中国科学院大学
University of Chinese Academy of Sciences

CS101

网络思维-1

名词术语，Web编程，连通性

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提纲

- 什么是网络思维
- 网络名词术语
- Web编程
  - 网页执行流程
  - 网页结构（DOM）
- 连通性
  - 名字空间
  - 网络拓扑

课件中包含教科书未包括的素材引用，特此致谢

逻辑、算法与系统回顾

- 高德纳算法定义中有两个有穷性。它们有什么区别？
- 一个算法是**一组有穷的规则**，给出求解特定类型问题的操作序列，并具备下列五个特征：
  - 有穷性。一个算法**在有限的步骤**之后必然终止。
  - …

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规则有穷性

步骤有穷性

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规则有穷性

步骤有穷性

- N比特图灵机加法
  - 规则有穷性 = ？
  - 步骤有穷性 = ？

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规则有穷性

步骤有穷性

- N比特加法图灵机
  - 规则有穷性 = 状态转移表只有有限行
  - 状态转移规则条数（行数）与N无关，小于某个常数，如50行
  - 规则有穷性 = O(1)
  - 步骤有穷性 = 在有限步骤之后总会停机
  - 一个步骤是一个状态转移
  - 执行的步骤个数与N有关，例如$O(N^3)$
  - 步骤有穷性 = $O(N^3)$

两类有穷

O(1)

O(f(N))

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  - …

规则有穷性

步骤有穷性

- N比特图灵机加法
  - 规则有穷性 = O(1)
  - 步骤有穷性 = $O(N^3)$
- N个数快速排序
  - 规则有穷性 = 程序代码行数有限 = 12行 = O(1)
  - 步骤有穷性 = 时间复杂度 = $O(N^2)$

两类有穷

O(1)

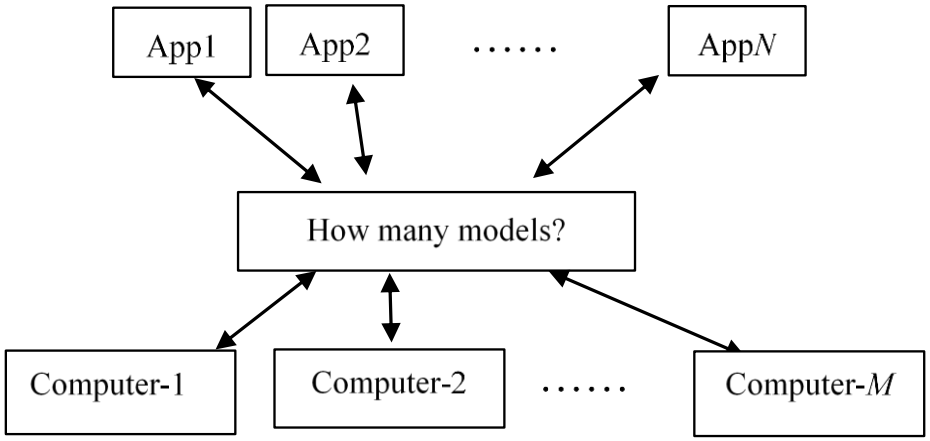
O(f(N))

为什么冯诺依曼体系结构是桥接模型，而图灵机不是？

- 本课程的300名同学们在做Go编程时，看见多少种计算机型号？

A. 1种

- 冯诺依曼模型是桥接模型（bridging model）
- 桥接应用与真实计算机
  - 针对冯诺依曼模型写的程序，可变换成真实计算机上运行的程序
  - 性能差别只有 O(1)



Millions of applications

1个抽象计算机：**von Neumann Model**

Thousand types of computers

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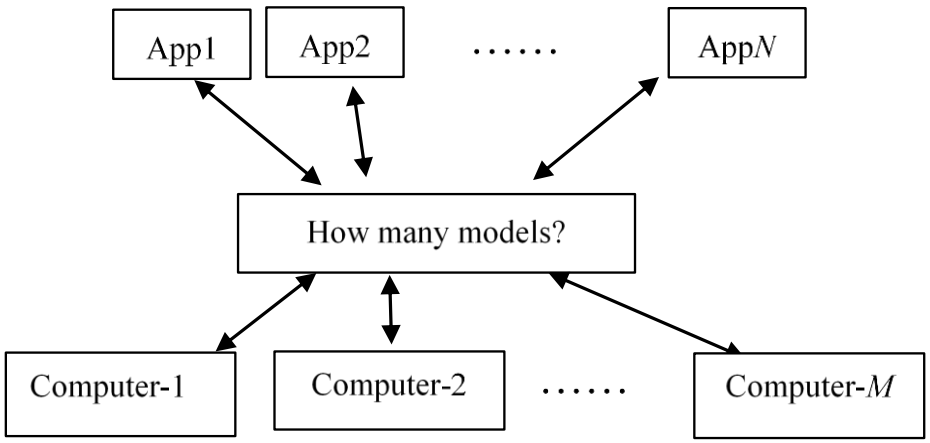
  - 性能差别只有 O(1)
  - 针对图灵机写的程序，在真实计算机上运行，性能差别可能高达 $O(N^4)$



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1. 什么是网络思维？

- 通过连通性与协议栈，研究多个节点连接而成的网络
  - Connectivity and Protocol Stack

从而创造价值

  - 发现很多有趣现象
  - 发明众多巧妙方法

- 很多问题涉及连接体，而非单体
  - 用名字空间和网络拓扑精准地描述连接体，将连接体作为计算过程的操作对象或执行系统
  - 在问题建模或解题过程中，不只使用单点做计算，而是采用连接体作为计算对象或计算系统
- 用户/数据/算法/部件的连接体

网络思维使人们发现了很多有趣现象

- E.g., what is your Erdös Number?
  - Measuring interdisciplinary nature of modern research
    - https://mathscinet.ams.org/mathscinet/freeTools.html?version=2
- Paul Erdös（爱尔迪西）, 匈牙利数学家 (1913–1996)
- “Master of Collaboration”, 1400篇论文，500合著者
- Erdös Number = 0 → Erdös himself
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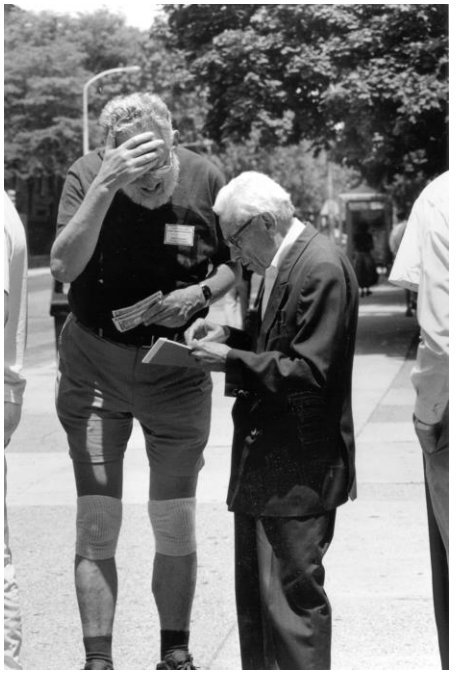
- Erdös Number = 3 → Erdös’ coauthor’s coauthor’s coauthor



金芳蓉教授网站
https://mathweb.ucsd.edu/~fan/photo/ep.html

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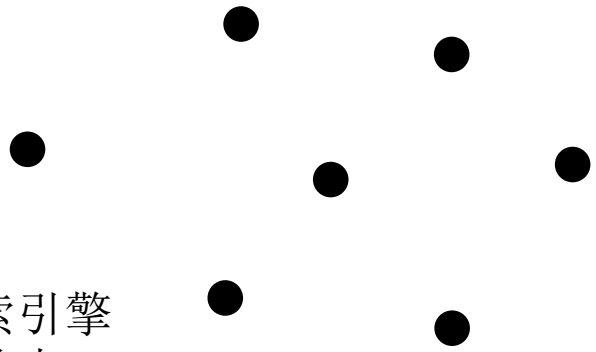
- Zhiwei Xu: 4
- Jialin Zhang: 3

