

ETCD 架构解析

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目录

第一章 etcd 编译安装	1
1.1 golang 环境	1
1.2 etcd 编译安装	2
1.3 etcd 编译文件 build 分析	2
1.4 etcd 版本	2
第二章 etcd server 分析	5
2.1 源码分析方法	5
2.1.1 配置文件法	5
2.1.2 日志法	5
2.1.3 调试跟踪法	5
2.1.4 框架预习法	5
2.1.5 GRPC 框架	5
2.1.6 GRPC 安装	8
2.2 etcd 启动调用关系	8
2.2.1 从监听地址出发分析 etcd 如何处理客户端请求	8
2.2.2 用调试器跟踪法继续分析客户端请求	12
2.2.3 框架分析之 ETCD 的 GRPC 服务	12
第三章 etcd 编译安装	15
3.1 golang 环境	15
3.2 etcd 编译安装	16
3.3 etcd 编译文件 build 分析	16
3.4 etcd 版本	16
3.4.1 画布操作	18
3.4.2 phtotshop 简介	20
参考文献	21
附录	23
致谢	33
作者简介	35

第一章 etcd 编译安装

1.1 golang 环境

当然在安装 etcd 前要先安装 go。并且设置好 GOPATH。可以用 apt,yum 或者源码安装,下载二进制安装等方式。从官网下载 golang 源码包。<https://golang.org/dl/>。

```
root@dockervm:~/go/src# go env
GO111MODULE=""
GOARCH="amd64"
GOBIN=""
GOCACHE="/root/.cache/go-build"
GOENV="/root/.config/go/env"
GOEXE=""
GOFLAGS=""
GOHOSTARCH="amd64"
GOHOSTOS="linux"
GONOPROXY=""
GONOSUMDB=""
GOOS="linux"
GOPATH="/root/go"
GOPRIVATE=""
GOPROXY="https://proxy.golang.org,direct"
GOROOT="/usr/local/go"
GOSUMDB="sum.golang.org"
GOTMPDIR=""
GOTOOLDIR="/usr/local/go/pkg/tool/linux_amd64"
GCCGO="gccgo"
AR="ar"
CC="gcc"
CXX="g++"
CGO_ENABLED="1"
GOMOD=""
CGO_CFLAGS="-g -O2"
CGO_CPPFLAGS=""
CGO_CXXFLAGS="-g -O2"
CGO_FFLAGS="-g -O2"
CGO_LDFLAGS="-g -O2"
PKG_CONFIG="pkg-config"
GOGCCFLAGS="-fPIC -m64 -pthread -fmessage-length=0
ches"
```

图 1.1: golang 环境变量

```

1 wget https://golang.org/doc/install?download=go1.13.5.linux-amd64.tar.gz
2 tar xvf go1.13.5.linux-amd64.tar.gz -C /usr/local
3 并在 vim ~/.bashrc 加入
4 export PATH=$PATH:/usr/local/go/bin

```

1.2 etcd 编译安装

```

1 #etcd 编译
2 mkdir -p $GOPATH/src/go.etcd.io/
3 cd $GOPATH/src/go.etcd.io/
4 git clone https://github.com/etcd-io/etcd.git
5 ./build
6 ./bin/etcd

```

```

root@dockervm:~/go/src/go.etcd.io/etcd# ./bin/etcd
[WARNING] Deprecated '--logger=capnslog' flag is set; use '--logger=zap' flag instead
2019-12-12 12:56:57.536110 I | etcdmain: etcd Version: 3.5.0-pre
2019-12-12 12:56:57.536652 I | etcdmain: Git SHA: 378b05b8d
2019-12-12 12:56:57.536929 I | etcdmain: Go Version: go1.10.4
2019-12-12 12:56:57.537314 I | etcdmain: Go OS/Arch: linux/amd64
2019-12-12 12:56:57.537647 I | etcdmain: setting maximum number of CPUs to 1, total number of available CPUs is 1
2019-12-12 12:56:57.538025 W | etcdmain: no data-dir provided, using default data-dir ./default.etcd
[WARNING] Deprecated '--logger=capnslog' flag is set; use '--logger=zap' flag instead
2019-12-12 12:56:57.540593 I | embed: name = default
2019-12-12 12:56:57.541455 I | embed: data dir = default.etcd
2019-12-12 12:56:57.542031 I | embed: member dir = default.etcd/member
2019-12-12 12:56:57.542372 I | embed: heartbeat = 100ms
2019-12-12 12:56:57.542686 I | embed: election = 1000ms
2019-12-12 12:56:57.542978 I | embed: snapshot count = 100000
2019-12-12 12:56:57.543339 I | embed: advertise client URLs = http://localhost:2379
2019-12-12 12:56:57.861111 I | etcdserver: starting member 8e9e05c52164694d in cluster cdf818194e3a8c32
raft2019/12/12 12:56:57 INFO: 8e9e05c52164694d switched to configuration voters=()
raft2019/12/12 12:56:57 INFO: 8e9e05c52164694d became follower at term 0
raft2019/12/12 12:56:57 INFO: newRaft 8e9e05c52164694d [peers: [], term: 0, commit: 0, applied: 0, lastindex: 0, lastterm: 0]
raft2019/12/12 12:56:57 INFO: 8e9e05c52164694d became follower at term 1
raft2019/12/12 12:56:57 INFO: 8e9e05c52164694d switched to configuration voters=(10276657743932975437)
2019-12-12 12:56:58.012522 W | auth: simple token is not cryptographically signed
2019-12-12 12:56:58.128437 I | etcdserver: starting server... [version: 3.5.0-pre, cluster version: to be decided]
2019-12-12 12:56:58.134720 I | etcdserver: 8e9e05c52164694d as single-node; fast-forwarding 9 ticks (election ticks 10)
2019-12-12 12:56:58.135431 I | embed: listening for peers on 127.0.0.1:2380
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d switched to configuration voters=(10276657743932975437)
2019-12-12 12:56:58.136818 I | etcdserver/membership: added member 8e9e05c52164694d [http://localhost:2380] to cluster cdf818194e3a8c32
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d is starting a new election at term 1
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d became candidate at term 2
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d received MsgVoteResp from 8e9e05c52164694d at term 2
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d became leader at term 2
raft2019/12/12 12:56:58 INFO: raft.node: 8e9e05c52164694d elected leader 8e9e05c52164694d at term 2
2019-12-12 12:56:58.263397 I | etcdserver: setting up the initial cluster version to 3.5
2019-12-12 12:56:58.263744 I | etcdserver/membership: set the initial cluster version to 3.5
2019-12-12 12:56:58.264386 I | embed: ready to serve client requests
2019-12-12 12:56:58.265136 N | embed: serving insecure client requests on 127.0.0.1:2379, this is strongly discouraged!
2019-12-12 12:56:58.295344 N | etcdserver/membership: set the initial cluster version to 3.5
2019-12-12 12:56:58.295855 I | etcdserver/api: enabled capabilities for version 3.5

```

图 1.2: etcd 运行

1.3 etcd 编译文件 build 分析

etcd 的 build 文件如图 3.3 所示。golang 的编译非常简洁快速。直接编译出了 etcd 和 etcdctl 两个可执行文件。

1.4 etcd 版本

本书开写时的 etcd 的最新版本。如果看代码，要用与本书一致比较好。

```
49 etcd_build() {
50     out="bin"
51     if [[ -n "${BINDIR}" ]]; then out="${BINDIR}"; fi
52     toggle_failpoints_default
53
54     # Static compilation is useful when etcd is run in a container. $GO_BUILD_FLAGS is OK
55     # shellcheck disable=SC2086
56     CGO_ENABLED=0 go build $GO_BUILD_FLAGS \
57         -installsuffix cgo \
58         -ldflags "$GO_LDFLAGS" \
59         -o "${out}/etcd" "${REPO_PATH}" || return
60     # shellcheck disable=SC2086
61     CGO_ENABLED=0 go build $GO_BUILD_FLAGS \
62         -installsuffix cgo \
63         -ldflags "$GO_LDFLAGS" \
64         -o "${out}/etcdctl" "${REPO_PATH}/etcdctl" || return
65 }
```

