

TO: T10 Membership
FROM: Paul A. Suhler, Quantum Corporation
DATE: 18 February 2009
SUBJECT: T10/08-409r9, ADT-2: Internet ADT (iADT)

Revisions

T10/07-469:

- 0 [Initial revision](#) (2 November 2007)
- 1 [First revision](#) (9 March 2008)
Changed name to Network ADT (iADT).
Added registered port number.
Allowed iADT ports to use any port number.
Removed iADT-specific baud rate and Timeout_{ACK}.
- 2 [Second revision](#) (11 April 2008)
Deleted the ABORT service request and the ABORTED service indication.
Added analysis of existing state machines, link services, and frame header fields.
Added analysis of physical layer connections.
- 3 [Third revision](#) (30 April 2008)
Added discussion of including legacy ADT signals in new Custom Connector section.
Added proposed connector signal name and pinout.
- 4 [Fourth revision](#) (29 May 2008)
Separated the concept of an “ADT port” from an “ADT interconnect port.”
Added link layer protocol services generic to all physical layers, as well as mappings to RS-422, TCP, and UDP.
Added requirement for ADT ports using Ethernet to ignore negotiated baud rate in computing acknowledgement timeout.
- 5 [Fifth revision](#) (13 June 2008)
Incorporated changes from 4 June 2008 teleconference, minutes in [T10/08-256r0](#).
Enhanced model section.
Removed LED connections from ADT Ethernet bus description.
Added descriptions of LED blinking.
Specified a fixed Timeout_{ACK} in seconds for ADT TCP connections.
Deleted ADT UDP interconnect.
- 6 [Sixth revision](#) (9 July 2008)
Incorporated changes from 18 June 2008 teleconference, minutes in [T10/08-269r0](#).
Added definitions.
Modified layer figure.
Modified connection tables.
Added ladder diagrams for transport services.
Added background discussion of connection closing and I_T nexus loss.
Capitalize initial letters, per editor’s guidance.
- 7 [Seventh revision](#) (25 July 2008)
Incorporated changes from 14 July 2008 meeting, minutes in [T10/08-291r0](#).
Moved connection definitions into separate subclause from electrical characteristics.
Reorganized conventions subclauses to match SAM-4 and added a conventions subclause for ladder diagrams.
Revised ladder diagrams. (For connection establishment, used a single diagram with optional inter-device communication, rather than different diagrams for ADT serial and iADT ports as the working group had recommended.)

Changed terminology from ADT TCP interconnect port to iADT interconnect port.
 Changed RS-422 references to match the actual number of the document (ANSI/EIA/TIA-422-B-1994).

Defined that deassertion of the Sense_a or Sense_d connection may invoke the **Closed** service indication and added a reason argument to **Closed**.

See [T10/08-301r0](#) for a change to ADC-3 indicating that I_T nexus loss by bridging manager may be decoupled from command processing by local SMC device server.

8 [Eighth revision](#) (31 August 2008)

Incorporated changes from 13 August 2008 teleconference, minutes in [T10/08-329r0](#).

This revision does not address any of the questions raised by IBM's [T10/08-332r0](#):

- Support for short-lived connections, i.e., not having connection loss cause I_T nexus loss.
- Specifying what to do if a connection cannot be established.
- Relevance of the Sense_a signal.
- Removing all references to Ethernet.
- Specifying signals to facilitate locating the drive in a library.

9 [Ninth revision](#) (6 October 2008)

Incorporated changes from 8 September 2008 meeting, minutes in [T10/08-372r0](#).

Deleted retirement to send a Close event to Port state machine upon connection close.

Removed requirement to have Sense_a/Sense_d asserted to establish a connection.

Incorporated comments from IBM's [T10/08-392r0](#) and from an IBM e-mail about the Sockets API. This includes a new informative subclause 6.4.6.

Renamed Close service request and Closed service indication to Disconnect and Disconnected. Added ADT Port argument to protocol services to identify the ADT port.

Deleted service responses that are generated only in response to invalid requests, e.g., coding errors like NULL arguments. Added subclause 6.2.11 and Table w indicating possible causes of other errors and recovery procedures.

Deleted some of the detailed renumbering instructions; the editor is capable of doing this himself.

T10/08-409:

0 [Tenth revision](#) (22 October 2008)

Incorporated changes from 8 October 2008 teleconference, minutes in [T10/08-408r0](#).

Incorporated and expanded connection state machine from [T10/08-407r1](#).

Included rules on invocation of service request in connection state descriptions.

Included use of sockets API function calls in connection state descriptions.

Adopted the term sADT port for ADT serial port.

1 [Eleventh revision](#) (3 November 2008)

Incorporated changes from an offline discussion with IBM.

Eliminated the concept of distinct ADT and ADT interconnect ports in favor of having an ADT port which may include multiple sessions.

Defined session to be an association between two ADT ports which is begun by a login and terminated by a logout (explicit or implicit). A session persists across multiple connections.

Modified layering diagrams to be consistent with SAM-4 Figure 31, Protocol service reference model.

For consistency with SAM-4, replaced connection layer "protocol services" with "connection services" and changed some indications into confirmations.

Added Sent connection service confirmation.

Split Disconnected service indication into Disconnected service confirmation and Disconnect Received service indication.

2 [Twelfth revision](#) (11 November 2008)

Incorporated changes from the 3 November 2008 teleconference, minutes in [T10/08-445r0](#).

Specified that a disconnect while not Paused shall cause an I_T nexus loss and implemented this by augmenting the Port and Transmitter state machines.

Removed mention of Sockets API calls in Connection state machine transitions.
Added C5:Listening and Connecting state to resolve race condition.
For reference during discussions, added a copy of the TCP state machine from RFC 793 and illustrated its mapping to the Connection state machine; see the General discussion section.
This revision still requires a cleanup of the wording of the Connection state machine to make it consistent with the descriptions of existing state machines.

- 3 [Thirteenth revision](#) (1 December 2008)
Incorporated changes from the 12 November 2008 teleconference, minutes in [T10/08-462r0](#).
Moved Sockets API information to an informative annex.
Specified use of two TCP state machines.
Always listen for TCP connection on port 4169.
Included some IBM comments as notes.
- 4 [Fourteenth revision](#) (18 December 2008)
Incorporated changes from the 3 December 2008 teleconference, minutes in [T10/09-010r0](#).
Modified Fig. 3 (4) to show both sADT and iADT connections.
Use “link layer” consistently rather than “session layer.”
Modified layer figures to show “transport layer” and an instance of the STPL. Reordered descriptive paragraphs.
Added definition of logout duration time and used it in the text.
Added text and Fig. 14a to clause 6 about resolving simultaneous connections, and put example ladder diagrams in a new informative Annex E.
Removed connection-related services from sADT, and added a column to Table 14 indicating whether each service is supported by iADT or both sADT and iADT.
Removed Connection state machine.
Added a statement to the first paragraph of each connection request’s description in 6.2 stating when it shall not be invoked. This replaces the table of allowed service requests for each state in the (now-removed) connection state machine.
Added a table for each service request explaining for each service response the meaning and error recovery procedure.
Finished purging references to Listen service request.
Incorporated IBM service discovery proposal.
Added numerous comments in [green](#) to highlight particular points requiring review.
- 5 [Fifteenth revision](#) (21 January 2008)
Incorporated changes from the 12 January 2009 Meeting, minutes in [T10/08-462r0](#).
Added IBM’s changes to 6.2.6 AER control IU.
Added IBM’s text for implicit logout to 4.3.2.4.4 Transition P2:Logged-In to P3:Logged-Out.
- 6 [Sixteenth revision](#) (21 January 2009)
Same as previous revision, but without change tracking.
- 7 [Seventeenth revision](#) (28 January 2009)
Incorporated changes from the 28 January 2009 teleconference, minutes in [T10/08-064r0](#).
- 8 [Eighteenth revision](#) (17 February 2009)
Incorporated changes suggested after the 28 January 2009 teleconference.
Added iADT-TLS port number, 9614/tcp.
Added Sockets API mappings for **Connected** and for **Disconnect Immediate**.
Added use of iADT-DISC multicast address.
Organized description of discovery descriptors into one table.
Revised iADT-DISC.
Multicast addresses are pending from IANA.
An informative annex on the use of multicast should be added to ADT-2 separately from this proposal.
- 9 [Nineteenth revision](#) (18 February 2009)
Incorporated changes from the 18 February 2009 teleconference, minutes in [T10/09-073r0](#).

Corrected column title in tables w+4 and w+5 from "Service Response" to "Reason."
Proposal is complete, except for multicast addresses in 6.5.3.

General

To allow future data transfer devices to have improved and alternate means to communicate with automation devices, Ethernet is proposed as an ADT port. One possible configuration would be an isolated subnet with the library controller and all drives attached. These ports will typically be 10/100BaseT, so there will be a great increase in bandwidth above the fastest existing RS422-based ADI ports.

Implementing an ADI Ethernet port could be done in two ways. One would be to use iSCSI to carry SCSI commands, data, and status and then to invent a new protocol for VHF data. A simpler approach would be to transport the entire ADT protocol over a networking protocol. This proposal is to do the latter, and is named Internet ADT (iADT).

A straightforward implementation of iADT would be to open a TCP connection between the automation device and the data transfer device. A TCP connection (also known as a stream) provides bi-directional reliable delivery of a stream of bytes. The existing ADT link layer protocol provides the necessary framing. While TCP error correction would prevent framing errors and parity errors from reaching the ADT layer, it would still be possible for acknowledgement timeouts to occur.

To avoid the need to modify ADT-2 to specify mapping of TCP connections to I_T nexuses, this proposal sidesteps the issue by stating that one ADT port connects to one other ADT port, without reference to the interconnect layer. At the interconnect layer, this proposal defines ADT interconnect ports through which ADT ports connect. There are two types of ADT interconnect ports, serial and Ethernet. One ADT serial port (sADT port) can connect only to one other sADT port, while multiple ADT Ethernet ports can connect to one another. Nevertheless, when ADT ports connect via ADT Ethernet ports, each ADT port can connect to only one other ADT port.

This organization of the standard minimizes changes to the clauses for link, transport, and SCSI application layers.

Technical issues

The following are technical issues which must be considered in developing this proposal:

Timeouts

- After discussion in the May 2008 working group meeting, it was decided that the acknowledgement timeout should be used. While its use in detecting corrupted frames is not necessary when using TCP, it can still be used in recovering from a skip in frame numbers in at least one observed case. See the discussion below under ADT link layer analysis.

Negotiated Parameters

- Of the parameters in the Login IU, only Major/Minor Revision, Maximum Payload Size, and Maximum Ack Offset seem to be needed in iADT. Baud rate is unnecessary.

Port Numbers

- The original intent of this proposal was to use a fixed port number for the iADT port on both ends (sockets) of the TCP connection. A registered port number (4169) was obtained from the [Internet Assigned Numbers Authority \(IANA\)](#). However, existing Sockets implementations appear to dynamically assign the port number of the port performing a TCP active OPEN, so this requirement is relaxed. Instead, the only socket required to use 4169 is one in the device performing a passive OPEN (Listen). I.e, a DTD will do a passive OPEN on port 4169 and the library will connect to that port. Similarly, the library could do a passive OPEN on 4169 if it is desired for the DTDs to initiate the connection.

- If the network segment inside the library connects to a router that connects outside the library, then the drive can be protected by requiring the router not to pass packets with the iADT port number in either the Source Port or Destination Port field of the TCP header. Requiring the receiving end of a connection request to use the iADT port number will facilitate this protection.

I_T Nexuses and TCP Connections

- With the advent of the session in 08-409r1, the I_T nexus is now defined as a session and the X_ORIGIN bit. In 08-409r2, the session is defined to be a pair { local IP address, remote IP address }. These IP addresses shall remain constant for the lifetime of the session.
- This standard requires that a TCP server for iADT listen on port number 4169. Use of the iADT protocol to connect to other port numbers is beyond the scope of this standard.
- There was a question whether the TCP ABORT could map to a device reset. David Black has since advised against this, saying "...an attempt to use this sort of TCP feature as a carrier of SCSI level function/semantics is not a good idea in general." Moreover, it is not clear (1) what events in a host already cause a TCP ABORT, and (2) whether the OS function to reset a storage device could be made to send an ABORT. Finally, [RFC 793](#) specifies that an ABORT causes release of the TCB (control block), as does a CLOSE. This implies that an ABORT should also cause an I_T nexus loss.

Physical Layer

- The actual physical layer mandates Ethernet autonegotiation without mentioning specific speeds.

Custom Connector

The working group decided not to pursue a standard connector to include Ethernet. Instead, an ADT Ethernet "bus" is specified to list those connections which would be mandatory and optional.

- 1000BaseT requires four pairs of wires; usually all are wired in RJ-45 connectors and in Ethernet cables. However, 10 and 100BaseT only require two pair, so we discard the other two. There is no forecast need for an ADT Ethernet port to support Gigabit Ethernet.
- The ADT Ethernet bus will include the ADT Sense_a line. Standalone DTDs may use Ethernet. Examples of how to discover presence in a library include a jumper or an extra pin on the Ethernet connector. If the DTD is not installed in a library, then it will enable its primary port(s) regardless of the saved setting of the port enable (PE) bit.
- Support for the Reset_a connection is optional. In Ethernet, this will cause either a disconnection or a hard reset.
- Support for the Sense_d connection is optional.
- There is support for one or two LED connections to indicate Ethernet signal sense and activity. The connection will directly drive an LED which is pulled up via a resistor. The current and voltage characteristics of the connections are specified, but not those of the LED or resistor. This is intended to give designers maximum flexibility.
- The working group decided not to specify serial diagnostic connections in the ADT Ethernet bus.

Discovery

- The working group discussed how to discover the IP address of the library's and DTD's iADT ports. One possible means of discovery would be to use the Discovery and Description steps of the [Universal Plug and Play \(UPnP\)](#) protocol. This uses broadcast of UDP datagrams and does not require a server to track service locations. This would require the DTD to support

an HTTP server. Proposal [T10/08-198r0](#) describes how UPnP could be used. The final decision was to use a custom discovery method (see 6.5).

ADT link layer analysis

This section examines ADT's link-level specification for areas that are irrelevant to iADT, including frame header fields, information units, and state machines. While the current revision of the proposal makes no changes to the link layer, this information is retained for reference.

Much of the error recovery in ADT is to detect and correct physical-layer corruption of frames; these can be corrected by retransmitting the corrupted frame and are termed recoverable errors. Other errors, such as specifying an invalid protocol, setting a reserved bit, and sending a too-long packet can be due to firmware errors at a higher level. Simple retransmission cannot fix these errors and they are termed unrecoverable. TCP's reliable delivery will eliminate the recoverable errors, but cannot fix the unrecoverable errors.

State machines

The Transmitter Error and Receiver Error state machines are only used to recover from out of order or lost frames. TCP makes them unnecessary, and along with them the Initiate Recovery IUs.

Frame header fields

All of the frame header fields in ADT appear to be necessary in iADT. The following table summarizes the reasons.

Table 1 – Applicability of ADT frame header fields

Field	Comments
PROTOCOL	Needed to differentiate SCS Encapsulation, Fast Access, etc.
FRAME TYPE	Needed for various protocols
X_ORIGIN	Needed to distinguish exchanges originated by library from those originated by the DTD. This is effectively a part of the EXCHANGE ID field.
EXCHANGE ID	Needed to differentiate overlapped commands, etc.
FRAME NUMBER	Needed to associate ACKs and NAKs with frames.
PAYLOAD SIZE	Needed to help trap errors in frame assembly.

Timeouts

The original intent of the acknowledgement IU timeout in ADT was to recover from lost or corrupted (and thus discarded) frames. TCP should protect against both of these, so the only possible causes for this timeout would be slow processing in the receiver of the frame to be acknowledged or slow network transmission. However, a case was presented in which the acknowledgement timeout was used to recover from a malformed ACK IU. As a result, this revision of the proposal retains the acknowledgement timeout.

Link service IUs

Following is a summary of which ADT Link Service IUs are needed and which are not needed.

Table 2 – Applicability of ADT link service IUs

IU type	Comments
Login IU	Yes – Need a mechanism to agree on Major Revision, Minor Revision, Maximum Payload Size, and Maximum Ack Offset. Baud Rate is not used, but a fixed value can be specified, probably 9,600.
Logout IU	Yes – Need to provide logout duration and reason code.
Pause IU	Yes – This should probably be required before closing a connection.
NOP IU	No – Does anyone feel that this is needed?

Initiate Recovery IU	Yes
Initiate Recovery ACK IU	Yes
Initiate Recovery NAK IU	Yes
Device Reset IU	Yes
Timeout IU	Yes
ACK IU	Yes – While the flow control function of the ACK IU may not be needed, it still serves the purpose of indicating that a frame did not have non-recoverable errors. See the discussion below of the NAK IU.
NAK IU	Yes – See the following discussion of status codes.

The NAK IU is necessary to report certain errors that are due to an incorrectly-assembled frame; they are not related to corrupted or out-of-order frames. All of these errors are non-recoverable, i.e., they cannot be fixed by retransmission. For example, the upper layer assembling the frame may exceed the maximum payload length or may have a mismatch between the payload length field and the actual payload length.

