



TransferJet™ Overview

Concept and Technology

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TransferJet Consortium



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INTRODUCTION

Two worlds exist for today's consumer: content creation and content playback. The traditional end user still consumes multimedia content by watching TV, listening to music, and viewing family photos. But many end users spend almost as much time producing content. They produce video, music, and photos using cameras, camcorders, cell phones, and digital video recorders (DVRs) to shoot, snap, and record events whenever and wherever they happen. The reason this has become so popular is simple: it is very easy to create content with modern equipment. But there is a problem. Content is easier to create than to transfer. This limits the potential for playback and sharing and creates a kind of bottleneck between content production and content consumption. For example, end users want to view digital family photos on their big screen TV. It is possible today using cables and menus. But is that the best way? Does the complexity allow people to fully enjoy photos at their convenience? Is every member of the family able to view photos in this way? What about the end user that wants to transfer digital photos to their PC? That is also possible using a memory card or a USB cable. And many people successfully navigate that existing procedure. But is there a better way? Or does this procedure also limit the enjoyment factor? Many other opportunities exist for sharing content between devices. Every device has some advantage. Some, like camcorders and digital cameras, are better at creating content. Others, like TVs and notebook computers, are better at playing back content. Still others, like cell phones, fulfill both roles in a portable platform. Clearly, the ability to share content between devices is necessary to bridge the two worlds thus enhancing the enjoyment and value of individual devices. This technical overview presents a solution – TransferJet™ – which solves the content sharing problem in a way that also achieves high performance, low cost, high security, and most importantly, extreme ease of use.



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1. Technology Development

TransferJet™ is a new wireless technology that combines the speed of UWB (Ultra-Wide Band) with the ease of NFC (Near Field Communications). By doing so, TransferJet™ delivers a transfer speed of 560 Mbps available.

The key concept of TransferJet™ is this “touch” model of user operation. This model requires only a simple touch motion from the user to make things happen. Touch is such a natural motion that people tend to “get it” very quickly. Clearly, touch is a very natural and intuitive motion. From a user standpoint, TransferJet™ can be thought of as a universal touch-activated interface which instantly connects a wide variety of consumer (and non-consumer) electronic products. The TransferJet™ technical specifications have been developed in order to realize simplicity of use based on the “touch” model.

1.1. Initial Reference Use Case

The TransferJet Consortium has studied various usage scenarios that are suitable for this “touch” model and prioritized them according to consumer/commercial needs. The TransferJet Consortium ultimately selected the following three use cases as the initial reference use cases. The TransferJet™ 1.0 technical specifications were developed to implement these initial reference use cases.

1.1.1. File Exchange

TransferJet™ enables high speed transfer of large data files (photos, video, images, etc) between two electronic products such as mobile phones, digital cameras, camcorders, computers, TVs, game products, and printers. Using this technology in its simplest form, data can be sent at high speed with just a single touch.

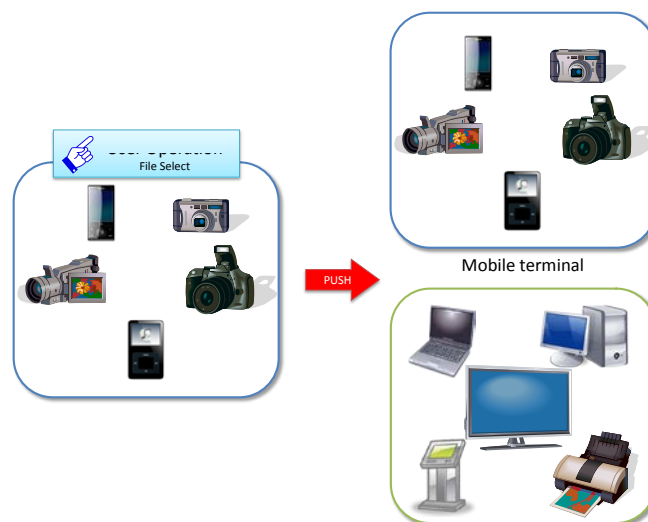
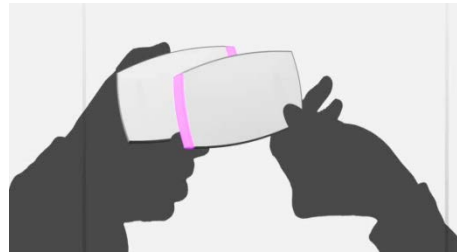


Fig. 1-1 File Exchange (Push)



In this use case, a user can push any data file from her/his mobile terminal to another mobile/stationary terminal just by touching. In certain cases, the user may select the specific data to send as well as the location to store (or method to process) the received data before the actual touch operation. For example, students can share music with friends merely by touching the cell phone to the music player. A tourist can store and archive digital video simply by placing the camcorder close to the PC.



Alternatively, the user can get any data file from another mobile/stationary terminal with a similar touch operation. In most cases, the data to transfer has been selected by the sender and, therefore, the receiver does not have to select the file but just touch and receive it.

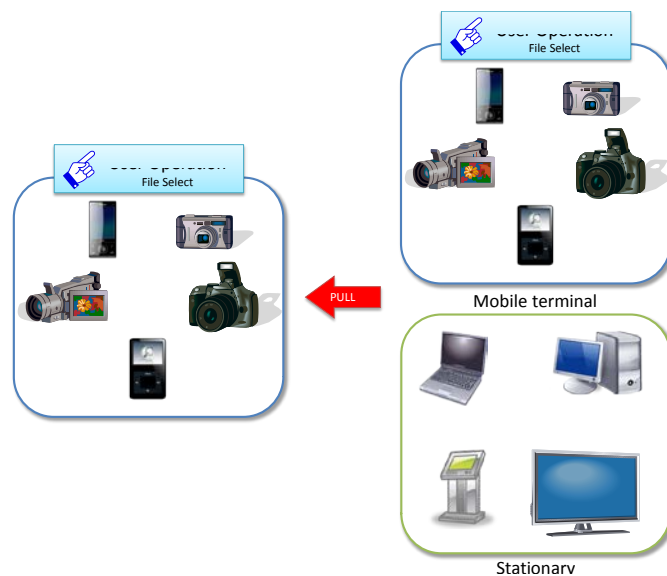
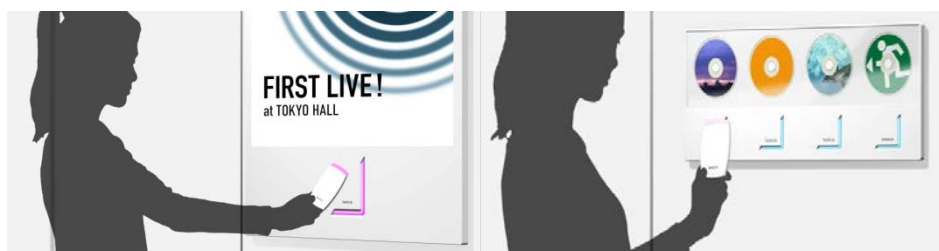


Fig. 1-2 File Exchange (Pull)

As examples of location-based public applications, it is possible to create digital signage and digital kiosks. A person might get files such as coupons, movie trailers, event info or sound clips by touching TransferJet™ pads (target points) placed in public locations. A theme park visitor could download electronic maps and event schedules by touching TransferJet™ pads at the park entrance or other locations.





1.1.2. File access and real time content consumption

A user might access a file system on her/his mobile terminal (such as cell phone, digital camera, or camcorder) by placing it on a TransferJet™ target point connected to a host terminal such as a computer, digital TV, projector or other device. Once connected, one can access, retrieve, manage, and execute any files on the mobile terminal in the same way as local files. The user can play back and enjoy streamed contents on the host terminal having a high resolution display and a high quality surround sound, without any physical cable connection.

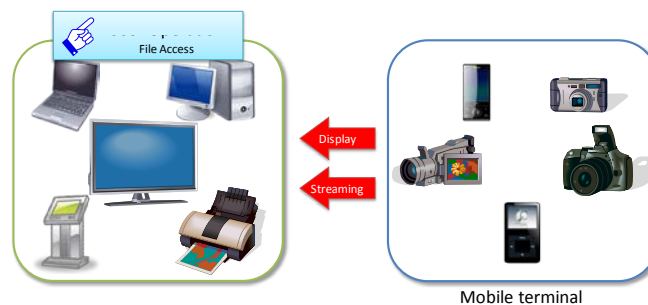


Fig. 1-3 File access and real time content consumption

A family can display digital photos and movies on their living room TV by touching the camera or camcorder to the TV itself or placing on a TransferJet™ pad connected to a STB. The user can control the playback with the TV remote.



1.1.3. Print Services

The last use case is a special case of the previous two. If a file is transferred to a printer, it should be printed in an appropriate manner. In general, there are two possible ways of printing. A user may operate her/his mobile terminal to select the specific file to print and then touch the printer, which will then print in its default mode.

Alternatively, a user may put the mobile terminal on a TransferJet™ pad of the printer, and then select a file to print by operating the printer. In the latter case, the user can specify various print configurations supported by the printer, such as paper size, layout, color.



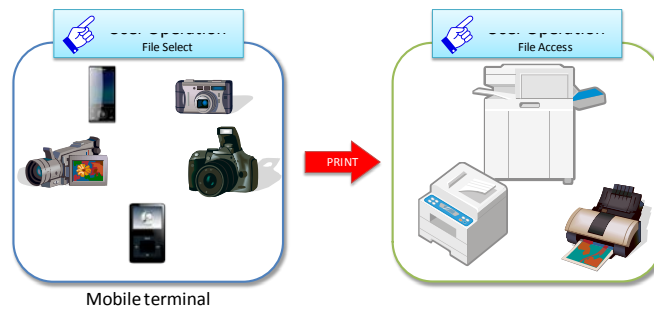


Fig. 1-4 Print service

1.2. Technical Implementation

In order to realize the initial reference use cases, the TransferJet Consortium decided to support two major existing protocols: OBEX (abbreviation of OBject EXchange, also termed IrOBEX) and SCSI (abbreviation of Small Computer System Interface). By adopting these two well-defined and mature protocols, it is possible to incorporate TransferJet™ into a variety of commercial products, services, and applications.

After technical review, the consortium concluded that all initial reference use cases can be implemented by leveraging these two protocols. The file exchange is realized by utilizing the OBEX Inbox Service. The OBEX Folder Browsing Service and SCSI support the file access functions. SCSI is suitable for implementing the real time content consumption services. Print services can be achieved by using either OBEX or SCSI.

In conclusion, TransferJet™ 1.0 supports specific profiles of OBEX and SCSI. The details will be described in Section 4 “Protocol Conversion Layer”.



2. TransferJet™ Technology Overview

The unique qualities of TransferJet™ make it useful for many applications. TransferJet™ can transfer data at a peak speed of 560 Mbps, with an effective throughput up to 375 Mbps. The maximum range of operation is on the order of a few centimeters and the network topology is always point-to-point between two active (powered) devices. These last two features greatly enhance the simplicity of the system. The short range makes it possible to operate in the near field of the radio signal using very little transmit power – at or below -70 dBm/MHz. The point-to-point topology simplifies the network setup and management procedures. And since the near field is a non-polarized field, the two devices do not have to be precisely oriented to achieve a good connection. The spectrum is centered at 4.48 GHz, and occupies a bandwidth of 560 MHz. The choice of this spectrum, coupled with the extremely low transmit power, enables unlicensed operation in Japan, US, the EU, South Korea and other regulatory domains. In addition, TransferJet™ contains a robust protocol which includes error detection and correction, packet acknowledgement, and packet resend. All of these details work together to minimize complexity and interference. The low transmit power and point-to-point topology help to minimize power consumption. Finally, each TransferJet™ device can detect the presence of another device as it comes within range. Therefore, it is possible to save power by transmitting only when another device is detected. This is another advantage of the touch model.

2.1. TransferJet™ Basics

Since TransferJet™ communicates using a radio signal, it must comply with government regulations in any geographic region in which it operates. In the regions that have clearly established regulations, including Japan, South Korea, the EU, and the US, TransferJet™ is compliant for operation indoors or outdoors. The regulatory situation at the time of writing is shown below.