文件: go.etcd.io/etcd/build

build etcd: etcd/main.go -> etcd/etcdmain/etcdmain.go

图 1.3: etcd build

```
root@dockervm:~/go/src/go.etcd.io/etcd# ./bin/etcd --version
etcd Version: 3.5.0-pre
Git SHA: 378b05b8d
Go Version: go1.10.4
Go OS/Arch: linux/amd64
root@dockervm:~/go/src/go.etcd.io/etcd#
```

图 1.4: etcd 版本

第二章 etcd server 分析

2.1 源码分析方法

2.1.1 配置文件法

一般在看一个服务器的代码，可以从其配置文件入手。比如 etcd, 我们知道 etcd 服务器启动后必然会监听一个端口来与客户端通信，同时也会监听一个端口与其他 etcd 服务器通信 (这是因为 RAFT 算法中需要多个结点)。etcd 的启动配置见附录3.4.2

2.1.2 日志法

看 server 的日志是了解代码执行路径的比较好的办法。可以尝试打开 server 的 DEBUG 日志，得到更新详细的日志。还可以自己手动在代码加入日志，这就需要重新编译 server。但是像 go 这种编译速度比较快的可以一试。如果是 C++ 等编译比较慢的语言，将严重影响分析源码的效率。

2.1.3 调试跟踪法

在进一步跟踪代码的过程，经常会遇到虚函数, 接口，框架。导致跟踪断开。这也表示，代码走到了更低一层。而一般开源代码也不会有文档明确指出这一层提供的所有接口，以及用法。这就需要用调试器进一步跟踪。可以利用调试器的 watch 指令来监控某个 socket 或者说变量的引用。同时在客户端发送请求。就可以进一步跟踪到框架底层。

2.1.4 框架预习法

如果代码中使用了框架，先花上几小时熟悉这个框架的用法。甚至花几天去熟悉也很值。比如 etcd 中的用了 GRPC 框架，用了 http2, 用了 go 自带的 http2 的库。如果对这些不熟悉，那分析源码将会举步维艰。

2.1.5 GRPC 框架

GRPC 框架支持多语言, 并且使用了 ProtoBuffer。ProtoBuffer 是一种高效的序列化反序列化通信协议。增加字段后能兼容增加字段前的协议，再也不用担心一个协议字段的添加而导致客户端服务器转文不兼容了。同时，ProtoBuffer 定义了一种新语法来定义协议字段。这些协议的定义会被放在 proto 文件里。再由

protoc 命令加一些插件来生成不同语言的代码。比如 golang, 就会生成 pb.go。原来的 proto 文件中定义的 message 会被转换成 golang 的 struct。当然如果生成 java 代码就会转成 java 的 class 文件。

GRPC 不但通过 proto 来定义 RPC 通信协议, 同时也定义 RPC 服务器客户端的接口 (其实就是一个函数)。然后用 GRPC 的的插件 +protoc 来生成 RPC 服务器和客户端的代码。这此代码会把需要我们实现的 RPC 接口暴露出来, 我们只需要实现这些接口就能实现 RPC 调用。同时客户端接口也已经生成, 我们自己只要调用生成的客户端接口, 就能调用远程 RPC 服务器上的代码。Proto 定义如下图。

proto 定义:

```

1  // Copyright 2015 gRPC authors.
2  syntax = "proto3";
3  option java_multiple_files = true;
4  option java_package = "io.grpc.examples.helloworld";
5  option java_outer_classname = "HelloWorldProto";
6  package helloworld;
7  // The greeting service definition.
8  service Greeter {
9      // Sends a greeting
10     rpc SayHello (HelloRequest) returns (HelloReply) {}
11 }
12 // The request message containing the user's name.
13 message HelloRequest {
14     string name = 1;
15 }
16 // The response message containing the greetings
17 message HelloReply {
18     string message = 1;
19 }

```

服务器实现:

```

1  /*
2   * Copyright 2015 gRPC authors.
3   */
4  //go:generate protoc -I ../helloworld --go_out=plugins=grpc:../helloworld
5  ↪ ../helloworld/helloworld.proto
6  // Package main implements a server for Greeter service.
7  package main
8
9  import (
10     "context"
11     "log"
12     "net"
13
14     "google.golang.org/grpc"
15     pb "google.golang.org/grpc/examples/helloworld/helloworld"
16 )
17
18 const (
19     port = ":50051"
20 )
21
22 // server is used to implement helloworld.GreeterServer.
23 type server struct {
24     pb.UnimplementedGreeterServer
25 }

```

```

20 }
21 // SayHello implements helloworld.GreeterServer
22 func (s *server) SayHello(ctx context.Context, in *pb.HelloRequest)
    ↪ (*pb.HelloReply, error) {
23     log.Printf("Received: %v", in.GetName())
24     return &pb.HelloReply{Message: "Hello " + in.GetName()}, nil
25 }
26 func main() {
27     lis, err := net.Listen("tcp", port)
28     if err != nil {
29         log.Fatalf("failed to listen: %v", err)
30     }
31     s := grpc.NewServer()
32     pb.RegisterGreeterServer(s, &server{})
33     if err := s.Serve(lis); err != nil {
34         log.Fatalf("failed to serve: %v", err)
35     }
36 }

```

客户端调用:

```

1  /*
2   * Copyright 2015 gRPC authors.
3   */
4  // Package main implements a client for Greeter service.
5  package main
6  import (
7      "context"
8      "log"
9      "os"
10     "time"
11
12     "google.golang.org/grpc"
13     pb "google.golang.org/grpc/examples/helloworld/helloworld"
14 )
15 const (
16     address      = "localhost:50051"
17     defaultName = "world"
18 )
19 func main() {
20     // Set up a connection to the server.
21     conn, err := grpc.Dial(address, grpc.WithInsecure(),
22         ↪ grpc.WithBlock())
23     if err != nil {
24         log.Fatalf("did not connect: %v", err)
25     }
26     defer conn.Close()
27     c := pb.NewGreeterClient(conn)
28
29     // Contact the server and print out its response.
30     name := defaultName
31     if len(os.Args) > 1 {
32         name = os.Args[1]
33     }
34     ctx, cancel := context.WithTimeout(context.Background(), time.Second)
35     defer cancel()
36     r, err := c.SayHello(ctx, &pb.HelloRequest{Name: name})
37     if err != nil {
38         log.Fatalf("could not greet: %v", err)
39     }
40     log.Printf("Greeting: %s", r.GetMessage())
41 }

