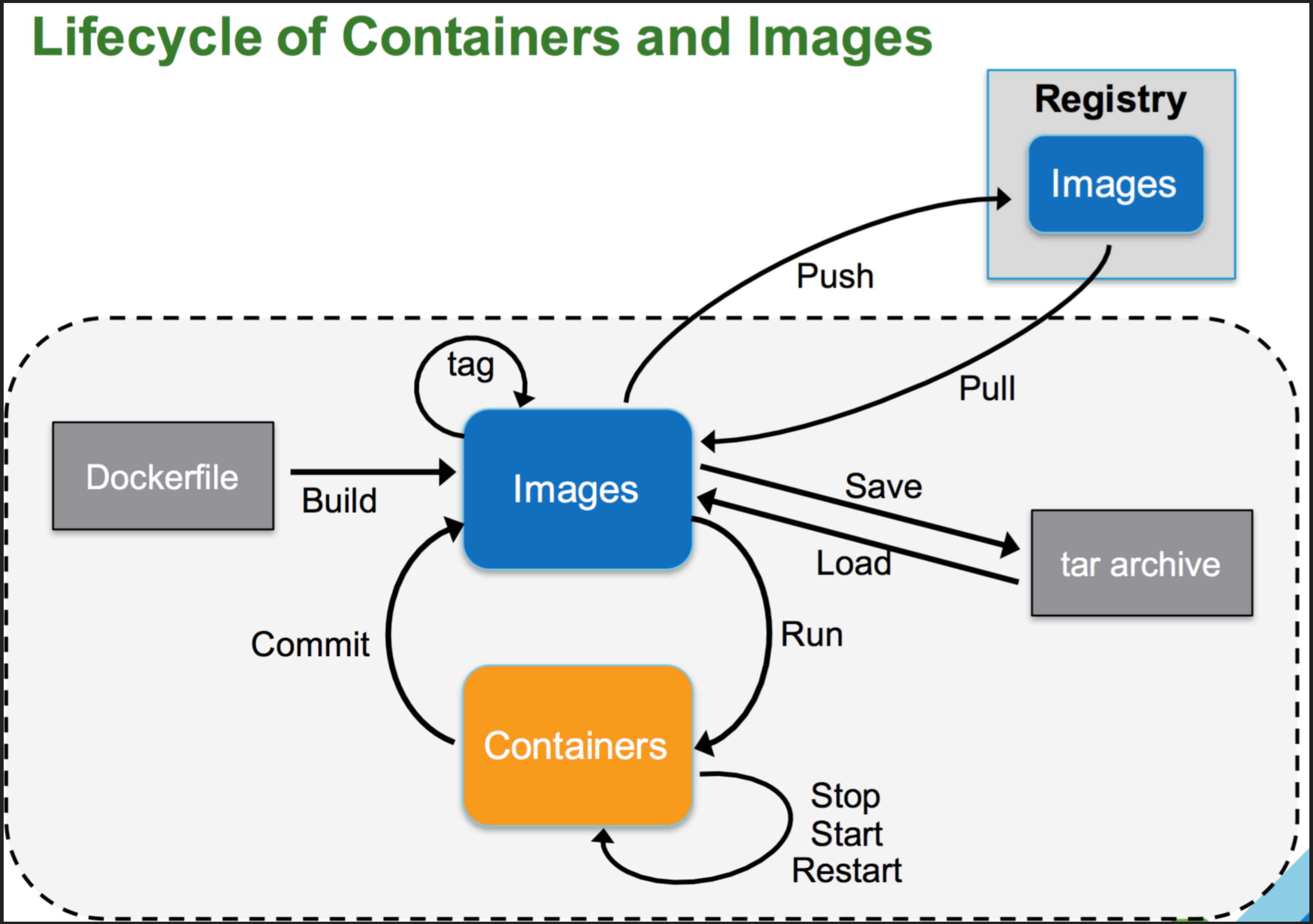
Docker Distribution二次开发实践

1. 基本概念介绍、理解
2. 源码架构剖析
3. 支持S3多bucket存储驱动实现
4. 测试性能对比
5. 总结问题

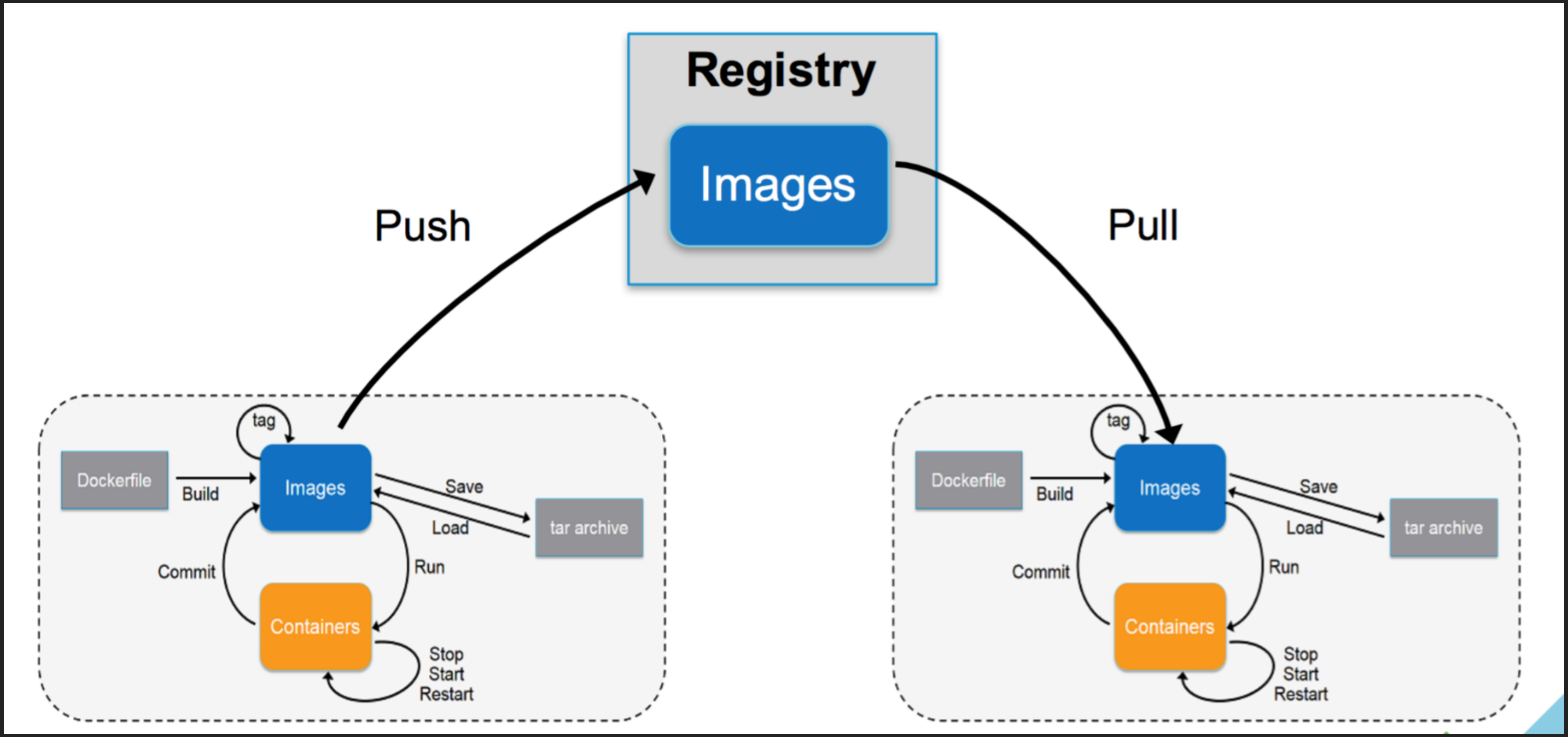
基本概念

Build - Ship - Run

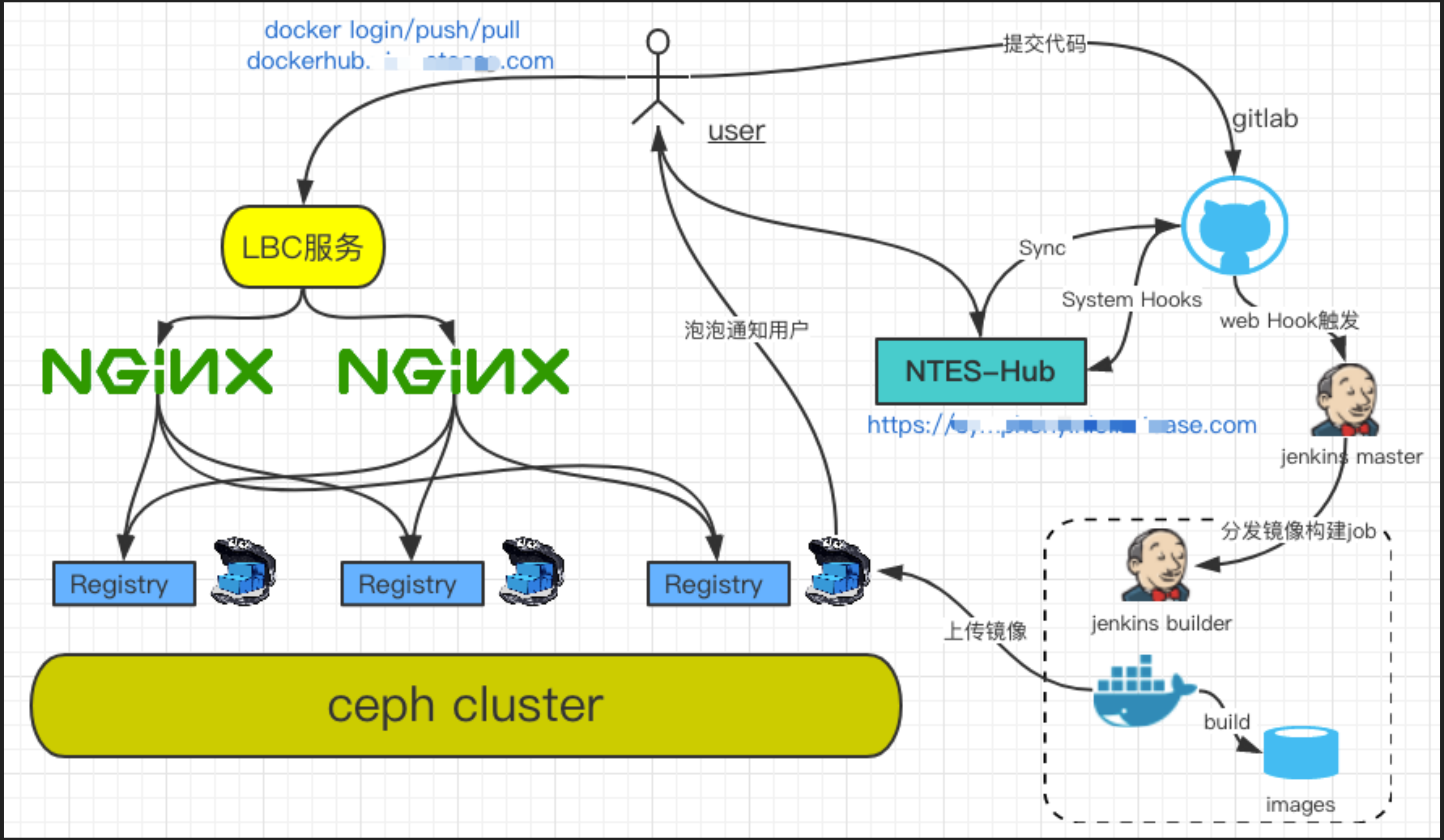


基本概念

Registry -管理镜像的核心组件

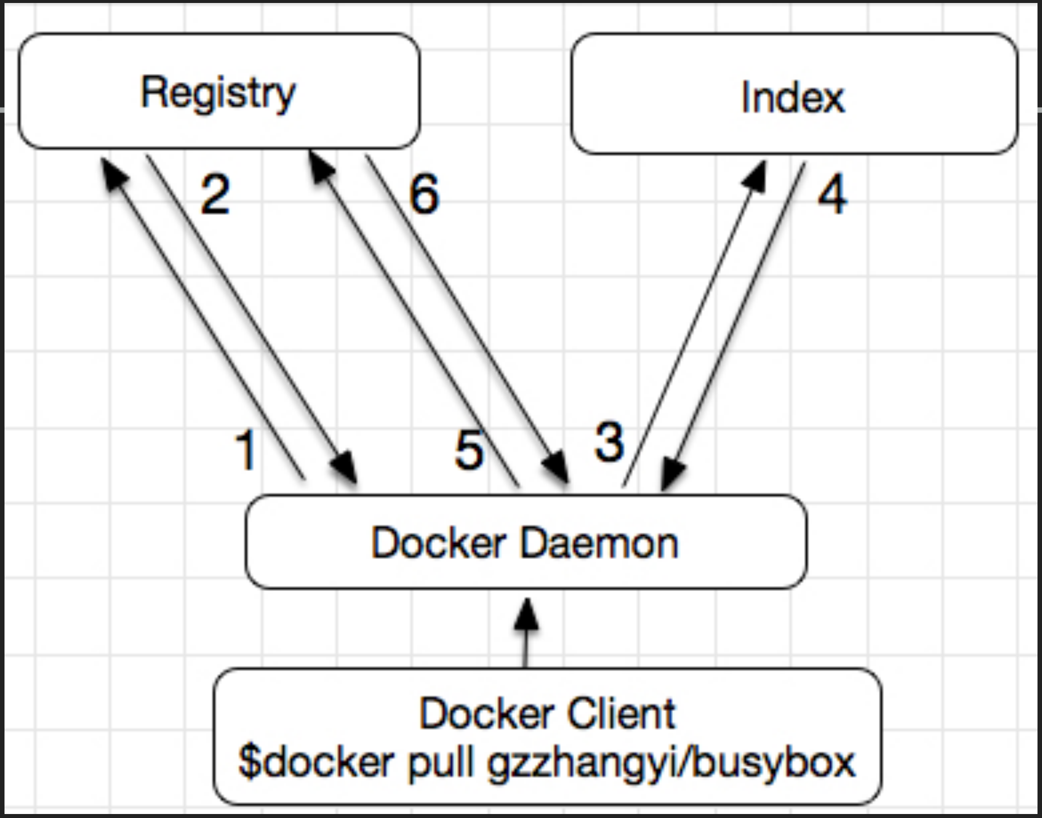


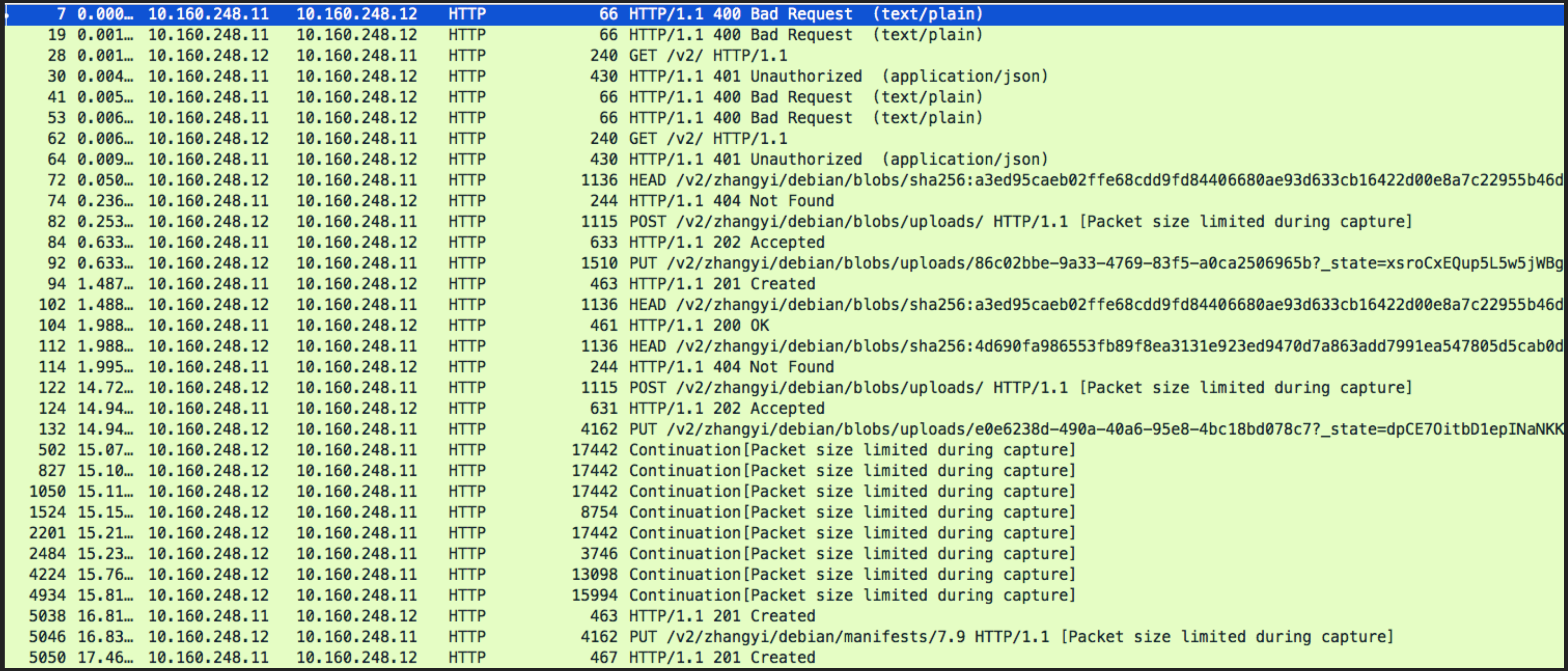
高可用镜像仓库服务架构



镜像仓库管理页面

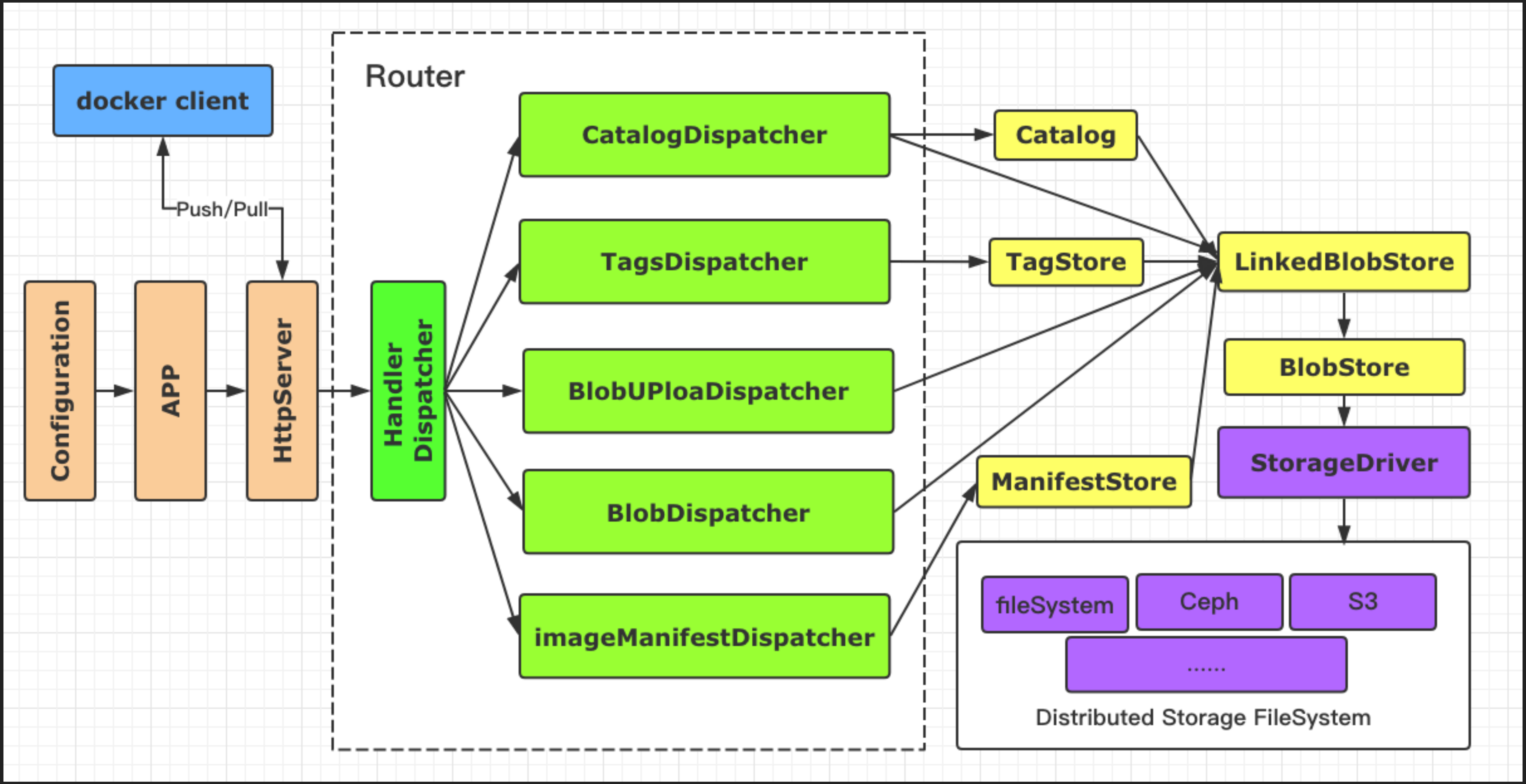
- 基于RBAC的权限用户管理
- 公有\私有镜像权限区分
- 镜像信息展示





```
   7 0.000… 10.160.248.11  10.160.248.12  HTTP        66 HTTP/1.1 400 Bad Request  (text/plain)
  19 0.001… 10.160.248.11  10.160.248.12  HTTP        66 HTTP/1.1 400 Bad Request  (text/plain)
  28 0.001… 10.160.248.12  10.160.248.11  HTTP       240 GET /v2/ HTTP/1.1
  30 0.004… 10.160.248.11  10.160.248.12  HTTP       430 HTTP/1.1 401 Unauthorized  (application/json)
  41 0.005… 10.160.248.11  10.160.248.12  HTTP        66 HTTP/1.1 400 Bad Request  (text/plain)
  53 0.006… 10.160.248.11  10.160.248.12  HTTP        66 HTTP/1.1 400 Bad Request  (text/plain)
  62 0.006… 10.160.248.12  10.160.248.11  HTTP       240 GET /v2/ HTTP/1.1
  64 0.009… 10.160.248.11  10.160.248.12  HTTP       430 HTTP/1.1 401 Unauthorized  (application/json)
  72 0.050… 10.160.248.12  10.160.248.11  HTTP      1136 HEAD /v2/zhangyi/debian/blobs/sha256:a3ed95caeb02ffe68cdd9fd84406680ae93d633cb16422d00e8a7c22955b46d
  74 0.236… 10.160.248.11  10.160.248.12  HTTP       244 HTTP/1.1 404 Not Found
  82 0.253… 10.160.248.12  10.160.248.11  HTTP      1115 POST /v2/zhangyi/debian/blobs/uploads/ HTTP/1.1 [Packet size limited during capture]
  84 0.633… 10.160.248.11  10.160.248.12  HTTP       633 HTTP/1.1 202 Accepted
  92 0.633… 10.160.248.12  10.160.248.11  HTTP      1510 PUT /v2/zhangyi/debian/blobs/uploads/86c02bbe-9a33-4769-83f5-a0ca2506965b?_state=xsroCxEQup5L5w5jWBg
  94 1.487… 10.160.248.11  10.160.248.12  HTTP       463 HTTP/1.1 201 Created