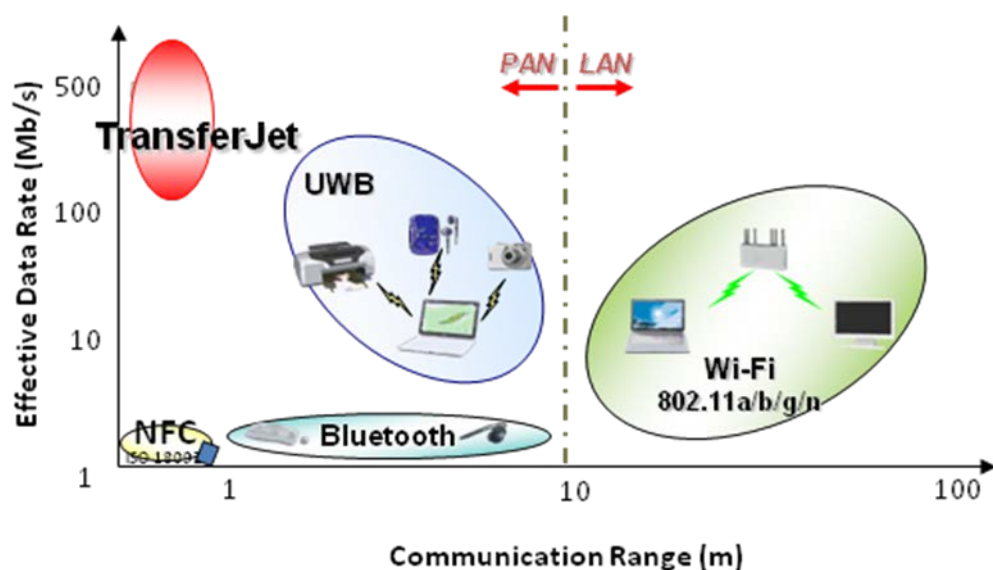


Fig. 2-1 Positioning of TransferJet™ Technology

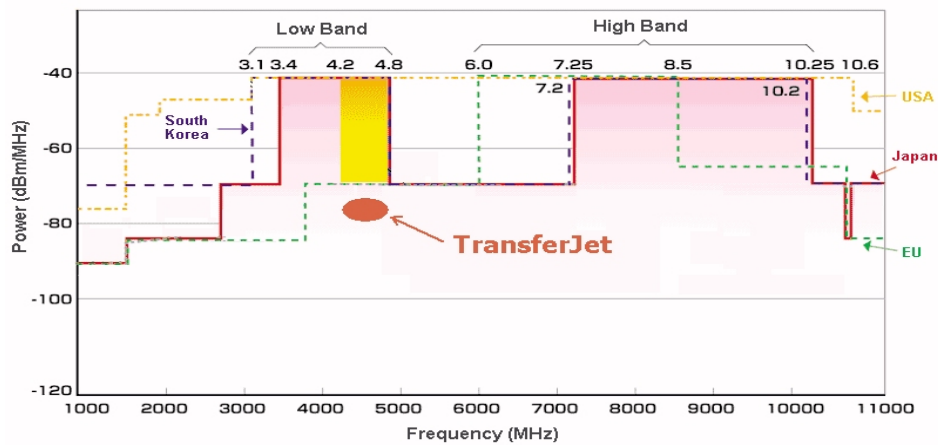


Fig. 2-2 UWB Regulatory Restrictions

Center Frequency	4.48 GHz
Transmission Power	At or below -70 dBm/MHz (average) Corresponds to low-intensity radio wave regulation in Japan, and with local regulations in other countries and regions.
Transmission Rate	560 Mbps (max) / 375 Mbps (effective throughput) System can adjust the transmission rate depending on the wireless environment.
Connection Distance	A few centimeters
Topology	1-to-1, Point-to-point
Antenna Element	Electric induction field coupler

Table 2-1 TransferJet™ Specifications

2.2. TransferJet™ Security

Although TransferJet™ is a near field, point-to-point technology, it is still a wireless connection. So security is a key question. Wireless connections such as 802.11 and Bluetooth have extensive and complex encryption technology built in to the link layer to make sure that an unauthorized receiver cannot access private information. Such link layer encryption is necessary for long range networks because it is impossible to physically restrict access to the



network as would be possible with a cabled solution such as Ethernet or USB. For security purposes, TransferJet™ is more like a physical cable. Therefore, it intentionally has no encryption built into the link layer. It would be very difficult for an attacker to gain access to a TransferJet™ connection from some distant location. The attacker would have to be physically a few centimeters away in order to access the connection, in which case it is easier to simply intercept the USB cable. Everything about TransferJet™ is designed to restrict both the signal level and range of the radiated signal. By eliminating link layer security, TransferJet™ saves power and cost, and further reduces complexity for the user. But it is possible to add encryption at the application layer. Some applications must protect a file's integrity during file transfer regardless of the connection type. TransferJet™ is perfectly compatible with these application-level security measures. Since each device has a unique ID, it is also possible to uniquely identify any device that attempts to establish a connection. So TransferJet™ achieves the best of both worlds, the simplicity of touch, with the security of a cable.

2.3. TransferJet™ Connection

At first glance, the short range of a few centimeters might be considered a disadvantage. But when combined with the touch usage model, it actually offers tremendous advantages. In addition to the low power consumption, the short range virtually eliminates multipath fading or shadowing that occurs in longer range solutions such as 802.11 or Bluetooth. Thus the connection is very reliable without the need for complex equalizers or advanced signal processing such as OFDM. This also helps to minimize cost and power consumption. But the biggest advantage is the ability for each TransferJet™ device to discover another TransferJet™ device that comes within range. Since the range is so short, the protocol can reach a key conclusion upon making this discovery: the user has just authorized a connection with the discovered device. Therefore, the protocol can connect the two devices with no further action required from the user. Once this connection is made, the application can take further steps such as transfer a file, query the user, display a file menu, etc. In this sense, the touch motion in the TransferJet™ world is similar to the cable plug-in action in the USB world. One might say that TransferJet™ provides the ease of a USB cable – without the cable. As with every other wireless protocol, devices must proceed through the necessary stages – search, discovery, selection, authentication, connection, and transfer – in order to complete a desired activity. But TransferJet™ is unique because all these steps are collapsed into a single motion: the “touch”.

2.4. Unique Coupler Element

Surprisingly, it is not so easy to restrict operation to such a short range. If two TransferJet™ devices are separated by *more* than a few centimeters, they should do nothing – not even detect each other. That is a very difficult task for a conventional antenna. A typical antenna is designed to radiate a signal as far as possible. To better understand this behavior, consider the field equations



shown below for an ideal dipole excited by a sinusoidal current.

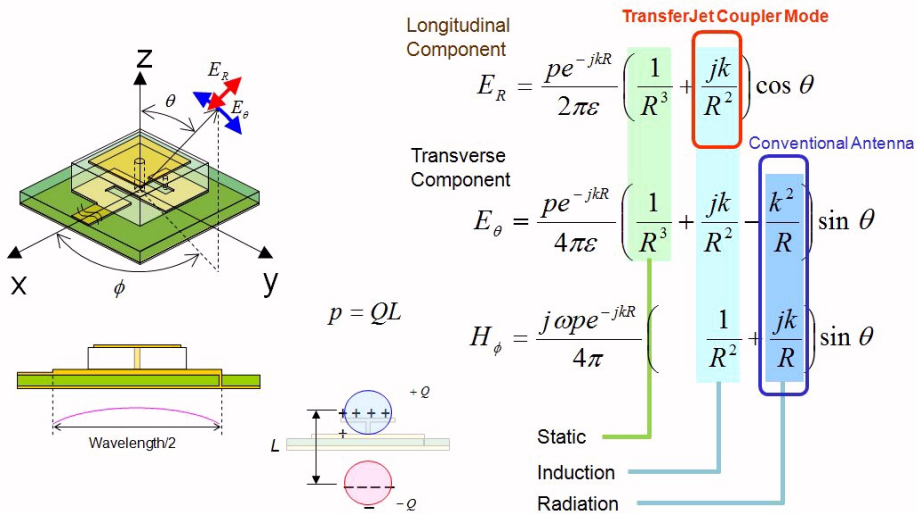


Fig. 2-3 TransferJet™ Coupler Design and Field equations for an Ideal Dipole

The variables in the above equations are as follows:

R = range or distance from the dipole in meters

$k = \omega\sqrt{\mu\epsilon}$ or angular wavenumber of a plane wave

$p = QL$ (where Q is the peak charge and L is the length of the dipole)

ω = angular frequency of the sinusoid in radians/sec

ϵ = permittivity of the propagating medium (air)

μ = permeability of the propagating medium (air)

Note that the field strength of the far-field parts of the signal varies inversely with range. The near field parts, on the other hand, vary inversely with the square of range. Therefore, the near field intensity drops off much faster with range than the far field. The far field also radiates real power. The far field transverse E and H components form the conventional TEM or Transverse Electro-Magnetic wave so common in wireless communications. By contrast, the near field is inductive because it does not radiate real power but instead stores power within the near field. The inductive power is only dissipated if another TransferJet™ coupler appears in the near field. Finally, the near field contains a longitudinal component. This component is important because it is not polarized, making it much easier for the user to align two devices as previously mentioned. All these factors are combined to produce the unique TransferJet™ coupler. The design of one such coupler is shown in Figure 6-4 along with the coordinate system from the ideal dipole analysis. This coupler is not a conventional antenna but instead is designed to suppress the far field component and emphasize the near field signal. The approach creates a virtual bubble of signal energy that drops off very quickly at any range beyond a few centimeters. The result is a usable sensitivity within this distance range. Two



typical TransferJet™ devices establish a connection when brought together. But once established, the link will not break unless the devices are separated beyond the bubble distance. This “soft” engage feature further enhances the convenience and ease to the end user.

2.5. Connection and Sequence

The two TransferJet™ devices that enable data transmission and reception serve as “Responder” and “Initiator” respectively, and they can establish a link only in this combination. Communications cannot take place between two Responders or two Initiators.

The two roles have no relation to the actual direction of data transfer. See Fig. 2-4.

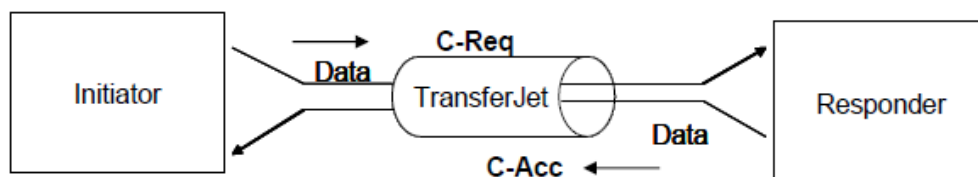


Fig. 2-4 Connection between Initiator and Responder

Example Use Case (File Transfer) Sequence, “Stationary” Device operates in “Initiator” Mode, “Mobile” Device operates in “Responder” Mode. See Fig. 2-5

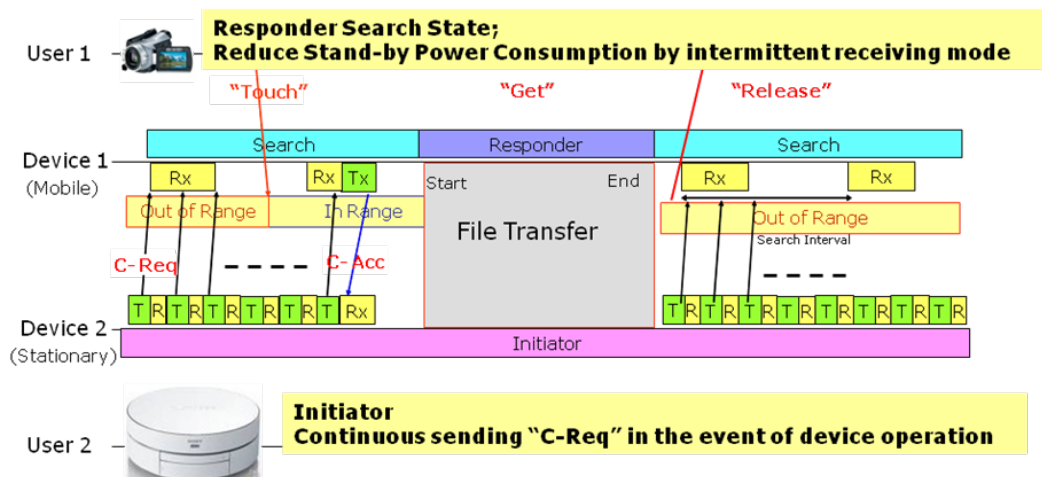


Fig. 2-5 Example Use Case (File Transfer) Sequence



2.6. Specification Details

TransferJet™ Specifications consist of the following three Layers.

