Generics and when to use them in Go

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1 November 2021

Overview of the Generic syntax

Constraints the concept

A type constraint defines the set of methods and operators a type must have to be usable generically

Because of their functional similarity to interfaces we can reuse that syntax.

```
type Stringer interface {
    String() string
}

type Writer interface{
    Write(p []byte) (n int, err error)
}
```

Type Sets in Constraints

We can also now add type sets to interfaces to define the operators that are permitted.

```
type OnlySignedInt interface {
    int | int8 | int16 | int32 | int64
}
```

This creates a constraint that can use all of the following operators (*, /, %, <<, >>, &, &^, +, -, |, ^, ==, !=, <, <=, >, >=)

The constraint above only matches things that are exactly int, int8, int16, int32, and int64. For example BetterInt would not be acceptable as an OnlySignedInt.

```
type BetterInt int
```

Type approximation elements

To include a type who's underlying type is another type we use the approximation element syntax

```
type SignedInt interface {
    ~int | ~int8 | ~int16 | ~int32 | ~int64
}
```

Method and type sets in constraint

Unsurprisingly we can use combinations of methods and type sets to further specify the constraint

```go
type SignedInt interface {
    ~int | ~int8 | ~int16 | ~int32 | ~int64
    Positive() bool
}

type BetterInt int

func (b BetterInt) Positive() bool {
    return b > 0
}
```

Predeclared constraints

There are two predeclared type constraints any and `comparable`

- any is an alias for interface`{}`. Which is just useful short hand for all types
- comparable is all types that you can use == and != on

Generic Functions

Generic Function syntax

We use type constraints to write functions on generic data.

```
func Print[T any](data T) {
    fmt.Println(data)
}
```

We can call this function by passing the type of our data as a type argument

```
    Print[int](10)
    Print[string]("Apple")
    Print[float64](999.99)
```

Using type inference we can omit the type argument

```
    Print(1234)
    Print("pear")
    Print(23.45)
    Print([]int{1,2,3})
```

Generic Search

Perhaps a more practical example of function

```
    func Search[T comparable](slice []T, value T) (result T, ok bool) {

        for _, v := range slice {
            if value == v {
                return v, true
            }
        }

        return result, ok
    */
}
```

Using generic search

```
    // Returns 0, false

    fmt.Println(runtime.Version())
    /* value, ok := Search([]int{1,2,3,4,5}, 6)
        fmt.Println(value, ok)

        // Returns "b", true
        letter, ok := Search([]string{"a", "b", "c", "d"}, "b")
        fmt.Println(letter, ok)

        // Does this compile?
        // value, ok := Search([]string{"a", "b", "c", "d"}, "b")
        // fmt.Println(values, ok)

        // Does this compile?
        // ints, ok := Search([][]int{ []int{1}, []int{2,3}, []int{4,5,6}}, []int{1})
        // fmt.Println(ints, ok)

        // Does this compile?
        // anything, ok := Search[interface{}]([]interface{}{ "a", 1, 1.23, false}, "a")
        // fmt.Println(anything, ok)
```

Run

Generic Types

Generic type

Performing functions on generic data in itself is useful. However go 1.18 offers us even more power with generic types.

A generic type can contain any one type that matches it's constraint.

```
// Stack represents a stack datastructure
type Stack[T any] []T

// Push appends to the end of the stack
func (s *Stack[T]) Push (elem T) {
    *s = append(*s, elem)
}

// Pop returns the last pushed item
func (s *Stack[T]) Pop() (elem T) {

    if len(*s) < 1 {
        return elem
    }

    return (*s)[len(*s)-1]
}
```

Using generic types

```
s := Stack[int]{1,2,3}
s.Push(4)
fmt.Println(s.Pop())

var s1 Stack[string]
fmt.Println(s1.Pop())
s1.Push("a")
s1.Push("b")
s1.Push("c")
fmt.Println(s1.Pop())

type X struct {
    A string
}

s2 := Stack[X]{}
s2.Push(X{ A: "A"})
s2.Push(X{ A: "B"})
```

Important note a generic type can contain only the type specified when it's instantiated

Another container example

Type parameters can be values in struct

```
type Queue[T any] struct {
    items chan []T // non-empty slices only
    empty chan bool   // holds true if the queue is empty
}

func NewQueue[T any]() *Queue[T] {
    items := make(chan []T , 1)
    empty := make(chan bool, 1)
    empty <- true
    return &Queue{items, empty}
}
```

Queue methods

```
func (q *Queue[T]) Get() T {
    items := <-q.items
    item := items[0]
    items = items[1:]
    if len(items) == 0 {
        q.empty <- true
    } else {
        q.items <- items
    }
    return item
}

func (q *Queue[T]) Put(item T) {
    var items []T
    select {
    case items = <-q.items:
    case <-q.empty:
    }
    items = append(items, item)
    q.items <- items
}
```

Queue usage

```
func main() {
    q1 := NewQueue[string]()
    q1.Put("apple")
    q1.Put("banana")
    q1.Put("kiwi")

    for i := 0; i < 3; i++ {
        go func() {
            fmt.Println(q1.Get())
        }()
    }
}
```

Non container example

We can have multiple same or different type parameters

```
func Map[T1, T2 any](s []T1, f func(T1) T2) []T2 {
    r := make([]T2, len(s))
    for i, v := range s {
        r[i] = f(v)
    }
    return r
}
```

Map usage

```
func toInt(s string) int {
    i, _ := strconv.Atoi(s)
    return
}

type Named struct {
    Name string
}

func main() {

    s := []string{"1","2","29480", "-2"}
    i := Map(s, toInt)
    fmt.Println(i)

    named := Map(s, func( x string) Named {
        return Named{
            Name: x,
        }
    })
    fmt.Println(named)
}
```

Guidelines

Write non generic code

Use the following to see if your code is canadiate for generics

1. Are you duplicating code
2. Is there a set (n > 1) of types that your code can operate on
3. Will the user of my code be willing to specify a type parameter

Final thoughts

So far I think generics are most valuable for collections and operations on collections. As such I think it is unlikely that you should often write generic code. Though you may frequently use generic code.

Thank you

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1 November 2021
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