Modules and Crates and Privacy Rules

- Note don't do this part on a company network,
- Company network makes it hard to install external packages

Packages

- `Cargo new` creates a new Package
  - Each package can have 2 types of crates
    - Binary Crates: codes you can execute
    - Library Crates: code you can access from others
  - Each crate has Modules
    - Modules allows you organize a chunk of code and change the privacy of the code
- There is also workspaces which can hold multiple packages
- 3 Main Rules of Packages:
  - All packages must contain at least one crate
  - A package can have upto at most 1 library crate
  - A package can have any number of binary crates

Crates

- In the `.toml` file there is no explicit crate to start
- However there are 2 automatic crates that can be created
  - If you have a `main.rs` file in the root of your src/ directory then it creates a **Binary Crate** with the same name as the package
    - The **root** of this Binary Crate will be from `main.rs`.
    - The rust compiler will start at main.rs for the crate
    - This will also make up the **root module**
  - If you have a `lib.rs` file in the root of your src/ directory then it creates a **Library Crate** with the same name as the package
    - All other conventions from the auto binary crate also will be applied for the library crate
    - A lib.rs file is not auto created with `cargo new` command
      - BUT you can auto make it if you use `cargo new --lib`
      - Note this will not make a main.rs then
- To create more binary crates outside of the automatic ones
  - You need to create a folder `bin/` inside the src/ directory
  - Each file in the bin/ folder will represent its own binary crate

Modules

- Modules are specified using the `mod` keyword in a rust file

- Restaurant Example:

```
mod front_of_house{
    mod hosting{
```

```
            fn add_to_waitlist(){}

            fn seat_at_table(){}
        }

        mod serving {
            fn take_order(){}

            fn serve_order(){}

            fn take_payment(){}
        }
    }
```

- In this example, we have a module to represent the front of the house
- In that module we have 2 nested modules that represent hosting and serving
- Within the nested modules has functions
  - Within a module you can define
    - Functions
    - Structs
    - Enums
    - Traits
    - Constants
    - etc.
- This creates a module tree for the crate and helps us organize our code
- The root of the tree will be called `crate` which is the default root module of either lib.rs or main.rs
- It is similar to a directory tree in linux

-

- How do we access the functions in the Modules?
- You need to use the `::` operator to give the path
- Example:

```
fn eat_at_restaurant(){
    //Absolute Path
    crate::front_of_house::hosting::add_to_waitlist();

    //Relative Path
    front_of_house::hosting::add_to_waitlist();
}
```

- Note that this will have privacy errors, but let's focus on the paths for now
- Here we are using two paths
  - Absolute Path

        - Needs to start at the root of the Module tree which is `crate` and then separates the scopes using the `::` operator
    - Relative Path
        - Starts from the current module automatically
        - In this case, since we are making this function globally in the same file, then it starts at the root module `crate` by default.
            - This means that we only need to specify the path after `crate`

Module Privacy Rules

- By default in rust, a child module is private to all of its parents
    - For instance, in our previous example, hosting is private to front_of_house module.
- By default, all parent modules are public to their child modules.
    - In this case, `crate` public to `front_of_house` which is public to `hosting`.
    - This means that only child module you want needs to be accessible outside of the module since the parents will be accessible by the child.
- By default, all functions of a module are private to the module it is in and all the parents above.
- Even if a module is public, the functions and information inside the moduel is private unless specified otherwise
- This system allows us to hide implementation details by default and only expose what we want to the outside world
- To make something public we use the `pub` keyword infront of any scope or function
- Example, Let's Fix our front of house:

```
mod front_of_house{
    pub mod hosting{
        pub fn add_to_waitlist(){}

        fn seat_at_table(){}
    }

    mod serving {
        fn take_order(){}

        fn serve_order(){}

        fn take_payment(){}
    }
}

fn eat_at_restaurant(){
    //Absolute Path
    crate::front_of_house::hosting::add_to_waitlist();
```

```
    //Relative Path
    front_of_house::hosting::add_to_waitlist();
}
```

- Understanding paths and permissions we can utilize some shortcuts
- One thing to note, within a module, all functions at the same level are visibile to each other
- Another thing to note is the `super::` keyword, which is takes advantage of the relative path from the parent to the child.
- `super::` takes the function of the parent.
- Exmample:

```
fn serve_order(){}
mod back_of_house{
    fn fix_incorrect_order(){

        cook_order();
        super::serve_order();
    }
    fn cook_order(){}

}
```

  - Here we call the serve_order() function from the `crate` module
  - We can also see that cook_order() is visible since it is within the same module

- **Struct and Enums Privacy**
  - Structs
    - Structs within a module are private by default
    - But so is there fields, methods, and associated functions
    - You need to be careful when accessing, mutating, or creating a struct as every part of the struct needs the `pub` keyword to be fully public
    - Example of a Struct

```
mod cafe{
    pub struct Breakfast{
        pub toast : String,
        soup_of_the_day : String,
    }

    impl Breakfast{
```

```
        pub fn summer(toast: &str)->Breakfast{
            Breakfast{
                toast : String::from(toast),
                soup_of_the_day: String::from("chowder"),

            }
        }
    }
}

pub fn eat_breakfast(){
    let mut meal = cafe::Breakfast::summer("Wheat");

    // meal.soup_of_the_day = String::from("chicken noodle");
    meal.toast = String::from("Rye");

    /* Error
    let new_meal = cafe::Breakfast{
        toast : String::from("Sourdough"),
        soup_of_the_day : String::from("hot and spicy")
    };
    */
}
```

- We can notice that the struct had to be made public and so is the constructor function `summer()`
- Also note that the `toast` field is public and can be modified but not the `soup` field
- Even though the struct is public and the toast field is public, because the `soup` field is private we cannot make a constructor of the Struct outside of the associated function `summer()`
- To that point, we cannot even make a constructor outside of the `cafe` module because of this.
- The `new_meal` instance of Breakfast is going to be an error since `soup` is private.