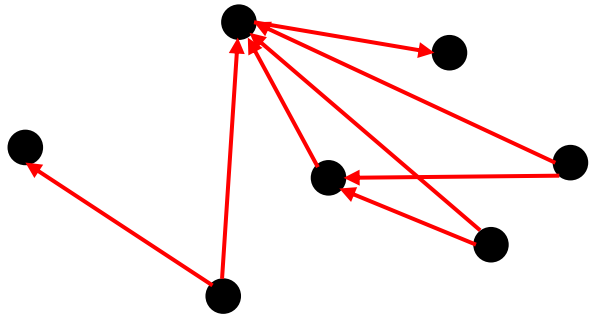
网络思维催生新概念、新方法

- 第一代 vs. 第二代搜索引擎
- 1st generation search engines
  - Computed search results by matching the keywords in search queries to the contents of webpages (*nodes*)
  - Only utilized nodes of the network of webpages
- 2nd generation search engines
  - Around 1996, Jon Kleinberg, Robin Li (李彦宏), and Larry Page observed a phenomenon:
    - Web links also significantly influence the relevance of search results
  - Utilized both nodes and interconnections to develop the 2G search engines with better results
    - More fully utilizes network thinking and created Google and Baidu, serving billions of users and generating annual revenue over $100 billion



第一代搜索引擎
只利用了节点

第二代搜索引擎
利用了节点和边



逛博物馆的反思：从学历史到pagerank

- 前几天去了Harrisburg，逛了两个博物馆…不由得想起中学时候我历史一直不好。出博物馆之后我就开始思考这个问题——我在初高中的一个误区就是，我忽略了事件之间的关系。
- 如果每件事都是一个点的话，那我的错误可能就在于，我过于注重每个点(vertex)内部的样子，却忽略了点与点之间的关系。

- 这似乎对应了网络思维中的连通性。
- 这里书中列出了两条，我觉得恰好能够对应学习历史的方法：

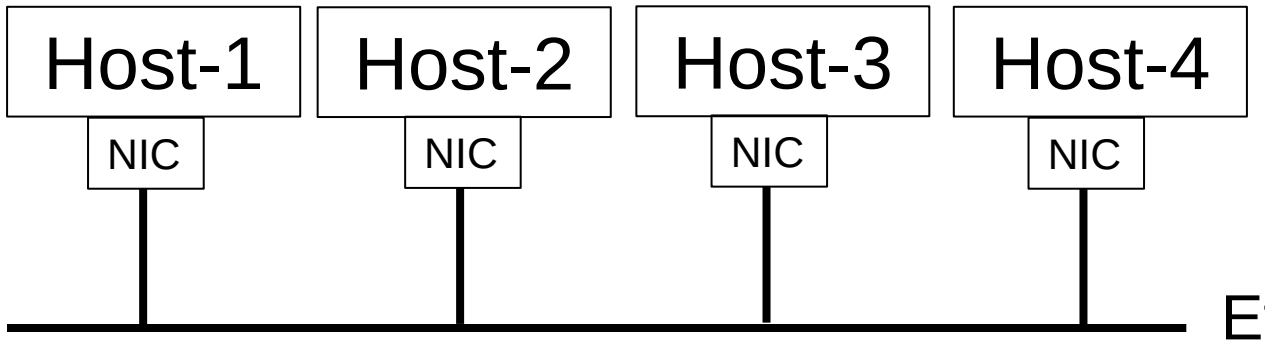
唐寅的博文
2022.05.08

国科大2017级

现在美读博士

化解冲突的巧妙方法

- Four hosts connected by an Ethernet
  - NIC (network interfacing circuitry) for networking operations
- Conflict example: Host-3与4在通信时，Host-1与2试图通信
  - Host-1 tries to send a message to Host-2, while the cable is used by Host-3 communicating with Host-4
- Exponential backoff to resolve conflict 指数退避方法
  - When first try fails, Host-1 waits for a random time in [0, T]
  - When second try fails, Host-1 waits for a random time in [0, 2T]
  - When third try fails, Host-1 waits for a random time in [0, 4T]



有冲突的连通性

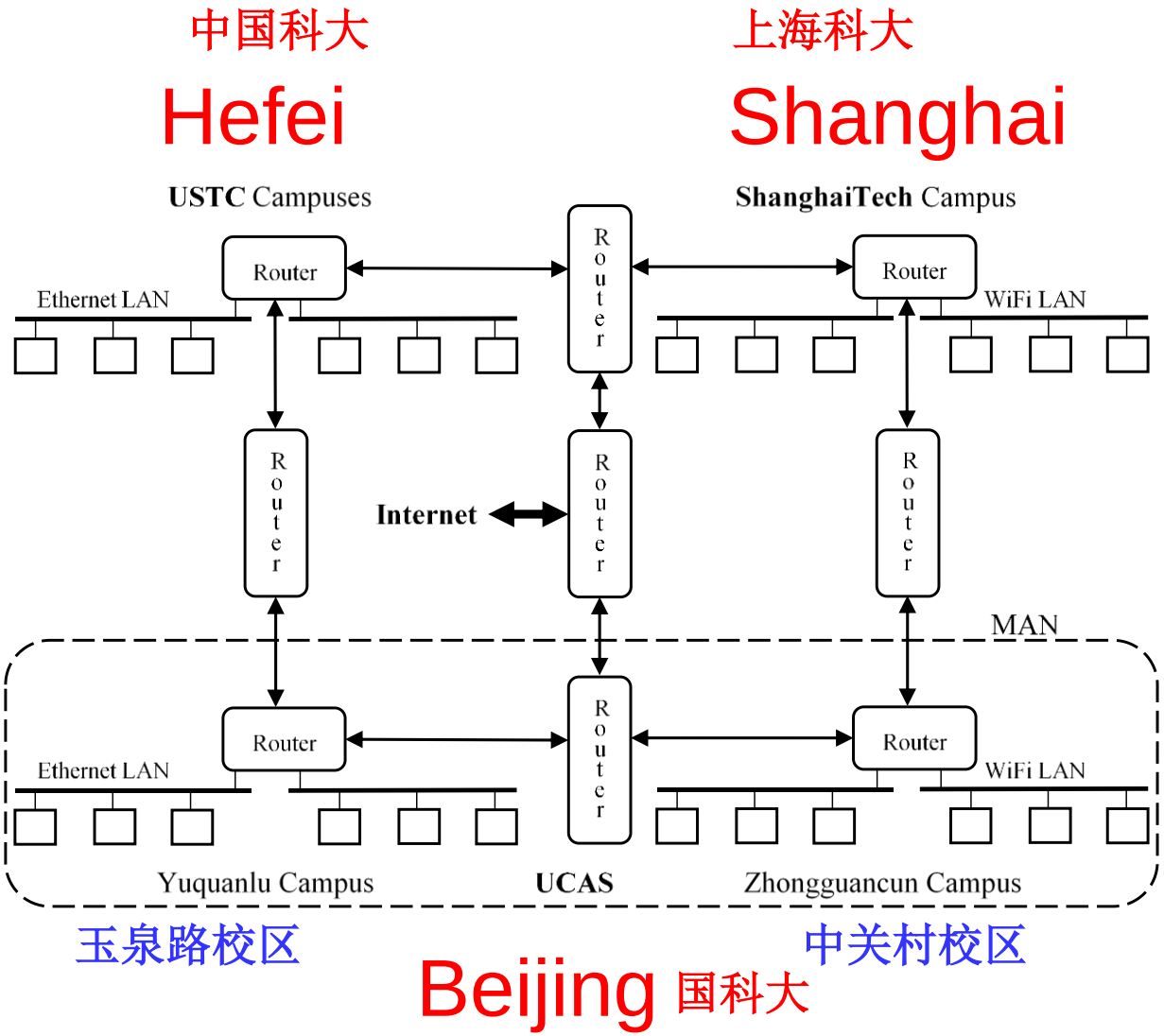
什么是网络思维？

- 通过连通性与协议栈，研究多个节点连接而成的网络
  - 很多问题涉及用户/数据/算法/部件的连接体，而非单体

- 连接体就是网络，即多个节点连接或通信的整体
  - 必有连接，可有通信
- 网络是客体（object，宾语）：文献网
  - 全球计算机科学文献网络，连接是引用；无通信
- 网络是主体（subject，主语）：机群（cluster of computers）
  - 机群 算出 文献网；机群的节点之间有通信
- 三类网络：硬件互联（interconnect）、社会网络、互联网
  - 以互联网为主要场景

2. 网络名词术语

- LAN 局域网
  Local Area Network
- MAN 城域网
  Metropolitan Area Network
- WAN 广域网
  Wide Area Network



