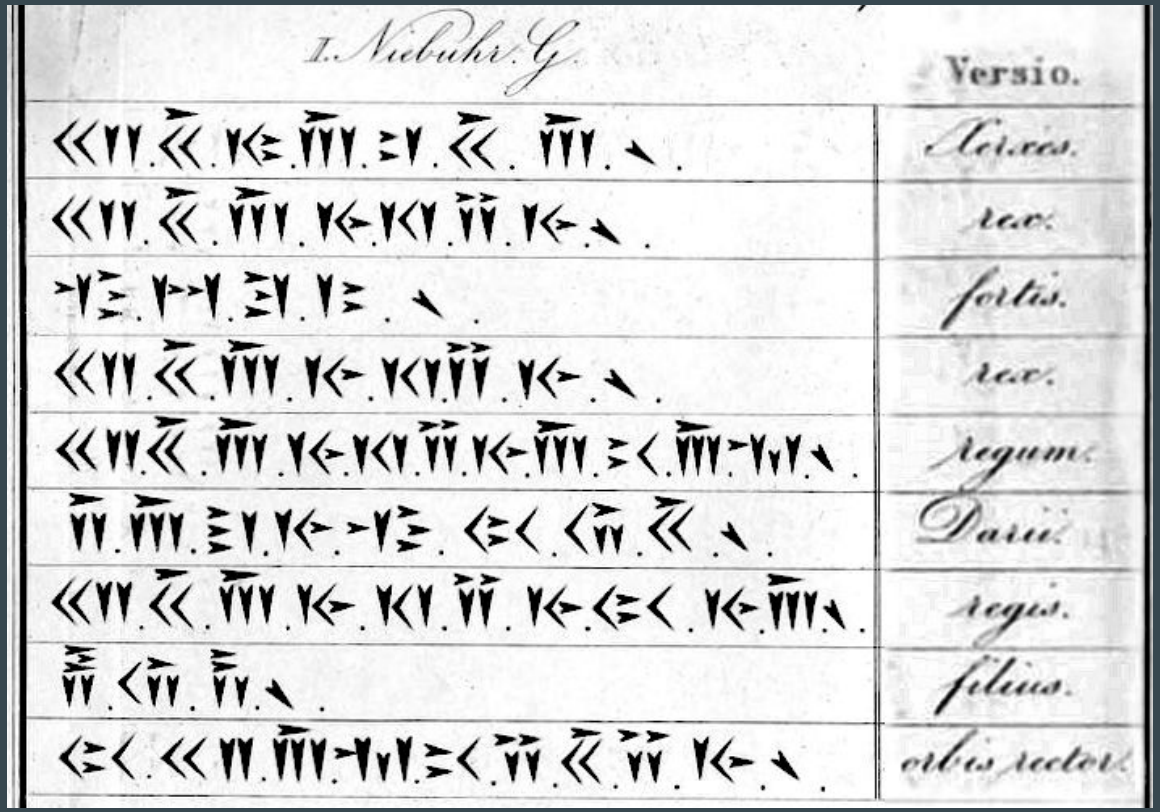
String Theory

...

How hard can it be to deal with text?

Text!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Text Manipulation in Computer Programs

Different approaches exist for handling textual data.

Goal: understand the tradeoffs of some approaches!

Why? Understand and appreciate design decisions of different programming languages.

C, Java

C “Strings” - Basics

- Everything* is bytes in memory -> Strings are bytes in memory.

```
char *name = "Alice";
```

* Well, yes, but actually, no: some “bytes in memory” have special constraints (read-only, I/O, MMU, …)

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- Strings are memory that contains 8-bit chars and ends with ‘\0’

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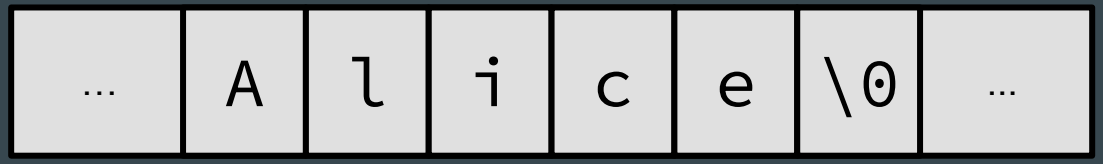

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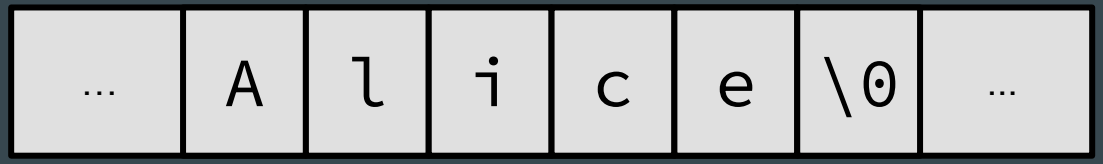

