Software Architectures

Lecture 8. P2P architecture

Professor:
Yushan (Michael) Sun
Fall 2020

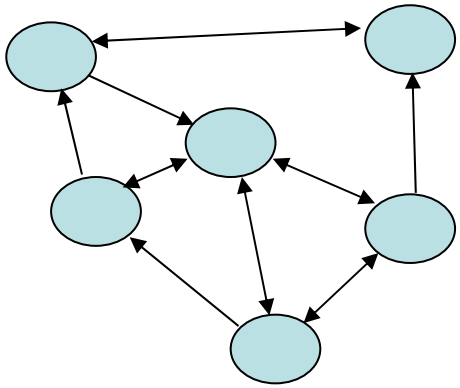
Contents:

Introduction to P2P Architecture

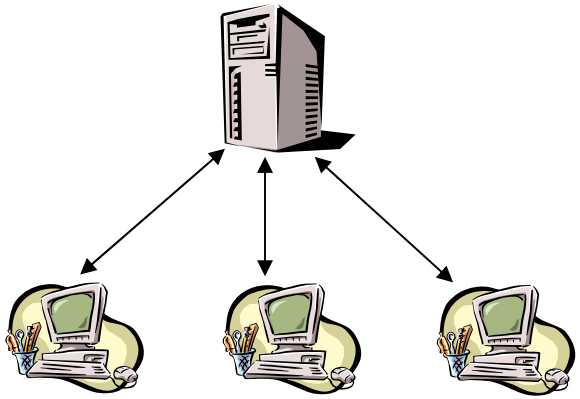
P2P架构引言

1. Introduction to P2P

P2P (Peer to peer) 思想:



P2P架构



客户端-服务器架构

1. P2P使得任何的网络感知设备可以为另外一个网络感知设备提供服务。P2P enables any network-aware device to provide services to another network-aware device
2. P2P网络的一个节点既是客户端，又是服务器。A peer in P2P network acts as both a client and a server

1. Introduction to P2P

P2P的概念：

Peer-to-Peer computing is described as the sharing of computer resources and services by direct exchange between systems.

- **These resources include the exchange of**
  a) **information,**
  b) **processing cycles,**
  c) **cache storage, and**
  d) **disk storage for files.**

1. Introduction to P2P

Advantage of P2P Architecture

a) 便宜的设备协作、利用集体力量. It allows economical clients (desktop computers, etc) to take advantage of their collective power to benefit the entire enterprise

b) 节点既是客户端又是服务器. Clients in a P2P network are also servers

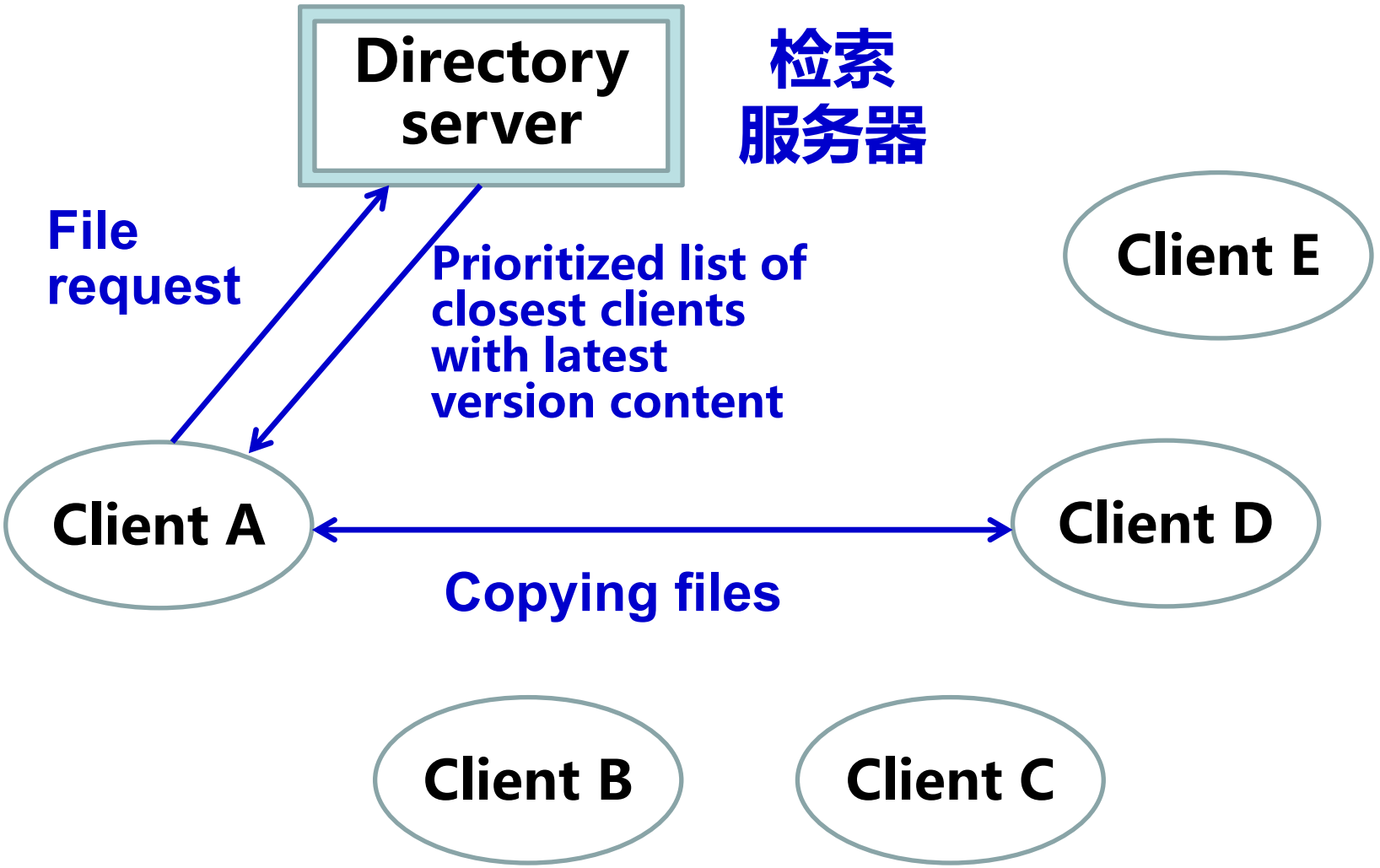
c) 无传统意义下的服务器超载现象. The load on servers in the traditional sense has reduced

