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# **PacketIO Documentation**

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PacketIO is a C++ library for framing packets sent or received over an Arduino [Stream](#), such as [Serial](#). It is distributed as a PlatformIO library.

The key feature of this library over other framing implementations, such as [PacketSerial](#), is that it operates on streams. This means that if your application layer is able to produce or consume streams, you can push these streams right the way through your program. Put simply, this means you can send arbitrarily large packets, without having to worry about allocating buffers.

The example below shows a contrived case when streams are needed - it duplicates whatever packets come in, but it works no matter how large the incoming packet is:

```
#include <Arduino.h>
#include <cobs/Stream.h>
#include <cobs/Print.h>
using namespace packetio;

COBSPrint cobs_out(Serial);
COBSStream cobs_in(Serial);

void setup() {
    Serial.begin();
}

void loop() {
    // send a packet
    cobs_out.print("Starting packet duplicator");
    cobs_out.end();

    // duplicate bytes of every packet read
    while(true) {
        int c = cobs_in.read();
        if(c == COBSStream::EOP) {
            // incoming packet ended - end ours too
            cobs_out.end();
            cobs_in.next();
        }
        else if(c != COBSStream::EOF) {
            // got a byte - duplicate it
            cobs_out.write(c);
            cobs_out.write(c);
        }
    }
}
```



### Basic interface

The framing methods are exposed through the *PacketPrint* and *PacketStream* interfaces.

**class** `packetio::PacketPrint` : **public** *Print*

Augments arduino's *Print* to add knowledge of packets.

Acts like a new *Print* for each packet. To stop printing to the current packet, and send new prints to the next one, call `:func:end`

This only concerns itself with the read parts of stream, and should not be used for writing.

Subclassed by *packetio::COBSPrint*, *packetio::EscapedPrint*< *EscapeCodes* >

#### Public Functions

**virtual** `bool end()` = 0

End the current packet.

**Return** true if successful

**virtual** `void abort()` = 0

Abort the current packet, preferably invalidating it if possible.

**class** `packetio::PacketStream` : **public** *Stream*

Augments arduino's *Stream* to add knowledge of packets.

Acts like a new stream for each packet, but instead of returning EOF when the packet is over, it returns EOP. EOF is returned when there is nothing to read, but the packet is not complete.

This only concerns itself with the read parts of stream, and should not be used for writing.

Subclassed by *packetio::COBSSStream*, *packetio::EscapedStream*< *EscapeCodes* >

## Public Functions

**virtual int read () = 0**

Read a single byte from the current packet.

**Return** The byte if available EOF if we have reached the end of the stream EOP if the current packet is complete

**virtual int peek () = 0**

Peek the next byte from the current packet.

**Return** The byte if available EOF if we have reached the end of the stream EOP if the current packet is complete

**virtual int available () = 0**

**Return** A lower bound on the number of bytes available. This count includes the EOP return value.

**virtual void next () = 0**

Advance to the next packet. If the current packet is not complete, then [read\(\)](#) will return EOF until it is.

## Public Static Attributes

**const int EOF = -1**

End Of File. This is already the value used by arduino.

**const int EOP = -2**

End Of Packet.

# Framing Protocols

## COBS

This is an implementation of [Consistent-Overhead Byte Stuffing](#).

This uses a null byte as an end of packet marker, and uses a clever technique to encode null bytes within the packet with minimal overhead. See the link above for more information.

```
class packetio::COBSPrint : public packetio::PacketPrint
```

```
class packetio::COBSStream : public packetio::PacketStream
```

## Escaped

This packet framer uses a special character to indicate end-of-frame, and an escape character to allow this to appear within a message. In the worst-case, this causes the packet to be twice the data size.

The choice of these special characters is parameterizable through template arguments. `encoded/codes.h` contains some example choices of values, including an implementation of [SLIP](#). To define your own, you can use code like the following:

```
#include <escaped/Print.h>
#include <escaped/Stream.h>
#include <escaped/codes.h>

using namespace packetio;

// end, escape, escaped end, escaped escape
typedef EscapeCodes<'A', '/', 'a', '\\> MyCodes;

EscapedPrint<MyCodes> printer(Serial);
EscapedStream<MyCodes> reader(Serial);
```

In this example, we use A to end a packet. So the packet ABCD/EFGH is encoded to /aBCD/\EFGHA. Here, the first A is replaced by the escape sequence /a, and the / is replaced with /\. Finally, an A is appended to end the packet.

**template** <uint8\_t *pEND*, uint8\_t *pESC*, uint8\_t *pESC\_END*, uint8\_t *pESC\_ESC*>

**struct** packetio::EscapeCodes

A trait type for indicating which markers to use in an *EscapedStream* or *EscapedPrint*. This type should be used as the type argument.

