Using Structs to Structure Related Data

A struct, or structure, is a custom data type that lets you package together and name multiple related values that make up a meaningful group. If you’re familiar with an object-oriented language, a struct is like an object’s data attributes. In this chapter, we’ll compare and contrast tuples with structs to build on what you already know and demonstrate when structs are a better way to group data.

We’ll demonstrate how to define and instantiate structs. We’ll discuss how to define associated functions, especially the kind of associated functions called methods, to specify behavior associated with a struct type. Structs and enums (discussed in Chapter 6) are the building blocks for creating new types in your program’s domain to take full advantage of Rust’s compile-time type checking.

Defining and Instantiating Structs

Structs are similar to tuples, discussed in “The Tuple Type” on page XX, in that both hold multiple related values. Like tuples, the pieces of a struct can be different types. Unlike with tuples, in a struct you’ll name each piece of data so it’s clear what the values mean. Adding these names means that structs are more flexible than tuples: you don’t have to rely on the order of the data to specify or access the values of an instance.

To define a struct, we enter the keyword struct and name the entire struct. A struct’s name should describe the significance of the pieces of data being grouped together. Then, inside curly brackets, we define the names and types of the pieces of data, which we call fields. For example, Listing 5-1 shows a struct that stores information about a user account.

src/main.rs

struct User {

active: bool,

username: String,

email: String,

sign\_in\_count: u64,

}

A User struct definition

To use a struct after we’ve defined it, we create an instance of that struct by specifying concrete values for each of the fields. We create an instance by stating the name of the struct and then add curly brackets containing key: value pairs, where the keys are the names of the fields and the values are the data we want to store in those fields. We don’t have to specify the fields in the same order in which we declared them in the struct. In other words, the struct definition is like a general template for the type, and instances fill in that template with particular data to create values of the type. For example, we can declare a particular user as shown in Listing 5-2.

src/main.rs

fn main() {

let user1 = User {

active: true,

username: String::from("someusername123"),

email: String::from("someone@example.com"),

sign\_in\_count: 1,

};

}

Creating an instance of the User struct

To get a specific value from a struct, we use dot notation. For example, to access this user’s email address, we use user1.email. If the instance is mutable, we can change a value by using the dot notation and assigning into a particular field. Listing 5-3 shows how to change the value in the email field of a mutable User instance.

src/main.rs

fn main() {

let mut user1 = User {

active: true,

username: String::from("someusername123"),

email: String::from("someone@example.com"),

sign\_in\_count: 1,

};

user1.email = String::from("anotheremail@example.com");

}

Changing the value in the email field of a User instance

Note that the entire instance must be mutable; Rust doesn’t allow us to mark only certain fields as mutable. As with any expression, we can construct a new instance of the struct as the last expression in the function body to implicitly return that new instance.

Listing 5-4 shows a build\_user function that returns a User instance with the given email and username. The active field gets the value of true, and the sign\_in\_count gets a value of 1.

src/main.rs

fn build\_user(email: String, username: String) -> User {

User {

active: true,

username: username,

email: email,

sign\_in\_count: 1,

}

}

A build\_user function that takes an email and username and returns a User instance

It makes sense to name the function parameters with the same name as the struct fields, but having to repeat the email and username field names and variables is a bit tedious. If the struct had more fields, repeating each name would get even more annoying. Luckily, there’s a convenient shorthand!

Using the Field Init Shorthand

Because the parameter names and the struct field names are exactly the same in Listing 5-4, we can use the field init shorthand syntax to rewrite build\_user so it behaves exactly the same but doesn’t have the repetition of username and email, as shown in Listing 5-5.

src/main.rs

fn build\_user(email: String, username: String) -> User {

User {

active: true,

username,

email,

sign\_in\_count: 1,

}

}

A build\_user function that uses field init shorthand because the username and email parameters have the same name as struct fields

Here, we’re creating a new instance of the User struct, which has a field named email. We want to set the email field’s value to the value in the email parameter of the build\_user function. Because the email field and the email parameter have the same name, we only need to write email rather than email: email.