Return

Unstructured P2P Architecture with Directory Server- 1st Generation P2P

第一代非结构化P2P架构-带有检索服务器

2. Unstructured P2P Architecture with Directory Server



P2P Architecture with directory server

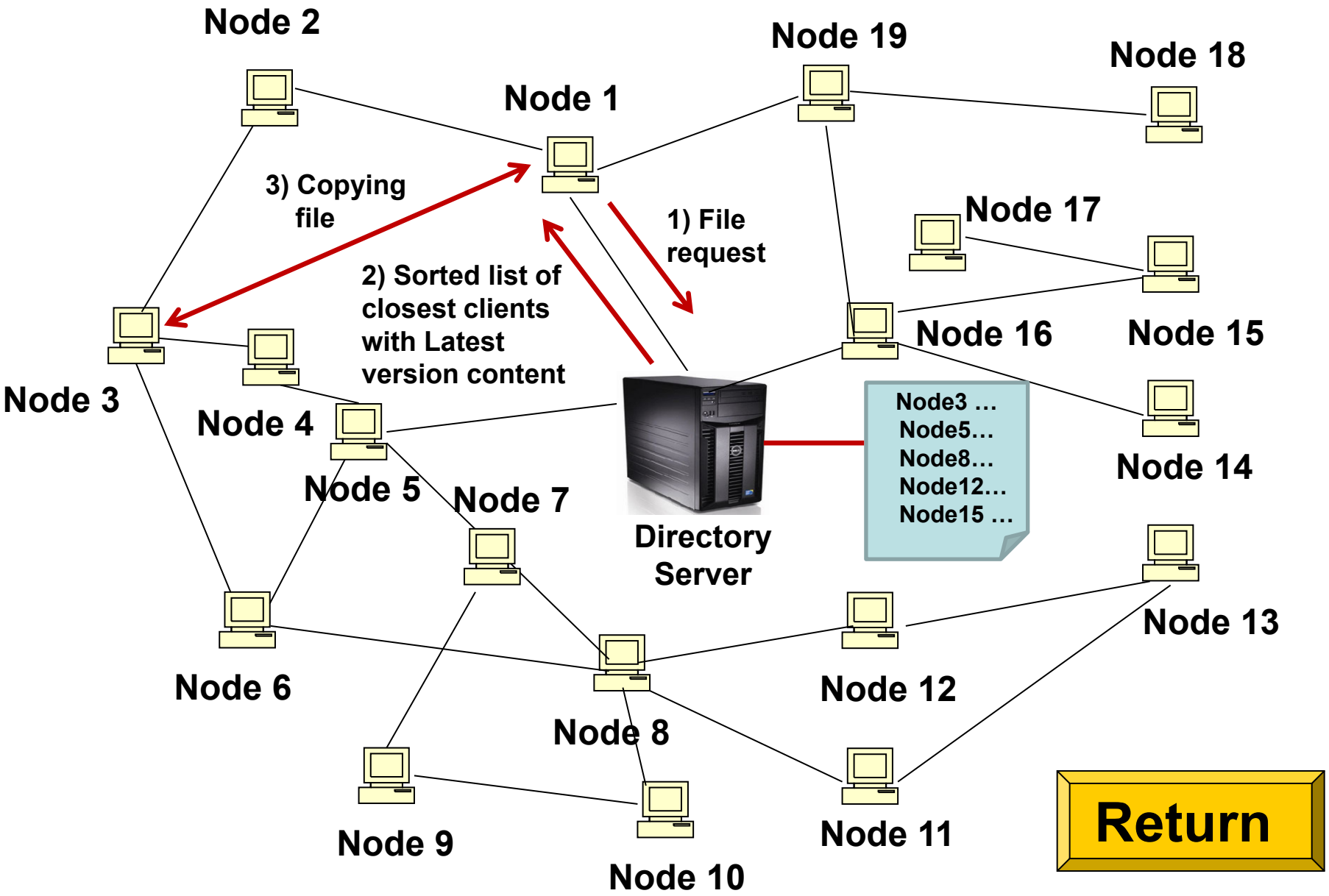
2. Unstructured P2P Architecture with Directory Server

Client A怎样查找其它有用的节点?

The interaction between clients by referencing a Directory Server

a) **发送请求. Send request**: Client A issues **a request** to the Directory server
b) **目录服务器查找对等节点. Find peers**. The Directory server then uses the lists it keep to find the peer that contains the content that Client A interests in and tells Client A
c) **开始互动. Interactions.** Client A can then directly interact with **that client**, in this case Client D which services his request.

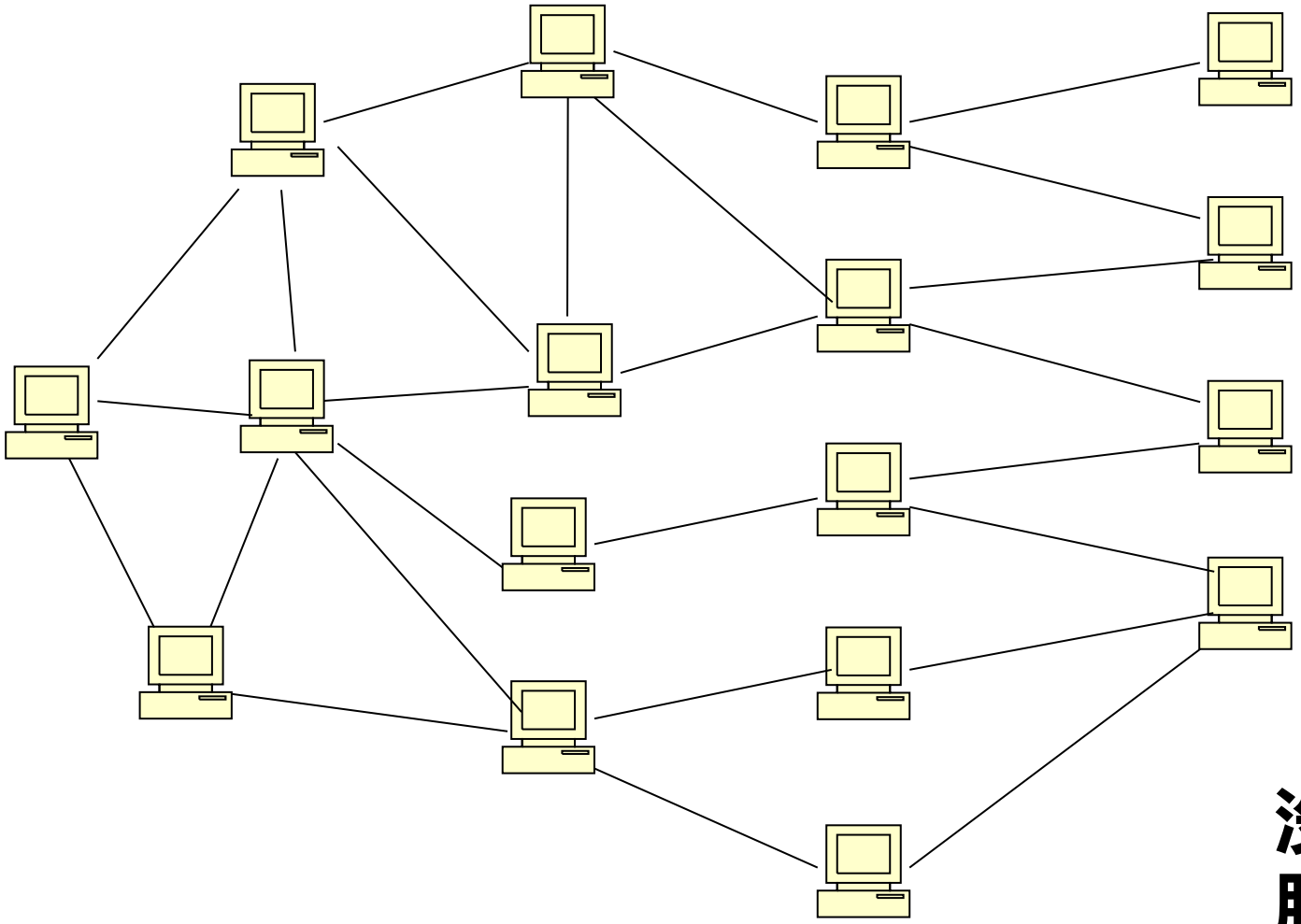
2. Unstructured P2P Architecture with Directory Server