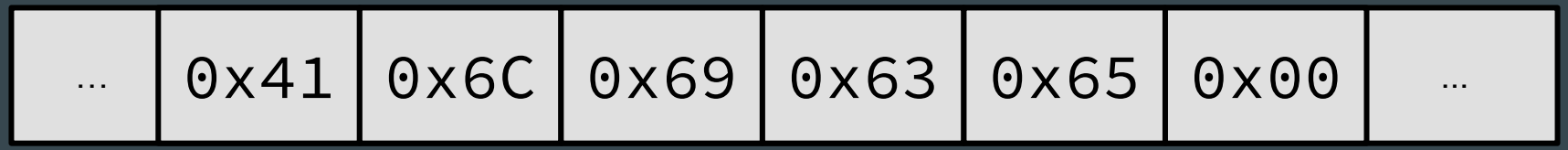

C “Strings” - Literals

- Everything* is bytes in memory -> Strings are bytes in memory.
- Strings are memory that contains 8-bit chars and ends with `‘\0’`
- `“String literals”`: **constant**, stored in the program binary

```
char *name = "Alice";
name[0] = 'B';
printf("%s", name);
```

C “Strings” - Literals

- Everything* is bytes in memory -> Strings are bytes in memory.
- Strings are memory that contains 8-bit chars and ends with `‘\0’`
- `“String literals”`: **constant**, stored in the program binary (where else?)

C “Strings” - Dynamic strings

- Strings on the heap: arbitrary length, modifiable, `malloc/free`

```c
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

int main() {
    char *name = malloc(12);
    strcpy(name, "Alice");
    printf("%s\n", name);
    name[0] = 'B';
    printf("%s\n", name);
    return 0;
}
```

C “Strings” - Dynamic strings

- Strings on the heap: arbitrary length, modifiable, `malloc/free`
- Helpful tool for any kind of heap allocation or (file) handle work:

  `valgrind`

  - Instruments system such that all allocations are tracked
  - Info about: Memory leaks, invalid read/writes, and more
  - IMHO, highly underrated tool

https://valgrind.org/

C “Strings” - Dynamic strings

- Strings on the heap: arbitrary length, modifiable, `malloc/free`

```
==11286== HEAP SUMMARY:
==11286==     in use at exit: 12 bytes in 1 blocks
==11286==   total heap usage: 2 allocs, 1 frees, 1,036 bytes allocated
==11286==
==11286== LEAK SUMMARY:
==11286==    definitely lost: 12 bytes in 1 blocks
```

C “Strings” - ASCII

Wait.... 8-bit? Isn’t that too small to do anything useful?

- ASCII has 127 letters; gotta be enough (?)
- `wchar_t`: implementation-defined mess
- C11 “`uchar.h`” universal char, ironically not yet supported in many implementations

C “Strings” - ASCII

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C “Strings” - Things going wrong I

```c
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

int main(int argc, char *argv[]) {
    int size = 0;
    scanf("%d", &size);
    int array[size];

    printf("Size of array: %d\n", sizeof(array));
}
```

C “Strings” - Things going wrong II

```c
#include "stdio.h"

int main() {
    for (int i = 0; i < 10; i++) {
        printf("Hello number \n" + i);
    }
}
```

Java

- Everything* is an object -> Strings are objects
- Strings are immutable - once you got a String, you cannot change it!
    - HOW? The public API is read-only. String is also marked as `‘final’`, preventing overriding

  That’s actually nice: no side-effects with shared Strings, Thread Safety

- StringBuilder or StringBuffer for when you want a buffer of char

* Well, yes, but actually, no: double, char, and friends are considered “primitive” types, on the stack

Java

Unicode is supported, but clumsy

- char is 16-bit on every architecture. 2^16 = 65535 (0xffff)

  But Unicode has 136,755 characters, at least!

