



When it all GOes right

Writing applications with Go for PostgreSQL

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ABOUT CYBERTEC



Highly specialized,
fast growing
IT company



International Team
(10 countries),
six locations worldwide



PostgreSQL Services &
Support



Owner managed
since 2000

AUSTRIA (HQ)

CYBERTEC POSTGRESQL
INTERNATIONAL (HQ)

SWITZERLAND

CYBERTEC POSTGRESQL
SWITZERLAND

URUGUAY

CYBERTEC POSTGRESQL
SOUTH AMERICA

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POLAND

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POLAND

SOUTH AFRICA

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SOUTH AFRICA

CUSTOMER SECTORS

- ICT
- Finance
- Regulatory
- Automotive
- Production
- Trade
- Universities
- and many more.



DATABASE - PRODUCTS



WHY

PostgreSQL?



ADVANCED OPEN
SOURCE DATABASE
SYSTEM



25 YEARS OF
DEVELOPMENT



NO
LICENSE COSTS



EXTENSIVE
FUNCTIONALITY



RELIABILITY



LOW
SUPPORT COSTS



SCALABILITY



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AGENDA

- Intro to Go
- IDE's and tools
- Drivers
- Useful extensions
- Testing
- CI/CD

When it all GOes right



Intro to Go

Why Go?

- Native binaries

Go compiles quickly and produces binary code fast.

- Simplicity

It's designed to be simple and easy to learn for developers of all levels.

- Concurrency

Go provides simple and efficient support for concurrent programming.

- Comprehensive tools

Go comes with a comprehensive set of tools and libraries.

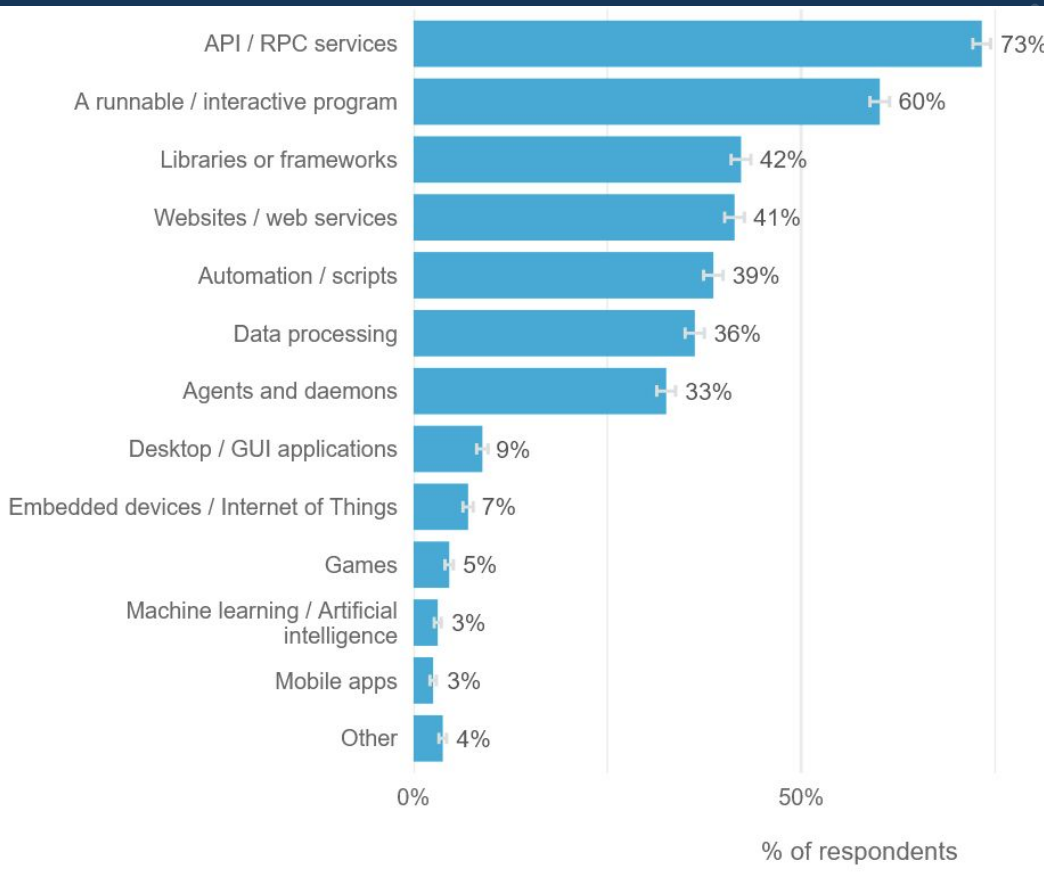
- Cross-platform

Go is designed to allow programs to be compiled and run on any platform.



