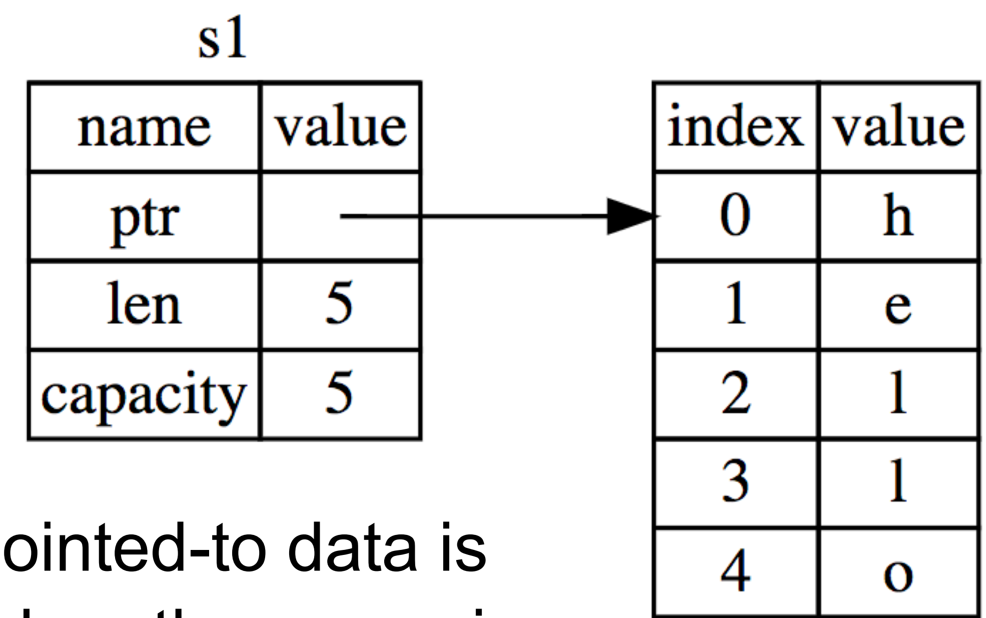
CMSC 330: Organization of Programming Languages

Strings, Slices, Vectors, HashMaps in Rust

`String` Representation

- Rust's **`String`** is a 3-tuple
  - A pointer to a byte array (interpreted as UTF-8)
  - A (current) length
  - A (maximum) capacity

Always: length ≤ capacity



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

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Code

```
let mut s = String::new();
println!("{}", s.capacity());
for _ in 0..5 {
  s.push_str("hello");
  println!("{},{}",
    s.len(),s.capacity());
}
```

Prints

0
5,5
10,10
15,20
20,20
25,40

Slices: Motivation

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

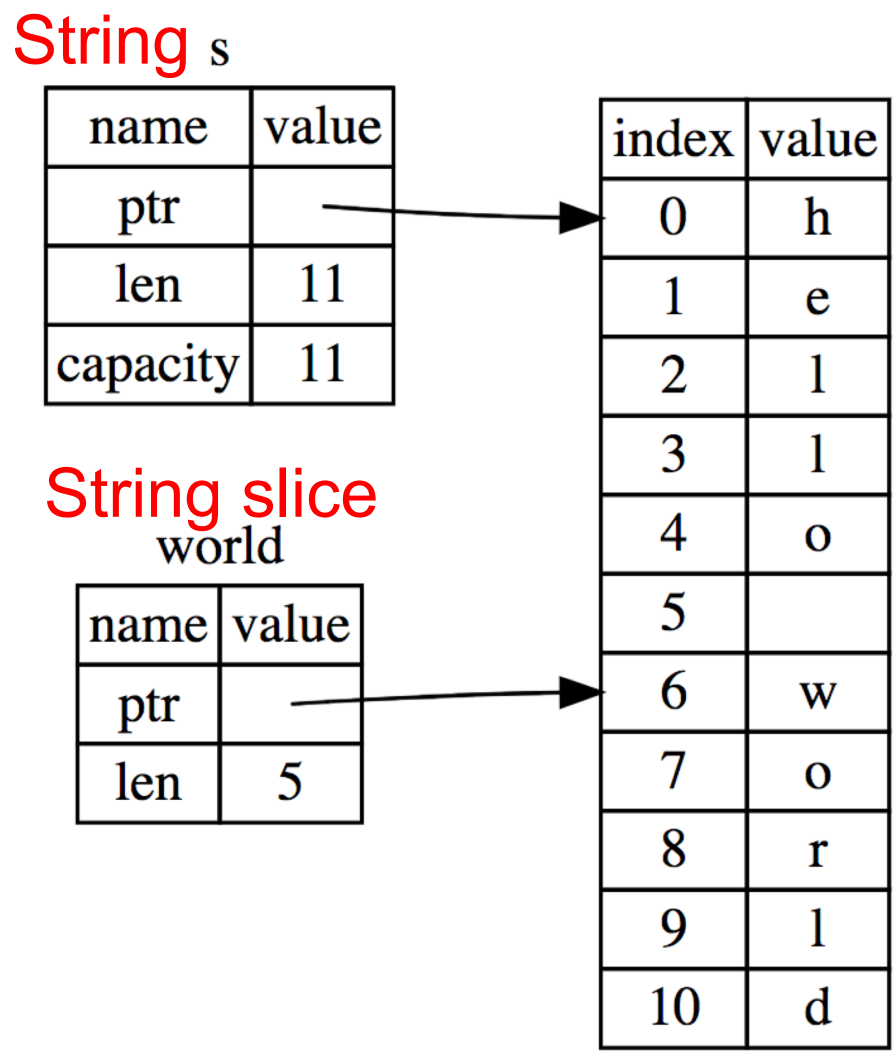
```
let first_word s =
  try
    let i = String.index s ' ' in
    String.sub s 0 i
  with Not_found -> s
```

- **`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

- 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 Slices in Rust

- 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

- 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

- A **`&str`** slice borrows 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

- **`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

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

Prints

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

- **`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
```

https://doc.rust-lang.org/book/second-edition/ch08-01-vectors.html

Aside: Options

- **`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 v {
    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

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

Vector and Strings

- Like **`String`**s, 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
```

- **`String`**s implemented internally as a **`Vec<u8>`**

HashMaps

- `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