Go Modules

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

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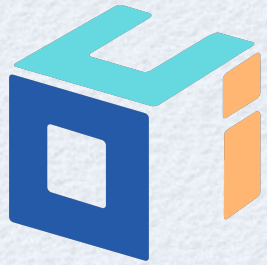


OCI | TRAINING

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
  - teammates can get same versions
  - repeatable builds

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  - can be a simple name for modules that will not be published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 in this example 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

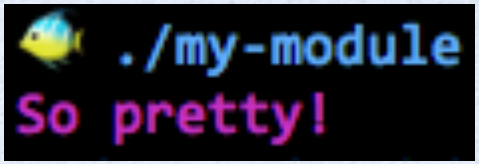
- Create **`main.go`** with following content

```
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-simple-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

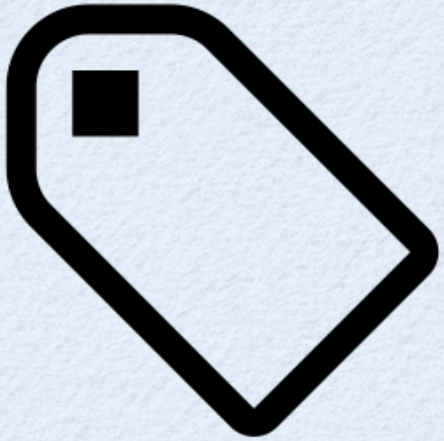
- Major versions
  - 0 or 1 are considered unstable
  - 2 or higher are considered stable

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
  - are 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 and import paths specify the major version to be used, 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 replaced 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
  - ex. `foo` needs `baz/v2.1.0` and `bar` needs `baz/v2.2.0`
- 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 module queries 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 this is always `v0.0.0` when the 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

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.

- 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

~/foo/bar/go.mod

```
module foo/bar
```

~/foo/bar/bar.go

```
package bar

import "fmt"

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

~/demo/go.mod

```
module demo

require foo/bar v0.0.0

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

~/demo/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?
  - including dependencies (or major 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!