Go Developer Survey 2022

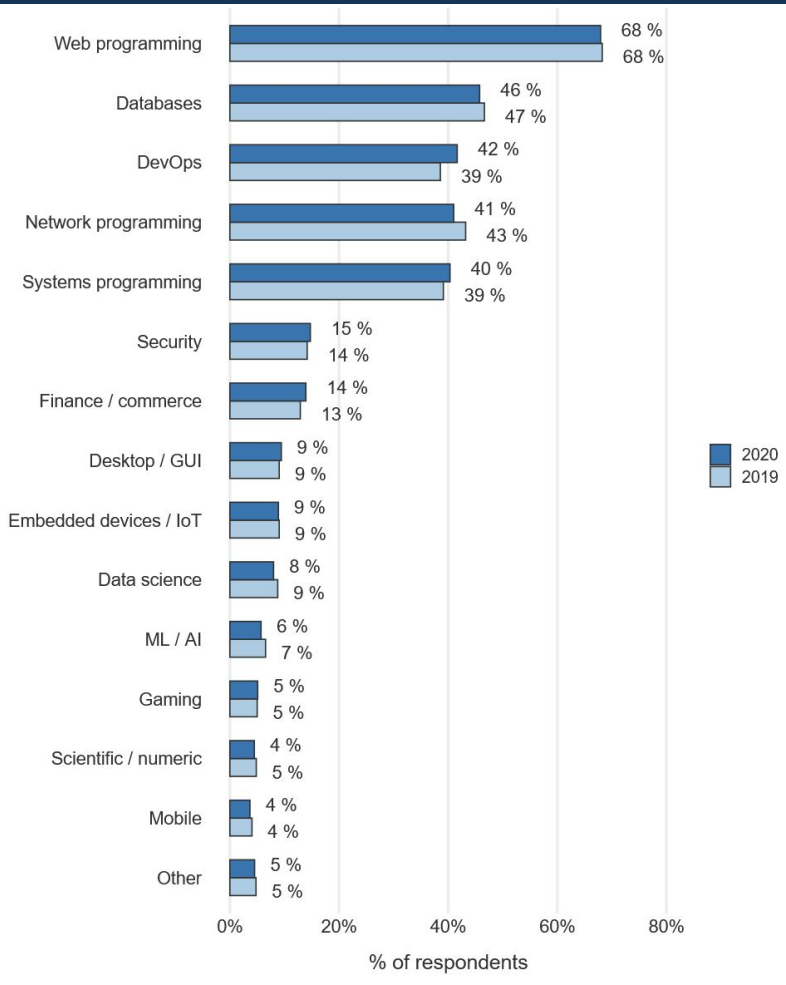
How did survey respondents use Go?





Go Developer Survey 2020

I work with Go
in the areas listed



● Top products written in Go

- **Kubernetes (K8s)** - production-grade container management
- **OpenShift** - a family of containerization software products
- **Moby** - a collaborative project for the container ecosystem
- **Hugo** - the world's fastest framework for building websites
- **Grafana** - observability and data visualization platform
- **frp** - a fast reverse proxy to expose a local server behind a NAT
- **Gogs** - painless self-hosted Git service
- **Etcd** - distributed reliable key-value store
- **Caddy** - fast, multi-platform web server with automatic HTTPS

Postgres-related Go products

- **CockroachDB** - a cloud-native distributed SQL database
- **pgweb** - a cross-platform client for PostgreSQL databases
- **stolon** - a cloud native PostgreSQL manager
- **postgres operators** by Zalando and by Crunchy
- **wal-g** - archives and restoration for Postgres
- **pgcenter** - top-like admin tool for troubleshooting Postgres
- **pgwatch2** - PostgreSQL metrics monitor/dashboard
- **pg_timetable** - advanced scheduling for PostgreSQL
- **pg_flame** - a flamegraph generator for EXPLAIN output