 102 1.488… 10.160.248.12  10.160.248.11  HTTP      1136 HEAD /v2/zhangyi/debian/blobs/sha256:a3ed95caeb02ffe68cdd9fd84406680ae93d633cb16422d00e8a7c22955b46d
 104 1.988… 10.160.248.11  10.160.248.12  HTTP       461 HTTP/1.1 200 OK
 112 1.988… 10.160.248.12  10.160.248.11  HTTP      1136 HEAD /v2/zhangyi/debian/blobs/sha256:4d690fa986553fb89f8ea3131e923ed9470d7a863add7991ea547805d5cab0d
 114 1.995… 10.160.248.11  10.160.248.12  HTTP       244 HTTP/1.1 404 Not Found
 122 14.72… 10.160.248.12  10.160.248.11  HTTP      1115 POST /v2/zhangyi/debian/blobs/uploads/ HTTP/1.1 [Packet size limited during capture]
 124 14.94… 10.160.248.11  10.160.248.12  HTTP       631 HTTP/1.1 202 Accepted
 132 14.94… 10.160.248.12  10.160.248.11  HTTP      4162 PUT /v2/zhangyi/debian/blobs/uploads/e0e6238d-490a-40a6-95e8-4bc18bd078c7?_state=dpCE7OitbD1epINaNKK
 502 15.07… 10.160.248.12  10.160.248.11  HTTP     17442 Continuation[Packet size limited during capture]
 827 15.10… 10.160.248.12  10.160.248.11  HTTP     17442 Continuation[Packet size limited during capture]
1050 15.11… 10.160.248.12  10.160.248.11  HTTP     17442 Continuation[Packet size limited during capture]
1524 15.15… 10.160.248.12  10.160.248.11  HTTP      8754 Continuation[Packet size limited during capture]
2201 15.21… 10.160.248.12  10.160.248.11  HTTP     17442 Continuation[Packet size limited during capture]
2484 15.23… 10.160.248.12  10.160.248.11  HTTP      3746 Continuation[Packet size limited during capture]
4224 15.76… 10.160.248.12  10.160.248.11  HTTP     13098 Continuation[Packet size limited during capture]
4934 15.81… 10.160.248.12  10.160.248.11  HTTP     15994 Continuation[Packet size limited during capture]
5038 16.81… 10.160.248.11  10.160.248.12  HTTP       463 HTTP/1.1 201 Created
5046 16.83… 10.160.248.12  10.160.248.11  HTTP      4162 PUT /v2/zhangyi/debian/manifests/7.9 HTTP/1.1 [Packet size limited during capture]
5050 17.46… 10.160.248.11  10.160.248.12  HTTP       467 HTTP/1.1 201 Created
```