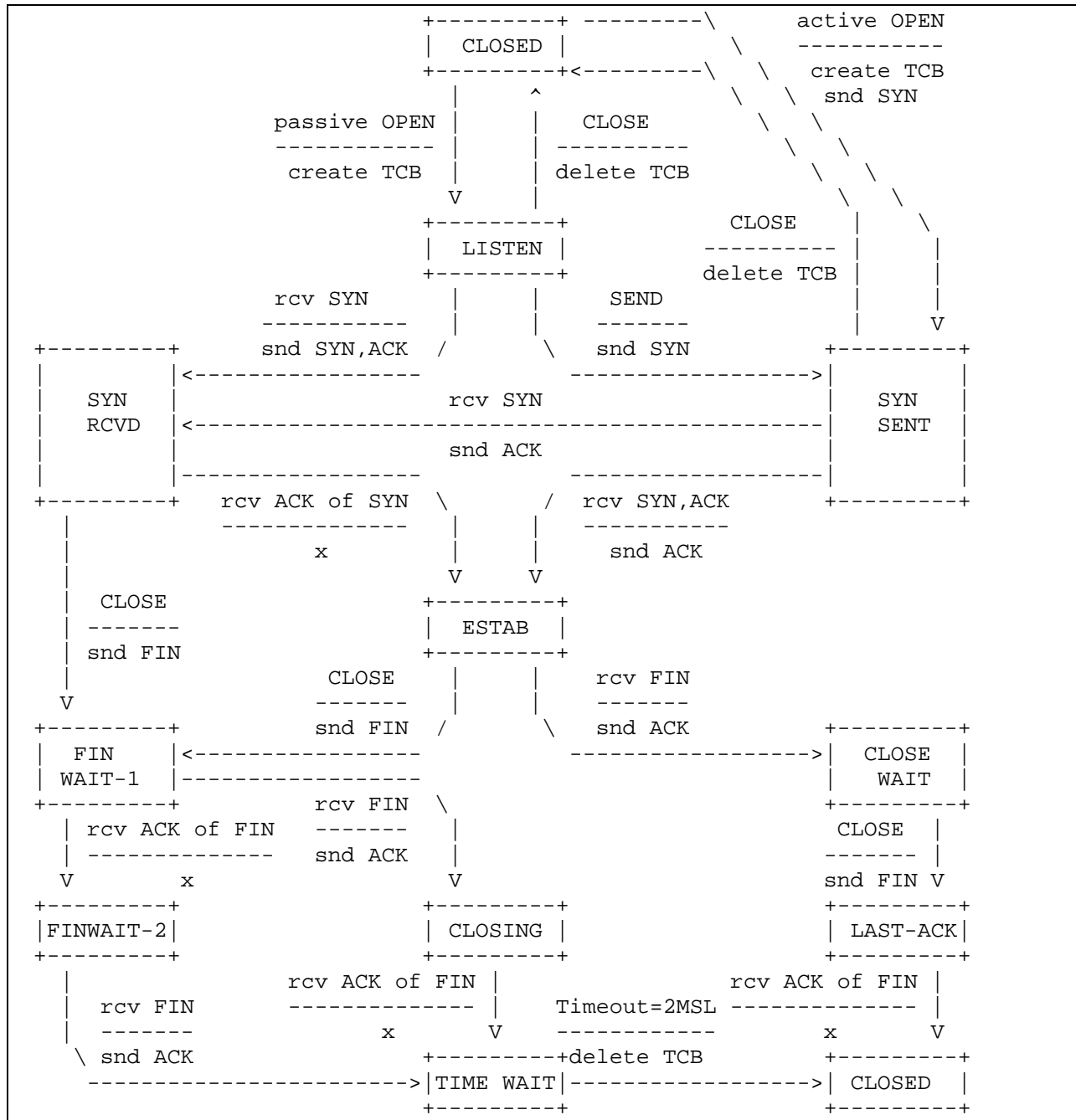
Table 3 – Applicability of NAK IU status codes

Status code	Comments
OVER-LENGTH	Yes – This error can occur and cannot necessarily be corrected by retransmission.
UNDER-LENGTH	Yes – This error can occur and cannot necessarily be corrected by retransmission.
UNEXPECTED FRAME NUMBER	Yes – The ACK may be malformed.
AWAITING INITIATE RECOVERY IU	Yes – This error can occur.
HEADER RESERVED BIT SET	Yes – This error can occur.
INVALID EXCHANGE ID	Yes – This error can occur.
UNSUPPORTED PROTOCOL	Yes – This error can occur.
OUT OF RESOURCES	Yes – This error can occur.
LOGIN IN PROGRESS	Yes – This error can occur.
INVALID OR ILLEGAL IU RECEIVED	Yes – This error can occur.
REJECTED, PORT IS LOGGED OUT	Yes – This error can occur.
MAXIMUM ACK OFFSET EXCEEDED	Yes – This error can occur.
MAXIMUM PAYLOAD SIZE EXCEEDED	Yes – This error can occur.
UNSUPPORTED FRAME TYPE FOR SELECTED PROTOCOL	Yes – This error can occur.
NEGOTIATION ERROR	Yes – This error can occur.
Vendor specific	Yes.

The result of the analysis and design was that iADT would support the entire ADT link layer, with modifications only as needed to support transient connections.

TCP Connection State Diagram

For reference, the TCP connection state diagram is reproduced from RFC 793, figure 6:



TCP Connection State Diagram

Editorial Notes

Paul Stone surveyed various T10 standards to determine how words in figures should be capitalized. The T10 style guide does not address this. Paul observed that the majority of standards capitalize initial letters, and requested that this proposal do likewise. Revision 6 incorporates this guidance; see also Revisions.

Revision 7 incorporates a conventions section for ladder diagrams. It also reorganizes the conventions section to more closely match that in SAM-4. However, it has retained the “state machine” terminology, while SAM-4 uses “state diagram.” See also Revisions.

Items Not Specified

The following technical issues have not been addressed in this proposal:

- While the maximum payload size decided on in ADT negotiation will continue to be driven by device resources, can it be kept independent of the TCP Maximum Segment Size (MSS), which is typically 1500 bytes in IPv4? An ADT frame split across multiple TCP segments might be handled inefficiently. (The MSS is the largest amount of data that can be sent in an unsegmented piece. The Maximum Transmission Unit (MTU) is the largest packet (header, data, and trailer) that can be sent. Because data is a component of a packet, MTU > MSS.)
- If a DTD is installed with both Ethernet and RS-422 ADI ports connected to the automation device, there could be confusion, although this would not be a new issue as currently nothing prohibits having two ADI ports. There is a practical issue, i.e., implementations may have taken shortcuts that would make the behavior of the ADC device server non-SAM-compliant with respect to multiple I_T nexuses. This is not a standards issue, and this proposal will not address the question of multiple ADI ports.
- Sockets APIs typically include an “out-of-band” channel that can be processed separately from regular data. This can be used to allow some data to bypass data sent earlier. This feature is not specified in this proposal, as it has no clear advantages and could potentially cause problems.

Changes to ADT-2 rev. 5

Markup conventions

Proposed additions are in **blue**, removed text is in **crossed-out red**.

Editor’s notes in **green** provide information on decisions to be made and actions to be performed before this proposal can be integrated into the standard.

Change to Introduction

Introduction

The Automation/Drive Interface - Transport Protocol - 2 (ADT-2) standard is divided into eight clauses:

Clause 1 is the scope.

Clause 2 enumerates the normative references that apply to this standard.

Clause 3 describes the definitions, symbols, and abbreviations used in this standard.

Clause 4 describes the conceptual relationship between this document and the SAM-3. It also describes concepts that cross boundaries between protocols supported by this transport.

Clause 5 describes the physical layer including connectors and signal levels.

Clause 6 describes the connection layer including connection services.

~~Clause 6~~7 describes the link layer including encoding, frame format, and link services functions.

~~Clause 7~~8 describes the transport layer and includes the method of encapsulating SCSI.

~~Clause 8~~9 describes the mapping between SCSI protocol services defined in SAM-3 and the services provided by this protocol.

The annexes provide information to assist with implementation of this standard.

Change to clause 2

Add the following subclauses:

2.1.4 IETF references

RFC 768, User Datagram Protocol

RFC 791, *Internet Protocol – DARPA Internet Program – Protocol Specification*

RFC 793, *Transmission Control Protocol (TCP) – DARPA Internet Program – Protocol Specification*

RFC 2365, *Administratively Scoped IP Multicast*

RFC 2460, *Internet Protocol, Version 6 (IPv6) Specification*

RFC 3493, *Basic Socket Interface Extensions for IPv6*

RFC 5246, *The Transport Layer Security (TLS) Protocol, version 1.2*

2.1.5 IEEE references

IEEE 802.3-2005, *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

2.2 Informative references

<...>

~~ANSI/TIA 422-B-1994 (R2000)~~ ANSI/EIA/TIA-422-B-1994 (revised January 27, 2000) Electrical Characteristics of Balanced Voltage Digital Interface Circuits. (RS-422)

Changes to clause 3

Add the following definitions:

3.1.x Connection: a link between two ADT ports by which the ports are able to exchange encoded characters (see 6.1).

3.1.x IP: Internet protocol (see RFC 791 and RFC 2460).

3.1.x LLC: Ethernet link layer control.

3.1.x Logout duration time: the length in seconds that a port shall remain in P3:Logged-out state (see 7.5.5).

3.1.x MAC: Ethernet media access control.

3.1.x MDI: Ethernet medium dependent interface.

3.1.x PHY: Ethernet physical layer.

3.1.x PLS: Ethernet physical signaling sublayer.

3.1.x Session: an association between two ADT. (see 7.6).

Reorganize clauses 3.4 through 3.6 as shown below and add a subclause for ladder diagram notation:

3.4 ~~Conventions~~ Editorial conventions

Certain words and terms used in this American National Standard have a specific meaning beyond the normal English meaning. These words and terms are defined either in clause 3 or in the text where they first appear. Names of signals, phases, messages, commands, statuses, sense keys, additional sense codes, and additional sense code qualifiers are in all uppercase (e.g., REQUEST SENSE), names of fields are in small uppercase (e.g., STATE OF SPARE), lower case is used for words having the normal English meaning.

Fields containing only one bit are usually referred to as the name bit instead of the name field.

~~Numbers that are not immediately followed by lower case b or h are decimal values.~~

~~Numbers immediately followed by lower case b (xxb) are binary values.~~

~~Numbers immediately followed by lower-case h (xxh) are hexadecimal values.~~

~~Decimals are indicated with a comma (e.g., two and one half is represented as 2,5).~~

~~Decimal numbers having a value exceeding 999 are represented with a space (e.g., 24 255).~~

An alphanumeric list (e.g., a,b,c or A,B,C) of items indicates the items in the list are unordered.

A numeric list (e.g., 1,2,3) of items indicate the items in the list are ordered (i.e., item 1 shall occur or complete before item 2).

In the event of conflicting information the precedence for requirements defined in this standard is:

- 1) text,
- 2) tables, then
- 3) figures.

3.5 Numeric conventions

Numbers that are not immediately followed by lower-case b or h are decimal values.

Numbers immediately followed by lower-case b (xxb) are binary values.

Numbers immediately followed by lower-case h (xxh) are hexadecimal values.

Decimals are indicated with a comma (e.g., two and one half is represented as 2,5).

Decimal numbers having a value exceeding 999 are represented with a space (e.g., 24 255).

3.6 Notation conventions

~~3.5~~ 3.6.1 Notation for ~~P~~rocedures and ~~F~~unctions

<...>

~~3.6~~ 3.6.2 ~~State machine conventions~~ Notation for state machines

~~3.6.1~~ 3.6.2.1 ~~State machine conventions overview~~ Notation for state machines overview

<...>

~~3.6.2~~ 3.6.2.2 ~~sub-state~~ Sub-state machines

<...>

~~3.6.3~~ 3.6.2.3 Transitions

<...>

~~3.6.4~~ 3.6.2.4 Messages, requests, and event notifications

<...>

3.6.3 Notation for communication sequence diagrams

Sequence diagrams are used to indicate communication among entities within a device and among devices. All communication sequence diagrams use the notation shown in Figure 3. Each entity is indicated by a horizontal bar with a label on top of a vertical bar. Entities within the same device are enclosed by a box with a label at the top of the box. Each communication is indicated by an arrow with an optional label. Solid arrows indicate mandatory communications and dashed arrows indicate optional communications. Time flows from the top of the diagram (i.e., first communication) to the bottom (i.e., last communication).

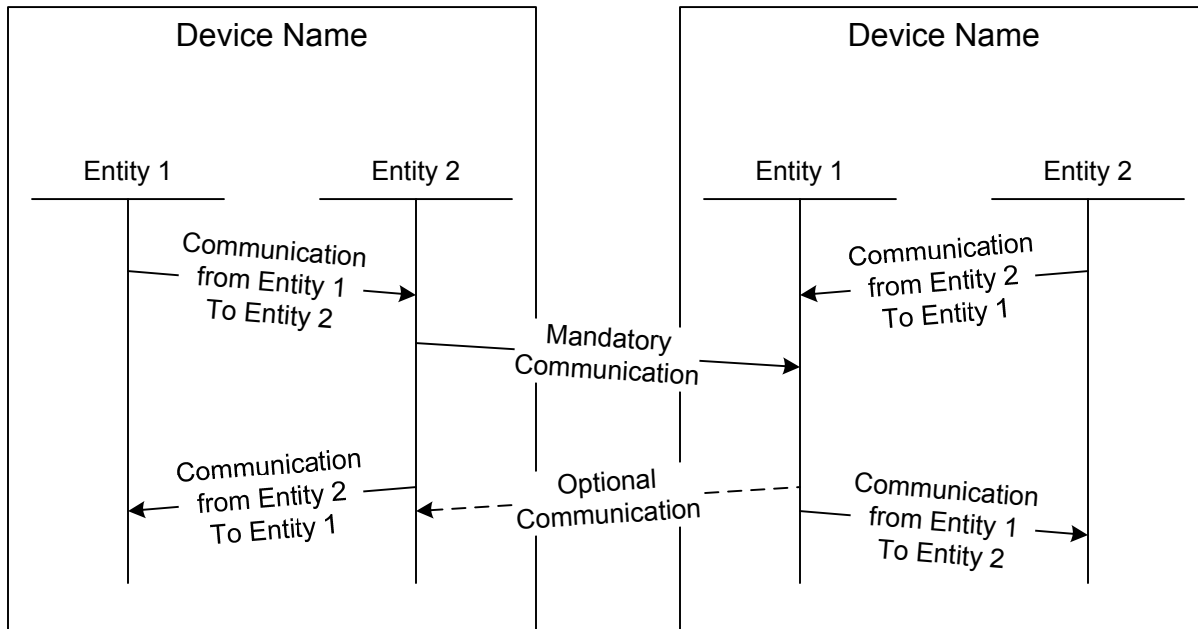


Figure 3 – Example communication sequence diagram

Changes to clause 4

Modify the beginning of clause 4.1:

4.1 Architecture

4.1.1 Architecture introduction

Figure 3 4 shows **an example of an ADT interface** examples of serial ADT (sADT) and internet ADT (iADT) interfaces (see 4.1.2) within a media changer containing two DT devices. Other common components of a media changer are also shown for reference. The components of an automation device are medium transport elements, data transfer (DT) devices, storage elements, and import/export elements (see SMC-3). The automation device may communicate with the DT devices through ADT ports, as defined in this standard. DT devices and automation devices communicate with initiator ports other than those in the automation device using primary ports.

Note: A media changer or DT device would not necessarily contain both sADT and iADT ports. They are both shown for comparison.