Pure P2P Architecture – 2nd Generation P2P

第二代非结构化P2P架构-纯P2P架构

3. Unstructured pure P2P Architecture



没有检索
服务器

Pure P2P architecture

3. Unstructured pure P2P Architecture

纯P2P架构的性质(characteristics of pure P2P Architecture)

a) **节点既是客户端又是服务器. Peers can act as clients and servers and have the same capability as its neighbors.**
b) **没有中心服务器. It has no central servers. It has every node as a Peer and has no central router.**
c) **两种路由结构. There are two routing structures,**
    1. **分布式目录. One is a distributed catalogue;**
    2. **直接发送消息. The other direct messaging.**

3. Unstructured pure P2P Architecture

Gnutella: Example of Pure P2P Architecture

- Gnutella简史
- Gnutella, a Pure P2P Model, is a file sharing application and protocol:
  - the end hosts join Gnutella by connecting to existing end hosts already on the Gnutella.
  - by Justin Frankel, published in 2000/03
  - Gnutella has become a Protocol now

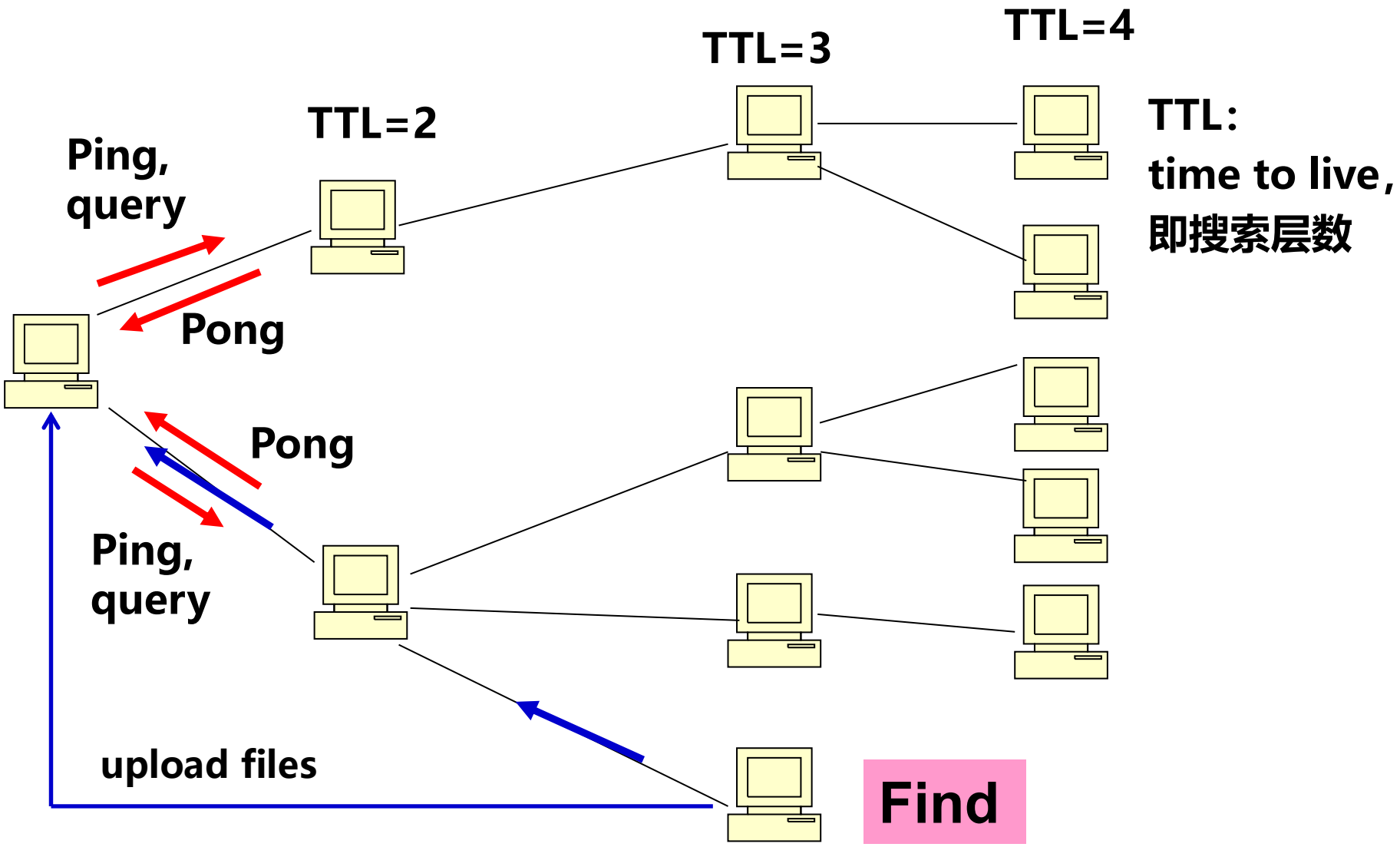
3. Unstructured pure P2P Architecture

Gnutella资源查找方式

To facilitate file sharing, messages are sent between end hosts.

- Queries for files are broadcasted on the overlay network (覆盖网络(应用层网络)), and
- Replies are routed back to the host that originally generated the query through the overlay network.

3. Unstructured pure P2P Architecture



Gnutella网络资源查找原理

3. Unstructured pure P2P Architecture

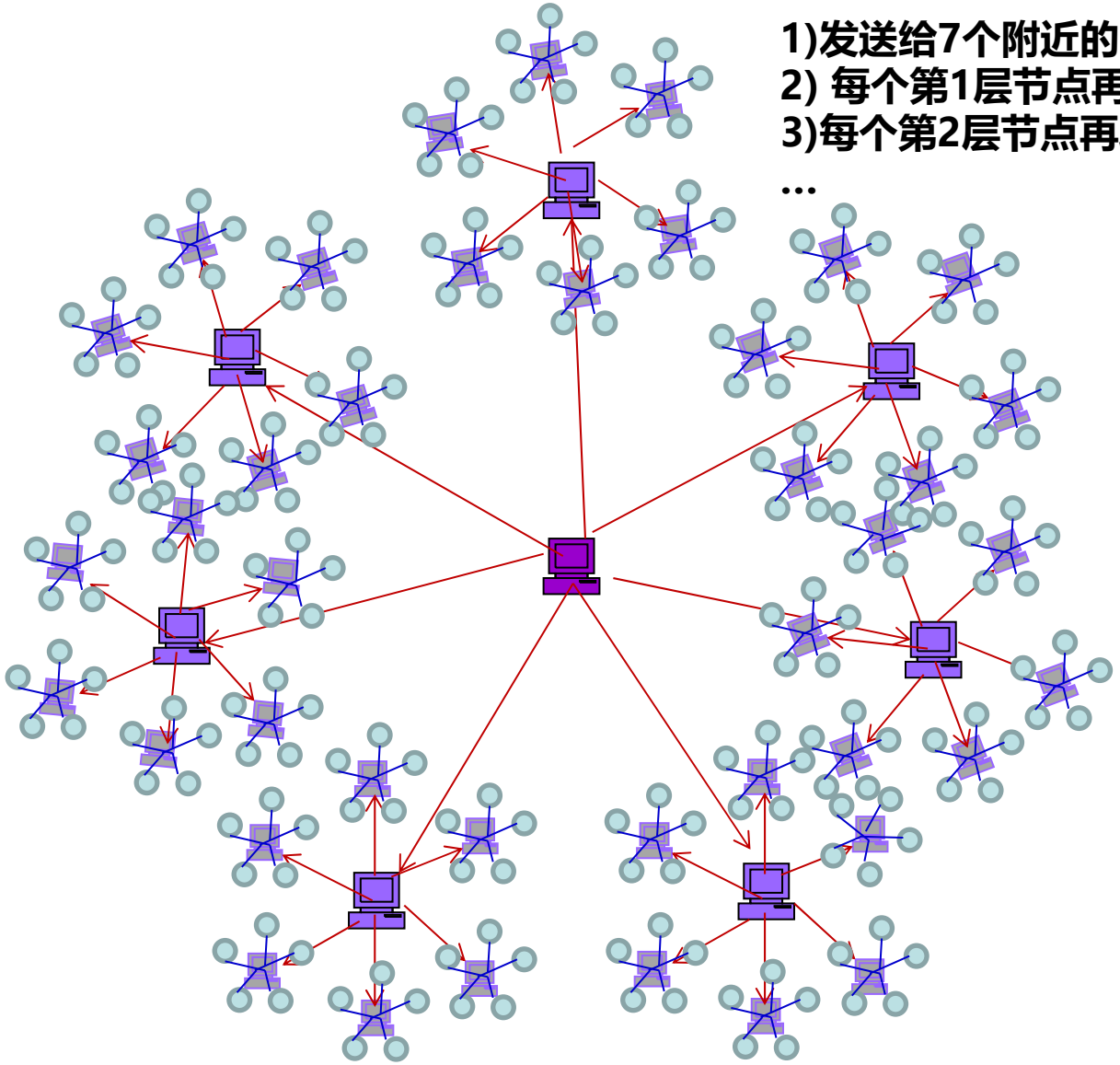
查询步骤 (Query steps):

