed with low overhead.

Easy integration with heterogeneous underlying communication infrastructure, ranging from Internet to dedicated spacecraft communication links.

While most of the ici package consists of libraries providing functionality that may be of general utility in

any complex embedded software system, the functions and macros described below are specifically designed to support operations of ION's delay-tolerant networking protocol stack.

TIMESTAMPBUFSZ
: This macro returns the recommended size of a buffer that is intended to contain a timestamp in ION-standard format:

    yyyy/mm/dd−hh:mm:ss

int **ionAttach()**
: Attaches the invoking task to ION infrastructure as previously established by running the *ionadmin* utility program. Returns zero on success, −1 on any error.

void **ionDetach()**
: Detaches the invoking task from ION infrastructure. In particular, releases handle allocated for access to ION's non-volatile database. **NOTE**, though, that **ionDetach()** has no effect when the invoking task is running in a non-memory-protected environment, such as VxWorks, where all ION resource access variables are shared by all tasks: no single task could detach without crashing all other ION tasks.

void ionProd(uvast fromNode, uvast toNode, unsigned int xmitRate, unsigned int owlt)
: This function is designed to be called from an operating environment command or a fault protection routine, to enable operation of a node to resume when all of its scheduled contacts are in the past (making it impossible to use a DTN communication contact to assert additional future communication contacts). The function asserts a single new unidirectional contact conforming to the arguments provided, including the applicable one-way light time, with start time equal to the current time (at the moment of execution of the function) and end time equal to the start time plus 2 hours. The result of executing the function is written to the ION log using standard ION status message logging functions.

    NOTE that the **ionProd()** function must be invoked twice in order to establish bidirectional communication.

void **ionTerminate()**
: Shuts down the entire ION node, terminating all daemons. The state of the node is retained in the node's SDR heap.

int ionStartAttendant(ReqAttendant *attendant)
: Initializes the semaphore in *attendant* so that it can be used for blocking ZCO space requisitions by **ionRequestZcoSpace()**. Returns 0 on success, −1 on any error.

void ionPauseAttendant(ReqAttendant *attendant)
: ''Ends'' the semaphore in *attendant* so that the task that is blocked on taking it is interrupted and may respond to an error or shutdown condition.

void ionResumeAttendant(ReqAttendant *attendant)
: Reinitializes the semaphore in *attendant* so that it can again be used for blocking ZCO space requisitions.

void ionStopAttendant(ReqAttendant *attendant)
: Destroys the semaphore in *attendant*, preventing a potential resource leak.

int ionRequestZcoSpace(ZcoAcct acct, vast fileSpaceNeeded, vast bulkSpaceNeeded, vast heapSpaceNeeded, unsigned char coarsePriority, unsigned char finePriority, ReqAttendant *attendant, ReqTicket *ticket)
: Lodges a request for ZCO space in the pool identified by *acct*. If the requested space can be provided immediately, it is reserved for use by the calling task. Otherwise, if *attendant* is non-NULL then the request is queued for service when space becomes available. In any case, **ticket* is set to the address of a ''ticket'' referencing this request. The status of the request can be interrogated by calling **ionSpaceAwarded()**. If this function returns 1 (True) then ZCO space may be consumed immediately and the ticket must then be destroyed by a call to **ionShred()**. Otherwise, if an attendant was provided, then the calling task should pend on the semaphore in *attendant* and upon successfully taking the semaphore it must consume the requested ZCO space and then **ionShred()** the ticket.

Otherwise the request for ZCO space has been definitively denied and, as always, the ticket must by destroyed by an invocation of **ionShred()**. Returns 0 on success, −1 on any failure.

int ionSpaceAwarded(ReqTicket *ticket)

Returns 1 if *ticket* is for a ZCO space request that has been serviced (ZCO space has been reserved per this request), 0 otherwise.

void ionShred(ReqTicket *ticket)

Dismisses the reservation of ZCO space (if any) requested by the call to **ionRequestZcoSpace()** that returned *ticket*. Calling **ionShred()** indicates either that the requested space was reserved (i.e., the request was ''serviced'') and has been claimed (consumed by the appending of a ZCO extent) or that the request has been canceled. Note that failure to promptly (within 3 seconds of reception) **ionShred()** the ticket for a service request will be interpreted as refusal of the reserved ZCO space, resulting in that space being made available for use by other tasks.

Object ionCreateZco(ZcoMedium source, Object location, vast offset, vast length, unsigned char coarsePriority, unsigned char finePriority, ZcoAcct acct, ReqAttendant *attendant)

This function provides a ''blocking'' implementation of admission control in ION. Like **zco_create()**, it constructs a zero-copy object (see **zco** (3)) that contains a single extent of source data residing at *location* in *source*, of which the first *offset* bytes are omitted and the next *length* bytes are included. But unlike **zco_create()**, **ionCreateZco()** can be configured to block (rather than return an immediate error indication) so long as the total amount of space in *source* that is available for new ZCO formation is less than *length*. **ionCreateZco()** operates by calling **ionRequestZcoSpace()**, then pending on the semaphore in *attendant* as necessary before creating the ZCO. **ionCreateZco()** returns when either (a) space has become available and the ZCO has been created, in which case the location of the ZCO is returned, or (b) the function has failed (in which case ((Object) −1) is returned), or (c) either *attendant* was null and sufficient space for the first extent of the ZCO was not immediately available or else the function was interrupted by **ionPauseAttendant()** before space for the ZCO became available (in which case 0 is returned).

vast ionAppendZcoExtent(Object zco, ZcoMedium source, Object location, vast offset, vast length, unsigned char coarsePriority, unsigned char finePriority, ReqAttendant *attendant)

Similar to **ionCreateZco()** except that instead of creating a new ZCO it appends an additional extent to an existing ZCO. Returns −1 on failure, 0 on interruption by **ionPauseAttendant()** or if *attendant* was NULL and sufficient space for the extent was not immediately available, *length* on success.

char ***getIonVersionNbr()**

Returns the name of the ION version installed on the local machine.

Sdr **getIonsdr()**

Returns a pointer to the SDR management object, previously acquired by calling **ionAttach()**, or zero on any error.

PsmPartition **getIonwm()**

Returns a pointer to the ION working memory partition, previously acquired by calling **ionAttach()**, or zero on any error.

int **getIonMemoryMgr()**

Returns the memory manager ID for operations on ION's working memory partition, previously acquired by calling **ionAttach()**, or −1 on any error.

int **ionLocked**();

Returns 1 if the calling task is the owner of the current SDR transaction. Assuring that ION is locked while related critical operations are performed is essential to the avoidance of race conditions.

uvast **getOwnNodeNbr()**

Returns the Bundle Protocol node number identifying this node, as declared when ION was initialized by *ionadmin*.

time_t **getCtime()**

Returns the current calendar (i.e., Unix epoch) time, as computed from local clock time and the computer's current offset from UTC (due to clock drift, **not** due to time zone difference; the **utcdelta**) as managed from *ionadmin*.

int **ionClockIsSynchronized()**

Returns 1 if the computer on which the local ION node is running has a synchronized clock , i.e., a clock that reports the current calendar (i.e., Unix epoch) time as a value that differs from the correct calendar time by an interval approximately equal to the currently asserted offset from UTC due to clock drift; returns zero otherwise.

If the machine's clock is synchronized then its reported values (as returned by **getCtime()**) can safely be used as the creation times of new bundles and the expiration time of such a bundle can accurately be computed as the sum of the bundle's creation time and time to live. If not, then the creation timestamp time of new bundles sourced at the local ION node must be zero and the creation timestamp sequence numbers must increase monotonically forever, never rolling over to zero.

void writeTimestampLocal(time_t timestamp, char *timestampBuffer)

Expresses the time value in *timestamp* as a local timestamp string in ION-standard format, as noted above, in *timestampBuffer*.

void writeTimestampUTC(time_t timestamp, char *timestampBuffer)

Expresses the time value in *timestamp* as a UTC timestamp string in ION-standard format, as noted above, in *timestampBuffer*.

time_t readTimestampLocal(char *timestampBuffer, time_t referenceTime)

Parses the local timestamp string in *timestampBuffer* and returns the corresponding calendar (i.e., Unix epoch) time value (as would be returned by **time** (2)), or zero if the timestamp string cannot be parsed successfully. The timestamp string is normally expected to be an absolute expression of local time in ION-standard format as noted above. However, a relative time expression variant is also supported: if the first character of *timestampBuffer* is '+' then the remainder of the string is interpreted as a count of seconds; the sum of this value and the time value in *referenceTime* is returned.

time_t readTimestampUTC(char *timestampBuffer, time_t referenceTime)

Same as **readTimestampLocal()** except that if *timestampBuffer* is not a relative time expression then it is interpreted as an absolute expression of UTC time in ION-standard format as noted above.

STATUS MESSAGES

ION uses **writeMemo()**, **putErrmsg()**, and **putSysErrmsg()** to log several different types of standardized status messages.

Informational messages

These messages are generated to inform the user of the occurrence of events that are nominal but significant, such as the controlled termination of a daemon or the production of a congestion forecast. Each informational message has the following format:

{*yyyy/mm/dd hh:mm:ss*} [i] *text*

Warning messages

These messages are generated to inform the user of the occurrence of events that are off-nominal but are likely caused by configuration or operational errors rather than software failure. Each warning message has the following format:

{*yyyy/mm/dd hh:mm:ss*} [?] *text*

Diagnostic messages

These messages are produced by calling **putErrmsg()** or **putSysErrmsg()**. They are generated to inform the user of the occurrence of events that are off-nominal and might be due to errors in software. The location within the ION software at which the off-nominal condition was detected is indicated in the message:

{*yyyy/mm/dd hh:mm:ss*} at line *nnn* of *sourcefilename*, *text* (*argument*)

Note that the *argument* portion of the message (including its enclosing parentheses) will be provided only when an argument value seems potentially helpful in fault analysis.

Bundle Status Report (BSR) messages

A BSR message informs the user of the arrival of a BSR, a Bundle Protocol report on the status of some bundle. BSRs are issued in the course of processing bundles for which one or more status report request flags are set, and they are also issued when bundles for which custody transfer is requested are destroyed prior to delivery to their destination endpoints. A BSR message is generated by **ipnadminep** upon reception of a BSR. The time and place (node) at which the BSR was issued are indicated in the message:

{*yyyy/mm/dd hh:mm:ss*} [s] (*sourceEID*)/*creationTimeSeconds*:*counter*/*fragmentOffset* status *flagsByte* at *time* on *endpointID*, '*reasonString*'.

Communication statistics messages

A network performance report is a set of eight communication statistics messages, one for each of eight different types of network activity. A report is issued every time contact transmission or reception starts or stops, except when there is no activity of any kind on the local node since the prior report. When a report is issued, statistic messages are generated to summarize all network activity detected since the prior report, after which all network activity counters and accumulators are reset to zero.

NOTE also that the **bpstats** utility program can be invoked to issue an interim network performance report at any time. Issuance of interim status reports does **not** cause network activity counters and accumulators to be reset to zero.

Statistics messages have the following format:

{*yyyy/mm/dd hh:mm:ss*} [x] *xxx* from *ttttttt* to *TTTTTTTT*: (0) *aaaa bbbbbbbbbb* (1) *cccc ddddddddd* (2) *eeee fffffffff* (+) *gggg hhhhhhhhhh*

xxx indicates the type of network activity that the message is reporting on. Statistics for eight different types of network activity are reported:

src This message reports on the bundles sourced at the local node during the indicated interval.

fwd
This message is about routing; it reports on the number of bundles queued for forwarding to neighboring nodes as selected by the routing procedure. When a bundle must be re-forwarded due to convergence-layer transmission failure it is counted a second time here.

xmt
This message reports on the bundles passed to the convergence layer protocol(s) for transmission from this node. Again, a re-forwarded bundle that is then re-transmitted at the convergence layer is counted a second time here.

rcv This message reports on the bundles from other nodes that were received at the local node.

dlv This message reports on the bundles delivered to applications via endpoints on the local node.

ctr This message reports on the custody refusal signals received at the local node.

rfw This message reports on bundles for which convergence-layer transmission failed at this node, causing the bundles to be re-forwarded.

exp This message reports on the bundles destroyed at this node due to TTL expiration.

ttttttt and *TTTTTTTT* indicate the start and end times of the interval for which statistics are being reported, expressed in *yyyy/mm/dd−hh:mm:ss* format. *TTTTTTTT* is the current time and *ttttttt* is the time of the prior report.

Each of the four value pairs following the colon (:) reports on the number of bundles counted for the indicated type of network activity, for the indicated traffic flow, followed by the sum of the sizes of the payloads of all those bundles. The four traffic flows for which statistics are reported are "(0)" the

priority−0 or ‘‘bulk’’ traffic, ‘‘(1)’’ the priority−1 ‘‘standard’’ traffic, ‘‘(2)’’ the priority−2 ‘‘expedited’’ traffic, and ‘‘(+)’’ the total for all classes of service.

Free-form messages

Other status messages are free-form, except that date and time are always noted just as for the documented status message types.

SEE ALSO

ionadmin (1), **rfxclock** (1), **bpstats** (1), **llcv** (3), **lyst** (3), **memmgr** (3), **platform** (3), **psm** (3), **sdr** (3), **zco** (3), **ltp** (3), **bp** (3), **cfdp** (3), **ams** (3), **bss** (3)

NAME

cbor – ION library for encoding and decoding CBOR data representations

SYNOPSIS

```
#include "cbor.h"
```

DESCRIPTION

ION's ''cbor'' library implements a subset of the Concise Binary Object Representation (CBOR) standard, RFC 7049; only those data types used in ION code are implemented. Unlike other CBOR implementations, ION CBOR is specifically intended for compatibility with zero-copy objects, i.e., the data being decoded need not all be in a memory buffer.

For all functions, **cursor* is a pointer to the location in the CBOR coding buffer at which bytes are to be encoded or decoded. This pointer is automatically advanced as the encoding or decoding operation is performed.

Most of the ION CBOR decoding functions entail the decoding of unsigned integers. The invoking code may require that an integer representation have a specific size by indicating the integer size ''class'' that is required. Class −1 indicates that an integer of any size is acceptable; the other classes (0, 1, 2, 4, 8) indicate the number of bytes of integer data that MUST follow the integers initial byte.

int cbor_encode_integer(uvast value, unsigned char **cursor)
: Represent this value in an integer of the smallest possible integer class. Cursor is automatically advanced. Returns number of bytes written.

int cbor_encode_fixed_int(uvast value, int class, unsigned char **cursor)
: Represent this value in an integer of the indicated class. Cursor is automatically advanced. Returns number of bytes written, 0 on encoding error.

int cbor_encode_byte_string(unsigned char *value, uvast size, unsigned char **cursor)
: *size* is the number of bytes to write. If value is NULL, only the size of the byte string is written; otherwise the byte string itself is written as well. Cursor is advanced by the number of bytes written in either case. Returns number of bytes written.

int cbor_encode_text_string(char *value, uvast size, unsigned char **cursor)
: *size* is the number of bytes to write. If value is NULL, only the size of the text string is written; otherwise the text string itself is written as well. Cursor is advanced by the number of bytes written in either case. Returns number of bytes written.

int cbor_encode_array_open(uvast size, unsigned char **cursor)
: If *size* is ((uvast) −1), the array is of indefinite size; otherwise *size* indicates the number of items in the array. Cursor is automatically advanced. Returns number of bytes written.

int cbor_encode_break(unsigned char **cursor)
: Break code is written at the indicated location. Cursor is automatically advanced. Returns number of bytes written (always 1).

int cbor_decode_initial_byte(unsigned char **cursor, unsigned int *bytesBuffered, int *majorType, int *additionalInfo)
: This function just extracts major type and additional info from the byte identified by *cursor*. Cursor is automatically advanced. Returns number of bytes decoded (always 1) or 0 on decoding error (e.g., no byte to decode).

int cbor_decode_integer(uvast *value, int class, unsigned char **cursor, unsigned int *bytesBuffered)
: If *class* is CborAny, any class of data item is accepted; otherwise only an integer data item of the indicated class is accepted. Cursor is automatically advanced. Returns number of bytes read, 0 on decoding error (e.g., integer is of the wrong class).

int cbor_decode_byte_string(unsigned char *value, uvast *size, unsigned char **cursor, unsigned int *bytesBuffered)
: Initial value of *size* is the maximum allowable size of the decoded byte string; the actual number of bytes in the byte string (which, **NOTE**, is less than the number of bytes read) is returned in *size*. If

value is non-NULL, the decoded byte string is copied into *value* and cursor is automatically advanced to the end of the byte string; otherwise, cursor is advanced only to the beginning of the byte string. Returns number of bytes read, 0 on decoding error (e.g., byte string exceeds maximum size).

int cbor_decode_text_string(char *value, uvast *size, unsigned char **cursor, unsigned int *bytesBuffered)
Initial value of *size* is the maximum allowable size of the decoded text string; the actual number of bytes in the text string (which, **NOTE**, is less than the number of bytes read) is returned in size. If *value* is non-NULL, the decoded text string is copied into *value* and cursor is automatically advanced to the end of the text string; otherwise, cursor is advanced only to the beginning of the text string. Returns number of bytes read, 0 on decoding error (e.g., text string exceeds maximum size).

int cbor_decode_array_open(uvast *size, unsigned char **cursor, unsigned int *bytesBuffered)
If *size* is zero, any array is accepted and the actual size of the decoded array is returned in *size*; ((uvast) −1) is returned in *size* if the array is of indefinite size. If *size* is ((uvast) −1), **only** an array of indefinite length is accepted. Otherwise, *size* indicates the required number of items in the array. Cursor is automatically advanced. Returns number of bytes read, 0 on decoding error (such as wrong number of items).

int cbor_decode_break(unsigned char **cursor, unsigned int *bytesBuffered)
Break code is read from the indicated location. Cursor is automatically advanced. Returns number of bytes read, 0 on decoding error (e.g., no break character at this location).

NAME

crc − ION library for computing several types of checksums.

SYNOPSIS

```
#include "crc.h"
```

DESCRIPTION

ION's ''crc'' library implements functions for computing four types of checksums: X.25 (16−bit), bzip2 (32−bit), CRC32 (32−bit), and CRC32C (32−bit).

All checksum computation functions were provided by Antara Teknik, LLC.

uint16_t ion_CRC16_1021_X25(const char *data, uint32_t dLen, uint16_t crc)

Computes the CRC16 value for poly 0x1021. *data* points to the data block over which the checksum value is to be computed, *len* must be the length of that data block, and *crc* is the current value of the checksum that is being incrementally computed over a multi-block extent of data (zero for the first block of this extent, or if this block is the entire extent).

uint32_t ion_CRC32_04C11DB7_bzip2(const char *data, uint32_t dLen, uint32_t crc)

Computes the bzip2 CRC32 checksum value for poly 0x04c11db7. *data* points to the data block over which the checksum value is to be computed, *len* must be the length of that data block, and *crc* is the current value of the checksum that is being incrementally computed over a multi-block extent of data (zero for the first block of this extent, or if this block is the entire extent).

uint32_t ion_CRC32_04C11DB7(const char *data, uint32_t dLen, uint32_t crc)

Computes the ISO-HDLC CRC32 value for poly 0x04c11db7. *data* points to the data block over which the checksum value is to be computed, *len* must be the length of that data block, and *crc* is the current value of the checksum that is being incrementally computed over a multi-block extent of data (zero for the first block of this extent, or if this block is the entire extent).

uint32_t ion_CRC32_1EDC6F41_C(const char *data, uint32_t dLen, uint32_t crc)

Computes the CRC32C value for poly 0x1edc6f41. *data* points to the data block over which the checksum value is to be computed, *len* must be the length of that data block, and *crc* is the current value of the checksum that is being incrementally computed over a multi-block extent of data (zero for the first block of this extent, or if this block is the entire extent).

NAME

llcv − library for manipulating linked−list condition variable objects

SYNOPSIS

```
#include "llcv.h"

typedef struct llcv_str
{
    Lyst            list;
    pthread_mutex_t mutex;
    pthread_cond_t  cv;
} *Llcv;

typedef int (*LlcvPredicate)(Llcv);

[see description for available functions]
```

DESCRIPTION

A ‘‘linked-list condition variable’’ object (LLCV) is an inter-thread communication mechanism that pairs a process-private linked list in memory with a condition variable as provided by the pthreads library. LLCVs echo in thread programming the standard ION inter-process or inter-task communication model that pairs shared-memory semaphores with linked lists in shared memory or shared non-volatile storage. As in the semaphore/list model, variable-length messages may be transmitted; the resources allocated to the communication mechanism grow and shrink to accommodate changes in data rate; the rate at which messages are issued is completely decoupled from the rate at which messages are received and processed. That is, there is no flow control, no blocking, and therefore no possibility of deadlock or ‘‘deadly embrace’’. Traffic spikes are handled without impact on processing rate, provided sufficient memory is provided to accommodate the peak backlog.

An LLCV comprises a Lyst, a mutex, and a condition variable. The Lyst may be in either private or shared memory, but the Lyst itself is not shared with other processes. The reader thread waits on the condition variable until signaled by a writer that some condition is now true. The standard Lyst API functions are used to populate and drain the linked list. In order to protect linked list integrity, each thread must call **llcv_lock()** before operating on the Lyst and **llcv_unlock()** afterwards. The other llcv functions merely effect flow signaling in a way that makes it unnecessary for the reader to poll or busy-wait on the Lyst.

Llcv llcv_open(Lyst list, Llcv llcv)

Opens an LLCV, initializing as necessary. The *list* argument must point to an existing Lyst, which may reside in either private or shared dynamic memory. *llcv* must point to an existing llcv_str management object, which may reside in either static or dynamic (private or shared) memory — but *NOT* in stack space. Returns *llcv* on success, NULL on any error.

void llcv_lock(Llcv llcv)

Locks the LLCV’s Lyst so that it may be updated or examined safely by the calling thread. Fails silently on any error.

void llcv_unlock(Llcv llcv)

Unlocks the LLCV’s Lyst so that another thread may lock and update or examine it. Fails silently on any error.

int llcv_wait(Llcv llcv, LlcvPredicate cond, int microseconds)

Returns when the Lyst encapsulated within the LLCV meets the indicated condition. If *microseconds* is non-negative, will return −1 and set *errno* to ETIMEDOUT when the indicated number of microseconds has passed, if and only if the indicated condition has not been met by that time. Negative values of the microseconds argument other than LLCV_BLOCKING (defined as −1) are illegal. Returns −1 on any error.

void llcv_signal(Llcv llcv, LlcvPredicate cond)
: Locks the indicated LLCV's Lyst; tests (evaluates) the indicated condition with regard to that LLCV; if the condition is true, signals to the waiting reader on this LLCV (if any) that the Lyst encapsulated in the indicated LLCV now meets the indicated condition; and unlocks the Lyst.

void llcv_signal_while_locked(Llcv llcv, LlcvPredicate cond)
: Same as **llcv_signal()** except does not lock the Llcv's mutex before signalling or unlock afterwards. For use when the Llcv is already locked; prevents deadlock.

void llcv_close(Llcv llcv)
: Destroys the indicated LLCV's mutex and condition variable. Fails silently (and has no effect) if a reader is currently waiting on the Llcv.

int llcv_lyst_is_empty(Llcv Llcv)
: A built-in "convenience" predicate, for use when calling **llcv_wait()**, **llcv_signal()**, or **llcv_signal_while_locked()**. Returns true if the length of the indicated LLCV's encapsulated Lyst is zero, false otherwise.

int llcv_lyst_not_empty(Llcv Llcv)
: A built-in "convenience" predicate, for use when calling **llcv_wait()**, **llcv_signal()**, or **llcv_signal_while_locked()**. Returns true if the length of the LLCV's encapsulated Lyst is non-zero, false otherwise.

SEE ALSO

lyst (3)

NAME

lyst – library for manipulating generalized doubly linked lists

SYNOPSIS

```
#include "lyst.h"

typedef int  (*LystCompareFn)(void *s1, void *s2);
typedef void (*LystCallback)(LystElt elt, void *userdata);

[see description for available functions]
```

DESCRIPTION

The ‘‘lyst’’ library uses two types of objects, *Lyst* objects and *LystElt* objects. A Lyst knows how many elements it contains, its first and last elements, the memory manager used to create/destroy the Lyst and its elements, and how the elements are sorted. A LystElt knows its content (normally a pointer to an item in memory), what Lyst it belongs to, and the LystElts before and after it in that Lyst.

Lyst lyst_create(void)
: Create and return a new Lyst object without any elements in it. All operations performed on this Lyst will use the allocation/deallocation functions of the default memory manager ‘‘std’’ (see **memmgr** (3)). Returns NULL on any failure.

Lyst lyst_create_using(unsigned memmgrId)
: Create and return a new Lyst object without any elements in it. All operations performed on this Lyst will use the allocation/deallocation functions of the specified memory manager (see **memmgr** (3)). Returns NULL on any failure.

void lyst_clear(Lyst list)
: Clear a Lyst, i.e. free all elements of *list*, calling the Lyst’s deletion function if defined, but without destroying the Lyst itself.

void lyst_destroy(Lyst list)
: Destroy a Lyst. Will free all elements of *list*, calling the Lyst’s deletion function if defined.

void lyst_compare_set(Lyst list, LystCompareFn compareFn)
LystCompareFn lyst_compare_get(Lyst list)
: Set/get comparison function for specified Lyst. Comparison functions are called with two Lyst element data pointers, and must return a negative integer if first is less than second, 0 if both are equal, and a positive integer if first is greater than second (i.e., same return values as **strcmp** (3)). The comparison function is used by the **lyst_insert()**, **lyst_search()**, **lyst_sort()**, and **lyst_sorted()** functions.

void lyst_direction_set(Lyst list, LystSortDirection direction)
: Set sort direction (either LIST_SORT_ASCENDING or LIST_SORT_DESCENDING) for specified Lyst. If no comparison function is set, then this controls whether new elements are added to the end or beginning (respectively) of the Lyst when **lyst_insert()** is called.

void lyst_delete_set(Lyst list, LystCallback deleteFn, void *userdata)
: Set user deletion function for specified Lyst. This function is automatically called whenever an element of the Lyst is deleted, to perform any user-required processing. When automatically called, the deletion function is passed two arguments: the element being deleted and the *userdata* pointer specified in the **lyst_delete_set()** call.

void lyst_insert_set(Lyst list, LystCallback insertFn, void *userdata)
: Set user insertion function for specified Lyst. This function is automatically called whenever a Lyst element is inserted into the Lyst, to perform any user-required processing. When automatically called, the insertion function is passed two arguments: the element being inserted and the *userdata* pointer specified in the **lyst_insert_set()** call.

unsigned long lyst_length(Lyst list)
: Return the number of elements in the Lyst.

LystElt lyst_insert(Lyst list, void *data)
: Create a new element whose content is the pointer value *data* and insert it into the Lyst. Uses the Lyst's comparison function to select insertion point, if defined; otherwise adds the new element at the beginning or end of the Lyst, depending on the Lyst sort direction setting. Returns a pointer to the newly created element, or NULL on any failure.

LystElt lyst_insert_first(Lyst list, void *data)
LystElt lyst_insert_last(Lyst list, void *data)
: Create a new element and insert it at the beginning/end of the Lyst. If these functions are used when inserting elements into a Lyst with a defined comparison function, then the Lyst may get out of order and future calls to **lyst_insert()** can put new elements in unpredictable locations. Returns a pointer to the newly created element, or NULL on any failure.

LystElt lyst_insert_before(LystElt element, void *data)
LystElt lyst_insert_after(LystElt element, void *data)
: Create a new element and insert it before/after the specified element. If these functions are used when inserting elements into a Lyst with a defined comparison function, then the Lyst may get out of order and future calls to **lyst_insert()** can put new elements in unpredictable locations. Returns a pointer to the newly created element, or NULL on any failure.

void lyst_delete(LystElt element)
: Delete the specified element from its Lyst and deallocate its memory. Calls the user delete function if defined.

LystElt lyst_first(Lyst list)
LystElt lyst_last(Lyst list)
: Return a pointer to the first/last element of a Lyst.

LystElt lyst_next(LystElt element)
LystElt lyst_prev(LystElt element)
: Return a pointer to the element following/preceding the specified element.

LystElt lyst_search(LystElt element, void *searchValue)
: Find the first matching element in a Lyst starting with the specified element. Returns NULL if no matches are found. Uses the Lyst's comparison function if defined, otherwise searches from the given element to the end of the Lyst.

Lyst lyst_lyst(LystElt element)
: Return the Lyst to which the specified element belongs.

void* lyst_data(LystElt element)
void* lyst_data_set(LystElt element, void *data)
: Get/set the pointer value content of the specified Lyst element. The set routine returns the element's previous content, and the delete function is *not* called. If the **lyst_data_set()** function is used on an element of a Lyst with a defined comparison function, then the Lyst may get out of order and future calls to **lyst_insert()** can put new elements in unpredictable locations.

void lyst_sort(Lyst list)
: Sort the Lyst based on the current comparison function and sort direction. A stable insertion sort is used that is very fast when the elements are already in order.

int lyst_sorted(Lyst list)
: Determine whether or not the Lyst is sorted based on the current comparison function and sort direction.

void lyst_apply(Lyst list, LystCallback applyFn, void *userdata)
: Apply the function *applyFn* automatically to each element in the Lyst. When automatically called, *applyFn* is passed two arguments: a pointer to an element, and the *userdata* argument specified in the call to **lyst_apply()**. *applyFn* should not delete or reorder the elements in the Lyst.

SEE ALSO

memmgr (3), **psm** (3)

NAME

memmgr – memory manager abstraction functions

SYNOPSIS

```
#include "memmgr.h"

typedef void *(* MemAllocator)
    (char *fileName, int lineNbr, size_t size);
typedef void (* MemDeallocator)
    (char *fileName, int lineNbr, void * blk);
typedef void *(* MemAtoPConverter) (unsigned int address);
typedef unsigned int (* MemPtoAConverter) (void * pointer);

unsigned int memmgr_add       (char *name,
                               MemAllocator take,
                               MemDeallocator release,
                               MemAtoPConverter AtoP,
                               MemPtoAConverter PtoA);
int memmgr_find               (char *name);
char *memmgr_name             (int mgrId);
MemAllocator memmgr_take      (int mgrId);
MemDeallocator memmgr_release (int mgrId);
MemAtoPConverter memmgr_AtoP  (int mgrId);
MemPtoAConverter memmgr_PtoA  (int mgrId;

int memmgr_open               (int memKey,
                               unsigned long memSize,
                               char **memPtr,
                               int *smId,
                               char *partitionName,
                               PsmPartition *partition,
                               int *memMgr,
                               MemAllocator afn,
                               MemDeallocator ffn,
                               MemAtoPConverter apfn,
                               MemPtoAConverter pafn);
void memmgr_destroy           (int smId,
                               PsmPartition *partition);
```

DESCRIPTION

‘‘memmgr’’ is an abstraction layer for administration of memory management. It enables multiple memory managers to coexist in a single application. Each memory manager specification is required to include pointers to a memory allocation function, a memory deallocation function, and functions for translating between local memory pointers and ‘‘addresses’’, which are abstract memory locations that have private meaning to the manager. The allocation function is expected to return a block of memory of size ‘‘size’’ (in bytes), initialized to all binary zeroes. The *fileName* and *lineNbr* arguments to the allocation and deallocation functions are expected to be the values of _ _FILE_ _ and _ _LINE_ _ at the point at which the functions are called; this supports any memory usage tracing via **sptrace** (3) that may be implemented by the underlying memory management system.

Memory managers are identified by number and by name. The identifying number for a memory manager is an index into a private, fixed-length array of up to 8 memory manager configuration structures; that is, memory manager number must be in the range 0–7. However, memory manager numbers are assigned dynamically and not always predictably. To enable multiple applications to use the same memory manager for a given segment of shared memory, a memory manager may be located by a predefined name of up to 15 characters that is known to all the applications.

The memory manager with manager number 0 is always available; its name is ‘‘std’’. Its memory allocation function is **calloc()**, its deallocation function is **free()**, and its pointer/address translation functions are merely casts.

unsigned int memmgr_add(char *name, MemAllocator take, MemDeallocator release, MemAtoPConverter AtoP, MemPtoAConverter PtoA)

Add a memory manager to the memory manager array, if not already defined; attempting to add a previously added memory manager is not considered an error. *name* is the name of the memory manager. *take* is a pointer to the manager's memory allocation function; *release* is a pointer to the manager's memory deallocation function. *AtoP* is a pointer to the manager's function for converting an address to a local memory pointer; *PtoA* is a pointer to the manager's pointer-to-address converter function. Returns the memory manager ID number assigned to the named manager, or −1 on any error.

NOTE: **memmgr_add()** is NOT thread-safe. In a multithreaded execution image (e.g., VxWorks), all memory managers should be loaded *before* any subordinate threads or tasks are spawned.

int memmgr_find(char *name)

Return the memmgr ID of the named manager, or −1 if not found.

char *memmgr_name(int mgrId)

Return the name of the manager given by *mgrId*.

MemAllocator memmgr_take(int mgrId)

Return the allocator function pointer for the manager given by *mgrId*.

memDeallocator memmgr_release(int mgrId)

Return the deallocator function pointer for the manager given by *mgrId*.

MemAtoPConverter memmgr_AtoP(int mgrId)

Return the address-to-pointer converter function pointer for the manager given by *mgrId*.

MemPtoAConverter memmgr_PtoA(int mgrId)

Return the pointer-to-address converter function pointer for the manager given by *mgrId*.

int memmgr_open(int memKey, unsigned long memSize, char **memPtr, int *smId, char *partitionName, PsmPartition *partition, int *memMgr, MemAllocator afn, MemDeallocator ffn, MemAtoPConverter apfn, MemPtoAConverter pafn);

memmgr_open() opens one avenue of access to a PSM managed region of shared memory, initializing as necessary.