Replace and renumber Figure 3:

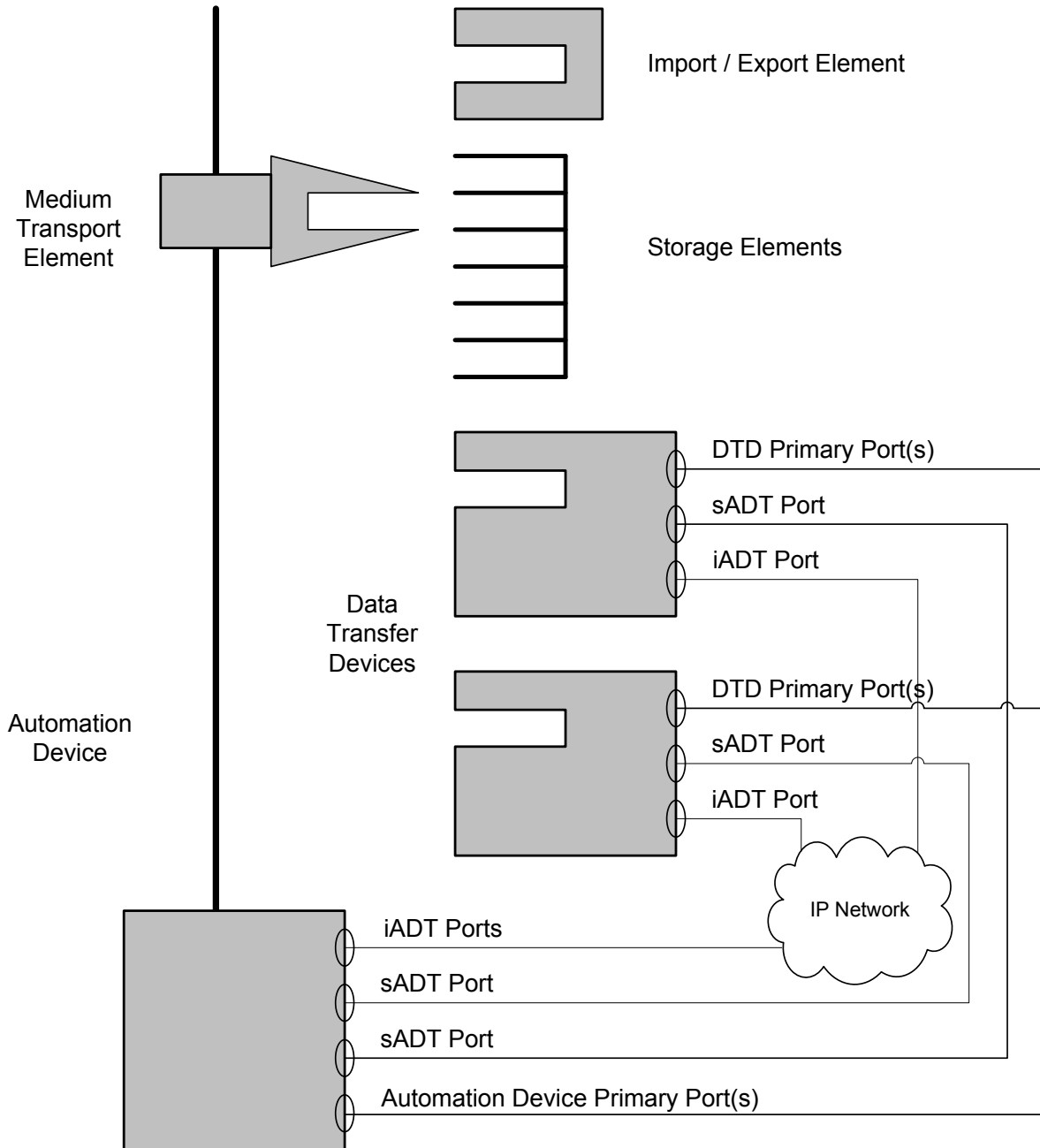


Figure 34 — Example Media Changer application of ADT

If ADI Bridging is enabled (see ADC-2), each ADT port in the DT device and automation device is a SCSI target/initiator port. If ADI Bridging is disabled, the DT device port is a SCSI target port and the automation device port is a SCSI initiator port.

4.1.2 ADT protocol layers

The ADT protocol defines communication between two ADT ports. The ADT protocol includes the SCSI Transport Protocol Layer (STPL) and the Interconnect Layer (see SAM-4). The STPL defined by ADT consists of the ADT Transport Layer. The Interconnect Layer defined by ADT consists of three layers, the Link Layer, the Connection Layer, and the Physical Layer.

Figure 5 shows the communication between ADT ports at the different layers of the protocol, from the physical layer to the SCSI transport protocol layer.

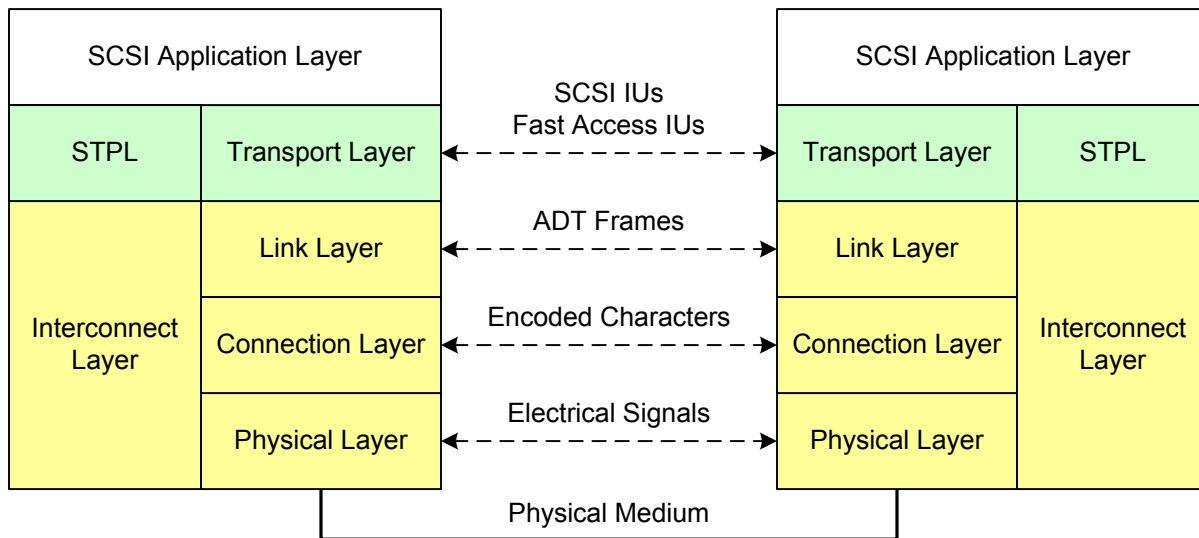


Figure 5 – ADT communication model

At the transport layer, information units (IUs) are passed between ADT ports. At the link layer, ADT frames are passed between ADT ports. At the connection layer, encoded characters are passed between ADT ports. At the physical layer, electrical signals are passed between ADT ports. The physical layers are connected by the physical medium.

The SCSI application layer (see clause 9) defines transport protocol services for processing SCSI commands and task management requests.

The ADT transport layer (see clause 8) provides transmission of two categories of information units (IUs), SCSI encapsulation IUs and fast access IUs, between ADT ports. The information units are represented as ADT frames.

The ADT link layer (see clause 7) provides establishment of sessions (see 3.1.x) between pairs of ADT ports and provides reliable transmission of ADT frames between the two ADT ports.

The ADT connection layer (see clause 6) provides transmission of encoded characters between ADT ports. Two transmission methods are defined: sADT and iADT. The sADT protocol supports transmission over an RS-422 physical layer. The iADT protocol supports transmission over a TCP connection (see RFC 793) and provides service discovery using UDP (see RFC 768). The TCP connection uses the Internet Protocol (IP) (see RFC 791 and RFC 2460) to provide transmission over a physical layer (e.g., Ethernet). The iADT protocol also supports transmission over a TCP connection secured using the Transport Layer Security (TLS) protocol (see RFC 5246).

The ADT physical layer (see clause 5) defines two physical connections for data, RS-422 and a physical layer capable of transporting IP packets (e.g., Ethernet), as well as sense, signal, and Ethernet LED connections.

The interface between the SCSI application layer and the SCSI transport protocol layer is called the protocol service interface. The interface between the SCSI transport protocol layer and the interconnect layer is called the interconnect service interface. The interface between the link layer and the connection layer is called the connection service interface.

Figure 6 shows the serial ADT (sADT) hierarchy of protocols which may be used to implement ADT on an RS-422 physical layer (see ANSI/EIA/TIA-422-B-1994 and 5.2.5.2).

ADT SCSI Encapsulation	ADT Fast Access	Transport Layer
ADT Link Layer		Link layer
sADT		Connection Layer
RS-422		Physical Layer

Figure 6 – sADT protocol hierarchy

Figure 7 is an example of the Internet ADT (iADT) hierarchy of protocols using an Ethernet physical layer (see IEEE 802.3-2005 and 5.2.5.3). iADT may be used to implement ADT on a physical layer supporting the Internet Protocol (IP).

ADT SCSI Encapsulation	ADT Fast Access	Transport Layer
ADT Link Layer		Link layer
iADT		Connection Layer
TCP		
IP		
Ethernet LLC		
Ethernet MAC		Physical Layer
Ethernet PHY		

Figure 7 – iADT protocol hierarchy

The term sADT port refers to an ADT port using the ADT serial transmit-receive connections (see 5.2.5.2) and the sADT connection layer (see 6.3). An sADT port may connect to one other sADT port in another device. Figure 8 shows connections corresponding to Figure 4.

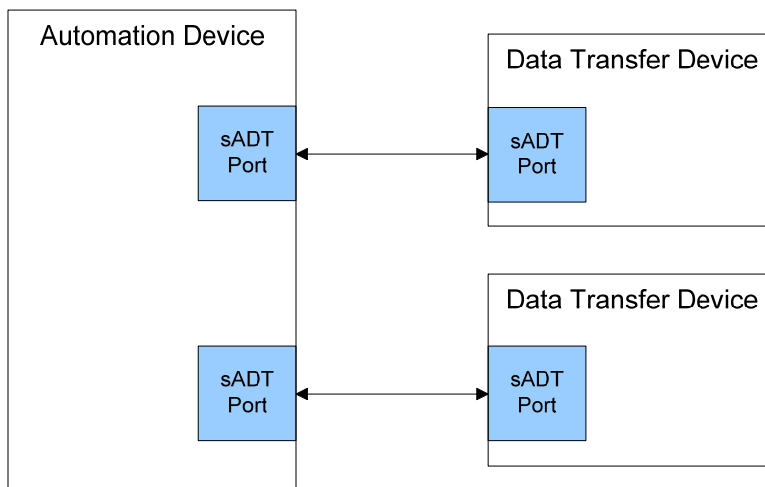


Figure 8 – sADT port example

The term iADT port refers to an ADT port using Internet Protocol (IP) transmit-receive connections, such as over Ethernet (see 5.2.5.3) and the iADT connection layer (see 6.4). An iADT port in one device may

connect to multiple iADT ports in other devices. Figure 9 shows iADT ports connected via an IP network, corresponding to the connections shown in Figure 4.

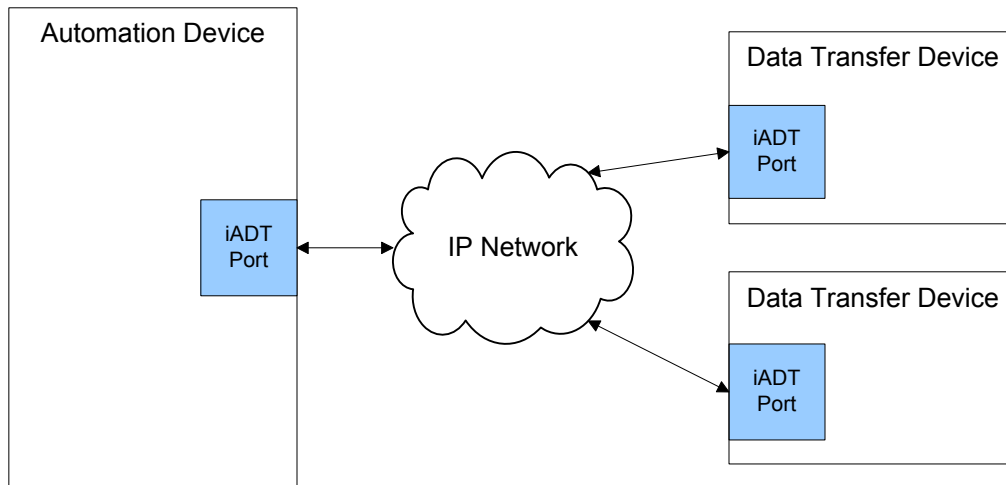


Figure 9 – iADT port example

4.2 Default operating parameters

The default operating parameters for a port are as follows:

- a) the baud rate shall be set to 9 600 *by an sADT port*;
- b) the ACK offset shall be set to 1; and
- c) the Maximum Payload size shall be 256 bytes.

These values shall remain in effect until the login process is complete, at which time the negotiated values shall take effect.

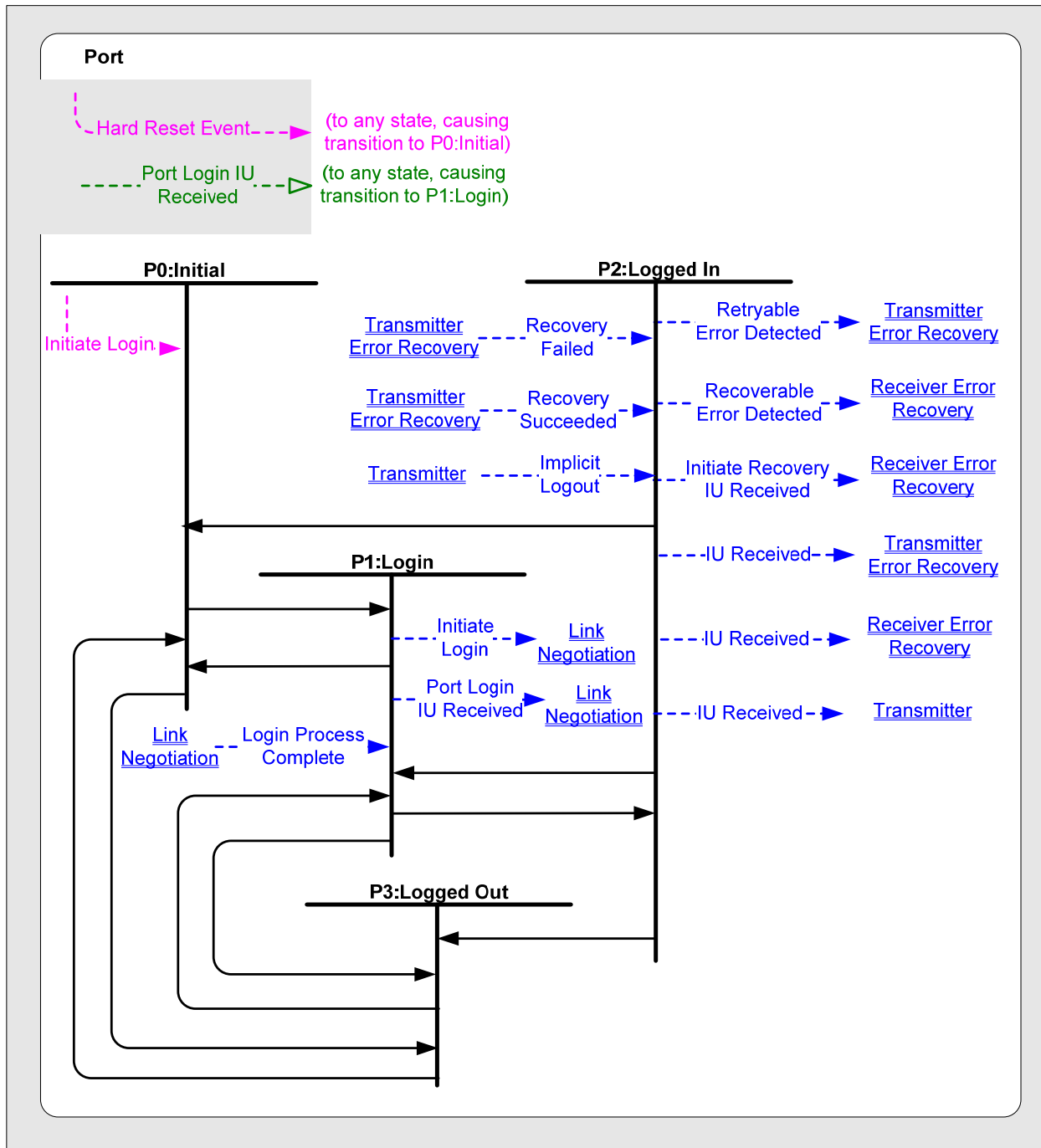
4.3 ADT state machines

<...>

4.3.2 Port state machine

<...>

Add the Implicit Logout message to P2:Logged-In state in the Port state machine figure:



<...>

No changes to 4.3.2.4:

4.3.2.4.4 Transition P2:Logged-In to P3:Logged-Out

A port shall transition to P3:Logged-Out state after it receives a Port Logout IU and sends the corresponding ACK IU.

A port shall transition to P3:Logged-Out state and set the logout duration time to a vendor-specific value which may be zero after it receives an Implicit Logout message.

When a port in a DT device receives an Implicit Logout message it shall:

- a) abort all open exchanges;
- b) disable Asynchronous Event Reporting;
- c) disable initiating port login exchanges; and
- d) set port operating parameters to default.

When a port in an automation device receives an Implicit Logout message it shall:

- a) abort all open exchanges;
- b) disable initiating port login exchanges; and
- c) set port operating parameters to default.