Top products written in Go

FIND MORE



<https://awesome-go.com/>

<https://github.com/avelino/awesome-go>

A curated list of awesome Go frameworks,
libraries and software

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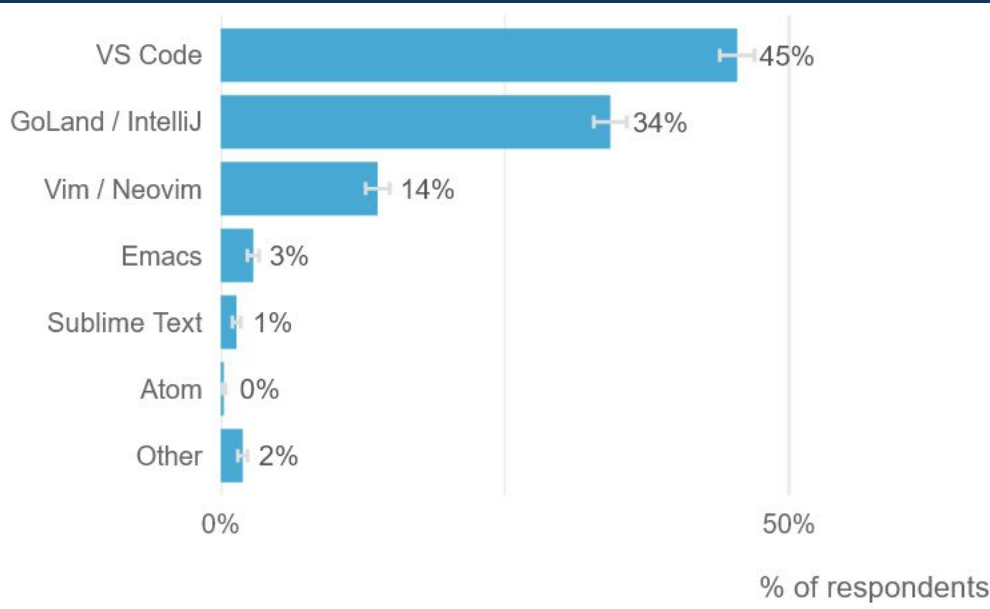


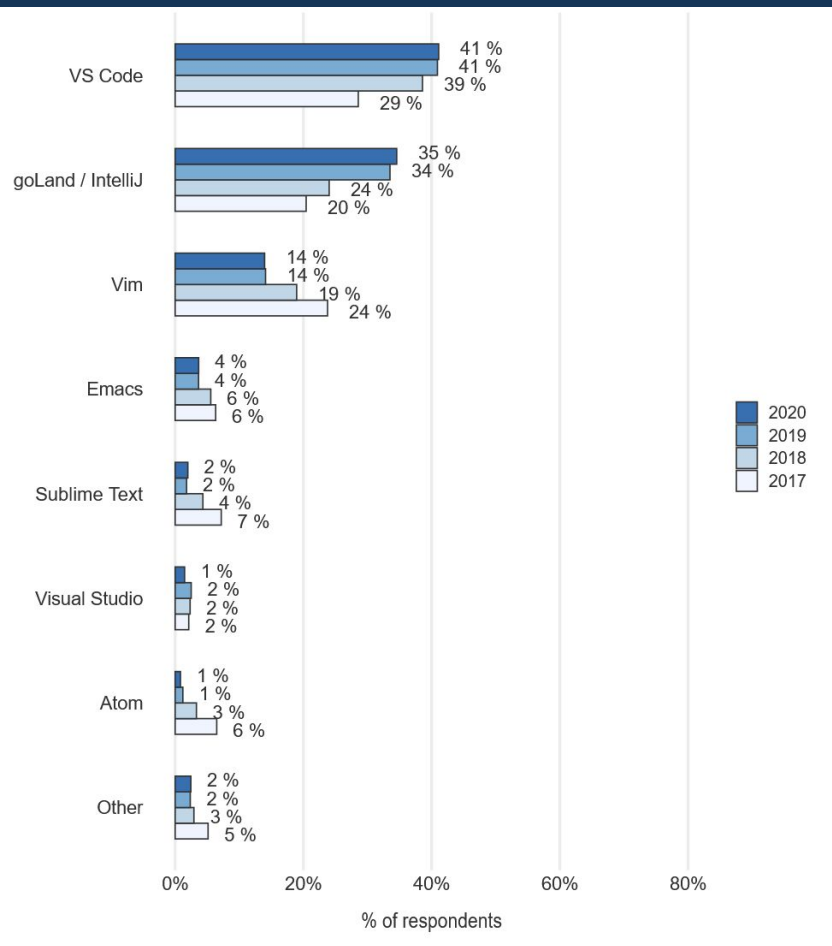
IDE's and tools



Go Developer Survey 2022

“My preferred editor for Go code is...”





Go Developer Survey 2020

“My preferred editor for Go code is...”

<https://go.dev/blog/survey2020-results>

● My environment

- **VSCode** with the official [vscode-go](#) plugin
- **mfridman/tparse** - summarizes go test output with color tables
- **golangci-lint** - fast linters Runner for Go
- **Tabnine** - the AI code completion tool
- **GoReleaser** - deliver Go binaries as quickly and easily as possible
- **PostgreSQL** - most advanced object-relational database
- **gitpod.io** - container-based ready-to-code developer environments