Network terms

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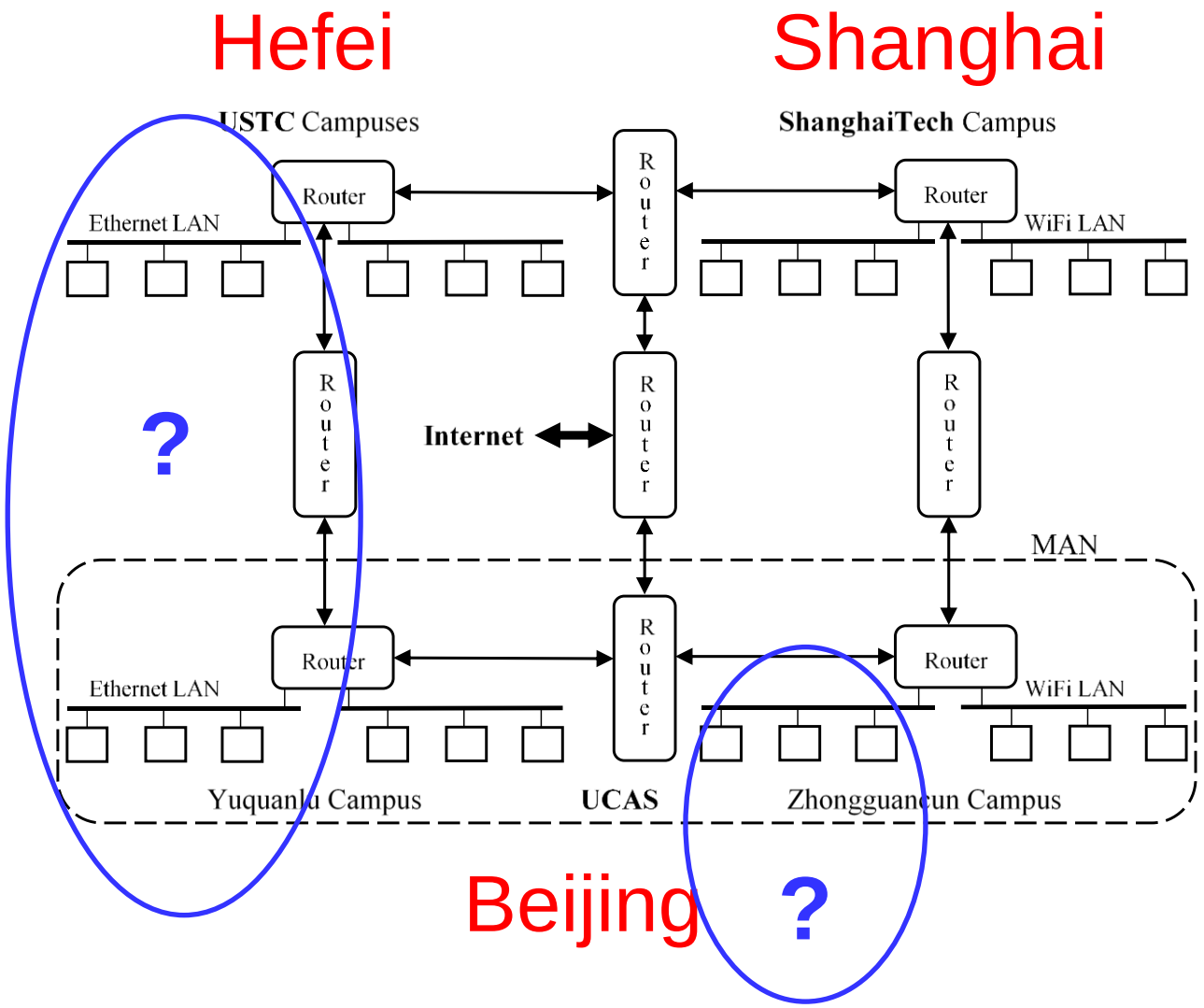
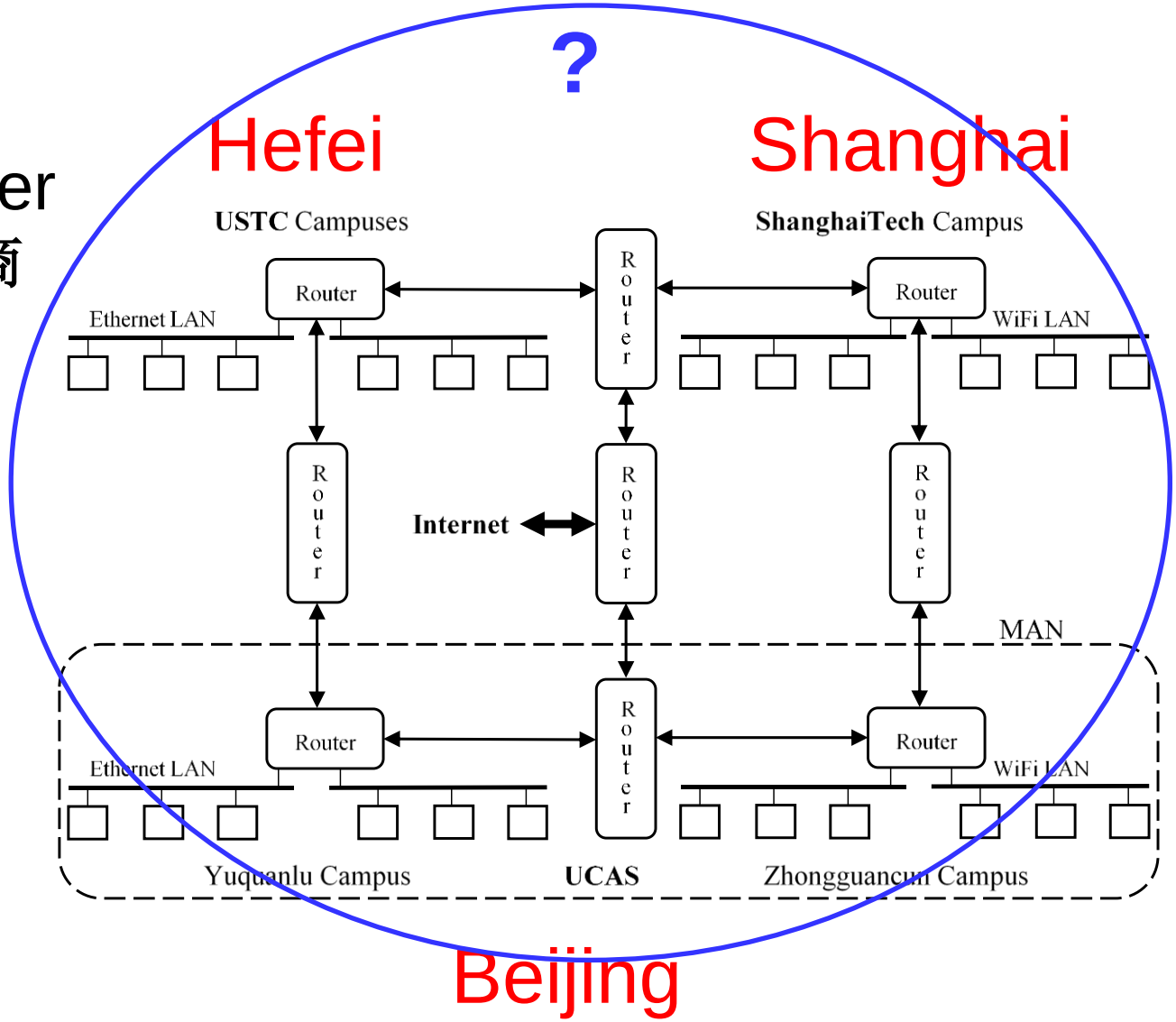


