(7-1) Streams and File Processing in C++

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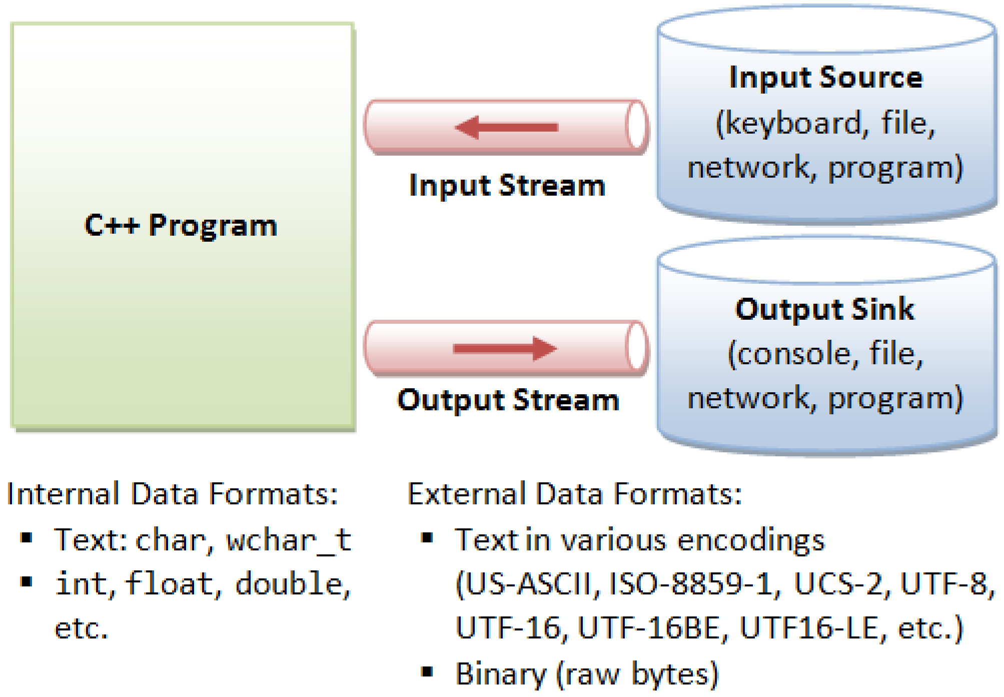
What is a Stream? A Refined Definition

- A *sequence* of objects (generally just considered bytes) that flow from a device to memory or from memory to a device
- For *input* operations, the bytes flow from the device (i.e. keyboard, network connection, disk, etc.) to main memory
- For *output* operations, the bytes flow from main menu to the device (screen, printer, etc.)

Abstraction of a Stream


C++ Program
Input Stream
Output Stream
Input Source
(keyboard, file, network, program)
Output Sink
(console, file, network, program)

Internal Data Formats:

- Text: char, wchar_t
- int, float, double, etc.

External Data Formats:

- Text in various encodings (US-ASCII, ISO-8859-1, UCS-2, UTF-8, UTF-16, UTF-16BE, UTF16-LE, etc.)
- Binary (raw bytes)

- Image courtesy of: http://www.ntu.edu.sg/home/ehchua/programming/cpp/images/IOstreams.png

Analogy for a Stream

- A conveyer belt
  - You can place an item in sequence on the belt, i.e. into the stream (insertion or output operation)
  - You can remove an item in sequence from the belt, i.e. take from the stream (extraction or input operation)

Classic Streams vs. Standard Streams

- The *classic* input/output streams for C++ supported byte-sized `char`s, which represented the ASCII characters
- Many alphabets require *more* characters than can be represented by a *byte* and the ASCII character set does not provide the characters
  - The *Unicode* character set provides these ones
- C++ provides *standard* stream libraries to process Unicode characters (`wchar_t`)

Standard Streams in C++ (1)

- For *standard* input/output streams, include `<iostream>`
  - `cin` is a predefined *object* of class `istream` and is connected to the standard input device (i.e. keyboard)
    - `cin >> var // cin applying stream extraction operator – stops at whitespace for strings`
  - `cout` is a predefined *object* of class `ostream` and is connected to the standard output device (i.e. screen)
    - `cout << var // cout applying stream insertion operator`

Standard Streams in C++ (2)

- *Member* function `getline()` will read a line from the stream
  - Inserts a null character at the end of the array of characters, removes and discards the ‘\n’ from the stream (i.e. stored as a C string)

Recall the File Processing Algorithm!

- Step 1: open the desired file
  - Opening is based on filename and permissions (read, write, or append)
  - Associates a file with a stream
- Step 2: process the file
  - Read data from the file
    - Does not affect file
  - Write data to the file
    - Completely overwrites existing file
  - Add data to the end of the file
    - Retains previous information in file
- Step 3: close the file
  - Disassociates a file from a stream

Files Streams in C++ (1)

- For input/output streams to work with *files*, include `<fstream>`
  - `ifstream` objects enable input from a file
  - `ofstream` objects enable output to a file
  - `fstream` objects for input from and output to a file
- Associate file with a file stream either during construction (applying the constructor or by calling `open()`)
  - `fstream fstr(“filename.txt”) // an instantiation of fstream object` or `fstr.open(“filename.txt”) // after instantiation`

Files Streams in C++ (2)

- Read from files using:
  - `fstr >> var; // applying the stream extraction operator – stops at whitespace for strings`
  - `fstr.getline () // to read entire line into a character array`
    - Stored as a C string
- Write to files using:
  - `fstr << var; // applying the stream insertion operator`

Files Streams in C++ (3)

- Each file ends with an end-of-file marker (EOF)
  - check if at end of file using `fstr.eof()`
- Close a file using:
  - `fstr.close();`

Closing Thoughts on Files

- Files are required for many applications
- Files may be created and manipulated in any manner appropriate for an application

References

- P.J. Deitel & H.M. Deitel, *C++: How to Program* (9th ed.), Prentice Hall, 2014
- J.R. Hanly & E.B. Koffman, *Problem Solving and Program Design in C (8th Ed.)*, Addison-Wesley, 2016

Collaborators

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