```

2.1.6 GRPC 安装

国内可能访问不了 google 的某些域名，可以从 github 来下载包。然后移动到对应的目录下。如果编译时发现缺少某些包，还是如这般操作，直到把依赖的包都下载下来。

```

1  #GRPC 安装
2  #protoc 的 golang 插件
3  go get github.com/golang/protobuf/protoc-gen-go
4  #golang 测试框架
5  go get github.com/golang/mock/gomock
6  #GRPC, 先从 github 上下载, 然后移动并重命名到 src/google.golang.org/grpc
7  go get github.com/grpc/grpc-go ; mkdir -p $(GOPATH)/src/google.golang.org; mv
   ↪ $(GOPATH)/src/github.com/grpc/grpc-go
   ↪ $(GOPATH)/src/google.golang.org/grpc
8
9  #GRPC 依赖库安装
10
11 #x 库
12 GOPATH=`go env GOPATH`
13 mkdir -p $(GOPATH)/src/golang.org/x
14 cd $(GOPATH)/src/golang.org/x
15 git clone https://github.com/golang/net.git net
16 git clone https://github.com/golang/text
17 git clone https://github.com/golang/sys
18
19 #GRPC 生成 GRPC 服务器用的库
20 cd $(GOPATH)/src/google.golang.org
21 git clone https://github.com/googleapis/go-genproto.git genproto
22
23 # 跑个例子看有没有安装好
24 启动 server: go run
   ↪ google.golang.org/grpc/examples/helloworld/greeter_server/main.go
25 启动 client: go run
   ↪ google.golang.org/grpc/examples/helloworld/greeter_client/main.go
26 启动 test: go test -test.v
   ↪ google.golang.org/grpc/examples/helloworld/mock_helloworld/hw_mock_test.go

```

2.2 etcd 启动调用关系

etcd 服务器启动，会启动很多模块，对外主要是处理客户端请求，对内有 etcd 多个服务器进程之间通信，也有 etcd 服务器内部的功能，比如 KV 存储，WAL 日志等。源码分析第一步，搞清楚 etcd 的启动初始化步骤。见图2.1和图2.2。

2.2.1 从监听地址出发分析 etcd 如何处理客户端请求

etcd 的启动参数里有 `-listen-client-urls 'http://localhost:2379'` 这么一项，见附录3.4.2。这便是 etcd 为处理客户端请求而监听的地址。通过搜索代码，得到2.2.1。然后找 `cfg.ec.LCUrls` 的引用位置。然后发现在【`embed/etcd.go:ConfigureClientListeners`】中使用了 `LCUrls`，并且监听了这个地址。使用的就是 golang 的 `net` 库。`ConfigureClientListeners` 是在【`embed/etcd.go`】中的 `StartEtcd(inCf)` 调用，调用图见2.2。`StartEtcd` 是 etcd 服务器的总控。这里启动了所有的服务。由于 Golang 的协程特性，可能在随时启动一个协程去服务。`Start` 可能只是在启动协议前做一些初始

```

3 (dlv) bt
0 0x000000000b7db8b in go.etcd.io/etcd/etcdserver.(*EtcdServer).start
   at ./etcdserver/server.go:746
1 0x000000000b7d8af in go.etcd.io/etcd/etcdserver.(*EtcdServer).Start
   at ./etcdserver/server.go:733
2 0x000000000d307b9 in go.etcd.io/etcd/embed.StartEtcd
   at ./embed/etcd.go:228
3 0x000000000d86ff0 in go.etcd.io/etcd/etcdmain.startEtcd
   at ./etcdmain/etcd.go:302
4 0x000000000d85b6e in go.etcd.io/etcd/etcdmain.startEtcdOrProxyV2
   at ./etcdmain/etcd.go:144
5 0x000000000d8fcff in go.etcd.io/etcd/etcdmain.Main
   at ./etcdmain/main.go:46
6 0x000000000d94440 in main.main
   at ./main.go:28
7 0x00000000042c5e2 in runtime.main
   at /usr/lib/go-1.10/src/runtime/proc.go:198
8 0x000000000459e51 in runtime.goexit
   at /usr/lib/go-1.10/src/runtime/asm_amd64.s:2361

```

图 2.1: etcd 的 dlv 调用栈

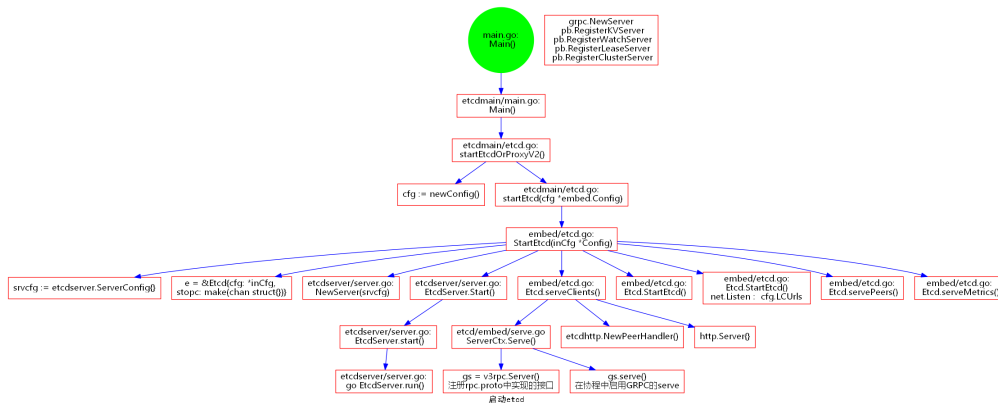


图 2.2: etcd 的启动初始化

化，比如 HTTP 服务就需要提前注册各种处理 URL 的 handler。

从监听地址来分析，依然是细节太多。大概能搞清楚服务器的启动初始化流程。但是对于分析一次客户端的请求过程这样的事儿还是显示力不从心。

```

1 # 中使用 listen-client-urls
2 root@dockervm:~/go/src/go.etcd.io/etcd# find . -type f -name "*.go"|xargs
   ↪ grep -n 'listen-client-urls'
3 ./etcdmain/config.go:139:
   ↪ flags.NewUniqueURLsWithExceptions(embed.DefaultListenClientURLs, ""),
   ↪ "listen-client-urls",
4 ./etcdmain/config.go:330:         cfg.ec.LCUrls =
   ↪ flags.UniqueURLsFromFlag(cfg.cf.flagSet, "listen-client-urls")
5 # 使用 LCURLs 的代码
6 root@dockervm:~/go/src/go.etcd.io/etcd# find . -type f -name "*.go"|xargs
   ↪ grep -n 'LCUrls'
7 //下边两行是在 StartProxy 里的，如果不是 Proxy 就不会走到这里
8 ./etcdmain/etcd.go:510: for _, u := range cfg.ec.LCUrls {
9 ./etcdmain/etcd.go:531: for _, u := range cfg.ec.LCUrls {
10 ./etcdmain/config.go:330:         cfg.ec.LCUrls =
   ↪ flags.UniqueURLsFromFlag(cfg.cf.flagSet, "listen-client-urls")
11 ./tools/etcd-dump-metrics/etcd.go:55:     cfg.LCUrls, cfg.ACUrls = curls, curls
12 ./embed/etcd.go:609:     for _, u := range cfg.LCUrls { # 这里是非 proxy 启动会
   ↪ 走到的地方
13 ./embed/config.go:181: LPUrIs, LCUrls []url.URL

1 //使用 listen-client-urls
2 func configureClientListeners(cfg *Config) (sctxs map[string]*serveCtx, err
   ↪ error) {