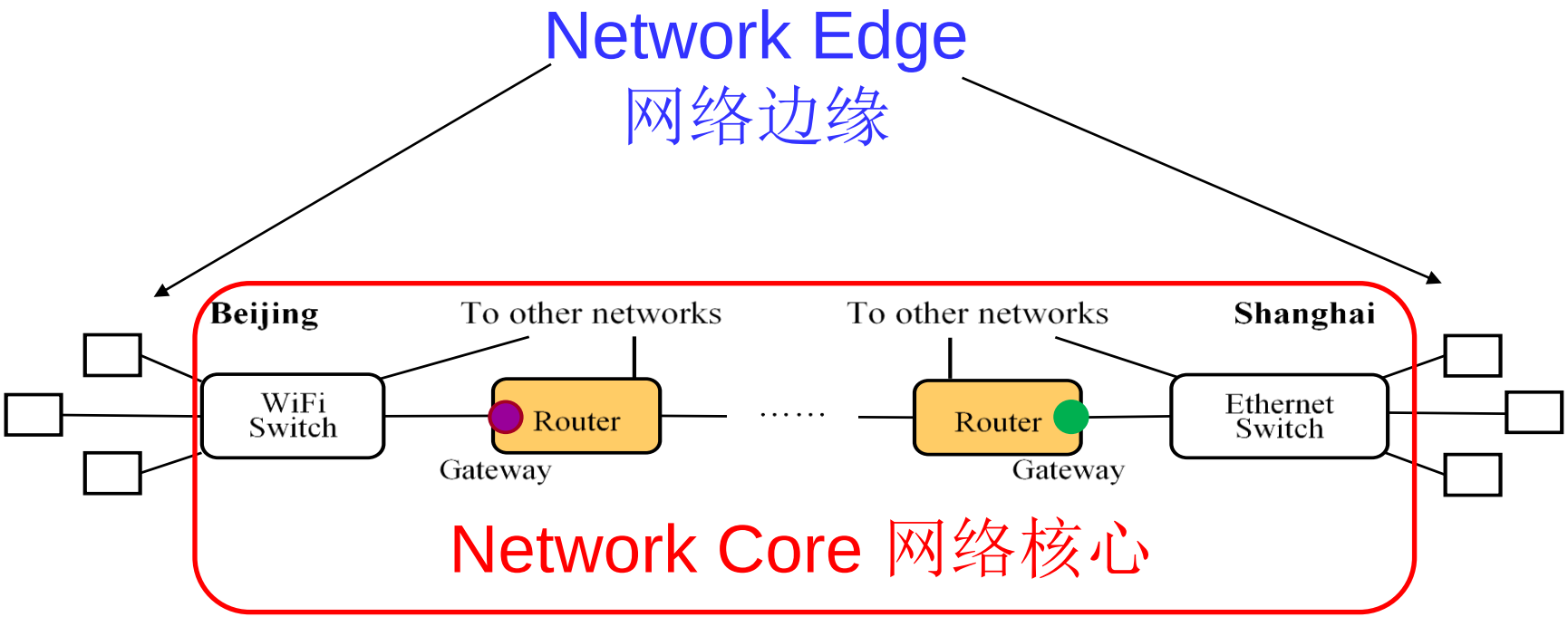
Network terms

- **ISP** Internet Service Provider
  互联网服务提供商
  - An institution providing Internet connection services
  - CSTNET for …ac.cn
  - CERNET for …edu.cn



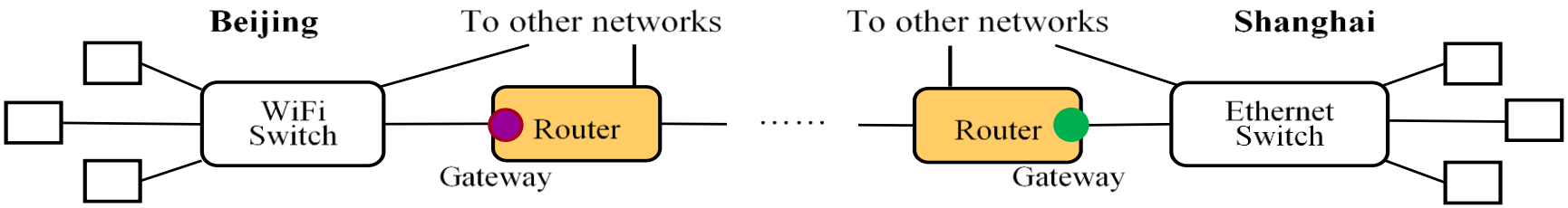
两类网络节点
宿主节点（宿主机）、组网设备节点

- Hosts: client nodes and server nodes at the network edge
  - 6 edge devices (hosts) are shown　　宿主机构成网络边缘
  - Client devices: laptop and desktop computers, smartphones, etc.　　客户端设备
  - Server devices: servers, Internet datacenters, supercomputers, etc.　　服务器设备
- Networking devices in the core of the network
  - 4 networking devices are shown　　组网设备构成网络核心



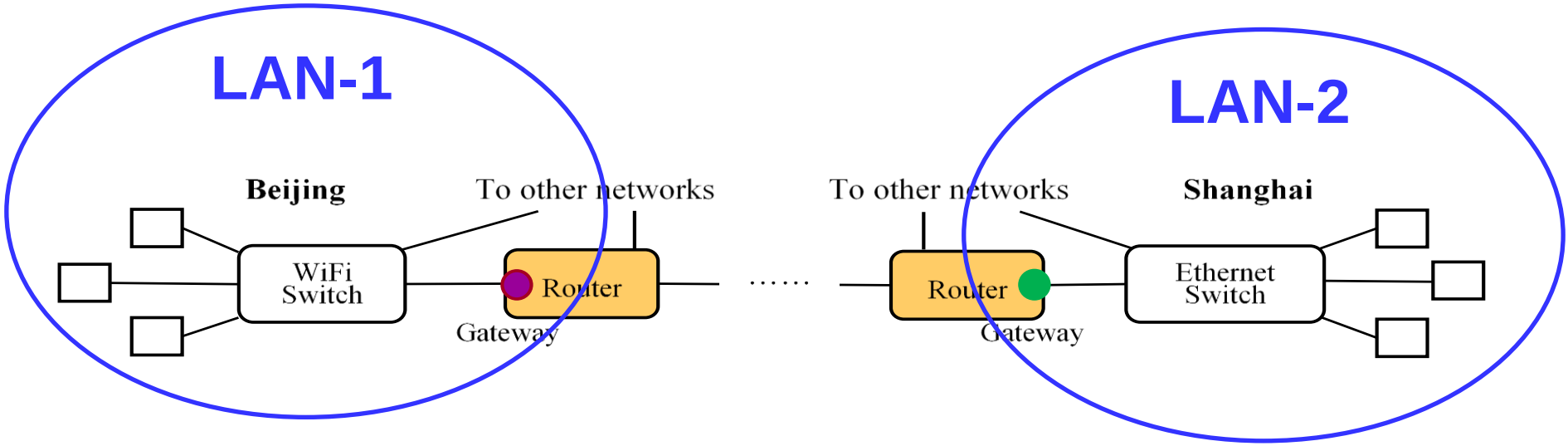
一次网络访问使用了那些网络节点?

- Zhang Lei uses her laptop in Beijing to access a supercomputer in Shanghai 张蕾使用笔记本访问上海超算
  1. Laptop computer 张蕾的笔记本电脑
  2. **AP + WiFi switch** **无线接入点、WiFi交换机（WiFi路由器）**
  3. Router at Beijing campus 位于北京国科大的路由器
  4. … 其他路由器
  5. Router at Shanghai campus 位于上海科大的路由器
  6. Ethernet switch connecting the supercomputer 上海科大的交换机
  7. Supercomputer 超级计算机



Internal network and outside network of an organization

- 网关：连接局域网与外界的路由器（端口）
- Gateway of network LAN-1 (purple)
  - The router connecting a network to the outside
    - In more detail, the port address of the router
- Gateway of network LAN-2 (green)



3. 网页编程

- HTML/CSS/JavaScript入门知识，提升学习能力
- 学习方法建议
  - 将已学到的Go编程知识拓展到Web编程
    - 注意语法不同点，例如每条语句后要加“;”
  - 通过例子学习新知识；实验课有详解，与助教一起做一遍
  - 提升自己的学习能力与创造性表达
    - 可参考往届同学个人作品库 https://www.solid.things.ac.cn:7245/web_exp

Graphics credit:
Siyue Li
50%时间创造
50%时间开发

https://teacher.solid.things.ac.cn:7243/public/web/Kitty_Band.html

万维网网址 URL

- Uniform Resource Locator 入门知识

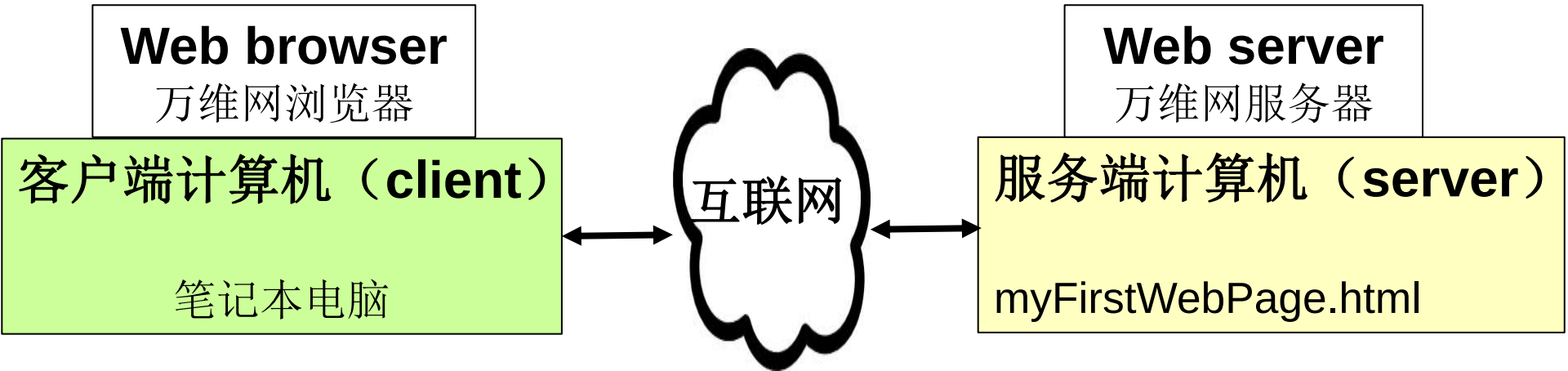
http :// **cs101.ucas.edu.cn** **/中文/**

协议 网站（域名或IP地址） 路径

- 其他协议：
  - file：访问本计算机的文件
  - ftp：访问互联网上任意计算机的文件
  - https：安全地访问Web资源
  - mailto：访问电子邮件地址