- Physical Layer (PHY)
- Connection Layer (CNL)
- Protocol Conversion Layer (PCL)

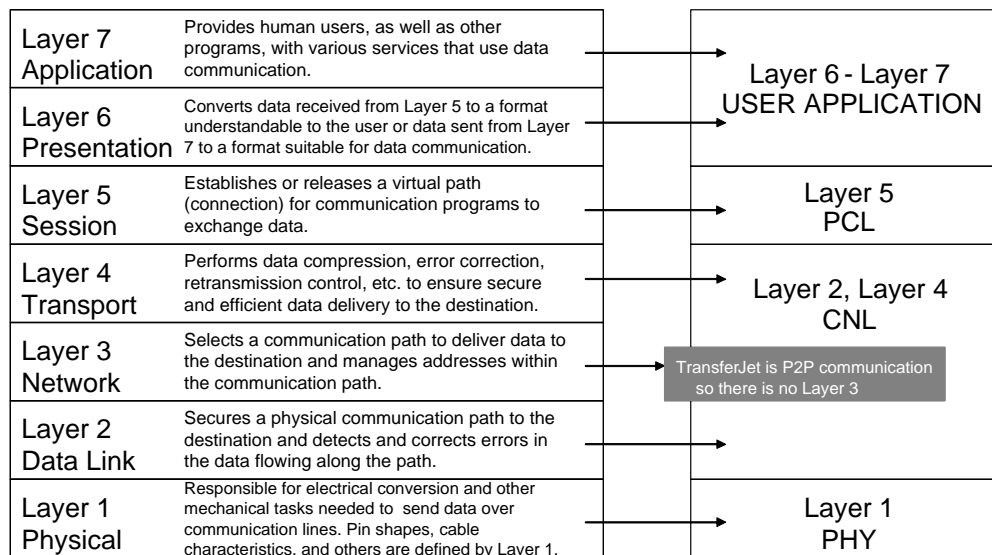


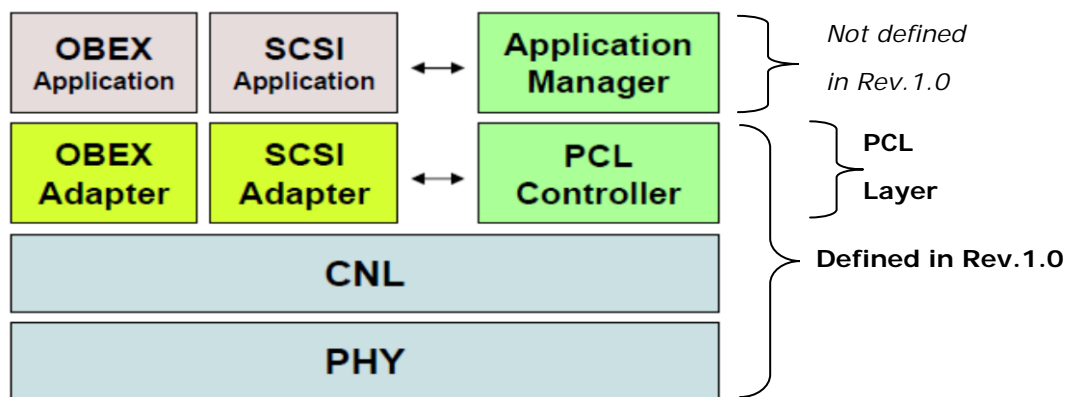
Fig. 2-6 TransferJet™ Layer Model and OSI Layer Model



3. Architecture and Hierarchy

The Physical layer, or PHY, defines the actual radio. This layer converts the digital information into an RF signal suitable for transmission across the TransferJet™ couplers. The Connection Layer, or CNL, manages the connection and data delivery. For connection management the CNL is responsible for establishing and releasing the connection to a peer TransferJet™ device. For data delivery, the CNL provides packets to carry the data payload and confirm successful delivery of those packets to the peer device. The Protocol Conversion Layer, or PCL, is responsible for converting from an Application's existing interface standards (such as SCSI or OBEX), and the TransferJet™ native protocol. In this way, for example, a stationary device can access data on a mobile device without modification to the application layer software. There is also a separate Application Management Layer (not defined in Rev. 1.0) that coordinates and manages the applications, as well as guidelines that define how devices should provide feedback to inform the user of the progress of a transfer operation.

Fig. 3-1 Hierarchical structure of TransferJet™ Stack



3.1. Physical Layer Overview

During transmission, the Physical Layer (PHY) receives the digital data stream from the upper Connection Layer (CNL) and converts to an analog RF signal centered at 4.48 GHz, which feeds the induction coupler element. The PHY data packets are structured in the form of Service Data Units (PSDU) separated by inter-frame spaces (IFS). The PSDU starts with a preamble, sync and header followed by a variable-length payload that can typically last about 2 msec. The PSDU applies forward error correction (FEC), spreading, scrambling and modulation together with multirate support capability. The modulation used is direct sequence spread spectrum (DS-SS). Complicated schemes such as OFDM are not needed since, unlike traditional wireless systems, the point-to-point proximity connection does not suffer from instabilities arising from reflections or interference. The transmitted RF power level is controlled such that it will not exceed -70 dBm. During reception, the PHY performs the reverse operations to convert the RF signal from the coupler into a digital data stream that can be handled by the upper CNL.



In conjunction with the special coupler optimized for the transmission and reception of longitudinal electric induction waves and having a sharp spatial attenuation characteristic, the PHY is designed to achieve excellent close proximity data transfer operating at a separation distance that is well below $1/2$ wavelength at the carrier frequency.

3.2. Modulation Scheme

Table 3-1 shows the PHY modulation parameters of this system. For the modulation scheme, the system employs Pi/2 shift BPSK at a chip rate (R_c) of 560 Mcps.

Here, the chip rate refers to the bandwidth occupied on the frequency axis, while the reciprocal of the chip rate ($1/R_c$) represents the interval between samples of the envelope concatenated along the time axis. Since the system utilizes Pi/2 shift BPSK for the modulation, the occupied bandwidth (R_s) on one channel (Ich or Qch) is half the bandwidth (R_c) of the envelope; hence, the relationship of $R_s = 1/2R_c$ is established.

Also, the system adopts a concatenated coding method using convolutional codes and Reed-Solomon codes for forward error correction (FEC).

Chip Rate: R_c	560 Mcps
Chip duration: $T_c = 1/R_c$	1.786 nsec
Symbol Rate: R_s	280 Msps
Carrier Center Frequency: F	4.48 GHz
Modulation	Pi/2 shift BPSK + DSSS
FEC	1/2 Convolutional code + Reed Solomon code

Table 3-1 Tx Signal Specification

3.3. Frame Format

Fig. 3-2 shows the format of the packet frame used by this system. This figure expresses the case of 2 CSDUs in the CPDU.

The CPDU frame from CNL is divided into 224-byte message blocks and RS (Reed-Solomon) parity is added after each 224-byte block. The size of the last message block will be 1 to 224 bytes as shown in Fig. 3-2. RS parity of the last message block is calculated by expanding the message size to 224 bytes with zero padding. The added zeros of the last block are not transmitted and will be recovered at the receiver.

Convolutional encoding is applied to the output of the RS-encoder. The output length of the convolutional encoder will be doubled due to the $R = 1/2$ convolutional code.

Tail bits which include all zero bits are added after the convolutional encoded data. These tail bits initialize the state of the Viterbi decoder in the receiver.



Finally, the transmitter adds spreading, scrambling, and Pi/2 BPSK mapping to form the Tx packet payload. This payload is combined with the Preamble, Sync word, and PHY Header to complete the Tx packet.

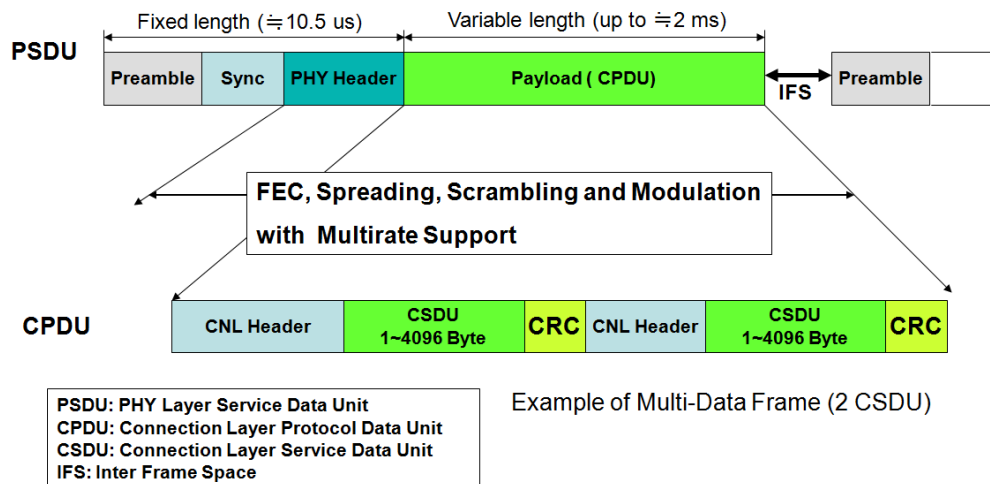


Fig. 3-2 PHY and CNL Packet Structure

3.4. Connection Layer Overview

The main functions of the Connection Layer (CNL) consist of establishing, maintaining and releasing the connection, or data link, between the two devices, as well as ensuring the integrity of the data transfer. One CNL Protocol Data Unit (CPDU) contains headers, subheaders, CRC bits and either one or two payload, each having 1-4096 Bytes of data. In terms of functionality, the device that transmits the initial connection request is defined as the “initiator” while the device that responds and accepts the request is called the “responder”. These terms refer to the initial handshaking sequence and have no relation to the actual direction of user application data (which is bi-directional). The initiator may send out the request signals continuously or in specific moments. The responder search state can minimize power consumption by means of intermittent operation.

In the rare event that there exists more than one device trying to establish a connection, the CNL will arbitrate the media access and select just one by means of random back-off.

Since all connections are point-to-point, there is no network or IP layer in the protocol stack and the CNL exchanges data directly with the upper PCL (Layers 4 and 5).



3.4.1. CNL state

The CNL has eight states and three sub-states to manage the connection as follows.

Table. 3-1 CNL states

State name	Description
Close	In this state, the CNL is not being activated.
Search	This state is for waiting for the connection request (C-Req).
Connection Request	This state is for requesting a link establishment.
Accept Waiting	This state is for waiting for the PCL response, after receiving the C-Req from the initiator candidate.
Response Waiting	This state is for waiting for the PCL response, after receiving the C-Acc from the responder candidate.
Responder Response	This state is for accepting a link connection.
Initiator Connected	In this state, the CNL is being connected.
Responder Connected	In this state, the CNL is being connected.

The Initiator Connected state and the Responder Connected state have the following sub-states.

Table. 3-2 CNL sub-states

Sub-state name	Description
Connected	In this sub-state, Data CPDU can be exchanged.
Local Hibernate	This sub-state is for performing hibernation while being connected.
Target Sleep	This state is used when it is assumed that the target is hibernating and the own entity is not hibernating.



Fig. 3-3 shows the CNL state transition.

