系统设计
Distributed System Design
(九章网站下载最新课件)

课程版本 v6.0 本节主讲人：老顽童

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什么是分布式系统？

一言以概之：用多台机器去解决一台机器上不能够解决的问题。

比如：存储不够？QPS太大？

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Overview 谷歌三剑客

- Distributed File System (Google File System)
  - 怎么有效存储数据?
  - No SQL 底层需要一个文件系统
- Bigtable = No-SQL Database
  - 怎么连接底层存储和上层数据
- Map Reduce
  - 怎么快速处理数据?

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Design Distributed File System
了解分布式文件系统后可以做什么？

1. Google，Microsoft面试可能会考到.
2. 学习经典系统，对其他系统设计也有帮助.

比如如何处理failure 和 recovery.

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Distributed File System	Company	开源
GFS	Google	No
HDFS	Yahoo(Altaba)Open Source of GFS	Yes

Distributed File System

Hadoop Distributed File System
VS
Google File System(GFS)

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1. 按照4S分析
   - Scenario 场景分析
   - Service 服务
   - Storage 存储

2. 理清楚work solution

3. Scale 升级优化

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Scenario 场景分析

需要设计哪些功能

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Scenario 场景分析

- 需求1
  - 用户写入一个文件， 用户读取一个文件.
  - 总存储量有多大?
    - 越大越好? 比如 >1000T
- 需求2
  - 多台机器存储这些文件
  - 支持多少台机器?
    - 越多越好? 几千台

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Service 服务

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Service 服务

Client user

\+

Server library

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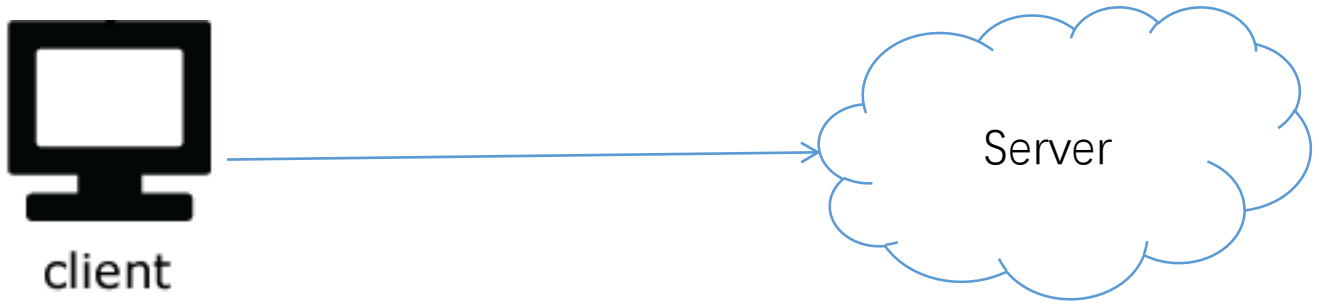

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多台机器怎么沟通?

社会主义 or 资本主义

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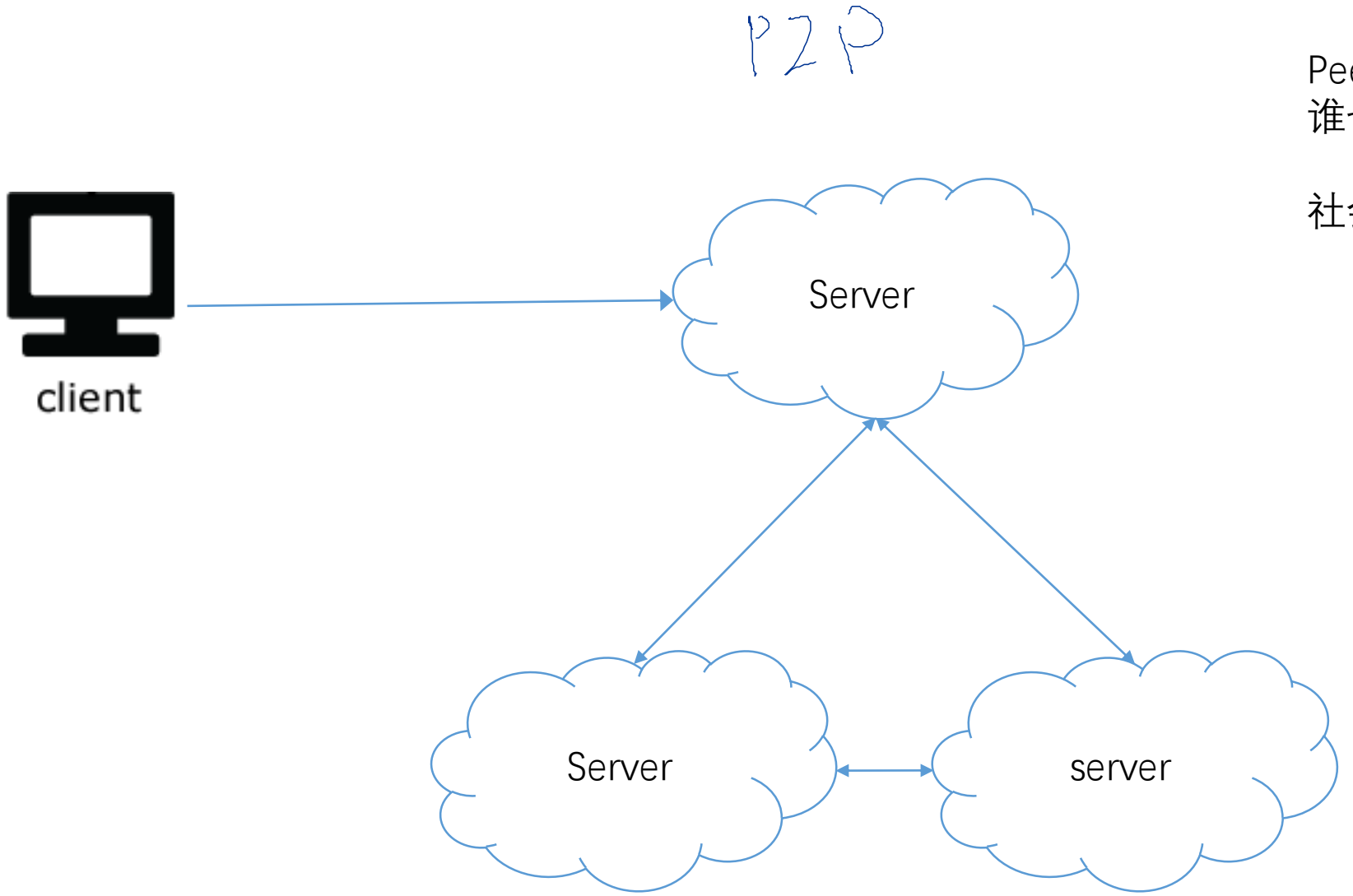