什么是Web客户端（客户机），什么是Web服务器？

- 客户机上运行浏览器，使用网址从Web服务器获取网页文件到客户机，再由浏览器处理并展示网页。（处理并展示=render）
  - 此时，Web服务器已经在运行



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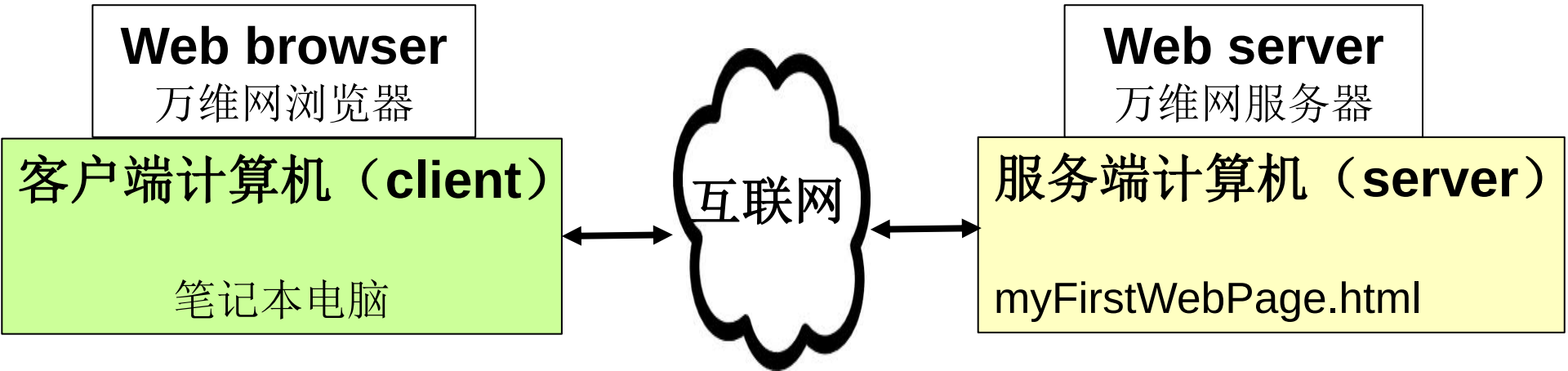
  - 此时，Web服务器已经在运行
- 浏览器：browser
- 万维网服务器：Web server
- 网址：URL http://127.0.0.1:8080/myFirstWebPage.html
- 网页：Webpage
- 网页文件：myFirstWebPage.html



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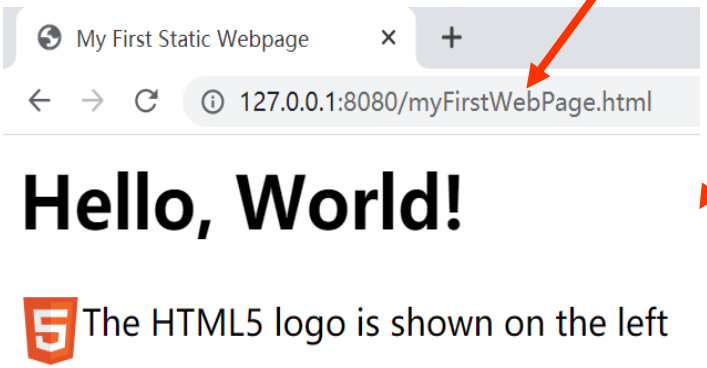
  - 此时，Web服务器已经在运行
- 客户机和服务器可以是同一台计算机（如同学的笔记本电脑）
  - Web服务器的IP地址是127.0.0.1，域名是localhost；8080是端口号




```
> cat myFirstWebPage.html
<html>
   <head>
      <meta charset="utf-8">
      <title>My First Static Webpage</title>
   </head>
   <body>
      <h1> Hello, World! </h1>
      <p>
          <img
src="https://www.w3.org/html/logo/downloads/HTML5_Badge.svg"
          style="float:left;width:30px;height:30px;">
          The HTML5 logo is shown on the left
      </p>
      <script>
      </script>
   </body>
</html>
>
```

假设客户机和服务器
都是某同学的笔记本电脑

开发你的第一个网页（静态网页）演示

- 在你电脑的Linux环境中执行WebServer.go

```
> cat WebServer.go
package main                    // WebServer.go，不支持HTTPS
import “net/http“
func main() {
   http.HandleFunc("/", func(w http.ResponseWriter, r *http.Request) {
            http.ServeFile(w, r, r.URL.Path[1:])
   })
   http.ListenAndServe(":8080", nil)
}
> go build WebServer.go
> ./WebServer &
> [1] 442
>
>
> kill 442
```

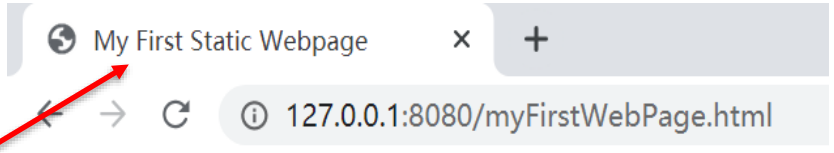
Run program WebServer in background
后台运行WebServer程序

WebServer 就绪
(442 is WebServer process ID)　进程号、进程ID

Stop WebServer
终止ID为442的进程

你的第一个网页（html文档）及其网页显示

- 在浏览器网址栏输入下列URL（网址）
  http://127.0.0.1:8080/myFirstWebPage.html
  - 127.0.0.1 is localhost

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    </script>
  </body>
</html>
>
```

网页头

网页体

Hello, World!

The HTML5 logo is shown on the left

另一个URL

HTML

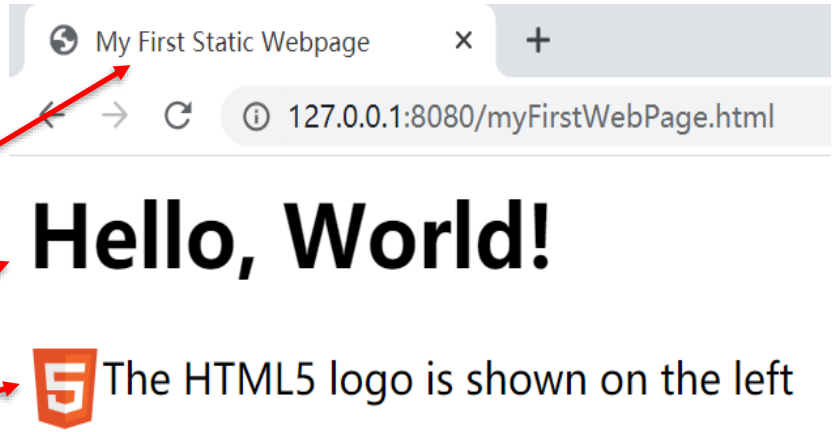
被<html> … </html>括起来

举一反三

Write your first Web program

- Enter “http://127.0.0.1:8080/myFirstWebPage.html” in a Web browser

```
> cat myFirstWebPage.html
<html>
   <head>
      <meta charset="utf-8">
      <title>My First Static Webpage</title>
   </head>
   <body>
      <h1> Hello, World! </h1>
      <p>
         <img src="https://www.w3.org/html/logo/downloads/HTML5_Badge.svg"
         style="float:left;width:30px;height:30px;">
         The HTML5 logo is shown on the left
      </p>
      <script>
      </script>
   </body>
</html>
>
```

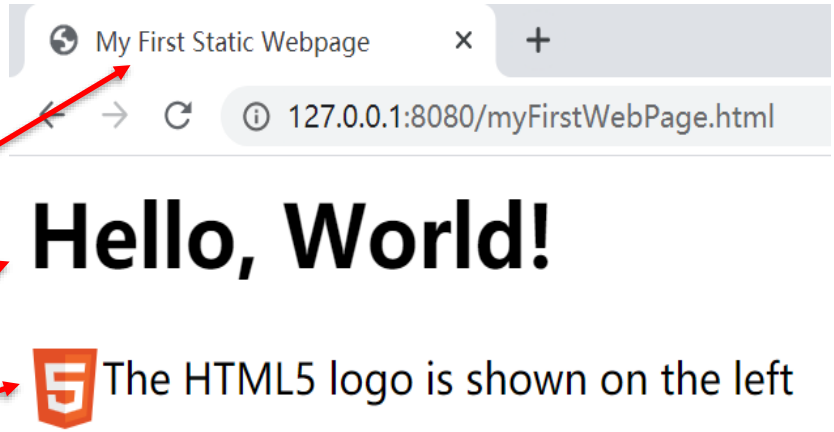


CSS 展示风格

图像浮在文字左边，30像素宽，30像素高

Write your first Web program

- Enter “http://127.0.0.1:8080/myFirstWebPage.html” in a Web browser