Creating Instances from Other Instances with Struct Update Syntax

It’s often useful to create a new instance of a struct that includes most of the values from another instance of the same type, but changes some. You can do this using struct update syntax.

First, in Listing 5-6 we show how to create a new User instance in user2 regularly, without the update syntax. We set a new value for email but otherwise use the same values from user1 that we created in Listing 5-2.

src/main.rs

fn main() {

--snip--

let user2 = User {

active: user1.active,

username: user1.username,

email: String::from("another@example.com"),

sign\_in\_count: user1.sign\_in\_count,

};

}

Creating a new User instance using all but one of the values from user1

Using struct update syntax, we can achieve the same effect with less code, as shown in Listing 5-7. The syntax .. specifies that the remaining fields not explicitly set should have the same value as the fields in the given instance.

src/main.rs

fn main() {

--snip--

let user2 = User {

email: String::from("another@example.com"),

..user1

};

}

Using struct update syntax to set a new email value for a User instance but to use the rest of the values from user1

The code in Listing 5-7 also creates an instance in user2 that has a different value for email but has the same values for the username, active, and sign\_in\_count fields from user1. The ..user1 must come last to specify that any remaining fields should get their values from the corresponding fields in user1, but we can choose to specify values for as many fields as we want in any order, regardless of the order of the fields in the struct’s definition.

Note that the struct update syntax uses = like an assignment; this is because it moves the data, just as we saw in “Variables and Data Interacting with Move” on page XX. In this example, we can no longer use user1 after creating user2 because the String in the username field of user1 was moved into user2. If we had given user2 new String values for both email and username, and thus only used the active and sign\_in\_count values from user1, then user1 would still be valid after creating user2. Both active and sign\_in\_count are types that implement the Copy trait, so the behavior we discussed in “Stack-Only Data: Copy” on page XX would apply. We can also still use user1.email in this example, because its value was not moved out of user1.

Using Tuple Structs Without Named Fields to Create Different Types

Rust also supports structs that look similar to tuples, called tuple structs. Tuple structs have the added meaning the struct name provides but don’t have names associated with their fields; rather, they just have the types of the fields. Tuple structs are useful when you want to give the whole tuple a name and make the tuple a different type from other tuples, and when naming each field as in a regular struct would be verbose or redundant.

To define a tuple struct, start with the struct keyword and the struct name followed by the types in the tuple. For example, here we define and use two tuple structs named Color and Point:

src/main.rs

struct Color(i32, i32, i32);

struct Point(i32, i32, i32);

fn main() {

let black = Color(0, 0, 0);

let origin = Point(0, 0, 0);

}

Note that the black and origin values are different types because they’re instances of different tuple structs. Each struct you define is its own type, even though the fields within the struct might have the same types. For example, a function that takes a parameter of type Color cannot take a Point as an argument, even though both types are made up of three i32 values. Otherwise, tuple struct instances are similar to tuples in that you can destructure them into their individual pieces, and you can use a . followed by the index to access an individual value. Unlike tuples, tuple structs require you to name the type of the struct when you destructure them. For example, we would write let Point(x, y, z) = origin; to destructure the values in the origin point into variables named x, y, and z.

Unit-Like Structs Without Any Fields

You can also define structs that don’t have any fields! These are called unit-like structs because they behave similarly to (), the unit type that we mentioned in “The Tuple Type” on page XX. Unit-like structs can be useful when you need to implement a trait on some type but don’t have any data that you want to store in the type itself. We’ll discuss traits in Chapter 10. Here’s an example of declaring and instantiating a unit struct named AlwaysEqual:

src/main.rs

struct AlwaysEqual;

fn main() {

let subject = AlwaysEqual;

}

To define AlwaysEqual, we use the struct keyword, the name we want, and then a semicolon. No need for curly brackets or parentheses! Then we can get an instance of AlwaysEqual in the subject variable in a similar way: using the name we defined, without any curly brackets or parentheses. Imagine that later we’ll implement behavior for this type such that every instance of AlwaysEqual is always equal to every instance of any other type, perhaps to have a known result for testing purposes. We wouldn’t need any data to implement that behavior! You’ll see in Chapter 10 how to define traits and implement them on any type, including unit-like structs.