Peer to peer
谁也看不惯谁

社会主义

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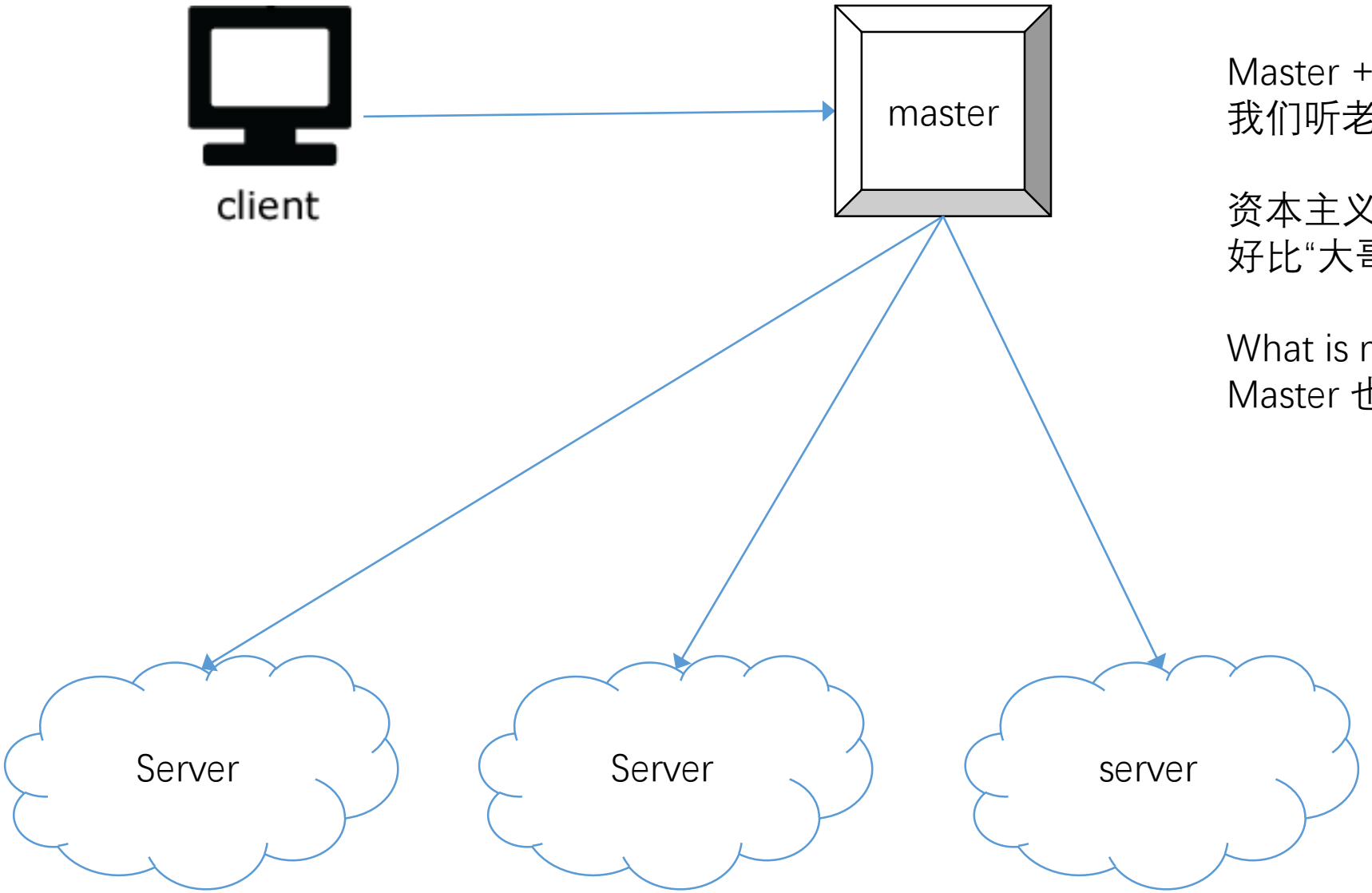
Service 服务



Master + Slave
我们听老大的

资本主义
好比“大哥和他的小弟”

What is master?
Master 也是一台机器

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Storage 存储

- Peer 2 Peer (BitComet, Cassandra, 不是课程重点，考察比较少)
  - Advantage
    - 一台机器挂了还可以工作
  - Disadvantage
    - 多台机器需要经常通信保持他们数据一致
      除高，稳定
- Master Slave
  - Advantage
    - Simple Design
    - 数据很容易保持一致
  - Disadvantage
    - 单master要挂
- Final Decision
  - Master + Slave
  - 单master挂了重启就是。

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Storage 存储

数据如何存储

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Storage 存储

- 大文件存在哪?
  - 内存? 硬盘?

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Storage 存储

- 大文件存在哪?
  - 内存? 硬盘?

- 怎么存在文件系统里面呢?
  - 怎么设计GFS?

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Interviewer: How to save a file in one machine?

普通的操作系统是怎么做的呢？100G

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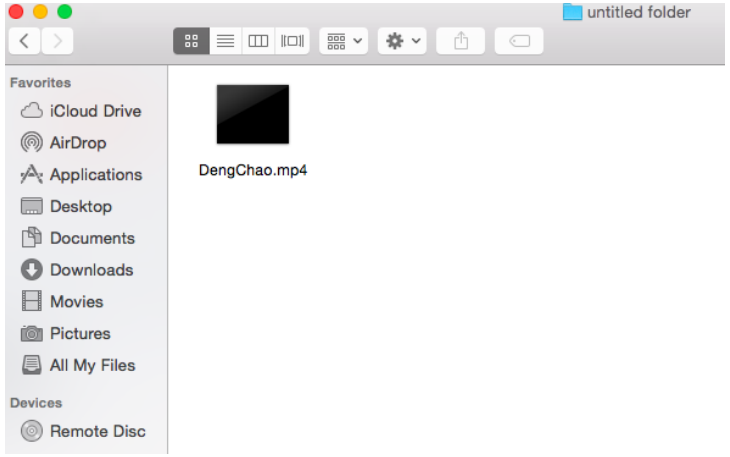
DengChao.mp4
一个文件有什么东西?



meta data
元数据

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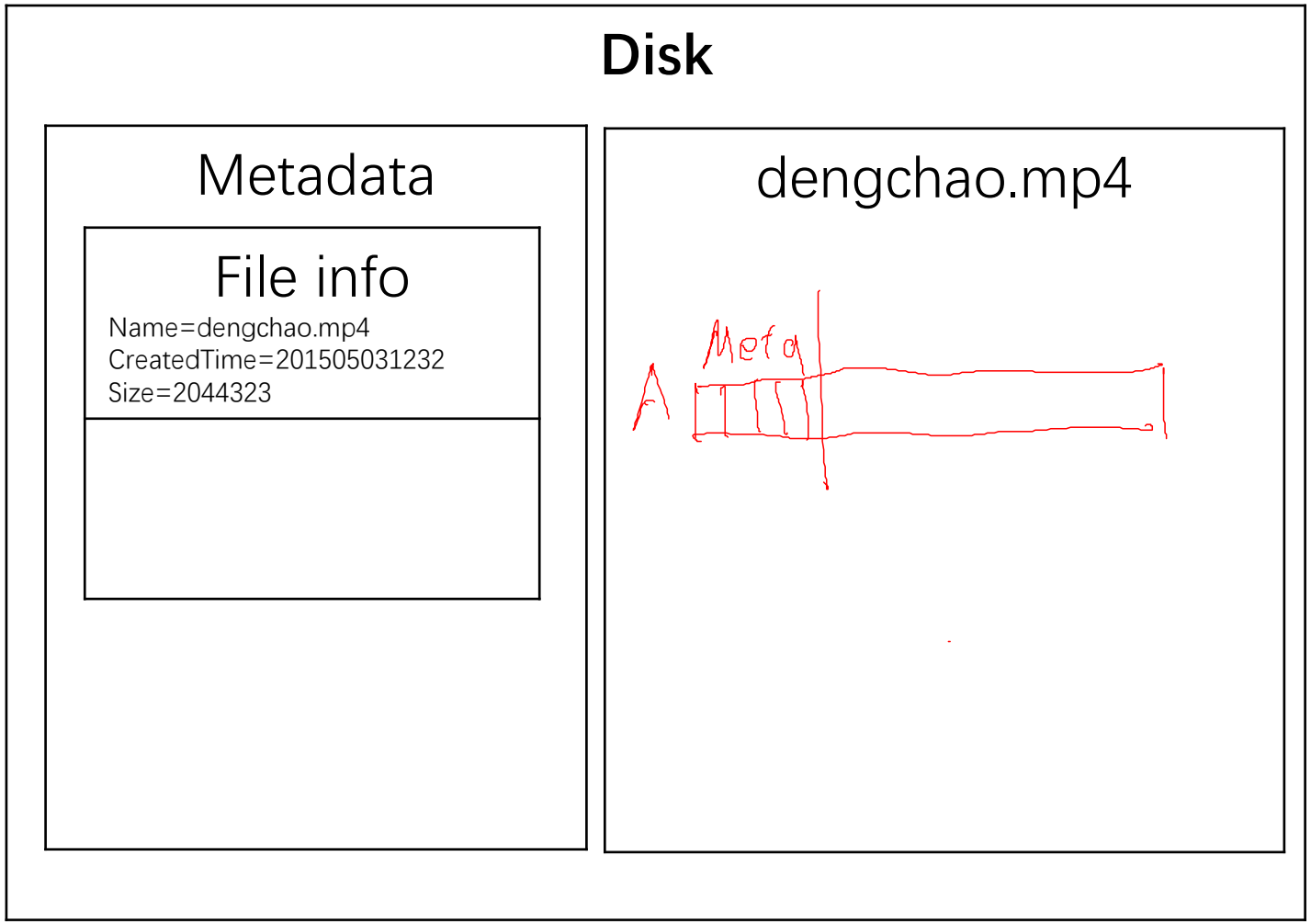
How to save a file in one machine