Docker Distribution 源码架构



源码解析三部曲 – 理解第三方库

`github.com/spf13/cobra :`

`github.com/docker/libtrust :`

`golang.org/x/net/context :`

`github.com/Sirupsen/logrus :`

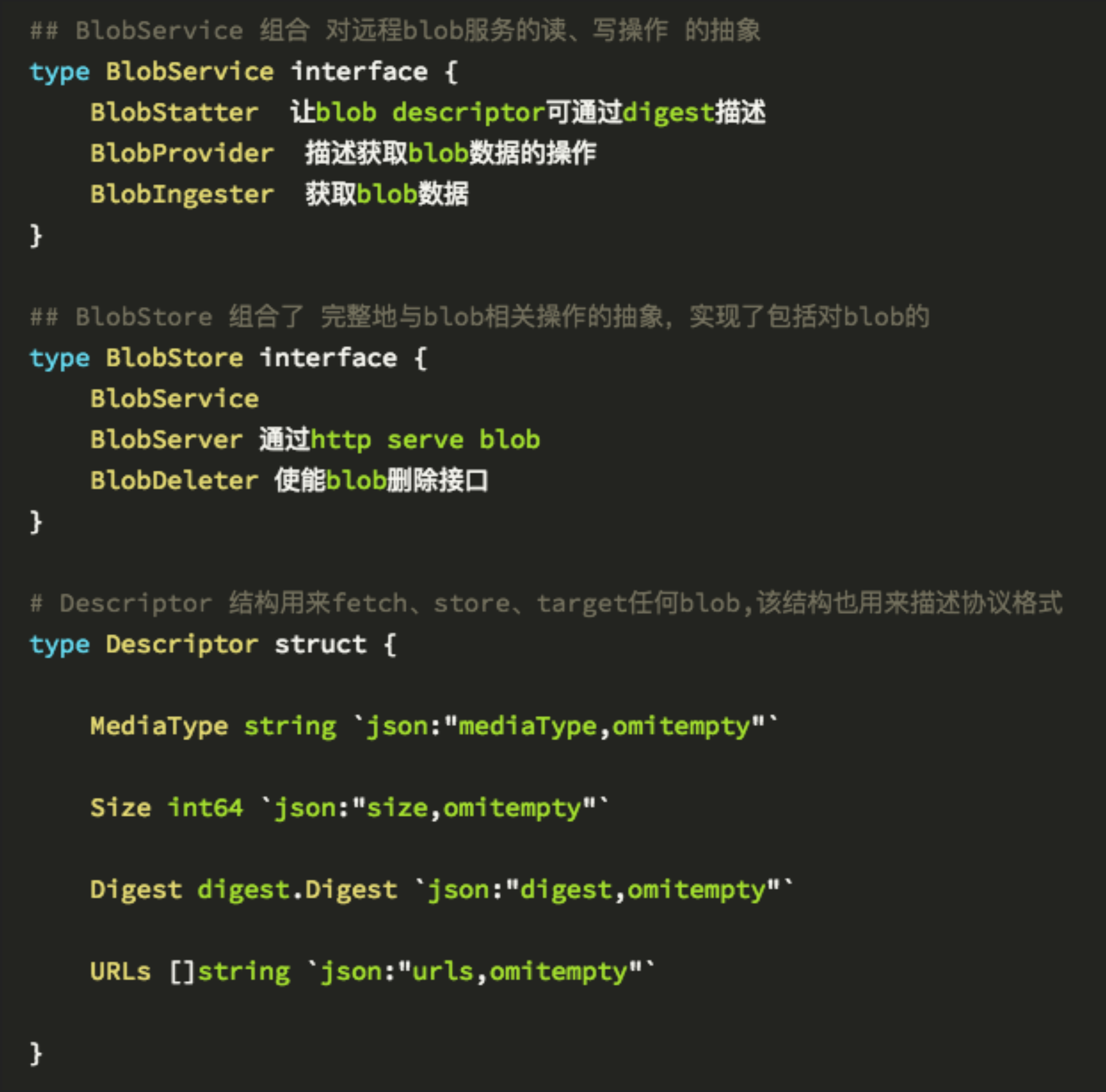
`net/http :`

`github.com/gorilla/handlers :`

源码解析三部曲 – 理解抽象

```
## ManifestService 描述提供镜像manifests的操作
type ManifestService interface {

    Exists(ctx context.Context, dgst digest.Digest) (bool, error)

    Get(ctx context.Context, dgst digest.Digest, options ...ManifestServiceOption) (Manifest,
error)

    Put(ctx context.Context, manifest Manifest, options ...ManifestServiceOption) (digest.Dige
st, error)

    Delete(ctx context.Context, dgst digest.Digest) error
}


## TagService 提供访问已标记对象的信息的接口
type TagService interface {

    Get(ctx context.Context, tag string) (Descriptor, error)

    Tag(ctx context.Context, tag string, desc Descriptor) error

    Untag(ctx context.Context, tag string) error

    All(ctx context.Context) ([]string, error)

    Lookup(ctx context.Context, digest Descriptor) ([]string, error)
}
```

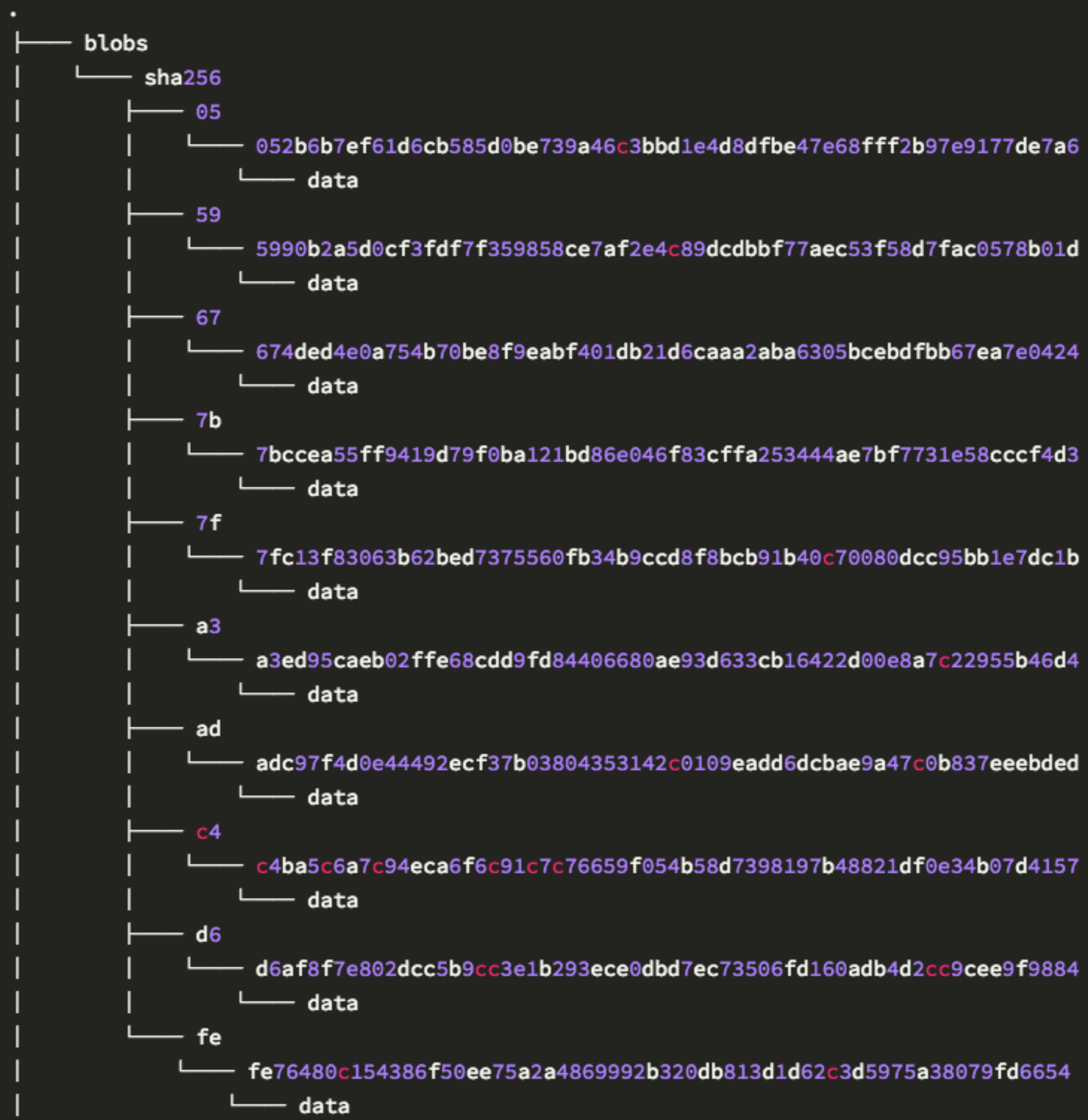
源码解析三部曲 – 理解抽象



```
## BlobService 组合 对远程blob服务的读、写操作 的抽象
type BlobService interface {
    BlobStatter  让blob descriptor可通过digest描述
    BlobProvider  描述获取blob数据的操作
    BlobIngester  获取blob数据
}

## BlobStore 组合了 完整地与blob相关操作的抽象，实现了包括对blob的
type BlobStore interface {
    BlobService
    BlobServer 通过http serve blob
    BlobDeleter 使能blob删除接口
}

# Descriptor 结构用来fetch、store、target任何blob,该结构也用来描述协议格式
type Descriptor struct {

    MediaType string `json:"mediaType,omitempty"`

    Size int64 `json:"size,omitempty"`

    Digest digest.Digest `json:"digest,omitempty"`

    URLs []string `json:"urls,omitempty"`

}
```

源码解析三部曲 – 理解流程

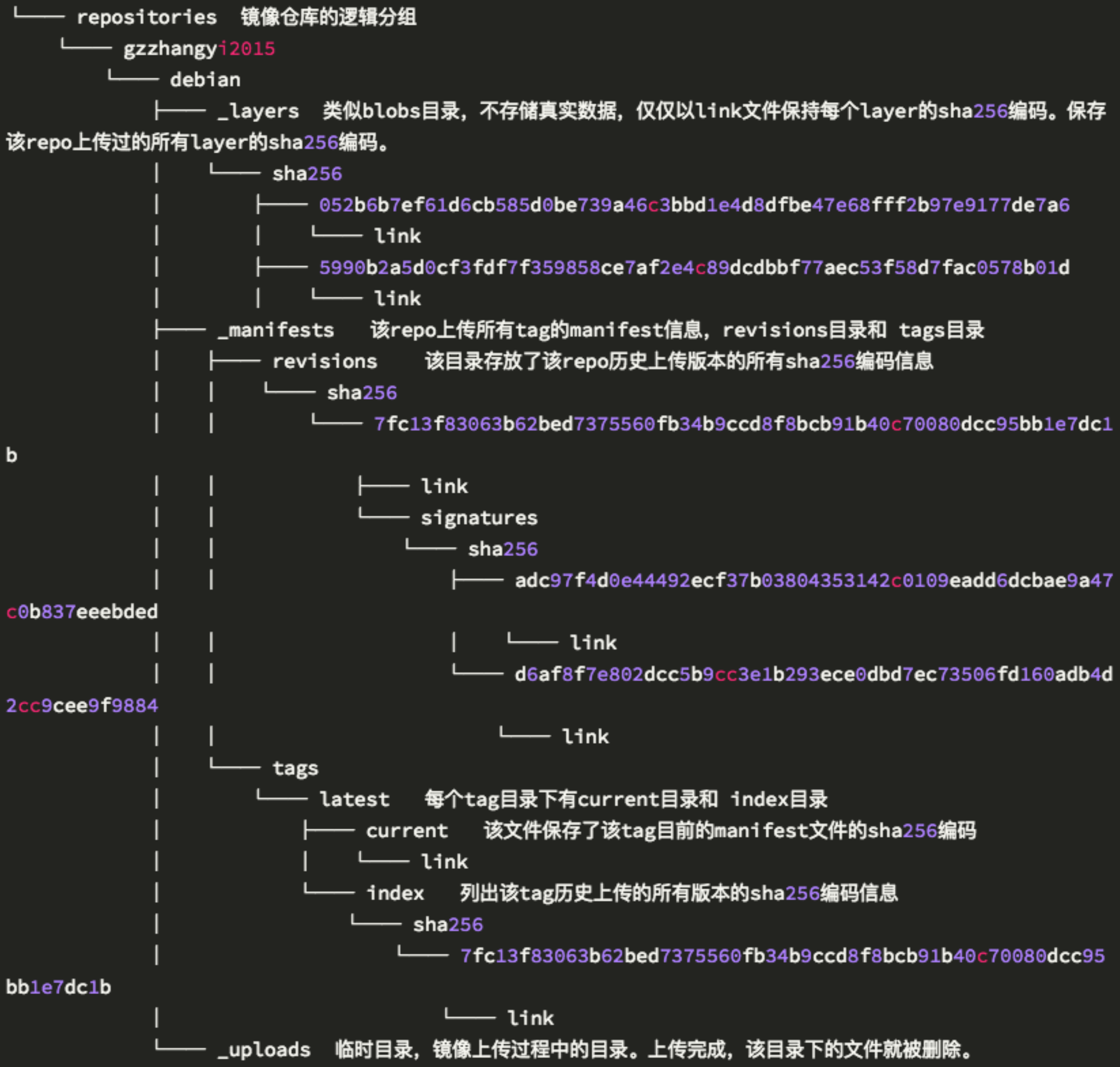
- 前提
  - 镜像在distribution的存储目录说明
  - blobs目录：
    - 存储每层数据
  - repositories目录：
    - 存放镜像仓库中的镜像的组织信息



```
.
├── blobs
│   └── sha256
│       ├── 05
│       │   └── 052b6b7ef61d6cb585d0be739a46c3bbd1e4d8dfbe47e68fff2b97e9177de7a6
│       │       └── data
│       ├── 59
│       │   └── 5990b2a5d0cf3fdf7f359858ce7af2e4c89dcdbbf77aec53f58d7fac0578b01d
│       │       └── data
│       ├── 67
│       │   └── 674ded4e0a754b70be8f9eabf401db21d6caaa2aba6305bcebdfbb67ea7e0424
│       │       └── data
│       ├── 7b
│       │   └── 7bccea55ff9419d79f0ba121bd86e046f83cffa253444ae7bf7731e58cccf4d3
│       │       └── data
│       ├── 7f
│       │   └── 7fc13f83063b62bed7375560fb34b9ccd8f8bcb91b40c70080dcc95bb1e7dc1b
│       │       └── data
│       ├── a3
│       │   └── a3ed95caeb02ffe68cdd9fd84406680ae93d633cb16422d00e8a7c22955b46d4
│       │       └── data
│       ├── ad
│       │   └── adc97f4d0e44492ecf37b03804353142c0109eadd6dcbae9a47c0b837eeebded
│       │       └── data
│       ├── c4
│       │   └── c4ba5c6a7c94eca6f6c91c7c76659f054b58d7398197b48821df0e34b07d4157
│       │       └── data
│       ├── d6
│       │   └── d6af8f7e802dcc5b9cc3e1b293ece0dbd7ec73506fd160adb4d2cc9cee9f9884
│       │       └── data
│       └── fe
│          └── fe76480c154386f50ee75a2a4869992b320db813d1d62c3d5975a38079fd6654
│              └── data
│
```