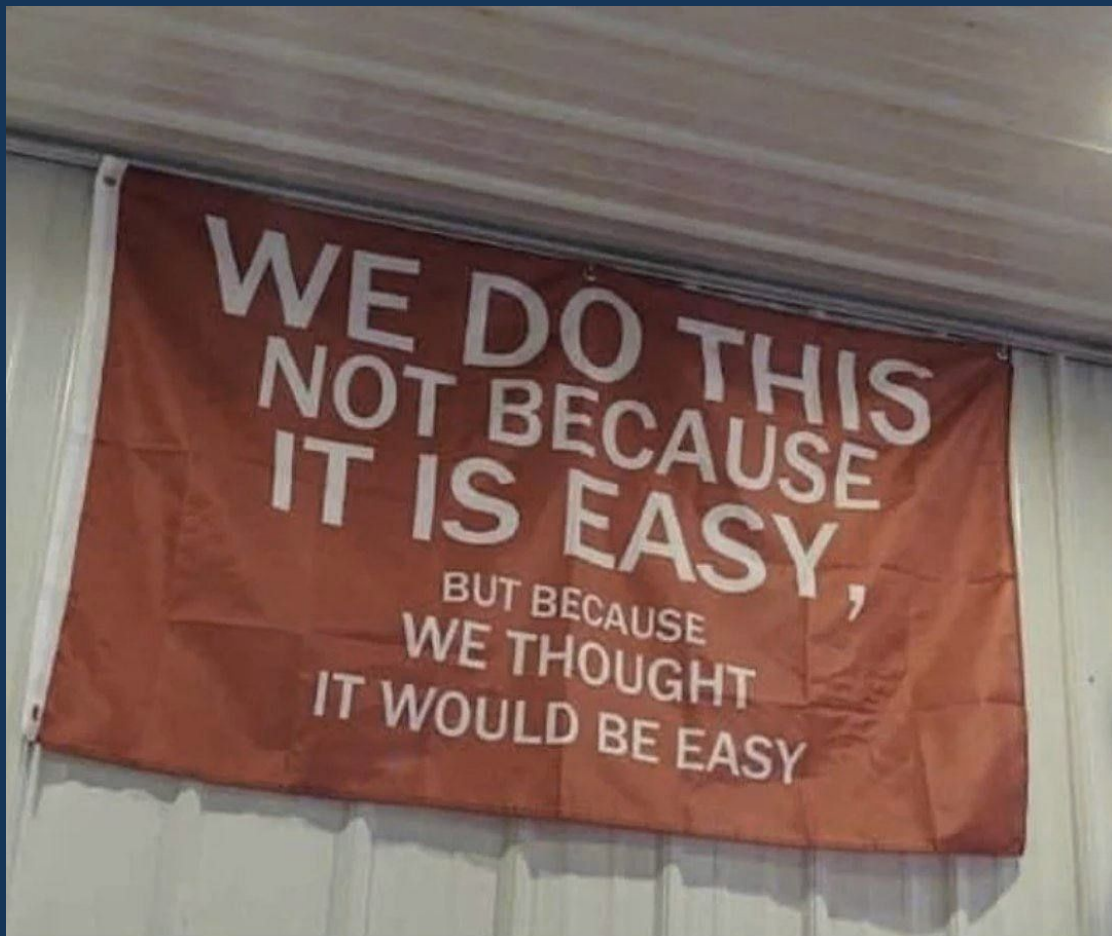
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PostgreSQL Drivers



Why do people
use ORM's?



Why shouldn't
people
use ORM's?