Metadata: 描述“其他数据”而存储的信息

Metadata 访问 常常多于 内容的访问

Metadata 和文件内容是存在一起还是分开？ 分开

文件内容是分开存储的呢？还是连续存储的呢？ 分开

连续存储不方便 删除

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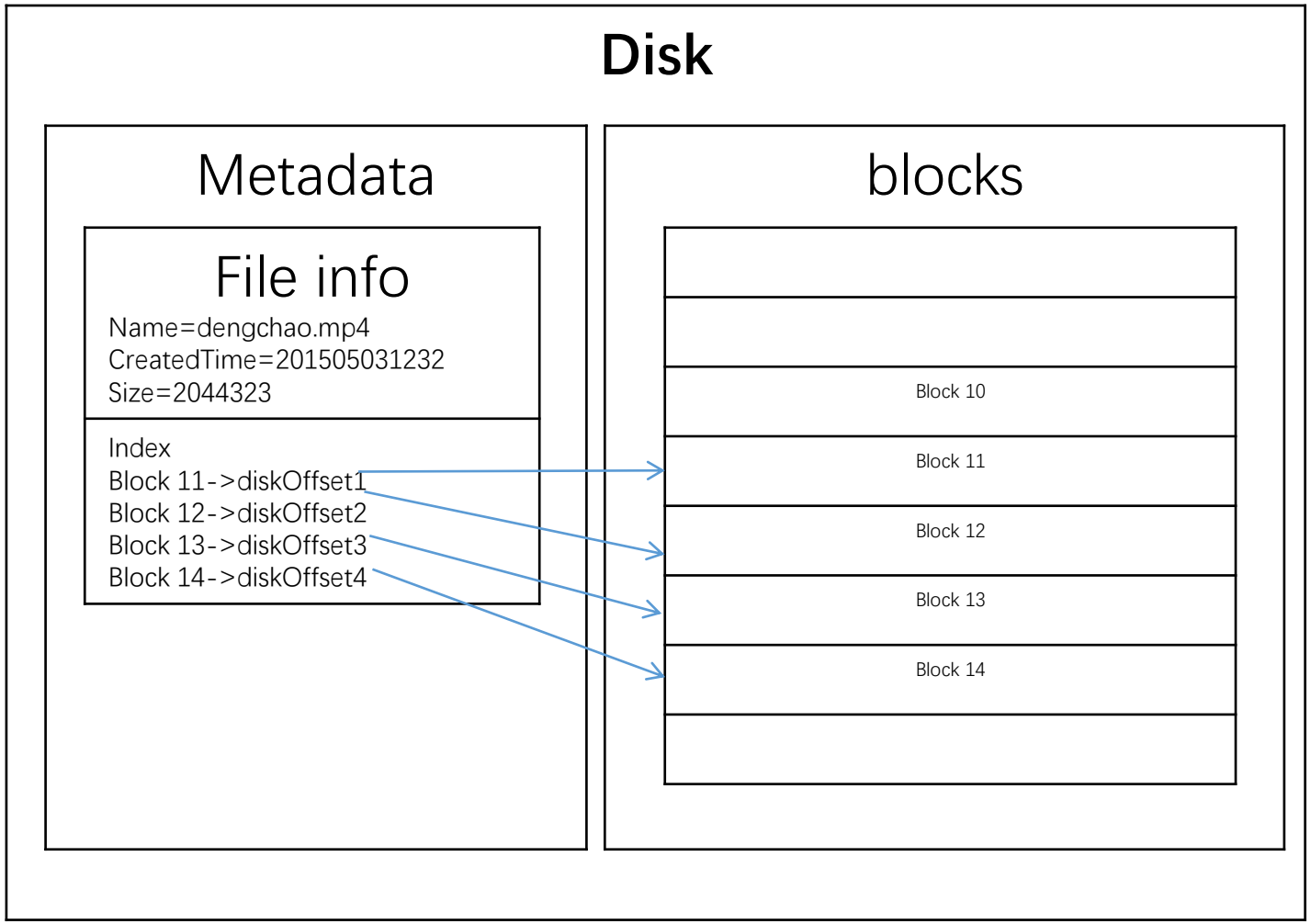
How to save a file in one machine



Key point

- 1 block = 4096Byte

4KB

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Interviewer: How to save a large file in one machine?

Is block size big enough?

100T(多文件)

=100*1024G

=100*1024*1024M

=100*1024*1024*1024K

=25*1024*1024*1024block

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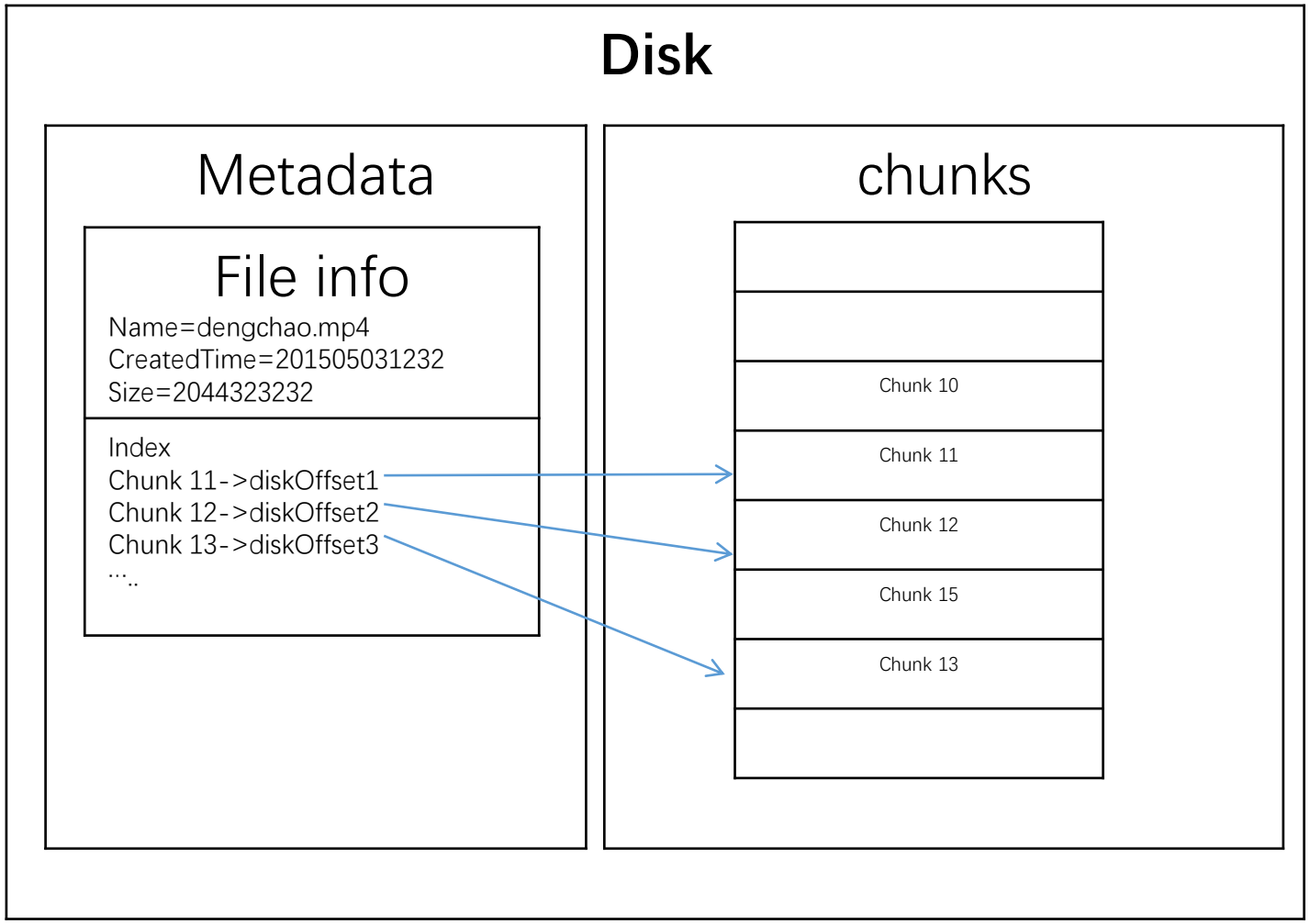
Interviewer: How to save a large file in one machine?



Key point

- 1 Chunk= 64M
  = 64*1024K

Advantage

- Reduce size of metadata

Disadvantage

- Waste space for small files

增加 Block 大小

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Interviewer: How to save extra-large file in several machine?

10P

Is one machine big enough?

