Capacity and length of a slice in Go

October 5, 2021

introduction slice array

In Go, the length of a slice tells you how many elements it contains. It can be obtained using the `len()` function. The capacity is the size of the slice's underlying array and can be obtained with the `cap()` function.

Difference between arrays and slices

To better understand the difference between the capacity and length of a slice, first, you should know the differences between arrays and slices.

Arrays

An array is an indexed collection of a certain `size` with values of the same `type`, declared as:

```
var name [sizeltype
```

'size' elements of type 'type'

Initializing an array

```
var a [4]int                    // array with zero values
var b [4]int = [4]int{0, 1, 2}    // partially initialized array
var c [4]int = [4]int{1, 2, 3, 4} // array initialization
d := [...]int{5, 6, 7, 0}         // ... - means that array size equals the number of

fmt.Printf("a: length: %d, capacity: %d, data: %v\n", len(a), cap(a), a)
fmt.Printf("b: length: %d, capacity: %d, data: %v\n", len(b), cap(b), b)
fmt.Printf("c: length: %d, capacity: %d, data: %v\n", len(c), cap(c), c)
fmt.Printf("d: length: %d, capacity: %d, data: %v\n", len(d), cap(d), d)
```

Output:

```
a: length: 4, capacity: 4, data: [0 0 0 0]
b: length: 4, capacity: 4, data: [0 1 2 0]
c: length: 4, capacity: 4, data: [1 2 3 4]
d: length: 4, capacity: 4, data: [5 6 7 0]
```

```
var a [4]int = [4]int{1, 2, 3, 4}
b := a
a[1] = 999
fmt.Println(a)
fmt.Println(b)
```

Output:

```
[1 999 3 4]
[1 2 3 4]
```

Slices

A slice declared as:

`var name []type`

is a data structure describing a piece of an array with three properties:

A slice **is not an array**. It describes a section of the underlying array stored under the `ptr` pointer.

Initializing a slice

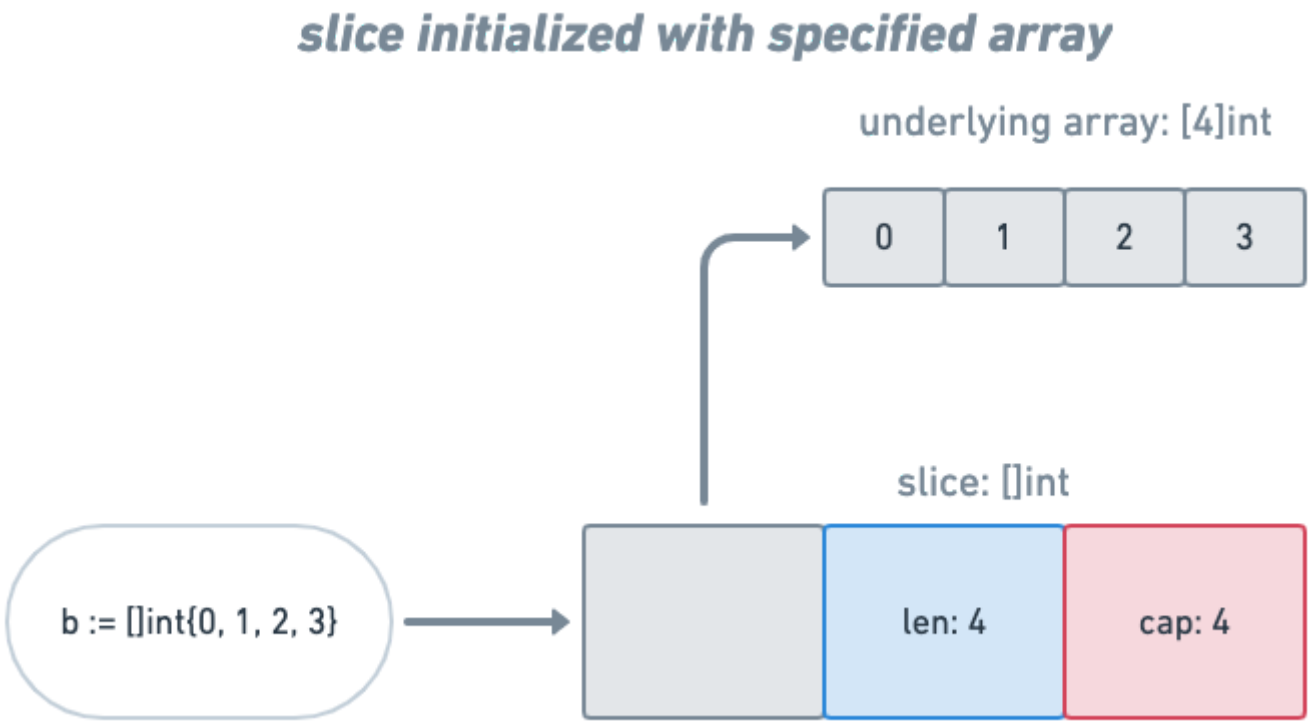
```
var a []int              // nil slice
b := []int{0, 1, 2, 3} // slice initialized with specified array
c := make([]int, 4)    // slice of size 4 initialized with zero-valued array of size 4
d := make([]int, 4, 5) // slice of size 4 initialized with zero-valued array of size 5

fmt.Printf("a: length: %d, capacity: %d, pointer to underlying array: %p, data: %v, is
fmt.Printf("b: length: %d, capacity: %d, pointer to underlying array: %p, data: %v, is
fmt.Printf("c: length: %d, capacity: %d, pointer to underlying array: %p, data: %v, is
fmt.Printf("d: length: %d, capacity: %d, pointer to underlying array: %p, data: %v, is
```