Pavlo Golub
@PavloGolub



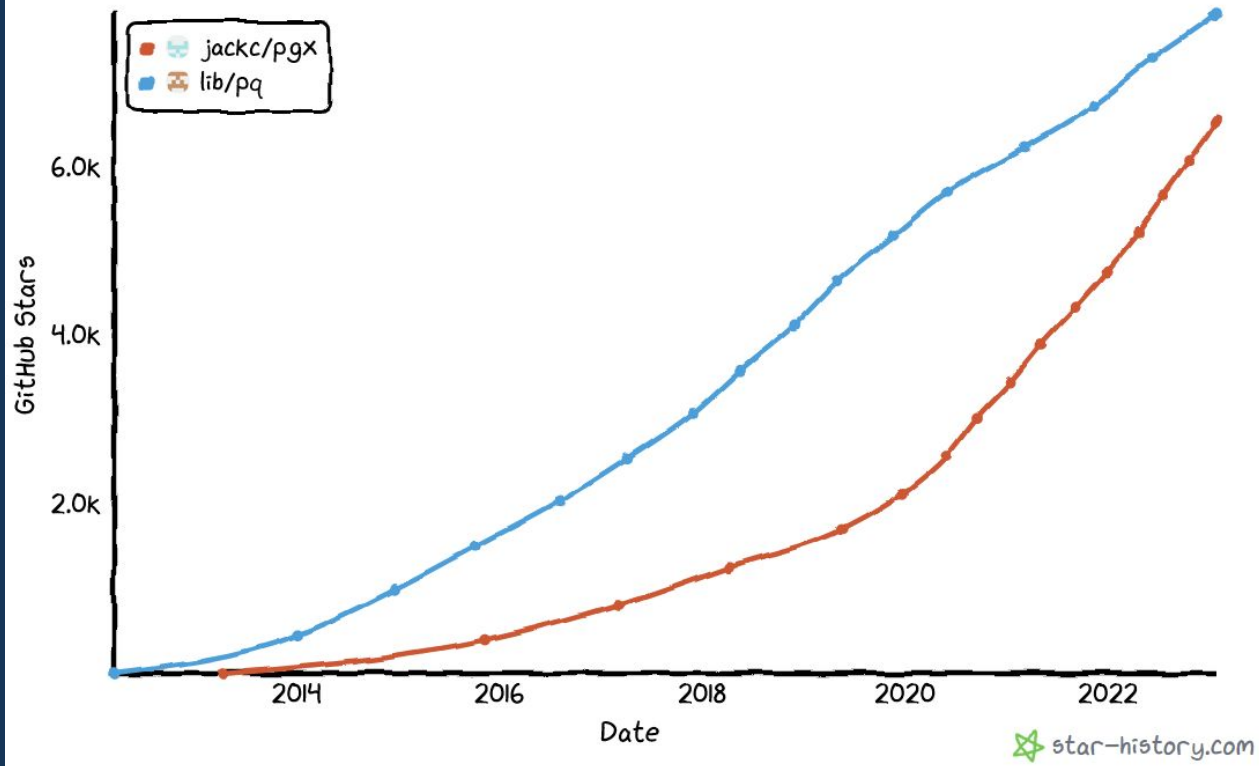
If God wanted us to use ORMs,
God would not have created SQL!

4:59 PM · Dec 14, 2022

● Drivers' availability

- **database/sql** is a set of database access interfaces
 - standard de facto creates database applications
 - needs implementation to work
 - read **go-database-sql.org** for more information
- **github.com/lib/pq** - pure Go Postgres driver for **database/sql**
 - is currently in maintenance mode
- **github.com/jackc/pgx** — PostgreSQL driver and toolkit for Go
 - is the default choice nowadays
 - use this even with **database/sql**

Star History



pgx vs database/sql

- Use **jackc/pgx** interface (not **database/sql**) when
 - The application only targets PostgreSQL.
 - No other libraries that require **database/sql** are in use.
- Otherwise use **database/sql** with **jackc/pgx/stdlib**
 - compatibility with non-PostgreSQL databases is required
 - when using other libraries that require **database/sql** such as **sqlx** or **gorm**

pgx unique features

- Support for approximately 70 different PostgreSQL types
- Automatic statement preparation and caching
- Batch queries
- Single-round trip query mode
- Full TLS connection control
- Binary format support for custom types
- COPY protocol support for faster bulk data loads
- Extendable tracing and logging support
- Connection pool with after-connect hook

pgx unique features

- Listen / Notify
- Conversion of PostgreSQL arrays to Go slice mappings
- `inet`, `cidr`, `hstore`, `json` and `jsonb` native support
- Large object support
- `NULL` mapping to `Null*` struct or pointer to pointer
- Supports `database/sql.Scanner` and `database/sql/driver.Valuer` interfaces for custom types
- Notice response handling
- Simulated nested transactions with savepoints

Hello World: database/sql

```
package main

import (
    "database/sql"
    "fmt"
    "os"

    _ "github.com/jackc/pgx/v5/stdlib"
)

func main() {
    db, err := sql.Open("pgx", os.Getenv("DATABASE_URL"))
    if err != nil {
        fmt.Fprintf(os.Stderr, "Unable to connect to database: %v\n", err)
        os.Exit(1)
    }
    defer db.Close()

    var greeting string
    err = db.QueryRow("select 'Hello, world!'").Scan(&greeting)
    if err != nil {
        fmt.Fprintf(os.Stderr, "QueryRow failed: %v\n", err)
        os.Exit(1)
    }

    fmt.Println(greeting)
}
```

Hello World:

jackc/pgx

```
package main

import (
    "context"
    "fmt"
    "os"

    "github.com/jackc/pgx/v5"
)

func main() {
    conn, err := pgx.Connect(context.Background(), os.Getenv("DATABASE_URL"))
    if err != nil {
        fmt.Fprintf(os.Stderr, "Unable to connect to database: %v\n", err)
        os.Exit(1)
    }
    defer conn.Close(context.Background())

    var greeting string
    err = conn.QueryRow(context.Background(), "select 'Hello, world!'").Scan(&greeting)
    if err != nil {
        fmt.Fprintf(os.Stderr, "QueryRow failed: %v\n", err)
        os.Exit(1)
    }

    fmt.Println(greeting)
}
```

