
**Universal Serial Bus
Communications Class Subclass
Specifications for Socket
Management Protocol**

Revision 0.1

September 4, 2019

Revision History

Table 1: Revision History

Version	Date	Comments
1.0	TBD	Initial Release

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1 Introduction

1.1 Purpose

The Socket Control Module (SCM) subclass is a protocol by which USB devices can efficiently manage and use Berkeley/POSIX-style sockets on the host.

The specification currently defines support for the INET (IPv4) and INET6 (IPv6) protocol families and the TCP and UDP protocols. Future versions may add support for additional families and protocols.

This protocol offers an alternative method for a device to communicate with remote servers. Existing approaches that operate at the L3 layer (IP/USB) or L2 layer (CDC ECM, EEM, NCM) have several disadvantages. In particular, they require the device to be assigned an IP address. Since many networks will assign only a single IP address to a host, this requires implementing some form of network address translation (NAT) on the host. Setting up the NAT requires userspace configuration in most operating systems, so the USB device is no longer truly plug and play.

1.2 Scope

This document specifies new device subclasses intended for use with Communication devices, based on the Universal Serial Bus Class Definitions for Communication Devices specification [USBCDC].

The intention of this specification is that all material presented here be upwards-compatible extensions of the [USBCDC] specification. New numeric codes are defined for subclass codes, protocol codes, management elements, and notification elements.

In some cases material from [USBCDC] is repeated for clarity. In such cases, [USBCDC] shall be treated as the controlling document.

In this specification, the word ‘shall’ or ‘must’ is used for mandatory requirements, the word ‘should’ is used to express recommendations and the word ‘may’ is used for options.

2 Overview

Socket Control Model (SCM) is a specification for efficient management of sockets on a host by its devices. SCM sends Application Layer traffic and internal socket management commands from the device to the host over USB. This module requires host implementations for each supported Network and Transport layer protocols, but other layers are beyond its scope.

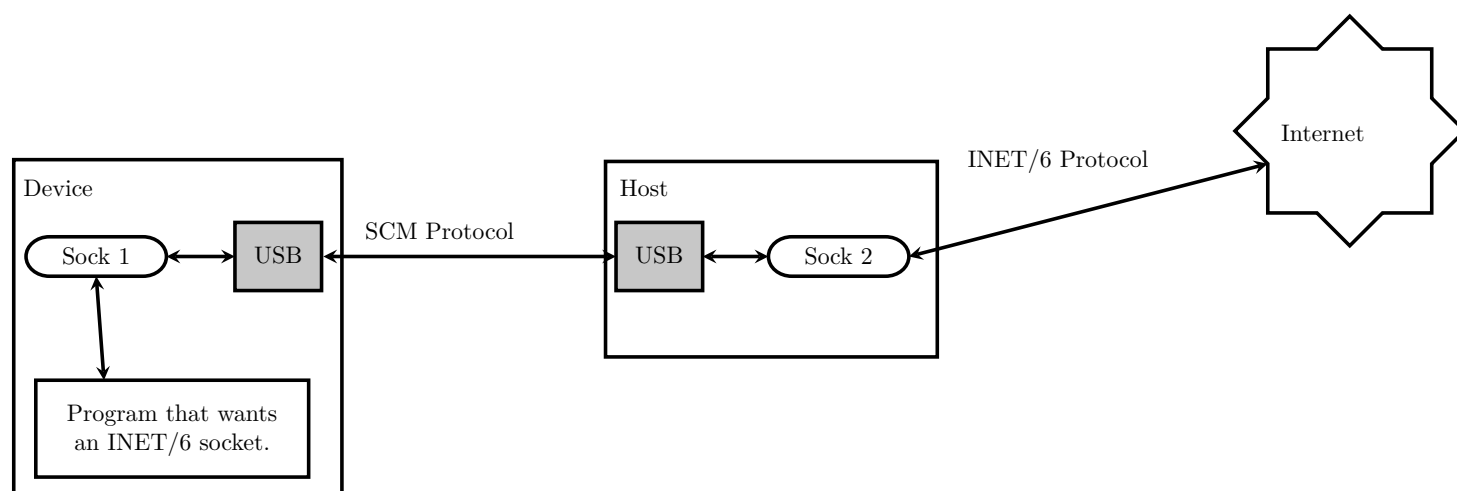
2.1 What is Socket Control Module (SCM)?