```

```

3     if err = updateCipherSuites(&cfg.ClientTLSInfo, cfg.CipherSuites); err !=
    ↪ nil {
4         return nil, err
5     }
6     if err = cfg.ClientSelfCert(); err != nil {
7         if cfg.logger != nil {
8             cfg.logger.Fatal("failed to get client self-signed certs",
    ↪ zap.Error(err))
9         } else {
10            plog.Fatalf("could not get certs (%v)", err)
11        }
12    }
13    if cfg.EnablePprof {
14        if cfg.logger != nil {
15            cfg.logger.Info("pprof is enabled", zap.String("path",
    ↪ debugutil.HTTPPrefixPProf))
16        } else {
17            plog.Infof("pprof is enabled under %s",
    ↪ debugutil.HTTPPrefixPProf)
18        }
19    }
20
21    sctxs = make(map[string]*serveCtx)
22    for _, u := range cfg.LCUrls { //可见可以监听多个地上, 一般只有一个
23        sctx := newServeCtx(cfg.logger)
24        if u.Scheme == "http" || u.Scheme == "unix" {
25            // .....
26        }
27        if (u.Scheme == "https" || u.Scheme == "unixs") &&
    ↪ cfg.ClientTLSInfo.Empty() {
28            return nil, fmt.Errorf("TLS key/cert (--cert-file, --key-file)
    ↪ must be provided for client url %s with HTTPS scheme",
    ↪ u.String())
29        }
30
31        network := "tcp"
32        addr := u.Host
33        if u.Scheme == "unix" || u.Scheme == "unixs" {
34            network = "unix"
35            addr = u.Host + u.Path
36        }
37        sctx.network = network
38
39        sctx.secure = u.Scheme == "https" || u.Scheme == "unixs"
40        sctx.insecure = !sctx.secure
41        if oldctx := sctxs[addr]; oldctx != nil {
42            oldctx.secure = oldctx.secure || sctx.secure
43            oldctx.insecure = oldctx.insecure || sctx.insecure
44            continue
45        }
46        //这里监听了地址, sctx.l
47        if sctx.l, err = net.Listen(network, addr); err != nil {
48            return nil, err
49        }
50        // net.Listener will rewrite ipv4 0.0.0.0 to ipv6 [::], breaking
51        // hosts that disable ipv6. So, use the address given by the user.
52        sctx.addr = addr
53
54        if fdLimit, fderr := runtimeutil.FDLimit(); fderr == nil {
55            // .....
56            sctx.l = transport.LimitListener(sctx.l,
    ↪ int(fdLimit-reservedInternalFDNum))
57        }
58
59        if network == "tcp" {
60            if sctx.l, err = transport.NewKeepAliveListener(sctx.l, network,
    ↪ nil); err != nil {
    ↪ return nil, err
61        }
62    }
63
64    defer func() {
65        if err == nil {
66            return
67        }

```

```

68         }
69         sctx.l.Close() //如果有错误就停止监听
70         // .....
71     }()
72     for k := range cfg.UserHandlers {
73         sctx.userHandlers[k] = cfg.UserHandlers[k]
74     }
75     sctx.serviceRegister = cfg.ServiceRegister
76     if cfg.EnablePprof || cfg.Debug {
77         sctx.registerPprof()
78     }
79     if cfg.Debug {
80         sctx.registerTrace()
81     }
82     sctxs[addr] = sctx //保存一个 sctx
83 }
84 return sctxs, nil
85 }

86 //在【embed/etcd.go】中的 StartEtcd(inCfg) 调用了 configureClientListeners
87 func StartEtcd(inCfg *Config) (e *Etcd, err error) {
88     //.....
89     serving := false
90     e = &Etcd{cfg: *inCfg, stopc: make(chan struct{})}
91     cfg := &e.cfg
92     //.....
93     //这里监听的地址是 server 之间通信的地址
94     if e.Peers, err = configurePeerListeners(cfg); err != nil {
95         return e, err
96     }
97     //.....
98     //这里监听的地址是 server 与 client 之间通信的地址
99     if e.sctxs, err = configureClientListeners(cfg); err != nil {
100         return e, err
101     }
102     //把 listen 状态的 conn 放到了 e.Clients 中，只用于服务器退出时关闭，可以检
103     ↪ 查所有
104     //用到 e.Clients 的地方
105     for _, sctx := range e.sctxs {
106         e.Clients = append(e.Clients, sctx.l)
107     }
108     //.....
109     srvcfg := etcdserver.ServerConfig{
110         Name:          cfg.Name,
111         ClientURLs:    cfg.ACUrls,
112         PeerURLs:      cfg.APUrls,
113         DataDir:       cfg.Dir,
114         DedicatedWALDir: cfg.WalDir,
115         //.....
116     }
117     print(e.cfg.logger, *cfg, srvcfg, memberInitialized)
118     if e.Server, err = etcdserver.NewServer(srvcfg); err != nil {
119         return e, err
120     }
121     //.....
122     //etcd 服务启动
123     e.Server.Start()
124     //server 之间服务启动
125     if err = e.servePeers(); err != nil {
126         return e, err
127     }
128     //处理客户端请求的服务启动
129     if err = e.serveClients(); err != nil {
130         return e, err
131     }
132 }
133
134
135
136
137
138
139

```

```

140     //
141     if err = e.serveMetrics(); err != nil {
142         return e, err
143     }
144
145     //.....
146     serving = true
147     return e, nil
148 }

```

2.2.2 用调试器跟踪法继续分析客户端请求

此方法要谨慎使用，否则会陷入无限的细节当中不能自拔，进而会浪费大量时间。尤其是一开始分析源码的时候，会跟踪到底层，加上 go 的协程交替执行，会让人一头雾水。

```

1  # 使用调试器 dlv 调试服务器监听端口
2  # 先安装好 dlv
3  # 同时修改 etcd/build 文件如下：和原来的相比加了-gcflags，这样 dlv 才能打印变量
   ↪ 值
4  etcd_build() {
5  out="bin"
6  if [[ -n "${BINDIR}" ]]; then out="${BINDIR}"; fi
7  toggle_failpoints_default

8  # Static compilation is useful when etcd is run in a container.
   ↪ $GO_BUILD_FLAGS is OK
9  # shellcheck disable=SC2086
10 CGO_ENABLED=0 go build $GO_BUILD_FLAGS \
11 -gcflags=all="-N -l" \
12 -installsuffix cgo \
13 -ldflags "$GO_LDFLAGS" \
14 -o "${out}/etcd" ${REPO_PATH} || return
15 # shellcheck disable=SC2086
16 CGO_ENABLED=0 go build $GO_BUILD_FLAGS \
17 -gcflags=all="-N -l" \
18 -installsuffix cgo \
19 -ldflags "$GO_LDFLAGS" \
20 -o "${out}/etcdctl" ${REPO_PATH}/etcdctl || return
21 }

22 # 最后编译 ./build

23 # 开始调试
24 root@dockervm:~/go/src/go.etcd.io/etcd# dlv --check-go-version=false exec
   ↪ ./bin/etcd
25 Type 'help' for list of commands.
26 (dlv) b embed.serve
27 Breakpoint 1 set at 0xd3a9fb for go.etcd.io/etcd/embed.(*serveCtx).serve()
   ↪ ./embed/serve.go:85
28 (dlv) c

```

2.2.3 框架分析之 ETCD 的 GRPC 服务

这里才是分析源码最快的方法。没有一个服务器不使用框架，或使用自己写的框架。尤其是网络框架。比如 HTTP, GRPC。在分析源码前，一定要花时间先把框架学习了。至少把框架的使用方法学习了。手动写几个框架的小应用更好。当然，框架实现细节可以延后学习。就比如 ETCD 使用的 GRPC 框架。在学习 GRPC 框架前，无论是看代码，调试程序，都没法找到 ETCD 是如何处理客户端请求的。直到学了 GRPC 框架，才恍然大悟，原来 GRPC 框架要求所有 RPC 服务接口都要定义在 proto 里。所以看了【etcdserver/etcdserverpb/rpc.proto】文件后