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Ownership of Struct Data

In the User struct definition in Listing 5-1, we used the owned String type rather than the &str string slice type. This is a deliberate choice because we want each instance of this struct to own all of its data and for that data to be valid for as long as the entire struct is valid.

It’s also possible for structs to store references to data owned by something else, but to do so requires the use of lifetimes, a Rust feature that we’ll discuss in Chapter 10. Lifetimes ensure that the data referenced by a struct is valid for as long as the struct is. Let’s say you try to store a reference in a struct without specifying lifetimes, like the following in src/main.rs; this won’t work:

struct User {

active: bool,

username: &str,

email: &str,

sign\_in\_count: u64,

}

fn main() {

let user1 = User {

active: true,

username: "someusername123",

email: "someone@example.com",

sign\_in\_count: 1,

};

}

The compiler will complain that it needs lifetime specifiers:

$ cargo run

Compiling structs v0.1.0 (file:///projects/structs)

error[E0106]: missing lifetime specifier

--> src/main.rs:3:15

|

3 | username: &str,

| ^ expected named lifetime parameter

|

help: consider introducing a named lifetime parameter

|

1 ~ struct User<'a> {

2 | active: bool,

3 ~ username: &'a str,

|

error[E0106]: missing lifetime specifier

--> src/main.rs:4:12

|

4 | email: &str,

| ^ expected named lifetime parameter

|

help: consider introducing a named lifetime parameter

|

1 ~ struct User<'a> {

2 | active: bool,

3 | username: &str,

4 ~ email: &'a str,

|

In Chapter 10, we’ll discuss how to fix these errors so you can store references in structs, but for now, we’ll fix errors like these using owned types like String instead of references like &str.

An Example Program Using Structs

To understand when we might want to use structs, let’s write a program that calculates the area of a rectangle. We’ll start by using single variables, and then refactor the program until we’re using structs instead.

Let’s make a new binary project with Cargo called rectangles that will take the width and height of a rectangle specified in pixels and calculate the area of the rectangle. Listing 5-8 shows a short program with one way of doing exactly that in our project’s src/main.rs.

src/main.rs

fn main() {

let width1 = 30;

let height1 = 50;

println!(

"The area of the rectangle is {} square pixels.",

area(width1, height1)

);

}

fn area(width: u32, height: u32) -> u32 {

width \* height

}

Calculating the area of a rectangle specified by separate width and height variables

Now, run this program using cargo run:

The area of the rectangle is 1500 square pixels.

This code succeeds in figuring out the area of the rectangle by calling the area function with each dimension, but we can do more to make this code clear and readable.

The issue with this code is evident in the signature of area:

fn area(width: u32, height: u32) -> u32 {

The area function is supposed to calculate the area of one rectangle, but the function we wrote has two parameters, and it’s not clear anywhere in our program that the parameters are related. It would be more readable and more manageable to group width and height together. We’ve already discussed one way we might do that in “The Tuple Type” on page XX: by using tuples.

Refactoring with Tuples

Listing 5-9 shows another version of our program that uses tuples.

src/main.rs

fn main() {

let rect1 = (30, 50);

println!(

"The area of the rectangle is {} square pixels.",

1 area(rect1)

);

}

fn area(dimensions: (u32, u32)) -> u32 {

2 dimensions.0 \* dimensions.1

}

Specifying the width and height of the rectangle with a tuple

In one way, this program is better. Tuples let us add a bit of structure, and we’re now passing just one argument 1. But in another way, this version is less clear: tuples don’t name their elements, so we have to index into the parts of the tuple 2, making our calculation less obvious.