In order for multiple tasks to share access to this memory region, all must cite the same *memkey* and *partitionName* when they call **memmgr_open()**. If shared access is not necessary, then *memKey* can be SM_NO_KEY and *partitionName* can be any valid partition name.

If it is known that a prior invocation of **memmgr_open()** has already initialized the region, then *memSize* can be zero and *memPtr* must be NULL. Otherwise *memSize* is required and the required value of *memPtr* depends on whether or not the memory that is to be shared and managed has already been allocated (e.g., it's a fixed region of bus memory). If so, then the memory pointer variable that *memPtr* points to must contain the address of that memory region. Otherwise, **memPtr* must contain NULL.

memmgr_open() will allocate system memory as necessary and will in any case return the address of the shared memory region in **memPtr*.

If the shared memory is newly allocated or otherwise not yet under PSM management, then **memmgr_open()** will invoke **psm_manage()** to manage the shared memory region. It will also add a catalogue for the managed shared memory region as necessary.

If *memMgr* is non-NULL, then **memmgr_open()** will additionally call **memmgr_add()** to establish a new memory manager for this managed shared memory region, as necessary. The index of the applicable memory manager will be returned in *memMgr*. If that memory manager is newly created, then the supplied *afn*, *ffn*, *apfn*, and *pafn* functions (which can be written with reference to the memory

manager index value returned in *memMgr*) have been established as the memory management functions for local private access to this managed shared memory region.

Returns 0 on success, −1 on any error.

void memmgr_destroy(int smId, PsmPartition *partition);

memmgr_destroy() terminates all access to a PSM managed region of shared memory, invoking **psm_erase()** to destroy the partition and **sm_ShmDestroy()** to destroy the shared memory object.

EXAMPLE

```
/* this example uses the calloc/free memory manager, which is
 * called "std", and is always defined in memmgr. */

#include "memmgr.h"

main()
{
    int mgrId;
    MemAllocator myalloc;
    MemDeallocator myfree;
    char *newBlock;

    mgrId = memmgr_find("std");
    myalloc = memmgr_take(mgrId);
    myfree = memmgr_release(mgrId);
    ...

    newBlock = myalloc(5000);
    ...
    myfree(newBlock);
}
```

SEE ALSO

psm (3)

NAME

platform − C software portability definitions and functions

SYNOPSIS

```
#include "platform.h"

[see description for available functions]
```

DESCRIPTION

platform is a library of functions that simplify the porting of software written in C. It provides an API that enables application code to access the resources of an abstract POSIX-compliant ‘‘least common denominator’’ operating system — typically a large subset of the resources of the actual underlying operating system.

Most of the functionality provided by the platform library is aimed at making communication code portable: common functions for shared memory, semaphores, and IP sockets are provided. The implementation of the abstract O/S API varies according to the actual operating system on which the application runs, but the API’s behavior is always the same; applications that invoke the platform library functions rather than native O/S system calls may forego some O/S−specific capability, but they gain portability at little if any cost in performance.

Differences in word size among platforms are implemented by values of the *SPACE_ORDER* macro. ‘‘Space order’’ is the base 2 log of the number of octets in a word: for 32−bit machines the space order is 2 (2^2 = 4 octets per word), for 64−bit machines it is 3 (2^3 = 8 octets per word).

A consistent platform-independent representation of large integers is useful for some applications. For this purpose, *platform* defines new types **vast** and **uvast** (unsigned vast) which are consistently defined to be 64−bit integers regardless of the platform’s native word size.

The platform.h header file #includes many of the most frequently needed header files: sys/types.h, errno.h, string.h, stdio.h, sys/socket.h, signal.h, dirent.h, netinet/in.h, unistd.h, stdlib.h, sys/time.h, sys/resource.h, malloc.h, sys/param.h, netdb.h, sys/uni.h, and fcntl.h. Beyond this, *platform* attempts to enhance compatibility by providing standard macros, type definitions, external references, or function implementations that are missing from a few supported O/S’s but supported by all others. Finally, entirely new, generic functions are provided to establish a common body of functionality that subsumes significantly different O/S−specific capabilities.

PLATFORM COMPATIBILITY PATCHES

The platform library ‘‘patches’’ the APIs of supported O/S’s to guarantee that all of the following items may be utilized by application software:

```
The strchr(), strrchr(), strcasecmp(), and strncasecmp() functions.

The unlink(), getpid(), and gettimeofday() functions.

The select() function.

The FD_BITMAP macro (used by select()).

The MAXHOSTNAMELEN macro.

The NULL macro.

The timer_t type definition.
```

PLATFORM GENERIC MACROS AND FUNCTIONS

The generic macros and functions in this section may be used in place of comparable O/S−specific functions, to enhance the portability of code. (The implementations of these macros and functions are no-ops in environments in which they are inapplicable, so they’re always safe to call.)

FDTABLE_SIZE
: The FDTABLE_SIZE macro returns the total number of file descriptors defined for the process (or VxWorks target).

ION_PATH_DELIMITER
: The ION_PATH_DELIMITER macro returns the ASCII character — either '/' or '\' — that is used as a directory name delimiter in path names for the file system used by the local platform.

oK(expression)
: The oK macro simply casts the value of *expression* to void, a way of handling function return codes that are not meaningful in this context.

CHKERR(condition)
: The CHKERR macro is an ''assert'' mechanism. It causes the calling function to return −1 immediately if *condition* is false.

CHKZERO(condition)
: The CHKZERO macro is an ''assert'' mechanism. It causes the calling function to return 0 immediately if *condition* is false.

CHKNULL(condition)
: The CHKNULL macro is an ''assert'' mechanism. It causes the calling function to return NULL immediately if *condition* is false.

CHKVOID(condition)
: The CHKVOID macro is an ''assert'' mechanism. It causes the calling function to return immediately if *condition* is false.

void snooze(unsigned int seconds)
: Suspends execution of the invoking task or process for the indicated number of seconds.

void microsnooze(unsigned int microseconds)
: Suspends execution of the invoking task or process for the indicated number of microseconds.

void getCurrentTime(struct timeval *time)
: Returns the current local time (ctime, i.e., Unix epoch time) in a timeval structure (see gettimeofday(3C)).

void isprintf(char *buffer, int bufSize, char *format, ...)
: **isprintf()** is a safe, portable implementation of **snprintf()**; see the snprintf(P) man page for details. **isprintf()** differs from **snprintf()** in that it always NULL-terminates the string in *buffer*, even if the length of the composed string would equal or exceed *bufSize*. Buffer overruns are reported by log message; unlike **snprintf()**, **isprintf()** returns void.

size_t istrlen(const char *sourceString, size_t maxlen)
: **istrlen()** is a safe implementation of **strlen()**; see the **strlen** (3) man page for details. **istrlen()** differs from **strlen()** in that it takes a second argument, the maximum valid length of *sourceString*. The function returns the number of non-NULL characters in *sourceString* preceding the first NULL character in *sourceString*, provided that a NULL character appears somewhere within the first *maxlen* characters of *sourceString*; otherwise it returns *maxlen*.

char *istrcpy(char *buffer, char *sourceString, int bufSize)
: **istrcpy()** is a safe implementation of **strcpy()**; see the **strcpy** (3) man page for details. **istrcpy()** differs from **strcpy()** in that it takes a third argument, the total size of the buffer into which *sourceString* is to be copied. **istrcpy()** always NULL-terminates the string in *buffer*, even if the length of *sourceString* string would equal or exceed *bufSize* (in which case *sourceString* is truncated to fit within the buffer).

char *istrcat(char *buffer, char *sourceString, int bufSize)
: **istrcat()** is a safe implementation of **strcat()**; see the **strcat** (3) man page for details. **istrcat()** differs from **strcat()** in that it takes a third argument, the total size of the buffer for the string that is being aggregated. **istrcat()** always NULL-terminates the string in *buffer*, even if the length of *sourceString*

string would equal or exceed the sum of *bufSize* and the length of the string currently occupying the buffer (in which case *sourceString* is truncated to fit within the buffer).

char *igetcwd(char *buf, size_t size)

igetcwd() is normally just a wrapper around **getcwd** (3). It differs from **getcwd** (3) only when FSWWDNAME is defined, in which case the implementation of **igetcwd()** must be supplied in an included file named ''wdname.c''; this adaptation option accommodates flight software environments in which the current working directory name must be configured rather than discovered at run time.

void isignal(int signbr, void (*handler)(int))

isignal() is a portable, simplified interface to signal handling that is functionally indistinguishable from signal(P). It assures that reception of the indicated signal will interrupt system calls in SVR4 fashion, even when running on a FreeBSD platform.

void iblock(int signbr)

iblock() simply prevents reception of the indicated signal by the calling thread. It provides a means of controlling which of the threads in a process will receive the signal cited in an invocation of **isignal()**.

int ifopen(const char *fileName, int flags, int pmode)

ifopen() is a portable function for opening ''regular'' files. It operates in exactly the same way as **open()** except that it fails (returning −1) if *fileName* does not identify a regular file, i.e., it's a directory, a named pipe, etc.

NOTE that ION also provides **iopen()** which is nothing more than a portable wrapper for **open()**. **iopen()** can be used to open a directory, for example.

char *igets(int fd, char *buffer, int buflen, int *lineLen)

igets() reads a line of text, delimited by a newline character, from *fd* into *buffer* and writes a NULL character at the end of the string. The newline character itself is omitted from the NULL-terminated text line in *buffer*; if the newline is immediately preceded by a carriage return character (i.e., the line is from a DOS text file), then the carriage return character is likewise omitted from the NULL-terminated text line in *buffer*. End of file is interpreted as an implicit newline, terminating the line. If the number of characters preceding the newline is greater than or equal to *buflen*, only the first (*buflen* − 1) characters of the line are written into *buffer*. On error the function sets **lineLen* to −1 and returns NULL. On reading end-of-file, the function sets **lineLen* to zero and returns NULL. Otherwise the function sets **lineLen* to the length of the text line in *buffer*, as if from **strlen** (3), and returns *buffer*.

int iputs(int fd, char *string)

iputs() writes to *fd* the NULL-terminated character string at *string*. No terminating newline character is appended to *string* by **iputs()**. On error the function returns −1; otherwise the function returns the length of the character string written to *fd*, as if from **strlen** (3).

vast strtovast(char *string)

Converts the leading characters of *string*, skipping leading white space and ending at the first subsequent character that can't be interpreted as contributing to a numeric value, to a **vast** integer and returns that integer.

uvast strtouvast(char *string)

Same as **strtovast()** except the result is an unsigned **vast** integer value.

void findToken(char **cursorPtr, char **token)

Locates the next non-whitespace lexical token in a character array, starting at **cursorPtr*. The function NULL-terminates that token within the array and places a pointer to the token in **token*. Also accommodates tokens enclosed within matching single quotes, which may contain embedded spaces and escaped single-quote characters. If no token is found, **token* contains NULL on return from this function.

void *acquireSystemMemory(size_t size)

Uses **memalign()** to allocate a block of system memory of length *size*, starting at an address that is guaranteed to be an integral multiple of the size of a pointer to void, and initializes the entire block to binary zeroes. Returns the starting address of the allocated block on success; returns NULL on any

error.

int createFile(const char *name, int flags)
: Creates a file of the indicated name, using the indicated file creation flags. This function provides common file creation functionality across VxWorks and Unix platforms, invoking **creat()** under VxWorks and **open()** elsewhere. For return values, see **creat** (2) and **open** (2).

unsigned int getInternetAddress(char *hostName)
: Returns the IP address of the indicated host machine, or zero if the address cannot be determined.

char *getInternetHostName(unsigned int hostNbr, char *buffer)
: Writes the host name of the indicated host machine into *buffer* and returns *buffer*, or returns NULL on any error. The size of *buffer* should be (MAXHOSTNAMELEN + 1).

int getNameOfHost(char *buffer, int bufferLength)
: Writes the first (*bufferLength* − 1) characters of the host name of the local machine into *buffer*. Returns 0 on success, −1 on any error.

unsigned int **getAddressOfHost()**
: Returns the IP address for the host name of the local machine, or 0 on any error.

void parseSocketSpec(char *socketSpec, unsigned short *portNbr, unsigned int *hostNbr)
: Parses *socketSpec*, extracting host number (IP address) and port number from the string. *socketSpec* is expected to be of the form ''{ @ | hostname }[:<portnbr>]'', where @ signifies ''the host name of the local machine''. If host number can be determined, writes it into **hostNbr*; otherwise writes 0 into **hostNbr*. If port number is supplied and is in the range 1024 to 65535, writes it into **portNbr*; otherwise writes 0 into **portNbr*.

void printDottedString(unsigned int hostNbr, char *buffer)
: Composes a dotted-string (xxx.xxx.xxx.xxx) representation of the IPv4 address in *hostNbr* and writes that string into *buffer*. The length of *buffer* must be at least 16.

char *getNameOfUser(char *buffer)
: Writes the user name of the invoking task or process into *buffer* and returns *buffer*. The size of *buffer* must be at least *L_cuserid*, a constant defined in the stdio.h header file. Returns *buffer*.

int reUseAddress(int fd)
: Makes the address that is bound to the socket identified by *fd* reusable, so that the socket can be closed and immediately reopened and re-bound to the same port number. Returns 0 on success, −1 on any error.

int makeIoNonBlocking(int fd)
: Makes I/O on the socket identified by *fd* non-blocking; returns −1 on failure. An attempt to read on a non-blocking socket when no data are pending, or to write on it when its output buffer is full, will not block; it will instead return −1 and cause errno to be set to EWOULDBLOCK.

int watchSocket(int fd)
: Turns on the ''linger'' and ''keepalive'' options for the socket identified by *fd*. See **socket** (2) for details. Returns 0 on success, −1 on any failure.

void closeOnExec(int fd)
: Ensures that *fd* will NOT be open in any child process **fork()**ed from the invoking process. Has no effect on a VxWorks platform.

EXCEPTION REPORTING

The functions in this section offer platform-independent capabilities for reporting on processing exceptions.

The underlying mechanism for ICI's exception reporting is a pair of functions that record error messages in a privately managed pool of static memory. These functions — **postErrmsg()** and **postSysErrmsg()** — are designed to return very rapidly with no possibility of failing, themselves. Nonetheless they are not safe to call from an interrupt service routing (ISR). Although each merely copies its text to the next available location in the error message memory pool, that pool is protected by a mutex; multiple processes might be queued up to take that mutex, so the total time to execute the function is non-deterministic.

Built on top of **postErrmsg()** and **postSysErrmsg()** are the **putErrmsg()** and **putSysErrmsg()** functions, which may take longer to return. Each one simply calls the corresponding ‘‘post’’ function but then calls the **writeErrmsgMemos()** function, which calls **writeMemo()** to print (or otherwise deliver) each message currently posted to the pool and then destroys all of those posted messages, emptying the pool.

Recommended general policy on using the ICI exception reporting functions (which the functions in the ION distribution libraries are supposed to adhere to) is as follows:

```
In the implementation of any ION library function or any ION
task's top-level driver function, any condition that prevents
the function from continuing execution toward producing the
effect it is designed to produce is considered an "error".

Detection of an error should result in the printing of an
error message and, normally, the immediate return of whatever
return value is used to indicate the failure of the function
in which the error was detected.  By convention this value
is usually -1, but both zero and NULL are appropriate
failure indications under some circumstances such as object
creation.

The CHKERR, CHKZERO, CHKNULL, and CHKVOID macros are used to
implement this behavior in a standard and lexically terse
manner.  Use of these macros offers an additional feature:
for debugging purposes, they can easily be configured to
call sm_Abort() to terminate immediately with a core dump
instead of returning a error indication.  This option is
enabled by setting the compiler parameter CORE_FILE_NEEDED
to 1 at compilation time.

In the absence of either any error, the function returns a
value that indicates nominal completion.  By convention this
value is usually zero, but under some circumstances other
values (such as pointers or addresses) are appropriate
indications of nominal completion.  Any additional information
produced by the function, such as an indication of "success",
is usually returned as the value of a reference argument.
[Note, though, that database management functions and the
SDR hash table management functions deviate from this rule:
most return 0 to indicate nominal completion but functional
failure (e.g., duplicate key or object not found) and return
1 to indicate functional success.]

So when returning a value that indicates nominal completion
of the function -- even if the result might be interpreted
as a failure at a higher level (e.g., an object identified
by a given string is not found, through no failure of the
search function) -- do NOT invoke putErrmsg().

Use putErrmsg() and putSysErrmsg() only when functions are
unable to proceed to nominal completion.  Use writeMemo()
or writeMemoNote() if you just want to log a message.

Whenever returning a value that indicates an error:

        If the failure is due to the failure of a system call
```

```
or some other non-ION function, assume that errno
has already been set by the function at the lowest
layer of the call stack; use putSysErrmsg (or
postSysErrmsg if in a hurry) to describe the nature
of the activity that failed.  The text of the error
message should normally start with a capital letter
and should NOT end with a period.

Otherwise -- i.e., the failure is due to a condition
that was detected within ION -- use putErrmsg (or
postErrmg if pressed for time) to describe the nature
of the failure condition.  This will aid in tracing
the failure through the function stack in which the
failure was detected.  The text of the error message
should normally start with a capital letter and should
end with a period.

When a failure in a called function is reported to "driver"
code in an application program, before continuing or exiting
use writeErrmsgMemos() to empty the message pool and print a
simple stack trace identifying the failure.
```

char *system_error_msg( )
: Returns a brief text string describing the current system error, as identified by the current value of errno.

void setLogger(Logger usersLoggerName)
: Sets the user function to be used for writing messages to a user-defined ‘‘log’’ medium. The logger function’s calling sequence must match the following prototype:

```
void    usersLoggerName(char *msg);
```

The default Logger function simply writes the message to standard output.

void writeMemo(char *msg)
: Writes one log message, using the currently defined message logging function.

void writeMemoNote(char *msg, char *note)
: Writes a log message like **writeMemo()**, accompanied by the user-supplied context-specific text in *note*.

void writeErrMemo(char *msg)
: Writes a log message like **writeMemo()**, accompanied by text describing the current system error.

char *itoa(int value)
: Returns a string representation of the signed integer in *value*, nominally for immediate use as an argument to **putErrmsg()**. [Note that the string is constructed in a static buffer; this function is not thread−safe.]

char *utoa(unsigned int value)
: Returns a string representation of the unsigned integer in *value*, nominally for immediate use as an argument to **putErrmsg()**. [Note that the string is constructed in a static buffer; this function is not thread−safe.]

void postErrmsg(char *text, char *argument)
: Constructs an error message noting the name of the source file containing the line at which this function was called, the line number, the *text* of the message, and — if not NULL — a single textual *argument* that can be used to give more specific information about the nature of the reported failure (such as the value of one of the arguments to the failed function). The error message is appended to the list of messages in a privately managed pool of static memory, ERRMSGS_BUFSIZE bytes in

length.

If *text* is NULL or is a string of zero length or begins with a newline character (i.e., **text* == '\0' or '\n'), the function returns immediately and no error message is recorded.

The errmsgs pool is designed to be large enough to contain error messages from all levels of the calling stack at the time that an error is encountered. If the remaining unused space in the pool is less than the size of the new error message, however, the error message is silently omitted. In this case, provided at least two bytes of unused space remain in the pool, a message comprising a single newline character is appended to the list to indicate that a message was omitted due to excessive length.

void postSysErrmsg(char *text, char *arg)
Like **postErrmsg()** except that the error message constructed by the function additionally contains text describing the current system error. *text* is truncated as necessary to assure that the sum of its length and that of the description of the current system error does not exceed 1021 bytes.

int getErrmsg(char *buffer)
Copies the oldest error message in the message pool into *buffer* and removes that message from the pool, making room for new messages. Returns zero if the message pool cannot be locked for update or there are no more messages in the pool; otherwise returns the length of the message copied into *buffer*. Note that, for safety, the size of *buffer* should be ERRMSGS_BUFSIZE.

Note that a returned error message comprising only a single newline character always signifies an error message that was silently omitted because there wasn't enough space left on the message pool to contain it.

void writeErrmsgMemos( )
Calls **getErrmsg()** repeatedly until the message pool is empty, using **writeMemo()** to log all the messages in the pool. Messages that were omitted due to excessive length are indicated by logged lines of the form ''[message omitted due to excessive length]''.

void putErrmsg(char *text, char *argument)
The **putErrmsg()** function merely calls **postErrmsg()** and then **writeErrmsgMemos()**.

void putSysErrmsg(char *text, char *arg)
The **putSysErrmsg()** function merely calls **postSysErrmsg()** and then **writeErrmsgMemos()**.

void discardErrmsgs( )
Calls **getErrmsg()** repeatedly until the message pool is empty, discarding all of the messages.

void printStackTrace( )
On Linux machines only, uses **writeMemo()** to print a trace of the process's current execution stack, starting with the lowest level of the stack and proceeding to the **main()** function of the executable.

Note that (a) **printStackTrace()** is **only** implemented for Linux platforms at this time; (b) symbolic names of functions can only be printed if the *−rdynamic* flag was enabled when the executable was linked; (c) only the names of non-static functions will appear in the stack trace.

For more complete information about the state of the executable at the time the stack trace snapshot was taken, use the Linux *addr2line* tool. To do this, cd into a directory in which the executable file resides (such as /opt/bin) and submit an addr2line command as follows:

addr2line −e *name_of_executable stack_frame_address*

where both *name_of_executable* and *stack_frame_address* are taken from one of the lines of the printed stack trace. addr2line will print the source file name and line number for that stack frame.

WATCH CHARACTERS

The functions in this section offer platform-independent capabilities for recording ''watch'' characters indicating the occurrence of protocol events. See **bprc** (5), **ltprc** (5), **cfdprc** (5), etc. for details of the watch character production options provided by the protocol packages.

void setWatcher(Watcher usersWatcherName)
Sets the user function to be used for recording watch characters to a user-defined ‘‘watch’’ medium. The watcher function’s calling sequence must match the following prototype:

```
void    usersWatcherName(char token);
```

The default Watcher function simply writes the token to standard output.

void iwatch(char token)
Records one ‘‘watch’’ character, using the currently defined watch character recording function.

SELF-DELIMITING NUMERIC VALUES (SDNV)

The functions in this section encode and decode SDNVs, portable variable-length numeric variables that expand to whatever size is necessary to contain the values they contain. SDNVs are used extensively in the BP and LTP libraries.

void encodeSdnv(Sdnv *sdnvBuffer, uvast value)
Determines the number of octets of SDNV text needed to contain the value, places that number in the *length* field of the SDNV buffer, and encodes the value in SDNV format into the first *length* octets of the *text* field of the SDNV buffer.

int decodeSdnv(uvast *value, unsigned char *sdnvText)
Determines the length of the SDNV located at *sdnvText* and returns this number after extracting the SDNV’s value from those octets and storing it in *value*. Returns 0 if the encoded number value will not fit into an unsigned vast integer.

ARITHMETIC ON LARGE INTEGERS (SCALARS)

The functions in this section perform simple arithmetic operations on unsigned Scalar objects — structures encapsulating large positive integers in a machine-independent way. Each Scalar comprises two integers, a count of units [ranging from 0 to (2^30 − 1), i.e., up to 1 gig] and a count of gigs [ranging from 0 to (2^31 −1)]. A Scalar can represent a numeric value up to 2 billion billions, i.e., 2 million trillions.

void loadScalar(Scalar *scalar, signed int value)
Sets the value of *scalar* to the absolute value of *value*.

void increaseScalar(Scalar *scalar, signed int value)
Adds to *scalar* the absolute value of *value*.

void reduceScalar(Scalar *scalar, signed int value)
Adds to *scalar* the absolute value of *value*.

void multiplyScalar(Scalar *scalar, signed int value)
Multiplies *scalar* by the absolute value of *value*.

void divideScalar(Scalar *scalar, signed int value)
Divides *scalar* by the absolute value of *value*.

void copyScalar(Scalar *to, Scalar *from)
Copies the value of *from* into *to*.

void addToScalar(Scalar *scalar, Scalar *increment)
Adds *increment* (a Scalar rather than a C integer) to *scalar*.

void subtractFromScalar(Scalar *scalar, Scalar *decrement)
Subtracts *decrement* (a Scalar rather than a C integer) from *scalar*.

int scalarIsValid(Scalar *scalar)
Returns 1 if the arithmetic performed on *scalar* has not resulted in overflow or underflow.

int scalarToSdnv(Sdnv *sdnv, Scalar *scalar)
If *scalar* points to a valid Scalar, stores the value of *scalar* in *sdnv*; otherwise sets the length of *sdnv* to zero.

int sdnvToScalar(Scalar *scalar, unsigned char *sdnvText)
If *sdnvText* points to a sequence of bytes that, when interpreted as the text of an Sdnv, has a value that can be represented in a 61−bit unsigned binary integer, then this function stores that value in *scalar* and returns the detected Sdnv length. Otherwise returns zero.

Note that Scalars and Sdnvs are both representations of potentially large unsigned integer values. Any Scalar can alternatively be represented as an Sdnv. However, it is possible for a valid Sdnv to be too large to represent in a Scalar.

PRIVATE MUTEXES

The functions in this section provide platform-independent management of mutexes for synchronizing operations of threads or tasks in a common private address space.

int initResourceLock(ResourceLock *lock)
Establishes an inter-thread lock for use in locking some resource. Returns 0 if successful, −1 if not.

void killResourceLock(ResourceLock *lock)
Deletes the resource lock referred to by *lock*.

void lockResource(ResourceLock *lock)
Checks the state of *lock*. If the lock is already owned by a different thread, the call blocks until the other thread relinquishes the lock. If the lock is unowned, it is given to the current thread and the lock count is set to 1. If the lock is already owned by this thread, the lock count is incremented by 1.

void unlockResource(ResourceLock *lock)
If called by the current owner of *lock*, decrements *lock*'s lock count by 1; if zero, relinquishes the lock so it may be taken by other threads. Care must be taken to make sure that one, and only one, **unlockResource()** call is issued for each **lockResource()** call issued on a given resource lock.

SHARED MEMORY IPC DEVICES

The functions in this section provide platform-independent management of IPC mechanisms for synchronizing operations of threads, tasks, or processes that may occupy different address spaces but share access to a common system (nominally, processor) memory.

NOTE that this is distinct from the VxWorks "VxMP" capability enabling tasks to share access to bus memory or dual-ported board memory from multiple processors. The "platform" system will support IPC devices that utilize this capability at some time in the future, but that support is not yet implemented.

int sm_ipc_init( )
Acquires and initializes shared-memory IPC management resources. Must be called before any other shared-memory IPC function is called. Returns 0 on success, −1 on any failure.

void sm_ipc_stop( )
Releases shared-memory IPC management resources, disabling the shared-memory IPC functions until **sm_ipc_init()** is called again.

int sm_GetUniqueKey( )
Some of the "sm_" (shared memory) functions described below associate new communication objects with *key* values that uniquely identify them, so that different processes can access them independently. Key values are typically defined as constants in application code. However, when a new communication object is required for which no specific need was anticipated in the application, the **sm_GetUniqueKey()** function can be invoked to obtain a new, arbitrary key value that is known not to be already in use.

sm_SemId sm_SemCreate(int key, int semType)
Creates a shared-memory semaphore that can be used to synchronize activity among tasks or processes residing in a common system memory but possibly multiple address spaces; returns a reference handle for that semaphore, or SM_SEM_NONE on any failure. If *key* refers to an existing semaphore, returns the handle of that semaphore. If *key* is the constant value SM_NO_KEY, automatically obtains an unused key. On VxWorks platforms, *semType* determines the order in which the semaphore is given to multiple tasks that attempt to take it while it is already taken: if set to SM_SEM_PRIORITY then the semaphore is given to tasks in task priority sequence (i.e., the highest-priority task waiting for it

receives it when it is released), while otherwise (SM_SEM_FIFO) the semaphore is given to tasks in the order in which they attempted to take it. On all other platforms, only SM_SEM_FIFO behavior is supported and *semType* is ignored.

int sm_SemTake(sm_SemId semId)
: Blocks until the indicated semaphore is no longer taken by any other task or process, then takes it. Return 0 on success, −1 on any error.

void sm_SemGive(sm_SemId semId)
: Gives the indicated semaphore, so that another task or process can take it.

void sm_SemEnd(sm_SemId semId)
: This function is used to pass a termination signal to whatever task is currently blocked on taking the indicated semaphore, if any. It sets to 1 the ''ended'' flag associated with this semaphore, so that a test for **sm_SemEnded()** will return 1, and it gives the semaphore so that the blocked task will have an opportunity to test that flag.

int sm_SemEnded(sm_SemId semId)
: This function returns 1 if the ''ended'' flag associated with the indicated semaphore has been set to 1; returns zero otherwise. When the function returns 1 it also gives the semaphore so that any other tasks that might be pended on the same semaphore are also given an opportunity to test it and discover that it has been ended.

void sm_SemUnend(sm_SemId semId)
: This function is used to reset an ended semaphore, so that a restarted subsystem can reuse that semaphore rather than delete it and allocate a new one.

int sm_SemUnwedge(sm_SemId semId, int timeoutSeconds)
: Used to release semaphores that have been taken but never released, possibly because the tasks or processes that took them crashed before releasing them. Attempts to take the semaphore; if this attempt does not succeed within *timeoutSeconds* seconds (providing time for normal processing to be completed, in the event that the semaphore is legitimately and temporarily locked by some task), the semaphore is assumed to be wedged. In any case, the semaphore is then released. Returns 0 on success, −1 on any error.

void sm_SemDelete(sm_SemId semId)
: Destroys the indicated semaphore.

sm_SemId sm_GetTaskSemaphore(int taskId)
: Returns the ID of the semaphore that is dedicated to the private use of the indicated task, or SM_SEM_NONE on any error.

  This function implements the concept that for each task there can always be one dedicated semaphore, which the task can always use for its own purposes, whose key value may be known a priori because the key of the semaphore is based on the task's ID. The design of the function rests on the assumption that each task's ID, whether a VxWorks task ID or a Unix process ID, maps to a number that is out of the range of all possible key values that are arbitrarily produced by **sm_GetUniqueKey()**. For VxWorks, we assume this to be true because task ID is a pointer to task state in memory which we assume not to exceed 2GB; the unique key counter starts at 2GB. For Unix, we assume this to be true because process ID is an index into a process table whose size is less than 64K; unique keys are formed by shifting process ID left 16 bits and adding the value of an incremented counter which is always greater than zero.

int sm_ShmAttach(int key, int size, char **shmPtr, int *id)
: Attaches to a segment of memory to which tasks or processes residing in a common system memory, but possibly multiple address spaces, all have access.

  This function registers the invoking task or process as a user of the shared memory segment identified by *key*. If *key* is the constant value SM_NO_KEY, automatically sets *key* to some unused key value. If a shared memory segment identified by *key* already exists, then *size* may be zero and the value of **shmPtr* is ignored. Otherwise the size of the shared memory segment must be provided in *size* and a

new shared memory segment is created in a manner that is dependent on **shmPtr*: if **shmPtr* is NULL then *size* bytes of shared memory are dynamically acquired, allocated, and assigned to the newly created shared memory segment; otherwise the memory located at *shmPtr* is assumed to have been pre-allocated and is merely assigned to the newly created shared memory segment.

On success, stores the unique shared memory ID of the segment in **id* for possible future destruction, stores a pointer to the segment's assigned memory in **shmPtr*, and returns 1 (if the segment is newly created) or 0 (otherwise). Returns −1 on any error.

void sm_ShmDetach(char *shmPtr)
Unregisters the invoking task or process as a user of the shared memory starting at *shmPtr*.

void sm_ShmDestroy(int id)
Destroys the shared memory segment identified by *id*, releasing any memory that was allocated when the segment was created.

PORTABLE MULTI-TASKING

int sm_TaskIdSelf( )
Returns the unique identifying number of the invoking task or process.

int sm_TaskExists(int taskId)
Returns non-zero if a task or process identified by *taskId* is currently running on the local processor, zero otherwise.

void *sm_TaskVar(void **arg)
Posts or retrieves the value of the ''task variable'' belonging to the invoking task. Each task has access to a single task variable, initialized to NULL, that resides in the task's private state; this can be convenient for passing task-specific information to a signal handler, for example. If *arg* is non-NULL, then **arg* is posted as the new value of the task's private task variable. In any case, the value of that task variable is returned.

void sm_TaskSuspend( )
Indefinitely suspends execution of the invoking task or process. Helpful if you want to freeze an application at the point at which an error is detected, then use a debugger to examine its state.

void sm_TaskDelay(int seconds)
Same as **snooze** (3).

void sm_TaskYield( )
Relinquishes CPU temporarily for use by other tasks.

int sm_TaskSpawn(char *name, char *arg1, char *arg2, char *arg3, char *arg4, char *arg5, char *arg6, char *arg7, char *arg8, char *arg9, char *arg10, int priority, int stackSize)
Spawns/forks a new task/process, passing it up to ten command-line arguments. *name* is the name of the function (VxWorks) or executable image (UNIX) to be executed in the new task/process.

For UNIX, *name* must be the name of some executable program in the `$PATH` of the invoking process.

For VxWorks, *name* must be the name of some function named in an application-defined private symbol table (if PRIVATE_SYMTAB is defined) or the system symbol table (otherwise). If PRIVATE_SYMTAB is defined, the application must provide a suitable adaptation of the symtab.c source file, which implements the private symbol table.

''priority'' and ''stackSize'' are ignored under UNIX. Under VxWorks, if zero they default to the values in the application-defined private symbol table if provided, or otherwise to ICI_PRIORITY (nominally 100) and 32768 respectively.