1. **连接到P2P网络. Node A is first connected to the network.**
2. **查找新节点. Ping Node A Pings to the other Nodes (B and C) to discover new nodes on the network.**
3. **新节点回答. Pong A pong message is sent as a reply to a ping and provides information on a network node, including**
   - **IP address,**
   - **port number (端口号), and**
   - **number of files shared.**

3. Unstructured pure P2P Architecture

4. **发送请求消息.** A query message is used to search for files shared by other nodes on the network. It contains a query string and a minimum requested link speed.
5. **获得回答.** A query reply message contains
   - a list of files which match a given query,
   - the size of each file, and
   - the link speed of the responding node.
6. **上载文件.** A push message is used to upload file to clients behind a firewall who can not download files themselves.

3. Unstructured pure P2P Architecture



1)发送给7个附近的client(第1层)
2) 每个第1层节点再发送给6个附近的节点（第2层)
3)每个第2层节点再发送给5个附近的节点（第3层)
…

没找到

Search is not guaranteed if object is outside the search range!

3. Unstructured pure P2P Architecture

早期版本的Gnutella的缺点：

1）**不稳定的连接**. Unstable connectivity of the servants

- performance management difficult

2) **伸缩性问题**. Scalability issues: e.g. when TTL=10, will produce huge networks

3）**搜索范围不够大**，本应该存在的资源没有被覆盖

3. Unstructured pure P2P Architecture

关于Gnutella协议

- **Gnutella 采用分布式的协议，每个节点既是服务器又是客户端.** Gnutella is a distributed protocol such that the clients become servers and they become clients at the same time. A node
  - is a Client when it is looking for some data
  - is a Sever if it is servicing a request of another node.
- **The communication between the nodes is done by the TCP/IP protocol.**

3. Unstructured pure P2P Architecture

Gnutella的性质

a) 可靠性：If one computer goes down, the network is unaffected, hence more reliable.

b) 匿名性：Gnutella is anonymous-there is no need to provide a name or e-mail address to use Gnutella

c) 共享任何种类资源：Gnutella provides a mechanism to share any type of resource: photos, computer program, and movies, etc.

d) 纯P2P: Gnutella is Pure P2P and is completely decentralized.

Return

Unstructured Hierarchical P2P Architecture– 3nd Generation P2P

第三代P2P架构-非结构化层次化P2P架构

4. Unstructured Hierarchical P2P Architecture

- 纯P2P Gnutella V0.4存在的问题
- 网络大了、搜索量大增。Large scale P2P networks around the world caused the ever-increasing search traffic.
- 对于大网络，搜索应答率比的越来越低。The search recall ratio (the number of search results：the total number of available copies of the searched object) was significantly decreased as the network scale became larger

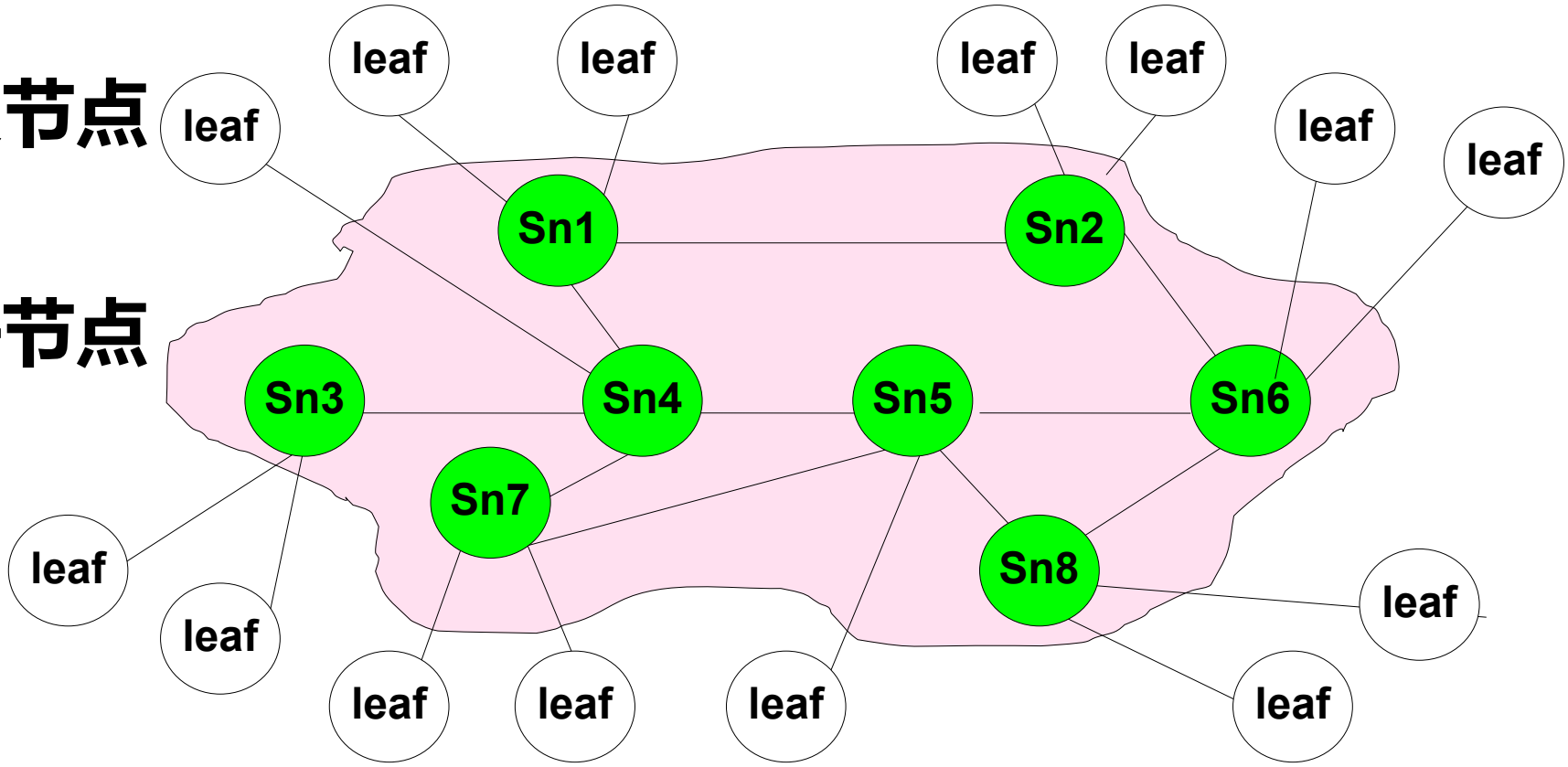
4. Unstructured Hierarchical P2P Architecture