Mixing up the width and height wouldn’t matter for the area calculation, but if we want to draw the rectangle on the screen, it would matter! We would have to keep in mind that width is the tuple index 0 and height is the tuple index 1. This would be even harder for someone else to figure out and keep in mind if they were to use our code. Because we haven’t conveyed the meaning of our data in our code, it’s now easier to introduce errors.

Refactoring with Structs: Adding More Meaning

We use structs to add meaning by labeling the data. We can transform the tuple we’re using into a struct with a name for the whole as well as names for the parts, as shown in Listing 5-10.

src/main.rs

1 struct Rectangle {

2 width: u32,

height: u32,

}

fn main() {

3 let rect1 = Rectangle {

width: 30,

height: 50,

};

println!(

"The area of the rectangle is {} square pixels.",

area(&rect1)

);

}

4 fn area(rectangle: &Rectangle) -> u32 {

5 rectangle.width \* rectangle.height

}

Defining a Rectangle struct

Here, we’ve defined a struct and named it Rectangle 1. Inside the curly brackets, we defined the fields as width and height, both of which have type u32 2. Then, in main, we created a particular instance of Rectangle that has a width of 30 and a height of 50 3.

Our area function is now defined with one parameter, which we’ve named rectangle, whose type is an immutable borrow of a struct Rectangle instance 4. As mentioned in Chapter 4, we want to borrow the struct rather than take ownership of it. This way, main retains its ownership and can continue using rect1, which is the reason we use the & in the function signature and where we call the function.

The area function accesses the width and height fields of the Rectangle instance 5 (note that accessing fields of a borrowed struct instance does not move the field values, which is why you often see borrows of structs). Our function signature for area now says exactly what we mean: calculate the area of Rectangle, using its width and height fields. This conveys that the width and height are related to each other, and it gives descriptive names to the values rather than using the tuple index values of 0 and 1. This is a win for clarity.

Adding Useful Functionality with Derived Traits

It’d be useful to be able to print an instance of Rectangle while we’re debugging our program and see the values for all its fields. Listing 5-11 tries using the println! macro as we have used in previous chapters. This won’t work, however.

src/main.rs

struct Rectangle {

width: u32,

height: u32,

}

fn main() {

let rect1 = Rectangle {

width: 30,

height: 50,

};

println!("rect1 is {rect1}");

}

Attempting to print a Rectangle instance

When we compile this code, we get an error with this core message:

error[E0277]: `Rectangle` doesn't implement `std::fmt::Display`

The println! macro can do many kinds of formatting, and by default, the curly brackets tell println! to use formatting known as Display: output intended for direct end user consumption. The primitive types we’ve seen so far implement Display by default because there’s only one way you’d want to show a 1 or any other primitive type to a user. But with structs, the way println! should format the output is less clear because there are more display possibilities: Do you want commas or not? Do you want to print the curly brackets? Should all the fields be shown? Due to this ambiguity, Rust doesn’t try to guess what we want, and structs don’t have a provided implementation of Display to use with println! and the {} placeholder.

If we continue reading the errors, we’ll find this helpful note:

= help: the trait `std::fmt::Display` is not implemented for `Rectangle`

= note: in format strings you may be able to use `{:?}` (or {:#?} for pretty-print) instead

Let’s try it! The println! macro call will now look like println!("rect1 is {rect1:?}");. Putting the specifier :? inside the curly brackets tells println! we want to use an output format called Debug. The Debug trait enables us to print our struct in a way that is useful for developers so we can see its value while we’re debugging our code.

Compile the code with this change. Drat! We still get an error:

error[E0277]: `Rectangle` doesn't implement `Debug`

But again, the compiler gives us a helpful note:

= help: the trait `Debug` is not implemented for `Rectangle`

= note: add `#[derive(Debug)]` to `Rectangle` or manually `impl Debug for Rectangle`

Rust does include functionality to print out debugging information, but we have to explicitly opt in to make that functionality available for our struct. To do that, we add the outer attribute #[derive(Debug)] just before the struct definition, as shown in Listing 5-12.

src/main.rs

#[derive(Debug)]

struct Rectangle {

width: u32,

height: u32,

}

fn main() {

let rect1 = Rectangle {

width: 30,

height: 50,

};

println!("rect1 is {rect1:?}");