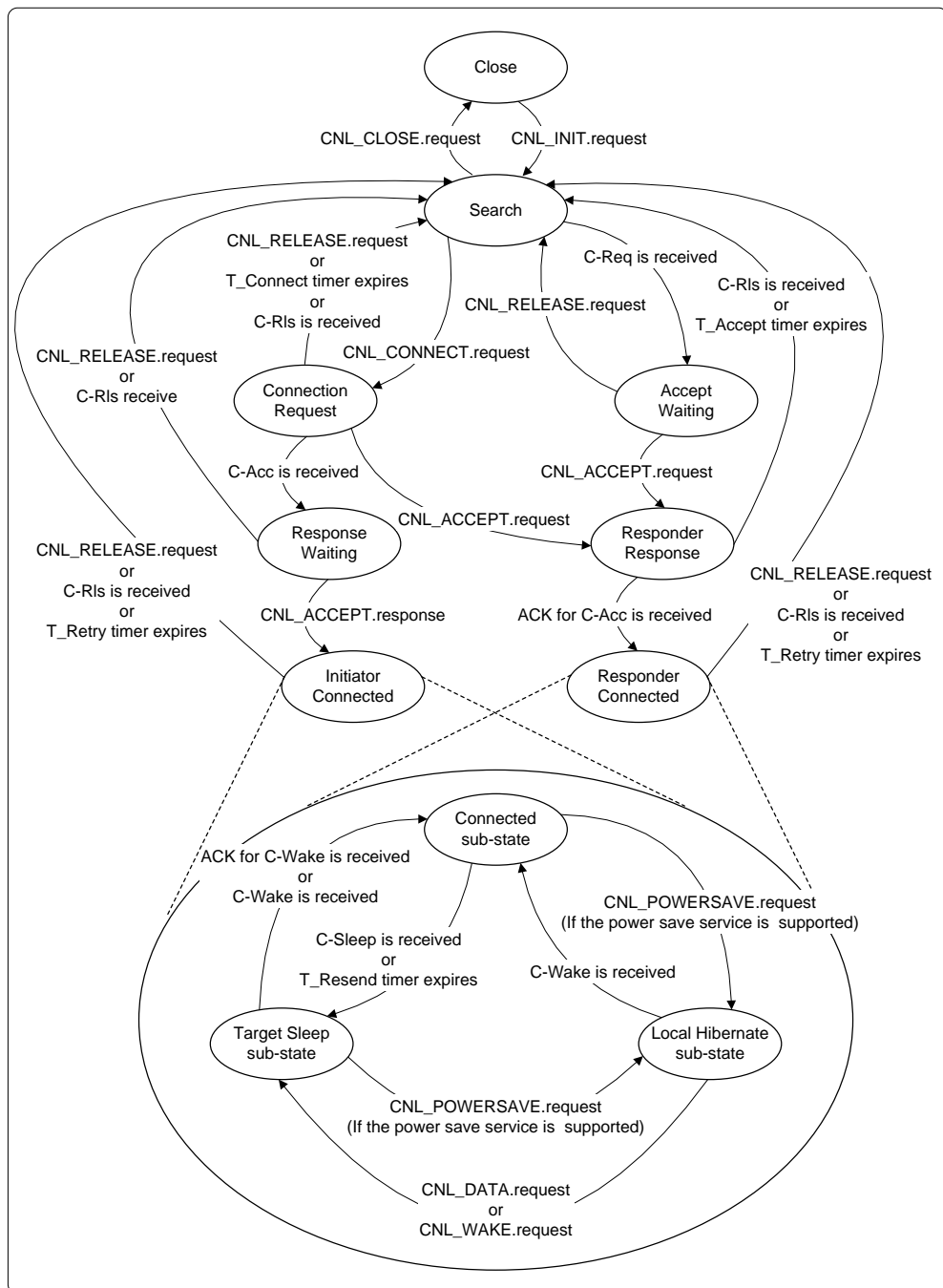


Fig. 3-3 CNL state transition



4. Protocol Conversion Layer Overview

The Protocol Conversion Layer provides the necessary control functions to enable basic communications with the upper layer as well as the adapter functions to map the lower CNL layer to the upper applications and system interfaces.

4.1. Protocol Conversion Layer Controller

The PCL Controller offers common services, such as initialization and basic communications (connection setup, connection release, and device authentication) to the Upper Layer.

4.1.1. Services

The PCL Controller provides the services (hereinafter called “PCLC Services”) described below, using the mechanisms provided by the CNL. Also the services composed of the PCLC Services and the services provided by PCL Adapter are hereinafter called “PCL Services”.

1. Connection Management service

The PCL Controller provides a service that manages the establishment and release of a connection between two TransferJet™ devices. When two TransferJet™ devices enter the communication range, the service establishes a CNL connection, unless the Device Modes (see 4.1.2) of both devices are Reactive Mode.

2. Device Authentication service

The PCL Controller provides a service for authenticating CNL-connected TransferJet™ devices. This device authentication is mutual.

3. Application-Service Control service

This service provides a framework for CNL-connected TransferJet™ devices to determine the desired Application-Service (this is defined as a service provided by a pair of applications that each is executed on the TransferJet™ device).

See 4.1.3 about Application-Service Parameter which is a combination of components necessary to determine the Application-Service.

4.1.2. Device Model and Device Modes

The PCL Controller supports the two types of use case described below, by working in conjunction with the Upper Layer.

- a) After a specific application starts on one device, that device touches a peer device. The peer device selects and starts the protocol and application corresponding to the application running on the other device.
- b) Two devices touch each other when no specific application has yet to start on either of them. Based on the priority relationship between the devices, the device with the higher priority starts an application. The other device



with the lower priority selects and starts the protocol and application corresponding to the application started on the higher priority device.

To implement these two types of use case, TransferJet™ devices dynamically use the three modes described in Table 4-1. These are called the Device Modes. The table also shows the priority relationship among the Device Modes. Hereinafter, the device with the higher priority value is referred to as the High Priority Device, and the device with the lower priority value is referred to as the Low Priority Device.

Device Mode	Device Mode priority	Description
Proactive Mode	High	A device in this mode uses the Application-Service provided by the peer device.
Flexible Mode	Middle	A device in this mode behaves differently depending on the mode of the peer device.
Reactive Mode	Low	A device in this mode is standing by to provide its Application-Service at the request of the peer device.

Table 4-1 Device Mode Definition

Use case (a) corresponds to the combination of either a Proactive Mode device and a Reactive Mode device or a Proactive Mode device and a Flexible Mode device. Use case (b) corresponds to the combination of a Flexible Mode device and a Reactive Mode device. A CNL connection is successfully established even in the case of any other combination except the case between the both Reactive Mode devices, although the PCLC Services will not be executed. This is summarized in Table 4-2.

	Proactive	Flexible	Reactive
Proactive	N/A	Use case (a)	Use case (a)
Flexible	Use case (a)	N/A	Use case (b)
Reactive	Use case (a)	Use case (b)	-

Table 4-2 Relationship between Device Mode Combinations and Use Cases

4.1.3. Application-Service Parameter

The Application-Service Parameter is a combination of components necessary to determine the Application-Service to be provided by a pair of two



TransferJet™ devices. Table 4-3 describes the components of this Application-Service Parameter.

Component	Description
Protocol	Communication protocol for data communication between the applications running on TransferJet™ devices.
Protocol Class	Defines the protocol operation rule to ensure interconnectivity communication between the applications running on TransferJet™ devices. This parameter is dependent on Protocol.
Protocol Extension	Defines a component necessary to determine an Application-Service that cannot be defined by Protocol and Protocol Class. This parameter is dependent on Protocol and Protocol Class.

Table 4-3 Application-Service Parameter

Protocol Class is a dependent concept of Protocol, and Protocol Extension is a dependent concept of Protocol and Protocol Class. An Application-Service is represented by the combination of Protocol, Protocol Class, and Protocol Extension. Fig. 4-1 shows the conceptual diagram of the Application-Service Parameter.

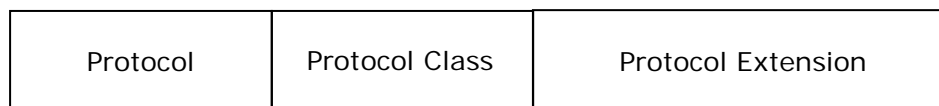


Fig. 4-1 Overview of Application-Service Parameter

A TransferJet™ device can start the desired Application-Service by the Upper Layer performing the following procedure via the PCL Controller.

1. Acquire the Application-Service Parameter list from the peer device.
2. Search Application-Services and determine the desired one, based on the Application-Service Parameter list acquired from the peer device.
3. Set the Application-Service Parameter corresponding to the desired Application-Service to the peer device.

This procedure allows an application to be executed that is associated with the Application-Service Parameter negotiated between the two TransferJet™ devices. In step 3, no more than one Application-Service Parameter can be set to a single TransferJet™ device at a time. Also, only a Proactive Mode Device can set an Application-Service Parameter to the peer device.



4.1.4. PCL Controller Message

PCLC Messages are control messages that two PCL Controllers exchange after CNL connection establishment. They are used to implement the PCLC Services.

PCLC Messages are categorized into four types described in Table 4-4.

The basic PCLC Message exchange procedure begins when the device sends a Request Message and ends when the device receives a Response Message for the request. Fig. 4-2 shows the sequence of this typical case.

If the processing requested by the peer device takes time and a Response Message cannot be returned within a certain amount of time, the responding device sends a Pending Message to notify the peer device that the request is being processed. A Pending Message is sent repeatedly until a Response Message is returned. Fig. 4-3 shows the sequence of this typical case.

An Abort Message is a special message used to request that the PCL Services be stopped forcibly.

The Request Message and the Abort Message are sent from High Priority Device, and the Response Message and the Pending Message are sent from Low Priority Device.

PCLC Message Type	Description
Request Message	Message that requests the PCLC of the peer device to perform processing.
Response Message	Message that is returned in response to a request from the PCLC of the peer device.
Pending Message	Message that notifies the PCLC of the peer device that its request is being processed.
Abort Message	Message that requests the PCLC of the peer device to abort the PCL Services.

Table 4-4 PCLC Message Type

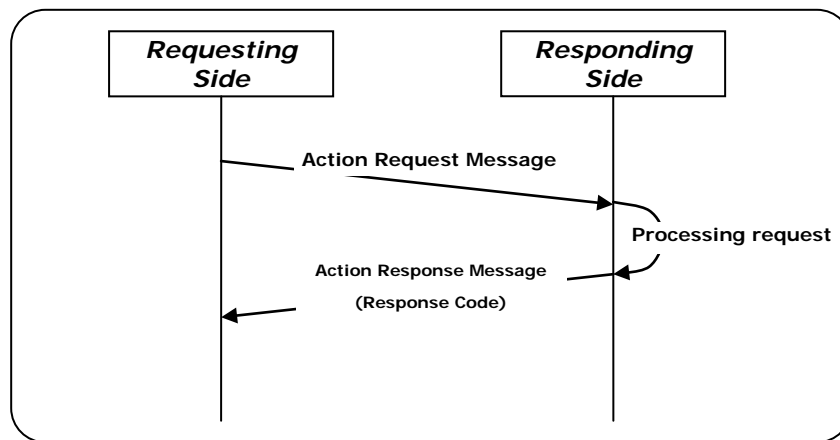


Fig. 4-2 Sequence That Applies When the Requested Processing Asked for the Responding Side Is Completed within ResPeriod

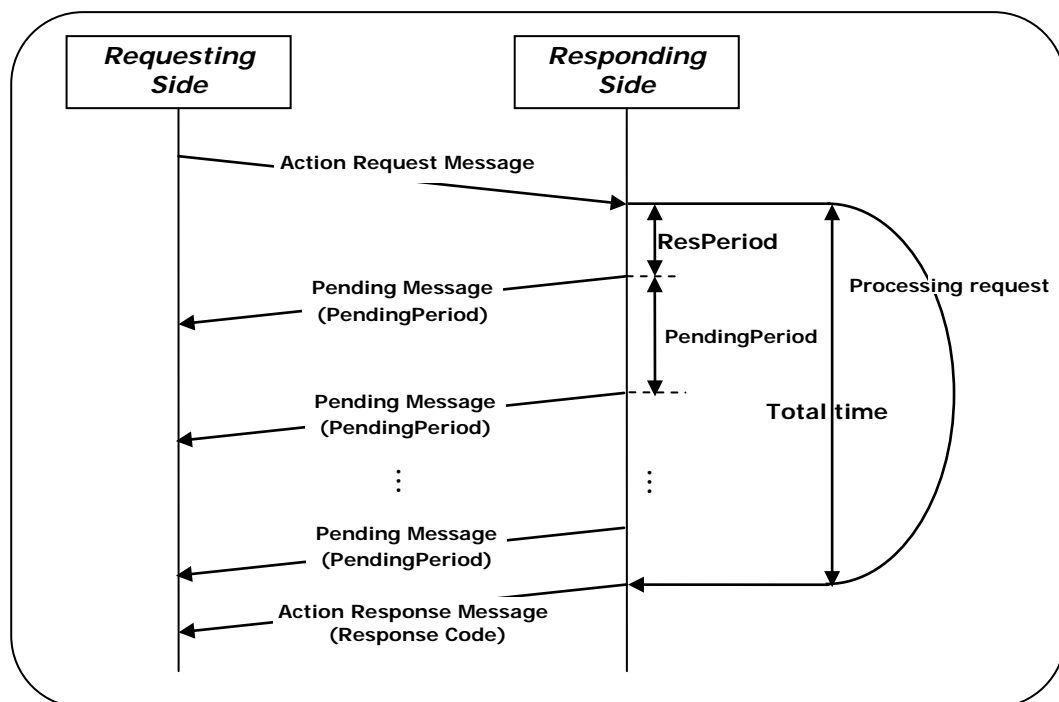


Fig. 4-3 Sequence That Applies When the Requested Processing Asked for the Responding Side Is Not Completed within ResPeriod



4.1.5. Overview Flow of PCL Controller

Fig. 4-4 shows overview flow in the typical case when the PCL Controller starts an Application-Service.