<...>

4.3.2.5.2 Transition P3:Logged-out to P0:Initial

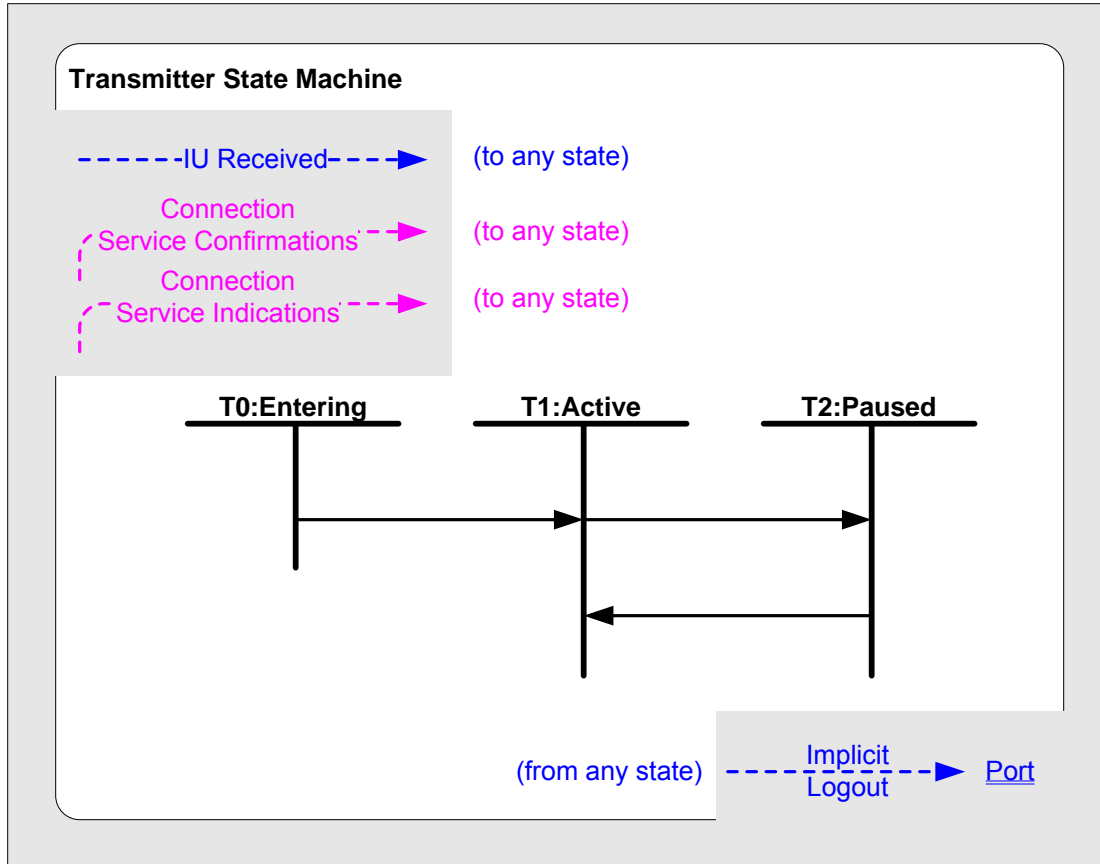
A port shall transition to P0:Initial after the logout duration time ~~specified in the Port Logout IU (see 6.5.5)~~ has expired.

<...>

4.3.4 Transmitter state machine

<...>

Add the Implicit Logout message to the Transmitter state machine figure and delete the unused transition from T1:Active to T0:Entering;



<...>

4.3.4.2 T0:Entering state

4.3.4.2.1 State description

On entry to this state the [sADT](#) port shall start a 100 millisecond timer. On entry to this state the [iADT](#) port may or may not start a 100 millisecond timer.

While in this state, a port shall not transmit [ADT information units](#).

If a **Disconnected** service confirmation or a **Disconnect Received** service indication is invoked by an [iADT](#) port while in this state, the port shall send an [Implicit Logout](#) message to the port state machine.

If a **Disconnect Immediate** service request is invoked by an [iADT](#) port while in this state, the port shall send an [Implicit Logout](#) message to the port state machine.

4.3.4.2.2 Transition T0:Entering to T1:Active

A port shall transition to T1:Active state when it receives a frame that is not corrupted (see 4.6.1.3) or after a period of 100 milliseconds or immediately if the [iADT](#) port is not using the 100 millisecond timer.

<...>

4.3.4.3 T1:Active state

4.3.4.3.1 State description

A port in T1:Active state may transmit and receive all types of information units.

If a **Disconnected** service confirmation or a **Disconnect Received** service indication is invoked by an iADT port while in this state, the port shall send an Implicit Logout message to the port state machine.

If a **Disconnect Immediate** service request is invoked by an iADT port while in this state, the port shall send an Implicit Logout message to the port state machine.

<...>

4.3.4.4 T2:Paused state

4.3.4.4.1 State description

A port in T2:Paused state shall not transmit a frame.

4.3.4.4.2 Transition T2:Paused to T1:Active

A port shall transition to T1:Active state after receiving any frame other than a Port Login IU, Port Logout IU, Pause IU, Device Reset IU, or acknowledgment IU.

If a **Disconnect Immediate** service request is invoked by an iADT port while in this state, the port shall send an Implicit Logout message to the port state machine.

<...>

4.8 I_T nexus loss

An I_T nexus loss event shall occur if an ADT port:

- a) sends a Port Login IU with the AOE bit set to one;
- b) receives a Port Login IU with the AOE bit set to one;
- c) receives an ACK IU in response to a Device Reset IU;
- d) **is an sADT port and** detects the change of state of the Sense line from presence to absence (i.e., Sense_a for DT device port and **Sense_b Sense_d** for automation device port (see figure 11); **or**
- ~~e) detects the assertion of the Reset_a line (see table 13).~~
- e) receives a **Reset Received** service indication (see 6.6.10); or
- f) receives an Implicit Logout message while the Port state machine is in the P2:Logged-In state.

<...>

4.10.1 Acknowledgement time-out period calculation

When changing operating parameters (see 3.1.32), **a an sADT** port shall calculate a new acknowledgement IU time-out period using the formula in figure **9 15**. The port shall apply the new acknowledgement IU time-out period to every frame transmitted after changing operating parameters

Renumber Figure 9 (Acknowledgement time-out period) and rename to “**sADT port** acknowledgement time-out period.” Add the following paragraph immediately following the figure:

An iADT port shall use an initial acknowledgement time-out period of 2,500 milliseconds.

Changes to clause 5

5 Physical layer

5.1 Physical layer introduction

The ADT physical layer defines a number of connection types. Some of these connections are used by all ADT ports, some are used only by sADT ports, and some are used only by iADT ports. A connector is defined which may be used by sADT ports.

~~5.1~~ 5.2 Electrical characteristics

Modify Note 6 as follows:

NOTE 6 The connection specifications in sub clauses ~~5.1.3 through 5.1.5~~ 5.2.3, 5.2.4, and 5.2.5.2 assume cable with a $R < 400$ ohms/km, $Z_0 = 100$ ohms (nominal), and $C = 50$ pF/m (nominal).

Renumber Figure 10 to 16.

Modify clause 5.1.5 as follows:

~~5.1.5~~ 5.2.5 Transmit-receive ~~connection~~ connections

5.2.5.1 Transmit-receive connections introduction

This standard defines two sets of transmit-receive connections. The serial transmit-receive connection applies to implementations using the transmit-receive connections defined in 5.2.5.2. The Ethernet transmit-receive connection applies to implementations using Ethernet connections (see IEEE 802.3-2005).

5.2.5.2 Serial transmit-receive connections

A serial Transmit-Receive (Tx-Rx) connection is a complete simplex signal path from one ~~ADT~~ sADT port to a second ~~ADT~~ sADT port. A Tx-Rx connection includes:

- a) a signal generator connected to the output compliance point of one ~~ADT~~ sADT port;
- b) a pair of transmission media from the output compliance point of one ~~ADT~~ sADT port to the input compliance point of a second ~~ADT~~ sADT port; and
- c) a signal receiver connected to the input compliance point of the second ~~ADT~~ sADT port.

A Tx-Rx connection shall conform to ~~TIA/EIA-422-B~~ ANSI/EIA/TIA-422-B-1994 as measured at the associated compliance points.

A Tx-Rx connection shall support 9 600 baud and may support the Modulation Rates listed in table 6.

A Tx-Rx connection shall use Non-return to Zero (NRZ) encoding of data bits to signaling elements. Hence, the data-signaling rate (in bps) equals the modulation rate (in baud).

A Tx-Rx connection shall transmit data bytes asynchronously adding one start bit, zero parity bits, and one stop bit to each data byte as depicted in figure ~~44~~ 17.

5.2.5.3 Ethernet transmit-receive connections

The electrical characteristics of Ethernet transmit-receive connections are defined in IEEE 802.3-2005.

Insert new clause 5.2.6:

5.2.6 Ethernet LED connections

Ethernet LED connections may be used by a DT device to drive light-emitting diodes (LEDs) to indicate the status of the Ethernet connections. Table 7 describes the electrical characteristics of an Ethernet LED connection at the output compliance point. The description assumes that:

- a) the output is an open-collector type;
- b) an LED and a resistor are connected in series between the output and the positive supply voltage.

Table 7 – Ethernet LED connection output characteristics

Signal State	Current	Voltage
Asserted	$-25 \text{ mA} < I_{OL}$	$0 \text{ V} < V_{OL} < 0.4 \text{ V}$
Negated	$I_{OL} < 20 \text{ }\mu\text{A}$	$V_{OH} < 5.5 \text{ V}$

Insert new clause 5.3 Connection names:

5.3 Connection instances

5.3.1 Sense connection instances

Table 8 defines the sense connections used by ADT ports:

Table 8 — Sense connections

Connection Name	O/M ^a	Connection Type	Driven By	Connection Definition
Sense _a	O/M ^b	Sense	automation device port	A DT device may use this connection to sense the presence or absence of an automation device.
Sense _{aux}	O	Sense		This standard does not define the use of this connection.
Sense _d	O	Sense	DT device port	An automation device may use this connection to sense the presence or absence of a DT device.

^a O indicates support is optional; M indicates support is mandatory.
^b Mandatory for sADT ports. Optional for iADT ports.

5.3.2 Signal connection instances

Table 9 defines the signal connections used by ADT ports:

Table 9 — Signal connections

Connection Name	O/M ^a	Connection Type	Driven By	Connection Definition
Reset _a	O	Signal	automation device port	An automation device may use this connection to signal a reset request to a DT device by invoking the Reset service request. A DT device shall treat the receipt of a signal on this connection as an invocation of the Reset Received service indication (see 6.2.11).
Signal _{aux}	O	Signal		This standard does not define the use of this connection.

^a O indicates support is optional; M indicates support is mandatory.

5.3.3 Serial transmit-receive connection instances

Table 10 defines the transmit-receive connections for sADT ports.

Table 10 – ADT serial transmit-receive connections

Connection Name	O/M ^a	Connection Type	Driven By	Connection Definition
Tx _a - Rx _d	M	Tx-Rx	automation device port	An automation device shall use this connection to send serialized data. A DT device shall receive serialized data on this connection.
Tx _d - Rx _a	M	Tx-Rx	DT device port	A DT device shall use this connection to send serialized data. An automation device shall receive serialized data on this connection.

^a O indicates support is optional, M indicates support is mandatory for sADT ports.

5.3.4 Ethernet transmit-receive connection instances

Table 11 defines the transmit-receive connections for iADT ports using Ethernet.

Table 11 – Ethernet transmit-receive connections for iADT ports using Ethernet

Connection Name	O/M ^a	Connection Type	Driven By	Connection Definition
TX_D1+	M	MDI ^b	^c	See IEEE 802.3-2005.
TX_D1-	M	MDI ^b	^c	See IEEE 802.3-2005.
RX_D2+	M	MDI ^b	^c	See IEEE 802.3-2005.
RX_D2-	M	MDI ^b	^c	See IEEE 802.3-2005.
BI_D3+	O	MDI ^b	^d	See IEEE 802.3-2005.
BI_D3-	O	MDI ^b	^d	See IEEE 802.3-2005.
BI_D4+	O	MDI ^b	^d	See IEEE 802.3-2005.
BI_D4-	O	MDI ^b	^d	See IEEE 802.3-2005.

^a O indicates support is optional, M indicates support is mandatory for iADT ports.

^b Medium Dependent Interface (MDI) and alternate MDI (MDI-X) are defined in IEEE 802.3-2005. An MDI connection shall support autonegotiation of link speed.

^c In the MDI configuration, the port drives the TX_D1 pair. In the MDI-X configuration, the port drives the RX_D2 pair.

^d The BI_D3 and BI_D4 pairs are driven as indicated by IEEE 802.3-2005.

5.3.5 Ethernet LED connection instances

Table 12 defines the **Ethernet** LED connections used by the DT device supporting Ethernet transmit-receive connections.

Table 12 – Ethernet LED connections

Connection Name	O/M ^a	Connection Type	Asserted By
LED _{active}	O	LED	DT device port
LED _{signal}	O	LED	DT device port

^a O indicates support is optional, M indicates support is mandatory.

A DT device supporting both the LED_{signal} and LED_{active} connections may signal in the following manner:

- a) if carrier is detected (see IEEE 802.3-2005), the LED_{signal} connection is asserted. If no carrier is detected, the LED_{signal} connection is deasserted and the LED_{active} connection is deasserted; and
- b) if data is being transmitted or received on the TX_D1 or RX_D2 connections (see IEEE 802.3-2005), the LED_{active} connection is alternately asserted and deasserted. If no data is being received on the TX_D1 or RX_D2 connections, the LED_{active} connection is deasserted.

A DT device supporting only the LED_{signal} connection may signal in the following manner:

- a) if no carrier is detected, the LED_{signal} connection is deasserted;
- b) if carrier is detected and no data is being received on the TX_D1 and RX_D2 connections, the LED_{signal} connection is asserted; and
- c) if data is being received on the TX_D1 or RX_D2 connections, the LED_{signal} connection is alternately asserted and deasserted.

Renumber clause 5.2 Connector pin-out to 5.3.

5.3 5.4 Connector pin-out

~~ADT~~ sADT ports shall may use the plug connector defined in SFF-8054. Table 8 13 defines the pinout for the ADT port connector on the DT device.

Table 8 13 – DT device ~~ADT~~ sADT port connector pinout

Pin Number	Connection Name	Reference
1	+Tx _a - Rx _d	Table 16
2	-Tx _a - Rx _d	Table 16
3	Ground	
4	-Tx _d - Rx _a	Table 16
5	+Tx _d - Rx _a	Table 16
6	Sense _d	Table 3
7	Sense _a	Table 3
8	Reset _a	Table 7
9	Signal _{aux}	Table 7
10	Sense _{aux}	Table 7

No connector pin-out is defined for the use of iADT ports.

New clause 6

Insert a new clause 6 between 5 (Physical layer) and 6 (Link layer):

6 Connection layer

6.1 Connection layer introduction

An ADT port shall establish a connection with another ADT port before transmitting or receiving encoded characters. Each connection is associated with one and only one session. A connection shall exist implicitly between two sADT ports which are physically connected. A connection between two iADT ports shall be established explicitly.

The ADT connection layer provides connection services for transmitting and receiving sequences of encoded characters between ADT ports. Table 14 lists the ADT connection services.

Table 14 – ADT connection services

Connection service	Connection service type	Invoked by device type	Supported by port type
Connect	Request	Either	iADT
Connected	Confirmation	Either	iADT
Connect Received	Indication	Either	iADT
Send	Request	Either	sADT and iADT
Sent	Confirmation	Either	sADT and iADT
Receive	Request	Either	sADT and iADT
Received	Confirmation	Either	sADT and iADT
Disconnect	Request	Either	iADT
Disconnected	Confirmation	Either	iADT
Disconnect Immediate	Request	Either	iADT
Disconnect Received	Indication	Either	iADT
Reset	Request	Automation device	sADT and iADT
Reset Received	Indication	DT device	sADT and iADT

An iADT port in a DT device shall listen for a connection from any iADT port and an iADT port in an automation device may listen for a connection from any iADT port. An iADT port may initiate a connection. An iADT port awaits a connection by performing a TCP passive OPEN specifying the iADT port number (4169/tcp) or the iADT over TLS (iADT-TLS) port number (9614/tcp) for the local port. An iADT port initiates a connection by invoking the **Connect** service request. When the connection is established, the active iADT port receives a **Connected** service confirmation and the passive iADT port receives a **Connect Received** service indication. The iADT ports may exchange TCP control segments in order to establish the connection.

All ADT IUs using the iADT-TLS port number shall use the Transport Layer Security (TLS) protocol (see RFC 5246).

Figure 18a shows an example of the relationships among the connection services used to establish a connection between two iADT ports. The communication between the two devices is defined in RFC 793 and may constitute more than the two communications shown.

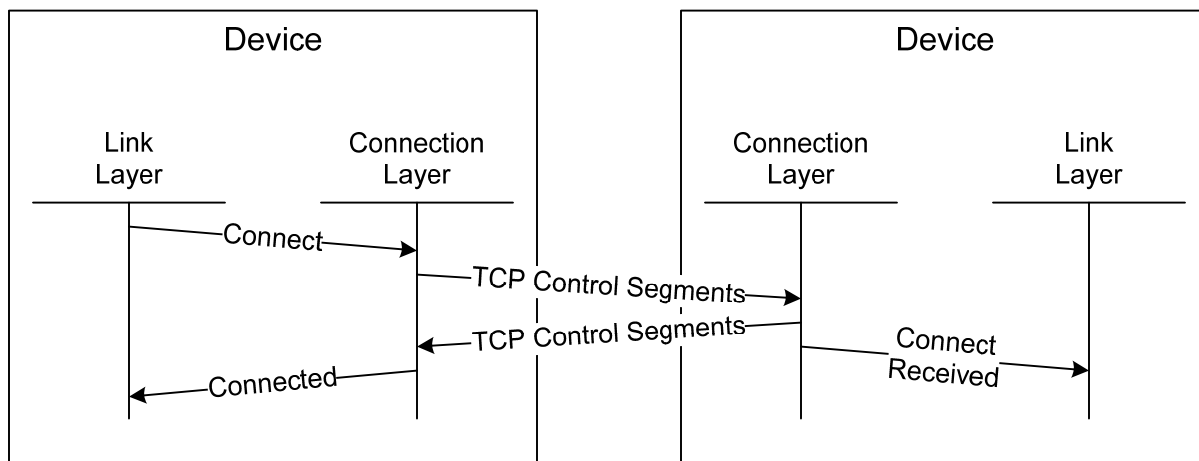


Figure 18a – Connection services for establishing a connection between iADT ports

Figure 19 shows the relationships among the connection services used to transfer data.

