Strings and Streams

Representing Text, Working with Streams from Files and Strings

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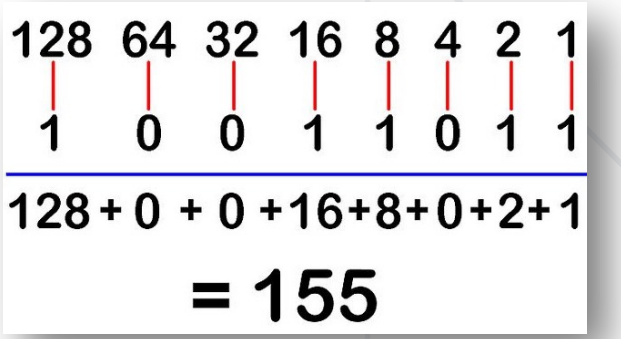
#cpp-fundamentals

Text in Computers

Bytes, Code Points, Encoding

Text in Computers

- Data is **bytes** of **1s** and **0s**
- Ways we interpret bytes:
  - **Binary number** -> integer types
  - **IEEE754** -> floating-point types
  - **Binary "code point"** -> char types
- **Characters** are just another interpretation of binary data



Text in Computers

- **Text is a sequence of characters**
- A character consists of **one or more bytes**
  - The binary representation of a **number**
  - Interpreted as a **code point** from a **character set**
- **Character set** – a group of characters
- **Code point** – unique number assigned to a character in a charset
  - ASCII code point **65** is '**A**'

Character Sets and Unicode

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- **ASCII** is the base charset – code points from **0** to **127**
  - English letters, digits, punctuation, control symbols
- **Extended ASCII** – code points from **128** to **255**
  - **Different charsets use those codepoints for different characters**
  - Windows Cyrillic code point **211** (**0xD3**) is **У**
  - Windows Greek code point **211** (**0xD3**) is **Σ**
- Unicode unifies charsets to represent **all the world's characters**

Text Representation

C-Strings and std::string class

Text Representation

- C++ has good native support for the **ASCII charset**
  - `char` data type covers code points 0 to 255

- **Text types** (sequences of characters) are called **strings**
- C++ has two standard ways of working with text
  - **Character arrays**
  - `std::string` – a "smart" wrapper of a C-String

Character Arrays

- An array of char (`char str[]` or `char* str`) with the following rules:
  - Should be null-terminated: end with `'\0'` which is `char(0)`
  - `'\0'` counts as an element – it affects array size
- Null-terminator tells C++ where the string ends
  - C++ arrays don't know their size

C-Strings

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- Initialization can happen with **array initializer** or **literal**
  - If using normal array initializer, don't forget the `'\0'` at the end

```
char text[12] = { 'C','+','+',' ','P','r','o','g','r','a','m','\0'};
char sameText[] = { 'C','+','+',' ','P','r','o','g','r','a','m', 0};
char sameTextAgain[] = "C++ Programming";
char sameTextYetAgain[12] = "C++ Programming";
```

- `cin` and `cout` can directly write to and read from C-Strings
  - `cout` prints until it reaches `'\0'`
  - `cin` works correctly only if array can fit entered data

C-String Built-in Functions

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- C-String functions are defined in the `<cstring>` header
- `strcat(char* destination, const char* source)`
  - Appends (concatenates) `source` C-String into `destination` C-String
  - `destination` needs to be long enough for source + null-terminator
- `strlen(const char* str)`
  - Returns length of C-String in `str`
- `strstr(const char* str, const char* search)`
  - Returns the address of **`search`** in **`str`** and **`NULL`** if not found
  - **`int index = strstr(str, search) - str;`** gets the index

std::string Class

std::string Class

- The C++ **string** encapsulates a null-terminated C-String
  - **#include<string>**
- Declare like a normal variable
  - Empty (**""**, size **0**) if only declared
  - Can be initialized with C-String or string literal

```
string theFoxPart = "the quick brown fox";
string theActionPart("jumps over");
char dogPartCString[] = "the lazy dog";
string sentence = theFoxPart + string("---") +
                  theActionPart + string(3, '-')
                  + dogPartCString;
```

std::string: Basics

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- Strings can be used with **cin/cout**

```
string name;
cin >> name;
cout << name;
```

- **size()** and **length()** return the **number of chars**

```
string greeting = "hello";
for (int i = 0; i < greeting.size(); i++)
{
    cout << greeting[i] << endl;
}
```

std::string: Basics

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- The [ ] operator is supported – similar to [ ] for a char array

```
string text = "hello";
text[1] = 'a';
cout << text << endl; //hallo
```