Returns the task/process ID of the new task/process on success, or −1 on any error.

void sm_TaskKill(int taskId, int sigNbr)
Sends the indicated signal to the indicated task or process.

void sm_TaskDelete(int taskId)
Terminates the indicated task or process.

void **sm_Abort()**
Terminates the calling task or process. If not called while ION is in flight configuration, a stack trace is printed or a core file is written.

int pseudoshell(char *script)
Parses *script* into a command name and up to 10 arguments, then passes the command name and arguments to **sm_TaskSpawn()** for execution. The **sm_TaskSpawn()** function is invoked with priority and stack size both set to zero, causing default values (possibly from an application-defined private symbol table) to be used. Tokens in *script* are normally whitespace-delimited, but a token that is enclosed in single-quote characters (') may contain embedded whitespace and may contain escaped single-quote characters (‘‘\’’). On any parsing failure returns –1; otherwise returns the value returned by **sm_TaskSpawn()**.

USER'S GUIDE

Compiling an application that uses ‘‘platform’’:
Just be sure to ‘‘#include ’’platform.h"" at the top of each source file that includes any platform function calls.

Linking/loading an application that uses ‘‘platform’’:

a. In a Solaris environment, link with these libraries:

```
-lplatform -socket -nsl -posix4 -c
```

b. In a Linux environment, simply link with platform:

```
-lplatform
```

c. In a VxWorks environment, use

```
ld 1, 0, "libplatform.o"
```

to load platform on the target before loading applications.

SEE ALSO

gettimeofday(3C)

NAME

psm – Personal Space Management

SYNOPSIS

```
#include "psm.h"

typedef enum { Okay, Redundant, Refused } PsmMgtOutcome;
typedef unsigned long PsmAddress;
typedef struct psm_str
{
        char            *space;
        int             freeNeeded;
        struct psm_str  *trace;
        int             traceArea[3];
} PsmView, *PsmPartition;

[see description for available functions]
```

DESCRIPTION

PSM is a library of functions that support personal space management, that is, user management of an application-configured memory partition. PSM is designed to be faster and more efficient than malloc/free (for details, see the DETAILED DESCRIPTION below), but more importantly it provides a memory management abstraction that insulates applications from differences in the management of private versus shared memory.

PSM is often used to manage shared memory partitions. On most operating systems, separate tasks that connect to a common shared memory partition are given the same base address with which to access the partition. On some systems (such as Solaris) this is not necessarily the case; an absolute address within such a shared partition will be mapped to different pointer values in different tasks. If a pointer value is stored within shared memory and used without conversion by multiple tasks, segment violations will occur.

PSM gets around this problem by providing functions for translating between local pointer values and relative addresses within the shared memory partition. For complete portability, applications which store addresses in shared memory should store these addresses as PSM relative addresses and convert them to local pointer values before using them. The PsmAddress data type is provided for this purpose, along with the conversion functions **psa()** and **psp()**.

int psm_manage(char *start, unsigned int length, char *name, PsmPartition *partitionPointer, PsmMgtOutcome *outcome)

Puts the *length* bytes of memory at *start* under PSM management, associating this memory partition with the identifying string *name* (which is required and which can have a maximum string length of 31). PSM can manage any contiguous range of addresses to which the application has access, typically a block of heap memory returned by a malloc call.

Every other PSM API function must be passed a pointer to a local ‘‘partition’’ state structure characterizing the PSM-managed memory to which the function is to be applied. The partition state structure itself may be pre-allocated in static or local (or shared) memory by the application, in which case a pointer to that structure must be passed to **psm_manage()** as the value of **partitionPointer*; if **partitionPointer* is null, **psm_manage()** will use **malloc()** to allocate this structure dynamically from local memory and will store a pointer to the structure in **partitionPointer*.

psm_manage() formats the managed memory as necessary and returns −1 on any error, 0 otherwise. The outcome to the attempt to manage memory is placed in *outcome*. An outcome of Redundant means that the memory at *start* is already under PSM management with the same name and size. An outcome of Refused means that PSM was unable to put the memory at *start* under PSM management as directed; a diagnostic message was posted to the message pool (see discussion of **putErrmsg()** in **platform** (3)).

char *psm_name(PsmPartition partition)
Returns the name associated with the partition at the time it was put under management.

char *psm_space(PsmPartition partition)
Returns the address of the space managed by PSM for *partition*. This function is provided to enable the application to do an operating-system release (such as **free()**) of this memory when the managed partition is no longer needed. *NOTE* that calling **psm_erase()** or **psm_unmanage()** [or any other PSM function, for that matter] after releasing that space is virtually guaranteed to result in a segmentation fault or other seriously bad behavior.

void *psp(PsmPartition partition, PsmAddress address)
address is an offset within the space managed for the partition. Returns the conversion of that offset into a locally usable pointer.

PsmAddress psa(PsmPartition partition, void *pointer)
Returns the conversion of *pointer* into an offset within the space managed for the partition.

PsmAddress psm_malloc(PsmPartition partition, unsigned int length)
Allocates a block of memory from the ''large pool'' of the indicated partition. (See the DETAILED DESCRIPTION below.) *length* is the size of the block to allocate; the maximum size is 1/2 of the total address space (i.e., 2G for a 32−bit machine). Returns NULL if no free block could be found. The block returned is aligned on a doubleword boundary.

void psm_panic(PsmPartition partition)
Forces the ''large pool'' memory allocation algorithm to hunt laboriously for free blocks in buckets that may not contain any. This setting remains in force for the indicated partition until a subsequent **psm_relax()** call reverses it.

void psm_relax(PsmPartition partition)
Reverses **psm_panic()**. Lets the ''large pool'' memory allocation algorithm return NULL when no free block can be found easily.

PsmAddress psm_zalloc(PsmPartition partition, unsigned int length)
Allocates a block of memory from the ''small pool'' of the indicated partition, if possible; if the requested block size — *length* — is too large for small pool allocation (which is limited to 64 words, i.e., 256 bytes for a 32−bit machine), or if no small pool space is available and the size of the small pool cannot be increased, then allocates from the large pool instead. Small pool allocation is performed by an especially speedy algorithm, and minimum space is consumed in memory management overhead for small-pool blocks. Returns NULL if no free block could be found. The block returned is aligned on a word boundary.

void psm_free(PsmPartition partition, PsmAddress block)
Frees for subsequent re-allocation the indicated block of memory from the indicated partition. *block* may have been allocated by either **psm_malloc()** or **psm_zalloc()**.

int psm_set_root(PsmPartition partition, PsmAddress root)
Sets the ''root'' word of the indicated partition (a word at a fixed, private location in the PSM bookkeeping data area) to the indicated value. This function is typically useful in a shared-memory environment, such as a VxWorks address space, in which a task wants to retrieve from the indicated partition some data that was inserted into the partition by some other task; the partition root word enables multiple tasks to navigate the same data in the same PSM partition in shared memory. The argument is normally a pointer to something like a linked list of the linked lists that populate the partition; in particular, it is likely to be an object catalog (see **psm_add_catlg()**). Returns 0 on success, −1 on any failure (e.g., the partition already has a root object, in which case **psm_erase_root()** must be called before **psm_set_root()**).

PsmAddress psm_get_root(PsmPartition partition)
Retrieves the current value of the root word of the indicated partition.

void psm_erase_root(PsmPartition partition)
Erases the current value of the root word of the indicated partition.

PsmAddress psm_add_catlg(PsmPartition partition)
Allocates space for an object catalog in the indicated partition and establishes the new catalog as the partition's root object. Returns 0 on success, −1 on any error (e.g., the partition already has some other root object).

int psm_catlg(PsmPartition partition, char *objName, PsmAddress objLocation)
Inserts an entry for the indicated object into the catalog that is the root object for this partition. The length of *objName* cannot exceed 32 bytes, and *objName* must be unique in the catalog. Returns 0 on success, −1 on any error.

int psm_uncatlg(PsmPartition partition, char *objName)
Removes the entry for the named object from the catalog that is the root object for this partition, if that object is found in the catalog. Returns 0 on success, −1 on any error.

int psm_locate(PsmPartition partition, char *objName, PsmAddress *objLocation, PsmAddress *entryElt)
Places in **objLocation* the address associated with *objName* in the catalog that is the root object for this partition and places in **entryElt* the address of the list element that points to this catalog entry. If *name* is not found in catalog, set **entryElt* to zero. Returns 0 on success, −1 on any error.

void psm_usage(PsmPartition partition, PsmUsageSummary *summary)
Loads the indicated PsmUsageSummary structure with a snapshot of the indicated partition's usage status. PsmUsageSummary is defined by:

```
typedef struct {
    char            partitionName[32];
    unsigned int    partitionSize;
    unsigned int    smallPoolSize;
    unsigned int    smallPoolFreeBlockCount[SMALL_SIZES];
    unsigned int    smallPoolFree;
    unsigned int    smallPoolAllocated;
    unsigned int    largePoolSize;
    unsigned int    largePoolFreeBlockCount[LARGE_ORDERS];
    unsigned int    largePoolFree;
    unsigned int    largePoolAllocated;
    unsigned int    unusedSize;
} PsmUsageSummary;
```

void psm_report(PsmUsageSummary *summary)
Sends to stdout the content of *summary*, a snapshot of a partition's usage status.

void psm_unmanage(PsmPartition partition)
Terminates local PSM management of the memory in *partition* and destroys the partition state structure **partition*, but doesn't erase anything in the managed memory; PSM management can be re-established by a subsequent call to **psm_manage()**.

void psm_erase(PsmPartition partition)
Unmanages the indicated partition and additionally discards all information in the managed memory, preventing re-management of the partition.

MEMORY USAGE TRACING

If PSM_TRACE is defined at the time the PSM source code is compiled, the system includes built-in support for simple tracing of memory usage: memory allocations are logged, and memory deallocations are matched to logged allocations, ''closing'' them. This enables memory leaks and some other kinds of memory access problems to be readily investigated.

int psm_start_trace(PsmPartition partition, int traceLogSize, char *traceLogAddress)
Begins an episode of PSM memory usage tracing. *traceLogSize* is the number of bytes of shared memory to use for trace activity logging; the frequency with which ''closed'' trace log events must be

deleted will vary inversely with the amount of memory allocated for the trace log. *traceLogAddress* is normally NULL, causing the trace system to allocate *traceLogSize* bytes of shared memory dynamically for trace logging; if non-NULL, it must point to *traceLogSize* bytes of shared memory that have been pre-allocated by the application for this purpose. Returns 0 on success, −1 on any failure.

void psm_print_trace(PsmPartition partition, int verbose)
Prints a cumulative trace report and current usage report for *partition*. If *verbose* is zero, only exceptions (notably, trace log events that remain open — potential memory leaks) are printed; otherwise all activity in the trace log is printed.

void psm_clear_trace(PsmPartition partition)
Deletes all closed trace log events from the log, freeing up memory for additional tracing.

void psm_stop_trace(PsmPartition partition)
Ends the current episode of PSM memory usage tracing. If the shared memory used for the trace log was allocated by **psm_start_trace()**, releases that shared memory.

EXAMPLE

For an example of the use of psm, see the file psmshell.c in the PSM source directory.

USER'S GUIDE

Compiling a PSM application
Just be sure to ''#include ''psm.h"" at the top of each source file that includes any PSM function calls.

Linking/loading a PSM application
a. In a UNIX environment, link with libpsm.a.

b. In a VxWorks environment, use

```
ld 1, 0, "libpsm.o"
```

to load PSM on the target before loading any PSM applications.

Typical usage:
a. Call **psm_manage()** to initiate management of the partition.

b. Call **psm_malloc()** (and/or **psm_zalloc()**) to allocate space in the partition; call **psm_free()** to release space for later re-allocation.

c. When **psm_malloc()** returns NULL and you're willing to wait a while for a more exhaustive free block search, call **psm_panic()** before retrying **psm_malloc()**. When you're no longer so desperate for space, call **psm_relax()**.

d. To store a vital pointer in the single predefined location in the partition that PSM reserves for this purpose, call **psm_set_root()**; to retrieve that pointer, call **psm_get_root()**.

e. To get a snapshot of the current configuration of the partition, call **psm_usage()**. To print this snapshot to stdout, call **psm_report()**.

f. When you're done with the partition but want to leave it in its current state for future re-management (e.g., if the partition is in shared memory), call **psm_unmanage()**. If you're done with the partition forever, call **psm_erase()**.

DETAILED DESCRIPTION

PSM supports user management of an application-configured memory partition. The partition is functionally divided into two pools of variable size: a ''small pool'' of low-overhead blocks aligned on 4−byte boundaries that can each contain up to 256 bytes of user data, and a ''large pool'' of high-overhead blocks aligned on 8−byte boundaries that can each contain up to 2GB of user data.

Space in the small pool is allocated in any one of 64 different block sizes; each possible block size is (4i + n) where i is a ''block list index'' from 1 through 64 and n is the length of the PSM overhead information per block [4 bytes on a 32−bit machine]. Given a user request for a block of size q where q is in the range 1 through 256 inclusive, we return the first block on the j'th small-pool free list where j = (q − 1) / 4. If there

is no such block, we increase the size of the small pool [incrementing its upper limit by (4 * (j + 1)) + n], initialize the increase as a free block from list j, and return that block. No attempt is made to consolidate physically adjacent blocks when they are freed or to bisect large blocks to satisfy requests for small ones; if there is no free block of the requested size and the size of the small pool cannot be increased without encroaching on the large pool (or if the requested size exceeds 256), we attempt to allocate a large-pool block as described below. The differences between small-pool and large-pool blocks are transparent to the user, and small-pool and large-pool blocks can be freely intermixed in an application.

Small-pool blocks are allocated and freed very rapidly, and space overhead consumption is small, but capacity per block is limited and space assigned to small-pool blocks of a given size is never again available for any other purpose. The small pool is designed to satisfy requests for allocation of a stable overall population of small, volatile objects such as List and ListElt structures (see **lyst** (3)).

Space in the large pool is allocated from any one of 29 buckets, one for each power of 2 in the range 8 through 2G. The size of each block can be expressed as (n + 8i + m) where i is any integer in the range 1 through 256M, n is the size of the block's leading overhead area [8 bytes on a 32−bit machine], and m is the size of the block's trailing overhead area [also 8 bytes on a 32−bit machine]. Given a user request for a block of size q where q is in the range 1 through 2G inclusive, we first compute r as the smallest multiple of 8 that is greater than or equal to q. We then allocate the first block in bucket t such that 2 ** (t + 3) is the smallest power of 2 that is greater than r [or, if r is a power of 2, the first block in bucket t such that 2 ** (t + 3) = r]. That is, we try to allocate blocks of size 8 from bucket 0 [2**3 = 8], blocks of size 16 from bucket 1 [2**4 = 16], blocks of size 24 from bucket 2 [2**5 = 32, 32 > 24], blocks of size 32 from bucket 2 [2**5 = 32], and so on. t is the first bucket whose free blocks are ALL guaranteed to be at least as large as r; bucket t − 1 may also contain some blocks that are as large as r (e.g., bucket 1 will contain blocks of size 24 as well as blocks of size 16), but we would have to do a possibly time consuming sequential search through the free blocks in that bucket to find a match, because free blocks within a bucket are stored in no particular order.

If bucket t is empty, we allocate the first block from the first non-empty bucket corresponding to a greater power of two; if all eligible bucket are empty, we increase the size of the large pool [decrementing its lower limit by (r + 16)], initialize the increase as a free block and ''free'' it, and try again. If the size of the large pool cannot be increased without encroaching on the small pool, then if we are desperate we search sequentially through all blocks in bucket t − 1 (some of which may be of size r or greater) and allocate the first block that is big enough, if any. Otherwise, no block is returned.

Having selected a free block to allocate, we remove the allocated block from the free list, split off as a new free block all bytes in excess of (r + 16) bytes [unless that excess is too small to form a legal-size block], and return the remainder to the user. When a block is freed, it is automatically consolidated with the physically preceding block (if that block is free) and the physically subsequent block (if that block is free).

Large-pool blocks are allocated and freed quite rapidly; capacity is effectively unlimited; space overhead consumption is very high for extremely small objects but becomes an insignificant fraction of block size as block size increases. The large pool is designed to serve as a general-purpose heap with minimal fragmentation whose overhead is best justified when used to store relatively large, long-lived objects such as image packets.

The general goal of this memory allocation scheme is to satisfy memory management requests rapidly and yet minimize the chance of refusing a memory allocation request when adequate unused space exists but is inaccessible (because it is fragmentary or is buried as unused space in a block that is larger than necessary). The size of a small-pool block delivered to satisfy a request for q bytes will never exceed q + 3 (alignment), plus 4 bytes of overhead. The size of a large-pool block delivered to satisfy a request for q bytes will never exceed q + 7 (alignment) + 20 (the maximum excess that can't be split off as a separate free block), plus 16 bytes of overhead.

Neither the small pool nor the large pool ever decrease in size, but large-pool space previously allocated and freed is available for small-pool allocation requests if no small-pool space is available. Small-pool space previously allocated and freed cannot easily be reassigned to the large pool, though, because blocks in the large pool must be physically contiguous to support defragmentation. No such reassignment algorithm has yet been developed.

SEE ALSO

lyst (3)

NAME

sdr − Simple Data Recorder library

SYNOPSIS

```
#include "sdr.h"

[see below for available functions]
```

DESCRIPTION

SDR is a library of functions that support the use of an abstract data recording device called an ‘‘SDR’’ (‘‘simple data recorder’’) for persistent storage of data. The SDR abstraction insulates software not only from the specific characteristics of any single data storage device but also from some kinds of persistent data storage and retrieval chores. The underlying principle is that an SDR provides standardized support for user data organization at object granularity, with direct access to persistent user data objects, rather than supporting user data organization only at ‘‘file’’ granularity and requiring the user to implement access to the data objects accreted within those files.

The SDR library is designed to provide some of the same kinds of directory services as a file system together with support for complex data structures that provide more operational flexibility than files. (As an example of this flexibility, consider how much easier and faster it is to delete a given element from the middle of a linked list than it is to delete a range of bytes from the middle of a text file.) The intent is to enable the software developer to take maximum advantage of the high speed and direct byte addressability of a non-volatile flat address space in the management of persistent data. The SDR equivalent of a ‘‘record’’ of data is simply a block of nominally persistent memory allocated from this address space. The SDR equivalent of a ‘‘file’’ is a *collection* object. Like files, collections can have names, can be located by name within persistent storage, and can impose structure on the data items they encompass. But, as discussed later, SDR collection objects can impose structures other than the strict FIFO accretion of records or bytes that characterizes a file.

The notional data recorder managed by the SDR library takes the form of a single array of randomly accessible, contiguous, nominally persistent memory locations called a *heap*. Physically, the heap may be implemented as a region of shared memory, as a single file of predefined size, or both — that is, the heap may be a region of shared memory that is automatically mirrored in a file.

SDR services that manage SDR data are provided in several layers, each of which relies on the services implemented at lower levels:

At the highest level, a cataloguing service enables retrieval of persistent objects by name.

Services that manage three types of persistent data collections are provided for use both by applications and by the cataloguing service: linked lists, self-delimiting tables (which function as arrays that remember their own dimensions), and self-delimiting strings (short character arrays that remember their lengths, for speedier retrieval).

Basic SDR heap space management services, analogous to **malloc()** and **free()**, enable the creation and destruction of objects of arbitrary type.

Farther down the service stack are memcpy-like low-level functions for reading from and writing to the heap.

Protection of SDR data integrity across a series of reads and writes is provided by a *transaction* mechanism.

SDR persistent data are referenced in application code by Object values and Address values, both of which are simply displacements (offsets) within SDR address space. The difference between the two is that an Object is always the address of a block of heap space returned by some call to **sdr_malloc()**, while an Address can refer to any byte in the address space. That is, an Address is the SDR functional equivalent of a C pointer in DRAM, and some Addresses point to Objects.

Before using SDR services, the services must be loaded to the target machine and initialized by invoking the **sdr_initialize()** function and the management profiles of one or more SDR’s must be loaded by invoking the

sdr_load_profile() function. These steps are normally performed only once, at application load time.

An application gains access to an SDR by passing the name of the SDR to the **sdr_start_using()** function, which returns an Sdr pointer. Most other SDR library functions take an Sdr pointer as first argument.

All writing to an SDR heap must occur during a *transaction* that was initiated by the task issuing the write. Transactions are single-threaded; if task B wants to start a transaction while a transaction begun by task A is still in progress, it must wait until A's transaction is either ended or cancelled. A transaction is begun by calling **sdr_begin_xn()**. The current transaction is normally ended by calling the **sdr_end_xn()** function, which returns an error return code value in the event that any serious SDR-related processing error was encountered in the course of the transaction. Transactions may safely be nested, provided that every level of transaction activity that is begun is properly ended.

The current transaction may instead be cancelled by calling **sdr_cancel_xn()**, which is normally used to indicate that some sort of serious SDR-related processing error has been encountered. Canceling a transaction reverses all SDR update activity performed up to that point within the scope of the transaction — and, if the canceled transaction is an inner, nested transaction, all SDR update activity performed within the scope of every outer transaction encompassing that transaction *and* every other transaction nested within any of those outer transactions — provided the SDR was configured for transaction *reversibility*. When an SDR is configured for reversibility, all heap write operations performed during a transaction are recorded in a log file that is retained until the end of the transaction. Each log file entry notes the location at which the write operation was performed, the length of data written, and the content of the overwritten heap bytes prior to the write operation. Canceling the transaction causes the log entries to be read and processed in reverse order, restoring all overwritten data. Ending the transaction, on the other hand, simply causes the log to be discarded.

If a log file exists at the time that the profile for an SDR is loaded (typically during application initialization), the transaction that was being logged is automatically canceled and reversed. This ensures that, for example, a power failure that occurs in the middle of a transaction will never wreck the SDR's data integrity: either all updates issued during a given transaction are reflected in the current dataspace content or none are.

As a further measure to protect SDR data integrity, an SDR may additionally be configured for *object bounding*. When an SDR is configured to be ''bounded'', every heap write operation is restricted to the extent of a single object allocated from heap space; that is, it's impossible to overwrite part of one object by writing beyond the end of another. To enable the library to enforce this mechanism, application code is prohibited from writing anywhere but within the extent of an object that either (a) was allocated from managed heap space during the same transaction (directly or indirectly via some collection management function) or (b) was *staged* — identified as an update target — during the same transaction (again, either directly or via some collection management function).

Note that both transaction reversibility and object bounding consume processing cycles and inhibit performance to some degree. Determining the right balance between operational safety and processing speed is left to the user.

Note also that, since SDR transactions are single-threaded, they can additionally be used as a general mechanism for simply implementing ''critical sections'' in software that is already using SDR for other purposes: the beginning of a transaction marks the start of code that can't be executed concurrently by multiple tasks. To support this use of the SDR transaction mechanism, the additional transaction termination function **sdr_exit_xn()** is provided. **sdr_exit_xn()** simply ends a transaction without either signaling an error or checking for errors. Like **sdr_cancel_xn()**, **sdr_exit_xn()** has no return value; unlike **sdr_cancel_xn()**, it assures that ending an inner, nested transaction does not cause the outer transaction to be aborted and backed out. But this capability must be used carefully: the protection of SDR data integrity requires that transactions which are ended by **sdr_exit_xn()** must not encompass any SDR update activity whatsoever.

The heap space management functions of the SDR library are adapted directly from the Personal Space Management (*psm*) function library. The manual page for **psm** (3) explains the algorithms used and the rationale behind them. The principal difference between PSM memory management and SDR heap

management is that, for performance reasons, SDR reserves the ''small pool'' for its own use only; all user data space is allocated from the ''large pool'', via the **sdr_malloc()** function.

RETURN VALUES AND ERROR HANDLING

Whenever an SDR function call fails, a diagnostic message explaining the failure of the function is recorded in the error message pool managed by the ''platform'' system (see the discussion of **putErrmsg()** in **platform** (3)).

The failure of any function invoked in the course of an SDR transaction causes all subsequent SDR activity in that transaction to fail immediately. This can streamline SDR application code somewhat: it may not be necessary to check the return value of every SDR function call executed during a transaction. If the **sdr_end_xn()** call returns zero, all updates performed during the transaction must have succeeded.

SYSTEM ADMINISTRATION FUNCTIONS

int sdr_initialize(int wmSize, char *wmPtr, int wmKey, char *wmName)

Initializes the SDR system. **sdr_initialize()** must be called once every time the computer on which the system runs is rebooted, before any call to any other SDR library function.

This function attaches to a pool of shared memory, managed by PSM (see **psm** (3), that enables SDR library operations. If the SDR system is to access a common pool of shared memory with one or more other systems, the key of that shared memory segment must be provided in *wmKey* and the PSM partition name associated with that memory segment must be provided in *wmName*; otherwise *wmKey* must be zero and *wmName* must be NULL, causing **sdr_initialize()** to assign default values. If a shared memory segment identified by the effective value of *wmKey* already exists, then *wmSize* may be zero and the value of *wmPtr* is ignored. Otherwise the size of the shared memory pool must be provided in *wmSize* and a new shared memory segment is created in a manner that is dependent on *wmPtr*: if *wmPtr* is NULL then *wmSize* bytes of shared memory are dynamically acquired, allocated, and assigned to the newly created shared memory segment; otherwise the memory located at *wmPtr* is assumed to have been pre-allocated and is merely assigned to the newly created shared memory segment.

sdr_initialize() also creates a semaphore to serialize access to the SDR system's private array of SDR profiles.

Returns 0 on success, −1 on any failure.

void sdr_wm_usage(PsmUsageSummary *summary)

Loads *summary* with a snapshot of the usage of the SDR system's private working memory. To print the snapshot, use **psm_report()**. (See **psm** (3).)

void sdr_shutdown( )

Ends all access to all SDRs (see **sdr_stop_using()**), detaches from the SDR system's working memory (releasing the memory if it was dynamically allocated by **sdr_initialize()**), and destroys the SDR system's private semaphore. After **sdr_shutdown()**, **sdr_initialize()** must be called again before any call to any other SDR library function.

DATABASE ADMINISTRATION FUNCTIONS

int sdr_load_profile(char *name, int configFlags, long heapWords, int heapKey, int logSize, int logKey, char *pathName, char *restartCmd, unsigned int restartLatency)

Loads the profile for an SDR into the system's private list of SDR profiles. Although SDRs themselves are persistent, SDR profiles are not: in order for an application to access an SDR, **sdr_load_profile()** must have been called to load the profile of the SDR since the last invocation of **sdr_initialize()**.

name is the name of the SDR, required for any subsequent **sdr_start_using()** call.

configFlags specifies the configuration of the SDR, the bitwise ''or'' of some combination of the following:

SDR_IN_DRAM

SDR dataspace is implemented as a region of shared memory.

SDR_IN_FILE
SDR dataspace is implemented as a file.

SDR_REVERSIBLE
SDR transactions are logged and are reversed if canceled.

SDR_BOUNDED
Heap updates are not allowed to cross object boundaries.

heapWords specifies the size of the heap in words; word size depends on machine architecture, i.e., a word is 4 bytes on a 32−bit machine, 8 bytes on a 64−bit machine. Note that each SDR prepends to the heap a ''map'' of predefined, fixed size. The total amount of space occupied by an SDR dataspace in memory and/or in a file is the sum of the size of the map plus the product of word size and *heapWords*.

heapKey is ignored if *configFlags* does not include SDR_IN_DRAM. It should normally be SM_NO_KEY, causing the shared memory region for the SDR dataspace to be allocated dynamically and shared using a dynamically selected shared memory key. If specified, *heapKey* must be a shared memory key identifying a pre-allocated region of shared memory whose length is equal to the total SDR dataspace size, shared via the indicated key.

logSize specifies the maximum size of the transaction log (in bytes) if and only if the log is to be written to memory rather than to a file; otherwise it must be zero. *logKey* is ignored if *logSize* is zero. It should normally be SM_NO_KEY, causing the shared memory region for the transaction log to be allocated dynamically and shared using a dynamically selected shared memory key. If specified, *logKey* must be a shared memory key identifying a pre-allocated region of shared memory whose length is equal to *logSize*, shared via the indicated key.

pathName is ignored if *configFlags* includes neither SDR_REVERSIBLE nor SDR_IN_FILE. It is the fully qualified name of the directory into which the SDR's log file and/or dataspace file will be written. The name of the log file (if any) will be ''<sdrname>.sdrlog''. The name of the dataspace file (if any) will be ''<sdrname>.sdr''; this file will be automatically created and filled with zeros if it does not exist at the time the SDR's profile is loaded.

If a cleanup task must be run whenever a transaction is reversed, the command to execute this task must be provided in *restartCmd* and the number of seconds to wait for this task to finish before resuming operations must be provided in *restartLatency*. If *restartCmd* is NULL or *restartLatency* is zero then no cleanup task will be run upon transaction reversal.

Returns 0 on success, −1 on any error.

int sdr_reload_profile(char *name, int configFlags, long heapWords, int heapKey, int logSize, int logKey, char *pathName, char *restartCmd, unsigned int restartLatency)
For use when the state of an SDR is thought to be inconsistent, perhaps due to crash of a program that had a transaction open. Unloads the profile for the SDR, forcing the reversal of any transaction that is currently in progress when the SDR's profile is re-loaded. Then calls **sdr_load_profile()** to re-load the profile for the SDR. Same return values as sdr_load_profile.

Sdr sdr_start_using(char *name)
Locates SDR profile by *name* and returns a handle that can be used for all functions that operate on that SDR. On any failure, returns NULL.

char *sdr_name(Sdr sdr)
Returns the name of the sdr.

long sdr_heap_size(Sdr sdr)
Returns the total size of the SDR heap, in bytes.

void sdr_stop_using(Sdr sdr)
Terminates access to the SDR via this handle. Other users of the SDR are not affected. Frees the Sdr object.

void sdr_abort(Sdr sdr)
Terminates the task. In flight configuration, also terminates all use of the SDR system by all tasks.

void sdr_destroy(Sdr sdr)
Ends all access to this SDR, unloads the SDR's profile, and erases the SDR from memory and file system.

DATABASE TRANSACTION FUNCTIONS

int sdr_begin_xn(Sdr sdr)
Initiates a transaction. Returns 1 on success, 0 on any failure. Note that transactions are single-threaded; any task that calls **sdr_begin_xn()** is suspended until all previously requested transactions have been ended or canceled.

int sdr_in_xn(Sdr sdr)
Returns 1 if called in the course of a transaction, 0 otherwise.

void sdr_exit_xn(Sdr sdr)
Simply abandons the current transaction, ceasing the calling task's lock on ION. Must **not** be used if any dataspace modifications were performed during the transaction; **sdr_end_xn()** must be called instead, to commit those modifications.

void sdr_cancel_xn(Sdr sdr)
Cancels the current transaction. If reversibility is enabled for the SDR, canceling a transaction reverses all heap modifications performed during that transaction.

int sdr_end_xn(Sdr sdr)
Ends the current transaction. Returns 0 if the transaction completed without any error; returns −1 if any operation performed in the course of the transaction failed, in which case the transaction was automatically canceled.

DATABASE I/O FUNCTIONS

void sdr_read(Sdr sdr, char *into, Address from, int length)
Copies *length* characters at *from* (a location in the indicated SDR) to the memory location given by *into*. The data are copied from the shared memory region in which the SDR resides, if any; otherwise they are read from the file in which the SDR resides.

void sdr_peek(sdr, variable, from)
sdr_peek() is a macro that uses **sdr_read()** to load *variable* from the indicated address in the SDR dataspace; the size of *variable* is used as the number of bytes to copy.

void sdr_write(Sdr sdr, Address into, char *from, int length)
Copies *length* characters at *from* (a location in memory) to the SDR heap location given by *into*. Can only be performed during a transaction, and if the SDR is configured for object bounding then heap locations *into* through (*into* + (*length* − 1)) must be within the extent of some object that was either allocated or staged within the same transaction. The data are copied both to the shared memory region in which the SDR resides, if any, and also to the file in which the SDR resides, if any.

void sdr_poke(sdr, into, variable)
sdr_poke() is a macro that uses **sdr_write()** to store *variable* at the indicated address in the SDR dataspace; the size of *variable* is used as the number of bytes to copy.

char *sdr_pointer(Sdr sdr, Address address)
Returns a pointer to the indicated location in the heap − a ''heap pointer'' − or NULL if the indicated address is invalid. NOTE that this function *cannot be used* if the SDR does not reside in a shared memory region.

Providing an alternative to using **sdr_read()** to retrieve objects into local memory, **sdr_pointer()** can help make SDR-based applications run very quickly, but it must be used WITH GREAT CAUTION! Never use a direct pointer into the heap when not within a transaction, because you will have no assurance at any time that the object pointed to by that pointer has not changed (or is even still there). And NEVER de-reference a heap pointer in order to write directly into the heap: this makes transaction reversal impossible. Whenever writing to the SDR, always use **sdr_write()**.

Address sdr_address(Sdr sdr, char *pointer)
: Returns the address within the SDR heap of the indicated location, which must be (or be derived from) a heap pointer as returned by **sdr_pointer()**. Returns zero if the indicated location is not greater than the start of the heap mirror. NOTE that this function *cannot be used* if the SDR does not reside in a shared memory region.

void sdr_get(sdr, variable, heap_pointer)
: **sdr_get()** is a macro that uses **sdr_read()** to load *variable* from the SDR address given by *heap_pointer*; *heap_pointer* must be (or be derived from) a heap pointer as returned by **sdr_pointer()**. The size of *variable* is used as the number of bytes to copy.

void sdr_set(sdr, heap_pointer, variable)
: **sdr_set()** is a macro that uses **sdr_write()** to store *variable* at the SDR address given by *heap_pointer*; *heap_pointer* must be (or be derived from) a heap pointer as returned by **sdr_pointer()**. The size of *variable* is used as the number of bytes to copy.

HEAP SPACE MANAGEMENT FUNCTIONS

Object sdr_malloc(Sdr sdr, unsigned long size)
: Allocates a block of space from the of the indicated SDR's heap. *size* is the size of the block to allocate; the maximum size is 1/2 of the maximum address space size (i.e., 2G for a 32−bit machine). Returns block address if successful, zero if block could not be allocated.