}

Adding the attribute to derive the Debug trait and printing the Rectangle instance using debug formatting

Now when we run the program, we won’t get any errors, and we’ll see the following output:

rect1 is Rectangle { width: 30, height: 50 }

Nice! It’s not the prettiest output, but it shows the values of all the fields for this instance, which would definitely help during debugging. When we have larger structs, it’s useful to have output that’s a bit easier to read; in those cases, we can use {:#?} instead of {:?} in the println! string. In this example, using the {:#?} style will output the following:

rect1 is Rectangle {

width: 30,

height: 50,

}

Another way to print out a value using the Debug format is to use the dbg! macro, which takes ownership of an expression (as opposed to println!, which takes a reference), prints the file and line number of where that dbg! macro call occurs in your code along with the resultant value of that expression, and returns ownership of the value.

Note Calling the dbg! macro prints to the standard error console stream (stderr), as opposed to println!, which prints to the standard output console stream (stdout). We’ll talk more about stderr and stdout in “Writing Error Messages to Standard Error Instead of Standard Output” on page XX.

Here’s an example where we’re interested in the value that gets assigned to the width field, as well as the value of the whole struct in rect1:

src/main.rs

#[derive(Debug)]

struct Rectangle {

width: u32,

height: u32,

}

fn main() {

let scale = 2;

let rect1 = Rectangle {

1 width: dbg!(30 \* scale),

height: 50,

};

2 dbg!(&rect1);

}

We can put dbg! around the expression 30 \* scale 1 and, because dbg! returns ownership of the expression’s value, the width field will get the same value as if we didn’t have the dbg! call there. We don’t want dbg! to take ownership of rect1, so we use a reference to rect1 in the next call 2. Here’s what the output of this example looks like:

[src/main.rs:10:16] 30 \* scale = 60

[src/main.rs:14:5] &rect1 = Rectangle {

width: 60,

height: 50,

}

We can see the first bit of output came from 1 where we’re debugging the expression 30 \* scale, and its resultant value is 60 (the Debug formatting implemented for integers is to print only their value). The dbg! call at 2 outputs the value of &rect1, which is the Rectangle struct. This output uses the pretty Debug formatting of the Rectangle type. The dbg! macro can be really helpful when you’re trying to figure out what your code is doing!

In addition to the Debug trait, Rust has provided a number of traits for us to use with the derive attribute that can add useful behavior to our custom types. Those traits and their behaviors are listed in Appendix C. We’ll cover how to implement these traits with custom behavior as well as how to create your own traits in Chapter 10. There are also many attributes other than derive; for more information, see the “Attributes” section of the Rust Reference at https://doc.rust-lang.org/reference/attributes.html.

Our area function is very specific: it only computes the area of rectangles. It would be helpful to tie this behavior more closely to our Rectangle struct because it won’t work with any other type. Let’s look at how we can continue to refactor this code by turning the area function into an area method defined on our Rectangle type.

Method Syntax

Methods are similar to functions: we declare them with the fn keyword and a name, they can have parameters and a return value, and they contain some code that’s run when the method is called from somewhere else. Unlike functions, methods are defined within the context of a struct (or an enum or a trait object, which we cover in Chapter 6 and Chapter 18, respectively), and their first parameter is always self, which represents the instance of the struct the method is being called on.

Defining Methods

Let’s change the area function that has a Rectangle instance as a parameter and instead make an area method defined on the Rectangle struct, as shown in Listing 5-13.

src/main.rs

#[derive(Debug)]

struct Rectangle {

width: u32,

height: u32,

}

1 impl Rectangle {

2 fn area(&self) -> u32 {

self.width \* self.height

}

}

fn main() {

let rect1 = Rectangle {

width: 30,

height: 50,

};

println!(

"The area of the rectangle is {} square pixels.",

3 rect1.area()

);

}

Defining an area method on the Rectangle struct

To define the function within the context of Rectangle, we start an impl (implementation) block for Rectangle 1. Everything within this impl block will be associated with the Rectangle type. Then we move the area function within the impl curly brackets 2 and change the first (and in this case, only) parameter to be self in the signature and everywhere within the body. In main, where we called the area function and passed rect1 as an argument, we can instead use method syntax to call the area method on our Rectangle instance 3. The method syntax goes after an instance: we add a dot followed by the method name, parentheses, and any arguments.