Output:

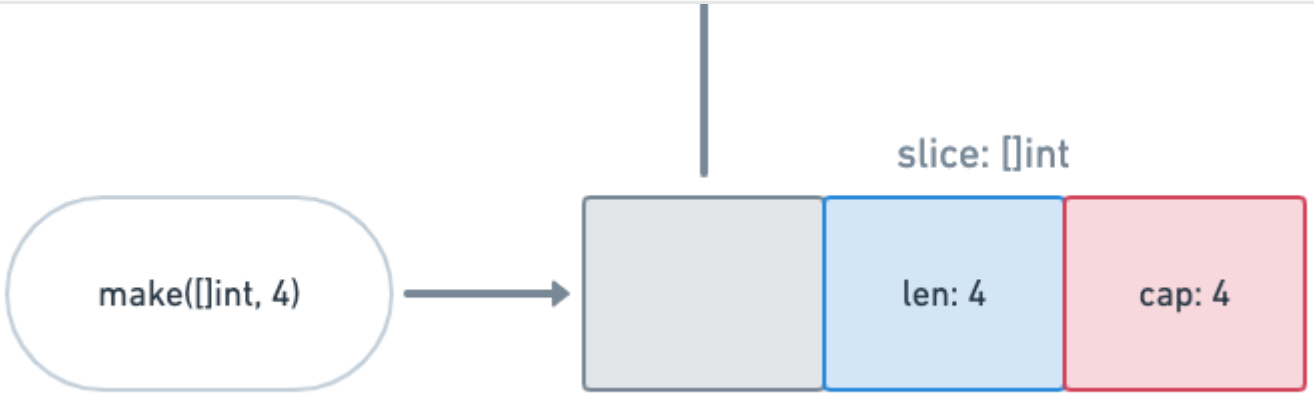
```
a: length: 0, capacity: 0, pointer to underlying array: 0x0, data: [], is nil: true
b: length: 4, capacity: 4, pointer to underlying array: 0xc00001e060, data: [0 1 2 3]
c: length: 4, capacity: 4, pointer to underlying array: 0xc00001e080, data: [0 0 0 0]
d: length: 4, capacity: 5, pointer to underlying array: 0xc000016180, data: [0 0 0 0]
```

As we see in the output `var a []int` creates a `nil` slice - a slice that has the length and capacity

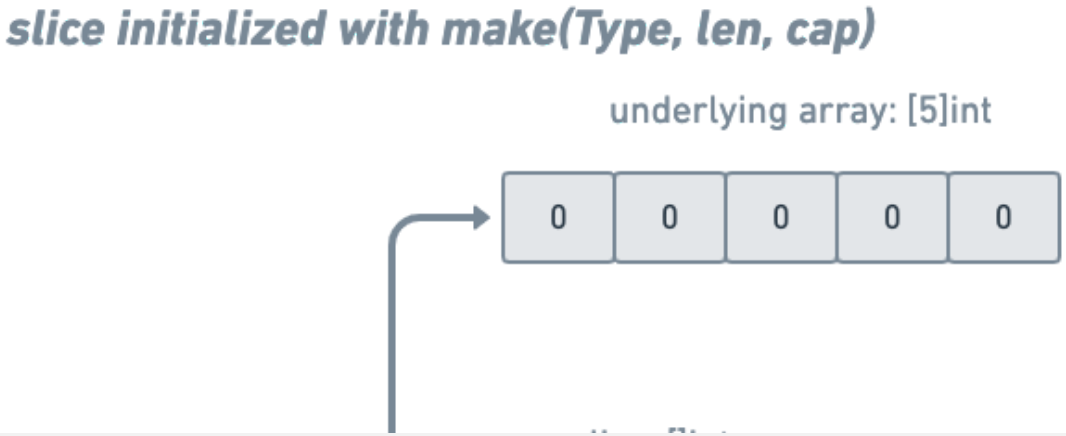
Initializing a slice with the specified array, i.e., `b := []int{0, 1, 2, 3}`, creates a new slice with capacity and length taken from the underlying array.



A slice can also be initialized with the built-in `make()` function that takes the type of a slice as the



There is also an alternative version of the `make()` function with three arguments: the first is the type of a slice, the second is the length, and the third is the capacity. In this way, you can create a slice with a capacity greater than the length.



the underlying array, a new array will be allocated. The `append()` function always returns a new, updated slice, so if you want to resize a slice `s` it is necessary to store the result in the same variable `s`.