这里的文件并不是指一个dengchao.mp4就那么大
而是很多个文件

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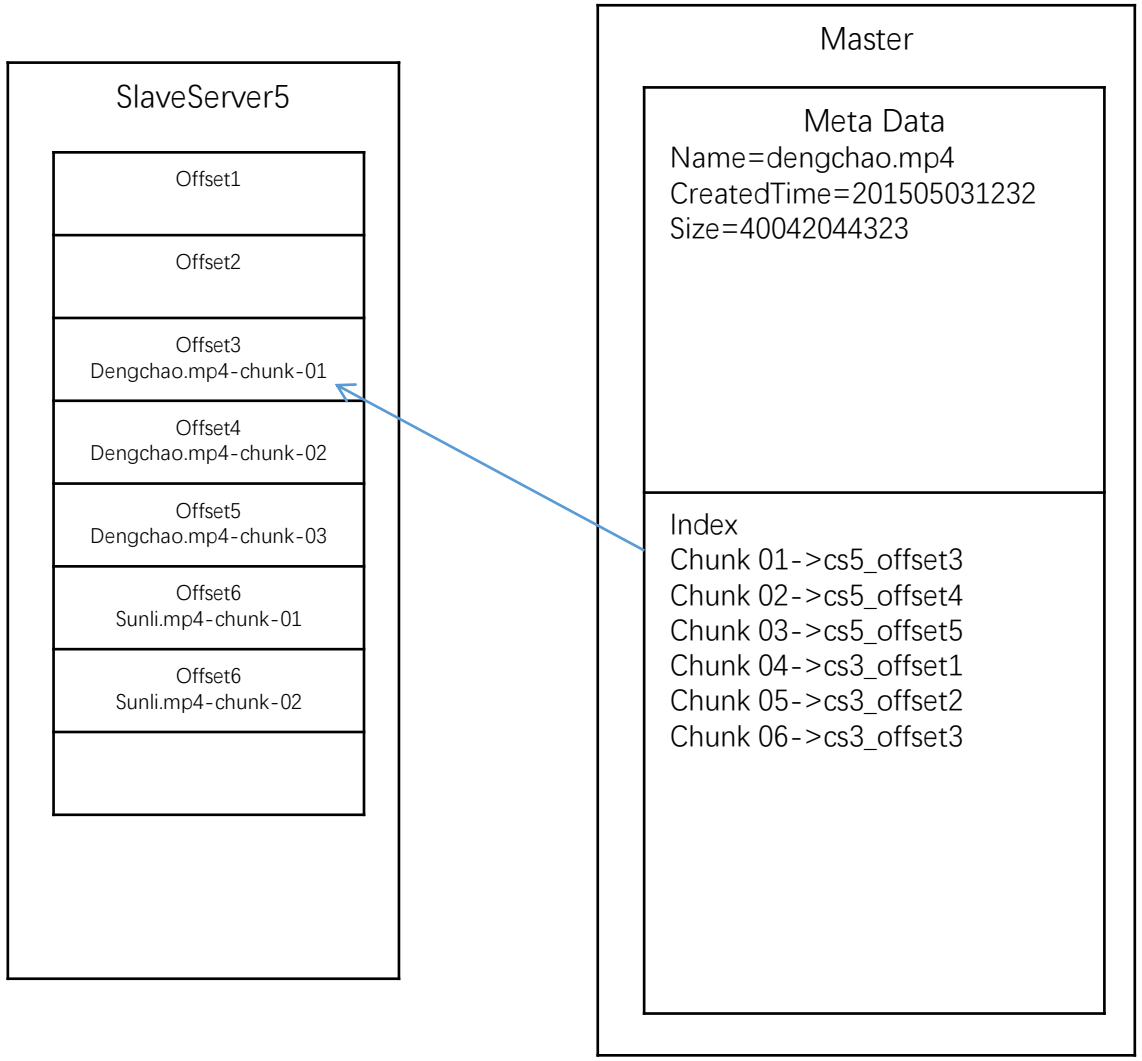
Scale about the Storage



Key point

- One master + many Chunk Servers

Slave Servers = Chunk Servers

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每个chunk的Offset偏移量可不可以不存在master上面？

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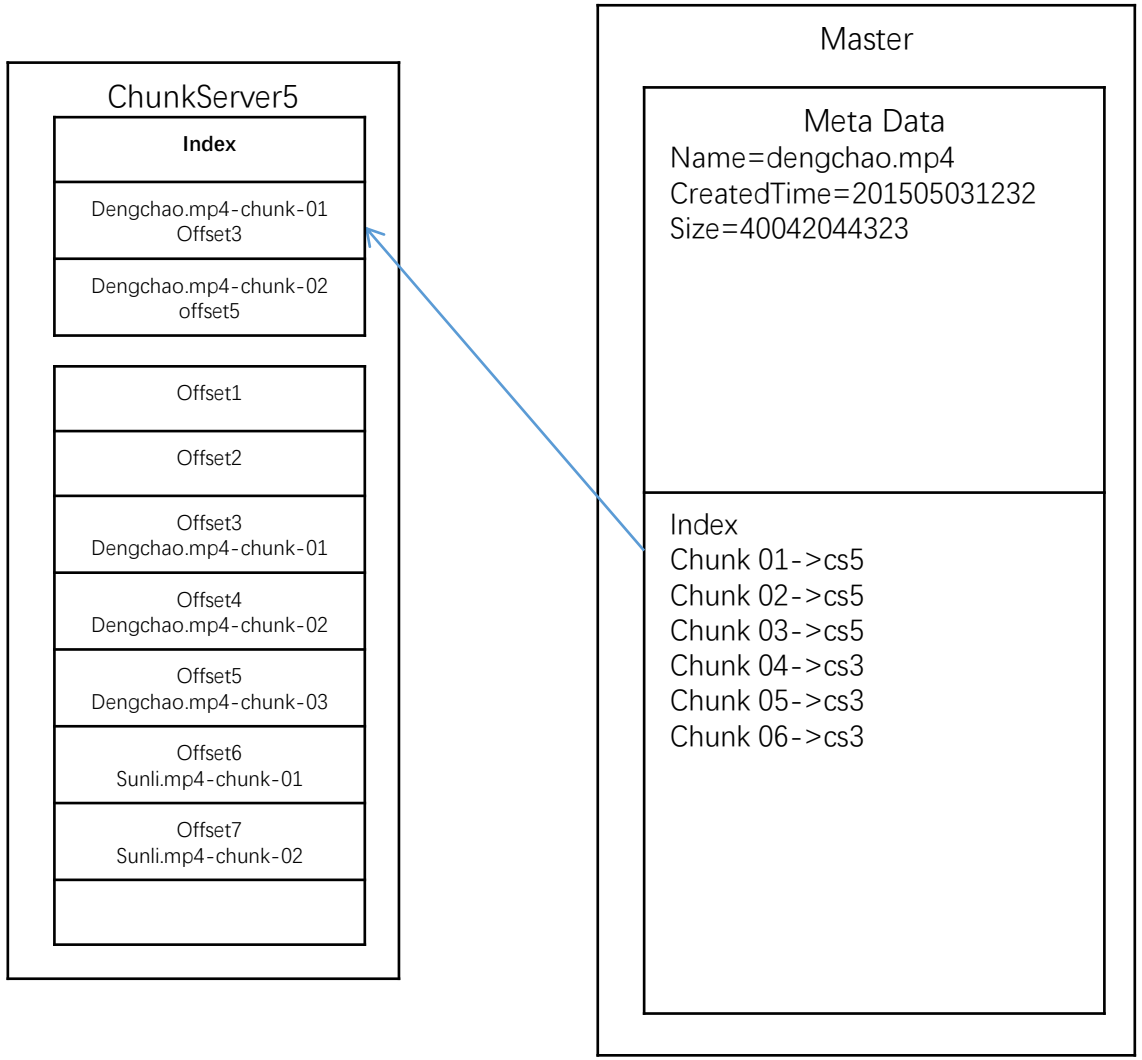
Scale about the Storage



Key point

- The master don't record the disk Offset of a chunk

Advantage

- Reduce the size of metadata in master
- Reduce the traffic between master and Chunk Server（chunk offset改变不需要通知master）

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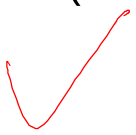
Master 存储10P 文件的metadata 需要多少容量?

1 chunk = 64MB needs 64B. (经验值)

10P needs 10G



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Overview

- 按照4S分析
  - Scenario 场景分析
  - Service 服务
  - Storage 存储
- 理清楚work solution
- Scale 升级优化

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One Work Solution for Read / Write

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Interviewer: How to write a file?

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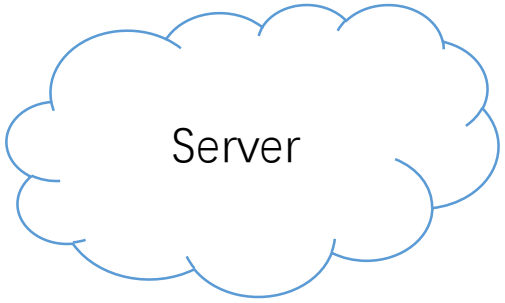
一次写入
还是拆分成多份多次写入?

write File_name=/gfs/home/dengchao.mp4

把大胖子直接写入呢?

还是把大胖子碎尸万段了后写入呢?