- 需要新设计，以便改善性能
- To tackle this problem, Gnutella v0.6 introduced two-layer hierarchy in its architecture as below

4. Unstructured Hierarchical P2P Architecture

超级节点
sn

叶子节点
leaf



非结构化层次P2P架构- 第3代P2P:
Gnutella v0.6 network topology

4. Unstructured Hierarchical P2P Architecture

- 架构的解释
- In this architecture, nodes are divided into into leaf nodes and ultrapeer nodes.
- 叶子节点 (A leaf node) : only maintains connection with its own ultrapeer,
- 超级节点 (An ultrapeer) :
  - maintains connections to its own leaf nodes and acts as proxy for them
  - connects to the other ultrapeers from the overlay

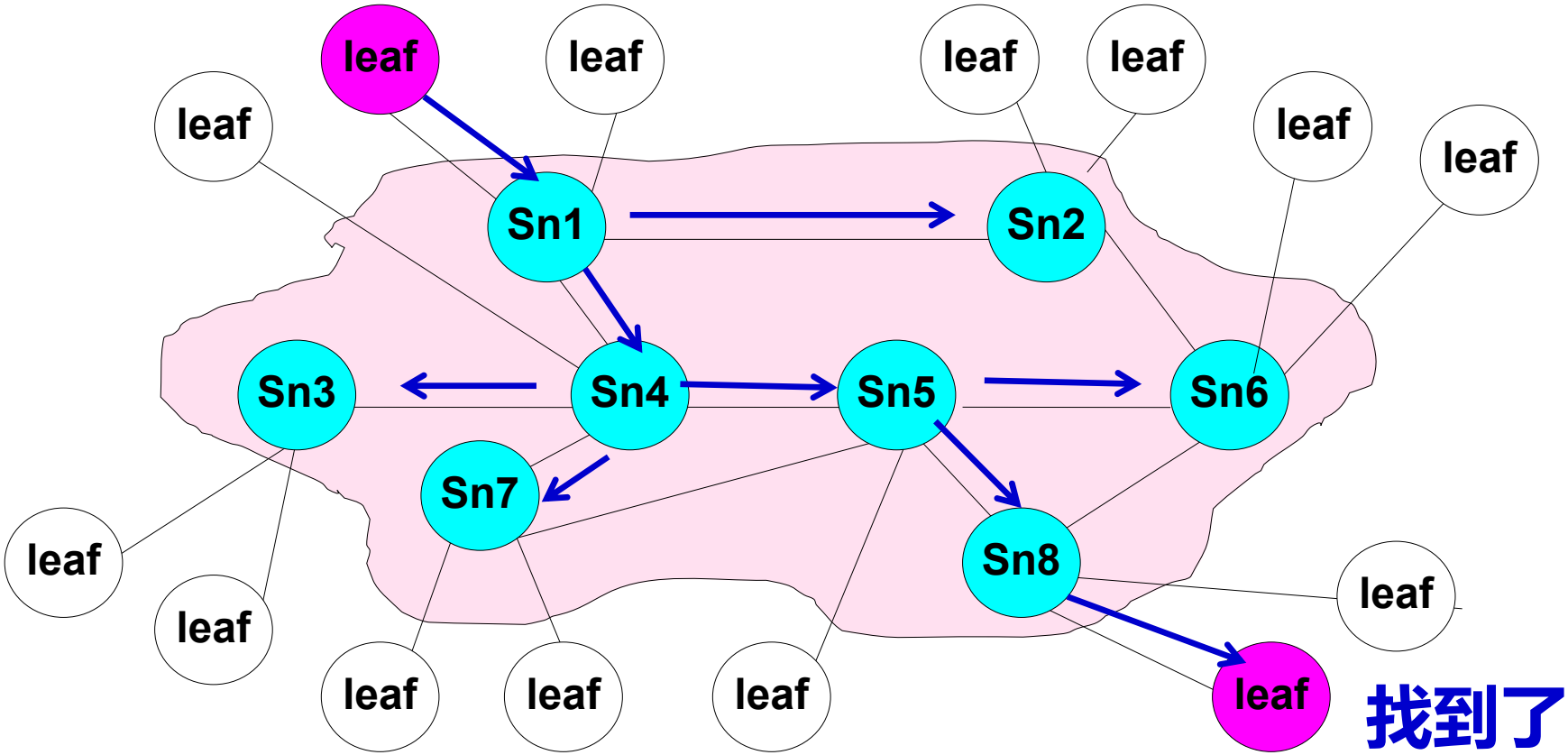
4. Unstructured Hierarchical P2P Architecture

- 在查找过程中，叶子节点的责任.
- Leaf nodes are only responsible for
  - initiating lookup requests,
  - receiving correlated lookup response, and
  - responding the requests that they can exactly answer,

4. Unstructured Hierarchical P2P Architecture

- 在查找过程中，超级节点的责任。
- Ultrapeers are responsible for
  - 转发请求到其它超级节点 forwarding lookup requests to other ultrapeers or
  - 转发请求到自己的叶子节点 its own connected leaf nodes, if it knows exactly the leaf node is able to answer the request.
- Ultrapeers can also initiate requests and receive correlated responses.
- At the level of ultrapeer, similar flooding-based mechanism as Gnutella v0.4 is utilized to forward the lookup requests.