SCM allows a USB connected device to remotely create and control sockets on its host. A device may only control sockets it has created, and it shall expect exclusive control over this socket. Devices cannot control sockets created by other devices on the same host, and the host will not expose a device's socket for use by other applications.

Prior to SCM, connected devices would have to be assigned an IP address requiring the host to bridge the device or use NAT which also requires userspace configurations to the host. SCM allows a host to act on behalf of its device and provide its network connection in a truly plug and play manner. This implicitly subjects the device to the same firewall rules and external network considerations without specific configuration.

The below figure illustrates a possible use case where a new socket type (Sock 1) is created on the device to interface with SCM. This allows userspace applications to interact with a standard protocol.

Figure 1: SCM Overview.



2.2 USB Endpoints

SCM's endpoint requirements consist of a bulk pair (In and Out) and command pair (In and Out). The SCM Device Class uses the standard Endpoint descriptor, as defined in chapter 9 of the USB Specification.

Additionally, SCM requires a pair of bulk-in/bulk-out endpoints and a control-in endpoint for receiving commands.

3 Socket Control Model (SCM)

The payload of the USB packet contains any combination of a single SCM packet, two or more SCM packets or a split SCM packet. SCM transfers can be split across USB packets but shall not be split across USB transfers.

3.1 SCM Packet Format

The packet format defines an SCM packet. For information regarding USB packets refer to [USB2.0] specification. Details packets formats can be found in section 8.4 of the [USB2.0] specification.

All SCM packets begin with a one-byte opcode (see Table 3), a one-byte message ID and a one-byte Socket ID.

While represented differently, both types of SCM packets will indicate the length of data being sent and then the data being sent. A packets data segment will always immediately proceed the header and this packet will always be sent in one USB transfer (although USB may split the SCM packet into many USB packets).

Figure 2: SCM Packet header and data.



3.2 SCM Error Codes

Table 2: ACK Codes for OPEN

Value	Name	Description
0	ESUCCESS	Success
1	EHOSTERR	An error has occurred on the host
2	EINVAL	Invalid parameters sent
3	EPROTONOSUPPORT	The protocol type is not supported on the domain.
4	ECONNREFUSED	No one is listening on remote address
5	ENETUNREACH	Network is unreachable to the host
6	ETIMEDOUT	Timeout while host attempted to perform operation.
7	EMISMATCH	Family for CONNECT to not match socks type on OPEN.
8	ENOTCONN	An operation has occurred on a non-connected socket which requires a connection.
9	ENOSOCK	Socket not found on the host

3.3 SCM Packet Types

SCM has two different types of commands: Command and Payload. Command supports quickly sending short messages and Payload supports sending large messages.

3.3.1 Common Fields

All SCM packets begin with the following three bytes:

1. **Opcode:** 8-bit unsigned integer identifying what type of packet follows. All Op Codes are defined as either a Command or Data type so this field is sufficient to decide which type of structure to expect.
2. **Message ID:** 8-bit unsigned integer provided to allow the receiver to identify the received message when replying. This is always generated by the sender, and the receiver may only reply using the given ID once. Sending an ACK or REPLY to an unknown Message ID causes undefined behavior.
3. **bSockID:** 8-bit unsigned integer identifying which sock is being sent to. Sock IDs are always created by the host during an OPEN command.

While represented differently, both packets also include a length parameter indicating how much data follows the header. Both length fields are the length of the payload, not including the header.