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一次 VS 多次

- 写入过程中出错了，那么需要重新写入，哪一种方法更好？
  - 一次传输得重新传输整个文件，多次只用重新传一小份。

- 如果是分成多份多次写入，那么每一份的大小？
  - 文件本来是按照Chunk来存储的，所以传输单位也是Chunk

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那每一个chunk是怎么写入server的呢？

直接写到chunk server？

需要先个master沟通，再写入chunk server？

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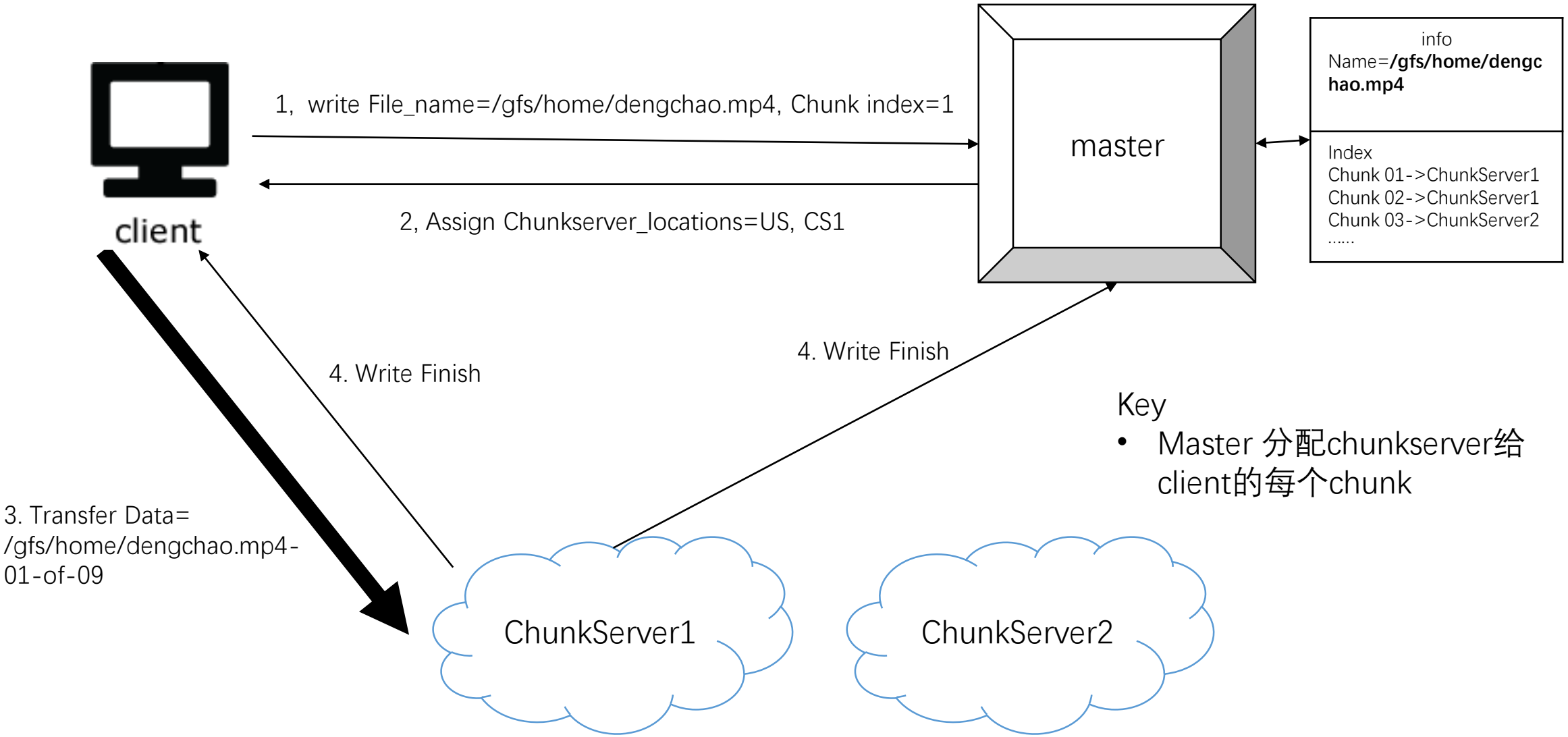
How to write a file?



Key

- Master 分配chunkserver给client的每个chunk

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要修改Dengchao.mp4怎么办?

/gfs/home/dengchao.mp4

要修改的部分在哪个chunk?

修改了过后chunk变大了要怎么处理?

修改了过后chunk变小了要怎么处理?

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要修改Dengchao.mp4怎么办?

One time to write, Many time to read.

先删掉/gfs/home/dengchao.mp4

重新把整个文件重写一份

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Interviewer: How to read a file?

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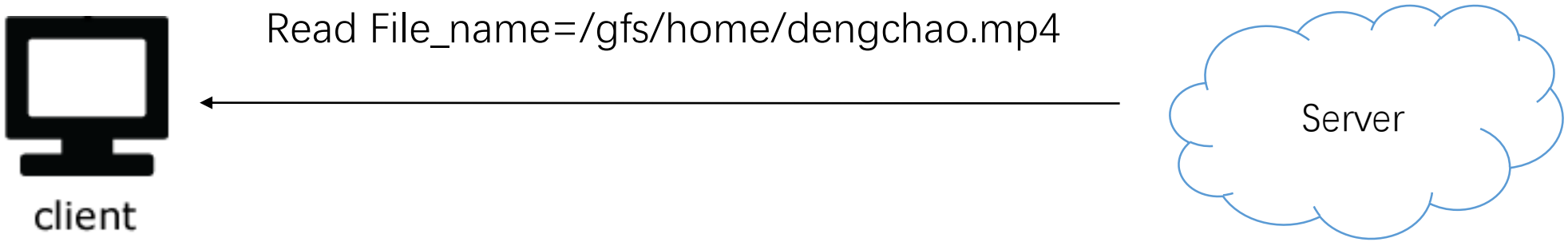
一次读整个文件？
还是拆分成多份多次读入？



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那么client怎么知道dengchao.mp4被切成了多少块?

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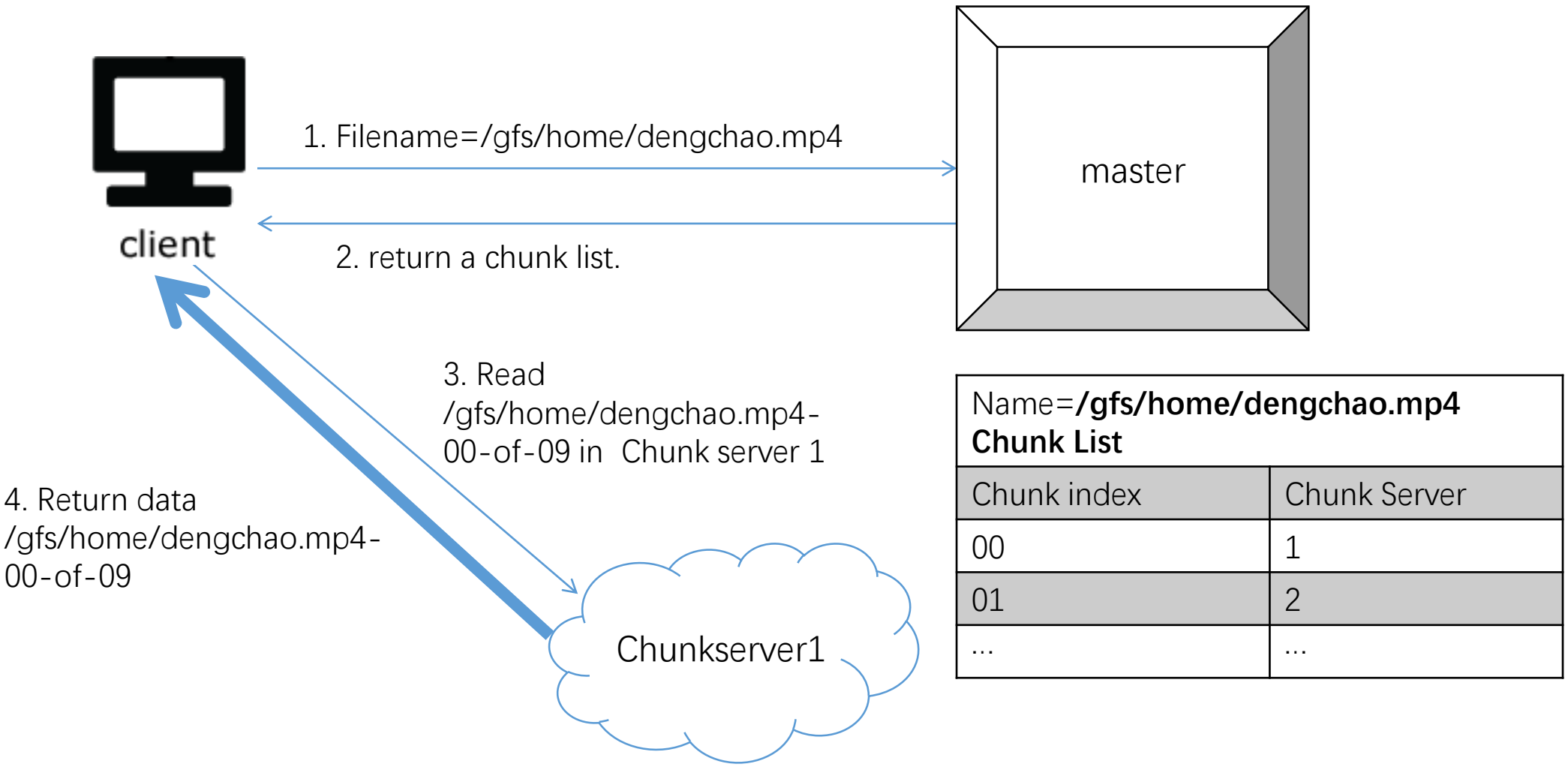
How to read from a file?