```
> cat myFirstWebPage.html
<html>
   <head>
      <meta charset="utf-8">
      <title>My First Static Webpage</title>
   </head>
   <body>
      <h1> Hello, World! </h1>
      <p>
         <img src="https://www.w3.org/html/logo/downloads/HTML5_Badge.svg"
         style="float:left;width:30px;height:30px;">
         The HTML5 logo is shown on the left
      </p>
      <script>
      </script>
   </body>
</html>
>
```

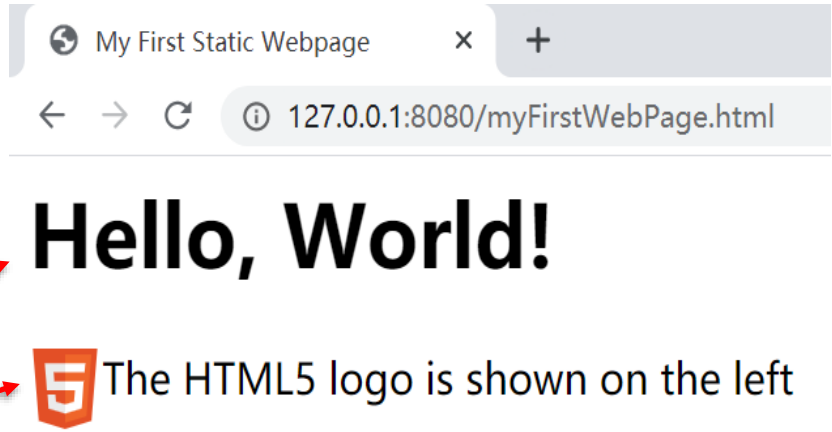
No JavaScript code in this webpage

This is a static webpage

静态网页可不用**JavaScript**

Write your first Web program

- Enter “http://127.0.0.1:8080/myFirstWebPage.html” in a Web browser
  - 127.0.0.1 is localhost




```
> cat myFirstWebPage.html
<html>
  <head>
    <meta charset="utf-8">
    <title>My First Static Webpage</title>
  </head>
  <body>
    <h1> Hello, World! </h1>
    <p>
      <img src="https://www.w3.org/html/logo/downloads/HTML5_Badge.svg"
      style="float:left;width:30px;height:30px;">
      The HTML5 logo is shown on the left
    </p>
    <script>
    </script>
  </body>
</html>
>
```

Web编程要点

- 在head里列出所有元素共性的东西
- 在body里列出网页(顺序)展示的**元素**
  - **此例子共有三个元素；p元素包含img元素**
- CSS指明元素的显示风格
- JavaScript代码操作元素（动态）

staticChildrensDay.html: code and output

- 使用JavaScript的例子

- Render the **Content** "2021.06.01";
- according to **Style** ~~60px, purple~~
- at the place indicated by **Element ID** "childrensDay"

```
> cat staticChildrensDay.html
<html>
   <head>
      <meta charset="utf-8">
      <title>Display the date of next Children's Day</title>
   </head>
   <body>
      <h1 style="text-align: center">Date of Next Children's Day</h1>
      <p style="text-align: center" id="childrensDay" ></p>
      <script>
         var x = document.getElementById("childrensDay");
         x.style.fontSize = "60px";
         x.style.color = "purple";
         x.innerHTML = "2021.06.01";
      </script>
   </body>
</html>
>
```

Element ID 元素ID

Style 风格

Content 内容

- 定义段落元素的ID = childrensDay
- 使用document.getElementById函数，使得变量x指称该段落元素
- x.style指称该段落元素的风格
- x.innerHTML指称该段落元素的内容

staticChildrensDay.html: code and output

- 加上两条风格说明

- Render the **Content** "2021.06.01";
- according to **Style** 60px, purple
- at the place indicated by **Element ID** "childrensDay"

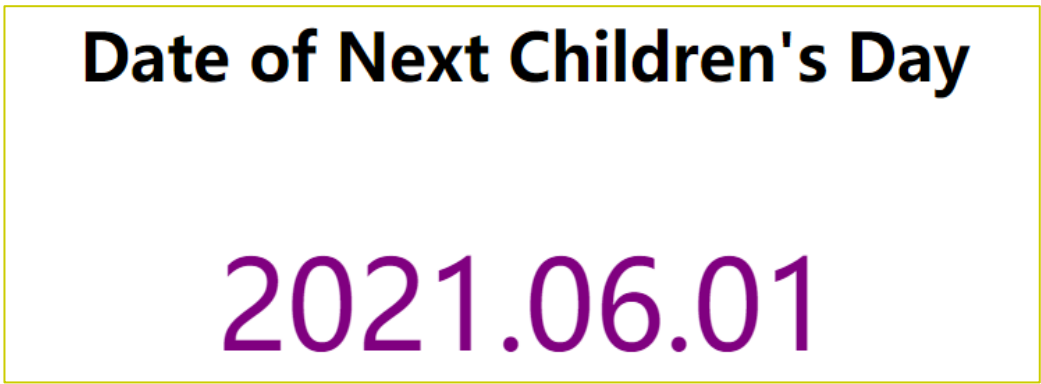
```
> cat staticChildrensDay.html
<html>
   <head>
      <meta charset="utf-8">
      <title>Display the date of next Children's Day</title>
   </head>
   <body>
      <h1 style="text-align: center">Date of Next Children's Day</h1>
      <p style="text-align: center" id="childrensDay" ></p>
      <script>
         var x = document.getElementById("childrensDay");
         x.style.fontSize = "60px";
         x.style.color = "purple";
         x.innerHTML = "2021.06.01";
      </script>
   </body>
</html>
>
```

Element ID

Style

Content

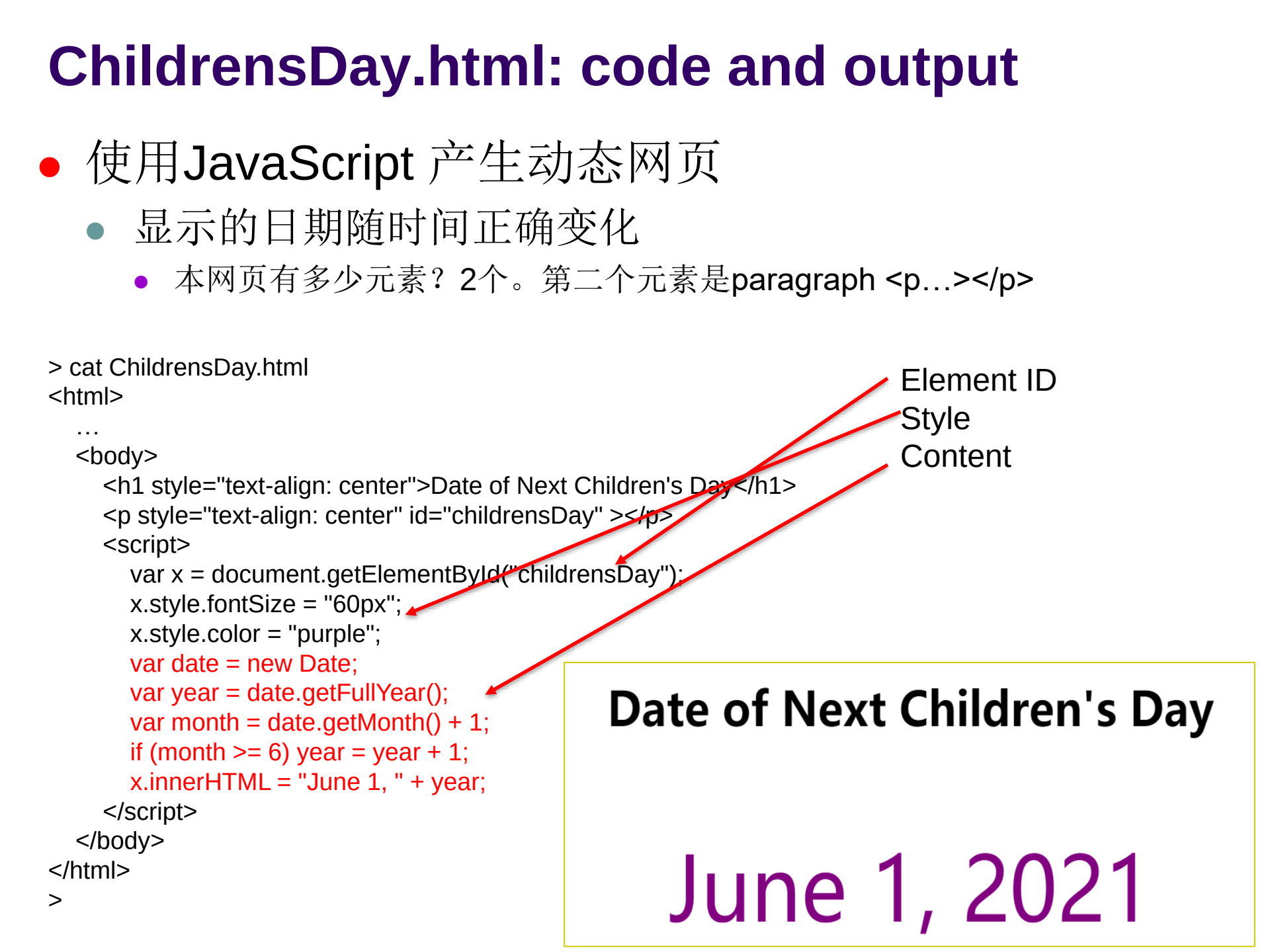
Display Content with 60 pixels font size and purple color



ChildrensDay.html: code and output

- 使用JavaScript 产生动态网页
  - 显示的日期随时间正确变化
    - 本网页有多少元素？2个。第二个元素是paragraph <p…></p>