Object sdr_insert(Sdr sdr, char *from, unsigned long size)
: Uses **sdr_malloc()** to obtain a block of space of size *size* and, if this allocation is successful, uses **sdr_write()** to copy *size* bytes of data from memory at *from* into the newly allocated block. Returns block address if successful, zero if block could not be allocated.

Object sdr_stow(sdr, variable)
: **sdr_stow()** is a macro that uses **sdr_insert()** to insert a copy of *variable* into the dataspace. The size of *variable* is used as the number of bytes to copy.

int sdr_object_length(Sdr sdr, Object object)
: Returns the number of bytes of heap space allocated to the application data at *object*.

void sdr_free(Sdr sdr, Object object)
: Frees for subsequent re-allocation the heap space occupied by *object*.

void sdr_stage(Sdr sdr, char *into, Object from, int length)
: Like **sdr_read()**, this function will copy *length* characters at *from* (a location in the heap of the indicated SDR) to the memory location given by *into*. Unlike **sdr_get()**, **sdr_stage()** requires that *from* be the address of some allocated object, not just any location within the heap. **sdr_stage()**, when called from within a transaction, notifies the SDR library that the indicated object may be updated later in the transaction; this enables the library to retrieve the object's size for later reference in validating attempts to write into some location within the object. If *length* is zero, the object's size is privately retrieved by SDR but none of the object's content is copied into memory.

long sdr_unused(Sdr sdr)
: Returns number of bytes of heap space not yet allocated to either the large or small objects pool.

void sdr_usage(Sdr sdr, SdrUsageSummary *summary)
: Loads the indicated SdrUsageSummary structure with a snapshot of the SDR's usage status. SdrUsageSummary is defined by:

```
typedef struct
{
        char            sdrName[MAX_SDR_NAME + 1];
        unsigned int    dsSize;
        unsigned int    smallPoolSize;
        unsigned int    smallPoolFreeBlockCount[SMALL_SIZES];
        unsigned int    smallPoolFree;
        unsigned int    smallPoolAllocated;
        unsigned int    largePoolSize;
        unsigned int    largePoolFreeBlockCount[LARGE_ORDERS];
        unsigned int    largePoolFree;
        unsigned int    largePoolAllocated;
        unsigned int    unusedSize;
} SdrUsageSummary;
```

void sdr_report(SdrUsageSummary *summary)
Sends to stdout a printed summary of the SDR's usage status.

int sdr_heap_depleted(Sdr sdr)
A Boolean function: returns 1 if the total available space in the SDR's heap (small pool free, large pool free, and unused) is less than 1/16 of the total size of the heap. Otherwise returns zero.

HEAP SPACE USAGE TRACING

If SDR_TRACE is defined at the time the SDR source code is compiled, the system includes built-in support for simple tracing of SDR heap space usage: heap space allocations are logged, and heap space deallocations are matched to logged allocations, ''closing'' them. This enables heap space leaks and some other kinds of SDR heap access problems to be readily investigated.

int sdr_start_trace(Sdr sdr, int traceLogSize, char *traceLogAddress)
Begins an episode of SDR heap space usage tracing. *traceLogSize* is the number of bytes of shared memory to use for trace activity logging; the frequency with which ''closed'' trace log events must be deleted will vary inversely with the amount of memory allocated for the trace log. *traceLogAddress* is normally NULL, causing the trace system to allocate *traceLogSize* bytes of shared memory dynamically for trace logging; if non-NULL, it must point to *traceLogSize* bytes of shared memory that have been pre-allocated by the application for this purpose. Returns 0 on success, −1 on any failure.

void sdr_print_trace(Sdr sdr, int verbose)
Prints a cumulative trace report and current usage report for *sdr*. If *verbose* is zero, only exceptions (notably, trace log events that remain open — potential SDR heap space leaks) are printed; otherwise all activity in the trace log is printed.

void sdr_clear_trace(Sdr sdr)
Deletes all closed trace log events from the log, freeing up memory for additional tracing.

void sdr_stop_trace(Sdr sdr)
Ends the current episode of SDR heap space usage tracing. If the shared memory used for the trace log was allocated by **sdr_start_trace()**, releases that shared memory.

CATALOGUE FUNCTIONS

The SDR catalogue functions are used to maintain the catalogue of the names, types, and addresses of objects within an SDR. The catalogue service includes functions for creating, deleting and finding catalogue entries and a function for navigating through catalogue entries sequentially.

void sdr_catlg(Sdr sdr, char *name, int type, Object object)
Associates *object* with *name* in the indicated SDR's catalogue and notes the *type* that was declared for this object. *type* is optional and has no significance other than that conferred on it by the application.

The SDR catalogue is flat, not hierarchical like a directory tree, and all names must be unique. The length of *name* is limited to 15 characters.

Object sdr_find(Sdr sdr, char *name, int *type)
: Locates the Object associated with *name* in the indicated SDR's catalogue and returns its address; also reports the catalogued type of the object in **type* if *type* is non-NULL. Returns zero if no object is currently catalogued under this name.

void sdr_uncatlg(Sdr sdr, char *name)
: Dissociates from *name* whatever object in the indicated SDR's catalogue is currently catalogued under that name.

Object sdr_read_catlg(Sdr sdr, char *name, int *type, Object *object, Object previous_entry)
: Used to navigate through catalogue entries sequentially. If *previous_entry* is zero, reads the first entry in the indicated SDR's catalogue; otherwise, reads the next catalogue entry following the one located at *previous_entry*. In either case, returns zero if no such catalogue entry exists; otherwise, copies that entry's name, type, and catalogued object address into *name*, **type*, and **object*, and then returns the address of the catalogue entry (which may be used as *previous_entry* in a subsequent call to **sdr_read_catlg()**).

USER'S GUIDE

Compiling an SDR application
: Just be sure to ''#include ''sdr.h"" at the top of each source file that includes any SDR function calls.

  For UNIX applications, link with ''−lsdr''.

Loading an SDR application (VxWorks)
```
ld < "libsdr.o"
```

: After the library has been loaded, you can begin loading SDR applications.

SEE ALSO

sdrlist (3), **sdrstring** (3), **sdrtable** (3)

NAME

sdrhash − Simple Data Recorder hash table management functions

SYNOPSIS

```
#include "sdr.h"

Object  sdr_hash_create         (Sdr sdr, int keyLength,
                                     int estNbrOfEntries,
                                     int meanSearchLength);
int     sdr_hash_insert         (Sdr sdr, Object hash, char *key,
                                     Address value, Object *entry);
int     sdr_hash_delete_entry   (Sdr sdr, Object entry);
int     sdr_hash_entry_value    (Sdr sdr, Object hash, Object entry);
int     sdr_hash_retrieve       (Sdr sdr, Object hash, char *key,
                                     Address *value, Object *entry);
int     sdr_hash_count          (Sdr sdr, Object hash);
int     sdr_hash_revise         (Sdr sdr, Object hash, char *key,
                                     Address value);
int     sdr_hash_remove         (Sdr sdr, Object hash, char *key,
                                     Address *value);
int     sdr_hash_destroy        (Sdr sdr, Object hash);
```

DESCRIPTION

The SDR hash functions manage hash table objects in an SDR.

Hash tables associate values with keys. A value is always in the form of an SDR Address, nominally the address of some stored object identified by the associated key, but the actual significance of a value may be anything that fits into a *long*. A key is always an array of from 1 to 255 bytes, which may have any semantics at all.

Keys must be unique; no two distinct entries in an SDR hash table may have the same key. Any attempt to insert a duplicate entry in an SDR hash table will be rejected.

All keys must be of the same length, and that length must be declared at the time the hash table is created. Invoking a hash table function with a key that is shorter than the declared length will have unpredictable results.

An SDR hash table is an array of linked lists. The location of a given value in the hash table is automatically determined by computing a ‘‘hash’’ of the key, dividing the hash by the number of linked lists in the array, using the remainder as an index to the corresponding linked list, and then sequentially searching through the list entries until the entry with the matching key is found.

The number of linked lists in the array is automatically computed at the time the hash table is created, based on the estimated maximum number of entries you expect to store in the table and the mean linked list length (i.e., mean search time) you prefer. Increasing the maximum number of entries in the table and decreasing the mean linked list length both tend to increase the amount of SDR heap space occupied by the hash table.

Object sdr_hash_create(Sdr sdr, int keyLength, int estNbrOfEntries, int meanSearchLength)
: Creates an SDR hash table. Returns the SDR address of the new hash table on success, zero on any error.

int sdr_hash_insert(Sdr sdr, Object hash, char *key, Address value, Object *entry)
: Inserts an entry into the hash table identified by *hash*. On success, places the address of the new hash table entry in *entry* and returns zero. Returns −1 on any error.

int sdr_hash_delete_entry(Sdr sdr, Object entry)
: Deletes the hash table entry identified by *entry*. Returns zero on success, −1 on any error.

Address sdr_hash_entry_value(Sdr sdr, Object hash, Object entry)
Returns the value of the hash table entry identified by *entry*.

int sdr_hash_retrieve(Sdr sdr, Object hash, char *key, Address *value, Object *entry)
Searches for the value associated with *key* in this hash table, storing it in *value* if found. If the entry matching *key* was found, places the address of the hash table entry in *entry* and returns 1. Returns zero if no such entry exists, −1 on any other failure.

int sdr_hash_count(Sdr sdr, Object hash)
Returns the number of entries in the hash table identified by *hash*.

int sdr_hash_revise(Sdr sdr, Object hash, char *key, Address value)
Searches for the hash table entry matching *key* in this hash table, replacing the associated value with *value* if found. Returns 1 if the entry matching *key* was found, zero if no such entry exists, −1 on any other failure.

int sdr_hash_remove(Sdr sdr, Object hash, char *key, Address *value)
Searches for the hash table entry matching *key* in this hash table; if the entry is found, stores its value in *value*, deletes the entry, and returns 1. Returns zero if no such entry exists, −1 on any other failure.

void sdr_hash_destroy(Sdr sdr, Object hash);
Destroys *hash*, destroying all entries in all linked lists of the array and destroying the hash table array structure itself. DO NOT use **sdr_free()** to destroy a hash table, as this would leave the hash table's content allocated yet unreferenced.

SEE ALSO

sdr (3), **sdrlist** (3), **sdrtable** (3)

NAME

sdrlist – Simple Data Recorder list management functions

SYNOPSIS

```
#include "sdr.h"

typedef int (*SdrListCompareFn)(Sdr sdr, Address eltData, void *argData);
typedef void (*SdrListDeleteFn)(Sdr sdr, Object elt, void *argument);

[see description for available functions]
```

DESCRIPTION

The SDR list management functions manage doubly-linked lists in managed SDR heap space. The functions manage two kinds of objects: lists and list elements. A list knows how many elements it contains and what its start and end elements are. An element knows what list it belongs to and the elements before and after it in the list. An element also knows its content, which is normally the SDR Address of some object in the SDR heap. A list may be sorted, which speeds the process of searching for a particular element.

Object sdr_list_create(Sdr sdr)

Creates a new list object in the SDR; the new list object initially contains no list elements. Returns the address of the new list, or zero on any error.

void sdr_list_destroy(Sdr sdr, Object list, SdrListDeleteFn fn, void *arg)

Destroys a list, freeing all elements of list. If *fn* is non-NULL, that function is called once for each freed element; when called, *fn* is passed the Address that is the element's data and the *argument* pointer passed to **sdr_list_destroy()**.

Do not use *sdr_free* to destroy an SDR list, as this would leave the elements of the list allocated yet unreferenced.

int sdr_list_length(Sdr sdr, Object list)

Returns the number of elements in the list, or −1 on any error.

void sdr_list_user_data_set(Sdr sdr, Object list, Address userData)

Sets the ''user data'' word of *list* to *userData*. Note that *userData* is nominally an Address but can in fact be any value that occupies a single word. It is typically used to point to an SDR object that somehow characterizes the list as a whole, such as a name.

Address sdr_list_user_data(Sdr sdr, Object list)

Returns the value of the ''user data'' word of *list*, or zero on any error.

Object sdr_list_insert(Sdr sdr, Object list, Address data, SdrListCompareFn fn, void *dataBuffer)

Creates a new list element whose data value is *data* and inserts that element into the list. If *fn* is NULL, the new list element is simply appended to the list; otherwise, the new list element is inserted after the last element in the list whose data value is ''less than or equal to'' the data value of the new element (in dataBuffer) according to the collating sequence established by *fn*. Returns the address of the newly created element, or zero on any error.

Object sdr_list_insert_first(Sdr sdr, Object list, Address data)
Object sdr_list_insert_last(Sdr sdr, Object list, Address data)

Creates a new element and inserts it at the front/end of the list. This function should not be used to insert a new element into any ordered list; use **sdr_list_insert()** instead. Returns the address of the newly created list element on success, or zero on any error.

Object sdr_list_insert_before(Sdr sdr, Object elt, Address data)
Object sdr_list_insert_after(Sdr sdr, Object elt, Address data)

Creates a new element and inserts it before/after the specified list element. This function should not be used to insert a new element into any ordered list; use **sdr_list_insert()** instead. Returns the address of the newly created list element, or zero on any error.

void sdr_list_delete(Sdr sdr, Object elt, SdrListDeleteFn fn, void *arg)
Delete *elt* from the list it is in. If *fn* is non-NULL, that function will be called upon deletion of *elt*; when called, that function is passed the Address that is the list element's data value and the *arg* pointer passed to **sdr_list_delete**().

Object sdr_list_first(Sdr sdr, Object list)
Object sdr_list_last(Sdr sdr, Object list)
Returns the address of the first/last element of *list*, or zero on any error.

Object sdr_list_next(Sdr sdr, Object elt)
Object sdr_list_prev(Sdr sdr, Object elt)
Returns the address of the element following/preceding *elt* in that element's list, or zero on any error.

Object sdr_list_search(Sdr sdr, Object elt, int reverse, SdrListCompareFn fn, void *dataBuffer);
Search a list for an element whose data matches the data in *dataBuffer*, starting at the indicated initial list element. If the *compare* function is non-NULL, the list is assumed to be sorted in the order implied by that function and the function is automatically called once for each element of the list until it returns a value that is greater than or equal to zero (where zero indicates an exact match and a value greater than zero indicates that the list contains no matching element); each time *compare* is called it is passed the Address that is the element's data value and the *dataBuffer* value passed to **sm_list_search**(). If *reverse* is non-zero, then the list is searched in reverse order (starting at the indicated initial list element) and the search ends when *compare* returns a value that is less than or equal to zero. If *compare* is NULL, then the entire list is searched (in either forward or reverse order, as directed) until an element is located whose data value is equal to ((Address) *dataBuffer*). Returns the address of the matching element if one is found, 0 otherwise.

Object sdr_list_list(Sdr sdr, Object elt)
Returns the address of the list to which *elt* belongs, or 0 on any error.

Address sdr_list_data(Sdr sdr, Object elt)
Returns the Address that is the data value of *elt*, or 0 on any error.

Address sdr_list_data_set(Sdr sdr, Object elt, Address data)
Sets the data value for *elt* to *data*, replacing the original value. Returns the original data value for *elt*, or 0 on any error. The original data value for *elt* may or may not have been the address of an object in heap data space; even if it was, that object was NOT deleted.

Warning: changing the data value of an element of an ordered list may ruin the ordering of the list.

USAGE

When inserting elements or searching a list, the user may optionally provide a compare function of the form:

```
int user_comp_name(Sdr sdr, Address eltData, void *dataBuffer);
```

When provided, this function is automatically called by the sdrlist function being invoked; when the function is called it is passed the content of a list element (*eltData*, nominally the Address of an item in the SDR's heap space) and an argument, *dataBuffer*, which is nominally the address in local memory of some other item in the same format. The user-supplied function normally compares some key values of the two data items and returns 0 if they are equal, an integer less than 0 if *eltData*'s key value is less than that of *dataBuffer*, and an integer greater than 0 if *eltData*'s key value is greater than that of *dataBuffer*. These return values will produce a list in ascending order. If the user desires the list to be in descending order, the function must reverse the signs of these return values.

When deleting an element or destroying a list, the user may optionally provide a delete function of the form:

```
void user_delete_name(Sdr sdr, Address eltData, void *argData)
```

When provided, this function is automatically called by the sdrlist function being invoked; when the function is called it is passed the content of a list element (*eltData*, nominally the Address of an item in the SDR's heap space) and an argument, *argData*, which if non-NULL is normally the address in local memory

of a data item providing context for the list element deletion. The user-supplied function performs any application-specific cleanup associated with deleting the element, such as freeing the element's content data item and/or other SDR heap space associated with the element.

SEE ALSO

lyst (3), **sdr** (3), **sdrstring** (3), **sdrtable** (3), **smlist** (3)

NAME

sdrstring − Simple Data Recorder string functions

SYNOPSIS

```
#include "sdr.h"

Object sdr_string_create (Sdr sdr, char *from);
Object sdr_string_dup    (Sdr sdr, Object from);
int    sdr_string_length (Sdr sdr, Object string);
int    sdr_string_read   (Sdr sdr, char *into, Object string);
```

DESCRIPTION

SDR strings are used to record strings of up to 255 ASCII characters in the heap space of an SDR. Unlike standard C strings, which are terminated by a zero byte, SDR strings record the length of the string as part of the string object.

To store strings longer than 255 characters, use **sdr_malloc()** and **sdr_write()** instead of these functions.

Object sdr_string_create(Sdr sdr, char *from)

Creates a ''self-delimited string'' in the heap of the indicated SDR, allocating the required space and copying the indicated content. *from* must be a standard C string for which **strlen()** must not exceed 255; if it does, or if insufficient SDR space is available, 0 is returned. Otherwise the address of the newly created SDR string object is returned. To destroy, just use **sdr_free()**.

Object sdr_string_dup(Sdr sdr, Object from)

Creates a duplicate of the SDR string whose address is *from*, allocating the required space and copying the original string's content. If insufficient SDR space is available, 0 is returned. Otherwise the address of the newly created copy of the original SDR string object is returned. To destroy, use **sdr_free()**.

int sdr_string_length(Sdr sdr, Object string)

Returns the length of the indicated self-delimited string (as would be returned by **strlen()**), or −1 on any error.

int sdr_string_read(Sdr sdr, char *into, Object string)

Retrieves the content of the indicated self-delimited string into memory as a standard C string (NULL terminated). Length of *into* should normally be SDRSTRING_BUFSZ (i.e., 256) to allow for the largest possible SDR string (255 characters) plus the terminating NULL. Returns length of string (as would be returned by **strlen()**), or −1 on any error.

SEE ALSO

sdr (3), **sdrlist** (3), **sdrtable** (3), **string** (3)

NAME

sdrtable − Simple Data Recorder table management functions

SYNOPSIS

```
#include "sdr.h"

Object  sdr_table_create        (Sdr sdr, int rowSize, int rowCount);
int     sdr_table_user_data_set (Sdr sdr, Object table, Address userData);
Address sdr_table_user_data     (Sdr sdr, Object table);
int     sdr_table_dimensions    (Sdr sdr, Object table, int *rowSize,
                                    int *rowCount);
int     sdr_table_stage         (Sdr sdr, Object table);
Address sdr_table_row           (Sdr sdr, Object table,
                                    unsigned int rowNbr);
int     sdr_table_destroy       (Sdr sdr, Object table);
```

DESCRIPTION

The SDR table functions manage table objects in the SDR. An SDR table comprises N rows of M bytes each, plus optionally one word of user data (which is nominally the address of some other object in the SDR's heap space). When a table is created, the number of rows in the table and the length of each row are specified; they remain fixed for the life of the table. The table functions merely maintain information about the table structure and its location in the SDR and calculate row addresses; other SDR functions such as **sdr_read()** and **sdr_write()** are used to read and write the contents of the table's rows. In particular, the format of the rows of a table is left entirely up to the user.

Object sdr_table_create(Sdr sdr, int rowSize, int rowCount)

Creates a ''self-delimited table'', comprising *rowCount* rows of *rowSize* bytes each, in the heap space of the indicated SDR. Note that the content of the table, a two-dimensional array, is a single SDR heap space object of size (*rowCount* x *rowSize*). Returns the address of the new table on success, zero on any error.

void sdr_table_user_data_set(Sdr sdr, Object table, Address userData)

Sets the ''user data'' word of *table* to *userData*. Note that *userData* is nominally an Address but can in fact be any value that occupies a single word. It is typically used to point to an SDR object that somehow characterizes the table as a whole, such as an SDR string containing a name.

Address sdr_table_user_data(Sdr sdr, Object table)

Returns the value of the ''user data'' word of *table*, or zero on any error.

void sdr_table_dimensions(Sdr sdr, Object table, int *rowSize, int *rowCount)

Reports on the row size and row count of the indicated table, as specified when the table was created.

void sdr_table_stage(Sdr sdr, Object table)

Stages *table* so that the array it encapsulates may be updated; see the discussion of **sdr_stage()** in **sdr** (3). The effect of this function is the same as:

```
sdr_stage(sdr, NULL, (Object) sdr_table_row(sdr, table, 0), 0)
```

Address sdr_table_row(Sdr sdr, Object table, unsigned int rowNbr)

Returns the address of the *rowNbr*th row of *table*, for use in reading or writing the content of this row; returns −1 on any error.

void sdr_table_destroy(Sdr sdr, Object table)

Destroys *table*, releasing all bytes of all rows and destroying the table structure itself. DO NOT use **sdr_free()** to destroy a table, as this would leave the table's content allocated yet unreferenced.

SEE ALSO

sdr (3), **sdrlist** (3), **sdrstring** (3)

NAME

smlist − shared memory list management library

SYNOPSIS

```
#include "smlist.h"

typedef int (*SmListCompareFn)
    (PsmPartition partition, PsmAddress eltData, void *argData);
typedef void (*SmListDeleteFn)
    (PsmPartition partition, PsmAddress elt, void *argument);

[see description for available functions]
```

DESCRIPTION

The smlist library provides functions to create, manipulate and destroy doubly-linked lists in shared memory. As with **lyst** (3), smlist uses two types of objects, *list* objects and *element* objects. However, as these objects are stored in shared memory which is managed by **psm** (3), pointers to these objects are carried as PsmAddress values. A list knows how many elements it contains and what its first and last elements are. An element knows what list it belongs to and the elements before and after it in its list. An element also knows its content, which is normally the PsmAddress of some object in shared memory.

PsmAddress sm_list_create(PsmPartition partition)
: Create a new list object without any elements in it, within the memory segment identified by *partition*. Returns the PsmAddress of the list, or 0 on any error.

void sm_list_unwedge(PsmPartition partition, PsmAddress list, int interval)
: Unwedge, as necessary, the mutex semaphore protecting shared access to the indicated list. For details, see the explanation of the **sm_SemUnwedge()** function in **platform** (3).

int sm_list_clear(PsmPartition partition, PsmAddress list, SmListDeleteFn delete, void *argument);
: Empty a list. Frees each element of the list. If the *delete* function is non-NULL, that function is called once for each freed element; when called, that function is passed the PsmAddress of the list element and the *argument* pointer passed to **sm_list_clear()**. Returns 0 on success, −1 on any error.

int sm_list_destroy(PsmPartition partition, PsmAddress list, SmListDeleteFn delete, void *argument);
: Destroy a list. Same as **sm_list_clear()**, but additionally frees the list structure itself. Returns 0 on success, −1 on any error.

int sm_list_user_data_set(PsmPartition partition, PsmAddress list, PsmAddress userData);
: Set the value of a user data variable associated with the list as a whole. This value may be used for any purpose; it is typically used to store the PsmAddress of a shared memory block containing data (e.g., state data) which the user wishes to associate with the list. Returns 0 on success, −1 on any error.

PsmAddress sm_list_user_data(PsmPartition partition, PsmAddress list);
: Return the value of the user data variable associated with the list as a whole, or 0 on any error.

int sm_list_length(PsmPartition partition, PsmAddress list);
: Return the number of elements in the list.

PsmAddress sm_list_insert(PsmPartition partition, PsmAddress list, PsmAddress data, SmListCompareFn compare, void *dataBuffer);
: Create a new list element whose data value is *data* and insert it into the given list. If the *compare* function is NULL, the new list element is simply appended to the list; otherwise, the new list element is inserted after the last element in the list whose data value is ‘‘less than or equal to’’ the data value of the new element (in *dataBuffer*) according to the collating sequence established by *compare*. Returns the PsmAddress of the new element, or 0 on any error.

PsmAddress sm_list_insert_first(PsmPartition partition, PsmAddress list, PsmAddress data);

PsmAddress sm_list_insert_last(PsmPartition partition, PsmAddress list, PsmAddress data);
Create a new list element and insert it at the start/end of a list. Returns the PsmAddress of the new element on success, or 0 on any error. Disregards any established sort order in the list.

PsmAddress sm_list_insert_before(PsmPartition partition, PsmAddress elt, PsmAddress data);
PsmAddress sm_list_insert_after(PsmPartition partition, PsmAddress elt, PsmAddress data);
Create a new list element and insert it before/after a given element. Returns the PsmAddress of the new element on success, or 0 on any error. Disregards any established sort order in the list.

int sm_list_delete(PsmPartition partition, PsmAddress elt, SmListDeleteFn delete, void *argument);
Delete an element from a list. If the *delete* function is non-NULL, that function is called upon deletion of *elt*; when called, that function is passed the PsmAddress of the list element and the *argument* pointer passed to **sm_list_delete()**. Returns 0 on success, −1 on any error.

PsmAddress sm_list_first(PsmPartition partition, PsmAddress list);
PsmAddress sm_list_last(PsmPartition partition, PsmAddress list);
Return the PsmAddress of the first/last element in *list*, or 0 on any error.

PsmAddress sm_list_next(PsmPartition partition, PsmAddress elt);
PsmAddress sm_list_prev(PsmPartition partition, PsmAddress elt);
Return the PsmAddress of the element following/preceding *elt* in that element's list, or 0 on any error.

PsmAddress sm_list_search(PsmPartition partition, PsmAddress elt, SmListCompareFn compare, void *dataBuffer);
Search a list for an element whose data matches the data in *dataBuffer*. If the *compare* function is non-NULL, the list is assumed to be sorted in the order implied by that function and the function is automatically called once for each element of the list until it returns a value that is greater than or equal to zero (where zero indicates an exact match and a value greater than zero indicates that the list contains no matching element); each time *compare* is called it is passed the PsmAddress that is the element's data value and the *dataBuffer* value passed to **sm_list_search()**. If *compare* is NULL, then the entire list is searched until an element is located whose data value is equal to ((PsmAddress) *dataBuffer*). Returns the PsmAddress of the matching element if one is found, 0 otherwise.

PsmAddress sm_list_list(PsmPartition partition, PsmAddress elt);
Return the PsmAddress of the list to which *elt* belongs, or 0 on any error.

PsmAddress sm_list_data(PsmPartition partition, PsmAddress elt);
Return the PsmAddress that is the data value for *elt*, or 0 on any error.

PsmAddress sm_list_data_set(PsmPartition partition, PsmAddress elt, PsmAddress data);
Set the data value for *elt* to *data*, replacing the original value. Returns the original data value for *elt*, or 0 on any error. The original data value for *elt* may or may not have been the address of an object in memory; even if it was, that object was NOT deleted.

Warning: changing the data value of an element of an ordered list may ruin the ordering of the list.

USAGE

A user normally creates an element and adds it to a list by doing the following:

1 obtaining a shared memory block to contain the element's data;

2 converting the shared memory block's PsmAddress to a character pointer;

3 using that pointer to write the data into the shared memory block;

4 calling one of the *sm_list_insert* functions to create the element structure (which will include the shared memory block's PsmAddress) and insert it into the list.

When inserting elements or searching a list, the user may optionally provide a compare function of the form:

```
int user_comp_name(PsmPartition partition, PsmAddress eltData,
                   void *dataBuffer);
```

When provided, this function is automatically called by the smlist function being invoked; when the

function is called it is passed the content of a list element (*eltData*, nominally the PsmAddress of an item in shared memory) and an argument, *dataBuffer*, which is nominally the address in local memory of some other item in the same format. The user-supplied function normally compares some key values of the two data items and returns 0 if they are equal, an integer less than 0 if *eltData*'s key value is less than that of *dataBuffer*, and an integer greater than 0 if *eltData*'s key value is greater than that of *dataBuffer*. These return values will produce a list in ascending order. If the user desires the list to be in descending order, the function must reverse the signs of these return values.

When deleting an element or destroying a list, the user may optionally provide a delete function of the form:

```
void user_delete_name(PsmPartition partition, PsmAddress elt, void *argData)
```

When provided, this function is automatically called by the smlist function being invoked; when the function is called it is passed the address of a list element (*elt* and an argument, *argData*, which if non-NULL is normally the address in local memory of a data item providing context for the list element deletion. The user-supplied function performs any application-specific cleanup associated with deleting the element, such as freeing the element's content data item and/or other memory associated with the element.

EXAMPLE

For an example of the use of smlist, see the file smlistsh.c in the utils directory of ICI.

SEE ALSO

lyst (3), **platform** (3), **psm** (3)

NAME

smrbt − shared−memory red−black tree management library

SYNOPSIS

```
#include "smrbt.h"

typedef int (*SmRbtCompareFn)
    (PsmPartition partition, PsmAddress nodeData, void *dataBuffer);
typedef void (*SmRbtDeleteFn)
    (PsmPartition partition, PsmAddress nodeData, void *argument);

[see description for available functions]
```

DESCRIPTION

The smrbt library provides functions to create, manipulate and destroy ‘‘red-black’’ balanced binary trees in shared memory. smrbt uses two types of objects, *rbt* objects and *node* objects; as these objects are stored in shared memory which is managed by **psm** (3), pointers to these objects are carried as PsmAddress values. An rbt knows how many nodes it contains and what its root node is. An node knows what rbt it belongs to and which nodes are its parent and (up to 2) children. A node also knows its content, which is normally the PsmAddress of some object in shared memory.

PsmAddress sm_rbt_create(PsmPartition partition)
: Create a new rbt object without any nodes in it, within the memory segment identified by *partition*. Returns the PsmAddress of the rbt, or 0 on any error.

void sm_rbt_unwedge(PsmPartition partition, PsmAddress rbt, int interval)
: Unwedge, as necessary, the mutex semaphore protecting shared access to the indicated rbt. For details, see the explanation of the **sm_SemUnwedge()** function in **platform** (3).

int sm_rbt_clear(PsmPartition partition, PsmAddress rbt, SmRbtDeleteFn delete, void *argument);
: Frees every node of the rbt, leaving the rbt empty. If the *delete* function is non-NULL, that function is called once for each freed node; when called, that function is passed the PsmAddress that is the node’s data and the *argument* pointer passed to **sm_rbt_clear()**. Returns 0 on success, −1 on any error.

void sm_rbt_destroy(PsmPartition partition, PsmAddress rbt, SmRbtDeleteFn delete, void *argument);
: Destroy an rbt. Frees all nodes of the rbt as in **sm_rbt_clear()**, then frees the rbt structure itself.

int sm_rbt_user_data_set(PsmPartition partition, PsmAddress rbt, PsmAddress userData);
: Set the value of a user data variable associated with the rbt as a whole. This value may be used for any purpose; it is typically used to store the PsmAddress of a shared memory block containing data (e.g., state data) which the user wishes to associate with the rbt. Returns 0 on success, −1 on any error.

PsmAddress sm_rbt_user_data(PsmPartition partition, PsmAddress rbt);
: Return the value of the user data variable associated with the rbt as a whole, or 0 on any error.

int sm_rbt_length(PsmPartition partition, PsmAddress rbt);
: Return the number of nodes in the rbt.

PsmAddress sm_rbt_insert(PsmPartition partition, PsmAddress rbt, PsmAddress data, SmRbtCompareFn compare, void *dataBuffer);
: Create a new rbt node whose data value is *data* and insert it into *rbt*. The nodes of an rbt are ordered by their notional ‘‘key’’ values; for this purpose, no two nodes may have the same key value. The key value of a node is assumed to be some function of the content of *dataBuffer*, which is assumed to be a representation in memory of the data value indicated by *data*, and that function must be implicit in the *compare* function, which must not be NULL. The new rbt node is inserted into the rbt in a tree location that preserves order in the tree, according to the collating sequence established by *compare*, and also ensures that no path (from root to leaf) in the tree is more than twice as long as any other path. This makes searching the tree for a given data value quite rapid even if the number of nodes in the tree is very large. Returns the PsmAddress of the new node, or 0 on any error.

void sm_rbt_delete(PsmPartition partition, PsmAddress rbt, SmRbtCompareFn compare, void *dataBuffer, SmRbtDeleteFn delete, void *argument);

Delete a node from *rbt*. *compare* must be the same function that was used to insert the node: the tree must be dynamically re-balanced upon node deletion, and the *compare* function and the data value of the node that is to be deleted (as represented in memory in *dataBuffer*) are required for this purpose. (Since the function descends the tree in search of the matching node anyway, in order to preserve balance, the address of the node itself is not needed.)

If the *delete* function is non-NULL, that function is called upon deletion of the indicated node. When called, that function is passed the PsmAddress that is the node's data value and the *argument* pointer passed to **sm_rbt_delete()**.

NOTE that this function does something highly devious to avoid extra tree-balancing complexity when node is deleted. For details, see the code, but the main point is that deleting a node **WILL MOVE NODES WITHIN THE TREE**. After the deletion, the next node may not be the one that would have been reported if you passed the to-be-deleted node to **sm_rbt_next()** before calling **sm_rbt_delete()**. This is important: do not apply updates (no insertions, and especially no deletions) while you are traversing a red-black tree sequentially. If you do, the result will not be what you expect.

PsmAddress sm_rbt_first(PsmPartition partition, PsmAddress rbt);
PsmAddress sm_rbt_last(PsmPartition partition, PsmAddress rbt);

Return the PsmAddress of the first/last node in *rbt*, or 0 on any error.