Name=**/gfs/home/dengchao.mp4**
Chunk List

Chunk index	Chunk Server
00	1
01	2
…	…

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- 存储各个文件数据的metadata

- 存储Map
  - 读取时找到对应的Chunk Server
  - 写入时分配空闲的Chunk Server

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One Work Solution

- 存储
  - 普通文件系统 Meta Data，Block
  - 大文件存储： Block-> Chunk
  - 多台机器超大文件: Chunk Server + Master
- 写入
  - Master + Client + Chunk Server 沟通流程
  - Master 维护metadata 和 Chunk Server 表
- 读出
  - Master + Client+ Chunk Server 沟通流程

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Scale 升级

系统如何优化与维护

GFS的精髓

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单Master 够不够?

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单Master 够不够?

工业界90%的系统都采用单master

Simple is perfect

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Single Master Failure

Double Master

Paper: Apache Hadoop Goes Realtime at Facebook

Multi Master

Paper: Paxos Algorithm

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Scale about the Failure and Recover

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Interviewer: How to identify whether a chunk on the disk is broken?

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Checksum

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Check Sum 检查一位错误

原来

数据	1	2	3	Checksum(xor)
二进制表示	01	10	11	00

错误后

数据	1	3	3	Checksum(xor)
二进制表示	01	11	11	01

done is better than perfect

- Checksum Method (MD5, SHA1, SHA256 and SHA512)
- Read More: https://en.wikipedia.org/wiki/Checksum

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How to identify whether a chunk on the disk is broken?

- 1 Checksum size?
- 4bytes = 32bit
- 1 chunk = 64MB
- Each chunk has a Checksum
- The size of Checksum of 1P file
- 1P/64MB*32bit = 62.5 MB

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什么时候写入checksum?

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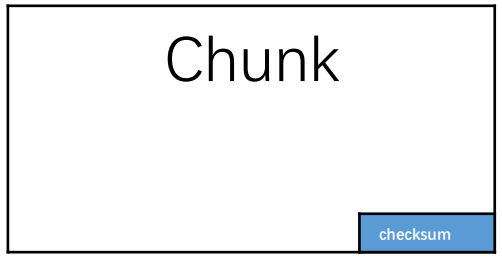
什么时候写入checksum?

Answer: 写入一块chunk的时候顺便写入



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什么时候检查checksum?

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什么时候检查checksum?

Answer: 读入这一块数据的时候检查

1. 重新读数据并且计算现在的checksum
2. 比较现在的checksum和之前存的checksum是否一样

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Interviewer: How to avoid chunk data loss when a Chunk Server is down/fail?

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Interviewer: How to avoid data loss when a Chunk Server is down/fail?

Answer: Replica （专业词汇）

做备份

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需要多少个备份?
每个备份放在哪?

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需要多少个备份?
每个备份放在哪?

1. 三个备份都放在一个地方(加州)。
2. 三个备份放在三个相隔较远的地方（加州，滨州，纽约州）
3. 两个备份相对比较近，另一个放在较远的地方（2个加州，1个滨州）

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Interviewer: How to recover when a chunk is broken?

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Interviewer: How to recover when a chunk is broken?

Answer: Ask master for help

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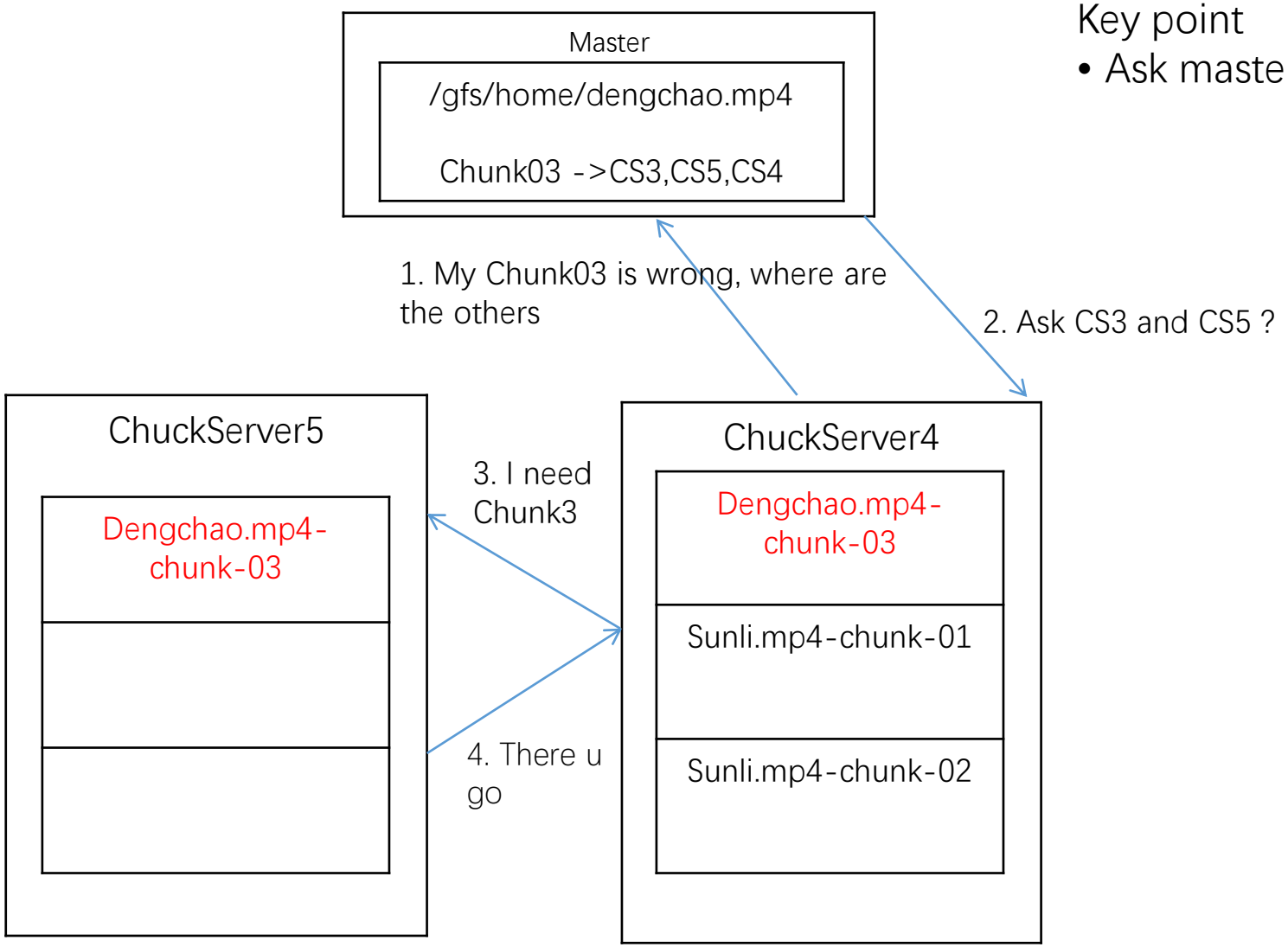

Key point

- Ask master for help

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How to find whether a Chunk Server is down?