3.3.2 Op Codes

Table 3: OP Codes

Opcode	Name	Type	Purpose
0x00	OPEN	Cmd	Open a socket on the host
0x01	CONNECT	Cmd	Connect an open socket to a given address
0x02	SHUTDOWN	Cmd	Indicates that the sender will not send any more traffic.
0x03	TRANSMIT	Data	Write data to a connected socket
0x04	ACK	Cmd	Acknowledge a command and indicate success
0x05	ACKDATA	Data	Similar to ACK but contains data.
0x06	CLOSE	Cmd	Close the socket.

3.3.3 Command

SCM Command operations relate to opening, closing and managing sockets across USB. These requests are infrequent and short in length so they do not need to be mixed with larger data transmissions that can take a long time to process. Command packets are always sent over the USB Control EP and have a maximum length of 64 bytes including the header.

0	8	16	24	31
wOPCode		wMsgID		
dSockID				
dPayloadLen				
Data (Up to 52 bytes)...				

3.3.4 Data

SCM Data packets are meant for forwarding data across USB bulk endpoints. These requests can contain large amounts of data. These requests are either for sending data transmitted across sockets or acknowledging messages with a response longer than 52 bytes.

0	8	16	24	31
wOPCode		wMsgID		
dSockID				
dPayloadLen				
Payload Data...				

SCM Packets All values in SCM packets are little endian unless otherwise noted. All IDs and integer values are unsigned unless otherwise noted.

3.3.5 SCM Command Packet Formats

3.3.5.1 OPEN

The OPEN command is always initiated by the device to the host. The device will send an OPEN packet with no Sock ID and the host will reply with an 8-bit ID to use to refer to this new socket on all future operations.

Table 4: Values for Family.

ID	Name
0x01	IP
0x02	IP6

Table 5: Values for Protocol.

ID	Name
0x01	TCP
0x02	UDP

Table 6: Values for Type.

ID	Name
0x01	Stream
0x02	Datagram

0	8	16	24	31
wOPCode (0x00)		wMsgID		
dSockID				
dPayloadLen (0x05)				
wAddrFamily		wProtocol		
bType				

Ack will return with a 4-byte integer representing the new Sock ID. This value will be aligned to a 4-byte interval.

Table 7: ACK Codes for OPEN

Name	Description
ESUCCESS	Success
EHOSTERR	An error has occured on the host
EINVAL	Host does not understand protocol or protocol family
EPROTONOSUPPORT	The protocol type is not supported on the domain.

3.3.5.2 CLOSE

When sent from device to host, this command disconnects (if connected) and closes a socket using the ID given during creation. If sent from host to device this will serve as a notification that the socket has been closed by the remote peer.

0	8	16	24	31
wOPCode (0x06)		wMsgID		
dSockID				
dPayloadLen (0x00)				

Upon completion an ACK command will be sent with no return data.

3.3.5.3 SHUTDOWN

Shutdown indicates that the sender will no longer transmit data to the receiver, but the receiver may still send messages.

0	8	16	24	31
wOPCode (0x02)		wMsgID		
dSockID				
dPayloadLen (0x00)				

Upon completion an ACK command will be sent with no return data.

3.3.5.4 ACK

Upon completion of a message the receiver will send this back to acknowledge receipt and indicate whether the operation was a success or a failure. Once USB has acknowledged receipt, the sender of an ACK will not wait for further confirmation that the recipient has received the message.

0	8	16	24	31
wOPCode (0x06)		wMsgID		
dSockID				
dPayloadLen				
wOrigOPCode		Return Code	Return Data...	
...Return data (Up to 49 bytes)				

3.3.5.5 CONNECT

Connect tells the host to connect a created socket to a given address. The address information passed will vary by protocol, the host and device should know which structs the other side will send and process those (these are typically the same on both ends).