PsmAddress sm_rbt_next(PsmPartition partition, PsmAddress node);
PsmAddress sm_rbt_prev(PsmPartition partition, PsmAddress node);

Return the PsmAddress of the node following/preceding *node* in that node's rbt, or 0 on any error.

NOTE that the red-black tree node insertion and deletion functions **WILL MOVE NODES WITHIN THE TREE**. This is important: do not apply updates (no insertions, and especially no deletions) while you are traversing a red-black tree sequentially, using **sm_rbt_next()** or **sm_rbt_prev()**. If you do, the result will not be what you expect.

PsmAddress sm_rbt_search(PsmPartition partition, PsmAddress rbt, SmRbtCompareFn compare, void *dataBuffer, PsmAddress *successor);

Search *rbt* for a node whose data matches the data in *dataBuffer*. *compare* must be the same function that was used to insert all nodes into the tree. The tree is searched until a node is found whose data value is ''equal'' (according to *compare*) to the data value represented in memory in *dataBuffer*, or until it is known that there is no such node in the tree. If the matching node is found, the PsmAddress of that node is returned and **successor* is set to zero. Otherwise, zero is returned and **successor* is set to the PsmAddress of the first node in the tree whose key value is greater than the key value of *dataBuffer*, according to *compare*, or to zero if there is no such successor node.

PsmAddress sm_rbt_rbt(PsmPartition partition, PsmAddress node);

Return the PsmAddress of the rbt to which *node* belongs, or 0 on any error.

PsmAddress sm_rbt_data(PsmPartition partition, PsmAddress node);

Return the PsmAddress that is the data value for *node*, or 0 on any error.

USAGE

A user normally creates an node and adds it to a rbt by doing the following:

1 obtaining a shared memory block to contain the node's data;

2 converting the shared memory block's PsmAddress to a character pointer;

3 using that pointer to write the data into the shared memory block;

4 calling the *sm_rbt_insert* function to create the node structure (which will include the shared memory block's PsmAddress) and insert it into the rbt.

When inserting or deleting nodes or searching a rbt, the user must provide a compare function of the form:

```
int user_comp_name(PsmPartition partition, PsmAddress node,
                   void *dataBuffer);
```

This function is automatically called by the smrbt function being invoked; when the function is called it is passed the data content of an rbt node (*node*, nominally the PsmAddress of an item in shared memory) and an argument, *dataBuffer*, which is nominally the address in local memory of some other data item in the same format. The user-supplied function normally compares some key values of the two data items and returns 0 if they are equal, an integer less than 0 if *node*'s key value is less than that of *dataBuffer*, and an integer greater than 0 if *node*'s key value is greater than that of *dataBuffer*. These return values will produce an rbt in ascending order.

When deleting an node or destroying a rbt, the user may optionally provide a delete function of the form:

```
void user_delete_name(PsmPartition partition, PsmAddress node,
                      void *argData)
```

When provided, this function is automatically called by the smrbt function being invoked; when the function is called it is passed the content of a rbt node (*node*, nominally the PsmAddress of an item in shared memory) and an argument, *argData*, which if non-NULL is normally the address in local memory of a data item providing context for the rbt node deletion. The user-supplied function performs any application-specific cleanup associated with deleting the node, such as freeing the node's content data item and/or other memory associated with the node.

EXAMPLE

For an example of the use of smrbt, see the file smrbtsh.c in the utils directory of ICI.

SEE ALSO

smrbtsh (1), **platform** (3), **psm** (3)

NAME

zco – library for manipulating zero–copy objects

SYNOPSIS

```
#include "zco.h"

typedef enum
{
    ZcoInbound = 0,
    ZcoOutbound = 1,
    ZcoUnknown = 2
} ZcoAcct;

typedef enum
{
    ZcoFileSource = 1,
    ZcoBulkSource = 2,
    ZcoObjSource = 3,
    ZcoSdrSource = 4,
    ZcoZcoSource = 5
} ZcoMedium;

typedef void (*ZcoCallback)(ZcoAcct);

[see description for available functions]
```

DESCRIPTION

''Zero-copy objects'' (ZCOs) are abstract data access representations designed to minimize I/O in the encapsulation of application source data within one or more layers of communication protocol structure. ZCOs are constructed within the heap space of an SDR to which implementations of all layers of the stack must have access. Each ZCO contains information enabling access to the source data objects, together with (a) a linked list of zero or more ''extents'' that reference portions of these source data objects and (b) linked lists of protocol header and trailer capsules that have been explicitly attached to the ZCO since its creation. The concatenation of the headers (in ascending stack sequence), source data object extents, and trailers (in descending stack sequence) is what is to be transmitted or has been received.

Each source data object may be either a file (identified by pathname stored in a ''file reference'' object in SDR heap) or an item in mass storage (identified by item number, with implementation-specific semantics, stored in a ''bulk reference'' object in SDR heap) or an object in SDR heap space (identified by heap address stored in an ''object reference'' object in SDR heap) or an array of bytes in SDR heap space (identified by heap address). Each protocol header or trailer capsule indicates the length and the address (within SDR heap space) of a single protocol header or trailer at some layer of the stack. Note that the source data object for each ZCO extent is specified indirectly, by reference to a content lien reference structure that refers to a heap space object, mass storage item, or file; the reference structures contain the actual locations of the source data together with reference counts, enabling any number of ''clones'' of a given ZCO extent to be constructed without consuming additional resources. These reference counts ensure that the reference structures and the source data items they refer to are deleted automatically when (and only when) all ZCO extents that reference them have been deleted.

Note that the safety of shared access to a ZCO is protected by the fact that the ZCO resides in SDR heap space and therefore cannot be modified other than in the course of an SDR transaction, which serializes access. Moreover, extraction of data from a ZCO may entail the reading of file-based source data extents, which may cause file progress to be updated in one or more file reference objects in the SDR heap. For this reason, all ZCO ''transmit'' and ''receive'' functions must be performed within SDR transactions.

Note also that ZCO can more broadly be used as a general-purpose reference counting system for non-volatile data objects, where a need for such a system is identified.

The total volume of file system space, mass storage space, and SDR heap space that may be occupied by inbound and (separately) outbound ZCO extents are system configuration parameters that may be set by ZCO library functions. Those limits are enforced when extents are appended to ZCOs: total inbound and outbound ZCO file space, mass storage, and SDR heap occupancy are updated continuously as ZCOs are created and destroyed, and the formation of a new extent is prohibited when the length of the extent exceeds the difference between the applicable limit and the corresponding current occupancy total. Doing separate accounting for inbound and outbound ZCOs enables inbound ZCOs to be formed (for data reception purposes) even when the total current volume of outbound ZCOs has reached its limit, and vice versa.

void zco_register_callback(ZcoCallback notify)
: This function registers the ''callback'' function that the ZCO system will invoke every time a ZCO is destroyed, making ZCO file, bulk, and/or heap space available for the formation of new ZCO extents. This mechanism can be used, for example, to notify tasks that are waiting for ZCO space to be made available so that they can resume some communication protocol procedure.

void zco_unregister_callback( )
: This function simply unregisters the currently registered callback function for ZCO destruction.

Object zco_create_file_ref(Sdr sdr, char *pathName, char *cleanupScript, ZcoAcct acct)
: Creates and returns a new file reference object, which can be used as the source data extent location for creating a ZCO whose source data object is the file identified by *pathName*. *cleanupScript*, if not NULL, is invoked at the moment the last ZCO that cites this file reference is destroyed [normally upon delivery either down to the ''ZCO transition layer'' of the protocol stack or up to a ZCO-capable application]. A zero-length string is interpreted as implicit direction to delete the referenced file when the file reference object is destroyed. Maximum length of *cleanupScript* is 255. *acct* must be ZcoInbound or ZcoOutbound, depending on whether the first ZCO that will reference this object will be inbound or outbound. Returns SDR location of file reference object on success, 0 on any error.

Object zco_revise_file_ref(Sdr sdr, Object fileRef, char *pathName, char *cleanupScript)
: Changes the *pathName* and *cleanupScript* of the indicated file reference. The new values of these fields are validated as for **zco_create_file_ref()**. Returns 0 on success, −1 on any error.

char *zco_file_ref_path(Sdr sdr, Object fileRef, char *buffer, int buflen)
: Retrieves the pathName associated with *fileRef* and stores it in *buffer*, truncating it to fit (as indicated by *buflen*) and NULL-terminating it. On success, returns *buffer*; returns NULL on any error.

int zco_file_ref_xmit_eof(Sdr sdr, Object fileRef)
: Returns 1 if the last octet of the referenced file (as determined at the time the file reference object was created) has been read by ZCO via a reader with file offset tracking turned on. Otherwise returns zero.

void zco_destroy_file_ref(Sdr sdr, Object fileRef)
: If the file reference object residing at location *fileRef* within the indicated Sdr is no longer in use (no longer referenced by any ZCO), destroys this file reference object immediately. Otherwise, flags this file reference object for destruction as soon as the last reference to it is removed.

Object zco_create_bulk_ref(Sdr sdr, unsigned long item, vast length, ZcoAcct acct)
: Creates and returns a new bulk reference object, which can be used as the source data extent location for creating a ZCO whose source data object is the mass storage item of length *length* identified by *item* (the semantics of which are implementation-dependent). Note that the referenced item is automatically destroyed at the time that the last ZCO that cites this bulk reference is destroyed (normally upon delivery either down to the ''ZCO transition layer'' of the protocol stack or up to a ZCO-capable application). *acct* must be ZcoInbound or ZcoOutbound, depending on whether the first ZCO that will reference this object will be inbound or outbound. Returns SDR location of bulk reference object on success, 0 on any error.

void zco_destroy_bulk_ref(Sdr sdr, Object bulkRef)
: If the bulk reference object residing at location *bulkRef* within the indicated Sdr is no longer in use (no longer referenced by any ZCO), destroys this bulk reference object immediately. Otherwise, flags this bulk reference object for destruction as soon as the last reference to it is removed.

Object zco_create_obj_ref(Sdr sdr, Object object, vast length, ZcoAcct acct)
: Creates and returns a new object reference object, which can be used as the source data extent location for creating a ZCO whose source data object is the SDR heap object of length *length* identified by *object*. Note that the referenced object is automatically freed at the time that the last ZCO that cites this object reference is destroyed (normally upon delivery either down to the ''ZCO transition layer'' of the protocol stack or up to a ZCO-capable application). *acct* must be ZcoInbound or ZcoOutbound, depending on whether the first ZCO that will reference this object will be inbound or outbound. Returns SDR location of object reference object on success, 0 on any error.

void zco_destroy_obj_ref(Sdr sdr, Object objRef)
: If the object reference object residing at location *objRef* within the indicated Sdr is no longer in use (no longer referenced by any ZCO), destroys this object reference object immediately. Otherwise, flags this object reference object for destruction as soon as the last reference to it is removed.

void zco_status(Sdr sdr)
: Uses the ION logging function to write a report of the current contents of the ZCO space accounting database.

vast zco_get_file_occupancy(Sdr sdr, ZcoAcct acct)
: Returns the total number of file system space bytes occupied by ZCOs (inbound or outbound) created in this Sdr.

void zco_set_max_file_occupancy(Sdr sdr, vast occupancy, ZcoAcct acct)
: Declares the total number of file system space bytes that may be occupied by ZCOs (inbound or outbound) created in this Sdr.

vast zco_get_max_file_occupancy(Sdr sdr, ZcoAcct acct)
: Returns the total number of file system space bytes that may be occupied by ZCOs (inbound or outbound) created in this Sdr.

int zco_enough_file_space(Sdr sdr, vast length, ZcoAcct acct)
: Returns 1 if the total remaining file system space available for ZCOs (inbound or outbound) in this Sdr is greater than *length*. Returns 0 otherwise.

vast zco_get_bulk_occupancy(Sdr sdr, ZcoAcct acct)
: Returns the total number of mass storage space bytes occupied by ZCOs (inbound or outbound) created in this Sdr.

void zco_set_max_bulk_occupancy(Sdr sdr, vast occupancy, ZcoAcct acct)
: Declares the total number of mass storage space bytes that may be occupied by ZCOs (inbound or outbound) created in this Sdr.

vast zco_get_max_bulk_occupancy(Sdr sdr, ZcoAcct acct)
: Returns the total number of mass storage space bytes that may be occupied by ZCOs (inbound or outbound) created in this Sdr.

int zco_enough_bulk_space(Sdr sdr, vast length, ZcoAcct acct)
: Returns 1 if the total remaining mass storage space available for ZCOs (inbound or outbound) in this Sdr is greater than *length*. Returns 0 otherwise.

vast zco_get_heap_occupancy(Sdr sdr, ZcoAcct acct)
: Returns the total number of SDR heap space bytes occupied by ZCOs (inbound or outbound) created in this Sdr.

void zco_set_max_heap_occupancy(Sdr sdr, vast occupancy, ZcoAcct acct)
: Declares the total number of SDR heap space bytes that may be occupied by ZCOs (inbound or outbound) created in this Sdr.

vast zco_get_max_heap_occupancy(Sdr sdr, ZcoAcct acct)
: Returns the total number of SDR heap space bytes that may be occupied by ZCOs (inbound or outbound) created in this Sdr.

int zco_enough_heap_space(Sdr sdr, vast length, ZcoAcct acct)

Returns 1 if the total remaining SDR heap space available for ZCOs (inbound or outbound) in this Sdr is greater than *length*. Returns 0 otherwise.

int zco_extent_too_large(Sdr sdr, ZcoMedium source, vast length, ZcoAcct acct)

Returns 1 if the total remaining space available for ZCOs (inbound or outbound) is NOT enough to contain a new extent of the indicated length in the indicated source medium. Returns 0 otherwise.

int zco_get_aggregate_length(Sdr sdr, Object location, vast offset, vast length, vast *fileSpaceOccupied, vast *bulkSpaceOccupied, vast *heapSpaceOccupied)

Populates **fileSpaceOccupied*, **bulkSpaceOccupied*, and **heapSpaceOccupied* with the total number of ZCO space bytes occupied by the extents of the zco at *location*, from *offset* to *offset* + *length*. If *offset* isn't the start of an extent or *offset* + *length* isn't the end of an extent, returns −1 in all three fields.

Object zco_create(Sdr sdr, ZcoMedium firstExtentSourceMedium, Object firstExtentLocation, vast firstExtentOffset, vast firstExtentLength, ZcoAcct acct)

Creates a new inbound or outbound ZCO. *firstExtentLocation* and *firstExtentLength* must either both be zero (indicating that **zco_append_extent()** will be used to insert the first source data extent later) or else both be non-zero. If *firstExtentLocation* is non-zero, then (a) *firstExtentLocation* must be the SDR location of a file reference object, bulk reference object, object reference object, SDR heap object, or ZCO, depending on the value of *firstExtentSourceMedium*, and (b) *firstExtentOffset* indicates how many leading bytes of the source data object should be skipped over when adding the initial source data extent to the new ZCO. A negative value for *firstExtentLength* indicates that the extent is already known not to be too large for the available ZCO space, and the actual length of the extent is the additive inverse of this value. On success, returns the SDR location of the new ZCO. Returns 0 if there is insufficient ZCO space for creation of the new ZCO; returns ((Object) −1) on any error.

int zco_append_extent(Sdr sdr, Object zco, ZcoMedium sourceMedium, Object location, vast offset, vast length)

Appends the indicated source data extent to the indicated ZCO, as described for **zco_create()**. Both the *location* and *length* of the source data must be non-zero. A negative value for *length* indicates that the extent is already known not to be too large for the available ZCO space, and the actual length of the extent is the additive inverse of this value. For constraints on the value of *location*, see **zco_create()**. Returns *length* on success, 0 if there is insufficient ZCO space for creation of the new source data extent, −1 on any error.

int zco_prepend_header(Sdr sdr, Object zco, char *header, vast length)
int zco_append_trailer(Sdr sdr, Object zco, char *trailer, vast length)
void zco_discard_first_header(Sdr sdr, Object zco)
void zco_discard_last_trailer(Sdr sdr, Object zco)

These functions attach and remove the ZCO's headers and trailers. *header* and *trailer* are assumed to be arrays of octets, not necessarily text. Attaching a header or trailer causes it to be written to the SDR. The prepend and append functions return 0 on success, −1 on any error.

Object zco_header_text(Sdr sdr, Object zco, int skip, vast *length)

Skips over the first *skip* headers of *zco* and returns the address of the text of the next header, placing the length of the header's text in **length*. Returns 0 on any error.

Object zco_trailer_text(Sdr sdr, Object zco, int skip, vast *length)

Skips over the first *skip* trailers of *zco* and returns the address of the text of the next trailer, placing the length of the trailer's text in **length*. Returns 0 on any error.

void zco_destroy(Sdr sdr, Object zco)

Destroys the indicated Zco. This reduces the reference counts for all files and SDR objects referenced in the ZCO's extents, resulting in the freeing of SDR objects and (optionally) the deletion of files as those reference count drop to zero.

void zco_bond(Sdr sdr, Object zco)
: Converts all headers and trailers of the indicated Zco to source data extents. Use this function to ensure that known header and trailer data are included when the ZCO is cloned.

int zco_revise(Sdr sdr, Object zco, vast offset, char *buffer, vast length)
: Writes the contents of *buffer*, for length *length*, into *zco* at offset *offset*. Returns 0 on success, −1 on any error.

Object zco_clone(Sdr sdr, Object zco, vast offset, vast length)
: Creates a new ZCO whose source data is a copy of a subset of the source data of the referenced ZCO. This procedure is required whenever it is necessary to process the ZCO's source data in multiple different ways, for different purposes, and therefore the ZCO must be in multiple states at the same time. Portions of the source data extents of the original ZCO are copied as necessary, but no header or trailer capsules are copied. Returns SDR location of the new ZCO on success, (Object) −1 on any error.

vast zco_clone_source_data(Sdr sdr, Object toZco, Object fromZco, vast offset, vast length)
: Appends to *toZco* a copy of a subset of the source data of *fromZCO*. Portions of the source data extents of *fromZCO* are copied as necessary. Returns total data length cloned, or −1 on any error.

vast zco_length(Sdr sdr, Object zco)
: Returns length of entire ZCO, including all headers and trailers and all source data extents. This is the size of the object that would be formed by concatenating the text of all headers, trailers, and source data extents into a single serialized object.

vast zco_source_data_length(Sdr sdr, Object zco)
: Returns length of entire ZCO minus the lengths of all attached header and trailer capsules. This is the size of the object that would be formed by concatenating the text of all source data extents (including those that are presumed to contain header or trailer text attached elsewhere) into a single serialized object.

ZcoAcct zco_acct(Sdr sdr, Object zco)
: Returns an indicator as to whether *zco* is inbound or outbound.

void zco_start_transmitting(Object zco, ZcoReader *reader)
: Used by underlying protocol layer to start extraction of an outbound ZCO's bytes (both from header and trailer capsules and from source data extents) for ''transmission'' — i.e., the copying of bytes into a memory buffer for delivery to some non-ZCO-aware protocol implementation. Initializes reading at the first byte of the total concatenated ZCO object. Populates *reader*, which is used to keep track of ''transmission'' progress via this ZCO reference.

  Note that this function can be called multiple times to restart reading at the start of the ZCO. Note also that multiple ZcoReader objects may be used concurrently, by the same task or different tasks, to advance through the ZCO independently.

void zco_track_file_offset(ZcoReader *reader)
: Turns on file offset tracking for this reader.

vast zco_transmit(Sdr sdr, ZcoReader *reader, vast length, char *buffer)
: Copies *length* as-yet-uncopied bytes of the total concatenated ZCO (referenced by *reader*) into *buffer*. If *buffer* is NULL, skips over *length* bytes without copying. Returns the number of bytes copied (or skipped) on success, 0 on any file access error, −1 on any other error.

void zco_start_receiving(Object zco, ZcoReader *reader)
: Used by overlying protocol layer to start extraction of an inbound ZCO's bytes for ''reception'' — i.e., the copying of bytes into a memory buffer for delivery to a protocol header parser, to a protocol trailer parser, or to the ultimate recipient (application). Initializes reading of headers, source data, and trailers at the first byte of the concatenated ZCO objects. Populates *reader*, which is used to keep track of ''reception'' progress via this ZCO reference and is required.

vast zco_receive_headers(Sdr sdr, ZcoReader *reader, vast length, char *buffer)
: Copies *length* as-yet-uncopied bytes of presumptive protocol header text from ZCO source data extents into *buffer*. If *buffer* is NULL, skips over *length* bytes without copying. Returns number of bytes copied (or skipped) on success, 0 on any file access error, −1 on any other error.

void zco_delimit_source(Sdr sdr, Object zco, vast offset, vast length)
: Sets the computed offset and length of actual source data in the ZCO, thereby implicitly establishing the total length of the ZCO's concatenated protocol headers as *offset* and the location of the ZCO's innermost protocol trailer as the sum of *offset* and *length*. Offset and length are typically determined from the information carried in received presumptive protocol header text.

vast zco_receive_source(Sdr sdr, ZcoReader *reader, vast length, char *buffer)
: Copies *length* as-yet-uncopied bytes of source data from ZCO extents into *buffer*. If *buffer* is NULL, skips over *length* bytes without copying. Returns number of bytes copied (or skipped) on success, 0 on any file access error, −1 on any other error.

vast zco_receive_trailers(Sdr sdr, ZcoReader *reader, vast length, char *buffer)
: Copies *length* as-yet-uncopied bytes of trailer data from ZCO extents into *buffer*. If *buffer* is NULL, skips over *length* bytes without copying. Returns number of bytes copied (or skipped) on success, 0 on any file access error, −1 on any other error.

void zco_strip(Sdr sdr, Object zco)
: Deletes all source data extents that contain only header or trailer data and adjusts the offsets and/or lengths of all remaining extents to exclude any known header or trailer data. This function is useful when handling a ZCO that was received from an underlying protocol layer rather than from an overlying application or protocol layer; use it before starting the transmission of the ZCO to another node or before enqueuing it for reception by an overlying application or protocol layer.

SEE ALSO

sdr (3)

NAME

ltp − Licklider Transmission Protocol (LTP) communications library

SYNOPSIS

```
#include "ltp.h"

typedef enum
{
    LtpNoNotice = 0,
    LtpExportSessionStart,
    LtpXmitComplete,
    LtpExportSessionCanceled,
    LtpExportSessionComplete,
    LtpRecvGreenSegment,
    LtpRecvRedPart,
    LtpImportSessionCanceled
} LtpNoticeType;

[see description for available functions]
```

DESCRIPTION

The ltp library provides functions enabling application software to use LTP to send and receive information reliably over a long-latency link. It conforms to the LTP specification as documented by the Delay-Tolerant Networking Research Group of the Internet Research Task Force.

The LTP notion of **engine ID** corresponds closely to the Internet notion of a host, and in ION engine IDs are normally indistinguishable from node numbers including the node numbers in Bundle Protocol endpoint IDs conforming to the ‘‘ipn’’ scheme.

The LTP notion of **client ID** corresponds closely to the Internet notion of ‘‘protocol number’’ as used in the Internet Protocol. It enables data from multiple applications — clients — to be multiplexed over a single reliable link. However, for ION operations we normally use LTP exclusively for the transmission of Bundle Protocol data, identified by client ID = 1.

int **ltp_attach()**

Attaches the application to LTP functionality on the lcoal computer. Returns 0 on success, −1 on any error.

void **ltp_detach()**

Terminates all access to LTP functionality on the local computer.

int **ltp_engine_is_started()**

Returns 1 if the local LTP engine has been started and not yet stopped, 0 otherwise.

int ltp_send(uvast destinationEngineId, unsigned int clientId, Object clientServiceData, unsigned int redLength, LtpSessionId *sessionId)

Sends a client service data unit to the application that is waiting for data tagged with the indicated *clientId* as received at the remote LTP engine identified by *destinationEngineId*.

clientServiceData must be a ‘‘zero-copy object’’ reference as returned by **ionCreateZco()**. Note that LTP will privately make and destroy its own reference to the client service data object; the application is free to destroy its reference at any time.

redLength indicates the number of leading bytes of data in *clientServiceData* that are to be sent reliably, i.e., with selective retransmission in response to explicit or implicit negative acknowledgment as necessary. All remaining bytes of data in *clientServiceData* will be sent as ‘‘green’’ data, i.e., unreliably. If *redLength* is zero, the entire client service data unit will be sent unreliably. If the entire client service data unit is to be sent reliably, *redLength* may be simply be set to LTP_ALL_RED (i.e., −1).

On success, the function populates **sessionId* with the source engine ID and the ‘‘session number’’

assigned to transmission of this client service data unit and returns zero. The session number may be used to link future LTP processing events, such as transmission cancellation, to the affected client service data. **ltp_send()** returns −1 on any error.

int ltp_open(unsigned int clientId)
Establishes the application's exclusive access to received service data units tagged with the indicated client service data ID. At any time, only a single application task is permitted to receive service data units for any single client service data ID.

Returns 0 on success, −1 on any error (e.g., the indicated client service is already being held open by some other application task).

int ltp_get_notice(unsigned int clientId, LtpNoticeType *type, LtpSessionId *sessionId, unsigned char *reasonCode, unsigned char *endOfBlock, unsigned int *dataOffset, unsigned int *dataLength, Object *data)
Receives notices of LTP processing events pertaining to the flow of service data units tagged with the indicated client service ID. The nature of each event is indicated by **type*. Additional parameters characterizing the event are returned in **sessionId*, **reasonCode*, **endOfBlock*, **dataOffset*, **dataLength*, and **data* as relevant.

The value returned in **data* is always a zero-copy object; use the zco_* functions defined in ''zco.h'' to retrieve the content of that object.

When the notice is an LtpRecvGreenSegment, the ZCO returned in **data* contains the content of a single LTP green segment. Reassembly of the green part of some block from these segments is the responsibility of the application.

When the notice is an LtpRecvRedPart, the ZCO returned in **data* contains the red part of a possibly aggregated block. The ZCO's content may therefore comprise multiple service data objects. Extraction of individual service data objects from the aggregated block is the responsibility of the application. A simple way to do this is to prepend the length of the service data object to the object itself (using zco_prepend_header) before calling ltp_send, so that the receiving application can alternate extraction of object lengths and objects from the delivered block's red part.

The cancellation of an export session may result in delivery of multiple LtpExportSessionCanceled notices, one for each service data unit in the export session's (potentially) aggregated block. The ZCO returned in **data* for each such notice is a service data unit ZCO that had previously been passed to **ltp_send()**.

ltp_get_notice() always blocks indefinitely until an LTP processing event is delivered.

Returns zero on success, −1 on any error.

void ltp_interrupt(unsigned int clientId)
Interrupts an **ltp_get_notice()** invocation. This function is designed to be called from a signal handler; for this purpose, *clientId* may need to be obtained from a static variable.

void ltp_release_data(Object data)
Releases the resources allocated to hold *data*, which must be a **received** client service data ZCO.

void ltp_close(unsigned int clientId)
Terminates the application's exclusive access to received service data units tagged with the indicated client service data ID.

SEE ALSO

ltpadmin (1), **ltprc** (5), **zco** (3)

NAME

tc − the Trusted Collective system for Delay−Tolerant Networking

SYNOPSIS

```
#include "tcc.h"

[see description for available functions]
```

DESCRIPTION

The TC system provides a trustworthy framework for delay-tolerant distribution of information that is of critical importance − that is, information that must be made available as needed and must not be corrupt − but is not confidential. As such it accomplishes some of the same objectives as are accomplished by ‘‘servers’’ in the Internet.

A central principle of TC is that items of critical information may have **effective times** which condition their applicability. For example, a change in rules restricting air travel will typically be scheduled to take effect on some stated date in the near future. Effective times enable critical information to be distributed far in advance of the time at which it will be needed, which is what makes TC delay-tolerant: when the time arrives at which a node needs a given item of critical information, the information is already in place. No query/response exchange is necessary.

The TC framework for a given TC **application** comprises (a) a collective authority, which should include several geographically distributed ‘‘authority’’ nodes, and (b) ‘‘client’’ nodes which utilize the services of the collective authority, possibly including the key authority nodes themselves. The framework is designed to convey to every participating client node the critical information submitted to the collective authority by all other participating client nodes, in a trustworthy manner, prior to the times at which those items of information become effective. It operates as follows.

The user function of a given TC application generates **records** containing critical information and issues those records as the application data units forming the payloads of BP bundles. The destination of each such bundle is the multicast group designated for receivers of the records of that application. The members of that multicast group are the authority nodes of the application’s collective authority.

The records are delivered to the **tcarecv** daemons of the authority nodes. Each such daemon validates the received records and inserts all valid records in its authority node’s private database of pending records.

Periodically, the **tcacompile** daemons of all authority nodes in the application’s collective authority simultaneously compile **bulletins** of all records recently received from user nodes. (A TC bulletin is simply an array of contiguous TC records.) These daemons then all issue their bulletins as the application data units forming the payloads of BP bundles. The destination of each such bundle is the multicast group designated for receivers of the bulletins of that application. The members of that multicast group are, again, the authority nodes of the application’s collective authority. In addition, each **tcacompile** daemon spawns one **tcapublish** process that is assigned the task of processing the bulletins compiled by all authority nodes during this iteration of the compilation cycle.

The bulletins are delivered to the **tcapublish** processes of all authority nodes in the application’s collective authority. The **tcapublish** processes then compute a common consensus bulletin, which includes all recently asserted records that all of the authority nodes have received and found valid.

Each **tcapublish** process then computes a hash for the consensus bulletin and erasure-codes the bulletin, producing a list of **code blocks**; the hashes and lists of blocks will be identical for all key authority nodes. It then issues a small subset of those code blocks as the application data units forming the payloads of BP bundles. The destination of each such bundle is the multicast group designated for receivers of the code blocks of the application. The members of that multicast group are the **tcc** (that is, TC **client**) daemons serving the application’s user nodes. The subsets of the block list issued by all **tcapublish** daemons are different, but each code block is tagged with the common bulletin hash.

The code blocks are delivered to the **tcc** daemons of all of the application’s user nodes, each of which uses the received code blocks to reassemble the consensus bulletin. Code blocks with differing bulletin hashes are not used to reassemble the same bulletin, and the erasure coding of the bulletin prevents failure to

receive all code blocks from preventing reassembly of the complete bulletin. When a consensus bulletin has been successfully reassembled, the records in the bulletin are delivered to the user function.

The **tcaboot** and **tcaadmin** utilities are used to configure the collective authority of a given TC application; the **tccadmin** utility is used to configure TC client functionality for a given TC application on a given user node.

The TC library functions provided to TC application user software are described below.

int tc_serialize(char *buffer, unsigned int buflen, uvast nodeNbr, time_t effectiveTime, time_t assertionTime, unsigned short datLength, unsigned char *datValue)

Forms in *buffer* a serialized TC record, ready for transmission as a BP application data unit, that contains the indicated node number, effective time, assertion time, application data length, and application data. Returns the length of the record, or −1 on any missing arguments.

int tcc_getBulletin(int blocksGroupNbr, char **bulletinContent, int *length)

Places in **bulletinContent* a pointer to an ION private working memory buffer containing the content of the oldest previously unhandled received TC bulletin for the application identified by *blocksGroupNbr*. Returns 0 on success, −1 on any system failure. A returned buffer length of 0 indicates that the function was interrupted and must be repeated.

Note that the calling function MUST **MRELEASE** the bulletin content buffer when processing is complete. Failure to do so will introduce a memory leak.

int tc_deserialize(char **buffer, int *buflen, unsigned short maxDatLength, uvast *nodeNbr, time_t *effectiveTime, time_t *assertionTime, unsigned short *datLength, unsigned char *datValue)

Parses out of the bulletin in *buffer* the data elements of a single serialized TC record: node number, effective time, assertion time, application data length, and application data. Returns −1 on any missing arguments, 0 on any record malformation, record length otherwise.

SEE ALSO

tcaboot (1), **tcaadmin** (1), **tcarecv** (1), **tcacompile** (1), **tcapublish** (1), **tccadmin** (1), **tcc** (1)

NAME

amsrc – CCSDS Asynchronous Message Service MIB initialization file

DESCRIPTION

The Management Information Base (MIB) for an AMS communicating entity (either **amsd** or an AMS application module) must contain enough information to enable the entity to initiate participation in AMS message exchange, such as the network location of the configuration server and the roles and message subjects defined for some venture.

AMS entities automatically load their MIBs from initialization files at startup. When AMS is built with the −DNOEXPAT compiler option set, the MIB initialization file must conform to the *amsrc* syntax described below; otherwise the *expat* XML parsing library must be linked into the AMS executable and the MIB initialization file must conform to the *amsxml* syntax described in **amsxml** (5).

The MIB initialization file lists *elements* of MIB update information, each of which may have one or more *attributes*. An element may also have sub-elements that are listed within the declaration of the parent element, and so on.

The declaration of an element may occupy a single line of text in the MIB initialization file or may extend across multiple lines. A single-line element declaration is indicated by a '*' in the first character of the line. The beginning of a multi-line element declaration is indicated by a '+' in the first character of the line, while the end of that declaration is indicated by a '−' in the first character of the line. In every case, the type of element must be indicated by an element-type name beginning in the second character of the line and terminated by whitespace. Every start-of-element line **must** be matched by a subsequent end-of-element line that precedes the start of any other element that is not a nested sub-element of this element.

Attributes are represented by whitespace-terminated <name>=<value> expressions immediately following the element-type name on a '*' or '+' line. An attribute value that contains whitespace must be enclosed within a pair of single-quote (') characters.

Two types of elements are recognized in the MIB initialization file: control elements and configuration elements. A control element establishes the update context within which the configuration elements nested within it are processed, while a configuration element declares values for one or more items of AMS configuration information in the MIB.

Note that an aggregate configuration element (i.e., one which may contain other interior configuration elements; venture, for example) may be presented outside of any control element, simply to establish the context in which subsequent control elements are to be interpreted.