```
> cat ChildrensDay.html
<html>
   …
   <body>
      <h1 style="text-align: center">Date of Next Children's Day</h1>
      <p style="text-align: center" id="childrensDay" ></p>
      <script>
         var x = document.getElementById("childrensDay");
         x.style.fontSize = "60px";
         x.style.color = "purple";
         var date = new Date;
         var year = date.getFullYear();
         var month = date.getMonth() + 1;
         if (month >= 6) year = year + 1;
         x.innerHTML = "June 1, " + year;
      </script>
   </body>
</html>
>
```



Date of Next Children's Day

June 1, 2021

JavaScript is an object-oriented language
JS是面向对象的语言

- 对象：将数据结构和操作数据的方法放在一个抽象中
  - Object: Data structure + methods to operate the data structure
  - 使用点记号调用某一对象的某一方法
    - Use the dot notation to access methods of an object
    - date.getMonth: call the getMonth method of the date object
    - document.getElementById: call the getElementById method of the document object

系统提供很多built-in对象，如
Date
Document
只需了解极少几个

```
<html>
<body>
<p id="myDate"></p>
<p id="myYear"></p>
<p id="myMonth"></p>
<script>
var date = new Date;
var year = date.getFullYear();
var month = date.getMonth() + 1;
document.getElementById("myDate").innerHTML = date;
document.getElementById("myYear").innerHTML = year;
document.getElementById("myMonth").innerHTML = month;
</script>
</body>
</html>
```

This Web code displays three paragraphs:
- Full information of the current date
- Current year
- Current month

Fri Apr 16 2021 19:19:50 GMT+0800 (中国标准时间)
2021
4

var date = new Date;
产生新对象并赋值（当前时刻）

Notes:
- Date is a system provided object
- document is a system provided object
- var date = new Date; create a new object
- Read textbook to see why month needs to add 1

The Web code can be rewritten as follows

- Note that the line of code
  - document.getElementById("myDate").innerHTML = date;

  is broken down into two shorter lines of code
  - var x = document.getElementById("myDate");
  - x.innerHTML = date;

Original Code

```
<html>
<body>
<p id="myDate"></p>
<p id="myYear"></p>
<p id="myMonth"></p>
<script>
var date = new Date;
var year = date.getFullYear();
var month = date.getMonth() + 1;
document.getElementById("myDate").innerHTML = date;
document.getElementById("myYear").innerHTML = year;
document.getElementById("myMonth").innerHTML = month;
</script>
</body>
</html>
```

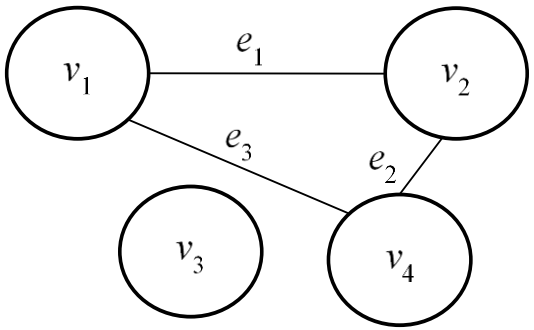
New Code