对 ETCD 服务器提供的 RPC 服务一目了然。然后就是找到这些接口的实现和注册。看看生成的 `rpc.pb.go` 文件，了解了接口，和注册函数 `RegisterKVServer`。然后再代码里搜索一下 `RegisterKVServer` 得到【`etcdserver/api/v3rpc/grpc.go:59`】。同时我们知道 GRPC 的 server 的创建是调用 `grpc.NewServer()`，同样搜索一下代码得到【`./etcdserver/api/v3rpc/grpc.go:57: grpcServer := grpc.NewServer(append(opts, gopts...))`】。最后在协程中调用 `grpcServer.Serve()` 开始服务。

```

1 # 搜索 RegisterKVServer
2 root@dockervm:~/go/src/go.etcd.io/etcd# find . -type f -name "*.go" |xargs
  ↪ grep -n -i 'RegisterKVServer'
3 ./proxy/grpcproxy/kv_test.go:88:      pb.RegisterKVServer(kvts.server,
  ↪ kvts.kp)
4 ./etcdmain/grpc_proxy.go:367:  pb.RegisterKVServer(server, kvp)
5 ./pkg/mock/mockserver/mockserver.go:135:      pb.RegisterKVServer(svr,
  ↪ &mockKVServer{})
6 ./etcdserver/api/v3rpc/grpc.go:59:      pb.RegisterKVServer(grpcServer,
  ↪ NewQuotaKVServer(s))
7 ./etcdserver/etcdserverpb/rpc.pb.go:3535:func RegisterKVServer(s
  ↪ *grpc.Server, srv KVServer) {

8 # 搜索 grpc.NewServer
9 root@dockervm:~/go/src/go.etcd.io/etcd# find . -type f -name "*.go" |xargs
  ↪ grep -n -i 'grpc\.NewServer'
10 ./proxy/grpcproxy/kv_test.go:87:      kvts.server = grpc.NewServer(opts...)
11 ./proxy/grpcproxy/cluster_test.go:109:  cts.server = grpc.NewServer(opts...)
12 ./etcdmain/grpc_proxy.go:361:  server := grpc.NewServer(
13 ./pkg/mock/mockserver/mockserver.go:134:      svr := grpc.NewServer()
14 ./etcdserver/api/v3rpc/grpc.go:57:      grpcServer :=
  ↪ grpc.NewServer(append(opts, gopts...))
15 ./vendor/github.com/grpc-ecosystem/go-grpc-middleware/doc.go:24:
  ↪ myServer := grpc.NewServer(
16 ./functional/agent/server.go:95:      srv.grpcServer =
  ↪ grpc.NewServer(opts...)

17 etcd/etcdserver/api/v3rpc/grpc.go 中 Server 的定义如下。可以返回了 grpc 的
  ↪ Server。
18 func Server(s *etcdserver.EtcdServer, tls *tls.Config, gopts
  ↪ ...grpc.ServerOption) *grpc.Server

```


第三章 etcd 编译安装

3.1 golang 环境

当然在安装 etcd 前要先安装 go。并且设置好 GOPATH。可以用 apt,yum 或者源码安装，下载二进制安装等方式。

```
root@dockervm:~/go/src# go env
GO111MODULE=""
GOARCH="amd64"
GOBIN=""
GOCACHE="/root/.cache/go-build"
GOENV="/root/.config/go/env"
GOEXE=""
GOFLAGS=""
GOHOSTARCH="amd64"
GOHOSTOS="linux"
GONOPROXY=""
GONOSUMDB=""
GOOS="linux"
GOPATH="/root/go"
GOPRIVATE=""
GOPROXY="https://proxy.golang.org,direct"
GOROOT="/usr/local/go"
GOSUMDB="sum.golang.org"
GOTMPDIR=""
GOTOOLDIR="/usr/local/go/pkg/tool/linux_amd64"
GCCGO="gccgo"
AR="ar"
CC="gcc"
CXX="g++"
CGO_ENABLED="1"
GOMOD=""
CGO_CFLAGS="-g -O2"
CGO_CPPFLAGS=""
CGO_CXXFLAGS="-g -O2"
CGO_FFLAGS="-g -O2"
CGO_LDFLAGS="-g -O2"
PKG_CONFIG="pkg-config"
GOGCCFLAGS="-fPIC -m64 -pthread -fmessage-length=0
ches"
```

图 3.1: golang 环境变量

3.2 etcd 编译安装

```

1 #etcd 编译
2 mkdir -p $GOPATH/src/go.etcd.io/
3 cd $GOPATH/src/go.etcd.io/
4 git clone https://github.com/etcd-io/etcd.git
5 ./build
6 ./bin/etcd

```

```

root@dockervm:~/go/src/go.etcd.io/etcd# ./bin/etcd
[WARNING] Deprecated '--logger=capnslog' flag is set; use '--logger=zap' flag instead
2019-12-12 12:56:57.536110 I | etcdmain: etcd Version: 3.5.0-pre
2019-12-12 12:56:57.536652 I | etcdmain: Git SHA: 379b05b8d
2019-12-12 12:56:57.536929 I | etcdmain: Go Version: go1.10.4
2019-12-12 12:56:57.537314 I | etcdmain: Go OS/Arch: linux/amd64
2019-12-12 12:56:57.537647 I | etcdmain: setting maximum number of CPUs to 1, total number of available CPUs is 1
2019-12-12 12:56:57.538025 W | etcdmain: no data-dir provided, using default data-dir ./default.etcd
[WARNING] Deprecated '--logger=capnslog' flag is set; use '--logger=zap' flag instead
2019-12-12 12:56:57.540593 I | embed: name = default
2019-12-12 12:56:57.541455 I | embed: data dir = default.etcd
2019-12-12 12:56:57.542031 I | embed: member dir = default.etcd/member
2019-12-12 12:56:57.542372 I | embed: heartbeat = 100ms
2019-12-12 12:56:57.542686 I | embed: election = 1000ms
2019-12-12 12:56:57.542978 I | embed: snapshot count = 100000
2019-12-12 12:56:57.543339 I | embed: advertise client URLs = http://localhost:2379
2019-12-12 12:56:57.861111 I | etcdserver: starting member 8e9e05c52164694d in cluster cdf818194e3a8c32
raft2019/12/12 12:56:57 INFO: 8e9e05c52164694d switched to configuration voters=()
raft2019/12/12 12:56:57 INFO: 8e9e05c52164694d became follower at term 0
raft2019/12/12 12:56:57 INFO: newRaft 8e9e05c52164694d [peers: [], term: 0, commit: 0, applied: 0, lastindex: 0, lastterm: 0]
raft2019/12/12 12:56:57 INFO: 8e9e05c52164694d became follower at term 1
raft2019/12/12 12:56:57 INFO: 8e9e05c52164694d switched to configuration voters=(10276657743932975437)
2019-12-12 12:56:58.012523 W | auth: simple token is not cryptographically signed
2019-12-12 12:56:58.128437 I | etcdserver: starting server... [version: 3.5.0-pre, cluster version: to_be_decided]
2019-12-12 12:56:58.134720 I | etcdserver: 8e9e05c52164694d as single-node; fast-forwarding 9 ticks (election ticks 10)
2019-12-12 12:56:58.135431 I | embed: listening for peers on 127.0.0.1:2380
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d switched to configuration voters=(10276657743932975437)
2019-12-12 12:56:58.136818 I | etcdserver/membership: added member 8e9e05c52164694d [http://localhost:2380] to cluster cdf818194e3a8c32
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d is starting a new election at term 1
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d became candidate at term 2
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d received MsgVoteResp from 8e9e05c52164694d at term 2
raft2019/12/12 12:56:58 INFO: 8e9e05c52164694d became leader at term 2
raft2019/12/12 12:56:58 INFO: raft.node: 8e9e05c52164694d elected leader 8e9e05c52164694d at term 2
2019-12-12 12:56:58.263397 I | etcdserver: setting up the initial cluster version to 3.5
2019-12-12 12:56:58.263744 I | etcdserver: published {Name:default ClientURLs:[http://localhost:2379]} to cluster cdf818194e3a8c32
2019-12-12 12:56:58.264386 I | embed: ready to serve client requests
2019-12-12 12:56:58.265136 W | embed: serving insecure client requests on 127.0.0.1:2379, this is strongly discouraged!
2019-12-12 12:56:58.295344 N | etcdserver/membership: set the initial cluster version to 3.5
2019-12-12 12:56:58.295855 I | etcdserver/api: enabled capabilities for version 3.5

