Go Modules

slides at https://github.com/mvolkmann/talks

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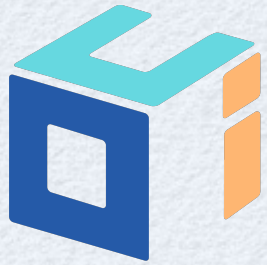


OCI | TRAINING

Past

- Lack of support for package versioning was a major issue before Go version 1.11
  - all projects under same **GOPATH** use same dependency versions
  - no record of dependency versions
  - hard for teammates to get same dependency versions
  - encourages use of a mono repo
- Leading contenders were
  - **vgo** from Russ Cox - https://github.com/golang/go/wiki/vgo
  - **dep** from Sam Boyer - https://golang.github.io/dep/

Present

- Go 1.11 includes experimental support for “modules”
- Mostly based on vgo
- Eliminates need to have code under **`GOPATH`**
- Adds support for dependency versioning

Modules

- A module is defined by a directory
  - referred to as "module root"
  - contains **`go.mod`** file and a set of source files
- **`go.mod`** can be created and updated manually
  - but there is no need to do either
- Easiest way to create **`go.mod`** for a new module
  - cd to its module root
  - run **`go mod init`** ***`module-name`***
- ***`module-name`***
  - is the import path other modules will use to import this one
  - typically a version control path such as **`github.com/mvolkmann/my-module`**
  - can be a simple name for modules that will not be published

Simple Example ...

- Create new directory named **`my-simple-module`** not under **`GOPATH`**
- **`cd`** to directory
- **`go mod init my-simple-module`**
  - a GitHub path is not specified because
    we are not planning to share this module with others
  - creates **`go.mod`** file containing **`module my-simple-module`**

later we will see other "directives" that can be in this file

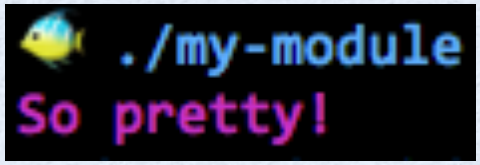
- Create **`main.go`** with following content

```
package main

import (
  "fmt"

  "github.com/ttacon/chalk"
)

func main() {
  fmt.Printf("%s%s%s\n", chalk.Magenta, "So pretty!", chalk.Reset)
}
```

imports a single community package that is not yet listed in **`go.mod`**

… Simple Example

- To build this application and update **`go.mod`** with dependency information, enter **`go build`**
  - creates executable file **`my-module`**
  - adds following to **`go.mod`**




```
require github.com/ttacon/chalk v0.0.0-20160626202418-22c06c80ed31
```

    - version string that follows dependency path will be explained later
  - creates **`go.sum`** file which stores checksum information for all dependencies
    - checksums are described later

Transition to Module Support

- In Go 1.11 it is possible to **use both**
  the **old** `GOPATH` approach **and**
  the **new** module approach
- Specified by environment variable `GO111MODULE`
  - when `off`, only `GOPATH` can be used
  - when `on`, only modules can be used
  - when `auto` or not set, either can be used and
    the **choice is based on** whether commands are run from a directory
    that contains a `go.mod` file or a descendant of such a directory
- If you have existing code that relies on `GOPATH` and
  you want to try modules in new or existing packages,
  not setting `GO111MODULE` is a good option

Adding Module Dependencies

- Easiest way
  - create source files that contain **`import`** statements for dependencies
  - run a command such as **`go build`**, **`go test`**, **`go list`**, or **`go vet`**
  - these commands trigger lookup of all dependencies
  - results are used to automatically update **`go.mod`**

Semantic Versioning

- Go modules prefer use of **semantic versioning** where version numbers have three parts referred to as major, minor, and patch
- For example, "1.2.3" represents
  - major version of 1
  - minor version of 2
  - patch version of 3
- **Patch** is incremented when backward-compatible **bug fixes** are made
- **Minor** is incremented when backward-compatible **new features** are added
- **Major** is incremented when **incompatible changes** are made

Module Code Layout

- No requirement to have a `src` directory in module root
- For simple modules
  - all source files can be in module root along with `go.mod`
- For modules defined by many source files
  - source files can be organized in subdirectories as desired, typically to indicate sets of related files

Dependency Source Code

- Source files for dependencies are not stored in the module root directories of modules that use them
- Instead they are stored in subdirectories of **`$GOPATH/pkg/mod`**
  - allows multiple modules to share them
  - when **`GOPATH`** is not set, **`$HOME/go`** is used
    - to see this, enter **`go env GOPATH`**
- Multiple versions of each dependency can be stored here
  - allows modules that depend on them to use different versions

Explicit Installs ...