源码解析三部曲 – 理解流程

- 前提
  - 镜像在distribution的存储目录说明
  - blobs目录：
    - 存储每层数据
  - repositories目录：
    - 存放镜像仓库中的镜像的组织信息



```
└── repositories  镜像仓库的逻辑分组
    └── gzzhangyi2015
        └── debian
            ├── _layers  类似blobs目录，不存储真实数据，仅仅以link文件保持每个layer的sha256编码。保存
该repo上传过的所有layer的sha256编码。
            |   └── sha256
            |       ├── 052b6b7ef61d6cb585d0be739a46c3bbd1e4d8dfbe47e68fff2b97e9177de7a6
            |       |   └── link
            |       ├── 5990b2a5d0cf3fdf7f359858ce7af2e4c89dcdbbf77aec53f58d7fac0578b01d
            |       |   └── link
            ├── _manifests   该repo上传所有tag的manifest信息，revisions目录和 tags目录
            |   ├── revisions    该目录存放了该repo历史上传版本的所有sha256编码信息
            |   |   └── sha256
            |   |       └── 7fc13f83063b62bed7375560fb34b9ccd8f8bcb91b40c70080dcc95bb1e7dc1
b
            |   |           ├── link
            |   |           └── signatures
            |   |               └── sha256
            |   |                   ├── adc97f4d0e44492ecf37b03804353142c0109eadd6dcbae9a47
c0b837eeebded
            |   |                   |   └── link
            |   |                   └── d6af8f7e802dcc5b9cc3e1b293ece0dbd7ec73506fd160adb4d
2cc9cee9f9884
            |   |                       └── link
            |   └── tags
            |       └── latest   每个tag目录下有current目录和 index目录
            |           ├── current   该文件保存了该tag目前的manifest文件的sha256编码
            |           |   └── link
            |           └── index   列出该tag历史上传的所有版本的sha256编码信息
            |               └── sha256
            |                   └── 7fc13f83063b62bed7375560fb34b9ccd8f8bcb91b40c70080dcc95
bb1e7dc1b
            |                       └── link
            └── _uploads  临时目录，镜像上传过程中的目录。上传完成，该目录下的文件就被删除。
```

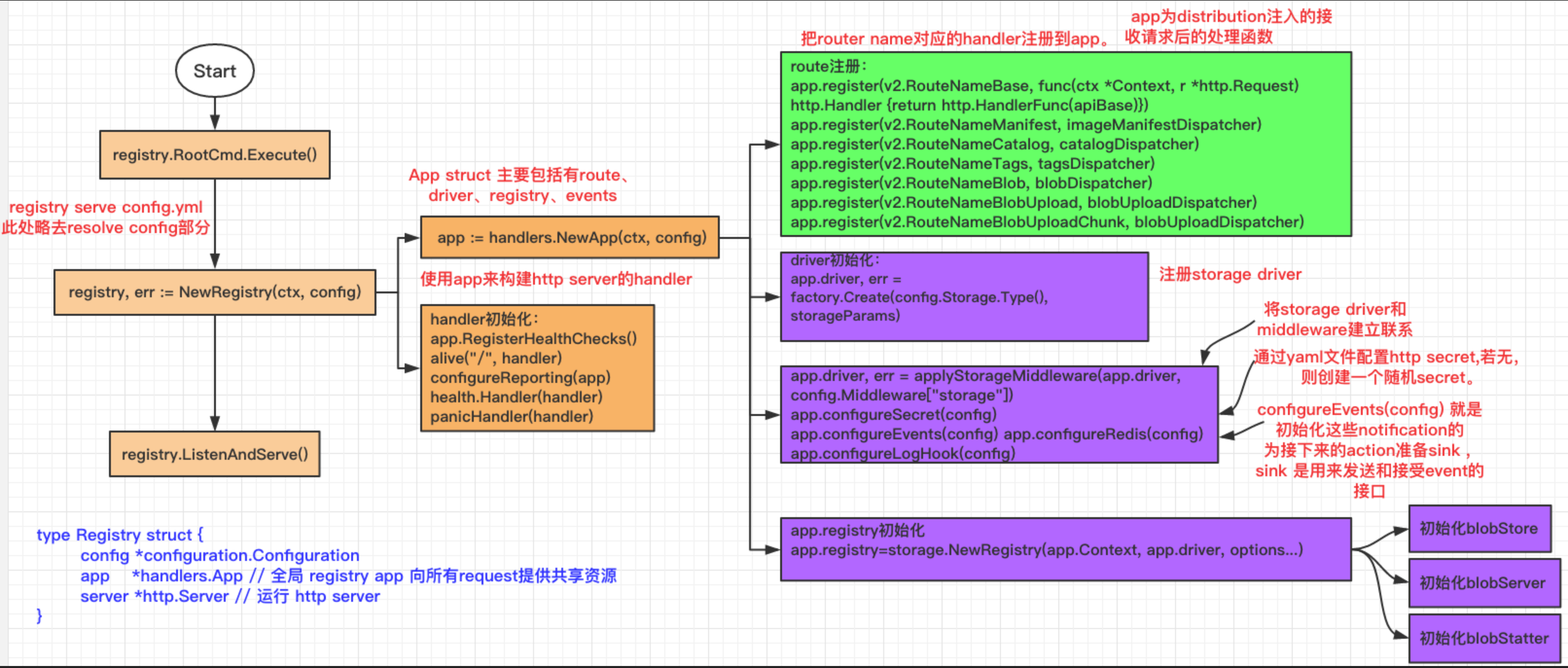
源码解析三部曲 – 理解流程

- 启动和初始化

```go
type App struct {
    context.Context

    Config *configuration.Configuration
    //main application router, configured with dispatchers
    router     *mux.Router
    //driver maintains the app global storage driver instance.
    driver     storagedriver.StorageDriver
    //registry is the primary registry backend for the app instance.
    registry   distribution.Namespace
    accessController auth.AccessController  // main access controller for application
    httpHost url.URL
    events struct { // registry事件的相关配置
        sink   notifications.Sink
        source notifications.SourceRecord
    }
    redis *redis.Pool
    trustKey libtrust.PrivateKey
    isCache bool
    readOnly bool
}
```

源码解析三部曲 – 理解流程

启动和初始化


Start
registry.RootCmd.Execute()
registry serve config.yml
此处略去resolve config部分
registry, err := NewRegistry(ctx, config)
registry.ListenAndServe()
App struct 主要包括有route、driver、registry、events
app := handlers.NewApp(ctx, config)
使用app来构建http server的handler
把router name对应的handler注册到app。
app为distribution注入的接收请求后的处理函数
注册storage driver
将storage driver和middleware建立联系
通过yaml文件配置http secret,若无，则创建一个随机secret。
configureEvents(config) 就是初始化这些notification的为接下来的action准备sink，sink 是用来发送和接受event的接口
初始化blobStore
初始化blobServer
初始化blobStatter

```
handler初始化：
app.RegisterHealthChecks()
alive("/", handler)
configureReporting(app)
health.Handler(handler)
panicHandler(handler)
```

```
route注册：
app.register(v2.RouteNameBase, func(ctx *Context, r *http.Request)
http.Handler {return http.HandlerFunc(apiBase)})
app.register(v2.RouteNameManifest, imageManifestDispatcher)
app.register(v2.RouteNameCatalog, catalogDispatcher)
app.register(v2.RouteNameTags, tagsDispatcher)
app.register(v2.RouteNameBlob, blobDispatcher)
app.register(v2.RouteNameBlobUpload, blobUploadDispatcher)
app.register(v2.RouteNameBlobUploadChunk, blobUploadDispatcher)
```

```
driver初始化：
app.driver, err =
factory.Create(config.Storage.Type(),
storageParams)
```

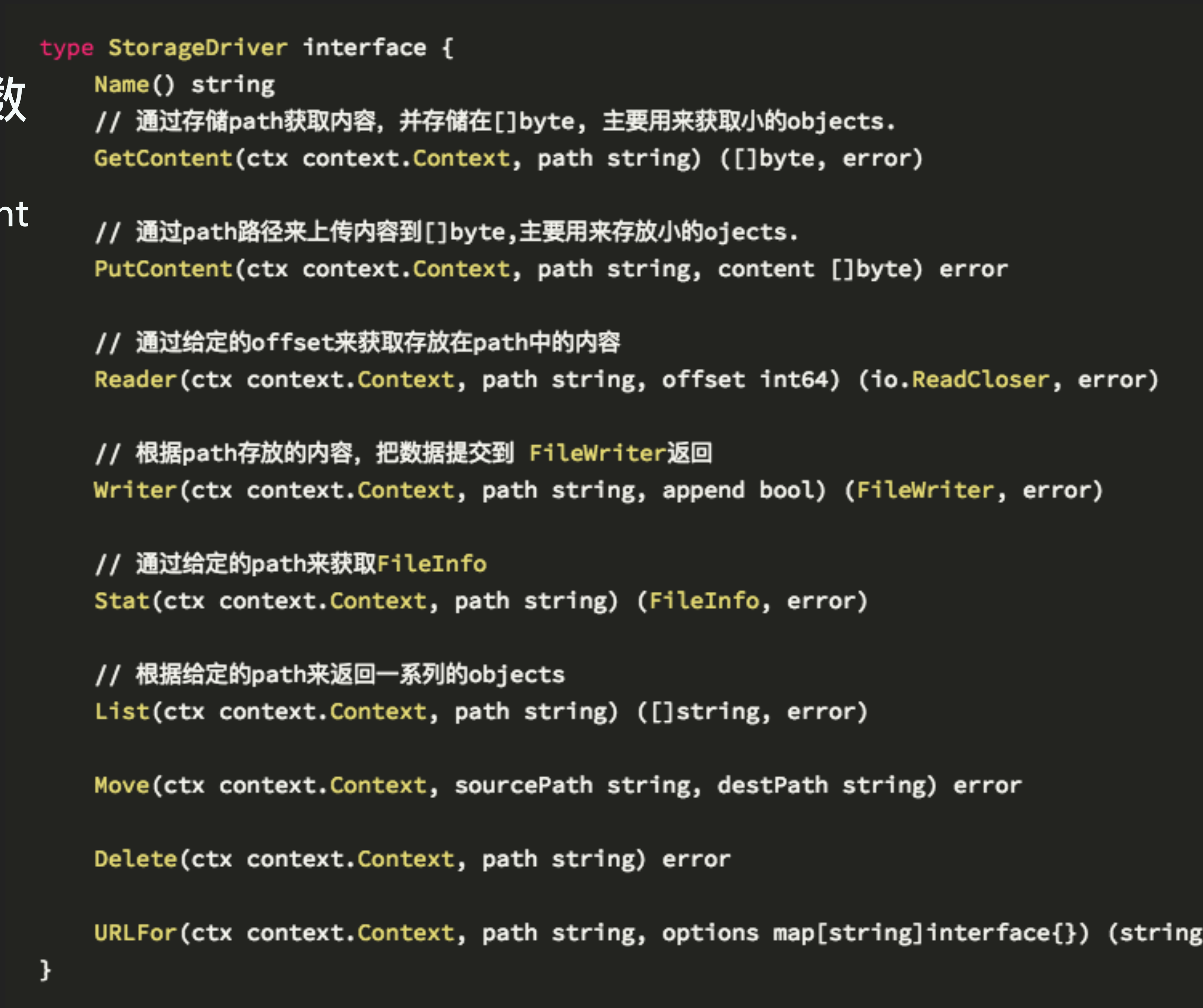
```
app.driver, err = applyStorageMiddleware(app.driver,
config.Middleware["storage"])
app.configureSecret(config)
app.configureEvents(config) app.configureRedis(config)
app.configureLogHook(config)
```

```
app.registry初始化
app.registry=storage.NewRegistry(app.Context, app.driver, options...)
```

```
type Registry struct {
        config *configuration.Configuration
        app    *handlers.App // 全局 registry app 向所有request提供共享资源
        server *http.Server // 运行 http server
}
```