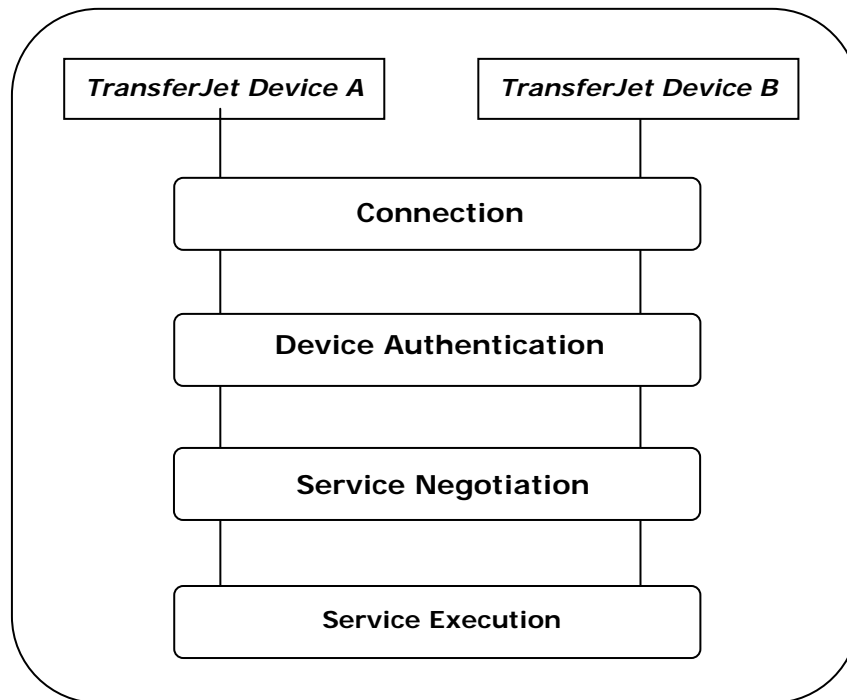


Fig. 4-4 Overview Flow When the PCL Controller Starts an Application-Service

- **Connection:**
When two TransferJet™ devices are brought close together within the communication range, the PCL Controller establishes a CNL connection between the TransferJet™ devices.
- **Authentication:**
When a CNL connection is successfully established, after exchanging device information (Vendor ID, Product ID, Product Class, Vendor Name, and Product Name) between CNL-connected TransferJet™ devices, the PCL Controller handles the exchange of PCL Controller Messages used to implement device authentication.
- **Service Negotiation:**
When device authentication is successful, the TransferJet™ device starts an Application-Service by the Upper Layer getting the Application-Service Parameter list and setting an Application-Service Parameter via the PCL Controller.
- **Service Execution:**
When an Application-Service successfully starts, an Application-Service is executed.



4.1.6. PCL Controller state

The PCL has three states (Unconnected/Connecting/Connected) and four sub-states (Authentication/Negotiating/Executing Service/No Service) to manage PCL connection.

Fig. 4-5 shows the PCL Controller state transition.

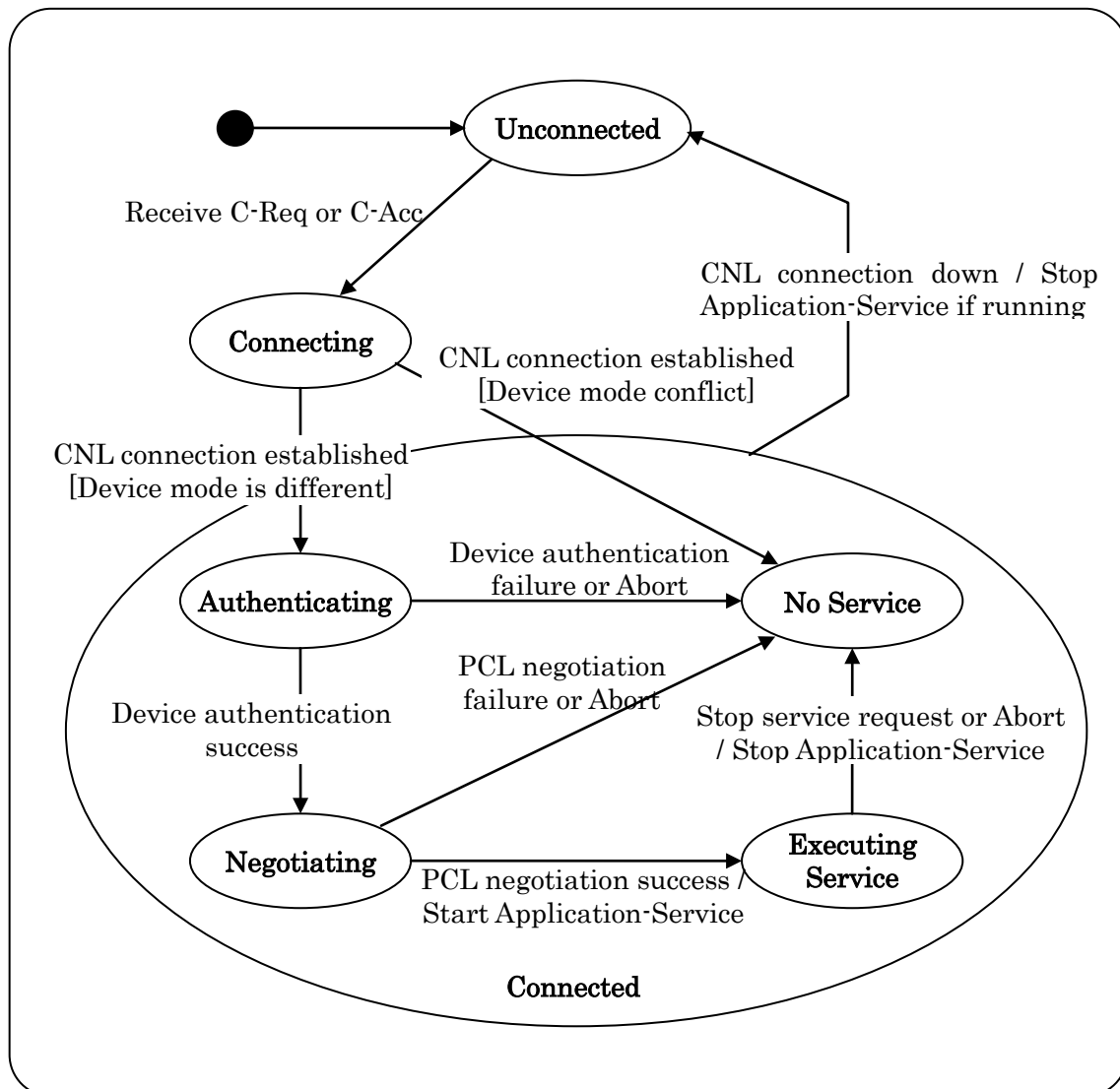


Fig. 4-5 PCL Controller state transition



4.2. Overview of OBEX Application and Adapter

PCL OBEX is a type of PCL Adapter that handles transparent user data transmission to the peer PCL OBEX. Only one connection is supported by PCL OBEX, and only the OBEX protocol is the allowable upper layer user. PCL OBEX consists of OBEX Server and OBEX Client, which have the same service and function to the user. Thus, they are not distinctively mentioned in the following descriptions. PCL Controller activates the PCL OBEX entity after TransferJet™ inter-device connection establishment and adapter type negotiation. Fig.4-6 shows the protocol stack including PCL OBEX.

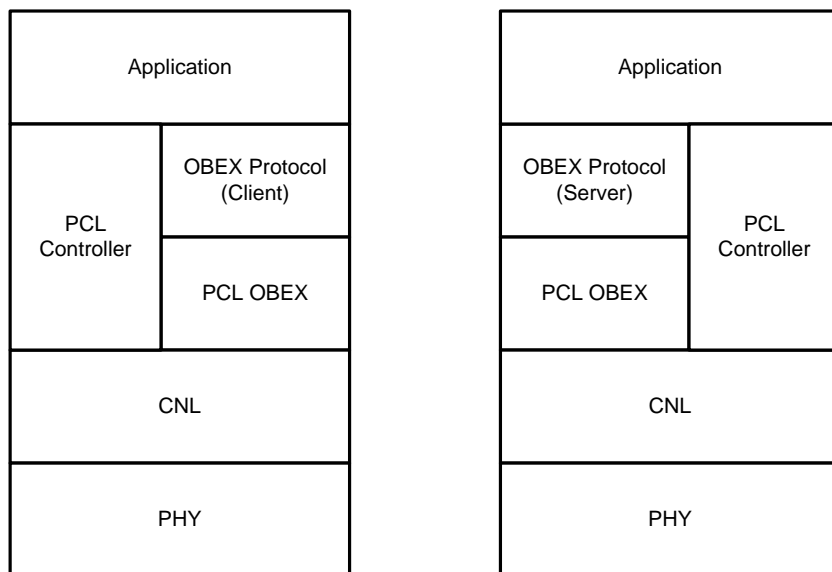


Fig.4-6 PCL OBEX Protocol Stack

The "Protocol Class" mentioned here describe the operation rules for the OBEX protocol specification used by the applications.

Protocol Class is determined taking into account such factors as the TransferJet™ characteristics, expected use cases, functions, and implementation cost. TransferJet™ Version 1.0 defines the following two basic Protocol Classes for the OBEX applications.

"Push Protocol Class"

This class allows the client to put an arbitrary file to the server.

It is based on the Inbox Service described in IrDA Object Exchange Protocol Ver.1.4.

"File Transfer Protocol Class"

This class supports file transfer and file/folder operation capabilities equivalent to those of FTP.



It is based on the Folder Browsing Service described in IrDA Object Exchange Protocol Ver.1.4.

4.2.1. Format of Protocol Data Unit

OBEX PCL PDU has no additional information such as header or padding. The maximum PCL OBEX PDU and PCL OBEX SDU sizes are the same as that of an OBEX packet defined for the OBEX protocol. Fig. 4-7 shows the OBEX protocol layer, PCL OBEX, and inter-layer data flow in CNL. The user data of the OBEX protocol (OBEX packet) is mapped to a PCL OBEX SDU one to one. PCL OBEX delivers PCL OBEX PDU to CNL in user data transmission. CNL divides it into CSDUs to generate CPDUs. To indicate the end of the PCL OBEX PDU, the More Fragment Bit of the final CPDU is set to 0. In user data reception, CNL connects those up to the CSDU with More Fragment Bit 0 in the same manner and passes it to PCL OBEX. PCL OBEX passes the PCL OBEX SDU to the OBEX protocol layer.