CONTROL ELEMENTS

ams_mib_init

Initializes an empty MIB. This element must be declared prior to the declaration of any other element.

Sub-elements: none

Attributes:

continuum_nbr
: Identifies the local continuum.

ptsname
: Identifies the primary transport service for the continuum. Valid values include "dgr" and "udp".

pubkey
: This is the name of the public key used for validating the digital signatures of meta-AMS messages received from the configuration server for this continuum. The value of this attribute (if present) must identify a key that has been loaded into the ION security database, nominally by **ionsecadmin** (1).

privkey
: This is the name of the private key used for constructing the digital signatures of meta-AMS messages sent by the configuration server for this continuum. This attribute should **only** be

present in the MIB initialization file for **amsd()**. The value of this attribute (if present) must identify a key that has been loaded into the ION security database, nominally by **ionsecadmin** (1).

ams_mib_add
This element contains a list of configuration items that are to be added to the MIB.

ams_mib_change
This element contains a list of configuration items that are to be revised in the MIB.

ams_mib_delete
This element contains a list of configuration items that are to be deleted from the MIB.

CONFIGURATION ELEMENTS

continuum
Identifies a known remote continuum.

Sub-elements: none

Attributes:

nbr Identifies the remote continuum.

name
Identifies the remote continuum.

neighbor
1 if the continuum is a neighbor of the local continuum, zero otherwise.

desc
A textual description of this continuum.

csendpoint
Identifies one of the network locations at which the configuration server may be reachable. If the configuration server might be running at any one of several locations, the number of other locations that are preferred to this one is noted; in this case, csendpoints must be listed within the ams_mib_add element in descending order of preference, i.e., with the most preferred network location listed first.

Sub-elements: none

Attributes:

epspec
Identifies the endpoint at which the configuration server may be reachable. The endpoint specification must conform to the endpoint specification syntax defined for the continuum's primary transport service; see the AMS Blue Book for details.

after
If present, indicates the number of other configuration server network locations that are considered preferable to this one. This attribute is used to ensure that csendpoints are listed in descending order of preference.

amsendpoint
Normally the specifications of the transport service endpoints at which an AMS application module can receive messages are computed automatically using standard transport-service-specific rules. However, in some cases it might be necessary for a module to receive messages at one or more non-standard endpoints; in these cases, amsendpoint elements can be declared in order to override the standard endpoint specification rules.

Sub-elements: none

Attributes:

tsname
Identifies the transport service for which a non-standard endpoint specification is being supplied.

epspec
: Identifies an endpoint at which the application module will be reachable, in the context of the named transport service. The endpoint specification must conform to the endpoint specification syntax defined for the named transport service; see the AMS Blue Book for details.

application
: Identifies one of the applications supported within this continuum.

Sub-elements: none

Attributes:

name
: Identifies the application.

pubkey
: This is the name of the public key used for validating the digital signatures of meta-AMS messages received from the registrars for all cells of any message space in this continuum that is characterized by this application name. The value of this attribute (if present) must identify a key that has been loaded into the ION security database, nominally by **ionsecadmin** (1).

privkey
: This is the name of the private key used for constructing the digital signatures of meta-AMS messages sent by the registrars for all cells of any message space in this continuum that is characterized by this application name. This attribute should **only** be present in the MIB initialization file for **amsd()**. The value of this attribute (if present) must identify a key that has been loaded into the ION security database, nominally by **ionsecadmin** (1).

venture
: Identifies one of the ventures operating within the local continuum.

Sub-elements: role, subject, unit, msgspace

Attributes:

nbr Identifies the venture.

appname
: Identifies the application addressed by this venture.

authname
: Identifies the authority under which the venture operates, distinguishing this venture from all other ventures that address the same application.

gweid
: Identifies the RAMS network endpoint ID of the RAMS gateway module for this venture's message space in the local continuum. Gateway endpoint ID is expressed as <protocol_name>@<eid_string> where *protocol_name* is either ''bp'' or ''udp''. If protocol name is ''bp'' then *eid_string* must be a valid Bundle Protocol endpoint ID; otherwise, *eid_string* must be of the form <hostname>:<port_number>. If the gweid attribute is omitted, the RAMS gateway module's RAMS network endpoint ID defaults to ''bp@ipn:<local_continuum_number>.<venture_number>''.

net_config
: Has the value ''tree'' if the RAMS network supporting this venture is configured as a tree; otherwise ''mesh'', indicating that the RAMS network supporting this venture is configured as a mesh.

root_cell_resync_period
: Indicates the number of seconds in the period on which resynchronization is performed for the root cell of this venture's message space in the local continuum. If this attribute is omitted, resynchronization in that cell is disabled.

role

Identifies one of the functional roles in the venture that is the element that's currently being configured.

Sub-elements: none

Attributes:

nbr Identifies the role.

name
Identifies the role.

authname
Identifies the authority under which the venture operates, distinguishing this venture from all other ventures that address the same application.

pubkey
This is the name of the public key used for validating the digital signatures of meta-AMS messages received from all application modules that register in this functional role. The value of this attribute (if present) must identify a key that has been loaded into the ION security database, nominally by **ionsecadmin** (1).

privkey
This is the name of the private key used for constructing the digital signatures of meta-AMS messages sent by all application modules that register in this functional role. This attribute should **only** be present in the MIB initialization file for application modules that register in this role. The value of this attribute (if present) must identify a key that has been loaded into the ION security database, nominally by **ionsecadmin** (1).

subject

Identifies one of the subjects on which messages may be sent, within the venture that is the element that's currently being configured.

Sub-elements: sender, receiver

Attributes:

nbr Identifies the subject.

name
Identifies the subject.

desc
A textual description of this message subject.

symkey
This is the name of the symmetric key used for both encrypting and decrypting the content of messages on this subject; if omitted, messages on this subject are not encrypted by AMS. If authorized senders and receivers are defined for this subject, then this attribute should **only** be present in the MIB initialization file for application modules that register in roles that appear in the subject's lists of authorized senders and/or receivers. The value of this attribute (if present) must identify a key that has been loaded into the ION security database, nominally by **ionsecadmin** (1).

marshal
This is the name associated with the content marshaling function defined for this message subject. If present, whenever a message on this subject is issued the associated function is automatically called to convert the supplied content data to a platform-independent representation for transmission; this conversion occurs before any applicable content encryption is performed. If omitted, content data are transmitted without conversion to a platform-independent representation. Marshaling functions are defined in the marshalRules table in the marshal.c source file.

unmarshal
: This is the name associated with the content unmarshaling function defined for this message subject. If present, whenever a message on this subject is received the associated function is automatically called to convert the transmitted content to local platform-specific representation; this conversion occurs after any applicable content decryption is performed. If omitted, received content data are delivered without conversion to a local platform-specific representation. Unmarshaling functions are defined in the unmarshalRules table in the marshal.c source file.

sender
: Identifies one of the roles in which application modules must register in order to be authorized senders of messages on the subject that is the element that's currently being configured.

Sub-elements: none

Attributes:

name
: Identifies the sender. The value of this attribute must be the name of a role that has been defined for the venture that is currently being configured.

receiver
: Identifies one of the roles in which application modules must register in order to be authorized receivers of messages on the subject that is the element that's currently being configured.

Sub-elements: none

Attributes:

name
: Identifies the receiver. The value of this attribute must be the name of a role that has been defined for the venture that is currently being configured.

unit
: Identifies one of the organizational units within the venture that is the element that's currently being configured.

Sub-elements: none

Attributes:

nbr Identifies the unit.

name
: Identifies the unit.

resync_period
: Indicates the number of seconds in the period on which resynchronization is performed, for the cell of this venture's message space that is the portion of the indicated unit which resides in the local continuum. If this attribute is omitted, resynchronization in that cell is disabled.

msgspace
: Identifies one of the message spaces in remote continua that are encompassed by the venture that is the element that's currently being configured.

Sub-elements: none

Attributes:

nbr Identifies the remote continuum within which the message space operates.

gweid
: Identifies the RAMS network endpoint ID of the RAMS gateway module for this message space. Gateway endpoint ID is expressed as <protocol_name>@<eid_string> where *protocol_name* is either "bp" or "udp". If protocol name is "bp" then *eid_string* must be a valid Bundle Protocol endpoint ID; otherwise, *eid_string* must be of the form <hostname>:<port_number>. If the gweid

attribute is omitted, the RAMS network endpoint ID of the message space's RAMS gateway module defaults to "bp@ipn:<remote_continuum_number>.<venture_number>".

symkey
: This is the name of the symmetric key used for both encrypting and decrypting all messages to and from modules in the remote message space that are forwarded between the local RAMS gateway server and modules in the local message space; if omitted, these messages are not encrypted. The value of this attribute (if present) must identify a key that has been loaded into the ION security database, nominally by **ionsecadmin** (1).

EXAMPLE

```
*ams_mib_init continuum_nbr=2 ptsname=dgr
+ams_mib_add
*continuum nbr=1 name=apl desc=APL
*csendpoint epspec=beaumont.stepsoncats.com:2357
*application name=amsdemo
+venture nbr=1 appname=amsdemo authname=test
*role nbr=2 name=shell
*role nbr=3 name=log
*role nbr=4 name=pitch
*role nbr=5 name=catch
*role nbr=6 name=benchs
*role nbr=7 name=benchr
*role nbr=96 name=amsd
*role nbr=97 name=amsmib
*role nbr=98 name=amsstop
*subject nbr=1 name=text desc='ASCII text'
*subject nbr=2 name=noise desc='more ASCII text'
*subject nbr=3 name=bench desc='numbered msgs'
*subject nbr=97 name=amsmib desc='MIB updates'
*subject nbr=98 name=amsstop desc='shutdown'
*unit nbr=1 name=orbiters
*unit nbr=2 name=orbiters.near
*unit nbr=3 name=orbiters.far
*msgspace nbr=2
-venture
-ams_mib_add
```

SEE ALSO

amsxml (5)

NAME

amsxml – CCSDS Asynchronous Message Service MIB initialization XML file

DESCRIPTION

The Management Information Base (MIB) for an AMS communicating entity (either **amsd** or an AMS application module) must contain enough information to enable the entity to initiate participation in AMS message exchange, such as the network location of the configuration server and the roles and message subjects defined for some venture.

AMS entities automatically load their MIBs from initialization files at startup. When AMS is built with the −DNOEXPAT compiler option set, the MIB initialization file must conform to the *amsrc* syntax described in **amsrc** (5); otherwise the *expat* XML parsing library must be linked into the AMS executable and the MIB initialization file must conform to the *amsxml* syntax described below.

The XML statements in the MIB initialization file constitute *elements* of MIB update information, each of which may have one or more *attributes*. An element may also have sub-elements that are listed within the declaration of the parent element, and so on.

Two types of elements are recognized in the MIB initialization file: control elements and configuration elements. A control element establishes the update context within which the configuration elements nested within it are processed, while a configuration element declares values for one or more items of AMS configuration information in the MIB.

For a discussion of the recognized control elements and configuration elements of the MIB initialization file, see the **amsrc** (5) man page. **NOTE**, though, that all elements of an XML-based MIB initialization file **must** be sub-elements of a single sub-element of the XML extension type **ams_load_mib** in order for the file to be parsed successfully by expat.

EXAMPLE

<?xml version=“1.0” standalone=“yes”?>

<ams_mib_load>

```
        <ams_mib_init continuum_nbr="2" ptsname="dgr"/>

        <ams_mib_add>

                <continuum nbr="1" name="apl" desc="APL"/>

                <csendpoint epspec="beaumont.stepsoncats.com:2357"/>

                <application name="amsdemo" />

                <venture nbr="1" appname="amsdemo" authname="test">

                        <role nbr="2" name="shell"/>

                        <role nbr="3" name="log"/>

                        <role nbr="4" name="pitch"/>

                        <role nbr="5" name="catch"/>

                        <role nbr="6" name="benchs"/>

                        <role nbr="7" name="benchr"/>

                        <role nbr="96" name="amsd"/>
```

```
                        <role nbr="97" name="amsmib"/>
                        <role nbr="98" name="amsstop"/>
                        <subject nbr="1" name="text" desc="ASCII text"/>
                        <subject nbr="2" name="noise" desc="more ASCII text"/>
                        <subject nbr="3" name="bench" desc="numbered msgs"/>
                        <subject nbr="97" name="amsmib" desc="MIB updates"/>
                        <subject nbr="98" name="amsstop" desc="shutdown"/>
                        <unit nbr="1" name="orbiters"/>
                        <unit nbr="2" name="orbiters.near"/>
                        <unit nbr="3" name="orbiters.far"/>
                        <msgspace nbr="2"/>
                    </venture>
                </ams_mib_add>
        </ams_mib_load>
```

SEE ALSO

amsrc (5)

NAME

petition.log – Remote AMS petition log

DESCRIPTION

The Remote AMS daemon **ramsgate** records all ‘‘petitions’’ (requests for data on behalf of AMS modules in other continua) in a file named **petition.log**. At startup, the **ramsgate** daemon automatically reads and processes all petitions in the **petition.log** file just as if they were received in real time, to re-establish the petition state that was in effect at the time the **ramsgate** daemon shut down. Note that this means that you can cause petitions to be, in effect, ‘‘pre-received’’ by simply editing this file prior to startup. This can be an especially effective way to configure a RAMS network in which long signal propagation times would otherwise retard real-time petitioning and thus delay the onset of fully functional message exchange.

Entries in **petition.log** are simple ASCII text lines, with parameters separated by spaces. Each line of **petition.log** has the following parameters:

protocolId
: This is a number that identifies the RAMS network protocol characterizing the network on which the petition was received: 1 == DTN Bundle Protocol, 2 = UDP.

gatewayID
: This is a string that identifies the remote RAMS gateway node that issued this petition.

controlCode
: This is a number that indicates whether the petition described by this line is one that is being asserted (2) or canceled (3).

subject
: A number that identifies the subject of the traffic to which the petition pertains.

continuumNumber
: Identifies the continuum for the domain of the petition.

unitNumber
: Identifies the unit for the domain of the petition.

roleNumber
: Identifies the role for the domain of the petition.

SEE ALSO

ramsgate (1), **ams** (3)

NAME

biberc − BIBE configuration commands file

DESCRIPTION

BIBE configuration commands are passed to **bibeadmin** either in a file of text lines or interactively at **bibeadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line.

BIBE configuration commands establish the parameters governing transmission of BIBE PDUs to specified **peer** nodes: anticipated delivery latency in the forward direction, anticipated delivery latency in the return direction, TTL for BIBE PDUs, priority for BIBE PDUs, ordinal priority for BIBE PDUs in the event that priority is Expedited, and (optionally) data label for BIBE PDUs. As such, they configure BIBE convergence-layer adapter (**bcla**) structures.

The formats and effects of the BIBE configuration commands are described below.

NOTE: in order to cause bundles to be transmitted via BIBE:

Plan

Remember that BIBE is a convergence-layer protocol; as such, it operates between two nodes that are topologically adjacent in a BP network (but in this case the BP network within which the nodes are topologically adjacent is an overlay on top of the real BP network). Since the sending and receiving nodes are topologically adjacent they are neighbors: the sending node MUST have an egress plan for transmission to the receiving (that is, **peer**) node, and there MUST be a BIBE outduct attached to that plan.

Routing

In order to compel bundles bound for some destination node to be forwarded via the BIBE peer node rather than over some other route computed by CGR, you have to override CGR routing for that bundle. The way to do this is to (a) tag the bundle with data label X (in ancillary data) and (b) use ipnadmin to establish at the sending node a *routing override* that coerces all bundles with data label X to be sent directly to the peer node.

If the peer node happens to be a true BP neighbor as well − that is, there is also a non-BIBE outduct attached to the egress plan for transmission to that node − then you additionally need to tell the egress plan management daemon (bpclm) for that node which bundles need to be forwarded using the BIBE outduct rather than the non-BIBE outduct. The way to do this is to use ipnadmin to establish at the sending node a *class-of-service override* that locally and temporarily OR's the BP_BIBE_REQUESTED flag (32) to the quality-of-service flags of any bundle tagged with data label X.

Quality of Service

If you want custody transfer to be invoked for each BIBE transmission of a bundle from the sending node to the peer node, you must additionally use ipnadmin to establish at the sending node a *class-of-service override* that locally and temporarily OR's the BP_CT_REQUESTED flag (64) to the quality-of-service flags of any bundle tagged with data label X.

If you need to establish a class-of-service override to set the BP_BIBE_REQUESTED flag (as described above) as well, then use the OR of BP_BIBE_REQUESTED and BP_CT_REQUESTED − that is, 96 − as the quality-of-service flags argument for that override.

NOTE that an alternative method of setting both the BP_BIBE_REQUESTED and BP_CT_REQUESTED flags for a given bundle is simply to request custody transfer when the bundle is sourced; this will OR that bundle's own quality-of-service flags (in ancillary data) with 96. But be careful: in this case the bundle will be permanently tagged with these flag values, meaning that it will be forwarded via BIBE with custody transfer over every "hop" of the end-to-end path to its destination, and if BIBE is unavailable at any forwarding node on the path then the bundle can never reach the destination node.

GENERAL COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by bibeadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

w { 0 | 1 | *activity_spec* }
The **watch** command. This command enables and disables production of a continuous stream of user-selected Bundle-in-Bundle Encapsulation custody transfer activity indication characters. A watch parameter of "1" selects all BIBE-CT activity indication characters; "0" de-selects all BIBE-CT activity indication characters; any other *activity_spec* such as "mw" selects all activity indicators in the string, de-selecting all others. BIBE will print each selected activity indication character to **stdout** every time a processing event of the associated type occurs:

w custody of bundle is accepted

m custody acceptance is received for one bundle

x custody of bundle is refused

& custody refusal is received for one bundle

$ bundle retransmitted due to expired custodial retransmission interval

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

BCLA COMMANDS

a bcla *peer_EID fwd_latency rtn_latency time_to_live priority ordinal* [*data label*]
The **add bcla** command. This command adds the neighboring node identified by *peer_EID* as a BIBE destination of the local node.

c bcla *peer_EID fwd_latency rtn_latency time_to_live priority ordinal* [*data label*]
The **change bcla** command. This command changes the transmission parameters governing BIBE PDU transmission to the indicated peer node.

d bcla *peer_EID*
The **delete bcla** command. This command deletes the **bcla** identified by *peer_EID*.

i bcla *peer_EID*
This command will print information (the transmission parameters) for the BIBE peer node identified by *peer_EID*.

l This command lists all of the local node's BIBE peers.

EXAMPLES

a bcla ipn:3.2 10 10 60 1 0 16
Declares that ipn:3.2 is a BIBE destination and that BIBE PDUs destined for this node are to be sent with TTL 60 seconds, priority 1 (standard), and data label 16; it is expected that BIBE PDUs sent to this node will arrive within 10 seconds and that BIBE PDUs sent from this node will arrive within 10 seconds.

SEE ALSO

bibeadmin (1), **bibeclo** (1)

NAME

bprc – Bundle Protocol management commands file

DESCRIPTION

Bundle Protocol management commands are passed to **bpadmin** either in a file of text lines or interactively at **bpadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the Bundle Protocol management commands are described below.

GENERAL COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by bpadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed and the crypto suite BP was compiled with. HINT: combine with **e 1** command to log the version number at startup.

1 The **initialize** command. Until this command is executed, Bundle Protocol is not in operation on the local ION node and most *bpadmin* commands will fail.

r '*command_text*'
The **run** command. This command will execute *command_text* as if it had been typed at a console prompt. It is used to, for example, run another administrative program.

s The **start** command. This command starts all schemes and all protocols on the local node.

m heapmax *max_database_heap_per_acquisition*
The **manage heap for bundle acquisition** command. This command declares the maximum number of bytes of SDR heap space that will be occupied by any single bundle acquisition activity (nominally the acquisition of a single bundle, but this is at the discretion of the convergence-layer input task). All data acquired in excess of this limit will be written to a temporary file pending extraction and dispatching of the acquired bundle or bundles. Default is the minimum allowed value (560 bytes), which is the approximate size of a ZCO file reference object; this is the minimum SDR heap space occupancy in the event that all acquisition is into a file.

m maxcount *max_value_of_bundle_ID_sequence_nbr*
The **manage maximum bundle ID sequence number** command. This command sets the maximum value that will be assigned as the sequence number in a bundle ID for any bundle sourced at a node that lacks a synchronized clock (such that the creation time in the ID of every locally sourced bundle is always zero). The default value is −1, i.e., unlimited.

x The **stop** command. This command stops all schemes and all protocols on the local node.

w { 0 | 1 | *activity_spec* }
The **BP watch** command. This command enables and disables production of a continuous stream of user-selected Bundle Protocol activity indication characters. A watch parameter of ''1'' selects all BP activity indication characters; ''0'' de-selects all BP activity indication characters; any other *activity_spec* such as ''acz˜'' selects all activity indication characters in the string, de-selecting all others. BP will print each selected activity indication character to **stdout** every time a processing event of the associated type occurs:

- **a** new bundle is queued for forwarding
- **b** bundle is queued for transmission
- **c** bundle is popped from its transmission queue
- **y** bundle is accepted upon arrival
- **z** bundle is queued for delivery to an application

~ bundle is abandoned (discarded) on attempt to forward it

! bundle is destroyed due to TTL expiration

bundle is queued for re-forwarding due to CL protocol failure

j bundle is placed in "limbo" for possible future re-forwarding

k bundle is removed from "limbo" and queued for re-forwarding

Note that a slightly amended interpretation should be applied to watch characters printed in the course of multicast transmission. The '~' character, meaning Abandoned (node did not forward this bundle), is printed by a node that is a leaf of the multicast tree, i.e., a node with no children; it cannot forward the bundle because it's got nobody to forward it to. The '!' character, meaning Destroyed (node destroyed a physical copy of a bundle), is printed by a node that has forwarded copies of the bundle to all of its children and no longer needs to retain the original – so it does an immediate permanent bundle destruction just as if the bundle's time to live had expired. Neither condition is anomalous.

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

SCHEME COMMANDS

a scheme *scheme_name* '*forwarder_command*' '*admin_app_command*'

The **add scheme** command. This command declares an endpoint naming "scheme" for use in endpoint IDs, which are structured as URIs: *scheme_name*:*scheme−specific_part*. *forwarder_command* will be executed when the scheme is started on this node, to initiate operation of a forwarding daemon for this scheme. *admin_app_command* will also be executed when the scheme is started on this node, to initiate operation of a daemon that opens a custodian endpoint identified within this scheme so that it can receive and process custody signals and bundle status reports.

c scheme *scheme_name* '*forwarder_command*' '*admin_app_command*'

The **change scheme** command. This command sets the indicated scheme's *forwarder_command* and *admin_app_command* to the strings provided as arguments.

d scheme *scheme_name*

The **delete scheme** command. This command deletes the scheme identified by *scheme_name*. The command will fail if any bundles identified in this scheme are pending forwarding, transmission, or delivery.

i scheme *scheme_name*

This command will print information (number and commands) about the endpoint naming scheme identified by *scheme_name*.

l scheme

This command lists all declared endpoint naming schemes.

s scheme *scheme_name*

The **start scheme** command. This command starts the forwarder and administrative endpoint tasks for the indicated scheme task on the local node.

x scheme *scheme_name*

The **stop scheme** command. This command stops the forwarder and administrative endpoint tasks for the indicated scheme task on the local node.

ENDPOINT COMMANDS

a endpoint *endpoint_ID* { q | x } ['*recv_script*']

The **add endpoint** command. This command establishes a DTN endpoint named *endpoint_ID* on the local node. The remaining parameters indicate what is to be done when bundles destined for this endpoint arrive at a time when no application has got the endpoint open for bundle reception. If 'x', then such bundles are to be discarded silently and immediately. If 'q', then such bundles are to be enqueued for later delivery and, if *recv_script* is provided, *recv_script* is to be executed.

c endpoint *endpoint_ID* { q | x } ['*recv_script*']
The **change endpoint** command. This command changes the action that is to be taken when bundles destined for this endpoint arrive at a time when no application has got the endpoint open for bundle reception, as described above.

d endpoint *endpoint_ID*
The **delete endpoint** command. This command deletes the endpoint identified by *endpoint_ID*. The command will fail if any bundles are currently pending delivery to this endpoint.

i endpoint *endpoint_ID*
This command will print information (disposition and script) about the endpoint identified by *endpoint_ID*.

l endpoint
This command lists all local endpoints, regardless of scheme name.

PROTOCOL COMMANDS

a protocol *protocol_name* [*protocol_class*]
The **add protocol** command. This command establishes access to the named convergence layer protocol at the local node.

The optional *protocol_class* argument indicates the reliability of the protocol. The value 1 indicates that the protocol natively supports bundle streaming; currently the only protocol in class 1 is BSSP. The value 2 indicates that the protocol performs no retransmission; an example is UDP. The value 8 (which is the default) indicates that the protocol detects data loss and automatically retransmits data accordingly; an example is TCP. Protocol class need not be specified when *protocol_name* is bssp, udp, tcp, stcp, brss, brsc, or ltp, as the protocol classes for these well-known protocols are hard-coded in ION.

In earlier versions of ION this command took two additional arguments, *payload_bytes_per_frame* and *overhead_bytes_per_frame*. These arguments are deprecated. BP configuration files that include **a protocol** commands in the old format will be processed correctly; the deprecated arguments will simply be ignored.

d protocol *protocol_name*
The **delete protocol** command. This command deletes the convergence layer protocol identified by *protocol_name*. The command will fail if any ducts are still locally declared for this protocol.

i protocol *protocol_name*
This command will print information about the convergence layer protocol identified by *protocol_name*.

l protocol
This command lists all convergence layer protocols that can currently be utilized at the local node.

s protocol *protocol_name*
The **start protocol** command. This command starts all induct and outduct tasks for inducts and outducts that have been defined for the indicated CL protocol on the local node.

x protocol *protocol_name*
The **stop protocol** command. This command stops all induct and outduct tasks for inducts and outducts that have been defined for the indicated CL protocol on the local node.

INDUCT COMMANDS

a induct *protocol_name duct_name* '*CLI_command*'
The **add induct** command. This command establishes a ''duct'' for reception of bundles via the indicated CL protocol. The duct's data acquisition structure is used and populated by the ''induct'' task whose operation is initiated by *CLI_command* at the time the duct is started.

c induct *protocol_name duct_name* '*CLI_command*'
The **change induct** command. This command changes the command that is used to initiate operation of the induct task for the indicated duct.

d induct *protocol_name duct_name*
The **delete induct** command. This command deletes the induct identified by *protocol_name* and *duct_name*. The command will fail if any bundles are currently pending acquisition via this induct.

i induct *protocol_name duct_name*
This command will print information (the CLI command) about the induct identified by *protocol_name* and *duct_name*.

l induct [*protocol_name*]
If *protocol_name* is specified, this command lists all inducts established locally for the indicated CL protocol. Otherwise it lists all locally established inducts, regardless of protocol.

s induct *protocol_name duct_name*
The **start induct** command. This command starts the indicated induct task as defined for the indicated CL protocol on the local node.

x induct *protocol_name duct_name*
The **stop induct** command. This command stops the indicated induct task as defined for the indicated CL protocol on the local node.

OUTDUCT COMMANDS

a outduct *protocol_name duct_name* '*CLO_command*' [*max_payload_length*]
The **add outduct** command. This command establishes a ''duct'' for transmission of bundles via the indicated CL protocol. The duct's data transmission structure is serviced by the ''outduct'' task whose operation is initiated by *CLO_command* at the time the duct is started. A value of zero for *max_payload_length* indicates that bundles of any size can be accommodated; this is the default.

c outduct *protocol_name duct_name* '*CLO_command*' [*max_payload_length*]
The **change outduct** command. This command sets new values for the indicated duct's payload size limit and the command that is used to initiate operation of the outduct task for this duct.

d outduct *protocol_name duct_name*
The **delete outduct** command. This command deletes the outduct identified by *protocol_name* and *duct_name*. The command will fail if any bundles are currently pending transmission via this outduct.

i outduct *protocol_name duct_name*
This command will print information (the CLO command) about the outduct identified by *protocol_name* and *duct_name*.

l outduct [*protocol_name*]
If *protocol_name* is specified, this command lists all outducts established locally for the indicated CL protocol. Otherwise it lists all locally established outducts, regardless of protocol.

s outduct *protocol_name duct_name*
The **start outduct** command. This command starts the indicated outduct task as defined for the indicated CL protocol on the local node.

x outduct *protocol_name duct_name*
The **stop outduct** command. This command stops the indicated outduct task as defined for the indicated CL protocol on the local node.

EGRESS PLAN COMMANDS

a plan *endpoint_name* [*transmission_rate*]
The **add plan** command. This command establishes an egress plan governing transmission to the neighboring node[s] identified by *endpoint_name*. The plan is functionally enacted by a **bpclm** (1) daemon dedicated to managing bundles queued for transmission to the indicated neighboring node[s].

NOTE that these ''plan'' commands supersede and generalize the egress plan commands documented in the **ipnrc** (5) and **dtn2rc** (5) man pages, which are retained for backward compatibility. **The syntax of the egress plan commands consumed by bpadmin is DIFFERENT from that of the commands consumed by ipnadmin and dtn2admin.** The *endpoint_name* identifying an egress plan is normally the node ID for a single node but may instead be ''wild-carded''. That is, when the last character of an

endpoint name ID is either '*' or '~' (these two wild-card characters are equivalent for this purpose), the plan applies to all nodes whose IDs are identical to the wild-carded node name up to the wild-card character. For example, a bundle whose destination EID name is "dtn://foghorn" would be routed by plans citing the following node IDs: "dtn://foghorn", "dtn://fogh*", "dtn://fog~", "//*". When multiple plans are all applicable to the same destination EID, the one citing the longest (i.e., most narrowly targeted) node ID will be applied.

An egress plan may direct that bundles queued for transmission to the node[s] matching *endpoint_name* be transmitted using one of the convergence-layer protocol "outducts" that have been attached to the plan, or instead that those bundles be routed to some other "gateway" endpoint (resulting in transmission according to some other egress plan). In the event that both a gateway endpoint and one or more outducts have been declared for a given plan, the gateway declaration prevails.

A *transmission_rate* may be asserted for an egress plan; this rate is used as the basis for transmission rate control in the absence of applicable contacts (in the node's contact plan, as per **ionrc**(5)). A transmission rate of zero (absent applicable contacts) disables rate control completely; this is the default.

c plan *endpoint_name* [*transmission_rate*]
The **change plan** command. This command sets a new value for the indicated plan's transmission rate.

d plan *endpoint_name*
The **delete plan** command. This command deletes the plan identified by *endpoint_name*. The command will fail if any bundles are currently pending transmission per this plan.

i plan *endpoint_name*
This command will print information (the transmission rate) about the plan identified by *endpoint_name*.

l plan
This command lists all locally established egress plans.

s plan *endpoint_name*
The **start plan** command. This command starts the **bpclm**(1) task for the indicated egress plan.

x plan *endpoint_name*
The **stop plan** command. This command stops the **bpclm**(1) task for the indicated egress plan.

b plan *endpoint_name*
The **block plan** command. This command disables transmission of bundles queued for transmission to the indicated node and reforwards all non-critical bundles currently queued for transmission to this node. This may result in some or all of these bundles being enqueued for transmission (actually just retention) to the pseudo-node "limbo".

u plan *endpoint_name*
The **unblock plan** command. This command re-enables transmission of bundles to the indicated node and reforwards all bundles in "limbo" in the hope that the unblocking of this egress plan will enable some of them to be transmitted.

g plan *endpoint_name gateway_endpoint_name*
The **declare gateway** command. This command declares the name of the endpoint to which bundles queued for transmission to the node[s] identified by *endpoint_name* must be re-routed. Declaring *gateway_endpoint_name* to be the zero-length string """" disables re-routing: bundles will instead be transmitted using the plan's attached convergence-layer protocol outduct[s].

a planduct *endpoint_name protocol_name duct_name*
The **attach outduct** command. This command declares that the indicated convergence-layer protocol outduct is now a viable device for transmitting bundles to the node[s] identified by *endpoint_name*.

d planduct *protocol_name duct_name*
The **detach outduct** command. This command declares that the indicated convergence-layer protocol outduct is no longer a viable device for transmitting bundles to the node[s] to which it is currently assigned.

EXAMPLES

a scheme ipn 'ipnfw' 'ipnadminep'
Declares the ''ipn'' scheme on the local node.

a protocol udp 1400 100 16384
Establishes access to the ''udp'' convergence layer protocol on the local node, estimating the number of payload bytes per ultimate (lowest-layer) frame to be 1400 with 100 bytes of total overhead (BP, UDP, IP, AOS) per lowest-layer frame, and setting the default nominal data rate to be 16384 bytes per second.

r 'ipnadmin flyby.ipnrc'
Runs the administrative program *ipnadmin* from within *bpadmin*.

SEE ALSO

bpadmin (1), **ipnadmin** (1), **dtn2admin** (1)

NAME

bpsecrc – BP security policy management commands file

DESCRIPTION

BP security policy management commands are passed to **bpsecadmin** either in a file of text lines or interactively at **bpsecadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. JSON commands may span multiple lines. The formats and effects of the BP security policy management commands are described below.

A parameter identifed as an *eid_expr* is an ''endpoint ID expression.'' For all commands, whenever the last character of an endpoint ID expression is the wild-card character '*', an applicable endpoint ID ''matches'' this EID expression if all characters of the endpoint ID expression prior to the last one are equal to the corresponding characters of that endpoint ID. Otherwise an applicable endpoint ID ''matches'' the EID expression only when all characters of the EID and EID expression are identical.