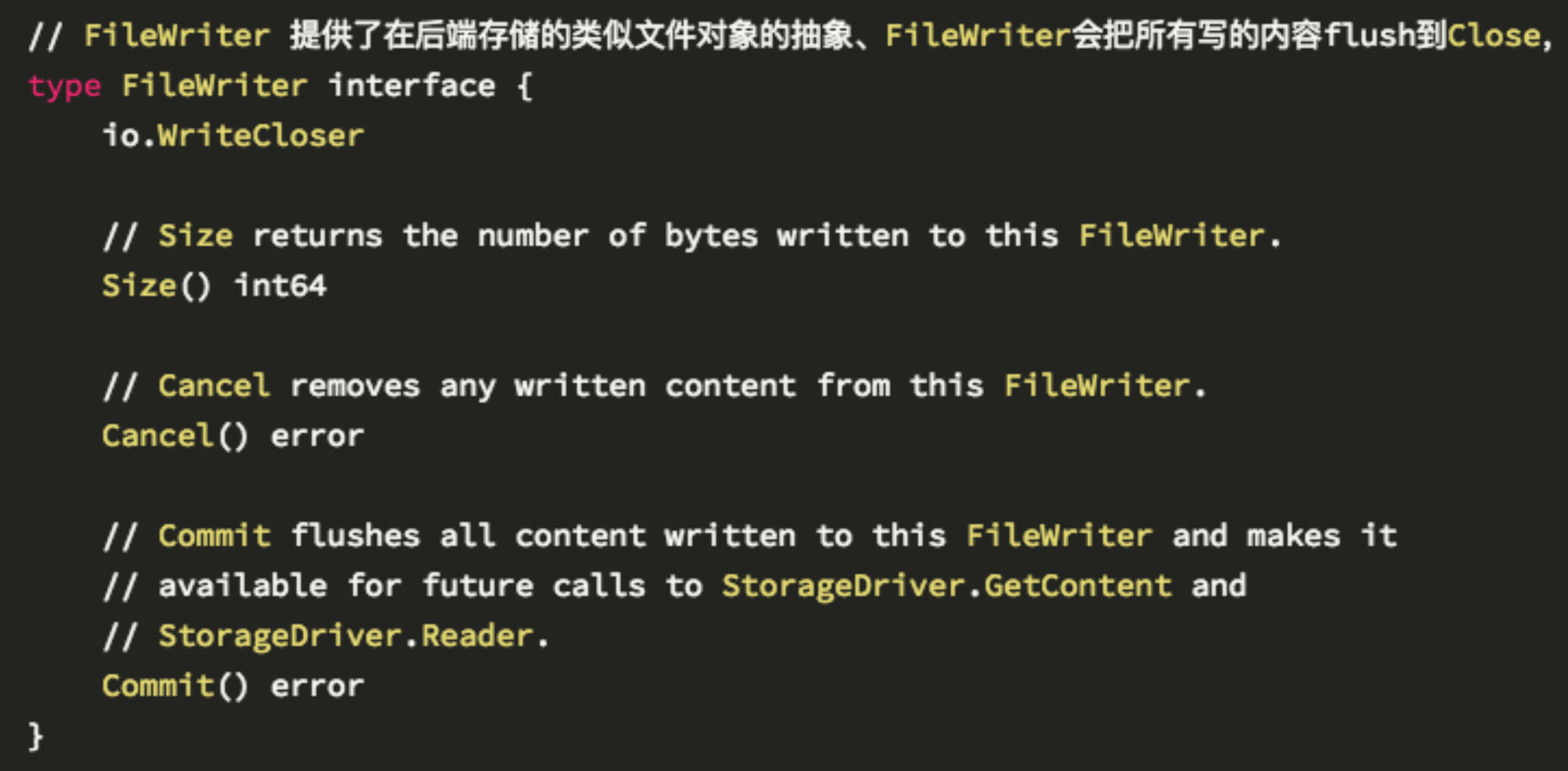
支持多bucket S3存储驱动实现

- Storagedriver.go中接口函数
  - Name/GetContent/PutContent
  - Reader/Writer
- Storagedriver / factory包
  - factory.register
  - factory.create



```
type StorageDriver interface {
    Name() string
    // 通过存储path获取内容，并存储在[]byte，主要用来获取小的objects.
    GetContent(ctx context.Context, path string) ([]byte, error)

    // 通过path路径来上传内容到[]byte,主要用来存放小的ojects.
    PutContent(ctx context.Context, path string, content []byte) error

    // 通过给定的offset来获取存放在path中的内容
    Reader(ctx context.Context, path string, offset int64) (io.ReadCloser, error)

    // 根据path存放的内容，把数据提交到 FileWriter返回
    Writer(ctx context.Context, path string, append bool) (FileWriter, error)

    // 通过给定的path来获取FileInfo
    Stat(ctx context.Context, path string) (FileInfo, error)

    // 根据给定的path来返回一系列的objects
    List(ctx context.Context, path string) ([]string, error)

    Move(ctx context.Context, sourcePath string, destPath string) error

    Delete(ctx context.Context, path string) error

    URLFor(ctx context.Context, path string, options map[string]interface{}) (string
}
```

支持多bucket S3存储驱动实现

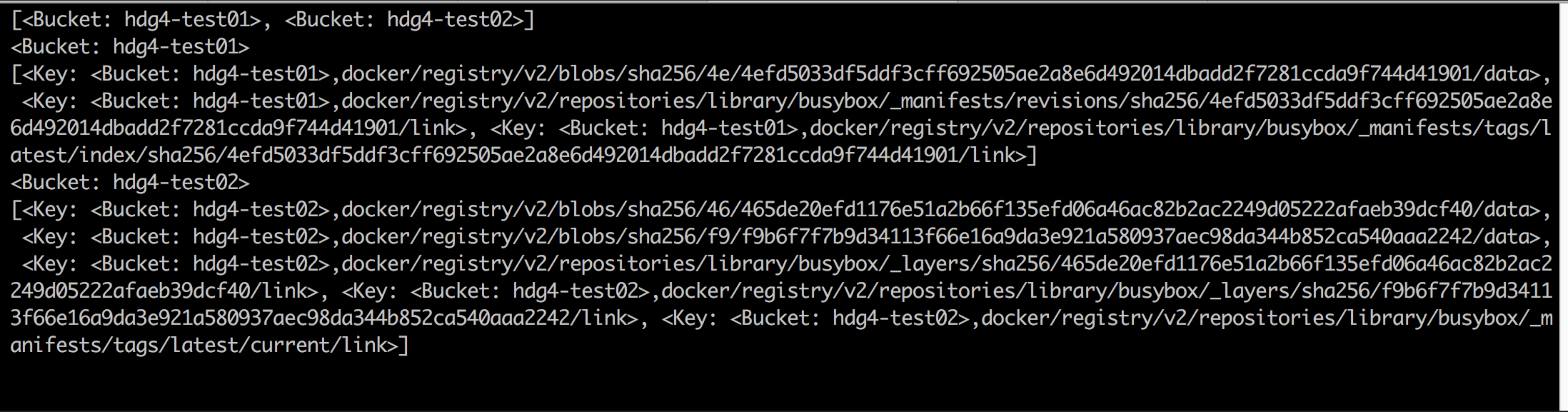


```go
// FileWriter 提供了在后端存储的类似文件对象的抽象、FileWriter会把所有写的内容flush到Close,
type FileWriter interface {
    io.WriteCloser

    // Size returns the number of bytes written to this FileWriter.
    Size() int64

    // Cancel removes any written content from this FileWriter.
    Cancel() error

    // Commit flushes all content written to this FileWriter and makes it
    // available for future calls to StorageDriver.GetContent and
    // StorageDriver.Reader.
    Commit() error
}
```

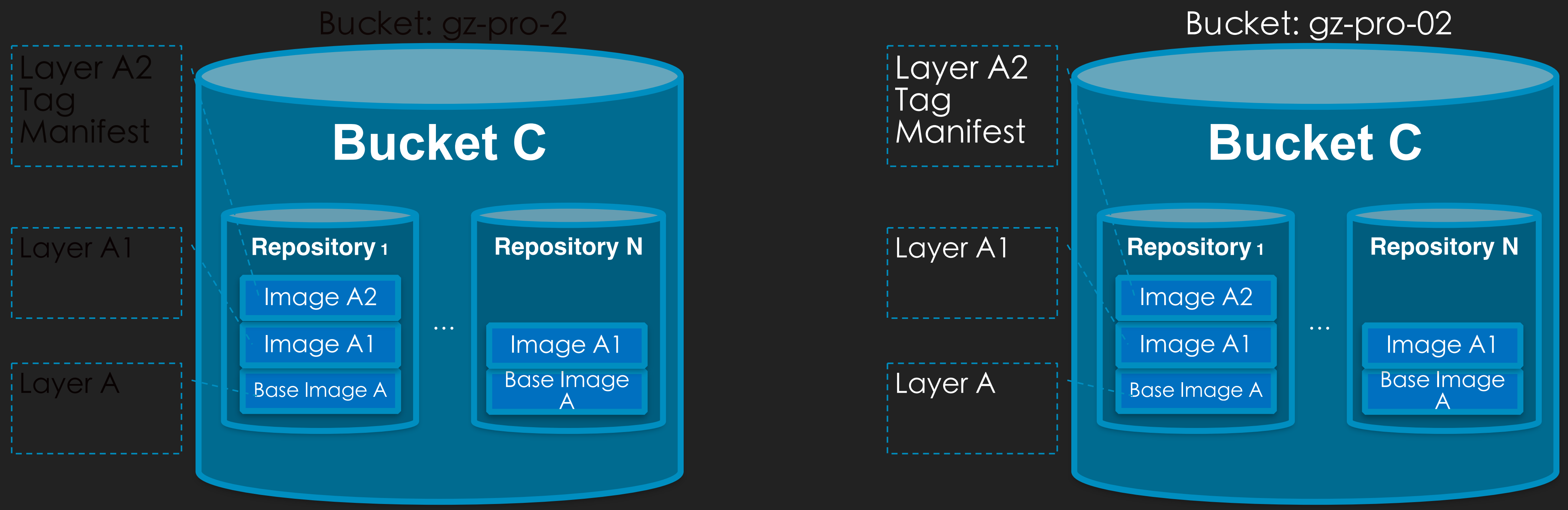
- S3存储模型
  - Bucket: 用于存储对象的容器，名称全局唯一。
  - Object: 所有资源的最终存放方式。
    - 元数据对应关系： key name —> 文件名称 , etag —> 文件md5

支持多bucket S3存储驱动实现

- 单个bucket大小 ≤ 2T
- 单个bucket拥有object数量 不建议超过100w个



```
[<Bucket: hdg4-test01>, <Bucket: hdg4-test02>]
<Bucket: hdg4-test01>
[<Key: <Bucket: hdg4-test01>,docker/registry/v2/blobs/sha256/4e/4efd5033df5ddf3cff692505ae2a8e6d492014dbadd2f7281ccda9f744d41901/data>,
 <Key: <Bucket: hdg4-test01>,docker/registry/v2/repositories/library/busybox/_manifests/revisions/sha256/4efd5033df5ddf3cff692505ae2a8e
6d492014dbadd2f7281ccda9f744d41901/link>, <Key: <Bucket: hdg4-test01>,docker/registry/v2/repositories/library/busybox/_manifests/tags/l
atest/index/sha256/4efd5033df5ddf3cff692505ae2a8e6d492014dbadd2f7281ccda9f744d41901/link>]
<Bucket: hdg4-test02>
[<Key: <Bucket: hdg4-test02>,docker/registry/v2/blobs/sha256/46/465de20efd1176e51a2b66f135efd06a46ac82b2ac2249d05222afaeb39dcf40/data>,
 <Key: <Bucket: hdg4-test02>,docker/registry/v2/blobs/sha256/f9/f9b6f7f7b9d34113f66e16a9da3e921a580937aec98da344b852ca540aaa2242/data>,
 <Key: <Bucket: hdg4-test02>,docker/registry/v2/repositories/library/busybox/_layers/sha256/465de20efd1176e51a2b66f135efd06a46ac82b2ac2
249d05222afaeb39dcf40/link>, <Key: <Bucket: hdg4-test02>,docker/registry/v2/repositories/library/busybox/_layers/sha256/f9b6f7f7b9d3411
3f66e16a9da3e921a580937aec98da344b852ca540aaa2242/link>, <Key: <Bucket: hdg4-test02>,docker/registry/v2/repositories/library/busybox/_m
anifests/tags/latest/current/link>]
```