IP Connect Packet

0	8	16	24	32
wOPCode (0x01)		wMsgID		
dSockID				
dPayloadLen (0x08)				
bFamily (0x00)	Reserved		wPort	
IP Address (in Network Byte Order ¹)				

IP6 Connect Packet

0	8	16	24	32
wOPCode (0x01)		wMsgID		
dSockID				
dPayloadLen (0x28)				
bFamily (0x01)	Reserved		wPort	
dFlowInfo				
dScopeID				
IP6 Addr In Network Byte Order...				
...IP6 Addr In Network Byte Order...				
...IP6 Addr In Network Byte Order...				
...IP6 Addr In Network Byte Order				

Upon completion an ACK command will be sent with no return data.

Table 8: ACK Codes for CONNECT

Name	Description
ESUCCESS	Success
EHOSTERR	An error has occurred on the host
ECONNREFUSED	No one is listening on remote address
ENETUNREACH	Network is unreachable
ETIMEDOUT	Timeout while attempting connection
EMISMATCH	Family or protocol for CONNECT to not match socks type on OPEN.
ENOSOCK	Socket ID not found on host.

3.3.6 SCM Data Packet Formats

Data packets contain arbitrary data immediately after the header of whatever length is contained in the header's length field.

Data Length will always be an unsigned 32-bit integer.

¹POSIX.1-2017 expects the address and port to be in network byte order regardless of the host byte order.

3.3.6.1 TRANSMIT

Sends data over the Bulk endpoint containing an arbitrary amount of data for a connected socket.

0	8	16	24	31
wOPCode (0x03)		wMsgID		
dSockID				
dPayloadLen				
Payload data...				

ACK will return with a 4-byte signed integer. On error the a negative number will be returned. Nonnegative return codes indicate a succesful trasnfer while positive return codes also indicate flow indicators (TODO: IMPLEMENT POSITIVE CODE BEHAVIOR).

Table 9: ACK Codes for TRANSMIT

Name	Description
ESUCCESS	Success
-EHOSTERR	An error has ocured on the host
-ENOTCONN	The socket on the remote side is not open and connected
-ENOSOCK	Sock ID not found on host.

3.3.6.2 REPLY

Similar to ACK but is a DATA type command. This should only be used for commands that can expect more than 60 bytes of data back.

0	8	16	24	31
wOPCode (0x05)		wMsgID		
dSockID				
dPayloadLen				
wOrigOPCode		Return Code	Payload Data...	
Payload data...				

3.4 SCM Packet Ordering

Synchronization must be maintained to ensure that all commands arrive at the detinsation in the order they were requested. In particular, CLOSE commands shall not be transmitted while there is still unsent data and more data shall not be queued to transmit while a CLOSE is waiting to be sent.

3.5 Multiple Devices and Seperation

A host may provide sockets to many devices, but a device may never manage a socket which is controlled by another device. It is the responsibility of the host to ensure packets from one device are never executed on sockets belonging to another.

4 Packet Processing

Fig A describes the process for the receiver on both ends to assemble and transmit packets from USB to their respective proxies. The `Send Command To Proxy` procedure can be assumed to be nonblocking, after which the data passed in can be safely freed.