At present, ION supports a subset of the proposed ''BPSec'' security protocol specification currently under consideration by the Internet Engineering Steering Group. Since BPSec is not yet a published standard, ION's Bundle Protocol security mechanisms will not necessarily interoperate with those of other BP implementations. This is unfortunate but (we hope) temporary, as BPSec represents a major improvement in bundle security. Future releases of ION will implement the entire BPSec specification.

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by bpsecadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

a bibrule *source_eid_expr destination_eid_expr block_type_number { '' | ciphersuite_name key_name }*
The **add bibrule** command. This command adds a rule specifying the manner in which Block Integrity Block (BIB) validation will be applied to blocks of type *block_type_number* for all bundles sourced at any node whose administrative endpoint ID matches *source_eid_expr* and destined for any node whose administrative endpoint ID ID matches *destination_eid_expr*.

If a zero-length string ('') is indicated instead of a *ciphersuite_name* then BIB validation is disabled for this source/destination EID expression pair: blocks of the type indicated by *block_type_number* in all bundles sourced at nodes with matching administrative endpoint IDs and destined for nodes with matching administrative endpoint IDs will be immediately deemed valid. Otherwise, a block of the indicated type that is attached to a bundle sourced at a node with matching administrative endpoint ID and destined for a node with matching administrative endpoint ID will only be deemed valid if the bundle contains a corresponding BIB computed via the ciphersuite named by *ciphersuite_name* using a key value that is identical to the current value of the key named *key_name* in the local security policy database.

c bibrule *source_eid_expr destination_eid_expr block_type_number { '' | ciphersuite_name key_name }*
The **change bibrule** command. This command changes the ciphersuite name and/or key name for the BIB rule pertaining to the source/destination EID expression pair identified by *source_eid_expr* and *destination_eid_expr* and the block identified by *block_type_number*. Note that the *eid_expr*s must exactly match those of the rule that is to be modified, including any terminating wild-card character.

d bibrule *source_eid_expr destination_eid_expr block_type_number*
The **delete bibrule** command. This command deletes the BIB rule pertaining to the source/destination EID expression pair identified by *sender_eid_expr* and *receiver_eid_expr* and the block identified by *block_type_number*. Note that the *eid_expr*s must exactly match those of the rule that is to be deleted, including any terminating wild-card character.

i bibrule *source_eid_expr destination_eid_expr block_type_number*
This command will print information (the ciphersuite and key names) about the BIB rule pertaining to *source_eid_expr*, *destination_eid_expr*, and *block_type_number*.

l bibrule
This command lists all BIB rules in the security policy database.

a bcbrule *source_eid_expr destination_eid_expr block_type_number { '' | ciphersuite_name key_name }*
The **add bcbrule** command. This command adds a rule specifying the manner in which Block Confidentiality Block (BCB) encryption will be applied to blocks of type *block_type_number* for all bundles sourced at any node whose administrative endpoint ID matches *source_eid_expr* and destined for any node whose administrative endpoint ID ID matches *destination_eid_expr*.

If a zero-length string ('') is indicated instead of a *ciphersuite_name* then BCB encryption is disabled for this source/destination EID expression pair: blocks of the type indicated by *block_type_number* in all bundles sourced at nodes with matching administrative endpoint IDs and destined for nodes with matching administrative endpoint IDs will be sent in plain text. Otherwise, a block of the indicated type that is attached to a bundle sourced at a node with matching administrative endpoint ID and destined for a node with matching administrative endpoint ID can only be deemed decrypted if the bundle contains a corresponding BCB computed via the ciphersuite named by *ciphersuite_name* using a key value that is identical to the current value of the key named *key_name* in the local security policy database.

c bcbrule *source_eid_expr destination_eid_expr block_type_number { '' | ciphersuite_name key_name }*
The **change bcbrule** command. This command changes the ciphersuite name and/or key name for the BCB rule pertaining to the source/destination EID expression pair identified by *source_eid_expr* and *destination_eid_expr* and the block identified by *block_type_number*. Note that the *eid_expr*s must exactly match those of the rule that is to be modified, including any terminating wild-card character.

d bcbrule *source_eid_expr destination_eid_expr block_type_number*
The **delete bcbrule** command. This command deletes the BCB rule pertaining to the source/destination EID expression pair identified by *sender_eid_expr* and *receiver_eid_expr* and the block identified by *block_type_number*. Note that the *eid_expr*s must exactly match those of the rule that is to be deleted, including any terminating wild-card character.

i bcbrule *source_eid_expr destination_eid_expr block_type_number*
This command will print information (the ciphersuite and key names) about the BCB rule pertaining to *source_eid_expr*, *destination_eid_expr*, and *block_type_number*.

l bcbrule
This command lists all BCB rules in the security policy database.

x *[{ ~| sender_eid_expr } [{ ~| receiver_eid_expr} [{ ~| bib | bcb }]]]*
This command will clear all rules for the indicated type of bundle security block between the indicated security source and security destination. If block type is omitted it defaults to ~ signifying ''all BPSec blocks''. If both block type and security destination are omitted, security destination defaults to ~ signifying ''all BSP security destinations''. If all three command-line parameters are omitted, then security source defaults to ~ signifying ''all BPSec security sources''.

a ***{ event_set : { name** *: event set name,* **desc** *: (opt) description } }*
The **add event_set** command. This command will add a named security operation event set to the system.

i ***{ event_set : { name** *: event set name } }*
The **info event_set** command for event sets displays the information the system maintains for a named event set. The security operation events and configured, optional processing actions associated with the event set are shown.

d ***{ event_set : { name** *: event set name } }*
The **delete event_set** command deletes a named event set from the system. A named event set cannot be deleted if it is referenced by a security policy rule. All security policy rules associated with the

named event set must be deleted before the event set itself may be deleted.

l ***{type : event_set}***
The **list event_set** command lists the names of all event sets defined in the system.

a ***{ event : { es_ref** *: event set name,* **event_id** *: security operation event ID* **actions** *: [opt. processing action, ... , opt. processing action],* **action_parms** *: [{ id: parm ID, value: parm value }, ... , { id: parm ID, value: parm value }] } }*
The **add event** command adds security operation event and associated optional processing action(s) to an event set. Multiple processing actions can be specified for a single security operation event.

d ***{ event : { es_ref** *: event set name,* **event_id** *: security operation event ID* **actions** *: [opt. processing action, ... , opt. processing action] } }*
The **delete event** command is used to delete optional processing actions from a named event set. To remove specific processing actions, include both the security operation event and optional processing actions to be removed in the command. To remove all processing actions for a security operation event, exclude the optional processing action field.

a ***{ policyrule : { desc** *: description,* **filter** *: { rule_id : Security policy rule id,* **role** *: Security policy role,* **src** *: Bundle source,* **dest** *: Bundle destination* **sec_src** *: Security source* **tgt** *: Security target block type,* **scid** *: Security context ID, },* **spec** *: { svc : Security service,* **scid** *: Security context ID,* **sc_parms** *: [{ id: SC parm ID, value: SC parm value }, ... , { id: SC parm ID, value: SC parm value }] },* **es_ref** *: Event set name } }*
The **add policyrule** command adds a policy rule to the system, describing a required security operation and the security policy role of the BPA applying the policy statement. The above command adds a policy rule referencing a named event set to the system.

d ***{ policyrule : { rule_id** *: Security policy rule ID } }*
The **delete policyrule** command deletes the policy rule identified by its rule ID.

i ***{policyrule** *: Security policy rule id }*
The **info policyrule** command displays the information for the policy rule matching the provided ID.

f ***{policyrule : { type : all | best, src** *: Bundle source,* **dest** *: Bundle destination,* **ssrc** *: Security source,* **scid** *: Security context ID,* **role** *: Security policy role } }*
The **find policyrule** command finds all policy rules matching the provided criteria when type **all** is selected, and finds the single policy rule that is determined to be the best match when type **best** is selected.

l ***{type : policyrule}***
The **list policyrule** command lists all policy rules currently defined in the system.

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

SEE ALSO

bpsecadmin (1)

NAME

dtn2rc − "dtn" scheme configuration commands file

DESCRIPTION

''dtn'' scheme configuration commands are passed to **dtn2admin** either in a file of text lines or interactively at **dtn2admin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line.

''dtn'' scheme configuration commands establish static routing rules for forwarding bundles to nodes identified by ''dtn''−scheme destination endpoints.

Static routes are expressed as **plan**s in the ''dtn''−scheme routing database. A plan that is established for a given node name associates a routing **directive** with the named node. Each directive is a string of one of two possible forms:

f *endpoint_ID*

...or...

x *protocol_name*/*outduct_name*

The former form signifies that the bundle is to be forwarded to the indicated endpoint, requiring that it be re-queued for processing by the forwarder for that endpoint (which might, but need not, be identified by another ''dtn''−scheme endpoint ID). The latter form signifies that the bundle is to be queued for transmission via the indicated convergence layer protocol outduct.

The node names cited in dtn2rc plans may be ''wild-carded''. That is, when the last character of a plan's node name is either '*' or '~' (these two wild-card characters are equivalent for this purpose), the plan applies to all nodes whose names are identical to the wild-carded node name up to the wild-card character. For example, a bundle whose destination EID is ''dtn://foghorn/x'' would be routed by plans citing the following node names: ''foghorn'', ''fogh*'', ''fog~'', ''*''. When multiple plans are all applicable to the same destination EID, the one citing the longest (i.e., most narrowly targeted) node name will be applied.

The formats and effects of the DTN scheme configuration commands are described below.

GENERAL COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by dtn2admin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

PLAN COMMANDS

a plan *node_name directive* [*nominal_xmit_rate*]
The **add plan** command. This command establishes a static route for the bundles destined for the node(s) identified by *node_nameID*. The *nominal_xmit_rate* is the assumed rate of transmission to this node in the absence of contact plan information. A *nominal_data_rate* of zero (the default) in the absence of contact plan information completely disables rate control.

Note that the plan commands consumed by dtn2admin are a simplified shortcut for submitting plan commands as consumed by bpadmin (see **bprc** (5)). The syntax of these commands is DIFFERENT from that of the more general and more powerful bpadmin commands.

c plan *node_nameID* [f *endpoint_ID*] [*nominal_xmit_rate*]
The **change plan** command. This command revises the ‘‘via node’’ and/or *nominal_data_rate* of the static route for the node(s) identified by *node_nameID*. To detach an outduct from the plan, use the ‘‘planduct’’ deletion command processed by bpadmin.

d plan *node_nameID*
The **delete plan** command. This command deletes the static route for the node(s) identified by *node_nameID*.

i plan *node_nameID*
This command will print information about the static route for the node(s) identified by *node_nameID*.

l plan
This command lists all static routes established in the DTN database for the local node.

EXAMPLES

a plan bbn2 f ipn:8.41
Declares a static route from the local node to node ‘‘bbn2’’. Any bundle destined for any endpoint whose node name is ‘‘bbn2’’ will be forwarded to endpoint ‘‘ipn:8.41’’.

a plan mitre* x ltp/6
Declares a static route from the local node to any node whose node name begins with ‘‘mitre’’. Any bundle destined for any endpoint whose node name begins with ‘‘mitre1’’ will be queued for transmission on LTP outduct 6.

SEE ALSO

dtn2admin (1)

NAME

ipnrc – IPN scheme configuration commands file

DESCRIPTION

IPN scheme configuration commands are passed to **ipnadmin** either in a file of text lines or interactively at **ipnadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line.

IPN scheme configuration commands (a) establish egress plans for direct transmission to neighboring nodes that are members of endpoints identified in the ''ipn'' URI scheme and (b) establish static default routing rules for forwarding bundles to specified destination nodes.

The egress **plan** established for a given node associates a **duct expression** with that node. Each duct expression is a string of the form "*protocol_name*/*outduct_name*" signifying that the bundle is to be queued for transmission via the indicated convergence layer protocol outduct.

Note that egress plans **must** be established for all neighboring nodes, regardless of whether or not contact graph routing is used for computing dynamic routes to distant nodes. This is by definition: if there isn't an egress plan to a node, it can't be considered a neighbor.

Static default routes are declared as **exits** in the ipn-scheme routing database. An exit is a range of node numbers identifying a set of nodes for which defined default routing behavior is established. Whenever a bundle is to be forwarded to a node whose number is in the exit's node number range **and** it has not been possible to compute a dynamic route to that node from the contact schedules that have been provided to the local node **and** that node is not a neighbor to which the bundle can be directly transmitted, BP will forward the bundle to the **gateway** node associated with this exit. The gateway node for any exit is identified by an endpoint ID, which might or might not be an ipn-scheme EID; regardless, directing a bundle to the gateway for an exit causes the bundle to be re-forwarded to that intermediate destination endpoint. Multiple exits may encompass the same node number, in which case the gateway associated with the most restrictive exit (the one with the smallest range) is always selected.

Note that ''exits'' were termed ''groups'' in earlier versions of ION. The term ''exit'' has been adopted instead, to minimize any possible confusion with multicast groups. To protect backward compatibility, the keyword ''group'' continues to be accepted by ipnadmin as an alias for the new keyword ''exit'', but the older terminology is deprecated.

Routing and class-of-service overrides may also be managed:

A routing override declares a neighboring node to which all bundles must be forwarded that meet specified criteria. This override is strictly local, affecting only forwarding from the local node, and it is applied before any route computed by CGR or IRR is considered.

A class-of-service override declares the class of service (priority and ordinal and [optionally] quality-of-service flags) that will condition – in terms of order and outduct selection – the forwarding of all bundles that meet specified criteria. Again this override is strictly local, affecting only forwarding from the local node.

The formats and effects of the IPN scheme configuration commands are described below.

GENERAL COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by ipnadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

PLAN COMMANDS

a plan *node_nbr duct_expression* [*nominal_data_rate*]

The **add plan** command. This command establishes an egress plan for the bundles that must be transmitted to the neighboring node identified by *node_nbr*. The *nominal_data_rate* is the assumed rate of transmission to this node in the absence of contact plan information. A *nominal_data_rate* of zero (the default) in the absence of contact plan information completely disables rate control.

Note that the plan commands consumed by ipnadmin are a simplified shortcut for submitting plan commands as consumed by bpadmin (see bprc (5)). The syntax of these commands is DIFFERENT from that of the more general and more powerful bpadmin commands.

c plan *node_nbr nominal_data_rate*

The **change plan** command. This command changes the nominal data rate for the indicated plan.

d plan *node_nbr*

The **delete plan** command. This command deletes the egress plan for the node identified by *node_nbr*.

i plan *node_nbr*

This command will print information about the egress plan for the node identified by *node_nbr*.

l plan

This command lists all egress plans established in the IPN database for the local node.

EXIT COMMANDS

a exit *first_node_nbr last_node_nbr gateway_endpoint_ID*

The **add exit** command. This command establishes an ''exit'' for static default routing as described above.

c exit *first_node_nbr last_node_nbr gateway_endpoint_ID*

The **change exit** command. This command changes the gateway node number for the exit identified by *first_node_nbr* and *last_node_nbr* .

d exit *first_node_nbr last_node_nbr*

The **delete exit** command. This command deletes the exit identified by *first_node_nbr* and *last_node_nbr*.

i exit *first_node_nbr last_node_nbr*

This command will print information (the gateway endpoint ID) about the exit identified by *first_node_nbr* and *last_node_nbr*.

l exit

This command lists all exits defined in the IPN database for the local node.

OVERRIDE COMMANDS

a rtovrd *data_label dest_node_nbr source_node_nbr neighbor*

The **add rtovrd** command. This command cause bundles characterized by *data_label*, *dest_node_nbr* (''all other destinations'' if this node number is zero) and *source_node_nbr* (''all other sources'' if this node number is zero) to be forwarded to *neighbor*. If *neighbor* is zero, the override will be ''learned'' by ION: the neighbor selected for this bundle, by whatever means, becomes the override for all subsequent matching bundles.

c rtovrd *data_label dest_node_nbr source_node_nbr neighbor*

The **change rtovrd** command. This command changes the override neighbor for the override identified by *data_label*, *dest_node_nbr*, and *source_node_nbr*. To cause ION to forget the override, use −1 as *neighbor*.

a cosovrd *data_label dest_node_nbr source_node_nbr priority ordinal* [*qos_flags*]

The **add cosovrd** command. This command cause bundles characterized by *data_label*, *dest_node_nbr* (''all other destinations'' if this node number is zero) and *source_node_nbr* (''all other

sources'' if this node number is zero) to have their effective class of service (priority and ordinal and, optionally, additional quality-of-service flags) changed as noted.

c cosovrd *data_label dest_node_nbr source_node_nbr priority ordinal* [*qos_flags*]
The **change cosovrd** command. This command changes the effective class of service (priority and ordinal and, optionally, additional quality-of-service flags) for the override identified by *data_label*, *dest_node_nbr*, and *source_node_nbr*. To cause ION to forget the override, use −1 as *priority*.

d ovrd *data_label dest_node_nbr source_node_nbr*
The **delete override** command. This command deletes all overrides identified by *data_label*, *dest_node_nbr*, and *source_node_nbr*.

i ovrd *data_label dest_node_nbr source_node_nbr*
This command will print information for all overrides identified by *data_label*, *dest_node_nbr*, and *source_node_nbr*.

l ovrd
This command lists all overrides defined in the IPN database for the local node.

EXAMPLES

a plan 18 ltp/18
Declares the egress plan to use for transmission from the local node to neighboring node 18. By default, any bundle for which the computed ''next hop'' node is node 18 will be queued for transmission on LTP outduct 18.

a exit 1 999 dtn://stargate
Declares a default route for bundles destined for all nodes whose numbers are in the range 1 through 999 inclusive: absent any other routing decision, such bundles are to be forwarded to ''dtn://stargate''.

SEE ALSO

ipnadmin (1)

NAME

lgfile – ION Load/Go source file

DESCRIPTION

The ION Load/Go system enables the execution of ION administrative programs at remote nodes:

The **lgsend** program reads a Load/Go source file from a local file system, encapsulates the text of that source file in a bundle, and sends the bundle to a designated DTN endpoint on the remote node.

An **lgagent** task running on the remote node, which has opened that DTN endpoint for bundle reception, receives the extracted payload of the bundle — the text of the Load/Go source file — and processes it.

Load/Go source file content is limited to newline-terminated lines of ASCII characters. More specifically, the text of any Load/Go source file is a sequence of *line sets* of two types: *file capsules* and *directives*. Any Load/Go source file may contain any number of file capsules and any number of directives, freely intermingled in any order, but the typical structure of a Load/Go source file is simply a single file capsule followed by a single directive.

Each *file capsule* is structured as a single start-of-capsule line, followed by zero or more capsule text lines, followed by a single end-of-capsule line. Each start-of-capsule line is of this form:

[*file_name*

Each capsule text line can be any line of ASCII text that does not begin with an opening ([) or closing (]) bracket character.

A text line that begins with a closing bracket character (]) is interpreted as an end-of-capsule line.

A *directive* is any line of text that is not one of the lines of a file capsule and that is of this form:

!*directive_text*

When **lgagent** identifies a file capsule, it copies all of the capsule's text lines to a new file named *file_name* that it creates in the current working directory. When **lgagent** identifies a directive, it executes the directive by passing *directive_text* to the **pseudoshell()** function (see **platform** (3)). **lgagent** processes the line sets of a Load/Go source file in the order in which they appear in the file, so the *directive_text* of a directive may reference a file that was created as the result of processing a prior file capsule line set in the same source file.

Note that lgfile directives are passed to **pseudoshell()**, which on a VxWorks platform will always spawn a new task; the first argument in *directive_text* must be a symbol that VxWorks can resolve to a function, not a shell command. Also note that the arguments in *directive_text* will be actual task arguments, not shell command-line arguments, so they should never be enclosed in double-quote characters ("). However, any argument that contains embedded whitespace must be enclosed in single-quote characters (') so that **pseudoshell()** can parse it correctly.

EXAMPLES

Presenting the following lines of source file text to **lgsend**:

[cmd33.bprc

x protocol ltp

]

!bpadmin cmd33.bprc

should cause the receiving node to halt the operation of the LTP convergence-layer protocol.

SEE ALSO

lgsend (1), **lgagent** (1), **platform** (3)

NAME

bssprc − Bundle Streaming Service Protocol management commands file

DESCRIPTION

BSSP management commands are passed to **bsspadmin** either in a file of text lines or interactively at **bsspadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the BSSP management commands are described below.

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by bsspadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

1 *est_max_nbr_of_sessions*
The **initialize** command. Until this command is executed, BSSP is not in operation on the local ION node and most *bsspadmin* commands will fail.

The command uses *est_max_nbr_of_sessions* to configure the hashtable it will use to manage access to transmission sessions that are currently in progress. For optimum performance, *est_max_nbr_of_sessions* should normally equal or exceed the summation of *max_nbr_of_sessions* over all spans as discussed below.

a span *peer_engine_nbr max_nbr_of_sessions max_block_size 'BE−BSO_command' 'RL−BSO_command* [*queuing_latency*]
The **add span** command. This command declares that a *span* of potential BSSP data interchange exists between the local BSSP engine and the indicated (neighboring) BSSP engine.

The *max_block_size* is expressed as a number of bytes of data. *max_block_size* is used to configure transmission buffer sizes; as such, it limits client data item size.

max_nbr_of_ _sessions constitutes, in effect, the local BSSP engine's retransmission ''window'' for this span. The retransmission windows of the spans impose flow control on BSSP transmission, reducing the chance ofx allocation of all available space in the ION node's data store to BSSP transmission sessions.

BE−BSO_command is script text that will be executed when BSSP is started on this node, to initiate operation of the best-efforts transmission channel task for this span. Note that " *peer_engine_nbr*" will automatically be appended to *BE−BSO_command* by **bsspadmin** before the command is executed, so only the link-service-specific portion of the command should be provided in the *LSO_command* string itself.

RL−BSO_command is script text that will be executed when BSSP is started on this node, to initiate operation of the reliable transmission channel task for this span. Note that " *peer_engine_nbr*" will automatically be appended to *RL−BSO_command* by **bsspadmin** before the command is executed, so only the link-service-specific portion of the command should be provided in the *LSO_command* string itself.

queuing_latency is the estimated number of seconds that we expect to lapse between reception of a block at this node and transmission of an acknowledging PDU, due to processing delay in the node. (See the 'm ownqtime' command below.) The default value is 1.

If *queuing latency* a negative number, the absolute value of this number is used as the actual queuing latency and session purging is enabled; otherwise session purging is disabled. If session purging is enabled for a span then at the end of any period of transmission over this span all of the span's export

sessions that are currently in progress are automatically canceled. Notionally this forces re-forwarding of the DTN bundles in each session's block, to avoid having to wait for the restart of transmission on this span before those bundles can be successfully transmitted.

a seat '*BE−BSO_command*' '*RL−BSO_command*'
The **add seat** command. This command declares that the local BSSP engine can receive BSSP PDUs via the link service input daemons that begin running when '*BE−BSO_command*' and '*RL−BSO_command*' are executed.

c span *peer_engine_nbr max_nbr_of_sessions max_block_size* '*BE−BSO_command*' '*RL−BSO_command* [*queuing_latency*]
The **change span** command. This command sets the indicated span's configuration parameters to the values provided as arguments.

d span *peer_engine_nbr*
The **delete span** command. This command deletes the span identified by *peer_engine_nbr*. The command will fail if any outbound blocks for this span are pending transmission.

d seat '*BE−BSO_command*' '*RL−BSO_command*'
The **delete span** command. This command deletes the seat identified by '*BE−BSO_command*' and '*RL−BSO_command*'.

i span *peer_engine_nbr*
This command will print information (all configuration parameters) about the span identified by *peer_engine_nbr*.

i seat '*BE−BSO_command*' '*RL−BSO_command*'
This command will print all information (i.e., process ID numbers) about the seat identified by '*BE−BSO_command*' and '*RL−BSO_command*'.

l span
This command lists all declared BSSP data interchange spans.

l seat
This command lists all declared BSSP data acquisition seats.

s ['*BE−BSI_command*' '*RL−BSI_command*']
The **start** command. This command starts reliable and best-efforts link service output tasks for all BSSP spans (to remote engines) from the local BSSP engine, and it starts the reliable and best-efforts link service input tasks for the local engine. '*BE−BSI_command*' and '*RL−BSI_command*' are deprecated but are supported for backward compatibility; if provided, the effect is the same as entering the command "a seat '*BE−BSO_command*' '*RL−BSO_command*'" prior to starting all daemon tasks.

m ownqtime *own_queuing_latency*
The **manage own queuing time** command. This command sets the number of seconds of predicted additional latency attributable to processing delay within the local engine itself that should be included whenever BSSP computes the nominal round-trip time for an exchange of data with any remote engine. The default value is 1.

x The **stop** command. This command stops all link service input and output tasks for the local BSSP engine.

w { 0 | 1 | <activity_spec> }
The **BSSP watch** command. This command enables and disables production of a continuous stream of user-selected BSSP activity indication characters. A watch parameter of "1" selects all BSSP activity indication characters; "0" de-selects all BSSP activity indication characters; any other *activity_spec* such as "df=" selects all activity indication characters in the string, de-selecting all others. BSSP will print each selected activity indication character to **stdout** every time a processing event of the associated type occurs:

d bssp send completed

e bssp block constructed for issuance

f bssp block issued

g bssp block popped from best-efforts transmission queue

h positive ACK received for bssp block, session ended

s bssp block received

t bssp block popped from reliable transmission queue

= unacknowledged best-efforts block requeued for reliable transmission

{ session canceled locally by sender

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

EXAMPLES

a span 19 20 4096 'udpbso node19.ohio.edu:5001' 'tcpbso node19.ohio.edu:5001'

Declares a data interchange span between the local BSSP engine and the remote engine (ION node) numbered 19. There can be at most 20 concurrent sessions of BSSP transmission activity to this node. Maximum block size for this span is set to 4096 bytes, and the best-efforts and reliable link service output tasks that are initiated when BSSP is started on the local ION node will execute the *udpbso* and *tcpbso* programs as indicated.

m ownqtime 2

Sets local queuing delay allowance to 2 seconds.

SEE ALSO

bsspadmin (1), **udpbsi** (1), **udpbso** (1), **tcpbsi** (1), **tcpbso** (1)

NAME

cfdprc – CCSDS File Delivery Protocol management commands file

DESCRIPTION

CFDP management commands are passed to **cfdpadmin** either in a file of text lines or interactively at **cfdpadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the CFDP management commands are described below.

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by cfdpadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

1 The **initialize** command. Until this command is executed, CFDP is not in operation on the local ION node and most *cfdpadmin* commands will fail.

a entity> <entity nbr> <UT protocol name> <UT endpoint name> <rtt> <incstype> <outcstype>
The **add entity** command. This command will add a new remote CFDP entity to the CFDP management information base. Valid UT protocol names are bp and tcp. Endpoint name is EID for bp, socket spec (*IP address*:*port number*) for tcp. RTT is round-trip time, used to set acknowledgement timers. incstype is the type of checksum to use when validating data received from this entity; valid values are 0 (modular checksum), 2 (CRC32C), and 15 (the null checksum). outcstype is the type of checksum to use when computing the checksum for transmitting data to this entity.

c entity> <entity nbr> <UT protocol name> <UT endpoint name> <rtt> <incstype> <outcstype>
The **change entity** command. This command will change information associated with an existing entity in the CFDP management information base.

d entity> <entity nbr>
The **delete entity** command. This command will delete an existing entity from the CFDP management information base.

i [<entity nbr>]
The **info** command. When **entity nbr** is provided, this command will print information about the indicated entity. Otherwise this command will print information about the current state of the local CFDP entity, including the current settings of all parameters that can be managed as described below.

s '*UTS command*'
The **start** command. This command starts the UT-layer service task for the local CFDP entity.

m discard { 0 | 1 }
The **manage discard** command. This command enables or disables the discarding of partially received files upon cancellation of a file reception. The default value is 1;

m requirecrc { 0 | 1 }
The **manage CRC data integrity** command. This command enables or disables the attachment of CRCs to all PDUs issued by the local CFDP entity. The default value is 0;

m fillchar *file_fill_character*
The **manage fill character** command. This command establishes the fill character to use for the portions of an incoming file that have not yet been received. The fill character is normally expressed in hex, e.g., the default value is 0xaa.

m ckperiod *check_cycle_period*
The **manage check interval** command. This command establishes the number of seconds following reception of the EOF PDU — or following expiration of a prior check cycle — after which the local CFDP will check for completion of a file that is being received. Default value is 86400 (i.e., one day).

m maxtimeouts *check_cycle_limit*
The **manage check limit** command. This command establishes the number of check cycle expirations after which the local CFDP entity will invoke the check cycle expiration fault handler upon expiration of a check cycle. Default value is 7.

m maxevents *event_queue_limit*
The **manage event queue limit** command. This command establishes the maximum number of unread service indications (CFDP ''events'') that may be queued up for delivery at any time. When the events queue length exceeds this figure, events are simply deleted (in decreasing age order, oldest first) until the the limit is no longer exceeded. Default value is 20.

m maxtrnbr *max_transaction_number*
The **manage transaction numbers** command. This command establishes the largest possible transaction number used by the local CFDP entity for file transmission transactions. After this number has been used, the transaction number assigned to the next transaction will be 1. The default value is 999999999.

m segsize *max_bytes_per_file_data_segment*
The **manage segment size** command. This command establishes the number of bytes of file data in each file data PDU transmitted by the local CFDP entity in the absence of an application-supplied reader function. The default value is 65000.

m inactivity *inactivity_period*
The **manage inactivity period** command. This command establishes the number of seconds that a CFDP file transfer is allowed to go idle before being canceled for inactivity. The default is one day.

x The **stop** command. This command stops the UT-layer service task for the local CFDP engine.

w { 0 | 1 | <activity_spec> }
The **CFDP watch** command. This command enables and disables production of a continuous stream of user-selected CFDP activity indication characters. A watch parameter of ''1'' selects all CFDP activity indication characters; ''0'' de-selects all CFDP activity indication characters; any other *activity_spec* such as ''p'' selects all activity indication characters in the string, de-selecting all others. CFDP will print each selected activity indication character to **stdout** every time a processing event of the associated type occurs:

p CFDP PDU transmitted

q CFDP PDU received

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

EXAMPLES

m requirecrc 1
Initiates attachment of CRCs to all subsequently issued CFDP PDUs.

SEE ALSO

cfdpadmin (1), **bputa** (1)

NAME

dtpcrc – Delay–Tolerant Payload Conditioning management commands file

DESCRIPTION

DTPC management commands are passed to **dtpcadmin** either in a file of text lines or interactively at **dtpcadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the DTPC management commands are described below.

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by dtpcadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

1 The **initialize** command. Until this command is executed, DTPC is not in operation on the local ION node and most *dtpcadmin* commands will fail.

a profile *profileID maxRtx aggrSizeLimit aggrTimeLimit TTL class_of_service report_to_endpointID* [*statusReportFlags*]
The **add profile** command. This command notes the definition of a single DPTC transmission profile. A transmission profile asserts the BP and DTPC configuration parameter values that will be applied to all application data items (encapsulated in DTPC application data units and transmitted in bundles) that are issued subject to this profile. Transmission profiles are globally defined; all transmission profiles must be provided, with identical parameter values, to all inter-communicating DTPC protocol entities.

profileID must be the positive integer that uniquely defines the profile.

maxRtx is the maximum number of times any single DTPC ADU transmitted subject to the indicated profile may be retransmitted by the DTPC entity. If *maxRtx* is zero, then the DTPC transport service features (in-order delivery, end-to-end acknowledgment, etc.) are disabled for this profile.

aggrSizeLimit is the size threshold for concluding aggregation of an outbound ADU and requesting transmission of that ADU. If *aggrSizeLimit* is zero, then the DTPC transmission optimization features (aggregation and elision) are disabled for this profile.

aggrTimeLimit is the time threshold for concluding aggregation of an outbound ADU and requesting transmission of that ADU. If *aggrTimeLimit* is zero, then the DTPC transmission optimization features (aggregation and elision) are disabled for this profile.

class_of_service is the class-of-service string as defined for **bptrace** (1).

report_to_endpointID identifies the BP endpoint to which all status reports generated from bundles transmitted subject to this profile will be sent.

statusReportFlags, if present, must be a sequence of status report flags, separated by commas, with no embedded whitespace. Each status report flag must be one of the following: rcv, ct, fwd, dlv, del.

d profile *profileId*
The **delete profile** command. This command erases the definition of the DTPC transmission profile identified by *profileId*.

i profile *profileId*
This command will print information (all configuration parameters) about the profile identified by *profileId*.

l profile
This command lists all known DTPC transmission profiles.

s The **start** command. This command starts the DTPC clock and daemon tasks for the local BP node.

x The **stop** command. This command stops all DTPC tasks and notifies all DTPC applications that DTPC service has been stopped.

w { 0 | 1 | <activity_spec> }
The **DTPC watch** command. This command enables and disables production of a continuous stream of user-selected DTPC activity indication characters. A watch parameter of ‘‘1’’ selects all DTPC activity indication characters; ‘‘0’’ de-selects all DTPC activity indication characters; any other *activity_spec* such as ‘‘o<r>’’ selects all activity indication characters in the string, de-selecting all others. DTPC will print each selected activity indication character to **stdout** every time a processing event of the associated type occurs:

o new aggregator created for profile and destination endpoint

\< new ADU aggregation initiated

r application data item added to aggregation

\> aggregation complete, outbound ADU created

– outbound ADU sent via BP

l ADU end-to-end acknowledgment sent

m ADU deleted due to TTL expiration

n ADU queued for retransmission

i inbound ADU collector created

u inbound ADU received

v ADU sequence gap detected

? inbound ADU discarded

***** ADU sequence gap deleted due to impending ADU TTL expiration

$ inbound ADU collector reset

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

EXAMPLES

a profile 5 6 1000000 5 3600 0.1 dtn:none
Notes the definition of DTPC transmission profile 5: transport services are enabled, with an end-to-end retransmission limit of 5; transmission optimization service is enabled, initiating bundle transmission whenever the aggregation of data items queued for transmission subject to this profile exceeds one million bytes or is more than five seconds old; the transmitted bundles will have one-hour lifetime, will not be subject to custody transfer, will be sent at ‘‘standard’’ priority, and will not be tracked by any bundle status report production.