- Solution: Store Unicode code point in 2 java chars (UTF-16).
  - Length of String != Number of chars in the String
  - Indexing a Unicode String is potentially an invalid operation

  - `String java = 💩; // works, 0x1F4A9 > 0xffff`

http://wiki.juneday.se/mediawiki/images/b/b4/Java_and_Unicode.pdf

Java

```
String str1 = "someString";
String str2 = "someString";
Scanner in = new Scanner(System.in);

while (true) {
    if (str1 == str2) {
        // Ironically, operator+ for string concatenation exists
        System.out.println("\"someString\" == \"" + str2 + "\" is true!");
    } else {
        System.out.println("\"someString\" == \"" + str2 + "\" is false!");
    }
    str2 = in.nextLine();
}
```

Java

```
String str1 = "someString";
String str2 = "someString";
Scanner in = new Scanner(System.in);

while (true) {
    if (str1 == str2) {
        [illegible] In[illegible]ically [illegible]or [illegible] for [illegible]ing [illegible]ation exists
        [illegible]tem.out.println("\"someString\" == \"" + str[illegible] "\" i[illegible]!");
    } else {
        System.out.println("\"someString\" == \"" + str2 + "\" is false!");
    }
    str2 = in.nextLine();
}
```

Leaky Abstraction

Java

Java does not support operator overloading (all proposals were rejected)

- Operator overloading? -> Assigning new meaning to +, -, !, ==, and so on

  matrix1 + matrix2 becomes something like:
  `Matrix::operator::add(matrix1, matrix2) -> Matrix`

But String is special case; ‘+’ is allowed for string concatenation

- string concatenation? Putting different strings together.

```
System.out.println(“This will be ” + 1 + “ string”);
```

Java

BTW:

Yes, this is how you print a string to Standard Output in Java:

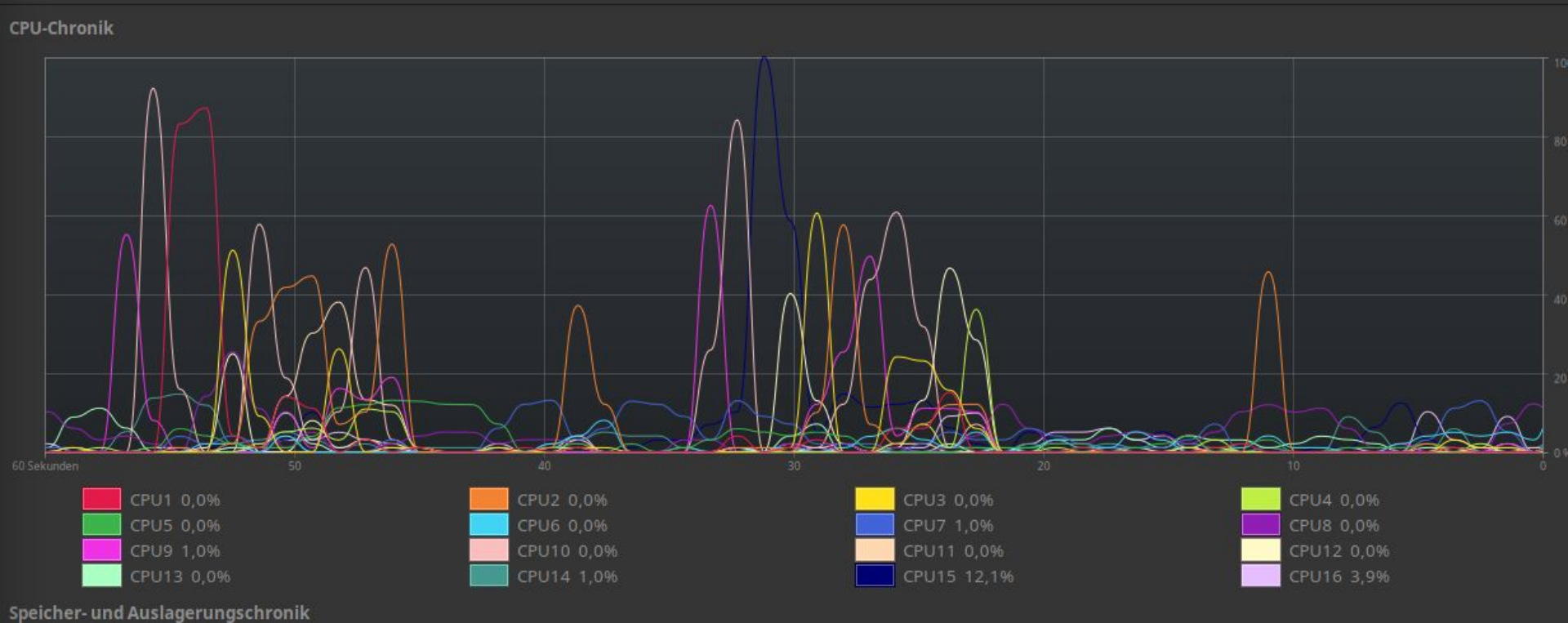
```
System.out.println(“This will be ” + 1 + “ string”);
```

Java

Another operator: ‘==’

Java

```
$> valgrind java StringExample
```



C

https://stackoverflow.com/questions/16870485/how-can-i-read-an-input-string-of-unknown-length