In the signature for area, we use &self instead of rectangle: &Rectangle. The &self is actually short for self: &Self. Within an impl block, the type Self is an alias for the type that the impl block is for. Methods must have a parameter named self of type Self for their first parameter, so Rust lets you abbreviate this with only the name self in the first parameter spot. Note that we still need to use the & in front of the self shorthand to indicate that this method borrows the Self instance, just as we did in rectangle: &Rectangle. Methods can take ownership of self, borrow self immutably, as we’ve done here, or borrow self mutably, just as they can any other parameter.

We chose &self here for the same reason we used &Rectangle in the function version: we don’t want to take ownership, and we just want to read the data in the struct, not write to it. If we wanted to change the instance that we’ve called the method on as part of what the method does, we’d use &mut self as the first parameter. Having a method that takes ownership of the instance by using just self as the first parameter is rare; this technique is usually used when the method transforms self into something else and you want to prevent the caller from using the original instance after the transformation.

The main reason for using methods instead of functions, in addition to providing method syntax and not having to repeat the type of self in every method’s signature, is for organization. We’ve put all the things we can do with an instance of a type in one impl block rather than making future users of our code search for capabilities of Rectangle in various places in the library we provide.

Note that we can choose to give a method the same name as one of the struct’s fields. For example, we can define a method on Rectangle that is also named width:

src/main.rs

impl Rectangle {

fn width(&self) -> bool {

self.width > 0

}

}

fn main() {

let rect1 = Rectangle {

width: 30,

height: 50,

};

if rect1.width() {

println!(

"The rectangle has a nonzero width; it is {}",

rect1.width

);

}

}

Here, we’re choosing to make the width method return true if the value in the instance’s width field is greater than 0 and false if the value is 0: we can use a field within a method of the same name for any purpose. In main, when we follow rect1.width with parentheses, Rust knows we mean the method width. When we don’t use parentheses, Rust knows we mean the field width.

Often, but not always, when we give a method the same name as a field we want it to only return the value in the field and do nothing else. Methods like this are called getters, and Rust does not implement them automatically for struct fields as some other languages do. Getters are useful because you can make the field private but the method public, and thus enable read-only access to that field as part of the type’s public API. We will discuss what public and private are and how to designate a field or method as public or private in Chapter 7.

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Where’s the -> Operator?

In C and C++, two different operators are used for calling methods: you use . if you’re calling a method on the object directly and -> if you’re calling the method on a pointer to the object and need to dereference the pointer first. In other words, if object is a pointer, object->something() is similar to (\*object).something().

Rust doesn’t have an equivalent to the -> operator; instead, Rust has a feature called automatic referencing and dereferencing. Calling methods is one of the few places in Rust with this behavior.

Here’s how it works: when you call a method with object.something(), Rust automatically adds in &, &mut, or \* so object matches the signature of the method. In other words, the following are the same:

p1.distance(&p2);

(&p1).distance(&p2);

The first one looks much cleaner. This automatic referencing behavior works because methods have a clear receiver—the type of self. Given the receiver and name of a method, Rust can figure out definitively whether the method is reading (&self), mutating (&mut self), or consuming (self). The fact that Rust makes borrowing implicit for method receivers is a big part of making ownership ergonomic in practice.