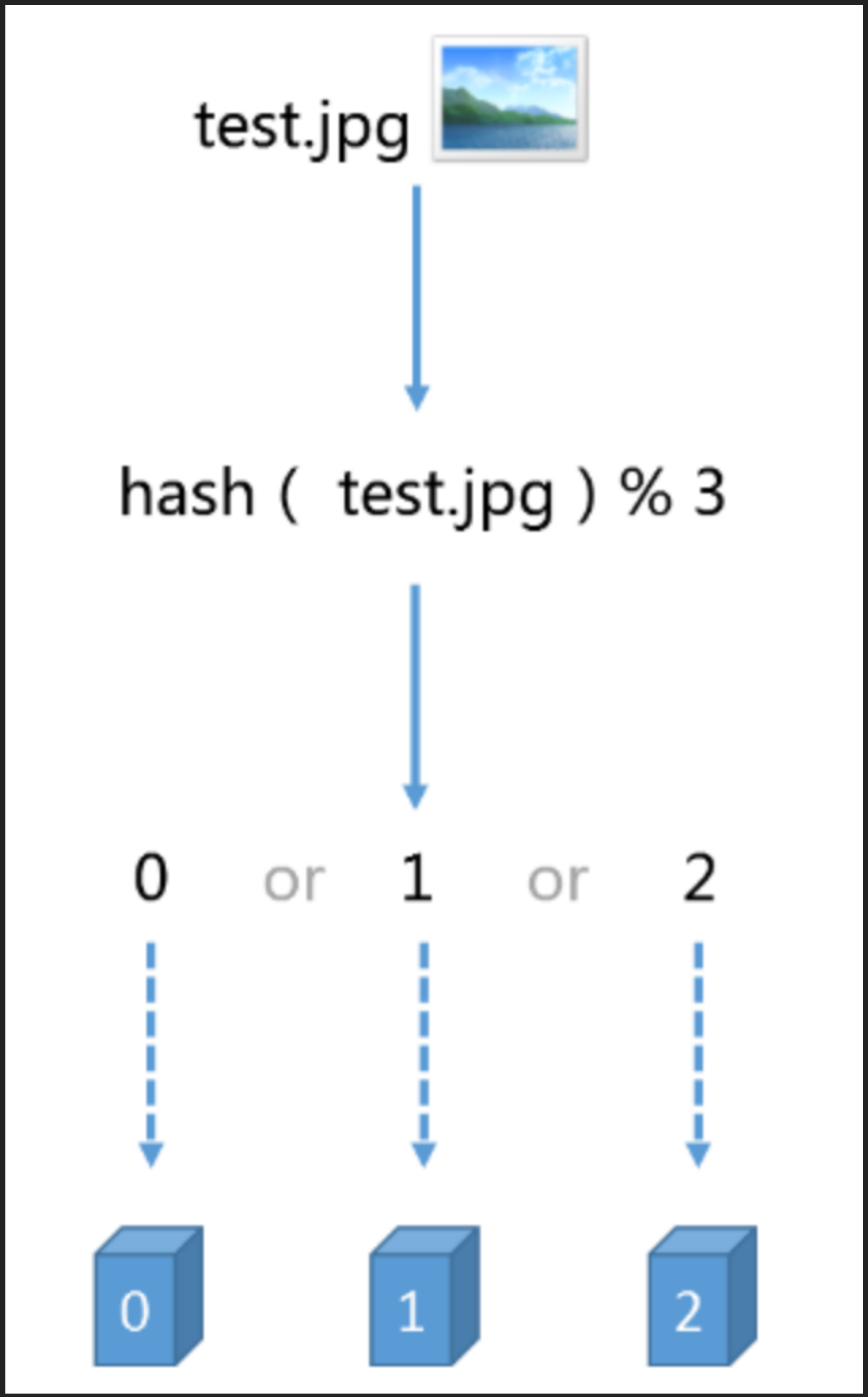
支持多bucket S3存储驱动实现

理解场景

- 普通存kv数据库的方式
  - 1. 增：当查询到bucket满，增加bucket. 每次存数据都要查kv DB.
  - 2. 删：当删除数据时，删映射(开销)，旧bucket空间浪费。
  - 3. bucket宕掉：分布式场景。
    - 影响全局。其他镜像的某一层可能在此bucket中。
    - 故障恢复。恢复数据多且慢。
  - 4. kv DB本身的高可用十分关键。且操作频繁，开销需要考虑。

支持多bucket S3存储驱动实现

普通的哈希算法



- 平衡性
  - key 能够均匀分布到不同bucket
  - “虚拟节点”
- 单调性
  - 一个bucket故障，引起所有bucket不可用
  - bucket增删尽量不影响原有的kv映射

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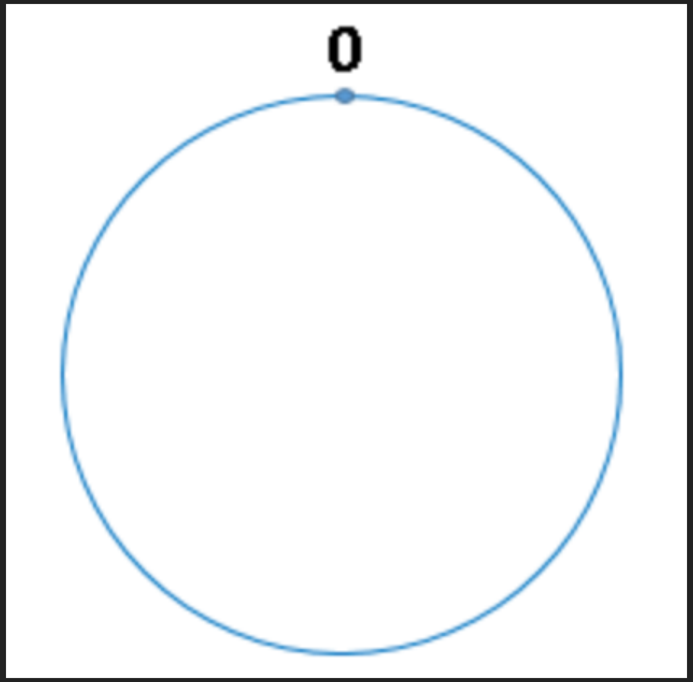
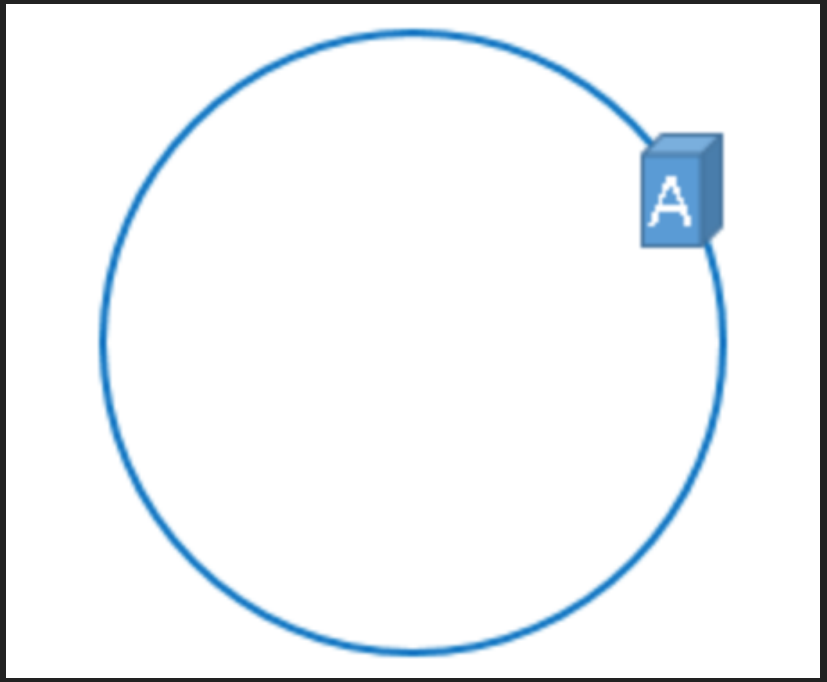
一致性哈希算法