- It is also possible to install dependencies with **`go get`**
  - updates **`go.mod`**
  - adds comment **`// indirect`** after path for new dependency
  - indicates that no code in current module has been seen yet that uses the dependency
- **`indirect`** comments
  - removed after uses of dependencies are added to module source files and a command such as **`go build`** is run
- **Not necessary** to use **`go get`** to install dependencies
  - since commands like **`go build`** add dependencies to **`go.mod`** on their own and they will be run eventually

... Explicit Installs

- **Primary reason** to use `go get` with modules
  - to **specify a specific version** to be installed
- Alternatively
  - once some version is installed,
    perhaps by running `go build`,
    the version to use can be modified by
    editing `go.mod` and re-running the command
- Changing version of a direct dependency
  - can change versions of its dependencies that are used
  - desirable since a specific version of a direct dependency
    may only work with specific versions of its dependencies

Releasing New Module Versions

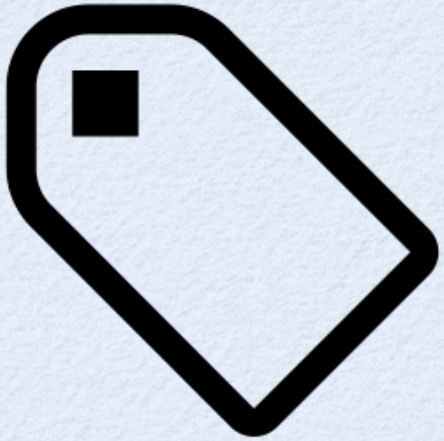
- Major versions
  - 0 or 1 are considered unstable
  - 2 or higher are considered stable

seems odd to me
that major version 1
is considered unstable

- To release a new unstable version of a module
  - push changes
  - add repository tag following pattern
    `v{major}.{minor}.{patch}`
- To release a new stable version of a module
  - modify module name in `go.mod` to end with new major version
    - for example `module github.com/mvolkmann/my-module/v2`
  - push changes
  - add repository tag just like for unstable versions

Adding a Git Tag

- From command-line
  - `git tag tag-name`
  - `git push origin tag-name`
- From GitHub web UI
  - click “release(s)” tab
  - press "Draft a new release” button
  - enter tag name
  - optionally enter title and description
  - if not considered stable, check “This is a pre-release”
  - press “Publish release” button



Importing Versions

- Unstable versions
  - can be imported without specifying major version
  - for example, `import github.com/mvolkmann/my-module`
  - will use latest version less than v2
- Stable versions
  - add major version to import paths in all source files that import it
  - for example, `import github.com/mvolkmann/my-module/v2`
  - only major version is specified, not minor or patch
  - referred to as "semantic import versioning"
- Presumably there will be tooling to automate this in the future
  - so it won't be necessary to manually update multiple source files

Ternary Example

- Create a reusable module
  - create GitHub repo at https://github.com/mvolkmann/ternary
  - clone the empty repo
  - create **`main.go`** (see next slide)
  - **`go mod init githhub.com/mvolkmann/ternary`** creates **`go.mod`**
  - add, commit, and push **`go.mod`** and **`main.go`**
  - add repository tag of **`v0.1.0`**
- Create an application that uses it
  - create directory **`ternary-demo`**
  - create **`main.go`** (ahead two slides)
  - **`go mod init ternary-demo`** creates **`go.mod`**
  - **`go build`** adds **`require`** to **`go.mod`**, installs **`ternary`** module, creates **`go.sum`**, and creates executable
  - **`./ternary-demo`** runs executable

ternary `main.go`

```
package ternary

// Any implements a ternary for any type.
// Typically a type assertion will be required.
// For example, color := ternary.Any(temperature >= 100, "red", "blue").(string)
func Any(cond bool, t interface{}, f interface{}) interface{} {
    if cond {
        return t
    }
    return f
}

// Int implements a ternary for int values.
func Int(cond bool, t int, f int) int {
    if cond {
        return t
    }
    return f
}

// String implements a ternary for string values.
func String(cond bool, t string, f string) string {
    if cond {
        return t
    }
    return f
}
```

ternary-demo `main.go`

```
package main

import (
    "fmt"

    t "github.com/mvolkmann/ternary"
)

func main() {
    temperature := 70
    color := t.String(temperature > 100, "red", "blue")
    fmt.Printf("color = %s\n", color)

    color = t.Any(temperature > 100, "red", "blue").(string)
    fmt.Printf("color = %s\n", color)
    fmt.Printf("color type = %T\n", color) // string
}
```

type assertion

Multiple Major Versions

- Since each version is stored separately, it is possible to use multiple major versions of a dependency in the same application
- But probably not a good idea

Versions Used

- Actual versions of dependencies that are used is determined by **`go.mod`**
- Several ways to specify a version, called "module queries"
- To add a module query to a **`require`** path, add a space and one of following