Methods with More Parameters

Let’s practice using methods by implementing a second method on the Rectangle struct. This time we want an instance of Rectangle to take another instance of Rectangle and return true if the second Rectangle can fit completely within self (the first Rectangle); otherwise, it should return false. That is, once we’ve defined the can\_hold method, we want to be able to write the program shown in Listing 5-14.

src/main.rs

fn main() {

let rect1 = Rectangle {

width: 30,

height: 50,

};

let rect2 = Rectangle {

width: 10,

height: 40,

};

let rect3 = Rectangle {

width: 60,

height: 45,

};

println!("Can rect1 hold rect2? {}", rect1.can\_hold(&rect2));

println!("Can rect1 hold rect3? {}", rect1.can\_hold(&rect3));

}

Using the as-yet-unwritten can\_hold method

The expected output would look like the following because both dimensions of rect2 are smaller than the dimensions of rect1, but rect3 is wider than rect1:

Can rect1 hold rect2? true

Can rect1 hold rect3? false

We know we want to define a method, so it will be within the impl Rectangle block. The method name will be can\_hold, and it will take an immutable borrow of another Rectangle as a parameter. We can tell what the type of the parameter will be by looking at the code that calls the method: rect1.can\_hold(&rect2) passes in &rect2, which is an immutable borrow to rect2, an instance of Rectangle. This makes sense because we only need to read rect2 (rather than write, which would mean we’d need a mutable borrow), and we want main to retain ownership of rect2 so we can use it again after calling the can\_hold method. The return value of can\_hold will be a Boolean, and the implementation will check whether the width and height of self are greater than the width and height of the other Rectangle, respectively. Let’s add the new can\_hold method to the impl block from Listing 5-13, shown in Listing 5-15.

src/main.rs

impl Rectangle {

fn area(&self) -> u32 {

self.width \* self.height

}

fn can\_hold(&self, other: &Rectangle) -> bool {

self.width > other.width && self.height > other.height

}

}

Implementing the can\_hold method on Rectangle that takes another Rectangle instance as a parameter

When we run this code with the main function in Listing 5-14, we’ll get our desired output. Methods can take multiple parameters that we add to the signature after the self parameter, and those parameters work just like parameters in functions.

Associated Functions

All functions defined within an impl block are called associated functions because they’re associated with the type named after the impl. We can define associated functions that don’t have self as their first parameter (and thus are not methods) because they don’t need an instance of the type to work with. We’ve already used one function like this: the String::from function that’s defined on the String type.

Associated functions that aren’t methods are often used for constructors that will return a new instance of the struct. These are often called new, but new isn’t a special name and isn’t built into the language. For example, we could choose to provide an associated function named square that would have one dimension parameter and use that as both width and height, thus making it easier to create a square Rectangle rather than having to specify the same value twice:

src/main.rs

impl Rectangle {

fn square(size: u32) -> 1 Self {

2 Self {

width: size,

height: size,

}

}

}

The Self keywords in the return type 1 and in the body of the function 2 are aliases for the type that appears after the impl keyword, which in this case is Rectangle.

To call this associated function, we use the :: syntax with the struct name; let sq = Rectangle::square(3); is an example. This function is namespaced by the struct: the :: syntax is used for both associated functions and namespaces created by modules. We’ll discuss modules in Chapter 7.

Multiple impl Blocks

Each struct is allowed to have multiple impl blocks. For example, Listing 5-15 is equivalent to the code shown in Listing 5-16, which has each method in its own impl block.

impl Rectangle {

fn area(&self) -> u32 {

self.width \* self.height

}

}

impl Rectangle {

fn can\_hold(&self, other: &Rectangle) -> bool {

self.width > other.width && self.height > other.height

}

}

Rewriting Listing 5-15 using multiple impl blocks

There’s no reason to separate these methods into multiple impl blocks here, but this is valid syntax. We’ll see a case in which multiple impl blocks are useful in Chapter 10, where we discuss generic types and traits.

Summary

Structs let you create custom types that are meaningful for your domain. By using structs, you can keep associated pieces of data connected to each other and name each piece to make your code clear. In impl blocks, you can define functions that are associated with your type, and methods are a kind of associated function that let you specify the behavior that instances of your structs have.

But structs aren’t the only way you can create custom types: let’s turn to Rust’s enum feature to add another tool to your toolbox.