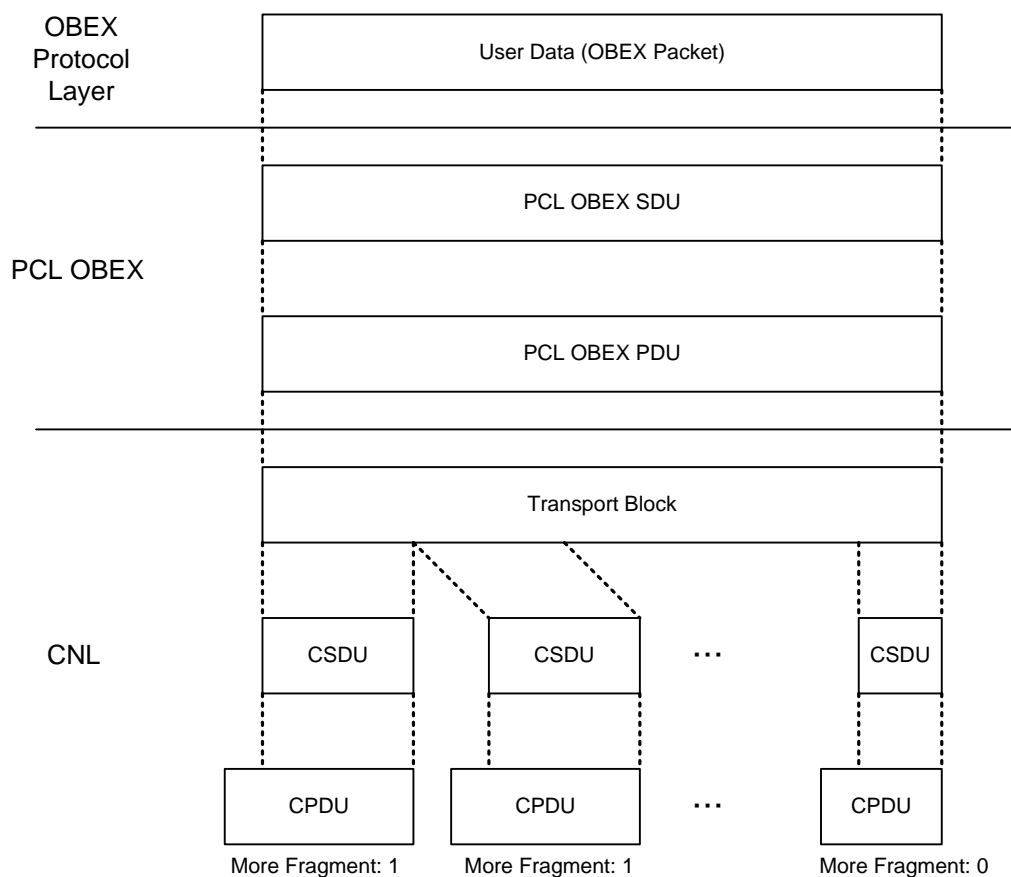


Fig. 4-7 Data Flow for PCL OBEX



4.2.2. Sequence

Fig. 4-8 shows an example of the data transmission sequence. PCL OBEX receives the start request PCL_OBEX_START.request from PCL Controller after TransferJet™ connection establishment and starts operating. After that, user data is transferred to/from the OBEX protocol layer with PCL_OBEX_DATA.request/ PCL_OBEX_DATA.indication until the stop request PCL_OBEX_STOP.request is received from PCL Controller.

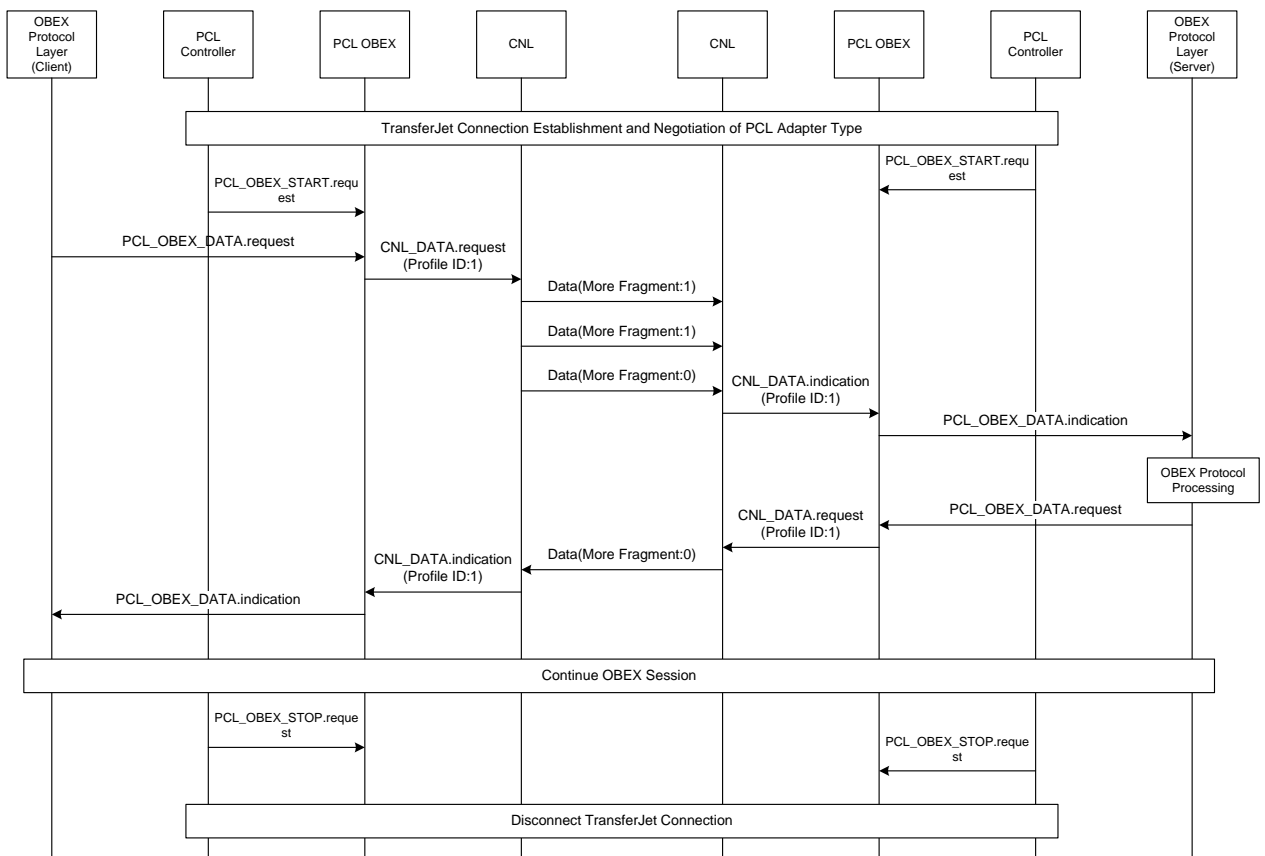


Fig. 4-8 Example of PCL OBEX sequence



4.3. Overview of SCSI Application and Adapter

PCL SCSI is a PCL Adapter that enables I/O operations between devices which support SCSI protocol. According to the SCSI protocol, the devices work as a SCSI Initiator or SCSI Target.

There is only one application client in the SCSI Initiator, single or multiple logical units in the SCSI Target. PCL SCSI maintains only one I_T nexus on TransferJet™ connection. Fig. 4-9 shows a protocol stack including PCL SCSI.

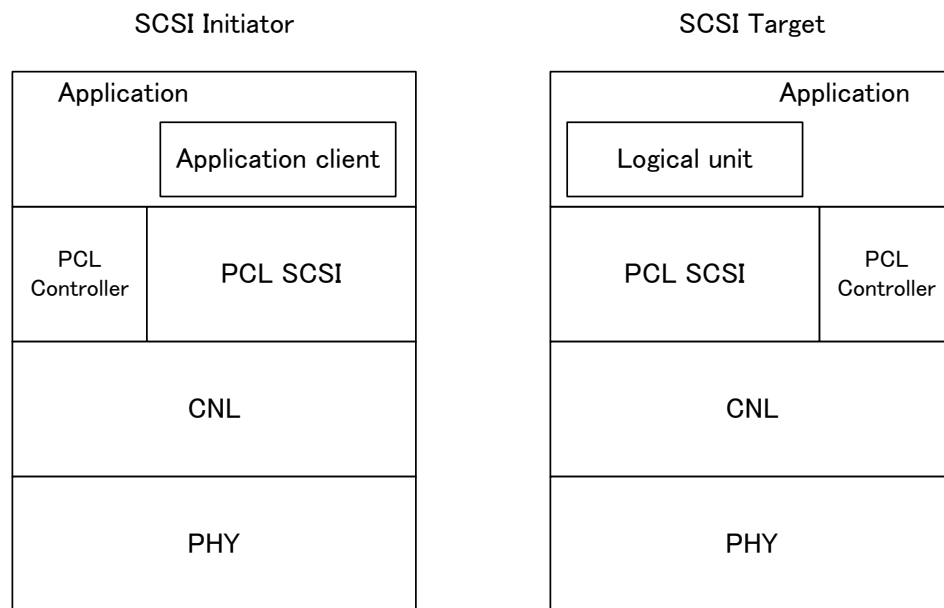


Fig. 4-9 PCL SCSI Protocol Stack

PCL SCSI defines the following Protocol Classes for SCSI applications which are meant to provide interoperability between an application client in the SCSI Initiator and a logical unit(s) in the SCSI Target. The Protocol Class is determined taking into consideration such factors as the TransferJet™ characteristics, expected use cases, functions, and implementation costs.

"Block Device Class"

This Protocol Class is used to communicate between an application client and a logical unit(s) supporting SCSI Block Commands.

This Protocol Class has the following two types of Protocol Class according to the device role of SCSI (Initiator/Target).

- Block Device Class - Target
- Block Device Class - Initiator

"Block Device Class + SD-SCSI Pass-Through"

This Protocol Class is used to communicate between an application client and a logical unit(s) supporting SCSI Block Commands and SD-SCSI Pass-Through Commands. The SD-SCSI Pass-Through Commands can be utilized to transfer arbitrary SD commands over "SD Command over SCSI Protocol" specified in



the TransferJet specifications.

This Protocol Class has the following two types of Protocol Class according to the device role of SCSI (Initiator/Target).

- Block Device Class + SD-SCSI Pass-Through - Target
- Block Device Class + SD-SCSI Pass-Through - Initiator

4.3.1. SCSI Implementations over TransferJet™

A SCSI Command is executed by transferring PCL SCSI PDU into which SCSI Command, SCSI Data (in/out) or SCSI Command Response is encapsulated.

To execute the SCSI Command, PCL SCSI defines two types of PDU, which are PDU of SCSI Command and PDU of SCSI Command Response. In the case of SCSI Command with data-in transfer, SCSI Data is included in the PDU of SCSI Command Response. In the case of SCSI Command with data-out transfer, SCSI Data is included in the PDU of SCSI Command. (See PCL SCSI Adapter Specification for the other types of PDU)

The data flow between PCL SCSI and CNL is shown below.