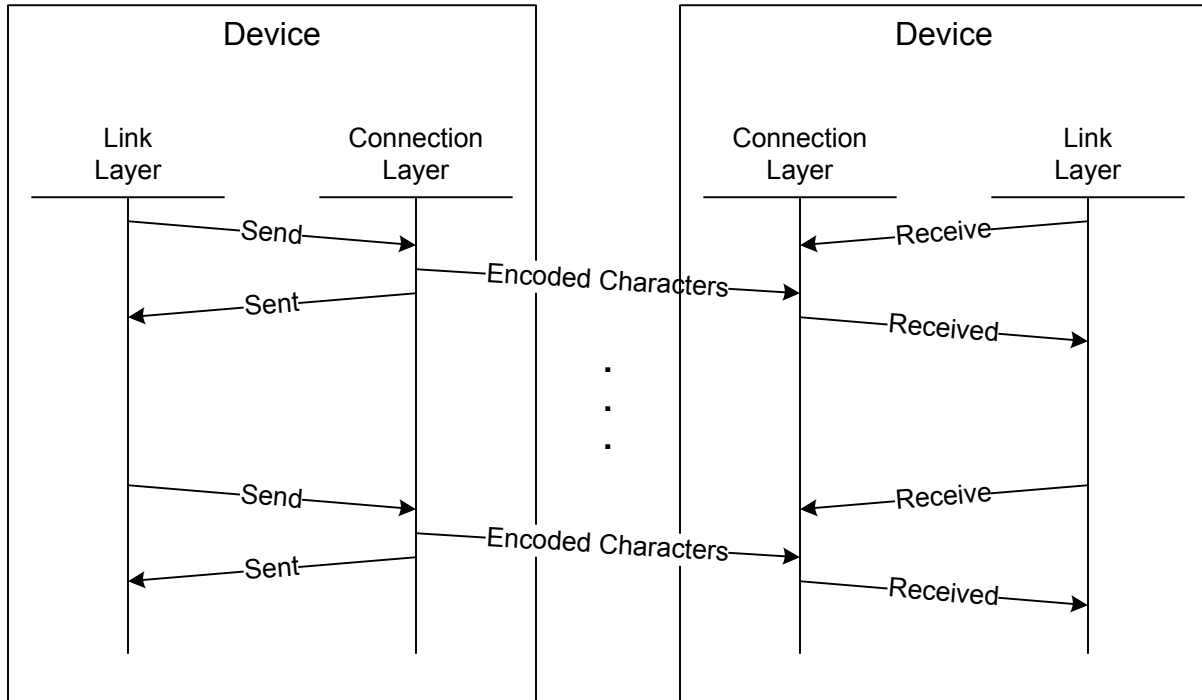


Figure 19 – Connection services for transferring data

An ADT port link layer sends encoded characters on a connection within a session by invoking the **Send** service request. When the **Sent** service confirmation is invoked, the characters have been accepted by the connection layer for delivery, and may have been transmitted.

An ADT port link layer receives encoded characters on a connection by invoking the **Receive** service request and then processing the **Received** service confirmation. When characters have been received by the connection layer, the **Received** service confirmation is invoked. The **Received** service confirmation indicates the number of characters that have been received. To receive more characters on the connection, the ADT port link layer must invoke the **Receive** service request again.

sADT ports transmit encoded characters on the RS-422 physical layer. iADT ports transmit encoded characters in TCP segments over the physical layer used by the iADT port.

Figure 20a shows the relationships among the connection services used to close a connection between two iADT ports. The communication between the two devices is defined in RFC 793 and may constitute more than the two communications shown.

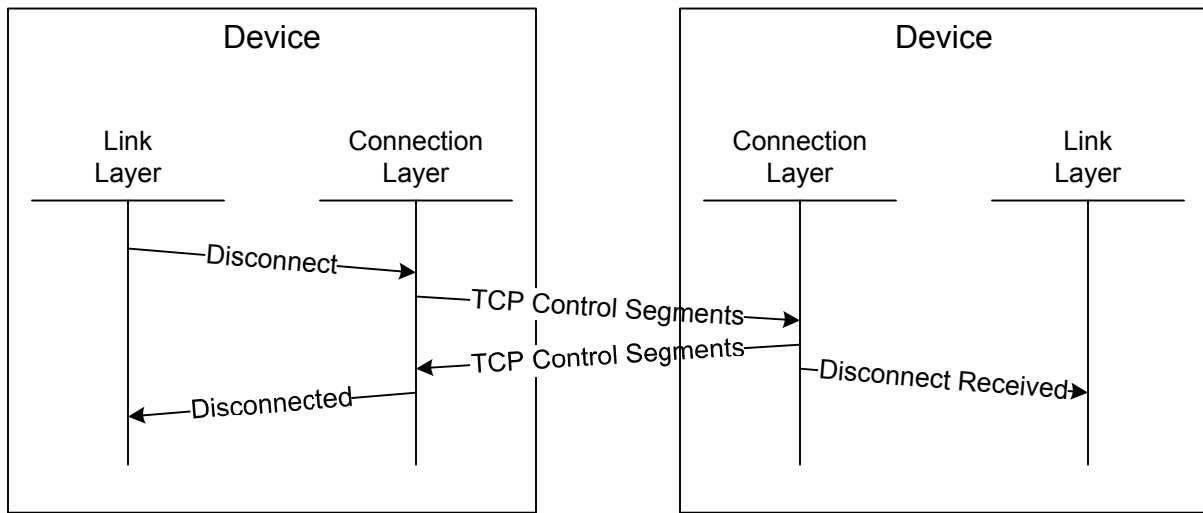


Figure 20a – Connection services for closing a connection between iADT ports

An iADT port link layer closes a connection by invoking the **Disconnect** service request. An iADT port shall attempt to transmit any characters that have been successfully submitted for delivery by earlier **Send** service requests before the connection is closed. When an iADT port receives a **Disconnected** service confirmation or a **Disconnect Received** service indication, the connection is closed and no more characters shall be received. iADT ports exchange TCP control segments in order to close the connection.

Figure 21 shows the relationships among the connection services used to perform a reset.

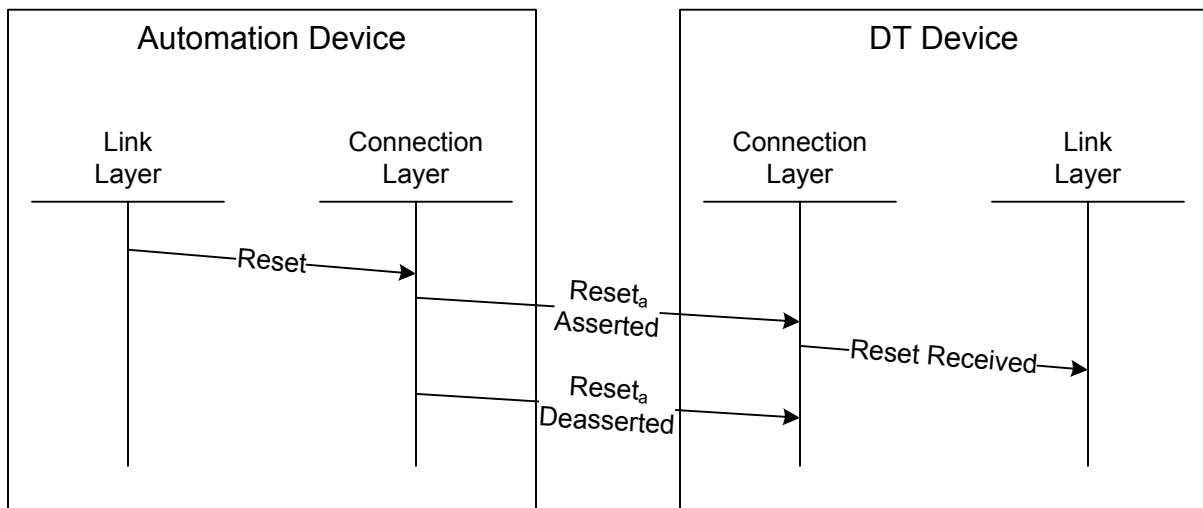


Figure 21 - Connection services for performing a reset

An ADT port link layer in an automation device resets an ADT port in a DT device by invoking the **Reset** service request. The ADT port then asserts the $Reset_a$ connection. Assertion of the $Reset_a$ connection causes the connection layer in the ADT port in the DT device to invoke a **Reset Received** service indication.

6.2 Connection layer connection service definitions

6.2.1 Connect request

A local iADT port link layer invokes the **Connect** connection service request to initiate a connection with a specific remote iADT port.

Service Response = Connect (IN (Session ID, Local IP Address, Remote IP Address, Method))

Input arguments:

Session ID: A link layer identifier for the session with which the connection will be associated.

Local IP Address: The IP address of the local iADT port.

Remote IP Address: The IP address of the remote iADT port.

Method: See Table w-1.

Table w-1 – Method

Value	Description
Unsecured	The connection is made via unsecured TCP
TLS	The connection is made via Transport Layer Security (TLS)

Note: The TCP port number of the remote port is defined in 6.1.

Service Response may be one of the values specified in Table w.

Table w – Connect service request error processing

Service Response	Cause	Possible error recovery procedure
GOOD	The request completed successfully	n/a
INVALID LOCAL IP ADDRESS	The Local IP Address argument did not specify a valid local IP address	Retry request with valid local IP address
INVALID REMOTE IP ADDRESS	The Remote IP Address argument did not specify a valid remote IP address	Retry request with valid remote IP address
NO PHYSICAL CONNECTION	The Sense connection was not asserted or because the Ethernet iADT port did not detect a signal	Not specified by this standard

6.2.2 Connected service confirmation

A local iADT port connection layer invokes the **Connected** service confirmation to notify the iADT port link layer that the connection initiated by a **Connect** service request has been established.

Connected (IN (Session ID, Connection ID))

Input arguments:

Session ID: A link layer identifier for the session with which the connection is associated.

Connection ID: A connection layer identifier for the connection.

6.2.3 Connect Received service indication

A local iADT port connection layer invokes the **Connect Received** service indication to notify the iADT port link layer that a connection initiated by a remote iADT port has been established.

Connect Received (IN (Connection ID, Remote IP Address))

Input arguments:

Connection ID: A connection layer identifier for the connection which was established.

Remote IP Address: The IP address of the remote iADT port.

6.2.4 Send service request

An ADT port link layer invokes the **Send** service request to send data on a connection. An ADT port link layer shall not invoke the **Send** service request for a session for which:

- a) there is no established connection; or
- b) a connection close has been initiated (i.e., the **Disconnect** service request has been invoked but the **Disconnected** service confirmation has not been invoked).

If a subsequent **Send** service request is invoked before all of the data in the buffer specified by a previous **Send** service request has been transmitted, then the ADT port shall transmit all of the data in the buffer for the previous invocation before transmitting any data in the buffer of the subsequent invocation.

If the **Send** service request returns a service response of **GOOD**, then the ADT port link layer may modify the contents of the buffer without affecting the data to be transmitted by the connection layer.

When the **Send** service request returns a service response of **GOOD**, then the characters may or may not have been transmitted on the physical connection.

Service Response = Send (IN (Session ID, Connection ID, Buffer, Buffer Size))

Input arguments:

Session ID: A link layer identifier for the session with which the connection is associated.

Connection ID: A connection layer identifier for the connection.

Buffer: A buffer containing data to be transmitted. The data in the buffer shall be encoded (see 7.2).

Buffer Size: The number of characters of encoded data to be transmitted on the connection.

Service Response may be one of the values specified in Table w+1.

Table w+1 – Send service request error processing

Service Response	Cause	Possible error recovery procedure
GOOD	The request completed successfully	n/a
INVALID CONNECTION STATE	The Connection argument did not specify an established connection.	Create new connection and retry operation
INVALID BUFFER	The Buffer argument did not specify a valid buffer.	Retry request with valid buffer.
OUT OF RESOURCES	The port lacked resources to accept more characters for transmission.	Retry send after a delay

6.2.5 Sent service confirmation

An ADT port connection layer invokes the **Sent** service confirmation to notify the ADT port link layer that the characters specified by the **Send** service request have been accepted for transmission. In an sADT port, the **Sent** service confirmation also indicates that the characters have been transmitted by the physical layer.

Sent (IN (Session ID, Connection ID))

Input arguments:

Session ID: A link layer identifier for the session with which the connection is associated.

Connection ID: A connection layer identifier for the connection.

6.2.6 Receive service request

An ADT port link layer invokes the **Receive** service request to receive data from a connection. The data received shall be processed as specified in clause 7. An ADT port link layer shall not invoke the **Receive** service request for a session for which there is no established connection.

An ADT port link layer may invoke the **Receive** service request for a connection for which a connection close has been initiated (i.e., the **Disconnect** service request has been invoked but the **Disconnected** service confirmation has not been processed).

If the link layer invokes the **Receive** service request a second time before the **Received** service confirmation has been invoked, then the connection layer shall reject the second **Receive** service request with a service response of **RECEIVE PENDING**.

Service Response = Receive (IN (Session ID, Connection ID, Buffer, Buffer Size))

Input arguments:

Session ID: A link layer identifier for the session with which the connection is associated.

Connection ID: A connection layer identifier for the connection.

Buffer: A buffer to contain received data.

Buffer Size: The maximum number of characters of encoded data to be placed in the buffer.

Service Response may be one of the values specified in Table w+2.

Table w+2 – Receive service request error processing

Service Response	Cause	Possible error recovery procedure
GOOD	The request completed successfully	n/a
INVALID CONNECTION STATE	The request failed because the Connection ID argument did not specify a valid connection.	Retry operation with a valid connection
RECEIVE PENDING	The request failed because the ADT port has invoked the Receive service request and the port has not yet invoked the Received service confirmation.	Retry Receive service request after processing Received service confirmation

6.2.7 Received service confirmation

A local ADT port connection layer invokes the **Received** service confirmation to notify the ADT port link layer that a number of characters have been received.

There is not a one-to-one correspondence between invocations of **Send** in the local ADT port and invocations of **Received** in the remote ADT port (i.e., the characters delivered in one invocation of **Received** on the remote port may have been sent by one or more invocations of **Send** on the local port). Similarly, the characters sent in one invocation of **Send** may be delivered in one or more invocations of **Received**.

An ADT frame may be transferred to the link layer in multiple invocations of the **Received** service indication. The beginning of the frame may not align with the start of the buffer and the end of the frame may not align with the end of the buffer (i.e., the first character in the buffer may not be an SOF and the last character in the buffer may not be an EOF).

If a connection is closed then the **Received** service confirmation may be invoked to deliver the characters which have been received. The received character count may be zero.

Received (IN (Session ID, Connection ID, Buffer, Received Character Count))

Input arguments:

Session ID: A link layer identifier for the session with which the connection is associated.

Connection ID: A connection layer identifier for the connection.

Buffer: A buffer containing data received. The data in the buffer shall be encoded (see 7.2).

Received Character Count: The number of characters received and placed in the buffer. The number of characters may be less than the buffer size specified in the corresponding invocation of the **Receive** service request (e.g., in a non-blocking implementation).

6.2.8 Disconnect service request

A local iADT port connection layer receives the **Disconnect** service request to close a connection to a remote iADT port. An iADT port link layer shall not invoke the **Disconnect** service request for a session for which:

- a) there is no established connection; or

- b) a connection close has been initiated (i.e., the **Disconnect** service request has been invoked but the **Disconnected** service confirmation has not been invoked).

Service Response = Disconnect (IN (Session ID, Connection ID))

Input arguments:

Session ID: A link layer identifier for the session with which the connection is associated.

Connection ID: A connection layer identifier for the connection.

Service Response may be one of the values specified in Table w+3.

Table w+3 – Disconnect service request error processing

Service Response	Cause	Possible error recovery procedure
GOOD	The request completed successfully	n/a
INVALID CONNECTION STATE	The request failed because the Connection ID argument did not specify a session with an established connection.	Not specified by this standard

6.2.9 Disconnect Immediate service request

An iADT port link layer invokes the **Disconnect Immediate** service request to close a connection without receiving any further data on the connection and without invoking a service confirmation.

Disconnect Immediate (IN (Connection ID))

Input arguments:

Connection ID: A connection layer identifier for the connection.

6.2.10 Disconnected service confirmation

A local iADT port connection layer invokes the **Disconnected** service confirmation to notify the iADT port link layer that either the connection has been closed or a **Connect** service request has failed. The iADT port connection layer shall not invoke the **Disconnected** service confirmation or the **Disconnect Received** service indication until all received characters have been transferred to the iADT port link layer by use of the **Received** service confirmation.

Disconnected (IN (Session ID, Reason))

Input arguments:

Session ID: A link layer identifier for the session with which the connection was associated.

Reason: The reason that the connection was closed.

Reason may be one of the values specified in Table w+4:

Table w+4 - Disconnected service confirmation error processing

Reason	Cause	Possible error recovery procedure
GOOD	The request completed successfully	n/a

SENSE DEASSERTED:	The port detected transition of the Sense _a connection from asserted to deasserted.	
LOSS OF SIGNAL:	The iADT port detected loss of signal.	
CONNECTION REFUSED:	The remote iADT port rejected the connection attempt.	Retry connection later.

6.2.11 Disconnect Received service indication

A local iADT port connection layer invokes the **Disconnect Received** service indication to notify the iADT port link layer that the connection has been closed by the remote port. The iADT port connection layer shall not invoke the **Disconnect Received** service indication until all received characters have been transferred to the link layer.

The value in the Connection ID argument shall not be used in any service requests until it is reported in the Connection ID argument of a subsequent **Connected** service confirmation or in the **Connection ID argument** of a subsequent **Connect Received** service indication.

