

# CMSC 330: Organization of Programming Languages

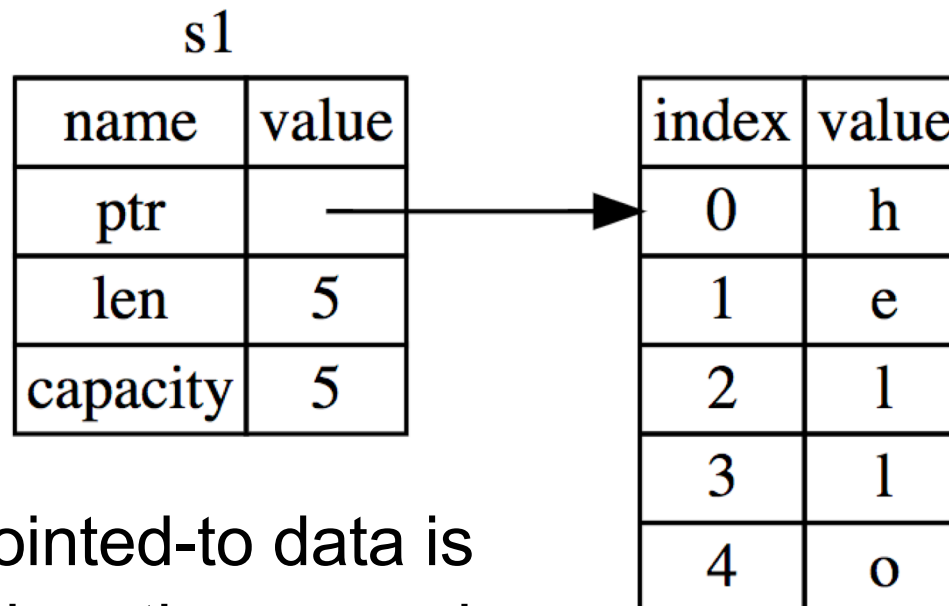
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## Strings, Slices, Vectors, HashMaps in Rust

# String Representation

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- Rust's `String` is a 3-tuple
    - A pointer to a `byte array` (interpreted as UTF-8)
    - A (current) `length`
    - A (maximum) `capacity`
- Always:  $\text{length} \leq \text{capacity}$



`String` pointed-to data is dropped when the owner is

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	Code	<u>Prints</u>
	<pre>let mut s = String::new(); println!("{}", s.capacity()); for _ in 0..5 {     s.push_str("hello");     println!("{}",         s.len(), s.capacity()); }</pre>	0 5,5 10,10 15,20 20,20 25,40

# Slices: Motivation

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- Suppose we want the first word of a string. Here's how we might do it in **OCaml**

```
let first_word s =  
  try  
    let i = String.index s ' ' in  
    String.sub s 0 i  
  with Not_found -> s
```

- **String.sub** **allocates new memory** and **copies** the sub-string's contents
  - This is a waste (especially with a large string) if both **s** and its substring are to be treated as **immutable**

# Slice: Shared Data, Separate Metadata

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- What we want is to have both strings **share the same underlying data**
- Happily, Rust's containers permit a way to present a **slice** of an object's contents

String s

name	value
ptr	→
len	11
capacity	11

String slice  
world

name	value
ptr	→
len	5

index	value
0	h
1	e
2	l
3	l
4	o
5	
6	w
7	o
8	r
9	l
10	d

# String Slices in Rust

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- If `s` is a `String`, then `&s[range]` is a **string slice**, where *range* can be as follows.
  - `i..j` is the range from `i` to `j`, inclusive
  - `i..` is the range from `i` to the current length
  - `..j` is the range from `0` to `j`
  - `..` is the range from `0` to the current length
- **`&str`** is the type of a `String` slice

# String Slice Example

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- Here's `first_word` in Rust, using slices:

```
fn first_word(s: &String) -> &str {
    let bytes = s.as_bytes();
    for (i, &item) in
        bytes.iter().enumerate() {
        if item == b' ' {
            return &s[0..i];
        }
    }
    &s[..]
}
```

# Using String Slices

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- A `&str` slice **borrow**s from the original string
  - Just like an **immutable `String`** reference
  - This **prevents dangling pointers**

```
let mut s = String::from("hello world");  
let word = first_word(&s); //borrow  
s.clear(); // Error! Can't take mut ref
```

- **String literals** are slices

```
let s:&str = "hello world";
```

- Should **use slices where possible**
  - E.g., `fn first_word(s:&str) -> &str`
    - Can convert `String s` to a slice via `&s[. .]`. Oftentimes, this coercion is done automatically (due to `Deref` trait)



# Strings Miscellany

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- `push_str(&mut self, string: &str)`
  - `string` argument is a slice, so doesn't take ownership, while `self` is a mutable reference, implying it is the only such reference

- **Iteration** over chars, bytes, etc. **Code** **Prints**

```
let s = String::from("hello");
for (i,c) in s.char_indices() {
    println!("{}", i, c);
}
```

0,h  
1,e  
2,l  
3,l  
4,o

- See also `split_at_whitespace`

<https://doc.rust-lang.org/std/string/struct.String.html>

# Vectors: Basics

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- `Vec<T>` in Rust is `ArrayList<T>` in Java

```
{ let mut v:Vec<i32> = Vec::new();  
  v.push(1); // adds 1 to v  
  v.push("hi"); //error - v contains i32s  
  let w = vec![1, 2, 3];  
} // v,w and their elements dropped
```

- Indexing can fail (`panic`) or `return an Option`

```
let v = vec![1, 2, 3, 4, 5];  
let third:&i32 = &v[2]; //panics if OOB  
let third:Option<&i32> = v.get(2); //None if OOB
```

# Aside: Options

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- `Option<T>` is an enumerated type, like an OCaml variant
  - `Some (v)` and `None` are possible values

```
let v = vec! [1, 2, 3, 4, 5];
let third:Option<i32> = v.get(2);
let z =
  match third {
    Some(i) => Some(i+1), //matches here
    None => None
  };
```

- We'll see more about enumerated types later
  - For now, follow your nose

# Vectors: Updates and Iteration

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```
let mut a = vec![10, 20, 30, 40, 50];
{ let p = &mut a[1]; //mutable borrow
  *p = 2; //updates a[1]
} //ownership restored
println!("vector contains {:?}", &a);
```

- If we remove the `{ }` block around the def of `p`, above, then the code fails
  - Not allowed to print via `a` while mutable borrow `p` is out
- Iterator variable can be mutable or immutable:

```
let v = vec![100, 32, 57];
for i in &v { println!("{}", i); }
for i in &mut v { *i += 50; }
```

# Vector and Strings

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- Like **Strings**, **vectors can have slices**

```
let a = vec![10, 20, 30, 40, 50];  
let b = &a[1..3]; // [20,30]  
let c = &b[1];    // 30  
println!("{}", c); // prints 30
```

- **Strings** implemented internally as a **Vec<u8>**

# HashMaps

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- `HashMap<K, V>` has the expected methods (roughly – see manual for gory details)
  - `new` : `()` -> `HashMap<K, V>`
  - `insert`: `(K, V)` -> `Option<V>`
  - `get` : `(&K)` -> `Option<&V>`
- See also
  - `get_mut`, `entry`, and `or_insert`

<https://doc.rust-lang.org/book/second-edition/ch08-03-hash-maps.html>

<https://doc.rust-lang.org/std/collections/struct.HashMap.html>