```

图 3.2: etcd 运行

3.3 etcd 编译文件 build 分析

etcd 的 build 文件如图 3.3 所示。golang 的编译非常简洁快速。直接编译出了 etcd 和 etcdctl 两个可执行文件。

3.4 etcd 版本

本书开写时的 etcd 的最新版本。如果看代码，要用与本书一致比较好。

Adobe Photoshop，简称“PS”，是由 Adobe Systems 开发和发行的图像处理软件。Photoshop 主要处理以像素所构成的数字图像。使用其众多的编修与绘图工具，可以有效地进行图片编辑工作。PS 有很多功能，在图像、图形、文字、视频、出版等各方面都有涉及。2003 年，Adobe Photoshop 8 被更名为 Adobe Photoshop CS。2013 年 7 月，Adobe 公司推出了新版本的 Photoshop CC，自此，Photoshop CS6 作为 Adobe CS 系列的最后一个版本被新的 CC 系列取代。截止 2016 年 12

```
49 etcd_build() {
50     out="bin"
51     if [[ -n "${BINDIR}" ]]; then out="${BINDIR}"; fi
52     toggle_failpoints_default
53
54     # Static compilation is useful when etcd is run in a container. $GO_BUILD_FLAGS is OK
55     # shellcheck disable=SC2086
56     CGO_ENABLED=0 go build $GO_BUILD_FLAGS \
57         -installsuffix cgo \
58         -ldflags "$GO_LDFLAGS" \
59         -o "${out}/etcd" ${REPO_PATH} || return
60     # shellcheck disable=SC2086
61     CGO_ENABLED=0 go build $GO_BUILD_FLAGS \
62         -installsuffix cgo \
63         -ldflags "$GO_LDFLAGS" \
64         -o "${out}/etcdctl" ${REPO_PATH}/etcdctl || return
65 }
```

图 3.3: etcd build

```
root@dockervm:~/go/src/go.etcd.io/etcd# ./bin/etcd --version
etcd Version: 3.5.0-pre
Git SHA: 378b05b8d
Go Version: go1.10.4
Go OS/Arch: linux/amd64
root@dockervm:~/go/src/go.etcd.io/etcd#
```

图 3.4: etcd 版本

月 Adobe PhotoshopCC2017 所有数据类型见表3.1。至于详情可以参考 [1] 和 [2]。Adobe Photoshop，简称“PS”，是由 Adobe Systems 开发和发行的图像处理软

表 3.1: OpenFlow 包格式

序号	类型	描述
1	Packet-In	发送到控制器
2	Packet-Out	发到交换机
3	Flow-Mod	修改流表项，增删改查，控制器发送到交换机的

件。Photoshop 主要处理以像素所构成的数字图像。使用其众多的编修与绘图工具，可以有效地进行图片编辑工作。PS 有很多功能，在图像、图形、文字、视频、出版等各方面都有涉及。2003 年，Adobe Photoshop 8 被更名为 Adobe Photoshop CS。2013 年 7 月，Adobe 公司推出了新版本的 Photoshop CC，自此，Photoshop CS6 作为 Adobe CS 系列的最后一个版本被新的 CC 系列取代。截止 2016 年 12 月 Adobe PhotoshopCC2017 为市场最新版本。跳转到第三章。[这里是百度](#)后面还有字这是楷体吗？

Adobe Photoshop，简称“PS”，是由 Adobe Systems 开发和发行的图像处理软件。Photoshop 主要处理以像素所构成的数字图像。使用其众多的编修与绘图工具，可以有效地进行图片编辑工作。PS 有很多功能，在图像、图形、文字、视频、出版等各方面都有涉及。2003 年，Adobe Photoshop 8 被更名为 Adobe Photoshop CS。2013 年 7 月，Adobe 公司推出了新版本的 Photoshop CC，自此，Photoshop

CS6 作为 Adobe CS 系列的最后一个版本被新的 CC 系列取代。截止 2016 年 12 月 Adobe PhotoshopCC2017 为市场最新版本。这是楷体吗？

$$f(x) = 3x^2 + 6(x - 2) - 1 \quad (3-1)$$

$$g(x) = 4x^2 + 6(x - 8) + 1 \quad (3-2)$$

$$E = mc^2 \quad (3-3)$$

Adobe Photoshop，简称“PS”，是由 Adobe Systems 开发和发行的图像处理软件。Photoshop 主要处理以像素所构成的数字图像。使用其众多的编修与绘图工具，可以有效地进行图片编辑工作。PS 有很多功能，在图像、图形、文字、视频、出版等各方面都有涉及。2003 年，Adobe Photoshop 8 被更名为 Adobe Photoshop CS。2013 年 7 月，Adobe 公司推出了新版本的 Photoshop CC，自此，Photoshop CS6 作为 Adobe CS 系列的最后一个版本被新的 CC 系列取代。截止 2016 年 12 月 Adobe PhotoshopCC2017 为市场最新版本。质能公式如公式(3-3)。这是楷体吗？

3.4.1 画布操作

1. 新建画布 Ctrl + N
2. 画布切换 F
3. 复位工作区 Alt -> W -> K -> R
4. 放大缩小 Alt + 鼠标滚轮 (Ctrl ++, Ctrl + -)
5. 缩放工具 Z(放大：鼠标点击画布，或按下 Alt 点击画布，可以放大缩小)
6. 移动画布 Space + 鼠标左键按下拖动
7. 切换画布 Ctrl + Tab
8. 显示网格 Ctrl + '
9. 显示参考线 Ctrl + ;
10. 显示标尺 Ctrl + R

Adobe Photoshop，简称“PS”，是由 Adobe Systems 开发和发行的图像处理软件。Photoshop 主要处理以像素所构成的数字图像。使用其众多的编修与绘图工具，可以有效地进行图片编辑工作。PS 有很多功能，在图像、图形、文字、视频、出版等各方面都有涉及。2003 年，Adobe Photoshop 8 被更名为 Adobe Photoshop CS。2013 年 7 月，Adobe 公司推出了新版本的 Photoshop CC，自此，Photoshop CS6 作为 Adobe CS 系列的最后一个版本被新的 CC 系列取代。截止 2016 年 12 月 Adobe PhotoshopCC2017 为市场最新版本。这是楷体吗？

Adobe Photoshop，简称“PS”，是由 Adobe Systems 开发和发行的图像处理软件。Photoshop 主要处理以像素所构成的数字图像。使用其众多的编修与绘图工

具，可以有效地进行图片编辑工作。PS 有很多功能，在图像、图形、文字、视频、出版等各方面都有涉及。2003 年，Adobe Photoshop 8 被更名为 Adobe Photoshop CS。2013 年 7 月，Adobe 公司推出了新版本的 Photoshop CC，自此，Photoshop CS6 作为 Adobe CS 系列的最后一个版本被新的 CC 系列取代。截止 2016 年 12 月 Adobe PhotoshopCC2017 为市场最新版本。Adobe Photoshop，简称“PS”，是



图 3.5: 风景 1



图 3.6: 风景 2

由 Adobe Systems 开发和发行的图像处理软件。Photoshop 主要处理以像素所构成的数字图像。使用其众多的编修与绘图工具，可以有效地进行图片编辑工作。PS 有很多功能，在图像、图形、文字、视频、出版等各方面都有涉及。2003 年，Adobe Photoshop 8 被更名为 Adobe Photoshop CS。2013 年 7 月，Adobe 公司推出了新版本的 Photoshop CC，自此，Photoshop CS6 作为 Adobe CS 系列的最后一个版本被新的 CC 系列取代。截止 2016 年 12 月 Adobe PhotoshopCC2017 为市场最新版本。如图3.5所示，又如图3.6所示。这是楷体吗？

Adobe Photoshop, 简称“PS”, 是由 Adobe Systems 开发和发行的图像处理软件。Photoshop 主要处理以像素所构成的数字图像。使用其众多的编修与绘图工具, 可以有效地进行图片编辑工作。PS 有很多功能, 在图像、图形、文字、视频、出版等各方面都有涉及。2003 年, Adobe Photoshop 8 被更名为 Adobe Photoshop CS。2013 年 7 月, Adobe 公司推出了新版本的 Photoshop CC, 自此, Photoshop CS6 作为 Adobe CS 系列的最后一个版本被新的 CC 系列取代。截止 2016 年 12 月 Adobe PhotoshopCC2017 为市场最新版本。这是楷体吗?