If an iADT port detects loss of signal, then the connection layer may invoke the **Disconnect Received** service indication.

Disconnect Received (IN (Connection ID, Reason))

Input arguments:

Connection ID: A connection layer identifier for the connection.

Reason: The reason that the connection was closed.

Reason may be one of the values specified in Table w+5:

Table w+5 – Disconnect Received service indication error processing

Reason	Cause	Possible error recovery procedure
GOOD	The request completed successfully	n/a
CLOSED STATE:	The iADT port detected loss of the TCP connection (see RFC 793) but not loss of signal.	
SENSE DEASSERTED:	The port detected transition of the Sense _a connection from asserted to deasserted.	
LOSS OF SIGNAL:	The iADT port detected loss of signal.	
CONNECTION LOST:	The connection is no longer valid.	

6.2.12 Reset service request

An ADT port link layer in an automation device invokes the **Reset** service request to request the reset of the remote ADT port by asserting the Reset_a connection (see table 9).

Reset (IN (DTD Identifier))

DTD Identifier: The identifier for the DT device to be reset.

6.2.13 Reset Received service indication

An ADT port connection layer invokes the **Reset Received** service indication in a DT device to indicate to the link layer that the ADT port has been reset (e.g., by assertion of the Reset_a connection (see table 9)).

Reset Received (IN (Reset Connection Identifier))

Reset Connection Identifier: An identifier for the Reset connection that was asserted.

6.3 sADT port support of connection services

6.3.1 Data transmission

Table x+3 shows how the arguments to the **Send** service request are used by the sADT port.

Table x+3 – Send service request usage by sADT port

Argument	sADT port implementation
Session ID	The link layer identifier for the session with which the connection is associated
Connection ID	The connection layer identifier for the connection
Buffer	The buffer containing data to be transmitted
Buffer Size	The number of characters in the buffer to be sent. The characters are encoded (i.e., the number includes Escape characters)

When the **Send** service request is successfully invoked by the link layer, the sADT port connection layer shall invoke the **Sent** service confirmation after the encoded characters have been transmitted by the physical port.

Table x+4 shows how the argument to the **Sent** service confirmation is used by the sADT port.

Table x+4 – Sent service confirmation usage by sADT port

Argument	sADT port implementation
Session ID	The value of the Session ID argument of the Send service request
Connection ID	The connection layer identifier for the connection

6.3.2 Data reception

Table x+5 shows how the arguments to the **Receive** service request are used by the sADT port.

Table x+5 – Receive service request usage by sADT port

Argument	sADT port implementation
Session ID	The link layer identifier for the session with which the connection is associated
Connection ID	The connection layer identifier for the connection
Buffer	The buffer to contain received data
Buffer Size	The maximum number of characters to be placed in the buffer

Table x+6 shows how the arguments to the **Received** service confirmation are set by the sADT port.

Table x+6 – Received service confirmation usage by sADT port

Argument	sADT port implementation
Session ID	The link layer identifier for the session with which the connection is associated
Connection ID	The connection layer identifier for the connection
Buffer	The buffer containing the received data. The buffer shall be the same buffer specified in the previous successful invocation of the Receive service request

	for this connection.
Received Character Count	The number of characters placed in the buffer

6.3.3 Performing a reset

An automation device link layer invokes the **Reset** service request to request a reset of the remote ADT port in a DT device. Table x+9 shows how the argument to the **Reset** service request is used by the sADT port.

Table x+9 – Reset service request usage by sADT port

Argument	sADT port implementation
DTD Identifier	The identifier for the DT device to be reset.

The link layer in a DT device shall treat the processing of the **Reset Received** service indication either:

- a) as a port logout (see 7.5.5); or
- b) as a hard reset (see 4.7).

Table x+10 shows how the argument to the **Reset Received** service indication is set by the sADT port.

Table x+10 – Reset Received service indication usage by sADT port

Argument	sADT port implementation
Reset Connection Identifier	An identifier for the Reset connection that was asserted.

6.4 iADT port support of connection services

6.4.1 Connection establishment

When an iADT port link layer invokes the **Connect** service request, the iADT port shall perform an active **OPEN** call (see RFC 793) with the foreign socket specified by the iADT port number and the remote IP address associated with the session. The local iADT port may learn the IP address of the remote iADT port by service discovery using UDP (see 6.5).

The iADT port may support more than one session. The local iADT port shall have at most one session for any given pair of IP addresses.

Table y shows how the arguments to the **Connect** service request are used by the iADT port.

Table y – Connect service request usage by iADT port

Argument	iADT port implementation
Session ID	The link layer identifier for the session with which the connection will be associated
Local IP Address	The IP address component of the local port argument of the OPEN call. The connection layer shall assign the port number component of the local port argument of the OPEN call
Remote IP Address	The IP address component of the foreign socket argument of the OPEN call. The port number component of the foreign socket argument of the OPEN call shall be the iADT port number based on the Method argument

Method	Shall be one of the arguments specified in Table w-1
---------------	--

Table y+2 shows how the arguments to the **Connected** service confirmation are set by the iADT port.

Table y+2 – Connected service confirmation usage by iADT port

Argument	iADT port implementation
Session ID	The value of the Session ID argument of the Connect service request
Connection ID	The connection layer identifier for the connection
Remote IP Address	IP address of the remote port

Table y+3 shows how the arguments to the **Connect Received** service indication are set by the iADT port.

Table y+3 – Connect Received service indication usage by iADT port

Argument	iADT port implementation
Connection ID	The connection layer identifier for the connection
Remote IP Address	IP address of the remote port

6.4.2 Data transmission

When the **Send** service request is invoked, the iADT port shall invoke the **SEND** call (see RFC 793) with an indication that the data is to be transmitted immediately. Table y+4 shows how the arguments to the **Send** service request are used by the iADT port.

Table y+4 – Send service request usage by iADT port

Argument	iADT port implementation
Session ID	The link layer identifier for the session with which the connection is associated
Connection ID	The connection layer identifier for the connection
Buffer	buffer address argument of the SEND call
Buffer Size	byte count argument of the SEND call

When the **Send** service request is successfully processed, the iADT port connection layer shall invoke the **Sent** service confirmation. Invocation of the **Sent** service confirmation by the iADT port does not indicate that the characters have been transmitted by the physical port.

Table y+5 shows how the argument to the **Sent** service confirmation is used by the iADT port.

Table y+5 – Sent service confirmation usage by iADT port

Argument	iADT port implementation
Session ID	The value of the Session ID argument of the Send service request
Connection ID	The connection layer identifier for the connection

6.4.3 Data reception

Table y+6 shows how the arguments to the **Receive** service request are used by the iADT port.

Table y+6 – Receive service request usage by iADT port

Argument	iADT port implementation
Session ID	The link layer identifier for the session with which the connection is associated
Connection ID	The connection layer identifier for the connection
Buffer	buffer address argument of the RECEIVE call (see RFC 793)
Buffer Size	byte count argument of the RECEIVE call

Table y+7 shows how the arguments to the **Received** service confirmation are used by the iADT port.

Table y+7 – Received service confirmation usage by iADT port

Argument	iADT port implementation
Session ID	The link layer identifier for the session with which the connection is associated
Connection ID	The connection layer identifier for the connection
Buffer	buffer address argument of the RECEIVE call
Received Character Count	The number of characters placed in the buffer

6.4.4 Closing a connection

When the link layer in an iADT port successfully invokes the **Disconnect** service request, then the iADT port shall invoke the **CLOSE** call (see RFC 793).

Note: TCP guarantees that characters previously transferred with the **SEND** call shall be sent prior to closing the connection.

Table y+8 shows how the arguments to the **Disconnect** service request is used by the iADT port.

Table y+8 – Disconnect service request usage by iADT port

Argument	iADT port implementation
Session ID	The link layer identifier for the session with which the connection is associated
Connection ID	The connection layer identifier for the connection

Table y+9 shows how the argument to the **Disconnect Immediate** service request is used by the iADT port.

Table y+9 – Disconnect Immediate service request usage by iADT port

Argument	iADT port implementation
Connection ID	The connection layer identifier for the connection

When an iADT port that had invoked the **Disconnect** service request enters the TCP CLOSED state (see RFC 793), the connection layer shall invoke the **Disconnected** service confirmation. Table y+10 shows how the argument to the **Disconnected** service confirmation is set by the iADT port. When an iADT port has invoked the **Connect** service request and the connection attempt fails, the connection layer shall invoke the **Disconnected** service confirmation.

Table y+10 – Disconnected service confirmation usage by iADT port

Argument	iADT port implementation
Session ID	The link layer identifier for the session with which the connection was associated
Reason	One of the Reasons listed in 6.2.10

When an iADT port that had not invoked the **Disconnect** service request enters the TCP CLOSED state (see RFC 793), the connection layer shall invoke the **Disconnect Received** service indication. Table y+11 shows how the argument to the **Disconnect Received** service indication is set by the iADT port.

Table y+11 – Disconnect Received service indication usage by iADT port

Argument	iADT port implementation
Connection ID	The connection layer identifier for the connection

Reason	One of the Reasons listed in 6.2.11
---------------	-------------------------------------

6.4.5 Performing a reset

An automation device link layer shall invoke the **Reset** service request to request the reset of the remote ADT port in a DT device. Table y+12 shows how the argument to the **Reset** service request is used by the iADT port.

Table y+12 – Reset service request usage by iADT port

Argument	iADT implementation
DTD Identifier	The identifier for the DT device to be reset

The link layer in a DT device shall treat the reception of the **Reset Received** service indication either:

- a) as a **Disconnect Received** service indication (see 6.2.8); or
- b) as a hard reset (see 4.7).

Table y+13 shows how the argument to the **Reset Received** service indication is set by the iADT port.

Table y+13 – Reset Received service indication usage by iADT port

Argument	iADT implementation
Reset Connection Identifier	An identifier for the Reset connection that was asserted

6.5 Service discovery for iADT ports using the iADT Discovery protocol

6.5.1 Service discovery introduction

Service discovery using the iADT Discovery (iADT-DISC) protocol provides for the automated discovery of IP addresses used by remote iADT ports.

6.5.2 Service discovery message

When the physical port inside an iADT port supporting the iADT-DISC protocol has been enabled the iADT port shall:

- a) begin the service discovery transmission processing (see 6.5.3);
- b) continually receive packets on the iADT-DISC port (4169/udp); and
- c) process service discovery messages received on the iADT-DISC port (see 6.5.4).

The data octets of the user datagram shall contain the service discovery message defined in table x.

Table x – Service discovery message

Byte	Bit	7	6	5	4	3	2	1	0
0		SIGNATURE ("iADT")							
3		INFORMATION TYPE							
4		DEVICE TYPE							
6	(MSB)	ADDITIONAL LENGTH							
7		(LSB)							
8		ADT MAJOR REVISION				ADT MINOR REVISION			
9		UNSEC	TLS	Reserved					

10	Reserved
11	Reserved
Service discovery descriptor(s)	
12	Service discovery descriptor [first] (see TBD)
	⋮
	⋮
n	Service discovery descriptor [last] (see TBD)

The SIGNATURE field shall be set to the ASCII string "iADT".

The INFORMATION TYPE field is defined in table y.

Table y

Value	Description
00h	Announcement
01h	Response
02h – FFh	Reserved

The DEVICE TYPE field is defined in table z-1.

Table z-1

Value	Description
00h	DT device
01h	Automation Device
02h	Monitoring Application
03h – FFh	Reserved

The ADDITIONAL LENGTH field is the length of the data that follows. The value in the ADDITIONAL LENGTH field shall be a multiple of four and shall not be greater than 500.

The ADT MAJOR REVISION field set to the value that is used in the Port Login Information Unit (see 6.5.4).

The ADT MINOR REVISION field set to the value that is used in the Port Login Information Unit.

The UNSEC bit set to one indicates that the iADT port accepts iADT connections on port 4169/tcp.

The TLS bit set to one indicates that the iADT port accepts iADT-TLS connections on port 9614/tcp.

The service discovery descriptor is defined in table z and shall be a multiple of four bytes in length.

Table z – Service discovery descriptor

Byte	Bit	7	6	5	4	3	2	1	0
0		DESCRIPTOR TYPE							
1		ADDITIONAL LENGTH (n-1)							
2		Reserved							
3		DESCRIPTOR LENGTH (m-3)							
4		DESCRIPTOR							
m		DESCRIPTOR							

m+1	_____	Pad bytes (optional)	_____
n	_____		_____

The DESCRIPTOR TYPE field (see table z+1) identifies the service discovery descriptor.

The ADDITIONAL LENGTH field indicates the number of additional bytes in the descriptor.

The DESCRIPTOR LENGTH field indicates the length of the DESCRIPTOR field.

See table z+1 for the definition of the DESCRIPTOR field.

Table z+1 – Descriptor types

DESCRIPTOR TYPE	Description	Support		DESCRIPTOR Field
		Device Type	Requirements	
00h	Reserved			
01h	T10 vendor ID	DT device	O	The same data as the T10 VENDOR IDENTIFICATION field of the standard INQUIRY data (see SPC-4) reported by the RMC device server (see ADC-3) in the DT device
		Automation device	O	The same data as the T10 PRODUCT IDENTIFICATION field of the standard INQUIRY data reported by the SMC device server in the automation device
		Monitoring application	I	
02h	T10 product ID	DT device	O	The same data as the T10 PRODUCT IDENTIFICATION field of the standard INQUIRY data (see SPC-4) reported by the RMC device server (see ADC-3) in the DT device
		Automation device	O	The same data as the T10 PRODUCT IDENTIFICATION field of the standard INQUIRY data reported by the SMC device server in the automation device
		Monitoring application	I	
03h	T10 product revision level	DT device	O	The same data as the T10 PRODUCT IDENTIFICATION field of the standard INQUIRY data (see SPC-4) reported by the RMC device server (see ADC-3) in the DT device
		Automation device	O	same data as the T10 PRODUCT REVISION LEVEL field of the standard INQUIRY data reported by the SMC device server in the automation

DESCRIPTOR TYPE	Description	Support		DESCRIPTOR Field
		Device Type	Requirements	
				device
		Monitoring application	I	
04h	Monitoring application vendor ID	Monitoring application	O	Left-aligned ASCII data containing a vendor-specific vendor identifier. If the vendor has an assigned T10 vendor ID, that value should be used.
		DT or automation device	I	
05h	Monitoring application product ID	Monitoring application	O	Left-aligned ASCII data containing a vendor-specific product identifier
		DT or automation device	I	
06h – 7Fh	Reserved			
80h – FFh	Vendor specific			
Support Key: M = mandatory O = optional I = invalid				

The pad bytes shall be used to pad the descriptor to a four-byte length. Each pad byte shall be set to 00h.

6.5.3 Service discovery transmission processing

If the INFORMATION TYPE field in the Service discovery message is set to Announcement, then the Service Discovery Message shall be sent to the iADT-DISC port on the iADT-DISC multicast address (i.e., 239.255.255.n for IPv4 or FF02::m for IPv6).

Editor's Note: Values for m and n are pending from IANA.

The iADT port shall delay a random time in the range zero to three seconds and then transmit the Service discovery message (see table x) once every three seconds until it receives a Service discovery message addressed to this iADT port or until a vendor specific number of messages have been sent. In the service discovery message the INFORMATION TYPE field shall be set to Announcement (i.e., 00h).

The purpose of the random delay is to avoid collisions between UDP packets from multiple devices.

6.5.4 Service discovery message reception processing

When processing a service discovery message the iADT port shall check the fields to determine how to process the message.

The iADT port shall save the address information for the device that transmitted the announcement message, delay a random time in the range zero to three seconds, and then transmit a service discovery message with the INFORMATION TYPE field set to Response (i.e., 01h) to the IP Address and port number that sent the announcement message if the INFORMATION TYPE field is set to Announcement (i.e., 00h) and

- a) this device is a DT device and the DEVICE TYPE field is not set to DT device (i.e., 00h); or
- b) this device is an Automation device and
 - A) the DEVICE TYPE field is set to Monitoring Application (i.e., 02h); or
 - B) the DEVICE TYPE field is set to DT device (i.e., 00h) and:

- a) it is known that this DT device is inside the automation device; or
- b) it is unknown that this DT device is inside the automation device

The iADT port should save the address information for the other device and may stop the transmission processing if in the received service discovery message:

- a) the INFORMATION TYPE field is set to Response (i.e., 01h);
- b) the DEVICE TYPE field is not set to Monitoring Application (i.e., 02h); and
- c) the DEVICE TYPE field is not the same as this device,

Editor's Note: When a future annex on how to use multicasting is added, place a reference here.

Changes to clause 6

Renumbered to clause 7 and changed as noted below.

The following contains new text in 7.2.6 which is not visible while change tracking is enabled.

67.2.6 AER Control information unit

An AER Control IU may be sent by an automation device port to a DT device port to enable or disable AER reporting. The payload of an AER Control IU shall contain a VHF Data structure, with the bits set to one for each field that the device shall report a change. **The values in VHF Data structure shall be maintained separately for each I_T nexus.** Multiple-bit fields shall have either all of the bits of the field set to one or all of the bits in the field set to zero. A DT device that receives a multi-bit field containing at least one bit set to zero shall treat that entire field as set to zero. A DT device shall consider reserved bits as not supported for AER notification.