#### Template Parameters

- *pEND*: The byte indicating end of frame
- *pESC*: The byte indicating that the following byte is an escape code
- *pESC\_END*: The escape code for encoding an in-data END value
- *pESC\_ESC*: The escape code for encoding an in-data ESC value

**template** <typename *EscapeCodes*>

**class** packetio::EscapedPrint : public packetio::PacketPrint

**template** <typename *EscapeCodes*>

**class** packetio::EscapedStream : public packetio::PacketStream

## SLIP

These is just a convenience aliases for escaped streams with the appropriate *EscapeCodes*.

**typedef** *EscapeCodes*<0xC0, 0xDB, 0xDC, 0xDD> packetio::SLIPEscapeCodes

**typedef** *EscapedPrint*<*SLIPEscapeCodes*> packetio::SLIPPrint

**typedef** *EscapedStream*<*SLIPEscapeCodes*> packetio::SLIPStream

## Listening for packets

**typedef** *PacketListener\_* packetio::PacketListener

Convenience typedef for a *PacketListener* with a sensible buffer size.

**template** <size\_t *BufferSize* = 256>

**class** packetio::PacketListener\_

Class for listening for packets on a *PacketStream*.

#### Template Parameters

- `BufferSize`: The size of the buffer to allocate for incoming packets

## Public Types

### **enum Error**

Types of error that can occur when receiving a packet.

*Values:*

#### **Overflow**

The end of the message could not be recieved because the buffer overflowed.

#### **Framing**

The message was framed incorrectly.

**typedef** LambdaPointer<void (uint8\_t \*, size\_t, *Error*)> **ErrorHandler**

**typedef** LambdaPointer<void (uint8\_t \*, size\_t)> **MessageHandler**

## Public Functions

**PacketListener\_** (*PacketStream &base*)

Construct a listener for the given packet stream.

void **update** ()

Read as much as possible from the underlying stream. If new packets are completed or errors occur, invoke the appropriate handler.

void **onMessage** (*MessageHandler handler*)

Set the handler to invoke when a message is recieved.

Note that because this is a LambdaPointer, the lambda function must have been allocated on the stack, such that its lifetime exceeds that of this object.

### **Parameters**

- `handler`: The handler to invoke. This will be called with the pointer to the start of the message, and its length.

void **onError** (*ErrorHandler handler*)

Set the handler to invoke when an error occurs.

Note that because this is a LambdaPointer, the lambda function must have been allocated on the stack, such that its lifetime exceeds that of this object.

### **Parameters**

- `handler`: The handler to invoke. This will be called with the pointer to the start of the message, and its length.

Example usage:

```
#include <packet_interface.h>
#include <PacketListener.h>
#include <cobs/Stream.h>
using namespace packetio;

void setup () {
    COBSStream cobs_serial_in(Serial);
```

```

PacketListener handler(cobs_serial_in);

int message_count = 0;
auto message_handler = [&](const uint8_t* buffer, size_t len) {
    message_count++;
};
handler.onMessage(&message_handler);

while(true) {
    handler.update();
    Serial.print("Message recieved: ");
    Serial.print(message_count);
    Serial.println();
}
}

```

## Internals

### Callback functions

The `LambdaPointer` class is used to provide contextfull callback functions, using c++11 lambdas

```
template <typename Out, typename... In>
```

```
template<>
```

```
class packetio::LambdaPointer<Out (In...)>
```

A wrapper for storing a pointer to a lambda function, that works with captured variables.

#### Template Parameters

- Out: lambda return type
- In: lambda argument types

#### Public Functions

```
template <typename T>
```

```
LambdaPointer (T *lambda)
```

Create a `LambdaPointer` from a lambda, possibly with captures.

#### Parameters

- lambda: A pointer to the lambda function. Because this a pointer, this must be allocated on the stack.

```
LambdaPointer (Out (*fptr)) In...
```

Create a `LambdaPointer` from a raw function pointer.

#### Parameters

- fptr: The context-less function

```
Out operator () (In... in)
```

Invoke the underlying function.

**operator bool ()**

Determine if the reference has been initialized.

## Mirror of the Arduino interface

These classes, found in `_compat`, allow testing on the desktop, and potentially execution on non-Arduino platforms

### class **Print**

Lightweight mirror of the (undocumented) arduino *Print* class, for use on other platforms.

Subclassed by *packetio::PacketPrint*, *Stream*

#### Public Functions

**virtual** size\_t **write** (uint8\_t) = 0

size\_t **write** (const char \*str)

**virtual** size\_t **write** (const uint8\_t \*buffer, size\_t size) = 0

size\_t **write** (const char \*buffer, size\_t size)

### class **Stream** : *Print*

Lightweight mirror of the arduino *Stream* class, for use on other platforms.

Subclassed by *packetio::PacketStream*

#### Public Functions

**virtual** int **available** () = 0

**virtual** int **read** () = 0

**virtual** int **peek** () = 0

**virtual** void **flush** () = 0

**Stream** ()

size\_t **readBytes** (char \*buffer, size\_t length)

size\_t **readBytes** (uint8\_t \*buffer, size\_t length)

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