- Slices are not comparable and simple equality comparison `a == b` is not possible. See how to compare slices.
- Initializing a slice with `var name []type` creates a `nil` slice that has length and capacity equal to 0 and no underlying array. See what is the difference between nil and empty slices.
- Just like arrays (and everything in Go), slices are **passed by value**. When you assign a slice to a new variable, the `ptr`, `len`, and `cap` are copied, including the `ptr` pointer that will **point to the same underlying array**. If you modify the copied slice, you modify the same shared array which makes all changes visible in the old and new slices:

```
var a []int = []int{1, 2, 3, 4}
b := a
a[1] = 999
fmt.Println(a)
fmt.Println(b)
```

Output:

```
[1 999 3 4]
[1 999 3 4]
```

```
var arr [4]int = [4]int{1, 2, 3, 4}
a := arr[1:3]
fmt.Printf("a: length: %d, capacity: %d, data: %v\n", len(a), cap(a), a)
```

Output:

```
a: length: 2, capacity: 3, data: [2 3]
```

We get the same results for the slice:

```
var s []int = []int{1, 2, 3, 4}
a := s[1:3]
fmt.Printf("a: length: %d, capacity: %d, data: %v\n", len(a), cap(a), a)
```

Output:

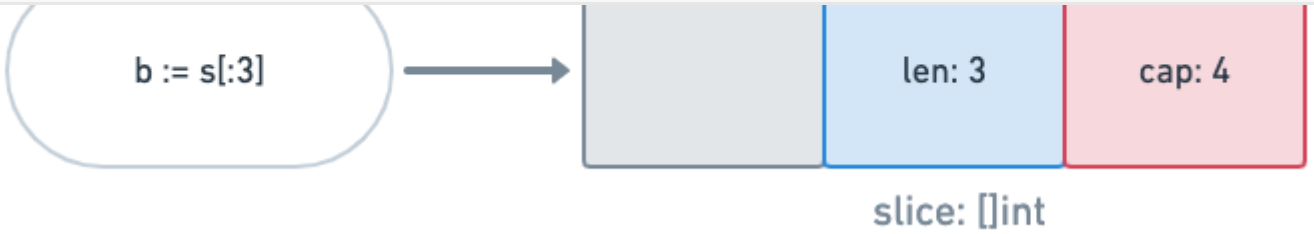
```
a: length: 2, capacity: 3, data: [2 3]
```

Re-slicing a slice or an array creates a new slice with length given by indices range and capacity equal to the number of elements in the underlying array from the index of the first element of the slice to the end of the array. See two more examples of re-slicing operation - for range without the first index `s[:3]`, and without the last index `s[3:]`:

```
b := s[:3]
fmt.Printf("b: length: %d, capacity: %d, data: %v\n", len(b), cap(b), b)
```

Output:

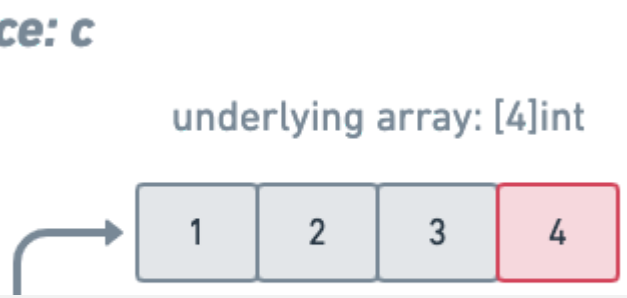
```
b: length: 3, capacity: 4, data: [1 2 3]
```




```
c := s[3:]
fmt.Printf("c: length: %d, capacity: %d, data: %v\n", len(c), cap(c), c)
```

Output:

```
c: length: 1, capacity: 1, data: [4]
```



The append() function

Appending is one of the most important operations for slices. Since arrays in Go are immutable, only with the `append()` function we can get a variable-length data collection. However, as we know, underneath slices still use arrays. The example below shows what happens when the number of slice items exceeds its capacity.

```
var s []int
for i := 0; i < 10; i++ {
    fmt.Printf("length: %d, capacity: %d, address: %p\n", len(s), cap(s), s)
    s = append(s, i)
}
```

Output:

```
length: 0, capacity: 0, address: 0x0
length: 1, capacity: 1, address: 0xc00001c0a0
length: 2, capacity: 2, address: 0xc00001c0b0
length: 3, capacity: 4, address: 0xc00001e080
length: 4, capacity: 4, address: 0xc00001e080
```

Conclusion

To understand the length and capacity of slices in Go, it is important to understand how slices work and what is the difference between slices and arrays. Slices are built on top of arrays to provide variable-length data collections. They consist of three elements - a pointer to the underlying array (underneath, slices use arrays as data storage), the length of the slice, and the capacity - the size of the underlying array. These 3 properties are copied when a slice value is passed, but the new pointer always points to the same shared array. The `append()` function makes slices expandable, creating a powerful and expressive data structure, one of the most used in Go.

Share:

Related

Copy a slice in Go

Learn how to make a deep copy of a slice

`introduction` `slice`

November 25, 2021

Check if the slice contains the given value in Go