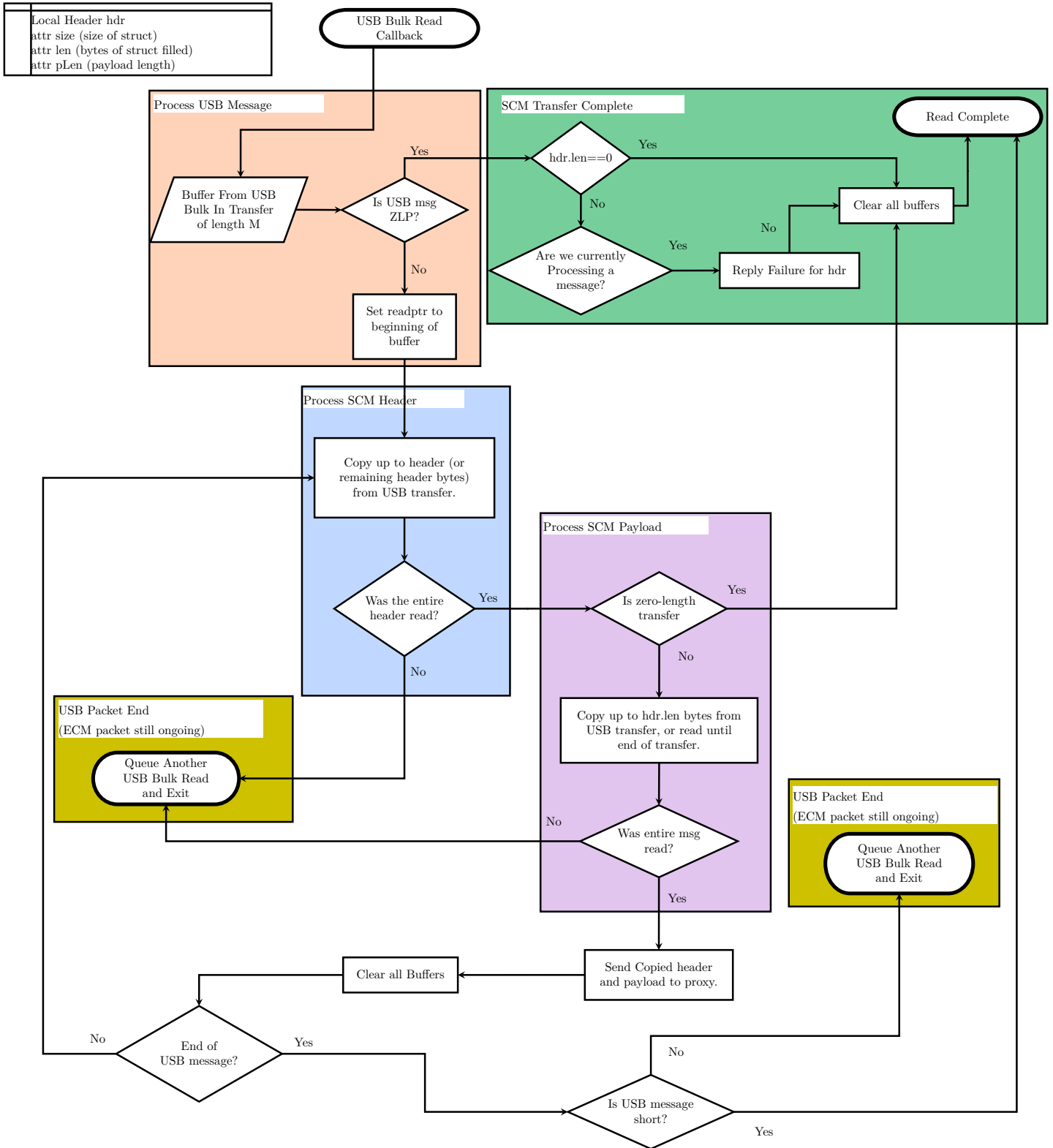
4.1 Processing Flow

4.1.1 Receiving SCM Packets From USB

SCM transmission packets are sent over USB bulk transfers. SCM transfers may not be split over multiple bulk transfers, but may be split over USB Bulk Packets within a single transfers. Many SCM transmission packets may be sent in one bulk transfer. This means that SCM packet headers may also be split between SCM packets.

SCM transfers will end with one of a short USB packet, zero-length packet over USB (if supported) or a zero-length SCM transfer. Sending a zero-length USB packet when the receiver is expecting the continuation of a SCM packet causes undefined behavior.