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3.4.2 phtotshop 简介

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附录

etcd 配置参数

```
1 root@dockervm:~/go/src/go.etcd.io/etcd# pwd
2 /root/go/src/go.etcd.io/etcd
3 root@dockervm:~/go/src/go.etcd.io/etcd# ./bin/etcd --help
4 Usage:

5 etcd [flags]
6 Start an etcd server.

7 etcd --version
8 Show the version of etcd.

9 etcd -h | --help
10 Show the help information about etcd.

11 etcd --config-file
12 Path to the server configuration file. Note that if a
   ↪ configuration file is provided, other command line flags
   ↪ and environment variables will be ignored.

13 etcd gateway
14 Run the stateless pass-through etcd TCP connection forwarding
   ↪ proxy.

15 etcd grpc-proxy
16 Run the stateless etcd v3 gRPC L7 reverse proxy.

17 Member:
18 --name 'default'
19 Human-readable name for this member.
20 --data-dir '${name}.etcd'
21 Path to the data directory.
22 --wal-dir ''
23 Path to the dedicated wal directory.
24 --snapshot-count '100000'
25 Number of committed transactions to trigger a snapshot to disk.
26 --heartbeat-interval '100'
27 Time (in milliseconds) of a heartbeat interval.
28 --election-timeout '1000'
29 Time (in milliseconds) for an election to timeout. See tuning
   ↪ documentation for details.
30 --initial-election-tick-advance 'true'
```

```
31 Whether to fast-forward initial election ticks on boot for
   ↪ faster election.
32 --listen-peer-urls 'http://localhost:2380'
33 List of URLs to listen on for peer traffic.
34 --listen-client-urls 'http://localhost:2379'
35 List of URLs to listen on for client traffic.
36 --max-snapshots '5'
37 Maximum number of snapshot files to retain (0 is unlimited).
38 --max-wals '5'
39 Maximum number of wal files to retain (0 is unlimited).
40 --quota-backend-bytes '0'
41 Raise alarms when backend size exceeds the given quota (0
   ↪ defaults to low space quota).
42 --backend-bbolt-freelist-type 'map'
43 BackendFreelistType specifies the type of freelist that boltdb
   ↪ backend uses(array and map are supported types).
44 --backend-batch-interval ''
45 BackendBatchInterval is the maximum time before commit the
   ↪ backend transaction.
46 --backend-batch-limit '0'
47 BackendBatchLimit is the maximum operations before commit the
   ↪ backend transaction.
48 --max-txn-ops '128'
49 Maximum number of operations permitted in a transaction.
50 --max-request-bytes '1572864'
51 Maximum client request size in bytes the server will accept.
52 --grpc-keepalive-min-time '5s'
53 Minimum duration interval that a client should wait before
   ↪ pinging server.
54 --grpc-keepalive-interval '2h'
55 Frequency duration of server-to-client ping to check if a
   ↪ connection is alive (0 to disable).
56 --grpc-keepalive-timeout '20s'
57 Additional duration of wait before closing a non-responsive
   ↪ connection (0 to disable).

58 Clustering:
59 --initial-advertise-peer-urls 'http://localhost:2380'
60 List of this member's peer URLs to advertise to the rest of the
   ↪ cluster.
61 --initial-cluster 'default=http://localhost:2380'
62 Initial cluster configuration for bootstrapping.
63 --initial-cluster-state 'new'
64 Initial cluster state ('new' or 'existing').
65 --initial-cluster-token 'etcd-cluster'
66 Initial cluster token for the etcd cluster during bootstrap.
67 Specifying this can protect you from unintended cross-cluster
   ↪ interaction when running multiple clusters.
68 --advertise-client-urls 'http://localhost:2379'
69 List of this member's client URLs to advertise to the public.
```

```
70 The client URLs advertised should be accessible to machines
   ↳ that talk to etcd cluster. etcd client libraries parse
   ↳ these URLs to connect to the cluster.
71 --discovery ''
72 Discovery URL used to bootstrap the cluster.
73 --discovery-fallback 'proxy'
74 Expected behavior ('exit' or 'proxy') when discovery services
   ↳ fails.
75 "proxy" supports v2 API only.
76 --discovery-proxy ''
77 HTTP proxy to use for traffic to discovery service.
78 --discovery-srv ''
79 DNS srv domain used to bootstrap the cluster.
80 --discovery-srv-name ''
81 Suffix to the dns srv name queried when bootstrapping.
82 --strict-reconfig-check 'true'
83 Reject reconfiguration requests that would cause quorum loss.
84 --pre-vote 'false'
85 Enable to run an additional Raft election phase.
86 --auto-compaction-retention '0'
87 Auto compaction retention length. 0 means disable auto
   ↳ compaction.
88 --auto-compaction-mode 'periodic'
89 Interpret 'auto-compaction-retention' one of:
   ↳ periodic|revision. 'periodic' for duration based retention,
   ↳ defaulting to hours if no time unit is provided (e.g.
   ↳ '5m'). 'revision' for revision number based retention.
90 --enable-v2 'false'
91 Accept etcd V2 client requests.

92 Security:
93 --cert-file ''
94 Path to the client server TLS cert file.
95 --key-file ''
96 Path to the client server TLS key file.
97 --client-cert-auth 'false'
98 Enable client cert authentication.
99 --client-crl-file ''
100 Path to the client certificate revocation list file.
101 --client-cert-allowed-hostname ''
102 Allowed TLS hostname for client cert authentication.
103 --trusted-ca-file ''
104 Path to the client server TLS trusted CA cert file.
105 --auto-tls 'false'
106 Client TLS using generated certificates.
107 --peer-cert-file ''
108 Path to the peer server TLS cert file.
109 --peer-key-file ''
110 Path to the peer server TLS key file.
111 --peer-client-cert-auth 'false'
```

```
112 Enable peer client cert authentication.
113 --peer-trusted-ca-file ''
114 Path to the peer server TLS trusted CA file.
115 --peer-cert-allowed-cn ''
116 Required CN for client certs connecting to the peer endpoint.
117 --peer-cert-allowed-hostname ''
118 Allowed TLS hostname for inter peer authentication.
119 --peer-auto-tls 'false'
120 Peer TLS using self-generated certificates if --peer-key-file
    ↪ and --peer-cert-file are not provided.
121 --peer-crl-file ''
122 Path to the peer certificate revocation list file.
123 --cipher-suites ''
124 Comma-separated list of supported TLS cipher suites between
    ↪ client/server and peers (empty will be auto-populated by
    ↪ Go).
125 --cors '*'
126 Comma-separated whitelist of origins for CORS, or cross-origin
    ↪ resource sharing, (empty or * means allow all).
127 --host-whitelist '*'
128 Acceptable hostnames from HTTP client requests, if server is
    ↪ not secure (empty or * means allow all).

129 Auth:
130 --auth-token 'simple'
131 Specify a v3 authentication token type and its options
    ↪ ('simple' or 'jwt').
132 --bcrypt-cost 10
133 Specify the cost / strength of the bcrypt algorithm for hashing
    ↪ auth passwords. Valid values are between 4 and 31.

134 Profiling and Monitoring:
135 --enable-pprof 'false'
136 Enable runtime profiling data via HTTP server. Address is at
    ↪ client URL + "/debug/pprof/"
137 --metrics 'basic'
138 Set level of detail for exported metrics, specify 'extensive'
    ↪ to include server side grpc histogram metrics.
139 --listen-metrics-urls ''
140 List of URLs to listen on for the metrics and health endpoints.

141 Logging:
142 --logger 'capnslog'
143 Specify 'zap' for structured logging or 'capnslog'. [WARN]
    ↪ 'capnslog' will be deprecated in v3.5.
144 --log-outputs 'default'
145 Specify 'stdout' or 'stderr' to skip journald logging even when
    ↪ running under systemd, or list of comma separated output
    ↪ targets.
146 --log-level 'info'
```

```
147 Configures log level. Only supports debug, info, warn, error,  
    ↪ panic, or fatal.  
  
148 v2 Proxy (to be deprecated in v4):  
149 --proxy 'off'  
150 Proxy mode setting ('off', 'readonly' or 'on').  
151 --proxy-failure-wait 5000  
152 Time (in milliseconds) an endpoint will be held in a failed  
    ↪ state.  
153 --proxy-refresh-interval 30000  
154 Time (in milliseconds) of the endpoints refresh interval.  
155 --proxy-dial-timeout 1000  
156 Time (in milliseconds) for a dial to timeout.  
157 --proxy-write-timeout 5000  
158 Time (in milliseconds) for a write to timeout.  
159 --proxy-read-timeout 0  
160 Time (in milliseconds) for a read to timeout.  
  
161 Experimental feature:  
162 --experimental-initial-corrupt-check 'false'  
163 Enable to check data corruption before serving any client/peer  
    ↪ traffic.  
164 --experimental-corrupt-check-time '0s'  
165 Duration of time between cluster corruption check passes.  
166 --experimental-enable-v2v3 ''  
167 Serve v2 requests through the v3 backend under a given prefix.  
168 --experimental-enable-lease-checkpoint 'false'  
169 ExperimentalEnableLeaseCheckpoint enables primary lessor to  
    ↪ persist lease remainingTTL to prevent indefinite  
    ↪ auto-renewal of long lived leases.  
170 --experimental-compaction-batch-limit 1000  
171 ExperimentalCompactionBatchLimit sets the maximum revisions  
    ↪ deleted in each compaction batch.  
172 --experimental-peer-skip-client-san-verification 'false'  
173 Skip verification of SAN field in client certificate for peer  
    ↪ connections.  
  
174 Unsafe feature:  
175 --force-new-cluster 'false'  
176 Force to create a new one-member cluster.  
  
177 CAUTIOUS with unsafe flag! It may break the guarantees given by  
    ↪ the consensus protocol!  
  
178 TO BE DEPRECATED:  
  
179 --debug 'false'  
180 Enable debug-level logging for etcd. [WARN] Will be deprecated  
    ↪ in v3.5. Use '--log-level=debug' instead.  
181 --log-package-levels ''
```