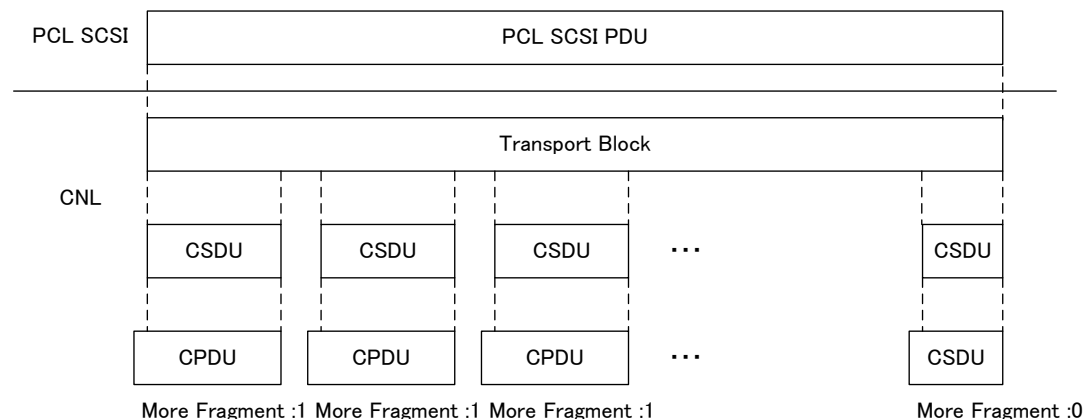


Fig. 4-10 Data flow of PCL SCSI

If the length of PCL SCSI PDU is greater than the maximum length of CSDU, the PCL SCSI PDU is divided into CSDUs, and CPDUs corresponding to each CSDU are created. When the CSDU is not the last one to be transmitted from a given PDU, then the CPDU whose More Fragment is set to '1' is transmitted. When the CSDU is the last one to be transmitted, the CPDU whose More Fragment is set to '0' is transmitted. When a CPDU whose More Fragment is set to '0' is received, it means that the PCL SCSI PDU has been received.



4.3.2. SCSI Command execution sequence

4.3.2.1. Sequence of SCSI Command without data transfer

Fig. 4-11 shows an example of sequence of SCSI Command without data transfer.

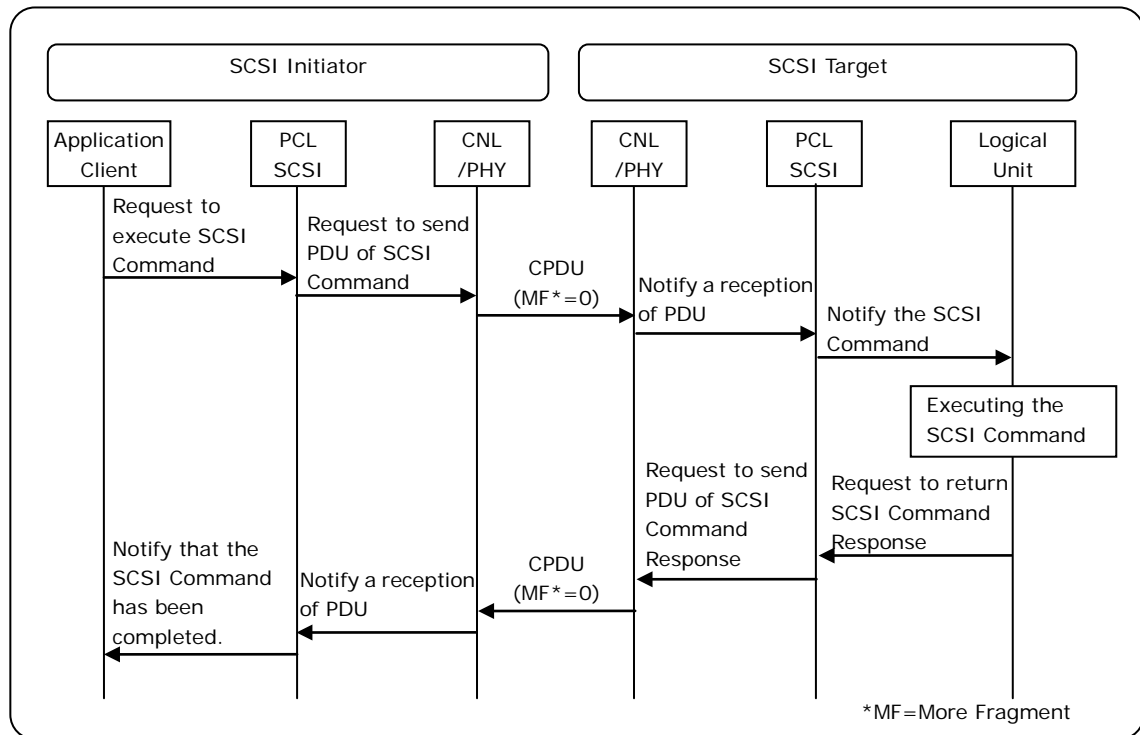


Fig. 4-11 Sequence of SCSI Command without data transfer

SCSI Initiator sends a PDU of SCSI Command to execute the SCSI Command. When the PDU has been received, SCSI Target sends a PDU of SCSI Command Response after the SCSI Command is completed.



4.3.2.2. Sequence of SCSI Command with data-in transfer

Fig. 4-12 shows an example of sequence of SCSI Command with data-in transfer.

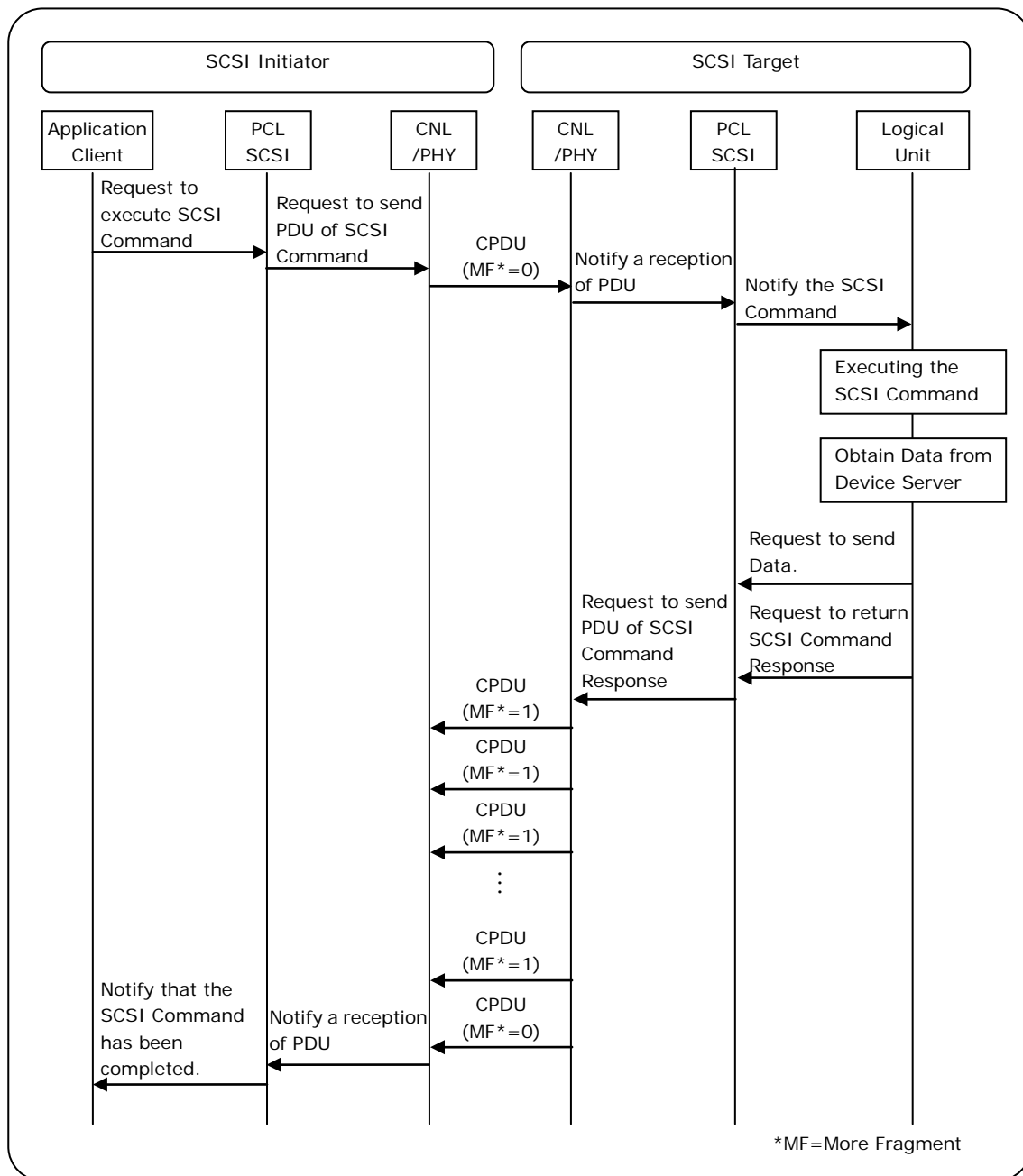


Fig. 4-12 Sequence of SCSI Command with data-in transfer

SCSI Initiator sends a PDU of SCSI Command to execute the SCSI Command. When the PDU has been received, SCSI Target executes the SCSI Command and obtains SCSI Data from Device Server. After the SCSI Command is completed, SCSI Target sends a PDU of SCSI Command Response including the SCSI Data.



4.3.2.3. Sequence of SCSI Command with data-out transfer

Fig. 4-13 shows an example of sequence of SCSI Command with data-out transfer.

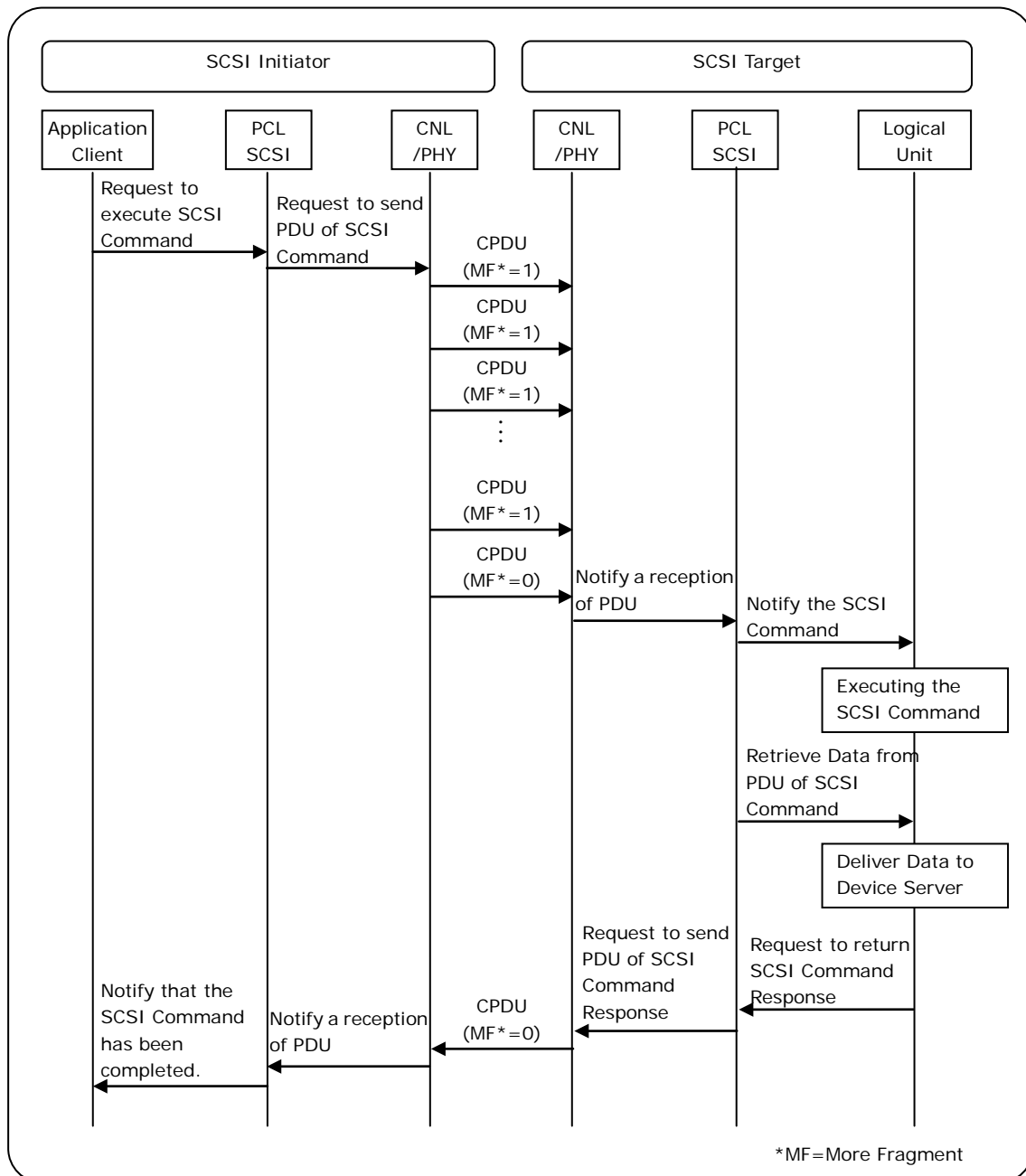


Fig. 4-13 Sequence of SCSI Command with data-out transfer

SCSI Initiator sends a PDU of SCSI Command including SCSI Data to execute the SCSI Command. When the PDU has been received, SCSI Target executes the SCSI Command, retrieves SCSI Data from the PDU and delivers the SCSI Data to Device Server. After the SCSI Command is completed, SCSI Target sends a PDU of SCSI Command Response.