- The + operator concatenates two strings

```
string helloName = hello + string(" ") + name;
cout << helloName << endl; //"hello George"
```

- c_str() - returns the actual C-string of the std::string object

std::string: Comparisons and Search

- Two strings can be compared with any comparison operator
  - operators **<**, **<=**, **==**, **>=**, **>** compare the strings lexicographically

```
string s1 = "cat", s2 = "canary";
if (s1 < s2) cout << s1 << " is before " << s2 << endl;
else cout << s1 << " is after " << s2 << endl;
```

- **str.find(search)**
  - Returns the index of **search** in the **str**
  - If **search** is not found, returns the **string::npos** value (**-1**)

```
cout << "nar" << " at index " << s1.find("nar") << " in " << s2;
```

std::string: Find All Occurrences

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- The `find(search, index)` overload takes a start index
  - The search starts from that index

```
string s = "aha";
cout << s.find("a", 1); // prints 2
```

- We can use this to search all occurrences of a substring

```
string str = "canary";
int foundIndex = str.find("a");
while (foundIndex != string::npos)
{
  cout << foundIndex << endl;
  foundIndex = str.find("a", foundIndex + 1);
}
```

std::string: Substring

- `substr(index, length)` returns a new string
  - With `length` characters, starting from `index`

```
string text = "abc";
cout << text.substr(1, 2); // prints bc
```

```
string fullName = "Ivan Ivanov";
string firstName = fullName.substr(0, 4);
string lastName = fullName.substr(5, 6);
cout << firstName << endl; // prints Ivan
cout << lastName << endl; // prints Ivanov
```

std::string: Erase and Replace

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- `erase(index, length)`
  - Changes a string by removing chars
  - Removes `length` characters, starting from `index`

```
string text = "abc";
text.erase(1,2);
cout << text; // prints a
```

- `replace(index, length, str)`
  - Changes a string by replacing
  - Characters in `[index, index + length)` replaced by `str`

```
string text = "abc";
text.replace(1, 2, "cme");
cout << text; // prints acme
```

Streams

Reading by Line and File Streams

Streams

- **Streams offer an abstraction over incoming or outgoing data of indefinite length**
  - `cin` and `cout` are abstractions of the console input or output
- Streams are **ways of reading / writing data**
- A stream can be constructed for any type of data container as:
  - **arrays, strings, memory**
  - **files, network connections, the keyboard buffer**

std::stringstream

- **A stream that works on a string**

```
#include<sstream>
```

- Can **read** data from a string
- Can **write** data to a string
  - There are limited `istringstream/ostringstream` versions that only read or write respectively
- Useful for working on a string "word-by-word"

Reading with std::istringstream

- **istringstream** is a limited **stringstream** than only reads
  - If you only want to read, use it instead of **stringstream**
- Initialize **istringstream** by giving it a **string** to read from

```
string str = "3 -2";
istringstream numbersStream(str);
```

- From then on, use the stream just like **cin**

```
int num1, num2;
numbersStream >> num1 >> num2;
int sum = num1 + num2;
```

Writing with std::ostringstream

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- **ostringstream** is a limited **stringstream** than only writes
- Initialize **ostringstream** like a normal variable

```
ostringstream stream;
```

- Use the stream just like **cout**

```
stream << "The sum is " << num1 + num2 << endl;
```

- To get the string when you're done, call **str()**

```
cout << stream.str();
```

Reading with getline() and Streams

- `getline(stream, targetStr)`
  - Reads an entire line of text until a delimiter `char` (additional parameter) is reached
  - From the provided `stream` and puts it into `targetStr`
  - Avoid mixing `cin>>` and `getline(cin,…)`

```
istringstream in("a word");

string line;
getline(in, line);
cout << line << endl; // a word
```

```
istringstream in("a.word");

string line;
getline(in, line, '.');
cout << line << endl; // a
```

Parsing Numbers from a Line

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- `getline()` already gives us the line as a string
- Streams allow us to **read strings or numbers separated by spaces**
- How do we know when to stop?
  - Streams can be used as a `bool` value
  - A stream is `true` if it still has something to read
  - A stream is `false` if the input ended or if there was an error

Parsing Numbers from a Line

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- Read the line from `cin` into a `string` with `getline()`
- Create an `istringstream` over that `string`
- Read numbers from the stream while the stream is `true`

```
string line;
getline(cin, line);
istringstream lineStream(line);
int numbers[100];
int currentNumber;
int count = 0;
while (lineStream >> currentNumber)
{
    numbers[count++];
}
```