- This gives users more flexibility in the different aspects of visibility to the Struct
- However it is a little more error proned

- Enums
  - Enums are private by default in a module however
  - Unlike a struct, all the fields/variants in an enum are public by default.
  - Meaning, as long as the enum is public, all the variants are public.
  - Example:

```
mod Meal{
    pub enum Appetizer{
        Soup,
```

```
        Salad,
    }
}

pub fn order(){
    let order1 = Meal::Appetizer::Soup;
    let order2 = Meal::Appetizer::Salad;
}
```

- This example is simple but there is not much else to it, once an enum is public it is accessible
- This is mainly due to private enum variants are not useful when programming

- **Use**
  - The Use Keyword we have seen before when importing modules or crates into a file
  - However a more true way to describe it is bringing something external into scope
  - `use` Can be used to bring modules outside of the file into scope or other Modules within the file into scope
  - Lets see an example:

```
mod BBQ{
    pub mod hosting{
        pub fn add_to_waitlist(){}
    }
}

//Absolute Path
use crate::BBQ::hosting;

//Relative Path
use self::BBQ::hosting;
pub fn eat_at_BBQ(){

    hosting::add_to_waitlist();

    hosting::add_to_waitlist();
}
```

- So in this example we define a module called BBQ and a hosting within it
- Now we see how we can bring the module hosting into scope
- This is done in two different ways
- The first way starts at the root `crate`
- The second way is a relative path and starts with the keyword `self`
- We could take it a step further and bring the function within hosting into scope, but rust prefers only bringing modules into scope

        - We want it to be clear where the function is coming from
    - Being clear about which module the function or Struct is being called from is very important but there is anothiner way of performing this with Structs
    - When bringing a module or struct or enum into scope that may conflict with an existing struct name, you can rename with the `as` keyword
    - `use std::io::Result as IoResult;`
    - `use std::fmt::Result as Result;`
    - Here we can see to types of Result coming into scope but we renamed one of them so that it is clear where the struct is coming from.
    - Now if we want external codes to see modules within our crate, we just need to add the `pub` keyword to the `use`
    - This will bring the scope that `use` has to external code to read.
        - `pub use self::cafe::Breakfast;`
        - Now external code will have access to Breakfast as well
    - The `use` keyword brings items into scope within our program and external dependencies into our scope
    - We can add dependencies in the `Cargo.toml` file and bring them into scope with use.
        - Example in `.toml` file:

```
[package]
name = "tutorial13_Modules"
version = "0.1.0"
edition = "2021"

# See more keys and their definitions at https://doc.rust-
lang.org/cargo/reference/manifest.html

[dependencies]
# ADDED DEPENDENCIES
rand = "0.5.5"
```

        - Example in importing dependency into your code
            - `use rand::{Rng, CryptoRng, Errorking::Transient}`
            - Here we are using **nested paths** which is used to bring multiple **pub** childs of a parent into scope with the brackets `{}`

- **Glob Operator**

    - If you want to bring **all public fields** of a module, including other modules and functions into scope, you can use the `*` operator at the end of the `use` path
        - `use std::io::*`

Defining the contents of a Module in separate files

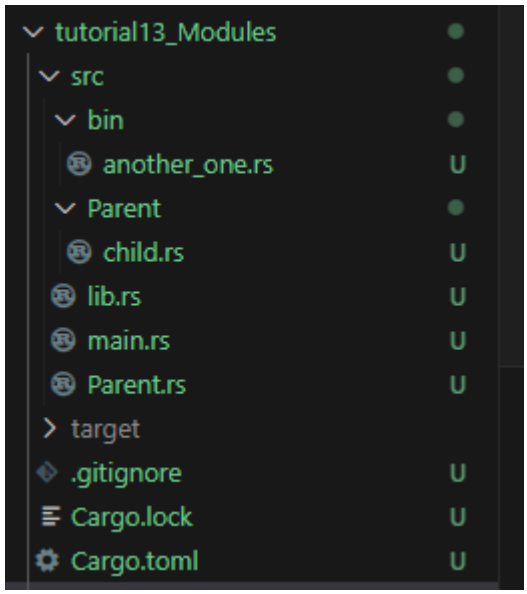
- Many times the module grows very large and you may want to dedicate an entire file to the contents of the module
- Well in rust we can define the module in a crate, while making the contents of the moduel in a separate file.
- Let's use the example and keep it in the `lib.rs`

```
mod Parent{
    pub mod child {
        pub fn new_fn(){}
    }
}
```

- Let's now move the contents of Parent to a file called `Parent.rs`
    - So in the `lib.rs` we now have the following
        - `mod Parent;`
    - So in Parent.rs we have the following

```
pub mod child{
  pub fn new_fn(){}
}
```

- And then make a folder called Parent/ in the same directory as the Parent.rs file
- Then make a `child.rs` file with the contents of child
    - So let's move the Parent.rs contents to child.rs
    - In `Parent.rs` we now have the following
        - `pub mod child;`
    - In `child.rs` we have the following
        - `pub fn new_fn(){}`
- Now we go back to the lib.rs file and we can see that there are no errors
- Your File System should look like this at the end



- Going through what each should have right now
  - Lib.rs: `mod Parent;`
  - Parent.rs: `pub child.rs;`
  - Parent/
    - child.rs: `pub fn new_fn(){}`