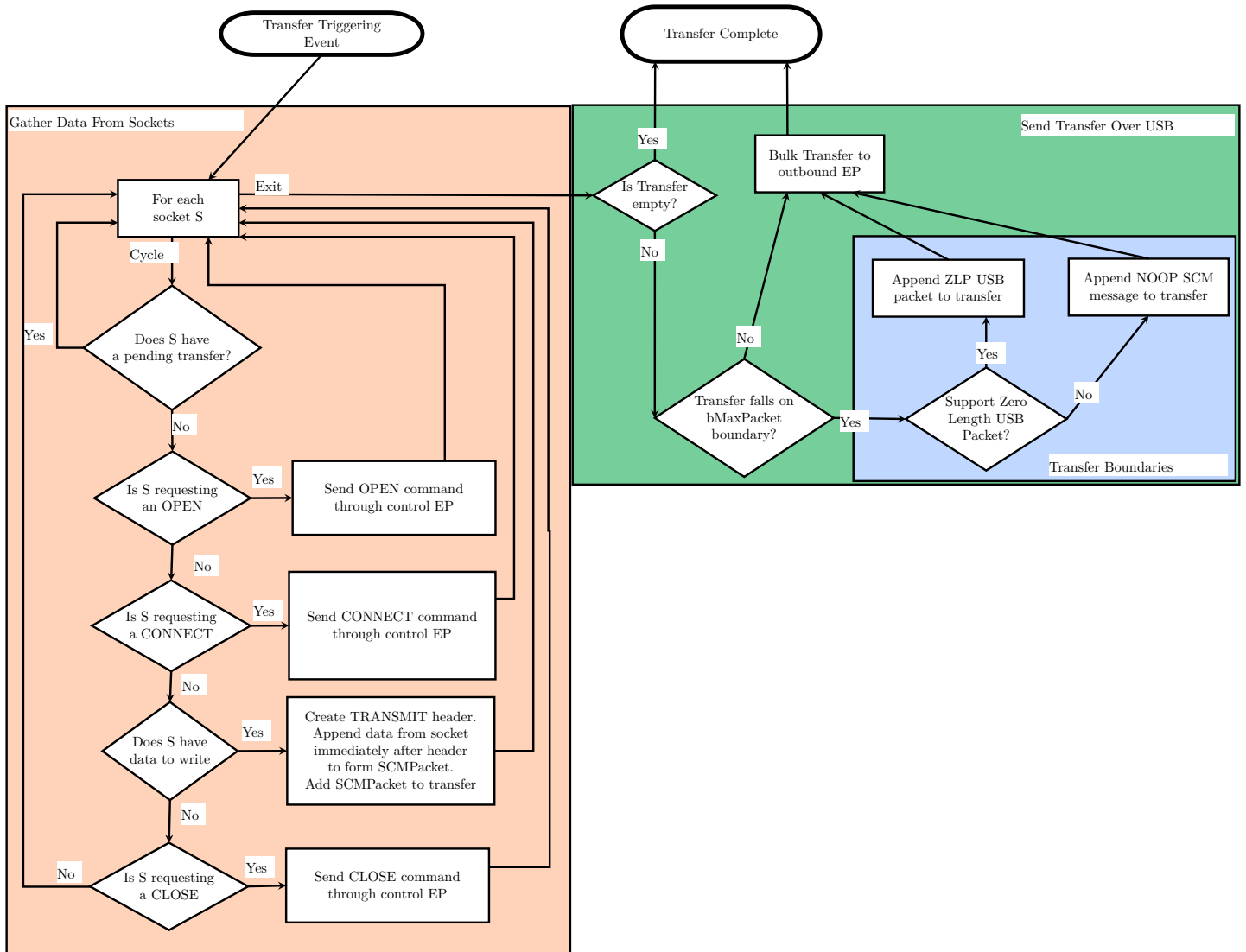
Figure 3: SCM Packet receive Flow.



4.1.2 Transmitting Data

The figure below illustrates how the host and device should send messages to eachother.