Hello World: pgx/pgxpool

```
package main

import (
    "context"
    "fmt"
    "os"

    "github.com/jackc/pgx/v5/pgxpool"
)

func main() {
    dbpool, err := pgxpool.New(context.Background(), os.Getenv("DATABASE_URL"))
    if err != nil {
        fmt.Fprintf(os.Stderr, "Unable to create connection pool: %v\n", err)
        os.Exit(1)
    }
    defer dbpool.Close()

    var greeting string
    err = dbpool.QueryRow(context.Background(), "select 'Hello, world!'").Scan(&greeting)
    if err != nil {
        fmt.Fprintf(os.Stderr, "QueryRow failed: %v\n", err)
        os.Exit(1)
    }

    fmt.Println(greeting)
}
```

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Useful extensions



Useful Extensions: database/sql + jmoiron/sqlx

These extensions to the built-in verbs:

- `MustExec() sql.Result` -- Exec, but panic on error
- `Queryx(...)` (`*sqlx.Rows`, `error`) - Query, but return an `sqlx.Rows`
- `QueryRowx(...)` `*sqlx.Row` -- QueryRow, but return an `sqlx.Row`

And these new semantics:

- `Get(dest interface{}, ...)` error
- `Select(dest interface{}, ...)` error



Useful Extensions: database/sql + jmoiron/sqlx

```
type Place struct {  
    Country      string  
    City         sql.NullString  
    TelephoneCode int `db:"telcode"`  
}  
  
rows, err := db.Queryx("SELECT * FROM place")  
for rows.Next() {  
    var p Place  
    err = rows.StructScan(&p)  
}
```

Useful Extensions: database/sql + jmoiron/sqlx

```
p := Place{}
pp := []Place{}

// this will pull the first place directly into p
err = db.Get(&p, "SELECT * FROM place LIMIT 1")

// this will pull places with telcode > 50 into the slice pp
err = db.Select(&pp, "SELECT * FROM place WHERE telcode > ?", 50)

// they work with regular types as well
var id int
err = db.Get(&id, "SELECT count(*) FROM place")

// fetch at most 10 place names
var names []string
err = db.Select(&names, "SELECT name FROM place LIMIT 10")
```



Useful Extensions:
jackc/pgx

It's perfect!
No extensions
needed!

Useful Extensions: jackc/pgx

```
type product struct {
    ID    int32
    Name  string
    Price int32
}

rows, _ := conn.Query(ctx, "select * from products where price < $1", 12)
products, err := pgx.CollectRows(rows, pgx.RowToStructByName[product])
if err != nil {
    fmt.Printf("CollectRows error: %v", err)
    return
}

for _, p := range products {
    fmt.Printf("%s: %d\n", p.Name, p.Price)
}
```

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Testing

● Testing Approaches

- Real PostgreSQL server
- Mocking libraries
 - **DATA-DOG/go-sqlmock**
 - **pashagolub/pgxmock**
- Mock PostgreSQL wire protocol
 - **jackc/pgmock**
 - **cockroachdb/cockroach-go/testserver**
 - **cockroachdb/copyist**

Mocking Example: pgxmock

```
type PgxFace interface {
    Begin(context.Context) (pgx.Tx, error)
    Close(context.Context) error
}

func recordStats(db PgxFace, userID, productID int) (err error) {
    if tx, err := db.Begin(context.Background()); err != nil {
        return
    }
    defer func() {
        switch err {
        case nil:
            err = tx.Commit(context.Background())
        default:
            _ = tx.Rollback(context.Background())
        }
    }()
    sql := "UPDATE products SET views = views + 1"
    if _, err = tx.Exec(context.Background(), sql); err != nil {
        return
    }
    sql = "INSERT INTO product_viewers (user_id, product_id) VALUES ($1, $2)"
    if _, err = tx.Exec(context.Background(), sql, userID, productID); err != nil {
        return
    }
    return
}
```

Mocking Example: pgxmock

```
// a successful case
func TestShouldUpdateStats(t *testing.T) {
    mock, err := pgxmock.NewPool()
    if err != nil {
        t.Fatal(err)
    }
    defer mock.Close()

    mock.ExpectBegin()
    mock.ExpectExec("UPDATE products").
        WillReturnResult(pgxmock.NewResult("UPDATE", 1))
    mock.ExpectExec("INSERT INTO product_viewers").
        WithArgs(2, 3).
        WillReturnResult(pgxmock.NewResult("INSERT", 1))
    mock.ExpectCommit()

    // now we execute our method
    if err = recordStats(mock, 2, 3); err != nil {
        t.Errorf("error was not expected while updating: %s", err)
    }

    // we make sure that all expectations were met
    if err := mock.ExpectationsWereMet(); err != nil {
        t.Errorf("there were unfulfilled expectations: %s", err)
    }
}
```