4. Unstructured Hierarchical P2P Architecture



查找过程示意图

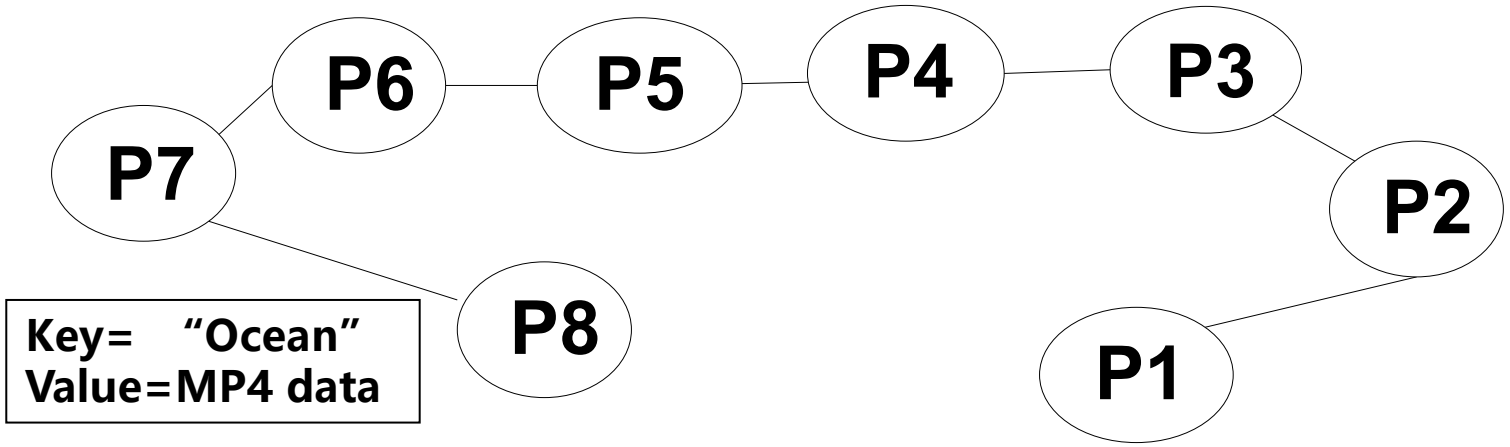
Return

Brief Introduction to Structured P2P Architecture*

结构化P2P软件体系结构简介*

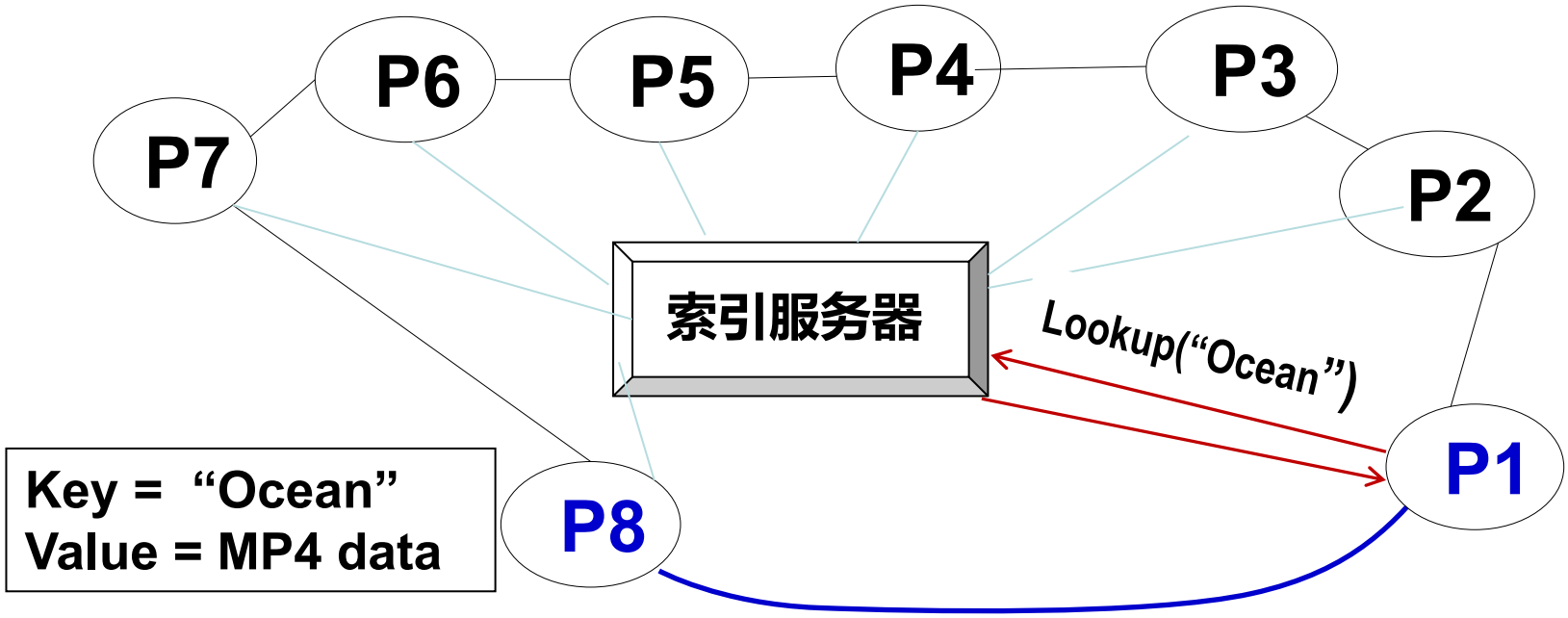
结构化P2P软件体系结构简介*

- **问题：** P2P网络中的一个节点P1怎样在P2P网络中查找带有所需资源的节点。例如，在如下图所示的P2P网络，怎样查找所需的资源（Key=“Ocean”，Value = MP4 data）呢?



结构化P2P软件体系结构简介*

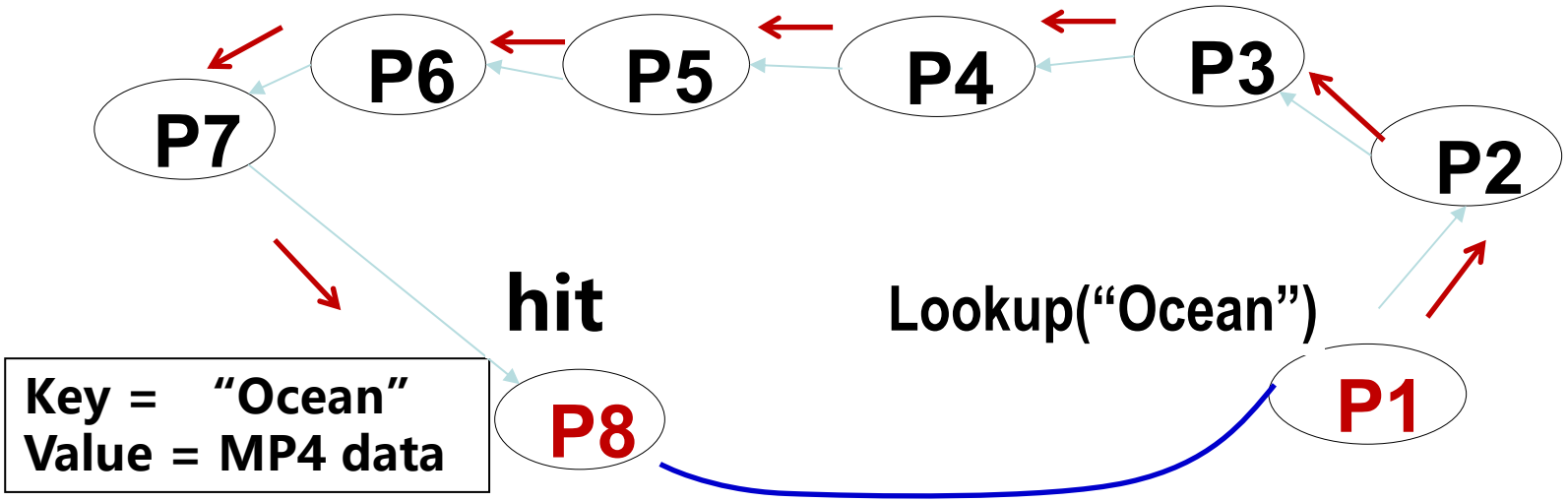
- **在第一代无结构化P2P网络中**：使用一个中心检索服务器接收所有的查询，服务器告知去哪下载其所需要的数据。



