Streams

Working with the various stream classes in POCO.

applied informatics

Overview

- Encoding and Decoding (Base64, HexBinary)
- Data Compression with zlib
- Binary I/O
- Utility Streams
  (CountingStream, LineEndingConverter, TeeStream, NullStream)
- FileStream
- Creating Your Own Streams

The POCO Stream Classes

- POCO provides a variety of stream classes, compatible with standard C++ IOStreams.
- Most POCO stream classes are implemented as filters, which means that they do not write to or read from a device, but rather from another stream they are connected to.
- A few utility classes in POCO make it easy for you to create your own stream buffer and stream classes.

Encoding and Decoding

> POCO provides filter stream classes for encoding and decoding data in Base64 and HexBinary format.

> Both Base64 and HexBinary can be used to encode arbitrary binary data using only printable ASCII characters.

> Base64 uses digits, upper and lowercase characters, as well as '+' and '-' to encode groups of 6 bits. The encoded data takes by a factor 1.33 as much space as the original data.

> HexBinary uses digits and the characters 'A' to 'F' to encode groups of 4 bit. The encoded data takes twice the space.

> See RFC 4648 for details.

Encoding and Decoding (cont'd)

- Poco::Base64Encoder   #include "Poco/Base64Encoder.h"
  Poco::HexBinaryEncoder   #include "Poco/HexBinaryEncoder.h"
  are output streams that must be constructed with another output stream, where Base64/HexBinary-encoded data is written to.

- Poco::Base64Decoder   #include "Poco/Base64Decoder.h"
  Poco::HexBinaryDecoder   #include "Poco/HexBinaryDecoder.h"
  are input streams that must be constructed with another input stream, where Base64/HexBinary-encoded data is read from.

```
#include "Poco/Base64Encoder.h"
#include <iostream>

using Poco::Base64Encoder;

int main(int argc, char** argv)
{
    Base64Encoder encoder(std::cout);

    encoder << "Hello, world!";

    return 0;
}
```