Mocking Example: pgxmock

```
// a failing test case
func TestShouldRollbackStatUpdatesOnFailure(t *testing.T) {
    mock, err := pgxmock.NewPool()
    if err != nil {
        t.Fatal(err)
    }
    defer mock.Close()

    mock.ExpectBegin()
    mock.ExpectExec("UPDATE products").
        WillReturnResult(pgxmock.NewResult("UPDATE", 1))
    mock.ExpectExec("INSERT INTO product_viewers").
        WithArgs(2, 3).
        WillReturnError(fmt.Errorf("some error"))
    mock.ExpectRollback()

    // now we execute our method
    if err = recordStats(mock, 2, 3); err == nil {
        t.Errorf("was expecting an error, but there was none")
    }

    // we make sure that all expectations were met
    if err := mock.ExpectationsWereMet(); err != nil {
        t.Errorf("there were unfulfilled expectations: %s", err)
    }
}
```

Coverage:

go test + tparse

```
basic master !2 ~2 1 1.19.5 go test ./... -coverprofile='c.out' -json | tparse -all
```

STATUS	ELAPSED	TEST	PACKAGE
PASS	0.00	TestShouldUpdateStats	basic
PASS	0.00	TestShouldRollbackStatUpdatesOnFailure	basic

STATUS	ELAPSED	PACKAGE	COVER	PASS	FAIL	SKIP
PASS	0.30s	github.com/pashagolub/pgxmock/v2/examples/basic	60.0%	2	0	0

```
basic master !2 ~2 1 1.19.5 go tool cover -func='c.out'
```

github.com/pashagolub/pgxmock/v2/examples/basic/basic.go:15:	recordStats	85.7%
github.com/pashagolub/pgxmock/v2/examples/basic/basic.go:39:	main	0.0%
total:	(statements)	60.0%

```
basic master !2 ~2 1 1.19.5 go tool cover -html='c.out'
```

Coverage: go tool cover

```
github.com/pashagolub/pgxmock/v2/examples/basic/basic.go (60.0%)  not tracked  not covered  covered

package main

import (
    "context"

    pgx "github.com/jackc/pgx/v5"
    pgxpool "github.com/jackc/pgx/v5/pgxpool"
)

type PgxFace interface {
    Begin(context.Context) (pgx.Tx, error)
    Close()
}

func recordStats(db PgxFace, userID, productID int) (err error) {
    tx, err := db.Begin(context.Background())
    if err != nil {
        return
    }
    defer func() {
        switch err {
        case nil:
            err = tx.Commit(context.Background())
        default:
            _ = tx.Rollback(context.Background())
        }
    }()
    sql := "UPDATE products SET views = views + 1"
    if _, err = tx.Exec(context.Background(), sql); err != nil {
        return
    }
    sql = "INSERT INTO product_viewers (user_id, product_id) VALUES ($1, $2)"
    if _, err = tx.Exec(context.Background(), sql, userID, productID); err != nil {
        return
    }
    return
}

func main() {
    // @NOTE: the real connection is not required for tests
    db, err := pgxpool.New(context.Background(), "postgres://rolname@hostname/dbname")
    if err != nil {
        panic(err)
    }
    defer db.Close()

    if err = recordStats(db, 1 /*some user id*/, 5 /*some product id*/); err != nil {
        panic(err)
    }
}
```


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CI/CD



GitHub Integration

- **Dependabot** - maintains repository's dependencies automatically
- **CodeQL** - action runs analysis engine to find security vulnerabilities
- **Build & Test** - action runs on each pull request, or manually
- **Release** - action runs on new tag, publishes release
- **Docker** - action runs on every commit, publishes Docker images

Github Actions: Dependabot

```
1  version: 2
2  updates:
3
4    # Maintain dependencies for Go modules
5    - package-ecosystem: gomod
6      directory: "/"
7      schedule:
8        interval: daily
9        time: "04:00"
10     open-pull-requests-limit: 10
11
12    # Maintain dependencies for GitHub Actions
13    - package-ecosystem: "github-actions"
14      directory: "/"
15      schedule:
16        interval: "daily"
```



Github Actions: CodeQL

```
1  name: "CodeQL"
2
3  on:
4    push:
5      branches: [ master ]
6    pull_request:
7      branches: [ master ]
8    schedule:
9      - cron: '19 11 * * 6'
10
11  jobs:
12    analyze:
13      name: Analyze
14      runs-on: ubuntu-latest
15      permissions:
16        actions: read
17        contents: read
18        security-events: write
19
20      strategy:
21        fail-fast: false
22        matrix:
23          language: [ 'go' ]
24
25      steps:
26      - name: Checkout repository
27        uses: actions/checkout@v3
28
29      # Initializes the CodeQL tools for scanning.
30      - name: Initialize CodeQL
31        uses: github/codeql-action/init@v2
32        with:
33          languages: ${{ matrix.language }}
34
35      - name: Autobuild
36        uses: github/codeql-action/autobuild@v2
37
38      - name: Perform CodeQL Analysis
39        uses: github/codeql-action/analyze@v2
```