hash(bucketB) % 2^32

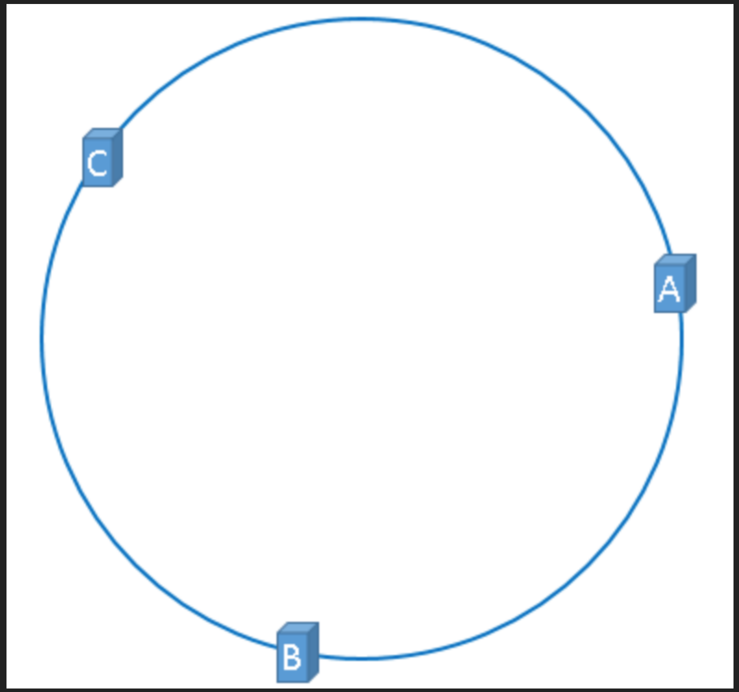
hash(bucketC) % 2^32

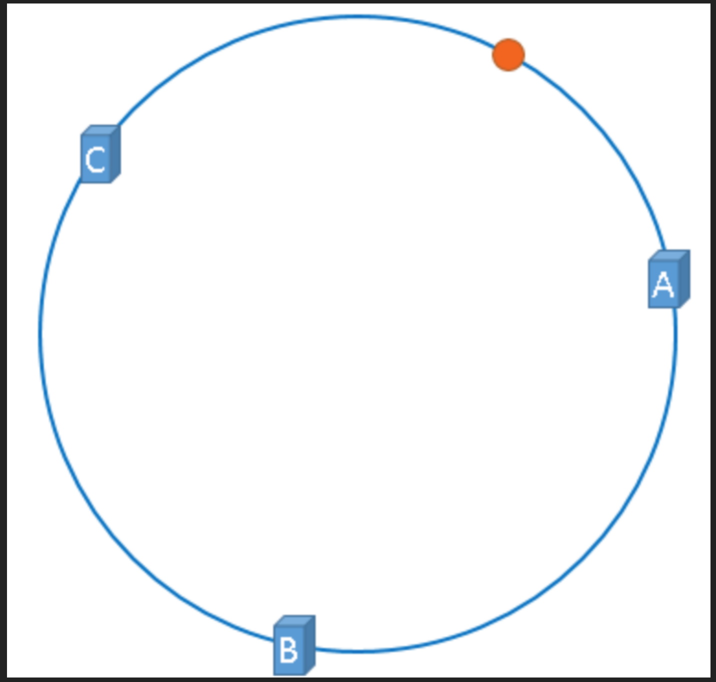


2^32

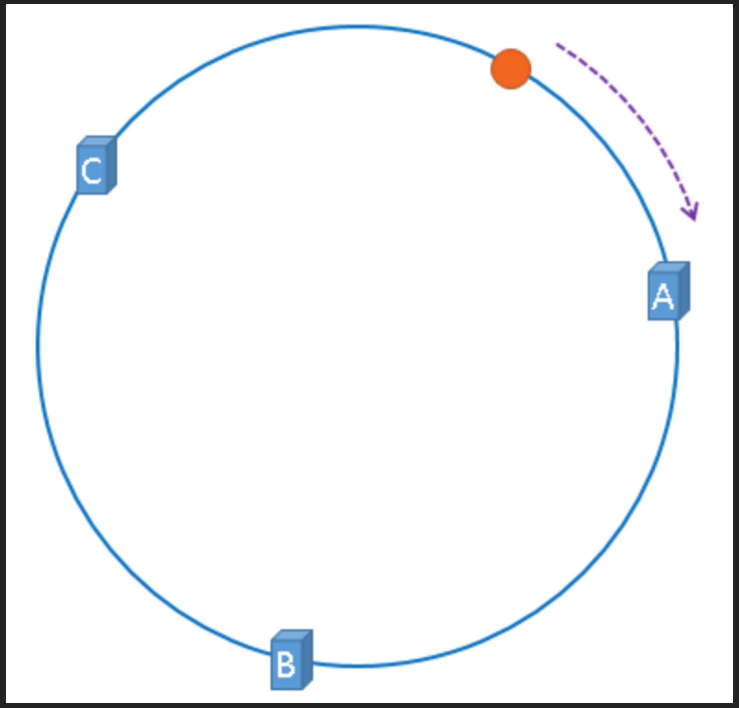


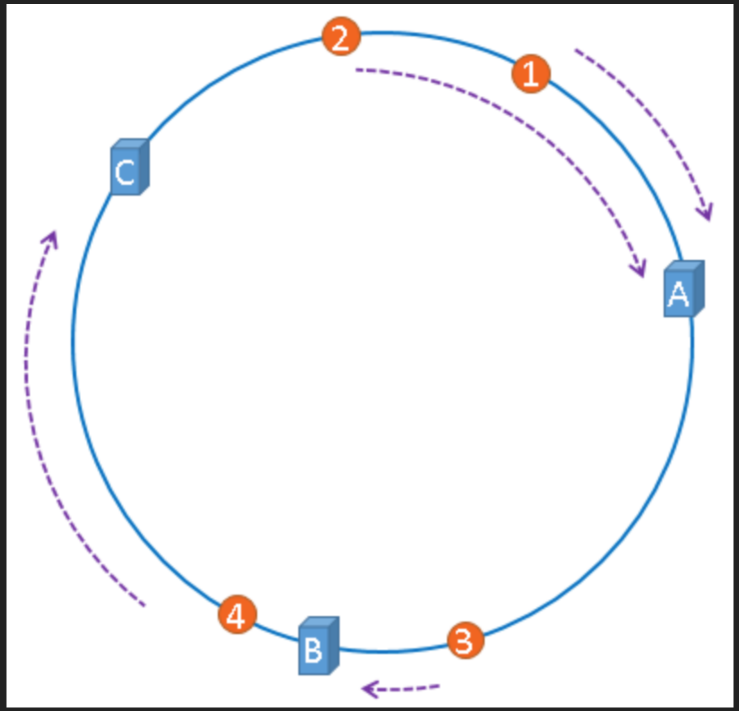
hash(bucketA) % 2^32





hash(digest) % 2^32





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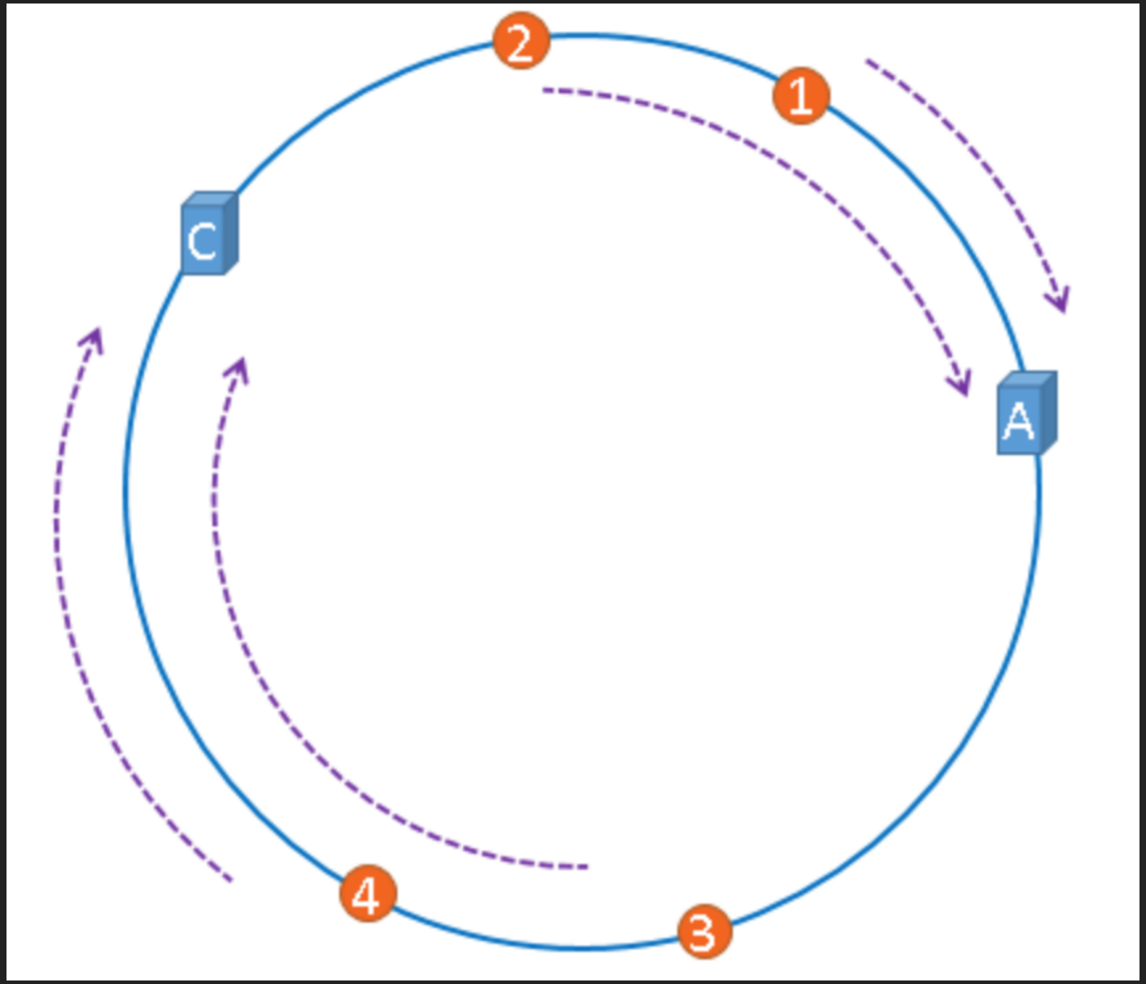
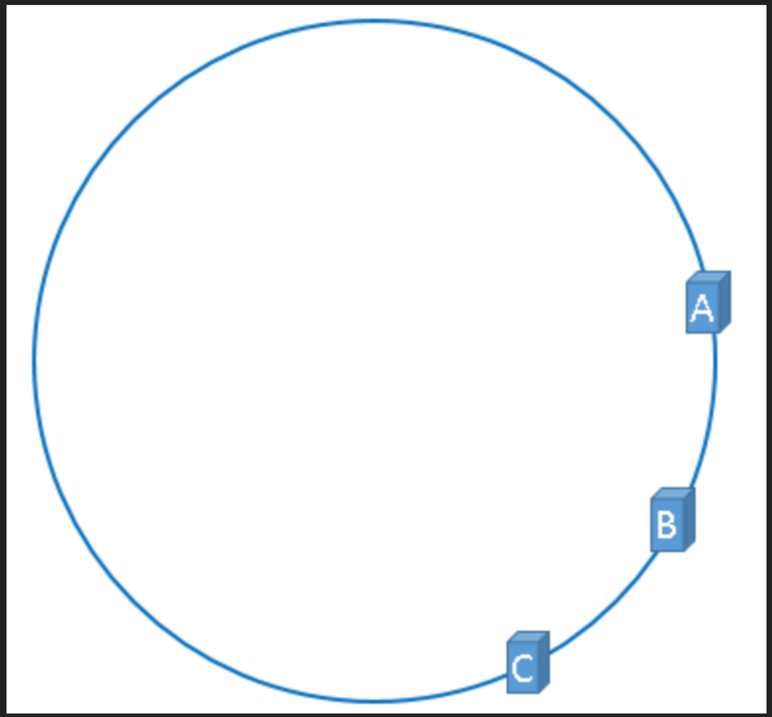
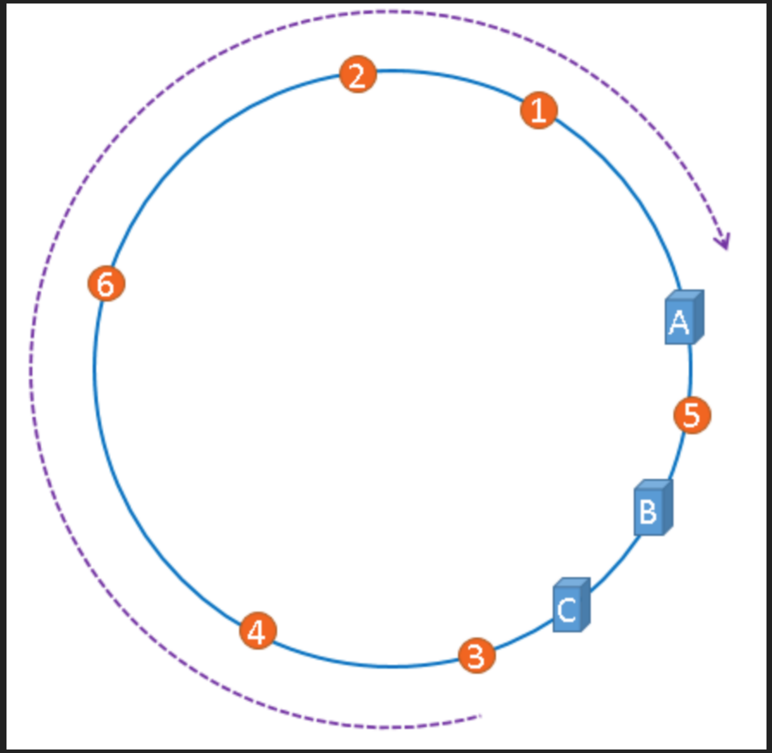
一致性哈希算法优点