File Streams

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```
#include<fstream>
```

- `ifstream` is for reading
- `ofstream` is for writing
- Text reading / writing with same operators, functions, concepts
  - `<<` for writing
  - `>>` for reading
  - `getline()` reads line, etc.
  - Can be used as `bool` just like `cin`, `cout` and `stringstream`

Using File Streams

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- Declare the stream and open the file
  - Input streams expect the **file to exist**

```
ifstream input;
input.open("input.txt");
int a, b;
input >> a >> b;
input.close();
```

  - Output streams **create or overwrite the file** on opening

```
ofstream output;
output.open("output.txt");
output << a + b << endl; output.close();
```

Using File Streams

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- **Declaration** and **opening** can be shortened

```
ifstream input("input.txt");
int a, b;
input >> a >> b;
input.close();
```

```
ofstream output("output.txt");

output << a + b << endl;
output.close();
```

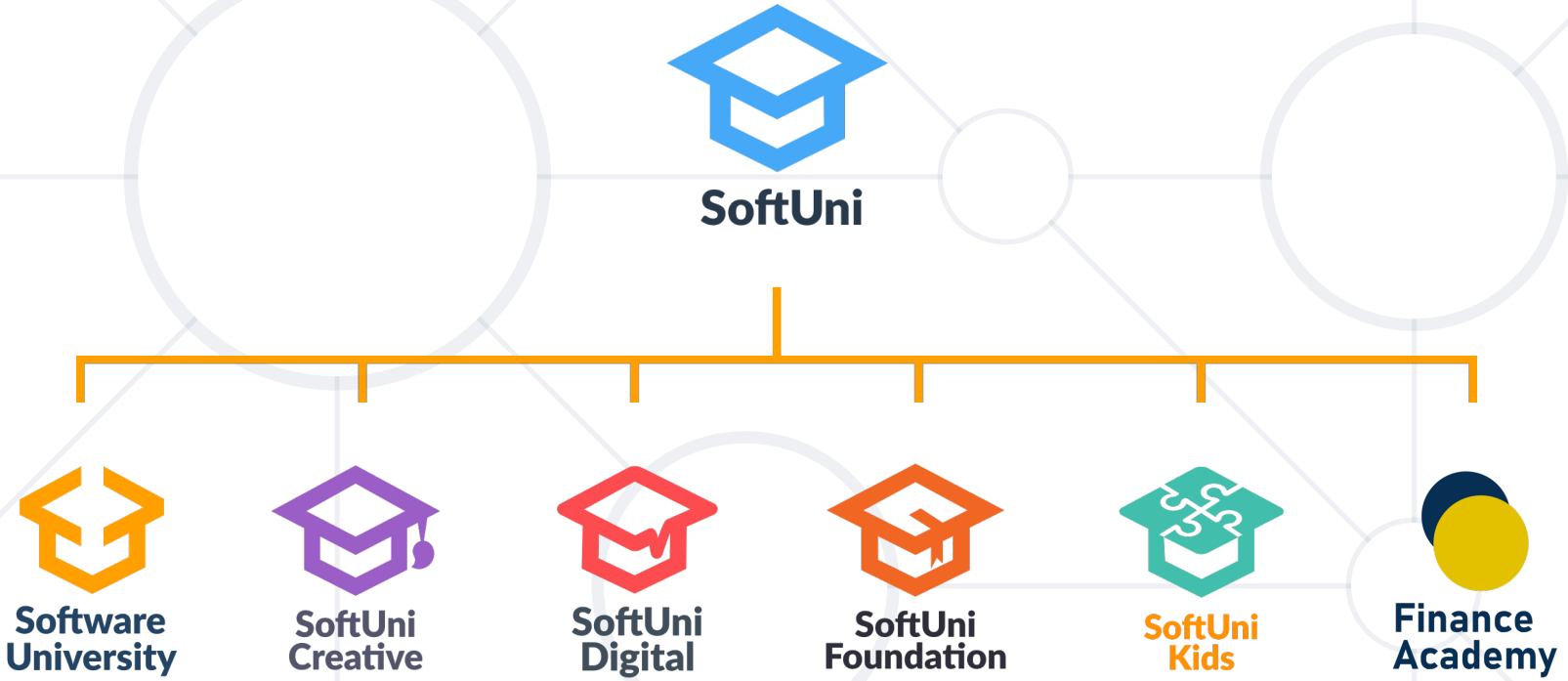
- `close()` is automatically called when stream goes out of scope
- To make an output stream append instead of overwrite:

```
ofstream output("output.txt", fstream::app);
```

Summary

- Text is a sequence of bytes interpreted by special rules
- Two standard ways of working with text:
  - `std::string` is the way for working with text
  - C-Strings (`char` arrays) are the legacy C approach
- Streams are abstractions for writing or reading data

Questions?



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