Github Actions:

Build & Test

```
90 test-postgresql-ubuntu:
91   if: true # false to skip job during debug
92   name: Test and Build on Ubuntu
93   runs-on: ubuntu-latest
94   steps:
95
96     - name: Start PostgreSQL on Ubuntu
97       run: |
98         sudo systemctl start postgresql.service
99         pg_isready
100
101     - name: Create scheduler user
102       run: |
103         sudo -u postgres psql --command="CREATE USER scheduler PASSWORD 'somestrong'" --command="\du"
104
105     - name: Create timetable database
106       run: |
107         sudo -u postgres createdb --owner=scheduler timetable
108         PGPASSWORD=somestrong psql --username=scheduler --host=localhost --list timetable
109
110     - name: Check out code
111       uses: actions/checkout@v3
112
113     - name: Set up Golang
114       uses: actions/setup-go@v3
115       with:
116         go-version: '1.19'
117
118     - name: Get dependencies
119       run: |
120         go mod download
121         go version
122
123     - name: GolangCI-Lint
124       uses: golangci/golangci-lint-action@v3
125       with:
126         version: latest
127
128     - name: Test
129       run: go test -failfast -v -timeout=300s -p 1 -coverprofile=profile.cov ./...
130
131     - name: Coveralls
132       uses: shogo82148/actions-goveralls@v1
133       with:
134         path-to-profile: profile.cov
```



Github Actions:

Release

```
1  name: Release
2  on:
3    release:
4      types: [created]
5
6  jobs:
7
8    goreleaser:
9      if: true # false to skip job during debug
10     runs-on: ubuntu-latest
11     name: goreleaser
12     steps:
13
14       - name: Set up Golang
15         uses: actions/setup-go@v3
16         with:
17           go-version: '1.19'
18
19       - name: Check out code into the Go module directory
20         uses: actions/checkout@v3
21
22       - name: Unshallow
23         run: git fetch --prune --unshallow
24
25       - name: Release via goreleaser
26         uses: goreleaser/goreleaser-action@v4
27         with:
28           args: release
29         env:
30           GITHUB_TOKEN: ${ secrets.GITHUB_TOKEN }
```

Github Actions:

Docker

```
16 docker:
17   if: true # false to skip job during debug
18   runs-on: ubuntu-latest
19   steps:
20
21   - name: Check out code
22     uses: actions/checkout@v3
23
24   - name: Set up Golang
25     uses: actions/setup-go@v3
26     with:
27       go-version: '1.19'
28
29   # despite the fact docker will build binary internally
30   # we want to stop workflow in case of any error before pushing to registry
31   - name: Get dependencies and Build
32     run: |
33       go version
34       go mod download
35       go build
36
37   - name: Version strings
38     id: version
39     run: |
40       echo "RELEASE_TIME=$(git show -s --format=%cI HEAD)" >> $GITHUB_OUTPUT
41
42   - name: Publish to Registry
43     uses: elgohr/Publish-Docker-Github-Action@v5
44     env:
45       VERSION: ${ github.ref_name }
46       COMMIT: ${ github.sha }
47       DATE: ${ steps.version.outputs.RELEASE_TIME }
48     with:
49       name: cybertecpostgresql/pg_timetable
50       username: ${ secrets.DOCKER_USERNAME }
51       password: ${ secrets.DOCKER_PASSWORD }
52       buildargs: VERSION,COMMIT,DATE
```

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Takeaways

Takeaways

- Go language is popular, fast, easy and well-scaled
- 45% of developers use Go to work with databases (go.dev survey)
- You can use your preferred editor or use special IDE's to work
- Kubernetes operators (including Postgres ones) are written in Go
- Go is flexible when working with Postgres: use **sql** or **pgx** interfaces
- Go has powerful programming tools and GitHub/GitLab integration
- Go is backwards-compatible. The API's may grow but not in a way that breaks existing Go v1 code

DON'T BE A STRANGER



PERSONAL GITHUB

www.github.com/pashagolub



CYBERTEC BLOG

www.cybertec-postgresql.com/en/blog/



CYBERTEC GITHUB

www.github.com/cybertec-postgresql



Be Inspired

“I would rather have questions that can't be answered than answers that can't be questioned.”

Richard Feynman

#StandWithUkraine