DT devices that do not support AER shall send a NAK IU in response with the PR bit set to zero and a status code of UNSUPPORTED FRAME TYPE FOR SELECTED PROTOCOL (see table 14).

Except as noted in this sub clause, DT devices that support AER shall respond to the receipt of an AER Control IU by sending an AER Control IU back to the automation device with the same x_origin and exchange ID values. The payload of the IU shall contain a VHF Data IU data structure. Each field that has been enabled for AER notification **for the I_T nexus** and is supported by the device shall have all bits in the field set to one. Each field that has been either disabled for AER notification **for the I_T nexus** or is not supported for AER notification by the device shall be set to zero. The default setting for all AER events in a DT device shall be zero.

All AER control fields shall be set to zero by the DT device at the start of the port login process when the AOE bit is set to one.

DT devices ports shall only send an AER Control IU in response to receiving an AER Control IU from an automation device port.

67.3 ADT frame header

<...>

The X_ORIGIN bit shall be set to zero if the ~~automation device originates the exchange~~ **device originating the exchange is acting as an automation device within that session**. The X_ORIGIN bit shall be set to one if the ~~DT device originates the exchange~~ **device originating the exchange is acting as a DT device within that session**. This bit shall remain constant for all frames associated with a given exchange.

<...>

67.5.4 Port login information unit

<...>

The BAUD RATE field indicates the speed that the port's physical interface in an sADT port shall run after completion of negotiation. The BAUD RATE field contains the desired nominal Baud rate divided by 100. All sADT ports shall default to operating at 9 600 Baud at power-up and following error conditions that require re-establishment of the operating parameters (see 4.6.2). If a an sADT port receives a Port Login IU containing a baud rate value less than 9 600 it shall respond with a NAK IU with a status code of NEGOTIATION ERROR (see table 14).

In an iADT port, the BAUD RATE field shall contain a value of 0000h.

<...>

67.5.5 Port logout information unit

After sending a Port Logout IU and before receiving the corresponding acknowledgement IU, a port may discard without acknowledgement any frame, other than an acknowledgement IU, received.

Upon receiving a Port Logout IU, a DT Device port shall:

- a) abort all open exchanges;
- b) disable Asynchronous Event Reporting;
- c) disable initiating Port Login exchanges; **and**
- d) set port operating parameters to default following transmission of the ACK IU for the Port Logout IU (see 4.2); **and**
- e) set the logout duration time to the value in the LOGOUT DURATION field. If the value in the field is zero, then set the logout duration time to infinite.

Upon receiving a Port Logout IU, an automation port shall:

- a) abort all open exchanges;
- b) disable initiating Port Login exchanges; **and**
- c) set port operating parameters to default following transmission of the ACK IU for the Port Logout IU (see 4.2); **and**
- d) set the logout duration time to the value in the LOGOUT DURATION field. If the value in the field is zero, then set the logout duration time to infinite.

If a DT device port sends a Port Logout IU to an automation port, then it should send a Port Login IU to the automation port within the logout duration time.

Knowledge of the logged out state may be volatile, as a result of a hard reset condition in the logged out port may cause the port to become active again and attempt to log in to the attached port.

The payload of the Port Logout IU is shown in table 16.

Table 16: Port Logout IU payload contents

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB) LOGOUT DURATION							
1	(LSB)							
2	ESR		REASON CODE					
3	Reserved							

The LOGOUT DURATION field contains the value to which the port that receives the Port Logout IU shall set the logout duration time (i.e., the length in seconds that the port that receives the Port Logout IU the port

shall remain in P3:Logged-out state). A value of zero indicates that the port that receives the Port Logout IU shall **set the logout duration time to infinite (i.e., the port shall** remain in the P3:Logged-out state until the port receives a Port Login IU).

The external stimulus required (ESR) bit set to one indicates that the port requires an external stimulus before initiating a negotiation exchange (see 6.5.13.1).

<...>

After a port sends an ACK IU in response to a Port Logout IU it shall set its operating parameters to default ~~and~~, enter the P3:Logged-Out state, **and if the port is an iADT port, close the connection**. Once the originator of a Port Logout IU receives an ACK IU for that exchange, it shall set its operating parameters to default ~~and~~, enter the P0:Initial state, **and if the port is an iADT port, close the connection**. See 4.3 for a definition of the port states.

7.6 Sessions

A session is a relationship between two ADT ports. The link layer manages sessions and associates connections with sessions. A session between two sADT ports is identified by two physically-connected sADT ports. A session between two iADT ports is identified by a unique pair of IP addresses.

A session between a local sADT port and a remote sADT port begins in the local sADT port when no session exists between the two sADT ports and the local sADT port transmits or receives a Login IU.

A session between a local iADT port and a remote iADT port begins in the local iADT port when no session exists between the two iADT ports and:

- a) the link layer invokes the **Connect** service request specifying the remote iADT port; or
- b) the connection layer invokes the **Connect Received** service indication specifying the remote iADT port.

A session between two ADT ports ends in the local ADT port after the local ADT port:

- a) processes a Logout IU (see 7.5.5) that was received on the local port;
- b) receives an ACK for a Logout IU the local port sent; or
- c) receives an implicit logout message (see 4.3.2.4.4).

In an iADT port, if:

- 1) a session exists;
- 2) a Login IU has been received; and
- 3) a new connection is established in the same session

then the previously-established session shall be terminated (i.e., perform an implicit logout and invoke the Disconnect Immediate service request) and a new session shall be created using the new connection.

In an iADT port, if:

- 1) a session exists;
- 2) a Login IU has not been received; and
- 3) a new connection is established in the same session

then the connection initiated by the DT device shall be closed (i.e., invoke the Disconnect Immediate service request) and the connection initiated by the automation device shall be used for this session.

Annex E contains examples of resolving redundant connections.

Changes to clause 7

78 Transport layer

78.1 SCSI Encapsulation

78.1.1 SCSI encapsulation overview

SCSI information units contain information required to implement the SCSI protocol. Information units are exchanged between an automation device transport layer and a DT device transport layer (see Figure 5). The X_ORIGIN bit in the ADT frame header conveys the SCSI initiator port and SCSI target port identities. The EXCHANGE ID value from the ADT frame header of an encapsulated SCSI protocol IU takes on the role of the task tag from SAM-3. The LUN is included in the SCSI Command IU and SCSI Task Management IU payload contents. See 4.9 for transport protocol variations from SAM-3. See clause 8 for the mapping of the IUs described in this clause to the SCSI transport protocol services.

<...>

78.2 Fast Access

78.2.1 Fast Access overview

This protocol is intended to provide a feature set beyond what is provided by SAM-3 to both take advantage of the features of the transport layer and work around its slower speed. The Fast Access protocol provides:

- a) a simple method for accessing the Very High Frequency (VHF) Data defined in ADC-2;
- b) an asynchronous event report, a method for a DT device to report asynchronous activity; and
- c) a method to control these asynchronous reports.

Fast Access protocol IUs shall be routed to the remote ADT port associated with the session.

<...>

Changes to clause 8

89 SCSI application layer

<...>

89.2 Transport layer protocol services to support Execute Command

<...>

Table 32 — Send SCSI Command transport layer protocol service arguments

Argument	ADT Implementation
I_T_L_Q nexus	I_T_L_Q nexus, where: <ul style="list-style-type: none"> a) I_T is used to select the session and to set the X_ORIGIN field; b) L is used to set the LUN field; and c) Q is set by the transport layer.

<...>

<...>

Table 33 — SCSI Command Received transport layer protocol service arguments

Argument	ADT Implementation
I_T_L_Q nexus	I_T_L_Q nexus, where: a) I_T is indicated by the session and the X_ORIGIN field; b) L is used to set the LUN field; and c) Q is set by the transport layer.
<...>	

<...>

Table 35 — Command Complete Received transport layer protocol service arguments

Argument	ADT Implementation
I_T_L_Q nexus	I_T_L_Q nexus, where: a) I_T is indicated by the session and the X_ORIGIN field; b) L is used to set the LUN field; and c) Q is set by the transport layer.
<...>	

<...>

Table 40 — Send Data-Out transport layer protocol service arguments

Argument	ADT Implementation
I_T_L_Q nexus	Used to select the session and to set the X_ORIGIN and EXCHANGE ID fields in the ADT frame(s) header.
<...>	

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Table 42 — Send Data-Out transport layer protocol service arguments

Argument	ADT Implementation
I_T_L_Q nexus	Used to select the session and to set the X_ORIGIN and EXCHANGE ID fields in the ADT frame(s) header.
<...>	

<...>

*New Annex D***Annex D
(informative)****iADT Connection Services Relationship to Sockets API**

In TCP/IP implementations, the TCP calls mentioned in clause 6 are typically invoked via a Sockets application programming interface (API). The details of the Sockets API varies between implementations. This annex describes the typical semantics of the Sockets API function calls and how the connection services may be mapped to those function calls.

Table D.1 describes the function calls in a typical Sockets API.

Table D.1 – Sockets API function calls

Function	Description
socket()	Creates a socket descriptor that represents a communication endpoint. The arguments to the socket() function tell the system which protocol to use, and what format address structure will be used in subsequent functions
bind()	Assigns a name to an unnamed socket that represents the address of the local communications endpoint (i.e., IP address and port number). When a socket is created with socket(), it exists in a name space (address family), but has no name assigned. bind() requests that a name be assigned to the socket.
connect()	Assigns the name of the remote communications endpoint and a connection is established between the endpoints. Performs a TCP active OPEN and causes entry to the SYN-SENT state. Return from connect() indicates transition to the ESTABLISHED state.
listen()	Enables the socket to accept a specified number of connection requests from remote sockets. Up to that number of requests may be queued on the socket; if additional requests are received before a queued request is removed, then the additional requests are rejected. listen() performs a TCP passive OPEN and causes entry to the LISTEN state. When an accept() is invoked on a socket with queued requests, then one request is removed and an additional request may be queued.
accept()	Accepts a connection request on a socket that is listening for connections. When accept() is processed: <ul style="list-style-type: none"> 1) a queued request is removed from the socket; 2) a new socket is created for the connection. The connection is defined by a remote IP address and port number and the local IP address and port number; 3) further packets on that connection are routed to the new socket; and 4) the original socket may be used to accept additional connection requests. <p>If no connection request is queued on the original socket, then the accept() may block until one arrives or until a close() is invoked on the socket.</p>
send()	Sends outgoing data on a connected socket. An error status on return from send() may indicate entry to the CLOSE-WAIT or FIN-WAIT-1 state.
recv()	Receives incoming data that has been received by a connected socket. An error status on return from recv() may indicate entry to the CLOSE-WAIT or FIN-WAIT-1 state.
shutdown()	Closes a connection, optionally preventing further sends and/or receives. Causes a transition from the ESTABLISHED state to the FIN-WAIT-1 state and eventually causes a transition to the CLOSED state.
close()	Deletes a socket descriptor created by the socket() function. If the socket was connected, the connection is terminated. Data that has yet to be delivered to the remote endpoint is discarded. To ensure transmission and reception of all pending packets, close() should be invoked after shutdown() has returned. If the deleted socket was the original one upon which the listen() was invoked, then no new connections can be accepted. Existing connections are unaffected.

Table D.2 shows how connection services may be mapped to Sockets API function calls. The **Reset** service request and **Reset Received** service indication are not listed because they are not relevant to the Sockets API.

Table D.2 – Connection service mapping to Sockets API functions

Connection service	Socket function	Notes
Connect	socket()	
	bind()	As part of processing a connect service request, bind() specifies a dynamic local port number.
	connect()	connect() specifies the remote socket address. This socket may not be reused for additional connections. Creating another connection requires invoking socket() to allocate a new socket resource and then invoking bind() and connect() on that new socket.
Connected		connect() may block until a connection is established with a remote socket.
Connect Received	accept()	accept() may block until a remote socket connects to the local socket. If so, then it returns the address of the remote socket. This return causes invocation of the Connected service confirmation, which returns the address of the remote socket in the Connection ID argument.
Send	send()	Invocation of the Send service request causes invocation of send().
Sent		The Sent service confirmation is invoked after send() returns.
Receive	recv()	Invocation of the Receive service request causes the invocation of recv(), which blocks until a message is received.
Received		recv() returns when a message is received. This return causes the invocation of the Received service confirmation.
Disconnect	shutdown()	The Disconnect service request causes invocation of shutdown()
	close()	close() deallocates the socket used for the TCP connection.
Disconnected	shutdown() return	Successful completion of closing a TCP connection which was initiated by the local port causes a return from close(). This causes invocation of the Disconnected service confirmation.
		Other events (e.g., physical port failure) may also cause invocation of Disconnected .
Disconnect Received	send() return recv() return	Closing of a TCP connection by the remote port causes invocation of the Disconnect Received service indication.
	close()	close() deallocates the socket used for the TCP connection.
Disconnect Immediate	shutdown()	The Disconnect Immediate service request causes invocation of shutdown()

*New Annex E***Annex E
(informative)****iADT Redundant Connection Resolution Examples****E.1 Introduction**

If two iADT ports initiate TCP connections simultaneously, then one of the connections is closed as specified in 7.6. The order in which each connection is established may appear differently on each iADT port depending upon transmission delays. This annex provides examples to illustrate the application of the rules in 7.6.

Figure E.1 shows the drawing conventions used in this annex. The communications associated with each connection are distinguished by use of color and solid or dashed lines. A vertical line with two horizontal lines adjacent to the Link Layer symbol indicates the beginning and end of a session. A letter on the line identifies the session. A shaded box connecting the link layers in each device and labeled "Login Processing" indicates when login processing is performed. Connection services that have a Connection ID argument show that argument in parentheses.

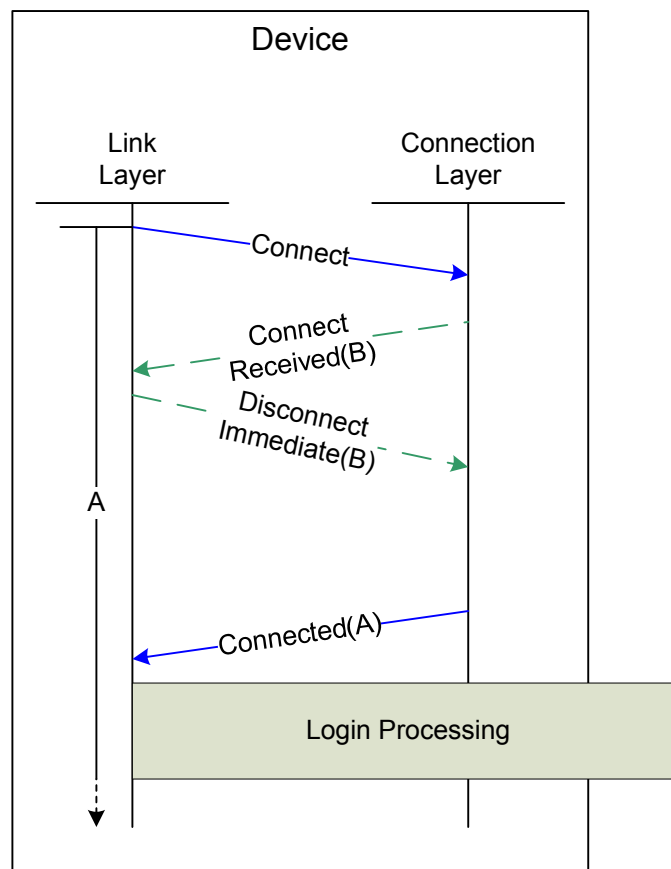


Figure E.1 – Examples of drawing conventions

E.2 Ambiguous connection establishment order

Figure E.2 shows the case in which each device sees the connections established in a different order (i.e., in the automation device the connection initiated by the DT device is established first, and in the DT device the connection initiated by the automation device is established first). No login is processed during the actions shown in this figure. Following the rules in 7.6, the automation device and the DT device close the connection initiated by the DT device.