Module Query Type	Example	Notes
fully-specified	`v1.2.3`	
minor version prefix	`v1.2`	latest starting with `v1.2`
major version prefix	`v1`	latest starting with `v1`
version comparison	`>=v1.2.3`	can also use >, <, and <=
latest	`latest`	
commit hash	`A1B2B3D`	
tag	`my-tag`	
branch name	`my-branch`	

haven't seen any examples using more than one in the same query

Version Details

- Running a command such as **`go build`**
  finds a version that matches each module query
  and updates **`go.mod`** with results
  - except when using a fully-specified version
    because then **`go.mod`** already has the version
- Rerunning commands like **`go build`** will not
  automatically get the latest matching versions
  since previously run commands will have caused
  modules queries to be replaced by actual versions
  - for example, a line like
    `require github.com/mvolkmann/ternary latest`
    could be replace by
    `require github.com/mvolkmann/ternary v0.1.0`

Issue

- **Sam Boyer** is the lead maintainer of **Dep**,
  a competing dependency management tool for Go
- Sam feels that this feature of Go modules **loses information**
  about the minimum versions that were deemed compatible
- Further, he feels this makes it
  hard to resolve diamond-shaped dependencies
  where multiple modules needed by an app
  depend on different minor versions of other modules
- See his talk "We need to talk about Go modules"
  - https://www.youtube.com/watch?v=7GGr3S41gjM&feature=youtu.be&t=14m55s

Versions Used

- **No automatic version updates** are ever performed
  - must modify version query in `go.mod`
    or bump major version in imports
- Means checking `go.mod` files into a version control repository provides a way to produce **repeatable builds**
- "Version comparison" **gets nearest version** to what is requested, not latest version that matches
  - example, if query is `>=1.2.3` and
    existing versions include `1.2.2`, `1.2.3`, and `1.2.4`,
    this will use version `1.2.3`
  - differs from how npm works

Pseudo Versions

- For dependencies that do not currently use semantic versioning, an alternate way to determine whether one version is later than another is needed
- Pseudo versions provide this
- Pseudo versions are strings that have three parts
  - **first**: version in the form `vmajor.minor.something`
  - **second**: commit time in UTC
  - **third**: first 12 characters of commit hash
  - parts are separated by dashes
- *`something`* in first part is complicated
  - fortunately it's not necessary to think about this because pseudo version strings are automatically generated when dependencies that lack semantic versioning tags are installed
  - seems to me that first part is `v0.0.0` when repository is not tagged with a version

Other `go.mod` Directives

- Besides **`module`** and **`require`** directives, **`go.mod`** files can also contain **`exclude`** and **`replace`** directives
- **`exclude`** specifies versions of dependencies that cannot be used
- **`replace`** specifies versions of dependencies that should be replaced by another version
  - one use is to use a local version of a package
  - **`replace`** ***`import-path => local-directory-path`***
- These can be used to avoid using versions that have known bugs or security issues

Using a Local Module

- An app can import packages from modules that only reside in a local directory, not at a URL or under **GOPATH**
- Example
  - package to import defined in **~/foo/bar**
    - **go mod init foo/bar**
  - application defined in **~/demo**
    - **go mod init demo**
    - edit **go.mod** to add **require** and **replace** directives

~/demo/go.mod

```
module demo

require foo/bar v0.0.0

replace foo/bar => /Users/Mark/foo/bar
```

There is some **controversy** over whether packages not in the standard library can have **import paths** whose first part does not contain a **dot**. See https://github.com/golang/go/issues/27503.

~/foo/bar/go.mod

```
module foo/bar
```

~/foo/bar/bar.go

```
package bar

import "fmt"

func Hello() {
    fmt.Println("Hello from bar!")
}
```

~/app/main.go

```
package main

import "foo/bar"

func main() {
    bar.Hello() // Hello from bar!
}
```

Tidying `go.mod` Files

- Over time the list of dependencies in a **`go.mod`** file can become out of date
  - missing required dependencies How could this happen?
  - listing dependencies (or versions of them) that are no longer used
- **`go mod tidy`**
  - adds missing dependencies to **`go.mod`**
  - removes unused dependencies from **`go.mod`**
- Primary purpose is to remove unused dependencies
  - since many other commands such as **`go build`** also add missing dependencies

Checksums

- Go modules use checksums to verify that downloaded dependency code has not been modified
- Checksums for each dependency are stored in **`go.sum`**
  - one for the package as a whole and one for each source file
- **`go mod verify`** reports all directories that hold downloaded module code and contain files that have been modified

Proxies

- Can configure a proxy server that hosts Go modules so they are installed from there instead of connecting to public source control repositories
- One reason is to restrict access to only modules that have been vetted
- A Go proxy server is a web server that responds to GET requests for module URLs
- To use one, set **`GOPROXY`** environment variable to point to the server
- For more information, enter **`go help goproxy`**

Wrap Up

- Go try modules!