182 Specify a particular log level for each etcd package (eg:
↪ 'etcdmain=CRITICAL,etcdserver=DEBUG').

示例 2 C# 代码

```
1  string title = "This is a Unicode   in the sky"
2  /*
3   Defined as  $\pi = \lim_{n \rightarrow \infty} \frac{P_n}{d}$  where  $P$  is the perimeter
4   of an  $n$ -sided regular polygon circumscribing a
5   circle of diameter  $d$ .
6   */
7  const double pi = 3.1415926535
```

```
1  #include <stdio.h>
2
3  int main() {
4      int sum=0;
5      int num=1;
6      int sum2=0;
7      int num2=2;
8      while (num<100){
9          sum=sum+num;
10         num=num+2;
11     }
12     printf("奇数和为:%d\n",sum);
13
14     while (num2<=100){
15         sum2=sum2+num2;
16         num2=num2+2;
17     }
18     printf("偶数和为: %d\n",sum2);
```

19 }

```
#include <stdlib.h>
```

```
#include <stdio.h>
```

```
#include <string.h>
```

```
#include <unistd.h>
```

```
#include <json.h>
```

```
#include "pubnub.h"
```

```
#include "pubnub-sync.h"
```

```
int
```

```
main(void)
```

```
{
```

```
    struct pubnub_sync *sync = pubnub_sync_init();
```

```
    struct pubnub *p = pubnub_init(
```

```
        /* publish_key */ "demo",
```

```
        /* subscribe_key */ "demo",
```

```
        /* pubnub_callbacks */
```

```
        ↪ &pubnub_sync_callbacks,
```

```
        /* pubnub_callbacks data */ sync);
```

```
    json_object *msg;
```

```
    /* Publish */
```



```
msg = json_object_new_object();
json_object_object_add(msg, "num",
    ↪ json_object_new_int(42));
json_object_object_add(msg, "str",
    ↪ json_object_new_string("\\"Hello, world!\\" she said.));

pubnub_publish(
    /* struct pubnub */ p,
    /* channel */ "my_channel",
    /* message */ msg,
    /* default timeout */ -1,
    /* callback; sync needs NULL! */ NULL,
    /* callback data */ NULL);

json_object_put(msg);

if (pubnub_sync_last_result(sync) != PNR_OK)
    return EXIT_FAILURE;

msg = pubnub_sync_last_response(sync);
printf("pubnub publish ok: %s\n",
    ↪ json_object_get_string(msg));
json_object_put(msg);

/* History */

pubnub_history(
```

```
/* struct pubnub */ p,  
/* channel */ "my_channel",  
/* #messages */ 10,  
/* default timeout */ -1,  
/* callback; sync needs NULL! */ NULL,  
/* callback data */ NULL);  
  
if (pubnub_sync_last_result(sync) != PNR_OK)  
    return EXIT_FAILURE;  
  
msg = pubnub_sync_last_response(sync);  
printf("pubnub history ok: %s\n",  
    ↪ json_object_get_string(msg));  
json_object_put(msg);  
  
/* Subscribe */  
  
do {  
    const char *channels[] = { "my_channel",  
    ↪ "demo_channel" };  
    pubnub_subscribe_multi(  
        /* struct pubnub */ p,  
        /* list of channels */ channels,  
        /* number of listed channels */ 2,  
        /* default timeout */ -1,  
        /* callback; sync needs NULL! */  
        ↪ NULL,  
        /* callback data */ NULL);  
}
```

```
if (pubnub_sync_last_result(sync) != PNR_OK)
    return EXIT_FAILURE;

msg = pubnub_sync_last_response(sync);
if (json_object_array_length(msg) == 0) {
    printf("pubnub subscribe ok, no news\n");
} else {
    char **msg_channels =
        ↪ pubnub_sync_last_channels(sync);
    for (int i = 0; i <
        ↪ json_object_array_length(msg); i++) {
        json_object *msg1 =
            ↪ json_object_array_get_idx(msg,
            ↪ i);
        printf("pubnub subscribe [%s]:
            ↪ %s\n", msg_channels[i],
            ↪ json_object_get_string(msg1));
    }
}

json_object_put(msg);
sleep(1);
} while (1);

pubnub_done(p);
return EXIT_SUCCESS;
}
```

致谢

谢谢！

作者简介