非结构化P2P网络Napster资源查找的方式

结构化P2P软件体系结构简介*

- **在第2代纯P2P网络中**：使用消息洪泛（message flooding）来定位数据。一个消息被发到系统内每一个节点，直到找到其需要的数据为止。



非结构化P2P网络Gnutella资源查找方式-有可能查不到资源

结构化P2P软件体系结构简介*

- **结构化P2P拓扑：**
- **全分布式结构化拓扑的P2P网络主要是采用分布式散列表(Distributed Hash Table, DHT)技术来组织网络中的结点，建立拓扑结构。**
- **一个对象的名字或关键词被映射为128位或160位的散列值。**
- **最经典的案例是Tapestry，Pastry，Chord和CAN技术。**

结构化P2P软件体系结构简介*

- 而DHT的主要思想是：为网络建立结构
- 用(fileName, machineIP)表示某文件在某计算机上
- 使用SHA-1作为哈希函数

  (fileName, machineIP)←→ (KID, VID)
- 每条文件索引被表示成一个(KID, VID)对，KID称为关键字，VID代表实际存储文件的节点的IP地址(+port)

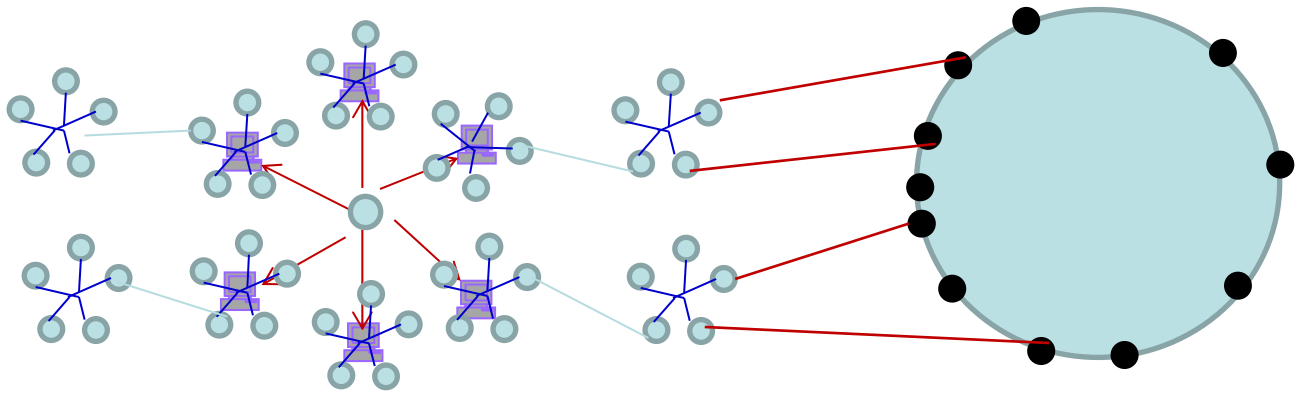
- 思想：集合{(KID, VID)}组成一张完整的文件索引哈希表。只要输入目标文件的K值，就可以从这张表中查出所有存储该文件的节点地址。

- Chord算法是全分布式结构化拓扑的一种实现。
- Chord算法

结构化P2P软件体系结构简介*

- **Chord算法**
- Chord把Node(机器的IP地址+Port)与Key (资源标识)映射到相同的空间。
- 哈希函数SHA-1会产生一个2^{160}的整数空间，每项为一个16字节（160bit）的大整数。具体地说：

  Node←→NID; Key←→KID
- 这些整数NID和KID首尾相连形成一个按大小顺时针排列的虚拟的环，称之为Chord环。



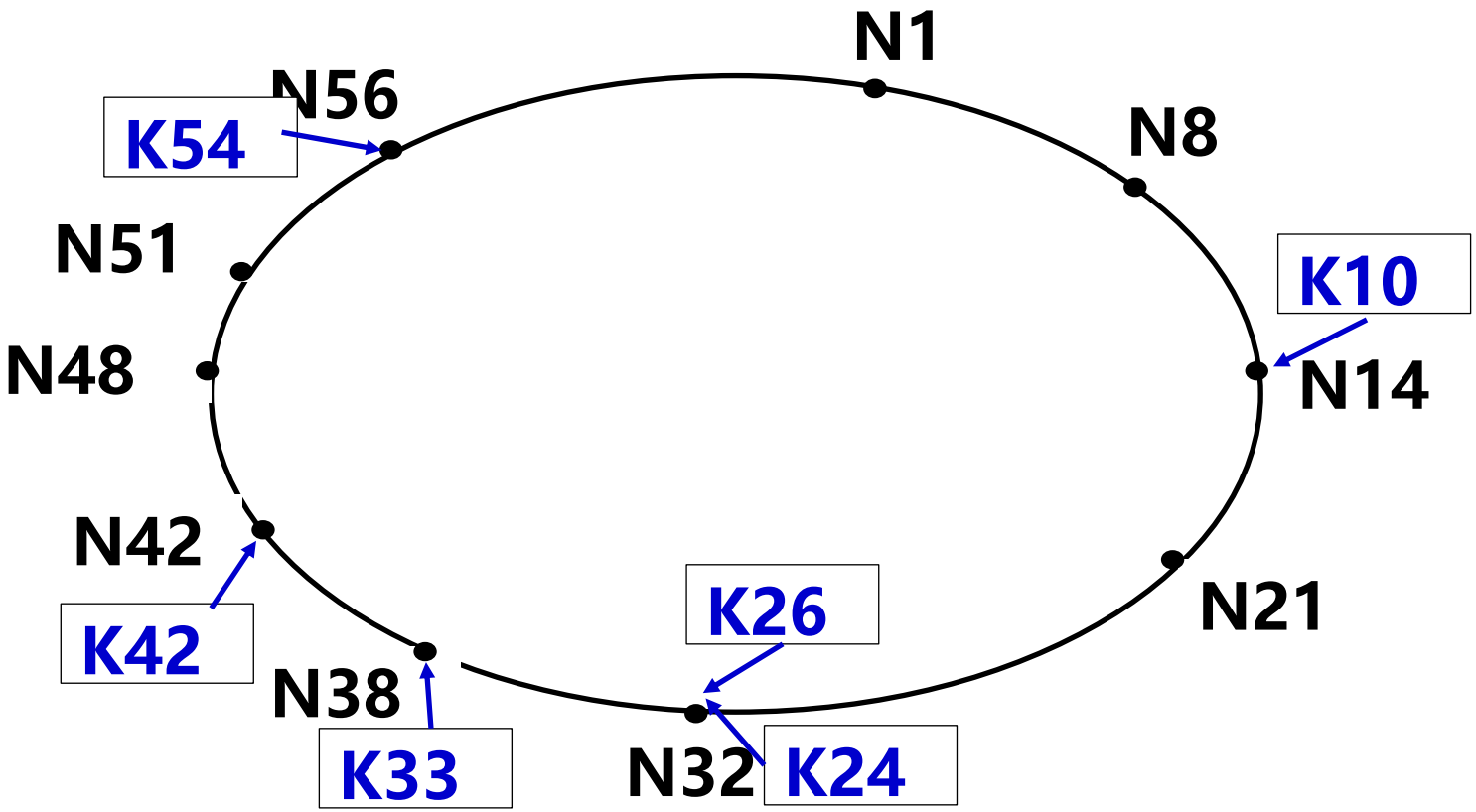
结构化P2P软件体系结构简介*

- Chord的构成：
- **节点ID**：NID(node identifier)，表示一个物理机器，是m位的一个数字，由节点机器的IP地址通过哈希操作得到；
- **资源ID**：KID（key identifiers），表示一个资源，称资源ID（或者key ID），是m位的一个数字，由fileName通过哈希操作得到。