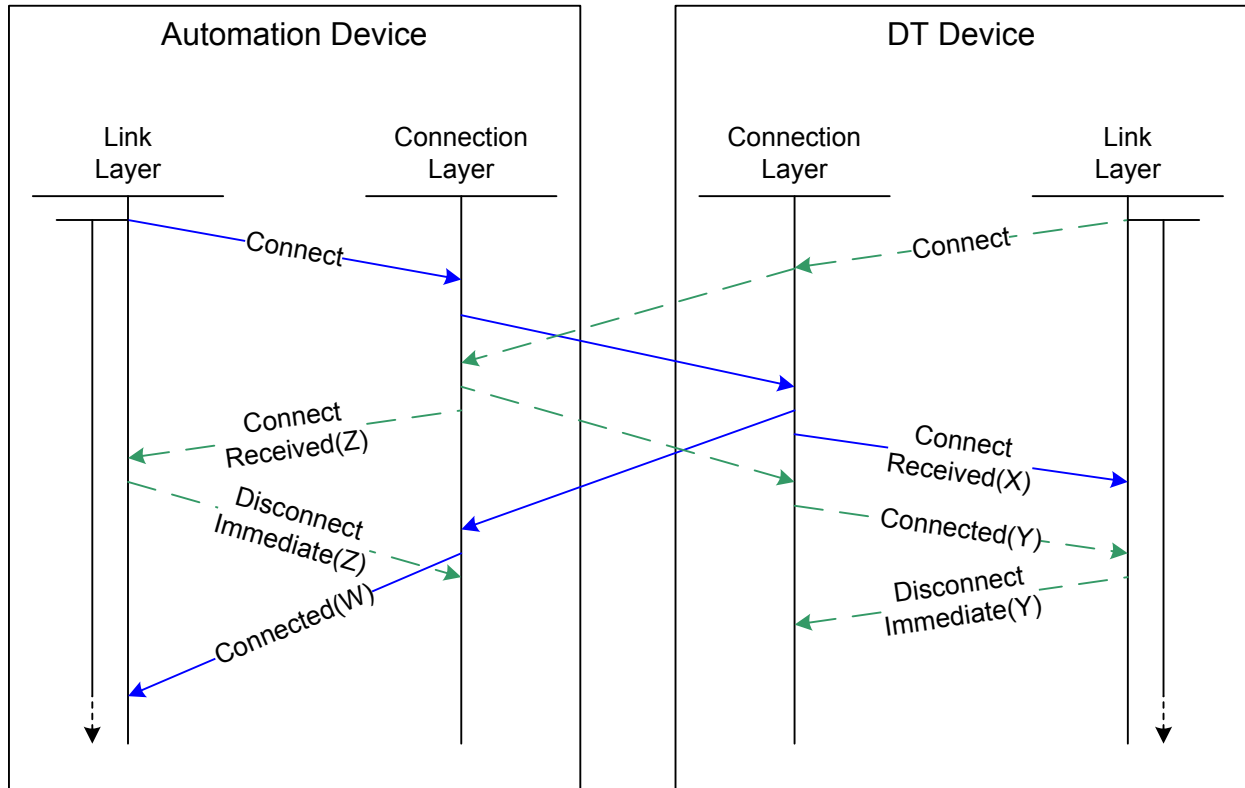


Figure E.2 - Ambiguous connection establishment order

E.3 Automation device-initiated connection established first

Figure E.3 shows the case in which both devices see the connection initiated by the automation device being established first. No login is processed during the actions shown in this figure. Following the rules in 7.6, the automation device and the DT device close the connection initiated by the DT device.

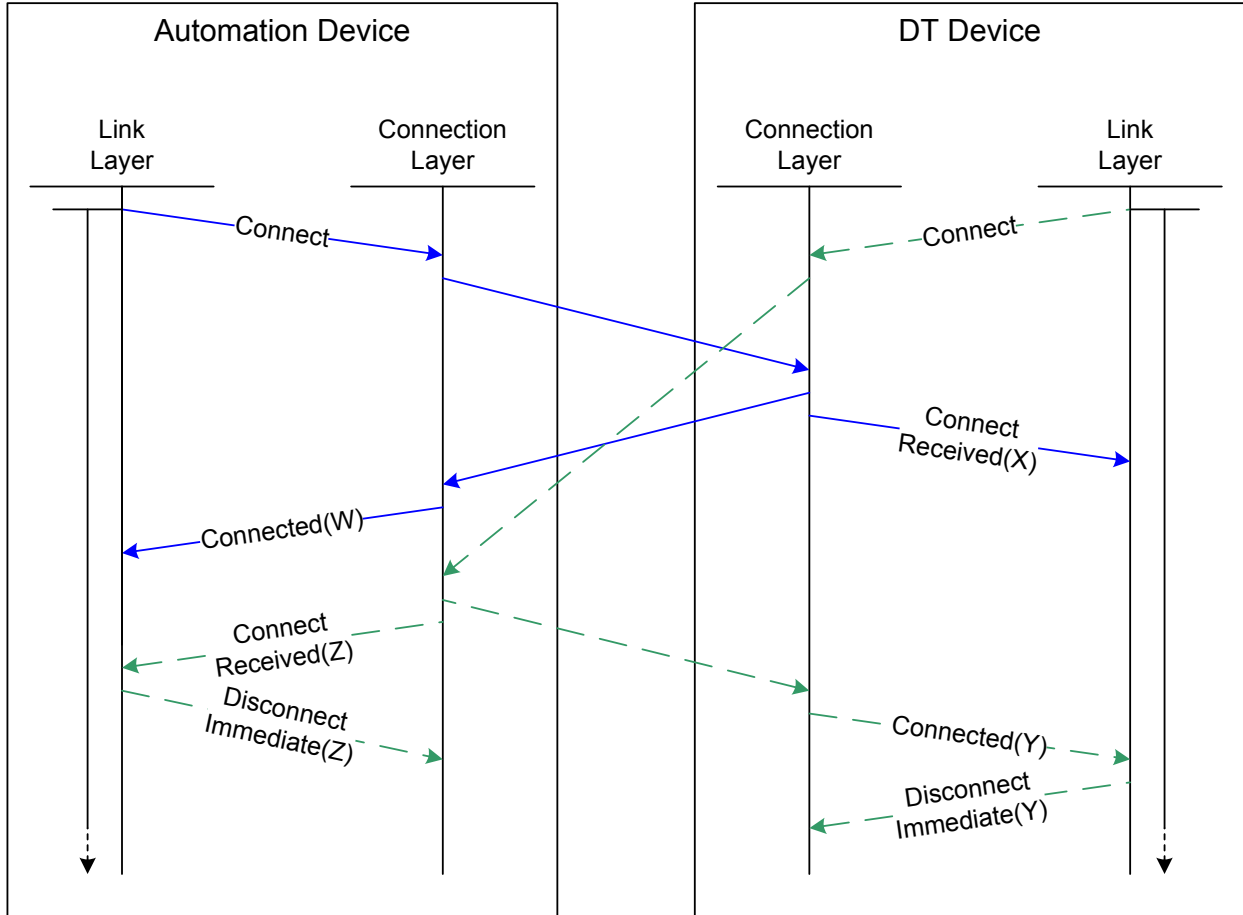


Figure E.3 - Automation device-initiated connection established first

E.4 DT device-initiated connection established first

Figure E.4 shows the case in which both devices see the connection initiated by the DT device being established first. No login is processed during the actions shown in this figure. Following the rules in 7.6, the automation and the DT device close the connection initiated by the DT device.

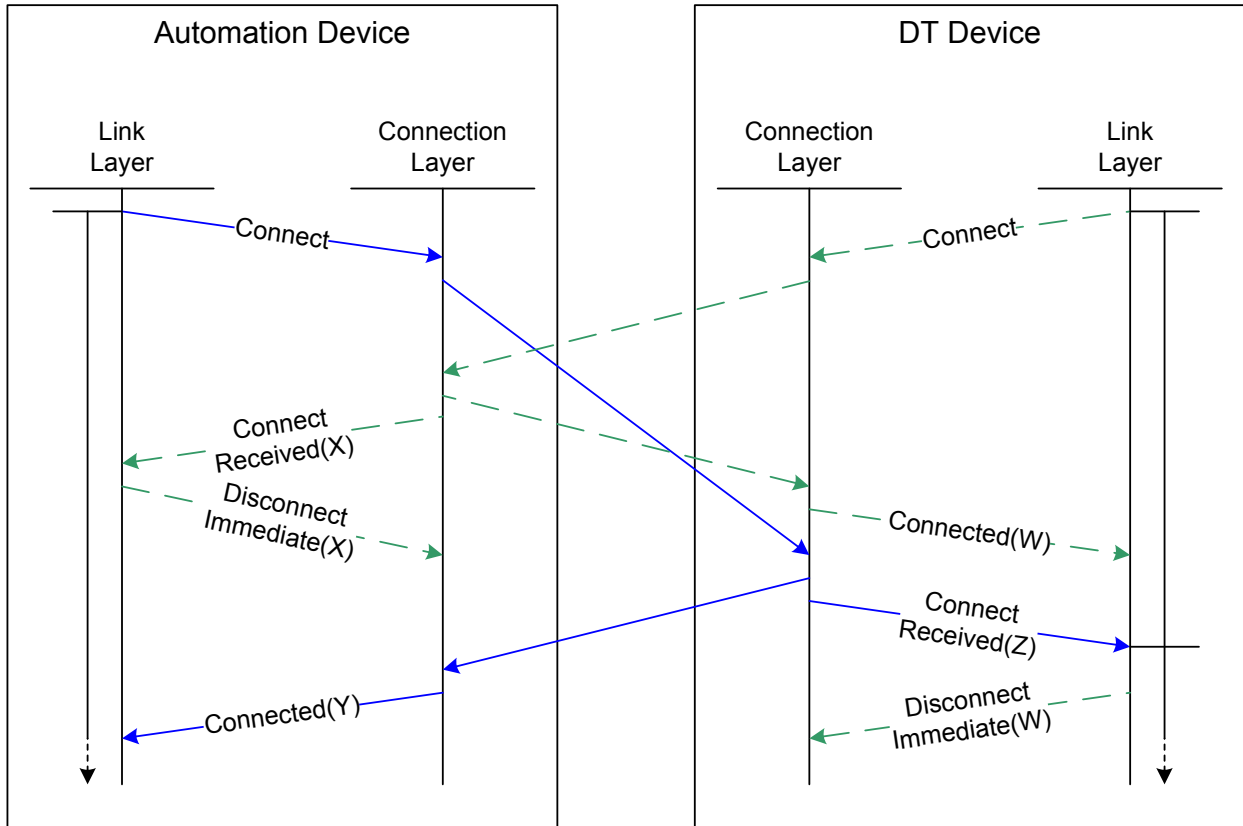


Figure E.4 - DT device-initiated connection established first

E.5 Login sent before second connection established

Figure E.5 shows the case in which the DT device establishes a connection and initiates login before the simultaneous connection initiated by the automation device has been established. Following the rules in 7.6, the connection initiated by the DT device is closed.

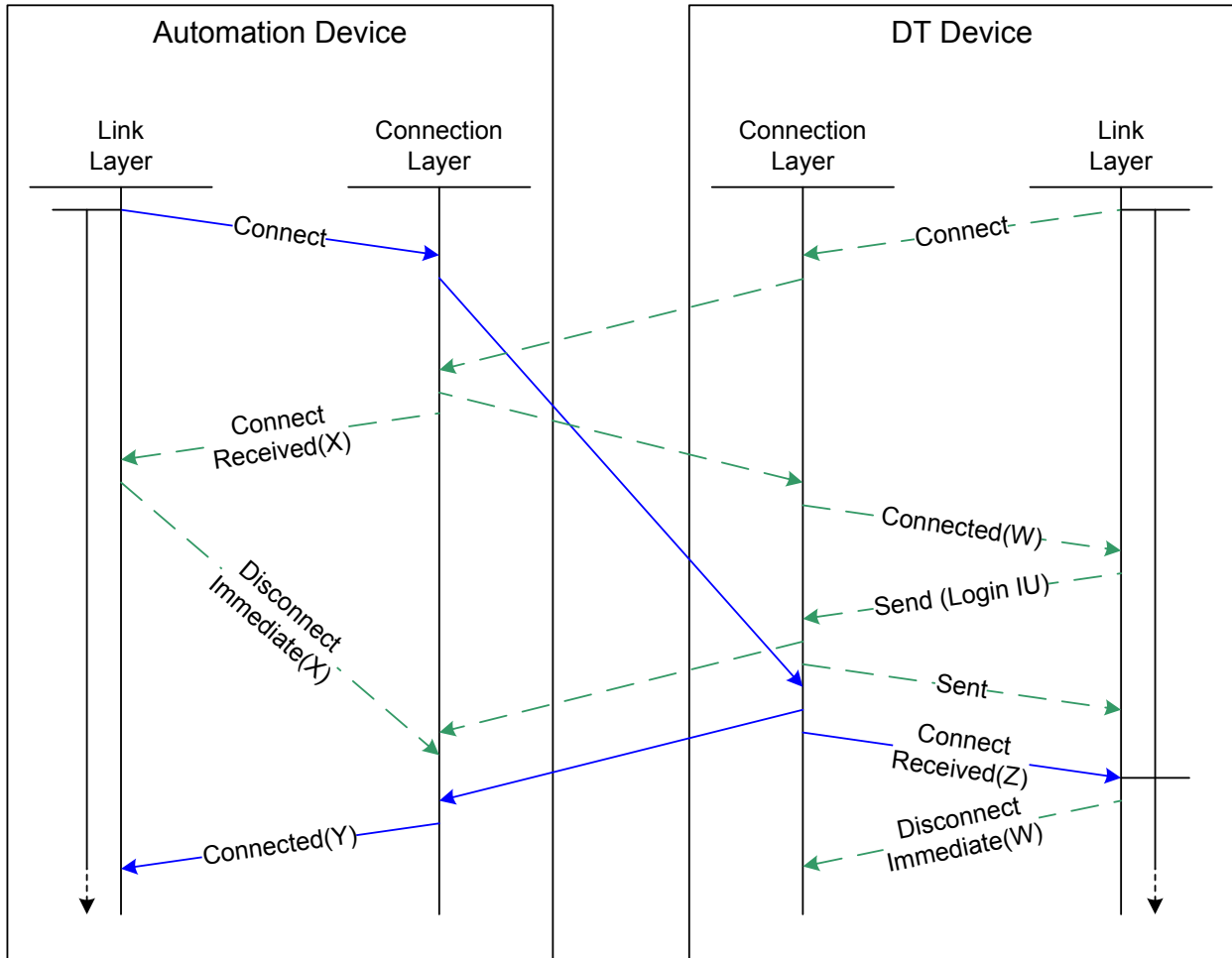


Figure E.7 – Login sent before second connection established

E.6 Connection received in session with established connection

Figure E.6 shows the case in which session A exists in both ports and then unexpectedly ends in one port, requiring establishment of a new session B and a new connection. Following the rules in 7.6, in the port processing the **Connect Received** service indication, session A ends, session B begins, connection Y is established, and the **Disconnect Immediate** service request is invoked to close the previous connection X. In the port initiating the connection, the new connection identifier is W. A new login is then processed.

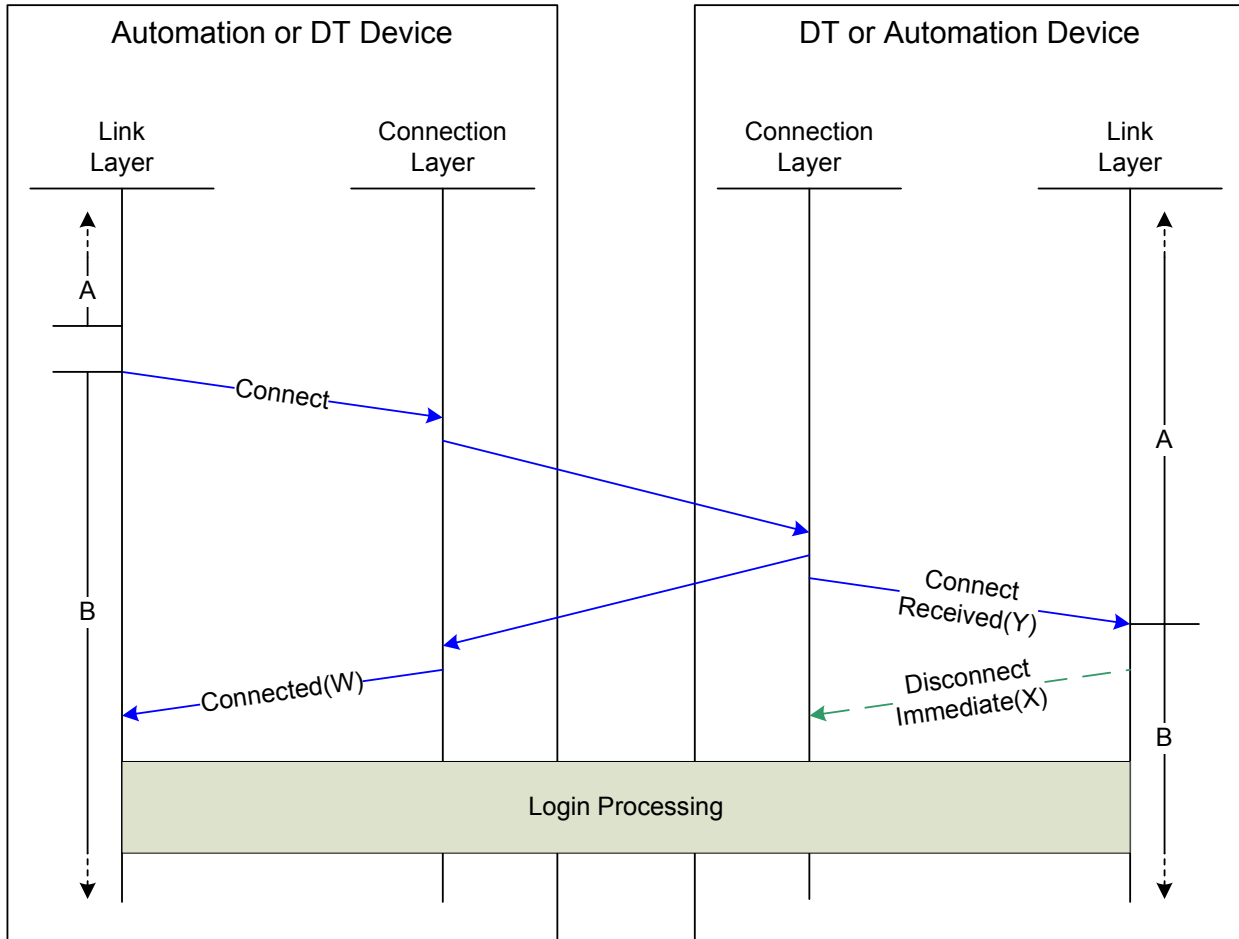


Figure E.6 – Duplicate DTD-initiated connections