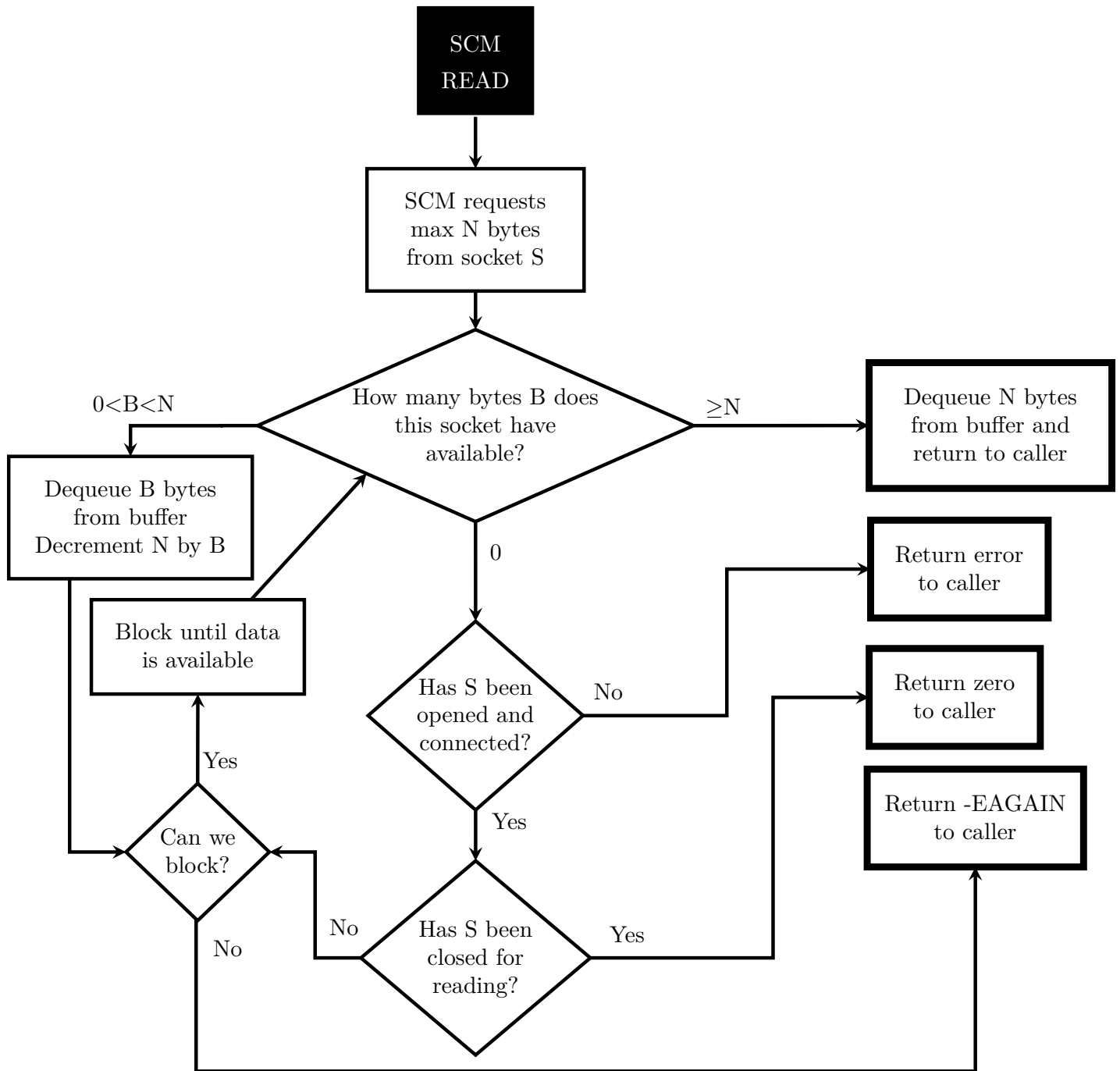
Figure 4: Sending To Peer.



4.1.3 Reading Transmitted Data

The figure below illustrates how either the host or device should its read functions. Read can only work with data that has already been transmitted, it does not ask for data from its peer since any sendable data will be sent automatically.