4.3.3. Requirements for logical unit

Requirements for logical unit are as follows:

- Includes only block devices (defined in SBC) in device server.
- Auto Contingent Allegiance (defined in SAM2) is not established.
- Linked command (defined in SAM2) execution is not permitted.
- All block devices included in logical unit is recommended to be write-protected.
- Asynchronous Event Reporting (defined in SAM2) is not supported.
- Task manager (defined in SAM2) in logical unit is required to detect overwrapped commands (defined in SAM2).

In addition, logical unit has limitation below as default:

- No command queuing of any kind supported.

Command queuing may be enabled to a logical unit.



5. Certification Program

One important activity of TransferJet Consortium is taking the TransferJet™ Specifications and verifying compliance by developing and implementing testing procedures. As one such activity, TransferJet Consortium administers the TransferJet™ Certification Program – designed to test and certify the technical design and basic interoperability of products and components utilizing TransferJet™ technology.

Basic Concepts

Compliance Components

Compliance is comprised of Conformance and Interoperability.

Conformance ensures that a product utilizing TransferJet™ technology correctly implements the technical specifications.

Interoperability ensures that products utilizing TransferJet™ technology are able to communicate and operate correctly with each other as defined in the technical specifications.

Compliance Testing

Compliance Testing is composed of a set of individual tests to verify compliance of products with the technical specifications. The test items and procedures are described in the following two documents.

Conformance Test Specification (CTS)

Interoperability Test Specification (ITS)

Certification

Certified Product means that Compliance of the product has been verified by passing the Certification Program which includes Compliance Testing.

Certification is not a warranty or guarantee of any kind by the Consortium but is a statement that the certified product has successfully passed the prescribed set of testing under a specific set of test conditions.

Product Types

Products which can be submitted to the Certification Program are categorized into the following types.

End Product: products designed to be used by End Users (consumers). There are two types of End Products.

Complete End Product: End Product in which all the mandatory layers of the TransferJet protocol stack are implemented.

Partial End Product: End Product in which some of the mandatory layers of the TransferJet protocol stack are not implemented within itself but, by combining with another Partial End Product, will together comprise a system such that all the mandatory layers of TransferJet protocol stack are implemented.

Component Product: products designed to be embedded into an End Product which will then comprise a complete TransferJet protocol stack.



Qualified Test Laboratory

Qualified Test Laboratory (QTL) is a facility which is officially accredited by the Consortium to provide testing services, and is equipped with appropriate test systems and operated by trained operators who perform the Compliance Tests.

Certification Processes

Certification Processes are the set of procedures established and performed by the Consortium, Consortium Members, and QTL to issue and maintain Certification. Certification Processes consist of the following:

Primary Certification Process: the fundamental process to issue Certification to an original, basic product

Certification Amendment Process: the process to amend an existing Certification.

Derivative Certification Process: the process to certify additional products that contain only Non-TransferJet Changes and/or Alternative Component Replacements.

External Change Process: the process to certify additional products that contain only External (non-functional) Changes.

Version-Up Certification Process: the process to certify TransferJet Implementation Change.

Rebranding Certification Process: the process to transfer a certification from one member company to another, for cases of OEM/Rebranding.

Test Case Waiver Process: the process to waive a Required Test Case in case there is a fault in Technical Specifications and/or Test Specifications with respect to the Test Cases.

Product Change Assessment Process: the process of reviewing with the Consortium about defining and approving allowed Product Changes.



6. Trademark and Logo

TransferJet Consortium defines the usages of the *TransferJet* trademark and logos to establish and maintain a consistent Visual Identity (VI) and brand awareness in the market and to ensure correct and consistent messaging to the users.

About the *TransferJet* Logo

Usage on Products and Literature

The use of *TransferJet* logos is allowed individually to products and literature that have demonstrated their compliance with TransferJet™ specifications. Details on licensing are specified in the Certification Program (including compliance testing) administered by TransferJet Consortium.

Usage for Other Purposes

The *TransferJet* logos can also be used for promoting the *TransferJet* concept, technology, usage models, specifications or certified products.

Usage by Non-Members of TransferJet Consortium

Approval is required by TransferJet Consortium in case non-members desire to use the *TransferJet* logos for whatever purpose.

Types of *TransferJet* Logos

There are three types, as shown below.

Brand Logo



Symbol Logo



Target Point Logo



The brand logo and symbol logo shall be used to represent TransferJet™ products. The target point logo shall be used to denote the place where the products should be touched, typically aligned with the center of the coupler.

**About the Target Point Logo**

The target point logo shall be displayed on all TransferJet™ products.

The target point logo is used to inform the users about the location where the products should be touched. Therefore, it should be displayed visibly and clearly, and placed where it is easy for users to touch.





7. What is the TransferJet Consortium?

The TransferJet Consortium was established by a group of international companies in July 2008 and has been registered as a General Incorporated Association in Japan since September 2011. The TransferJet Consortium focuses on the development of the specifications, compliance testing processes, certification program, as well as conduct marketing activities to promote the TransferJet™ technology, products, applications and services across industries and to consumers. Through these initiatives, the TransferJet Consortium aims to create, support and expand the market for TransferJet™ products.

8. TransferJet Consortium Goals

TransferJet Consortium has the common goal of developing the technology, products and services based on "TransferJet" wireless technology.

- (1) Development of the specifications of TransferJet™ wireless technology
- (2) Development of compliance testing processes and tools
- (3) Management of the certification program
- (4) Promotion of the TransferJet™ technology, concept and usage models

9. TransferJet Consortium Organizational Structure and Working Groups

The organization consists of a Management Meeting and three Working Groups, as shown in Fig. 9-1. In addition, there are Task Forces and other sub-groups that are formed at various times to address specific issues. Promoter company members participate in the Working Group activities. The purpose and scope of activity of each Working Group are as follows:

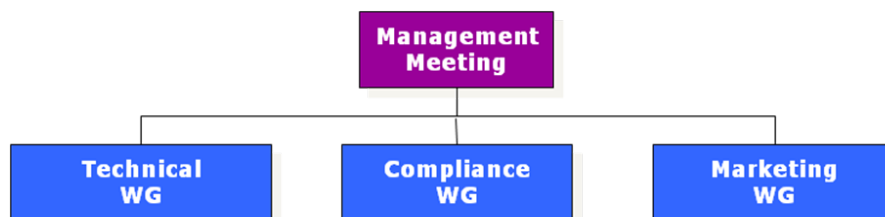


Fig. 9-1 TransferJet Consortium Organization

Technical Working Group

[Purpose]

Create and maintain the TransferJet™ technical specifications and implementation guidelines

[Scope]

Evaluate the approved use cases and develop technical requirements for the creation of the specifications and guidelines. Develop specifications covering the TransferJet™ physical layer, connection layer and protocol conversion layers to satisfy the above technical requirements. Coordinate and collaborate with other



Working Groups, as required. (Technical work related to compliance testing and certification will be addressed by the Compliance Working Group).

Compliance Working Group

[Purpose]

Develop and maintain the necessary policies, test tools, infrastructure and program for members to validate correct implementation and operation of their products in accordance with the TransferJet™ specifications and guidelines.

[Scope]

- Develop and maintain the test specifications for the technical specifications and the implementation guidelines published by the Technical Working Group
- Establish and execute policies and procedures for certification and enforcement of compliance with the technical specifications, the implementation guidelines and the test specifications
- Work with test equipment vendors and test laboratory operators to develop equipment and laboratories for the certification procedures
- Work with the marketing Working Group to resolve radio wave regulatory issues worldwide
- Organize testing events for the consortium member companies to improve interoperability of their products
- Disclose results of certification of compliance and keep documents

Marketing Working Group

[Purpose]

Compile and analyze use cases, execute strategies to globally promote and raise awareness of the TransferJet™ concept and technology, including proper usage of the TransferJet™ logo and trademarks.

[Scope]

- Develop and execute strategies to globally promote and raise awareness of the TransferJet™ concept and technology to the industry and consumers
- Execute proper usage of the TransferJet™ logo and trademarks
- Participate in domestic and foreign marketing/PR events
- Operate and maintain the contents of the TransferJet™ public website



10. Membership

Members list is shown at the below link.

http://www.transferjet.org/about_cons/index.html



11. Abbreviations and Acronyms

ANSI	American National Standards Institute
Application-Service	Service provided by a pair of applications that each is executed on the TransferJet™ device
Application-Service Control Service	Service which provides procedure for acquiring a list of the Application-Service Parameters available on the peer device, and procedure for setting the Application-Service Parameter to the peer device to request execution of the desired application corresponding to the Application-Service as the framework. However, detailed algorithm for determining a specific application using the Application-Service Parameter is not included in this service.
Application-Service parameter	Combination of components necessary to determine the Application-Service
BPSK	Binary Phase Shift Keying
CNL	CoNnection Layer
CPDU	Connection layer Protocol Data Unit
CRC	Cyclic Redundancy Check
CSDU	Connection layer Service Data Unit
FEC	Forward Error Collection
IrDA	Inferred Data Association
MUX	Multiplexer
OBEX	OBject EXchange
PCL	Protocol Conversion Layer
PCLC	PCL Controller
PCLC Services	Services provided by PCL Controller
PCL Services	PCLC services and services provided by PCL Adapter
PDU	Protocol Data Unit
PSD	Power Spectral Density
PSDU	Phy layer Service Data Unit
SAM2	SCSI-3 Architecture Model-2
SBC	SCSI Block Commands
SCSI	Small Computer System Interface
SDU	Service Data Unit
Service	Function provided to the outside of a layer
SPC2	SCSI Primary Commands-2
SRM	Single Response Mode
UWB	Ultra Wide Band



12. References

TransferJet™ PHY-CNL Specifications Version 1.2
TransferJet™ Specifications for Protocol Conversion Layer OBEX Adapter Version 1.0
TransferJet™ Specifications for Protocol Conversion Layer SCSI Adapter Version 1.1
TransferJet™ Specifications for Protocol Conversion Layer Controller Version 1.0
TransferJet™ Specifications for SCSI Application: SD Protocol over SCSI Protocol Version 1.0
TransferJet™ Protocol Class Specification for OBEX Application Version 1.0
TransferJet™ Protocol Class Specification for SCSI Application Version 1.1
TransferJet™ PCL Number Assignment Manual Version 1.2
TransferJet™ Unique ID Allocation Manual Revision 1.1
TransferJet™ Certification Program Reference Document Revision 1.0
TransferJet™ Test Case Reference Document Revision 1.2
TransferJet™ Conformance Test Specification Part 1 PHY/CNL Test Revision 1.1
TransferJet™ Conformance Test Specification Part 2 PCL Test Revision 1.0
TransferJet™ Interoperability Test Specification Revision 1.0
TransferJet™ Test Laboratory Management Document Revision 1.0
TransferJet™ Trademark Guideline Revision 1.3
TransferJet™ User Interface Guideline Revision 1.1
TransferJet™ Overview Whitepaper Spring 2009
IrDA Object Exchange Protocol Version 1.4 (July 27, 2007)
ANSI INCITS 366-2003(R2008) SCSI-3 Architecture Model-2
ANSI INCITS 306-1996(R2008) SCSI Block Commands
ANSI INCITS 351-2001 SCSI Primary Commands-2

Note : TransferJet specification is a part of ISO/IEC standards. (ISO/IEC-17568)

13. Qualified Test Laboratory (as of August 2015)

Allion Labs, Inc. <http://www.allion.com/>