分布式多bucket故障场景

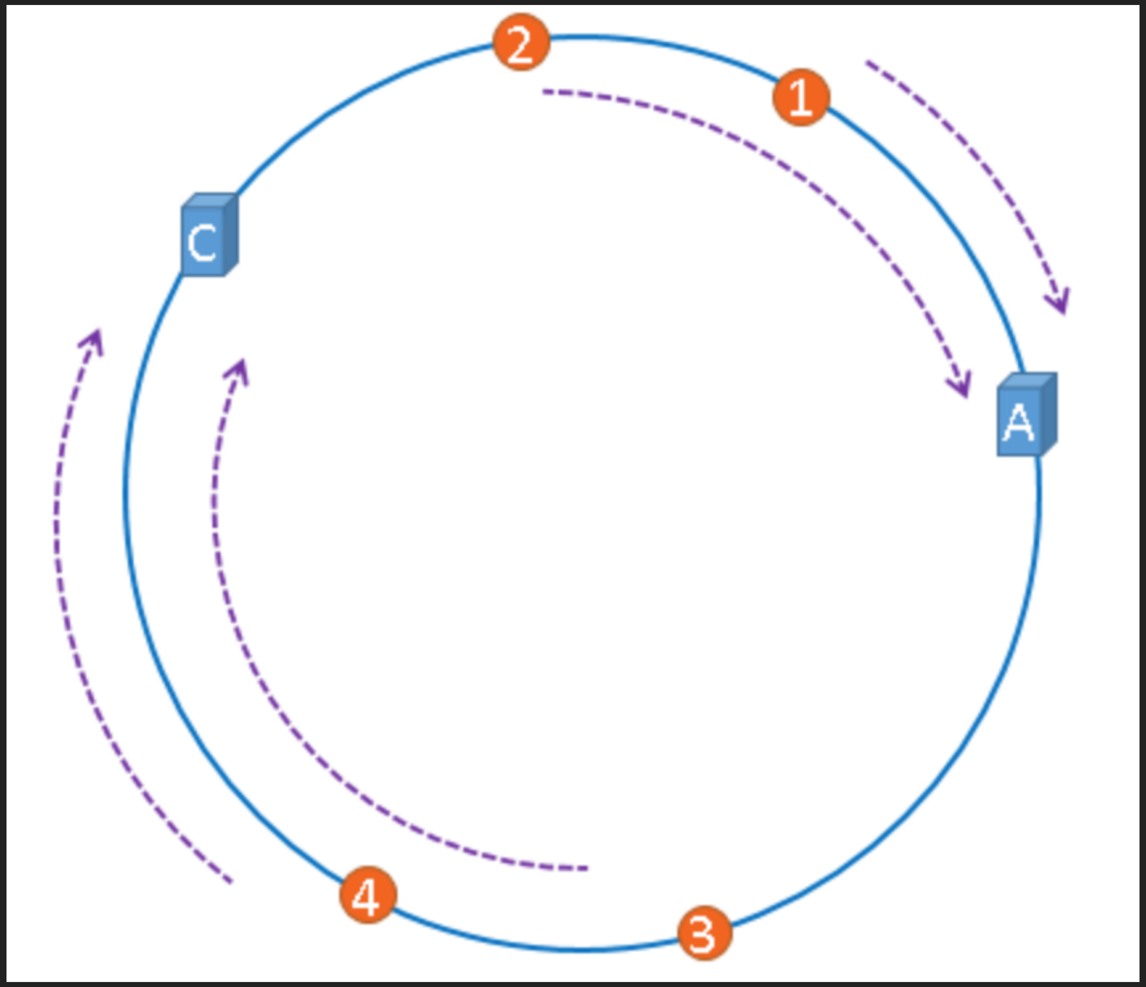




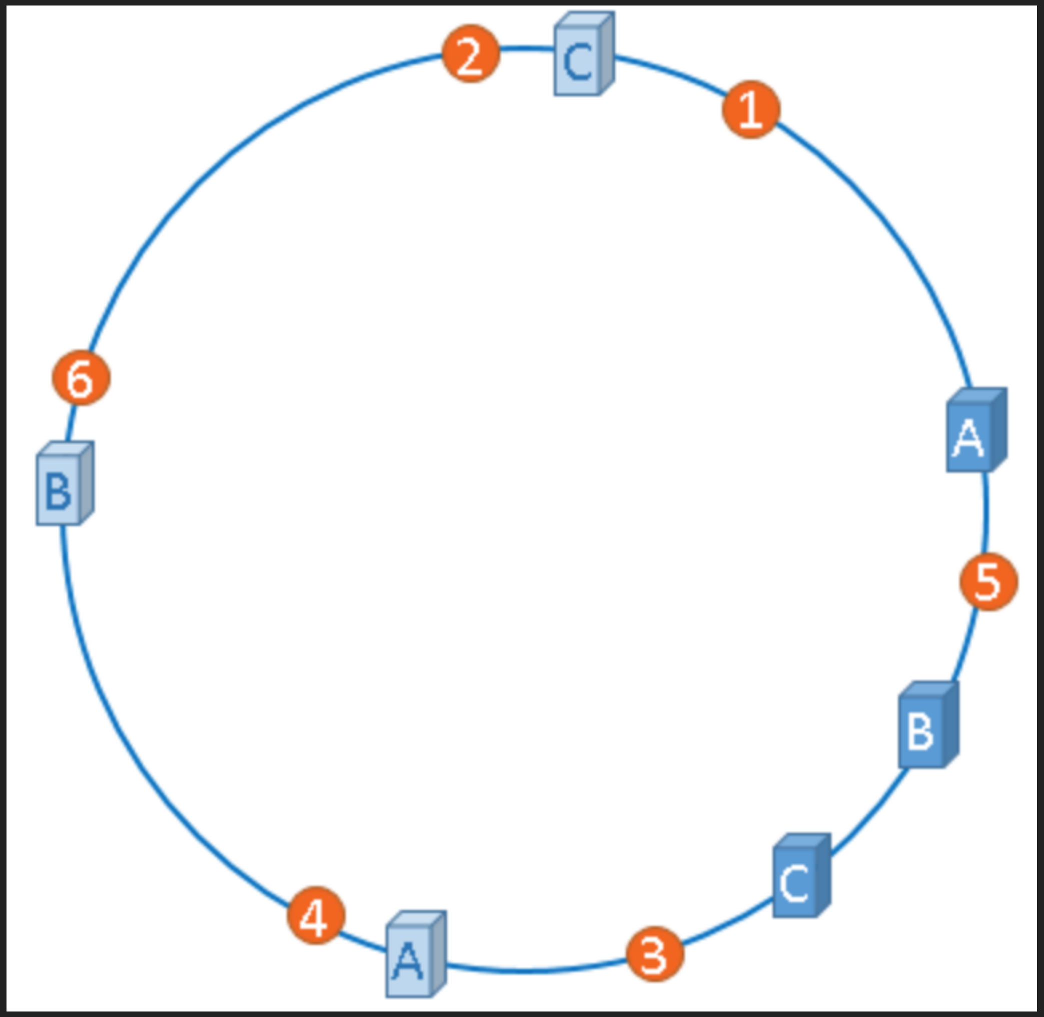
虚拟节点

支持多bucket S3存储驱动实现

一致性哈希算法优点



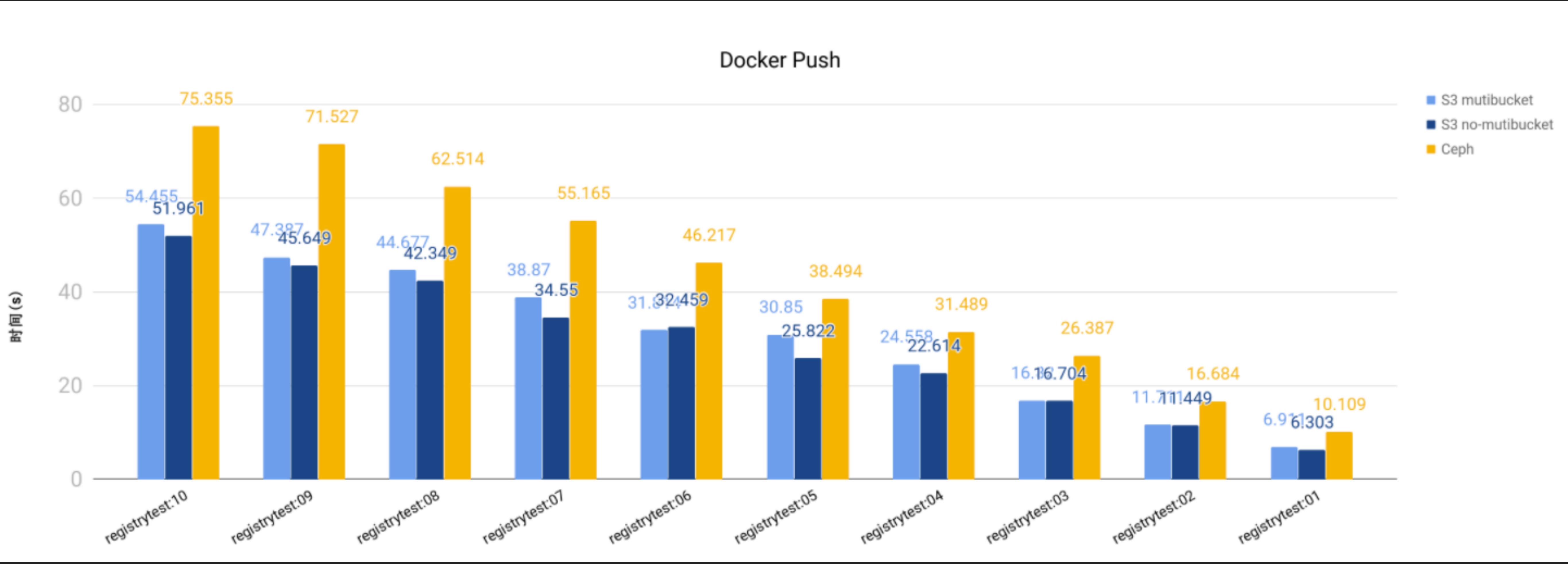
分布式多bucket故障场景



虚拟节点

性能测试对比

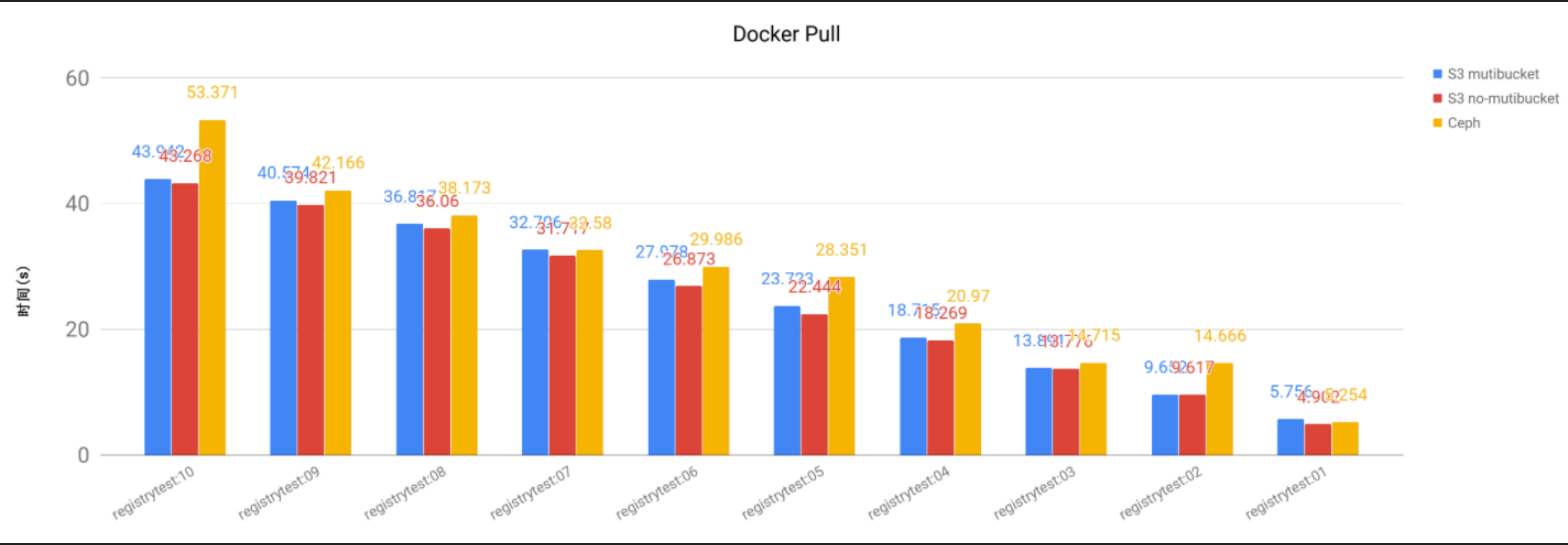
对比多bucket，单bucket，Ceph rados 对上传镜像速度的影响



- 结论：
  - 使用v2.5.2 distribution比v2.1.1上传性能显著增强

性能测试对比

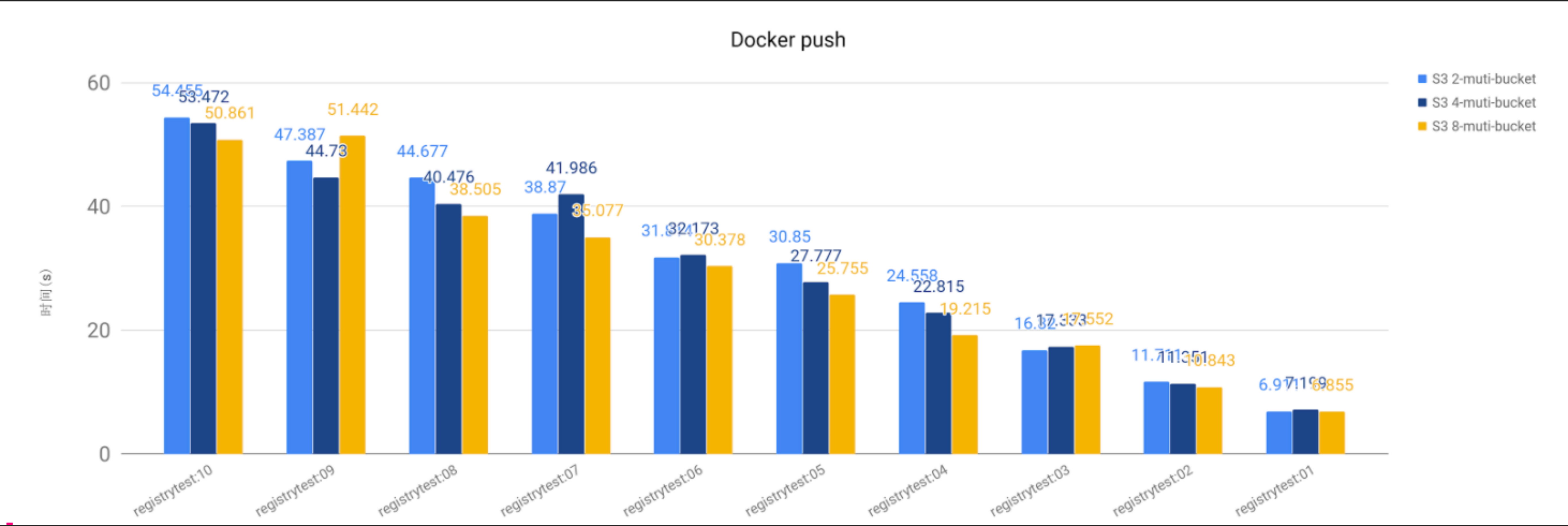
对比多bucket，单bucket，Ceph rados 对下载镜像速度的影响



- 结论：
  - 使用v2.5.2 distribution比v2.1.1下载性能显著增强

性能测试对比

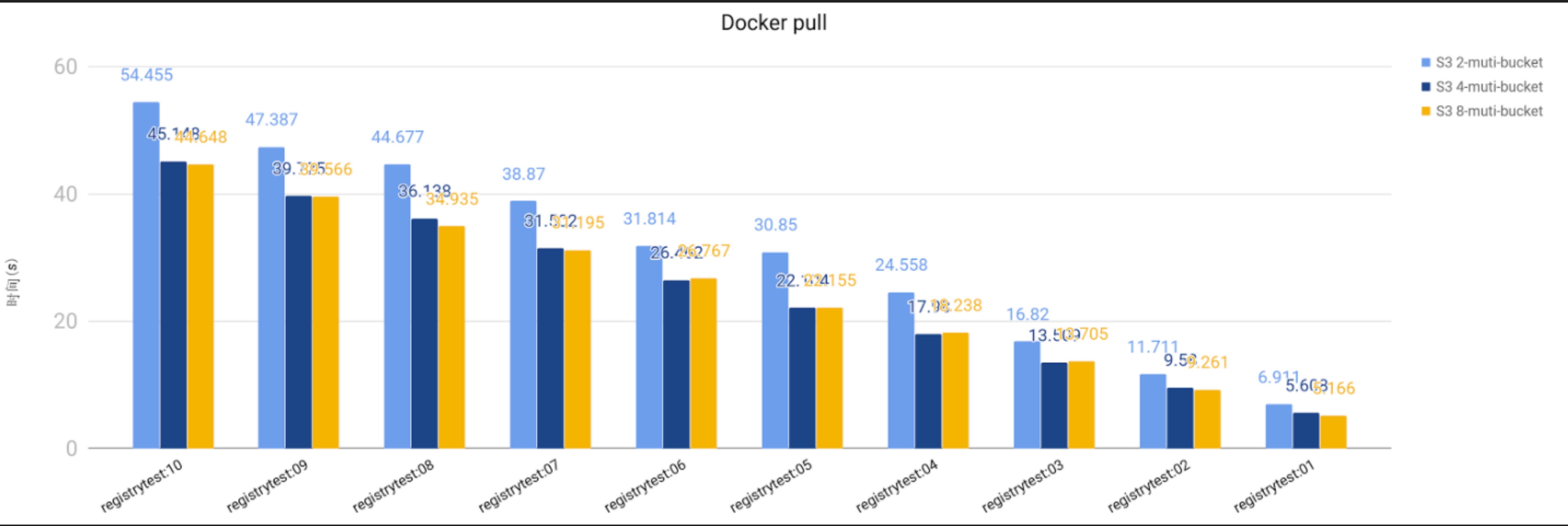
bucket数量对上传速度的影响



- 结论：
  - 使用多个bucket的场景对上传速度影响不大。
  - 单个bucket故障时，减小故障影响面，加快恢复速度。

性能测试对比

bucket数量对下载速度的影响



- 结论：
  - 使用多个bucket的场景能够加速下载。
  - 单个bucket故障时，减小故障影响面，加快恢复速度。

总结遇到的问题

- Registry源码编译
  - golang.org /google.com 等无法访问，翻墙
    - glide mirror/ base
    - github.com/sock-cli 解决，使用sock2http
- go aws library未使用基于DNS解析的bucket路由
    - 小小吉S3不支持（path-style）格式的资源访问
    - secure参数的坑：yes = https , no = http
    - v4auth：官方说默认关闭
      - 实际上在registry v2.4.1 默认使用v4auth
      - 大量配置并未实现

总结遇到的问题

- 两个S3 driver s3-aws / s3-goamz
  - 使用RegionEndpoint时，不去检验Region
  - 在v2.6.2实现了S3 V2auth的兼容，生成证书 setv2handler(s3obj)