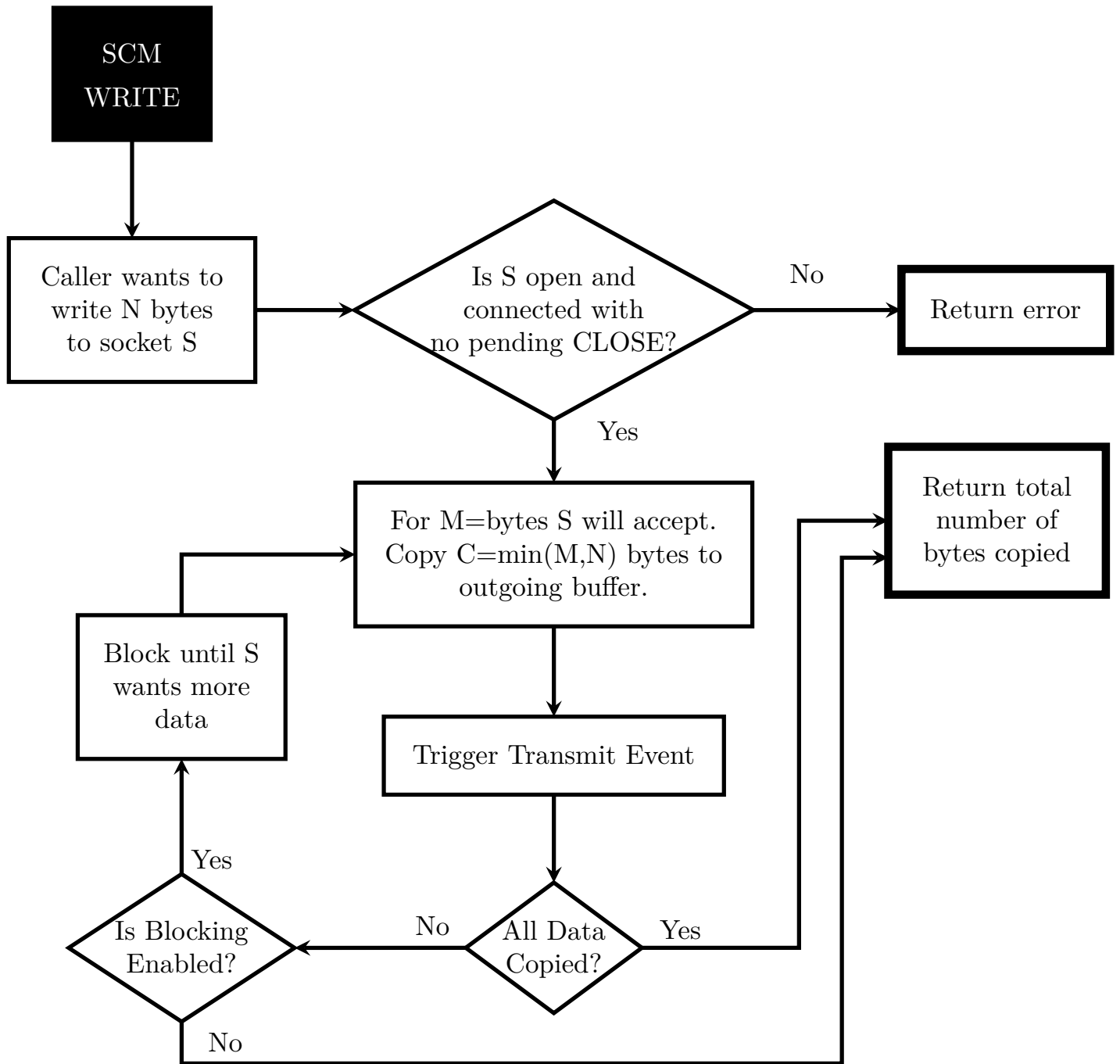
Figure 5: Reading Transmitted Data.



4.1.4 Writing Data

The figure below illustrates how either the host or device should its handle socket write calls.

Figure 6: Writing Data to SCM.



4.1.5 Command Flow

Commands involve controlling sockets and sending ACKs for commands.

Open and Connect require confirmation from the host before the device can change its behavior. Disconnect and Close take effect regardless of acknowledgement, subsequent writes on a closed channel will return an error.

Figure 7: Command Flow.