结构化P2P软件体系结构简介*

- **Chord环(Chord Ring)的构造**：将NID和KID分配到一个大小为2^m的环上，表示资源KID被分配到NID 上。(注：在这个环上的ID为$0-2^{m-1}$)。
- **Chord环上资源的分配。资源被分配到使得NID >= KID的第一个节点（NID）上，**如下图所示。
- 这个节点称为k的后继节点，例如N14是K10的后继节点，是环上从k起顺时针方向的第一个节点，记为successor(k)，

结构化P2P软件体系结构简介*



这是一个m=6的环（2^6=64），其中有10个节点，5个资源，K10的后继节点为N14，也就是说K10被分配给了N14。这样的分配是为了能够有效地查找。

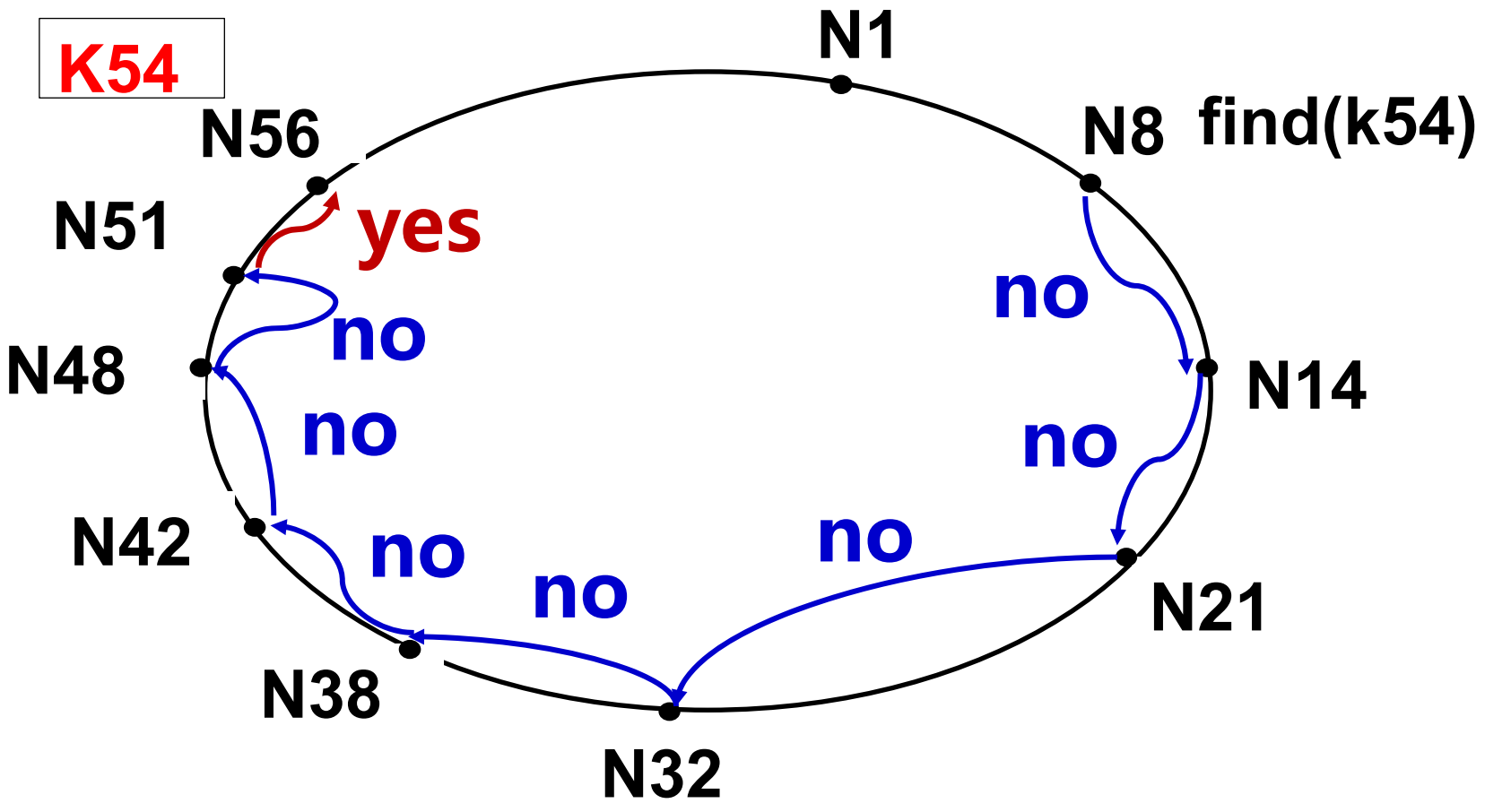
结构化P2P软件体系结构简介*

Chord资源查找

- 资源查找（定位）是Chord协议的核心功能。为了便于理解，我们介绍一个简单的资源定位方法。
- **简单方法**：考虑如下场景：节点n寻找KID=id的资源，此时节点n首先查询资源是否在下一个节点上（find_successor），即要查看资源k的KID是否在该节点NID和下一个节点的NID之间。
- 若是，则说明资源k被分配给了下一个节点，若不是则在下一个节点上发起同样的查询，问询下一个点是否有该资源。如此迭代下去。

结构化P2P软件体系结构简介*

例如下图



结构化P2P软件体系结构简介*

- 假设节点N8寻找K54这个资源
- N8.find_successor(K54)，发现54 ϵ (8; 14]不成立。
- N14.find_successor(K54)，发现54 ϵ (14; 21]不成立。
- N21.find_successor(K54)，发现54 ϵ (21; 32]不成立。
- N32.find_successor(K54)，发现54 ϵ (32; 38]不成立。
- N38.find_successor(K54)，发现54 ϵ (38; 42]不成立。
- N42.find_successor(K54)，发现54 ϵ (42; 48]不成立。
- N48.find_successor(K54)，发现54 ϵ (48; 51]不成立。
- N51.find_successor(K54)，发现54 ϵ (51; 56]成立。
- 于是得知资源K54在N56这个节点上。

结构化P2P软件体系结构简介*

- 缺点：查找速度为O(N)。
- 有改进的余地。
- Chord实际上使用了可伸缩资源定位的方式来提高效率；算法较为复杂，此课程省略。
- 由于覆盖网络采用了确定性拓扑结构，DHT可以提供精确的发现。
- 只要目的结点存在于网络中，DHT总能发现它，发现的准确性得到了保证。

Return

JXTA-P2P Protocol

JXTA Java™ Standard Edition v2.5: Programmers Guide

7. JXTA-P2P Protocol

- **What is JXTA Java?**
- **JXTA™ is a set of open, generalized peer-to-peer (P2P) protocols that allow any networked device, such as**
  - **sensors,**
  - **Cell phones,**
  - **computers, etc.,**

  to communicate and collaborate mutually as peers.

7. JXTA-P2P Protocol

JXTA™ 架构