SEE ALSO

dtpcadmin (1), **bptrace** (1)

NAME

ionconfig − ION node configuration parameters file

DESCRIPTION

ION node configuration parameters are passed to **ionadmin** in a file of parameter name/value pairs:

parameter_name parameter_value

Any line of the file that begins with a '#' character is considered a comment and is ignored.

ionadmin supplies default values for any parameters for which no value is provided in the node configuration parameters file.

The applicable parameters are as follows:

sdrName
: This is the character string by which this ION node's SDR database will be identified. (Note that the SDR database infrastructure enables multiple databases to be constructed on a single host computer.) The default value is ''ion''.

sdrWmSize
: This is the size of the block of dynamic memory that will be reserved as private working memory for the SDR system itself. A block of system memory of this size will be allocated (e.g., by **malloc()**) at the time the SDR system is initialized on the host computer. The default value is 1000000 (1 million bytes).

configFlags
: This is the bitwise ''OR'' (i.e., the sum) of the flag values that characterize the SDR database to use for this ION node. The default value is 13 (that is, SDR_IN_DRAM | SDR_REVERSIBLE | SDR_BOUNDED). The SDR configuration flags are documented in detail in **sdr** (3). To recap:

  SDR_IN_DRAM (1)
  : The SDR is implemented in a region of shared memory. [Possibly with write-through to a file, for fault tolerance.]

  SDR_IN_FILE (2)
  : The SDR is implemented as a file. [Possibly cached in a region of shared memory, for faster data retrieval.]

  SDR_REVERSIBLE (4)
  : Transactions in the SDR are written ahead to a log, making them reversible.

  SDR_BOUNDED (8)
  : SDR heap updates are not allowed to cross object boundaries.

heapKey
: This is the shared-memory key by which the pre-allocated block of shared dynamic memory to be used as heap space for this SDR can be located, if applicable. The default value is −1, i.e., not specified and not applicable.

pathName
: This is the fully qualified path name of the directory in which are located (a) the file to be used as heap space for this SDR (which will be created, if it doesn't already exist), in the event that the SDR is to be implemented in a file, and (b) the file to be used to log the database updates of each SDR transaction, in the event that transactions in this SDR are to be reversible. The default value is **/tmp**.

heapWords
: This is the number of words (of 32 bits each on a 32−bit machine, 64 bits each on a 64−bit machine) of nominally non-volatile storage to use for ION's SDR database. If the SDR is to be implemented in shared memory and no *heapKey* is specified, a block of shared memory of this size will be allocated (e.g., by **malloc()**) at the time the node is created. If the SDR is to be implemented in a file and no file named **ion.sdr** exists in the directory identified by *pathName*, then a file of this name and size will be created in this directory and initialized to all binary zeroes. The default value is 250000 words (1

million bytes on a 32−bit computer).

logSize
: This is the number of bytes of shared memory to use for ION's SDR transaction log. If zero (the default), the transaction log is written to a file rather than to memory. If the log is to be implemented in shared memory and no *logKey* is specified, a block of shared memory of this size will be allocated (e.g., by **malloc()**) at the time the node is created.

logKey
: This is the shared-memory key by which the pre-allocated block of shared dynamic memory to be used for the transaction log for this SDR can be located, if applicable. The default value is −1, i.e., not specified and not applicable.

wmKey
: This is the shared-memory key by which this ION node's working memory will be identified. The default value is 65281.

wmAddress
: This is the address of the block of dynamic memory — volatile storage, which is not expected to persist across a system reboot — to use for this ION node's working memory. If zero, the working memory block will be allocated from system memory (e.g., by **malloc()**) at the time the local ION node is created. The default value is zero.

wmSize
: This is the size of the block of dynamic memory that will be used for this ION node's working memory. If *wmAddress* is zero, a block of system memory of this size will be allocated (e.g., by **malloc()**) at the time the node is created. The default value is 5000000 (5 million bytes).

EXAMPLE

configFlags 1

heapWords 2500000

heapKey −1

pathName /usr/ion

wmSize 5000000

wmAddress 0

SEE ALSO

ionadmin (1)

NAME

ionrc – ION node management commands file

DESCRIPTION

ION node management commands are passed to **ionadmin** either in a file of text lines or interactively at **ionadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the ION node management commands are described below.

TIME REPRESENTATION

For many ION node management commands, time values must be passed as arguments. Every time value may be represented in either of two formats. Absolute time is expressed as:

yyyy/*mm*/*dd*–*hh*:*mm*:*ss*

Relative time (a number of seconds following the current *reference time*, which defaults to the current time at the moment *ionadmin* began execution but which can be overridden by the **at** command described below) is expressed as:

+*ss*

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by ionadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

1 *node_number* [{ *ion_config_filename* | '.' | '' }]
The **initialize** command. Until this command is executed, the local ION node does not exist and most *ionadmin* commands will fail.

The command configures the local node to be identified by *node_number*, a CBHE node number which uniquely identifies the node in the delay-tolerant network. It also configures ION's data space (SDR) and shared working-memory region. For this purpose it uses a set of default settings if no argument follows *node_number* or if the argument following *node_number* is ''; otherwise it uses the configuration settings found in a configuration file. If configuration file name '.' is provided, then the configuration file's name is implicitly "*hostname*.ionconfig"; otherwise, *ion_config_filename* is taken to be the explicit configuration file name. Please see **ionconfig**(5) for details of the configuration settings.

For example:

```
1 19 ''
```

would initialize ION on the local computer, assigning the local ION node the node number 19 and using default values to configure the data space and shared working-memory region.

@ *time*
The **at** command. This is used to set the reference time that will be used for interpreting relative time values from now until the next revision of reference time. Note that the new reference time can be a relative time, i.e., an offset beyond the current reference time.

^ *region_number*
The **region** command. This is used to select the region to which all ensuing "contact" operations (until this execution of ionadmin terminates, or until the next **region** command is processed) pertain. A **region** is an arbitarily managed set of nodes that customarily are able to use contact graph routing to compute forwarding routes among themselves, and which consequently share a common contact plan.

As such, there is a one-to-one correspondence between regions and contact plans, so in effect the **region** command is used to switch between contact plans. Regions are notionally quite small sets (on the order of 16−32 nodes) because contact graph routing is computationally intensive.

Information regarding up to two (2) regions may be managed at any single node.

By default, region number 1 (the ''universal'' region) is selected.

! [0 | 1]
''Announce'' control. Setting the announce flag to 1 causes contact plan updates (contact add/change/delete, range add/delete) to be multicast to all other nodes in the region in addition to being processed at the local node. Setting the announce flag to 0 disables this behavior.

a contact *start_time stop_time source_node dest_node xmit_data_rate* [*confidence*]
The **add contact** command. This command schedules a period of data transmission from *source_node* to *dest_node*. The period of transmission will begin at *start_time* and end at *stop_time*, and the rate of data transmission will be *xmit_data_rate* bytes/second. Our confidence in the contact defaults to 1.0, indicating that the contact is scheduled − not that non-occurrence of the contact is impossible, just that occurrence of the contact is planned and scheduled rather than merely imputed from past node behavior. In the latter case, *confidence* indicates our estimation of the likelihood of this potential contact.

The period of time between the start and stop times of a contact is termed the contact's ''interval''. The intervals of scheduled contacts are not allowed to overlap.

Commands pertaining to three different types of contact can be intermixed within an .ionrc file that defines a contact plan.

1 Registration
When *start_time* is ''−1'', the contact signifies the ''registration'' of a node in the region corresponding to the contact plan of which this contact is a part. In this case, *source_node* and *dest_node* must be identical and non-zero. A registration contact simply affirms the source node's permanent membership in this region, persisting even during periods when the node is able neither to send nor to receive data. When inserted into the contact plan, the contact's start and stop times are both automatically set to the maximum POSIX time, its data rate is set to zero, and its confidence value is set to 1.0.

2 Hypothetical
When *stop_time* is ''0'', the contact is ''hypothetical''. A hypothetical contact is an anticipated opportunity for the local node to transmit data to, or receive data from, some potentially neighboring node in the same region. The nature of that contact is completely unknown; if and when the contact occurs, the hypothetical contact will be transformed into a ''discovered'' contact for the duration of the opportunity, after which it will revert to being hypothetical. *source_node* and *dest_node* must **NOT** be identical, and one or the other must identify the local node. When inserted into the contact plan, the contact's start time is automatically set to zero, its stop time is set to the maximum POSIX time, its data rate is set to zero, and its confidence value is set to 0.0.

3 Scheduled
Otherwise, the contact is ''scheduled''. A scheduled contact is a managed opportunity to transmit data between nodes, as inferred (for example) from a spacecraft or ground station operating plan. *start_time* must be less than *stop_time* and *data_rate* and *confidence* must both be greater than zero.

c contact *start_time source_node dest_node xmit_data_rate* [*confidence*]
The **change contact** command. This command changes the data transmission rate and possibly our level of confidence in the scheduled period of data transmission from *source_node* to *dest_node* starting at *start_time*. Registration and hypothetical contacts cannot be changed.

d contact *start_time source_node dest_node*
The **delete contact** command. This command deletes the contact from *source_node* to *dest_node* starting at *start_time*. To delete all scheduled contacts between some pair of nodes, use '*' as

start_time. To delete a registration contact, use ‘‘−1’’ as *start_time*. To delete a hypothetical contact, use ‘‘0’’ as *start_time*.

i contact *start_time source_node dest_node*
This command will print information (stop time, data rate, confidence) about the scheduled period of transmission from *source_node* to *dest_node* that starts at *start_time*.

l contact
This command lists all contacts in the contact plan for the selected region.

b contact
The **brief contacts** command. This command writes a file of commands that will recreate the current list of contacts, for the selected region, in the node's ION database. The name of the file will be "contacts.*region_number*.ionrc".

a range *start_time stop_time one_node the_other_node distance*
The **add range** command. This command predicts a period of time during which the distance from *one_node* to *the_other_node* will be constant to within one light second. The period will begin at *start_time* and end at *stop_time*, and the distance between the nodes during that time will be *distance* light seconds.

NOTE that the ranges declared by these commands are directional. ION does not automatically assume that the distance from node A to node B is the same as the distance from node B to node A. While this symmetry is certainly true of geographic distance, the range that concerns ION is the latency in propagating a signal from one node to the other; this latency may be different in different directions because (for example) the signal from B to A might need to be forwarded along a different convergence-layer network path from the one used for the signal from A to B.

For this reason, the range identification syntax for this command is asymmetrical: ION interprets an **add range** command in which the node number of the first cited node is numerically less than that of the second cited node as implicitly declaring the same distance in the reverse direction (the normal case) **UNLESS** a second range command is present that cites the same two nodes in the opposite order, which overrides the implicit declaration. A range command in which the node number of the first cited node is numerically greater than that of the second cited node implies **ABSOLUTELY NOTHING** about the distance in the reverse direction.

d range *start_time one_node the_other_node*
The **delete range** command. This command deletes the predicted period of constant distance between *one_node* and *the_other_node* starting at *start_time*. To delete all ranges between some pair of nodes, use '*' as *start_time*.

NOTE that the range identification syntax for this command is asymmetrical, much as described for the **add range** command described above. ION interprets a **delete range** command in which the node number of the first cited node is numerically less than that of the second cited node as implicitly requesting deletion of the range in the opposite direction as well. A **delete range** command in which the node number of the first cited node is numerically greater than that of the second cited node deletes only the range in that direction; the asserted range in the opposite direction is unaffected.

i range *start_time one_node the_other_node*
This command will print information (the stop time and range) about the predicted period of constant distance between *one_node* and *the_other_node* that starts at *start_time*.

l range
This command lists all predicted periods of constant distance.

b range
The **brief ranges** command. This command writes a file of commands that will recreate the current list of ranges in the node's ION database. The file's name will be ‘‘ranges.ionrc’’.

m utcdelta *local_time_sec_after_UTC*

This management command sets ION's understanding of the current difference between correct UTC time and the localtime equivalent of the current calendar (i.e., Unix epoch) time as reported by the clock for the local ION node's computer. This delta is automatically applied to locally obtained time values whenever ION needs to know the current time. For machines that are synchronized by NTP, the value of this delta should be 0, the default.

Note that the purpose of the UTC delta is not to correct for time zone differences (which operating systems often do natively) but rather to compensate for error (drift) in clocks, particularly spacecraft clocks. The hardware clock on a spacecraft might gain or lose a few seconds every month, to the point at which its understanding of the current time − as reported out by the operating system and converted to UTC − might differ significantly from the actual value of UTC as reported by authoritative clocks on Earth. To compensate for this difference without correcting the clock itself (which can be difficult and dangerous), ION simply adds the UTC delta to the calendar time reported by the operating system.

Note that this means that setting the UTC delta is not a one-time node configuration activity but rather an ongoing node administration chore, because a drifting clock typically keeps on drifting.

m clockerr *known_maximum_clock_error*

This management command sets ION's understanding of the accuracy of the scheduled start and stop times of planned contacts, in seconds. The default value is 1. When revising local data transmission and reception rates, *ionadmin* will adjust contact start and stop times by this interval to be sure not to send bundles that arrive before the neighbor expects data arrival or to discard bundles that arrive slightly before they were expected.

m clocksync [{ 1 | 0 }]

This management command reports whether or not the computer on which the local ION node is running has a synchronized clock, as discussed in the description of the **ionClockIsSynchronized()** function (**ion** (3)).

If a Boolean argument is provided when the command is executed, the characterization of the machine's clock is revised to conform with the asserted value. The default value is 1.

m production *planned_data_production_rate*

This management command sets ION's expectation of the mean rate of continuous data origination by local BP applications throughout the period of time over which congestion forecasts are computed, in bytes per second. For nodes that function only as routers this variable will normally be zero. A value of −1, which is the default, indicates that the rate of local data production is unknown; in that case local data production is not considered in the computation of congestion forecasts.

m consumption *planned_data_consumption_rate*

This management command sets ION's expectation of the mean rate of continuous data delivery to local BP applications throughout the period of time over which congestion forecasts are computed, in bytes per second. For nodes that function only as routers this variable will normally be zero. A value of −1, which is the default, indicates that the rate of local data consumption is unknown; in that case local data consumption is not considered in the computation of congestion forecasts.

m inbound *heap_occupancy_limit* [*file_system_occupancy_limit*]

This management command sets the maximum number of megabytes of storage space in ION's SDR non-volatile heap, and/or in the local file system, that can be used for the storage of inbound zero-copy objects. A value of −1 for either limit signifies ''leave unchanged''. The default heap limit is 30% of the SDR data space's total heap size. The default file system limit is 1 Terabyte.

m outbound *heap_occupancy_limit* [*file_system_occupancy_limit*]

This management command sets the maximum number of megabytes of storage space in ION's SDR non-volatile heap, and/or in the local file system, that can be used for the storage of outbound zero-copy objects. A value of −1 for either limit signifies ''leave unchanged''. The default heap limit is 30% of the SDR data space's total heap size. The default file system limit is 1 Terabyte.

m search *max_free_blocks_to_search_through*
This management command sets the limit on the number of free blocks the heap space allocation function will search through in the nominal free space bucket, looking for a sufficiently large free block, before giving up and switching to the next higher non-empty free space bucket. The default value is 0, which yields the highest memory management speed but may leave heap space under-utilized: data objects may be stored in unnecessarily large heap space blocks. Increasing the value of the heap space search limit will manage space more efficiently – with less waste – but more slowly.

m horizon { 0 | *end_time_for_congestion_forecasts* }
This management command sets the end time for computed congestion forecasts. Setting congestion forecast horizon to zero sets the congestion forecast end time to infinite time in the future: if there is any predicted net growth in bundle storage space occupancy at all, following the end of the last scheduled contact, then eventual congestion will be predicted. The default value is zero, i.e., no end time.

m alarm '*congestion_alarm_command*'
This management command establishes a command which will automatically be executed whenever *ionadmin* predicts that the node will become congested at some future time. By default, there is no alarm command.

m usage
This management command simply prints ION's current data space occupancy (the number of megabytes of space in the SDR non-volatile heap and file system that are occupied by inbound and outbound zero-copy objects), the total zero-copy-object space occupancy ceiling, and the maximum level of occupancy predicted by the most recent *ionadmin* congestion forecast computation.

m home *home_region_number*
This management command asserts that the node's home region is the region that is identified by *home_region_number*. If no home region is asserted, home region number defaults to zero, the ''root region''.

m outer *outer_region_number*
This management command asserts that the node's outer region is the region that is identified by *outer_region_number*. Outer region number defaults to −1, ''no region'', indicating that the node is a ''terminal node''. When a node's outer region number is not −1, the node is able to function as a ''passageway'' by which bundles are conveyed between nodes in the home region and nodes in the outer region.

m passageway *node_number home_region_number outer_region_number*
This management command declares the home and outer region numbers for the indicated passageway node. If the outer region number is −1, then the node ceases to be a passageway; if the home region number is −1, then the passageway is simply removed. If neither region number is −1 but neither region is one of the regions of which the local node is a member, the command has no effect. Otherwise, the home and outer region numbers of the indicated node are recorded. (This information is needed in order to accomplish inter-region routing.)

r '*command_text*'
The **run** command. This command will execute *command_text* as if it had been typed at a console prompt. It is used to, for example, run another administrative program.

s The **start** command. This command starts the *rfxclock* task on the local ION node.

x The **stop** command. This command stops the *rfxclock* task on the local ION node.

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

EXAMPLES

@ 2008/10/05−11:30:00
Sets the reference time to 1130 (UTC) on 5 October 2008.

a range +1 2009/01/01−00:00:00 1 2 12
: Predicts that the distance between nodes 1 and 2 (endpoint IDs ipn:1.0 and ipn:2.0) will remain constant at 12 light seconds over the interval that begins 1 second after the reference time and ends at the end of calendar year 2009.

a contact +60 +7260 1 2 10000
: Schedules a period of transmission at 10,000 bytes/second from node 1 to node 2, starting 60 seconds after the reference time and ending exactly two hours (7200 seconds) after it starts.

SEE ALSO

ionadmin (1), **rfxclock** (1), **ion** (3)

NAME

ionsecrc – ION security database management commands file

DESCRIPTION

ION security database management commands are passed to **ionsecadmin** either in a file of text lines or interactively at **ionsecadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the ION security database management commands are described below.

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by ionsecadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

1 The **initialize** command. Until this command is executed, the local ION node has no security database and most *ionsecadmin* commands will fail.

a key *key_name file_name*
The **add key** command. This command adds a named key value to the security database. The content of *file_name* is taken as the value of the key. Named keys can be referenced by other elements of the security database.

c key *key_name file_name*
The **change key** command. This command changes the value of the named key, obtaining the new key value from the content of *file_name*.

d key *key_name*
The **delete key** command. This command deletes the key identified by *name*.

i key *key_name*
This command will print information about the named key, i.e., the length of its current value.

l key
This command lists all keys in the security database.

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

EXAMPLES

a key BABKEY ./babkey.txt
Adds a new key named ''BABKEY'' whose value is the content of the file ''./babkey.txt''.

SEE ALSO

ionsecadmin (1)

NAME

ltprc – Licklider Transmission Protocol management commands file

DESCRIPTION

LTP management commands are passed to **ltpadmin** either in a file of text lines or interactively at **ltpadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the LTP management commands are described below.

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by ltpadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

1 *est_max_export_sessions*
The **initialize** command. Until this command is executed, LTP is not in operation on the local ION node and most *ltpadmin* commands will fail.

The command uses *est_max_export_sessions* to configure the hashtable it will use to manage access to export transmission sessions that are currently in progress. For optimum performance, *est_max_export_sessions* should normally equal or exceed the summation of *max_export_sessions* over all spans as discussed below.

Appropriate values for the parameters configuring each "span" of potential LTP data exchange between the local LTP and neighboring engines are non-trivial to determine. See the ION LTP configuration spreadsheet and accompanying documentation for details.

a span *peer_engine_nbr max_export_sessions max_import_sessions max_segment_size aggregation_size_threshold aggregation_time_limit* '*LSO_command*' [*queuing_latency*]
The **add span** command. This command declares that a *span* of potential LTP data interchange exists between the local LTP engine and the indicated (neighboring) LTP engine.

The *max_segment_size* and *aggregation_size_threshold* are expressed as numbers of bytes of data. *max_segment_size* limits the size of each of the segments into which each outbound data *block* will be divided; typically this limit will be the maximum number of bytes that can be encapsulated within a single transmission frame of the underlying *link service*.

aggregation_size_threshold limits the number of LTP service data units (e.g., bundles) that can be aggregated into a single block: when the sum of the sizes of all service data units aggregated into a block exceeds this threshold, aggregation into this block must cease and the block must be segmented and transmitted.

aggregation_time_limit alternatively limits the number of seconds that any single export session block for this span will await aggregation before it is segmented and transmitted regardless of size. The aggregation time limit prevents undue delay before the transmission of data during periods of low activity.

max_export_sessions constitutes, in effect, the local LTP engine's retransmission "window" for this span. The retransmission windows of the spans impose flow control on LTP transmission, reducing the chance of allocation of all available space in the ION node's data store to LTP transmission sessions.

max_import_sessions is simply the neighoring engine's own value for the corresponding export session parameter; it is the neighboring engine's retransmission window size for this span. It reduces the chance of allocation of all available space in the ION node's data store to LTP reception sessions.

LSO_command is script text that will be executed when LTP is started on this node, to initiate

operation of a link service output task for this span. Note that " *peer_engine_nbr*" will automatically be appended to *LSO_command* by **ltpadmin** before the command is executed, so only the link-service-specific portion of the command should be provided in the *LSO_command* string itself.

queuing_latency is the estimated number of seconds that we expect to lapse between reception of a segment at this node and transmission of an acknowledging segment, due to processing delay in the node. (See the 'm ownqtime' command below.) The default value is 1.

If *queuing latency* a negative number, the absolute value of this number is used as the actual queuing latency and session purging is enabled; otherwise session purging is disabled. If session purging is enabled for a span then at the end of any period of transmission over this span all of the span's export sessions that are currently in progress are automatically canceled. Notionally this forces re-forwarding of the DTN bundles in each session's block, to avoid having to wait for the restart of transmission on this span before those bundles can be successfully transmitted.

a seat '*LSI_command*'

The **add seat** command. This command declares that the local LTP engine can receive LTP segments via the link service input daemon that begins running when *'LSI_command'* is executed.

c span *peer_engine_nbr max_export_sessions max_import_sessions max_segment_size aggregation_size_threshold aggregation_time_limit* '*LSO_command*' [*queuing_latency*]

The **change span** command. This command sets the indicated span's configuration parameters to the values provided as arguments.

d span *peer_engine_nbr*

The **delete span** command. This command deletes the span identified by *peer_engine_nbr*. The command will fail if any outbound segments for this span are pending transmission or any inbound blocks from the peer engine are incomplete.

d seat '*LSI_command*'

The **delete seat** command. This command deletes the seat identified by '*LSI_command*'.

i span *peer_engine_nbr*

This command will print information (all configuration parameters) about the span identified by *peer_engine_nbr*.

i seat '*LSI_command*'

This command will print all information (i.e., process ID number) about the seat identified by '*LSI_command*'.

l span

This command lists all declared LTP data interchange spans.

l seat

This command lists all declared LTP data acquisition seats.

s ['*LSI_command*']

The **start** command. This command starts link service input tasks for all LTP seats and output tasks for all LTP spans (to remote engines) from the local LTP engine. '*LSI_command*' is deprecated but is supported for backward compatibility; if provided, the effect is the same as entering the command "a seat '*LSI_command*'" prior to starting all daemon tasks.

m heapmax *max_database_heap_per_block*

The **manage heap for block acquisition** command. This command declares the maximum number of bytes of SDR heap space that will be occupied by the acquisition of any single LTP block. All data acquired in excess of this limit will be written to a temporary file pending extraction and dispatching of the acquired block. Default is the minimum allowed value (560 bytes), which is the approximate size of a ZCO file reference object; this is the minimum SDR heap space occupancy in the event that all acquisition is into a file.

m screening { y | n }
The **manage screening** command.

The **manage screening** command. This command disables or enables the screening of received LTP segments per the periods of scheduled reception in the node's contact graph.

By default, screening is enabled – that is, LTP segments from a given remote LTP engine (ION node) will be silently discarded when they arrive during an interval when the contact graph says the data rate from that engine to the local LTP engine is zero. The reason for this is that without a known nominal reception rate we cannot enforce reception rate control, which is needed in order to prevent resource exhaustion at the receiving node.

Note, though, that the enabling of screening implies that the ranges declared in the contact graph must be accurate and clocks must be synchronized; otherwise, segments will be arriving at times other than the scheduled contact intervals and will be discarded.

For some research purposes this constraint may be difficult to satisfy. For such purposes ONLY, where resource exhaustion at the receiving node is not at issue, screening may be disabled.

m ownqtime *own_queuing_latency*
The **manage own queuing time** command. This command sets the number of seconds of predicted additional latency attributable to processing delay within the local engine itself that should be included whenever LTP computes the nominal round-trip time for an exchange of data with any remote engine. The default value is 1.

m maxber *max_expected_bit_error_rate*
The **manage max bit error rate** command. This command sets the expected maximum bit error rate that LTP should provide for in computing the maximum number of transmission efforts to initiate in the transmission of a given block. (Note that this computation is also sensitive to data segment size and to the size of the block that is to be transmitted.) The default value is .0001 (10^−4).

m maxbacklog *max_delivery_backlog*
The **manage max delivery backlog** command. This command sets the limit on the number of blocks (service data units) that may be queued up for delivery to clients. While the queue is at this limit, red segments are discarded as it is not possible to deliver the blocks to which they pertain. The intent here is to prevent resource exhaustion by limiting the rate at which new blocks can be acquired and inserted into ZCO space. The default value is 10.

x The **stop** command. This command stops all link service input and output tasks for the local LTP engine.

w { 0 | 1 | <activity_spec> }
The **LTP watch** command. This command enables and disables production of a continuous stream of user-selected LTP activity indication characters. A watch parameter of ''1'' selects all LTP activity indication characters; ''0'' de-selects all LTP activity indication characters; any other *activity_spec* such as ''df{]'' selects all activity indication characters in the string, de-selecting all others. LTP will print each selected activity indication character to **stdout** every time a processing event of the associated type occurs:

- **d** bundle appended to block for next session
- **e** segment of block is queued for transmission
- **f** block has been fully segmented for transmission
- **g** segment popped from transmission queue
- **h** positive ACK received for block, session ended
- **s** segment received
- **t** block has been fully received

@ negative ACK received for block, segments retransmitted

= unacknowledged checkpoint was retransmitted

+ unacknowledged report segment was retransmitted

{ export session canceled locally (by sender)

} import session canceled by remote sender

[import session canceled locally (by receiver)

] export session canceled by remote receiver

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

EXAMPLES

a span 19 20 5 1024 32768 2 'udplso node19.ohio.edu:5001'

Declares a data interchange span between the local LTP engine and the remote engine (ION node) numbered 19. There can be at most 20 concurrent sessions of export activity to this node. Conversely, node 19 can have at most 5 concurrent sessions of export activity to the local node. Maximum segment size for this span is set to 1024 bytes, aggregation size threshold is 32768 bytes, aggregation time limit is 2 seconds, and the link service output task that is initiated when LTP is started on the local ION node will execute the *udplso* program as indicated.

m screening n

Disables strict enforcement of the contact schedule.

SEE ALSO

ltpadmin (1), **udplsi** (1), **udplso** (1)

NAME

dtkarc – DTKA user configuration commands file

DESCRIPTION

DTKA user configuration commands are passed to **dtkaadmin** either in a file of text lines or interactively at **dtkaadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the DTKA user function administration commands are described below.

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by dtkaadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

1 The **initialize** command. Until this command is executed, the DTKA user function is not in operation on the local ION node and most *dtkaadmin* commands will fail.

i The **info** This command will print information about the current state of the local node's DTKA user function, including the current settings of all parameters that can be managed as described below.

m keygentime *time*
The **manage key generation time** command. This command sets the time at which the node will next generate a public/private key pair and multicast the public key. The command is not needed in normal operations, because future key generation times are computed automatically as key pairs are generated. *time* must be in yyyy/mm/dd–hh:mm:ss format.

m interval *key_pair_generation_interval*
The **manage key pair generation interval** command. This interval, expressed as a number of seconds, controls the period on which the DTKA user function will generate new public/private key pairs. The default value is 604800 (one week).

m leadtime *key_pair_effectivenes_lead_time*
The **manage key pair effectivenes lead time** command. This interval, expressed as a number of seconds, controls the length of time after the time of key pair generation at which the key pair will become effective. The default value is 345600 (four days).

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

EXAMPLES

m interval 3600
Asserts that the DTKA function will generate a new key pair every 3600 seconds (one hour).

SEE ALSO

dtkaadmin (1)

NAME

tcarc – Trusted Collective authority configuration commands file

DESCRIPTION

TC authority configuration commands are passed to **tcaadmin** either in a file of text lines or interactively at **tcaadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the TC authority configuration commands are described below.

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by tcaadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with **e 1** command to log the version number at startup.

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

1 *multicast_group_number_for_TC_bulletins multicast_group_number_for_TC_records number_of_authorities_in_collective K R*
The **initialize** command. Until this command is executed, the authority function for the selected TC application is not in operation on the local ION node and most *tcaadmin* commands will fail.

K is the mandated **diffusion** for the selected TC application, i.e., the number of blocks into which each bulletin of published TC information is divided for transmission.

R is the mandated **redundancy** for the selected TC application, i.e., the percentage of blocks issued per bulletin that will be parity blocks rather than extents of the bulletin itself.

i The **info** This command will print information about the current state of the authority function for the selected TC application on the local node, including the current settings of all parameters that can be managed as described below.

s The **start** command. This command starts the **tcarecv** and **tcacompile** daemons of the authority function for the selected TC application on the local node.

m compiletime *time*
The **manage compile time** command. This command sets the time at which the authority function for the selected TC application on this node will next compile a bulletin. The command is not needed in normal operations, because future compile times are computed automatically as bulletins are compiled. *time* must be in yyyy/mm/dd–hh:mm:ss format.

m interval *bulletin_compilation_interval*
The **manage bulletin compilation interval** command. This interval, expressed as a number of seconds, controls the period on which the authority function for the selected TC appliction on this node will compile new key information bulletins. The default value is 3600 (one hour).

m grace *bulletin_consensus_grace_time*
The **manage bulletin consensus grace time** command. This interval, expressed as a number of seconds, controls the length of time the authority function for the selected TC application on this node will wait after publishing a bulletin before computing a consensus bulletin; this parameter is intended to relax the degree to which the system clocks of all members of the collective authority for this TC application must be in agreement. The default value is 60 (1 minute).

+ *authority_array_index node_number*
This command asserts that the trusted Nth member of the collective authority for the selected TC application, where N is the *authority_array_index* value, is the node identified by *node_number*.

– *authority_array_index*
This command asserts that the Nth member of the collective authority for the selected TC application, where N is the *authority_array_index* value, is no longer trusted; bulletins received from this collective authority member must be discarded.

a *node_number*
This command adds the node identified by *node_number* to the list of nodes hosting **authorized_clients** for the selected TC application. Once this list has been populated, TC records for this application that are received from clients residing on nodes that are not in the list are automatically discarded by the authority function residing on the local node.

d *node_number*
This command deletes the node identified by *node_number* from the list of nodes hosting **authorized_clients** for the selected TC application.

l This command lists all nodes currently hosting **authorized_clients** for the selected TC application.

x The **stop** command. This command stops the **tcarecv** and **tcacompile** daemons of the authority function for the selected TC application on the local node.

EXAMPLES

+ 3 6913
Asserts that node 6913 is now member 3 of the collective authority for the selected application.

SEE ALSO

tcaadmin (1), **dtka** (3)

NAME

tccrc – Trusted Collective client configuration commands file

DESCRIPTION

TC client configuration commands are passed to **tccadmin** either in a file of text lines or interactively at **tccadmin**'s command prompt (:). Commands are interpreted line-by line, with exactly one command per line. The formats and effects of the TC client configuration commands are described below.

COMMANDS

? The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

Comment line. Lines beginning with **#** are not interpreted.

e { 1 | 0 }
Echo control. Setting echo to 1 causes all output printed by tccadmin to be logged as well as sent to stdout. Setting echo to 0 disables this behavior.

v Version number. Prints out the version of ION currently installed. HINT: combine with**e 1** command to log the version number at startup.

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **h** command.

1 *number_of_authorities_in_collective* [*K* [*R*]]
The **initialize** command. Until this command is executed, the client daemon for the selected TC application is not in operation on the local ION node and most *tccadmin* commands will fail.

K is the mandated **diffusion** for the selected TC application, i.e., the number of blocks into which each bulletin of published TC information is divided for transmission.

R is the mandated **redundancy** for the selected TC application, i.e., the percentage of blocks issued per bulletin that will be parity blocks rather than extents of the bulletin itself.

i The **info** This command will print information about the current state of the client daemon for the selected TC application on the local node, i.e., the identities of the TC authority nodes that the client daemon recognizes.

s The **start** command. This command starts the client daemon (**tcc**) for the selected TC application.

m authority *authority_array_index node_number*
This command asserts that the Nth member of the collective authority for the selected TC application, where N is the *authority_array_index* value, is the node identified by *node_number*.

x The **stop** command. This command stops the client daemon (**tcc**) for the selected TC application.

h The **help** command. This will display a listing of the commands and their formats. It is the same as the **?** command.

EXAMPLES

m authority 3 6913
Asserts that node 6913 is member 3 of the collective authority for the selected application.

SEE ALSO

tccadmin (1)