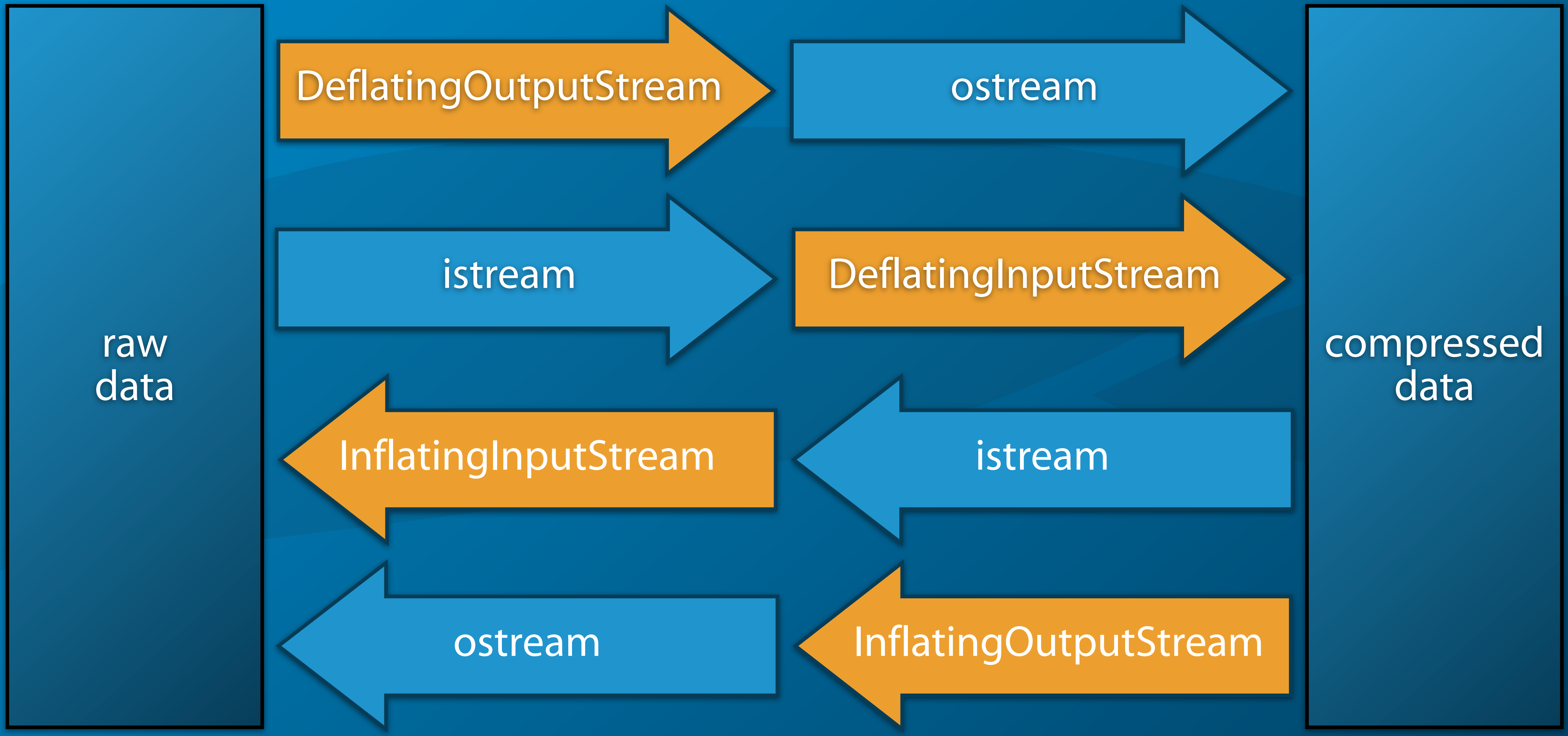
ZLib Compression

> POCO provides filter stream wrappers for zlib, supporting "deflate" and "gzip" style compression.

> Input and output streams are provided for compression (deflating) and expansion (inflating).

> Four stream classes (two input streams and two output streams) are available.

ZLib Stream Classes



ZLib Stream Classes (cont'd)

- Deflating Streams
  - #include "Poco/DeflatingStream.h"
  - Poco::DeflatingInputStream
  - Poco::DeflatingOutputStream
- Inflating Streams
  - #include "Poco/InflatingStream.h"
  - Poco::InflatingInputStream
  - Poco::InflatingOutputStream

ZLib Stream Classes (cont'd)

- Poco::DeflatingInputStream
  Poco::DeflatingOutputStream
  is constructed with another input/output stream and an optional argument specifying the compression type:
  Poco::DeflatingStreamBuf::STREAM_ZLIB (deflate/zlib type)
  Poco::DeflatingStreamBuf::STREAM_GZIP (gzip type)
- Poco::InflatingInputStream
  Poco::InflatingOutputStream
  is constructed with another input/output stream and an optional argument specifying the compression type:
  Poco::InflatingStreamBuf::STREAM_ZLIB (deflate/zlib type)
  Poco::InflatingStreamBuf::STREAM_GZIP (gzip type)

```
#include "Poco/DeflatingStream.h"
#include <fstream>

using Poco::DeflatingOutputStream;
using Poco::DeflatingStreamBuf;

int main(int argc, char** argv)
{
    std::ofstream ostr("test.gz", std::ios::binary);
    DeflatingOutputStream deflater(ostr, DeflatingStreamBuf::STREAM_GZIP);

    deflater << "Hello, world!";

    // ensure buffers get flushed before connected stream is closed
    deflater.close();
    ostr.close();

    return 0;
}
```

Counting Streams

- Poco::CountingInputStream and Poco::CountingOutputStream count the number of characters and lines in a file. They also keep track of the current line number and column position.
- #include "Poco/CountingStream.h"

Line Ending Conversion

> Poco::InputLineEndingConverter and Poco::OutputLineEndingConverter converts line endings in text files between Unix (LF), DOS/Windows (CRLF) and Macintosh (CR) format.

> #include "Poco/LineEndingConverter.h"

> Poco::LineEnding defines line ending formats:
NEWLINE_DEFAULT (the default for the current platform)
NEWLINE_CR (Macintosh line endings)
NEWLINE_CRLF (DOS/Windows line endings)
NEWLINE_LF (Unix line endings)

Splitting Streams

- Poco::TeeInputStream and Poco::TeeOutputStream copy all characters going through them (read or written) to one or more output streams.
- #include "Poco/TeeStream.h"
- These streams are quite useful for debugging purposes.
- void addStream(std::ostream& ostr)
  adds an output stream to a Poco::TeeInputStream or Poco::TeeOutputStream.

```
#include "Poco/TeeStream.h"
#include <iostream>
#include <fstream>

using Poco::TeeOutputStream;

int main(int argc, char** argv)
{
    TeeOutputStream tee(std::cout);

    std::ofstream fstr("output.txt");
    tee.addStream(fstr);

    tee << "Hello, world!" << std::endl;

    return 0;
}
```

The Null Stream

> Poco::NullOutputStream discards all data written to it.