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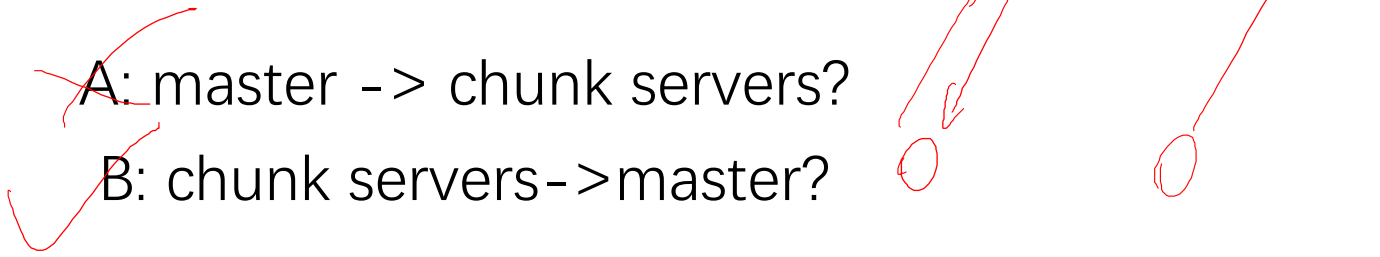
How to find whether a Chunk Server is down?

Answer: Heart Beat.

A: master -> chunk servers?

B: chunk servers->master?



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Scale about the Write

Interviewer: Whether write to only one server is safe?

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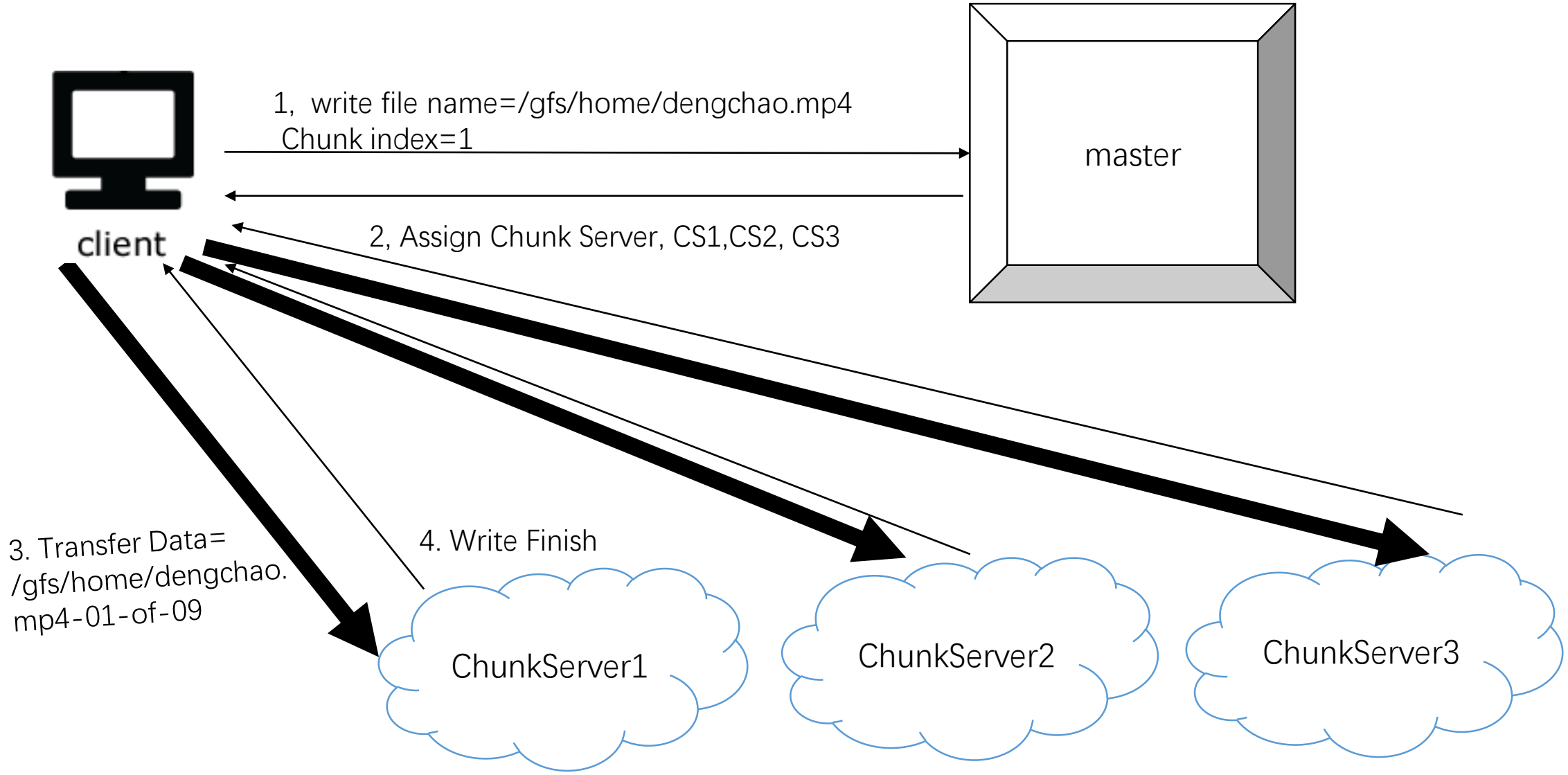
How to write a file?



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chuck 作三面

Interviewer: How to solve Client bottleneck?

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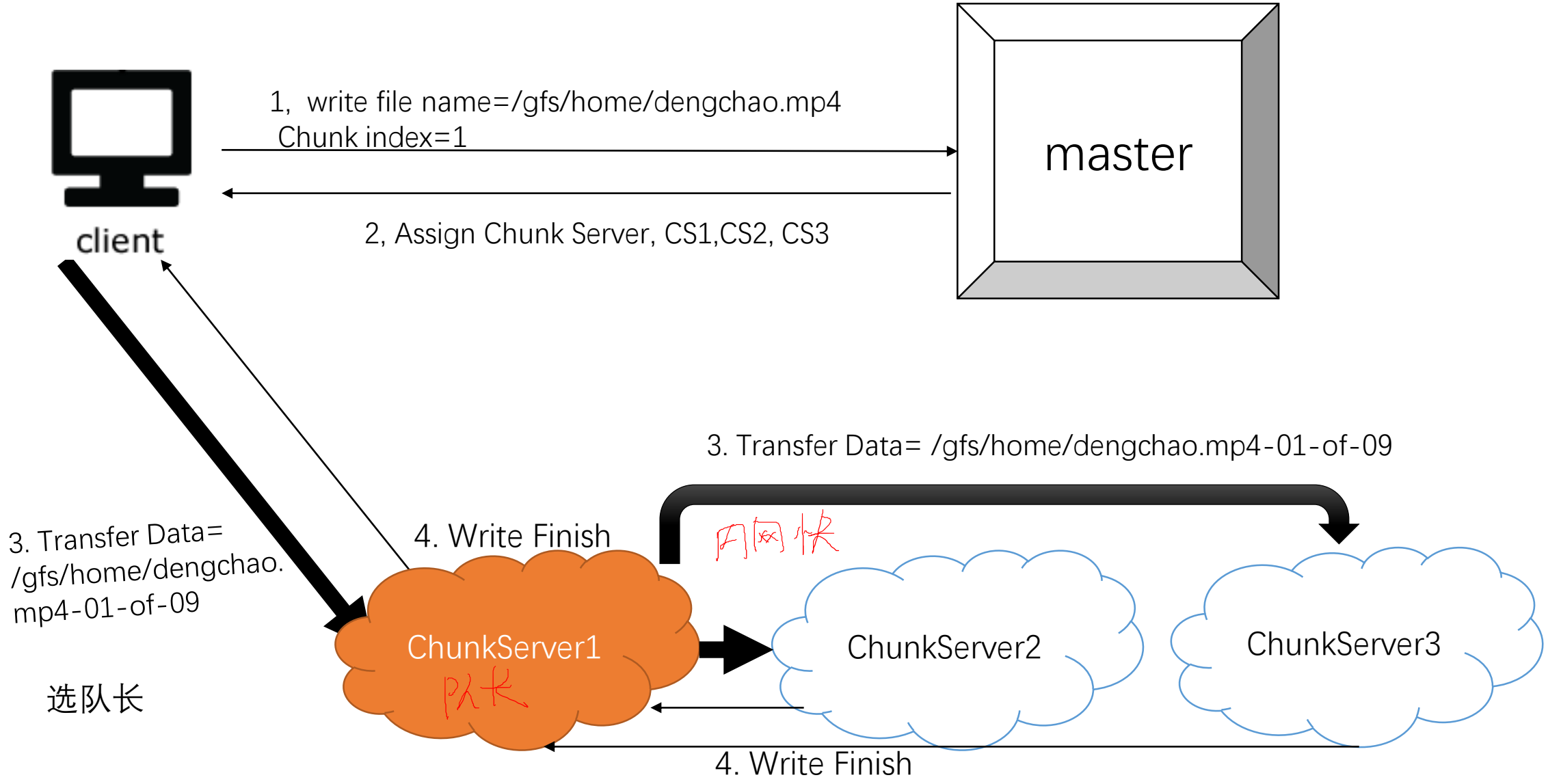
How to solve Client bottleneck?