> Poco::NullInputStream signals end-of-file for every read operation.

> #include "Poco/NullStream.h"

Writing and Reading Binary Data

- Poco::BinaryWriter is used to write the value of basic types in binary form to an output stream, using a stream-like interface.
- #include "Poco/BinaryWriter.h"
- Poco::BinaryReader is used to read basic types in binary form (produced by a Poco::BinaryWriter) from an input stream.
- #include "Poco/BinaryReader.h"
- Both support big endian and little endian byte order for writing and reading, as well as automatic byte order conversions.
- These classes are useful for exchanging binary data between systems with a different architecture.

The BinaryWriter Class

- Poco::BinaryWriter supports stream insertion operators (<<) for all built-in C++ types, as well as C strings and std::string.
- Unsigned integers (32 and 64 bit) can be written in a special compact 7 bit encoded format:
  - The value is written out seven bits at a time, starting with the seven least significant bits.
  - The most significant bit of a byte indicates whether there are more bytes coming.
  - A value that fits into seven bits takes one storage byte.
  - For a 32-bit value, at most five bytes are used.

The BinaryWriter Class (cont'd)

- void write7BitEncoded(UInt32 value)
  void write7BitEncoded(UInt64 value)
  writes an unsigned integer in the compact 7 bit encoded format to the underlying output stream
- void writeRaw(const std::string& rawData)
  writes rawData as is to the underlying stream
- void writeBOM()
  writes a byte order mark (the 16 bit value 0xFEFF in host byte order) to the stream. A BinaryReader uses the BOM to automatically enable byte order conversion, if required.

BinaryWriter and Byte Order

- A BinaryWriter is constructed with an output stream, and an optional byte order argument.
- The byte order can be one of the following:
  - NATIVE_BYTE_ORDER (default)
  - BIG_ENDIAN_BYTE_ORDER
  - NETWORK_BYTE_ORDER
  - LITTLE_ENDIAN_BYTE_ORDER

BinaryWriter Stream State

- Poco::BinaryWriter provides convenience functions to determine or change the state of the underlying output stream.
- void flush()
  flushes the underlying stream
- bool good()
  returns true if the stream is okay
- bool fail()
  returns the state of the stream's fail bit
- bool bad()
  returns the state of the stream's bad bit

The BinaryReader Class

- Poco::BinaryReader provides stream extraction operators (>>) for all built-in C++ types, as well as std::string.
- void read7BitEncoded(UInt32& value)
  void read7BitEncoded(UInt64& value)
  read an integer stored in 7 bit compressed format
- void readRaw(int length, std::string& value)
  reads length bytes of raw data into value
- void readBOM()
  reads a byte order mark and enables or disables automatic byte order conversion for all data read in the future

The BinaryReader Class (cont'd)

- bool good()
  returns true if the stream is okay
- bool fail()
  returns the state of the stream's fail bit
- bool bad()
  returns the state of the stream's bad bit
- bool eof()
  returns the state of the stream's eof bit

```
#include "Poco/BinaryWriter.h"
#include <fstream>

using Poco::BinaryWriter;

int main(int argc, char** argv)
{
    std::ofstream ostr("binary.dat", std::ios::binary);
    BinaryWriter writer(ostr);

    writer.writeBOM();
    writer << "Hello, world!" << 42;
    writer.write7BitEncoded(123);
    writer << true;

    return 0;
}
```

```
#include "Poco/BinaryReader.h"
#include <fstream>

using Poco::BinaryReader;

int main(int argc, char** argv)
{
    std::ifstream istr("binary.dat", std::ios::binary);
    BinaryReader reader(istr);

    reader.readBOM();

    std::string hello;
    int i;
    bool b;

    reader >> hello >> i;
    reader.read7BitEncoded(i);
    reader >> b;

    return 0;
}
```

Cross-Platform Considerations

- Poco::BinaryWriter and Poco::BinaryReader can be used to exchange data between systems with different architectures.
- Either write the data in a fixed byte order (e.g., big endian), or use a byte order mark and write in native byte order.
- Be careful with integers. Prefer Poco::UIntXX and Poco::IntXX to (unsigned) short, (unsigned) int and (unsigned) long.
- For textual data, ensure that a common encoding (e.g., Latin-1 or UTF-8) is used.

File Streams

- POCO provides stream classes for reading and writing files: FileStream, FileInputStream, FileOutputStream
- #include "Poco/FileStream.h"
- On Windows platforms, the path passed to a File Stream is UTF-8 encoded.
- No line ending conversion is performed. File streams are always open in binary mode. Seeking is supported.
- Use InputLineEndingConverter or OutputLineEndingConverter if you need CR-LF conversion.

Writing Your Own Stream Classes

- POCO provides stream buffer class templates that simplify the implementation of custom stream classes.
- Streams are implemented by first creating a stream buffer class (streambuf), and then adding IOS, istream and ostream classes.
- The following stream buffer class templates are available:
  - Poco::BasicUnbufferedStreamBuf
  - Poco::BasicBufferedStreamBuf
  - Poco::BasicBufferedBidirectionalStreamBuf

UnbufferedStreamBuf

- Poco::BasicUnbufferedStreamBuf is a class template that must be instantiated for a character type.
- Poco::UnbufferedStreamBuf is an instantiation of Poco::BasicUnbufferedStreamBuf for char.
- #include "Poco/UnbufferedStreamBuf.h"
- Poco::UnbufferedStreamBuf is the simplest way to implement a custom stream. It does not do any buffering.

UnbufferedStreamBuf (cont'd)

- Subclasses must override the following member functions:
  - int readFromDevice()
    reads and returns a single (unsigned) byte. Returns char_traits::eof() (-1) if no more data is available.

    NOTE: Never return a char value directly, as char might be signed. Always use int charToInt(char c) to convert the character to an integer.

  - int writeToDevice(char c)
    writes a single byte. Returns the byte (as integer) if successful, otherwise char_traits::eof() (-1).

```
#include "Poco/UnbufferedStreamBuf.h"
#include <ostream>
#include <cctype>

class UpperStreamBuf: public UnbufferedStreamBuf
{
public:
    UpperStreamBuf(std::ostream& ostr): _ostr(ostr)
    {
    }

protected:
    int writeToDevice(char c)
    {
        _ostr.put(toupper(c));
        return charToInt(c);
    }

private:
    std::ostream& _ostr;
};
```

```
class UpperIOS: public virtual std::ios
{
public:
    UpperIOS(std::ostream& ostr): _buf(ostr)
    {
        poco_ios_init(&_buf);
    }

protected:
    UpperStreamBuf _buf;
};


class UpperOutputStream: public UpperIOS, public std::ostream
{
public:
    UpperOutputStream(std::ostream& ostr):
        UpperIOS(ostr),
        std::ostream(&_buf)
    {
    }
};
```

```
int main(int argc, char** argv)
{
    UpperOutputStream upper(std::cout);

    upper << "Hello, world!" << std::endl;

    return 0;
}
```

Buffered Streams

> Poco::BasicBufferedStreamBuf is a class template that must be instantiated for a character type.

> Poco::BufferedStreamBuf is an instantiation of Poco::BasicBufferedStreamBuf for char.

> #include "Poco/BufferedStreamBuf.h"

> An instance of Poco::BufferedStreamBuf supports either reading or writing, but not both.

> Poco::BasicBufferedBidirectionalStreamBuf supports reading and writing. Internally, it maintains two buffers.

> #include "Poco/BufferedBidirectionalStreamBuf.h"

Buffered Streams (cont'd)

- Subclasses of Buffered[Bidirectional]StreamBuf must override the following member functions:
  - int readFromDevice(char* buffer, std::streamsize length)
    read up to length characters and place them in buffer. Return the number of characters read, or -1 if something went wrong.
  - int writeToDevice(const char* buffer, std::streamsize length)
    write length bytes starting from buffer and return the number of bytes written, or -1 if something went wrong.

Stream Buffers and Exceptions

- Exceptions thrown by stream buffers will normally be catched by the stream class and result in the stream's bad bit being set. The exception will not propagate; instead, the stream's bad bit will be set.
- This behavior of a stream can be changed by calling the exceptions() member function of a stream with true as argument.

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