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Interviewer: 怎么样选队长?

1. 找距离最近的（快）
2. 找现在不干活的（平衡traffic）less busy

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Interviewer: How to solve Chunk Server failure?

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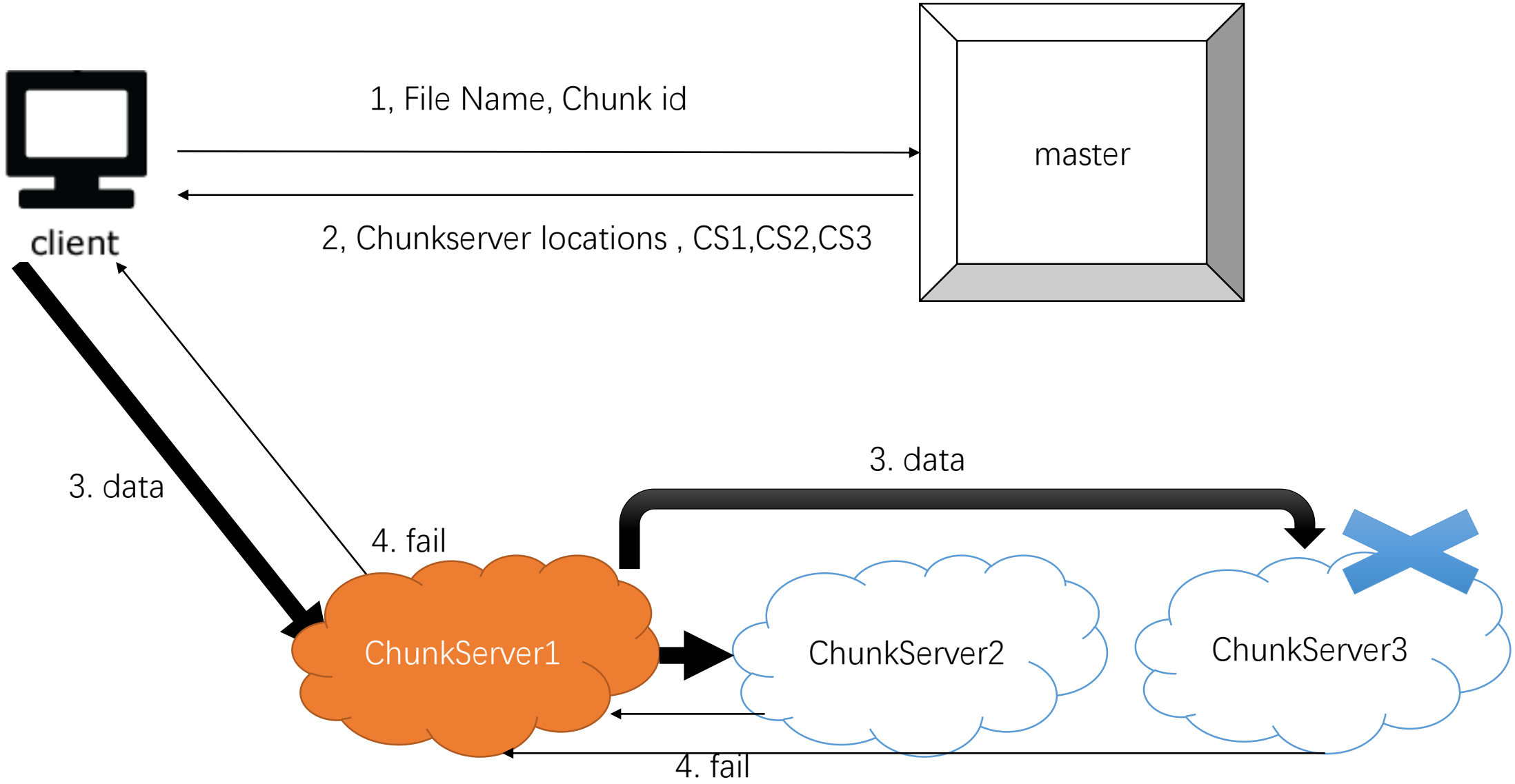
How to solve Chunk Server failure?



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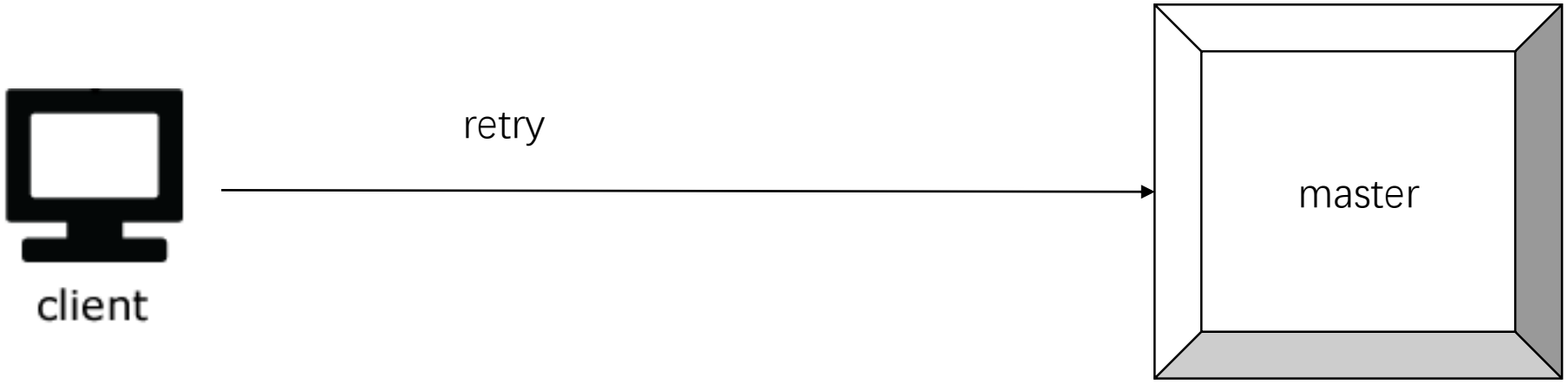
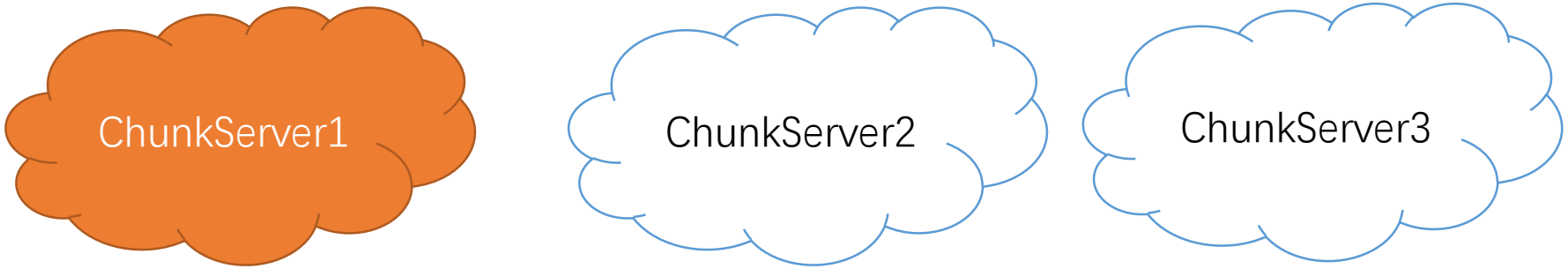
How to solve Chunk Server failure?





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总结 Summary

- Key Point: Master-Slave
- Storage:
  - Save a file in one machine -> a big file in one machine -> a extra big file in multi-machine
  - Multi-machine
    - How to use the **master?**
    - How to traffic and storage of master?
- Read:
  - The process of reading a file
- Write:
  - The process of writing a file
  - How to reduce master traffic?
    - Client 和 Chunk Server沟通
  - How to reduce client traffic?
    - Leader Election
- Failure and Recover (key)
  - Discover the failure a chunk?
    - **Check Sum**
  - Avoid the failure a chunk?
    - **Replica**
  - Recover the failure?
    - Ask master
  - Discover the failure of the Chunk Server?
    - **Heart Beat**
  - Solve the failure of writing Chunk Server?
    - Retry

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Google onsite non-abstract large scale system design 真题

https://www.jiuzhang.com/qa/627/

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Read More

- Expert/Master, http://url.cn/dOLFCs
- Expert/Master, http://url.cn/eErkhm
- Expert/Master, http://url.cn/LqTkoa

- 为什么说学习GFS对我们其他的系统设计也有好处呢?
  - Master Slave Pattern
  - How to handle failure
  - How to use GFS

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Q & A

disk Read time 10ms
net time = 0.5ms

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