```
<html>
<body>
<p id="myDate"></p>
<p id="myYear"></p>
<p id="myMonth"></p>
<script>
var date = new Date;
var year = date.getFullYear();
var month = date.getMonth() + 1;
var x = document.getElementById("myDate");
x.innerHTML = date;
var y = document.getElementById("myYear");
y.innerHTML = year;
var z = document.getElementById("myMonth");
z.innerHTML = month;
</script>
</body>
</html>
```

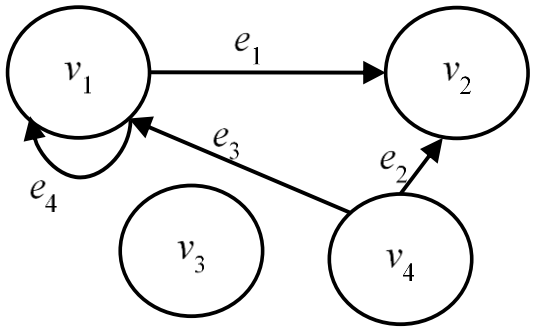
4. Connectivity (互联互通，连通性)

- Connectivity refers to the structure of a network
  - Often expressed as a graph $G =< V, E >$ of two sets
    - Set of nodes (vertices): $V = \{v_1, v_2, \ldots, v_n\}$
    - Set of edges (links): $E = \{e_1, e_2, \ldots, e_m\}$
- Connectivity studies *naming* and *topology* problems
  - Naming: How to name the nodes of a network? How to find a specific node? How to refer to a specific node? 如何命名网络的节点、发现节点、指向节点？
  - How are the nodes interconnected? Does the network structure change over time?

- Undirected
- $V = \{v_1, v_2, v_3, v_4\}$
- $E = \{e_1, e_2, e_3\}$
- Directed
- $V = \{v_1, v_2, v_3, v_4\}$
- $E = \{e_1, e_2, e_3, e_4\}$



undirected graph



directed graph

4.1 Naming 名字空间与命名

- Every network has one or more **namespaces**
  - Consisting of all names specified by a naming scheme
    - Naming scheme: a function assigning (mapping) a legitimate string to a node or an edge
  - Specified by a standards body 名字空间与命名方法由志愿者社区标准确定
    - Institute of Electrical and Electronics Engineers (IEEE) 国际电气与电子工程师协会
    - Internet Engineering Task Force (IETF) 国际互联网工程任务组
    - World Wide Web Consortium (W3C) 万维网联盟

Namespace	Instance	Remark on naming schemes
Personal name	Joan Smith	Personal names in a country
WeChat user	ZhongguanVillager	Any legitimate string per WeChat standard
URL	cs101.ucas.edu.cn/	Universal Resource Locator of a webpage
Internet site	www.ict.ac.cn	Any domain name by IETF standards
Email address	zxu@ict.ac.cn	userName@domainName
IP address	159.226.97.84	Internet Protocol address per IETF standards
Phone number	189-6666-8888	11 decimal digits by Telcom provider standards
MAC address	00-1E-C9-43-24-42	12 hexadecimal digits per IEEE standards

Naming issues and considerations

- *Uniqueness*. Does a name map to a unique node? 唯一性
  - The email address namespace enjoys uniqueness, but the namespace of personal names of a country's population does not have uniqueness. There may be multiple persons named Joan Smith, causing *name conflicts*, which in turn may lead to wrong connections.
  - 可与身份证号比较

Namespace	Name (a legitimate string)	Uniqueness
Personal name 自然人姓名	Joan Smith	?
WeChat user 微信名	ZhongguanVillager	?
URL 万维网网址	cs101.ucas.edu.cn/	?
Internet site 因特网域名	www.ict.ac.cn	?
Email address 电子邮件地址	zxu@ict.ac.cn	?
IP address IP地址	159.226.97.84	?
Phone number 手机号码	189-6666-8888	?
MAC address MAC地址	00-1E-C9-43-24-42	?

Naming issues and considerations

- *Uniqueness*. Does a name map to a unique node?
  - The email address namespace enjoys uniqueness, but the namespace of personal names of a country's population does not have uniqueness. There may be multiple persons named Joan Smith, causing *name conflicts*, which in turn may lead to wrong connections.

Namespace	Name (a legitimate string)	Uniqueness
Personal name	Joan Smith	No
WeChat user	ZhongguanVillager	No
URL	cs101.ucas.edu.cn/	Yes
Internet site	www.ict.ac.cn	Yes
Email address	zxu@ict.ac.cn	Yes
IP address	159.226.97.84	Yes
Phone number	189-6666-8888	Yes
MAC address	00-1E-C9-43-24-42	Yes

Naming issues and considerations

- *Autonomy*. Can a user create or change a name on his own? 自主性
  - Autonomy has the advantage of convenience, but may lead to chaos
  - One may change a URL, but Web links to the old URL become invalid
  - Creating or modifying a name may need to go through a centralized process
    - Involving an authority of name registry

Namespace	Name (a legitimate string)	Autonomy
Personal name	Joan Smith	?
WeChat user	ZhongguanVillager	?
URL	cs101.ucas.edu.cn/	?
Internet site	www.ict.ac.cn	?
Email address	zxu@ict.ac.cn	?
IP address	159.226.97.84	?
Phone number	189-6666-8888	?
MAC address	00-1E-C9-43-24-42	?

Naming issues and considerations

- *Autonomy*. Can a user create or change a name on his own?
  - Autonomy has the advantage of convenience, but may lead to chaos
  - One may change a URL, but Web links to the old URL become invalid
  - Creating or modifying a name may need to go through a centralized process
    - Involving an authority of name registry

Namespace	Name (a legitimate string)	Autonomy
Personal name	Joan Smith	Yes
WeChat user	ZhongguanVillager	Mostly Yes
URL	cs101.ucas.edu.cn/	Hierarchically Centralized
Internet site	www.ict.ac.cn	Hierarchically Centralized
Email address	zxu@ict.ac.cn	Hierarchically Centralized
IP address	159.226.97.84	Hierarchically Centralized
Phone number	189-6666-8888	Choose from a centralized pool
MAC address	00-1E-C9-43-24-42	Hierarchically Centralized

Naming issues and considerations

- *Friendliness*. Are the names user-friendly, i.e., understandable by humans?
  用户友好性：是否对人（用户）友好，便于用户理解？
  - The eight name schemes in Table have roughly decreasing user friendliness
  - "Joan Smith" is much more understandable than "00-1E-C9-43-24-42", which is the name of the network interface circuitry in a computer, also called MAC address

Namespace	Name (a legitimate string)	User Friendliness
Personal name	Joan Smith	Yes
WeChat user	ZhongguanVillager 中关村民	Mostly Yes
URL	cs101.ucas.edu.cn/	Somewhat friendly
Internet site	www.ict.ac.cn	Somewhat friendly
Email address	zxu@ict.ac.cn	Somewhat friendly
IP address	159.226.97.84	No
Phone number	189-6666-8888	No
MAC address	00-1E-C9-43-24-42	No

Naming issues and considerations

- *Name conversion*. An entity can have two namespaces.
  - The Internet site with domain name www.ict.ac.cn has an IP address 159.226.97.84
  - The Domain Name System (**DNS**) converts a domain name to its IP address
    DNS将互联网域名转换为IP地址
    - **http://www.ict.ac.cn → http://159.226.97.84**
  - Addresses are a special form of names, and can be used to access entities directly
- Two types of IP addresses are used today **两类IP地址**
  - **IPv4 addresses** use **32 bits** and can generate 2^{32} different IP addresses
    - Each IPv4 address is organized as a 4-field format xxx.xxx.xxx.xxx such as 159.226.97.84 IPv4地址通常写成“.”区分开的4个字段，每个从0到255
    - Each field is a decimal number from 0 to 255 159.266.97.84是非法的

Naming issues and considerations

- *Name conversion*. An entity can have two namespaces.
  - The Internet site with domain name www.ict.ac.cn has an IP address 159.226.97.84
  - The Domain Name System (**DNS**) converts a domain name to its IP address
    DNS将互联网域名转换为IP地址
    - **http://www.ict.ac.cn → http://159.226.97.84**
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    - Each field is a decimal number from 0 to 255 159.266.97.84是非法的
  - **IPv6 addresses** use **128 bits** and can generate 2^{128} different IP addresses
  - *** Each IPv6 address is an 8-field format
    xxxx.xxxx.xxxx.xxxx.xxxx.xxxx.xxxx.xxxx
    such as 2001:0db8:85a3:0000:0000:8a2e:0370:7334
  - ***IPv6地址通常写成“:”区分开的8个字段，每个包含4个Hex数

Naming issues and considerations

- *Name conversion*. An entity can have two namespaces.
  - The Internet site with domain name www.ict.ac.cn has an IP address 159.226.97.84
  - The Domain Name System (**DNS**) converts a domain name to its IP address
    DNS将互联网域名转换为IP地址
    - **http://www.ict.ac.cn → http://159.226.97.84**
  - Addresses are a special form of names, and can be used to access entities directly
- Two types of IP addresses are used today **两类IP地址**
  - **IPv4 addresses** use **32 bits** and can generate 2^{32} different IP addresses
    - Each IPv4 address is organized as a 4-field format xxx.xxx.xxx.xxx such as 159.226.97.84 IPv4地址通常写成“.”区分开的4个字段
    - Each field is a decimal number from 0 to 255 159.266.97.84是非法的
  - **IPv6 addresses** use **128 bits** and can generate 2^{128} different IP addresses
    - *** Each IPv6 address is an 8-field format xxxx.xxxx.xxxx.xxxx.xxxx.xxxx.xxxx.xxxx such as 2001:0db8:85a3:0000:0000:8a2e:0370:7334
- IPv4 addresses exhaustion occurred as of November 2019
  - There are $2^{128-32} = 2^{96}$ times as many IPv6 addresses as IPv4 addresses 2019年11月，全球IPv4地址已穷尽

万维网网址 URL

- Uniform Resource Locator 入门知识

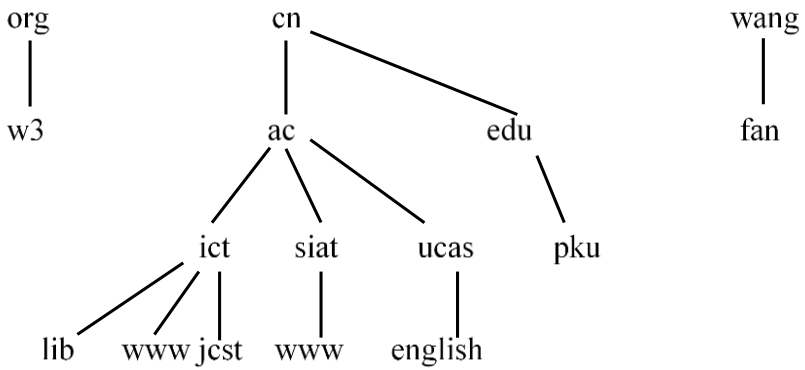
http **://** **cs101.ucas.edu.cn** **/中文/**

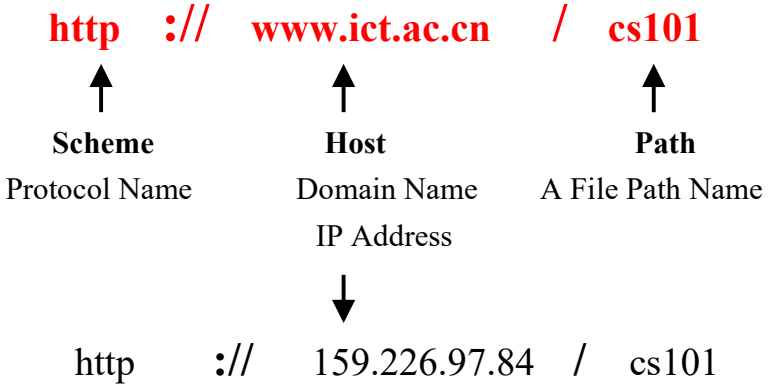
协议 网站（域名或IP地址） 路径

- 其他协议：
  - file：访问本计算机的文件
  - ftp：访问互联网上任意计算机的文件
  - https：安全地访问Web资源
  - mailto：访问电子邮件地址

Domain name hierarchy and URL

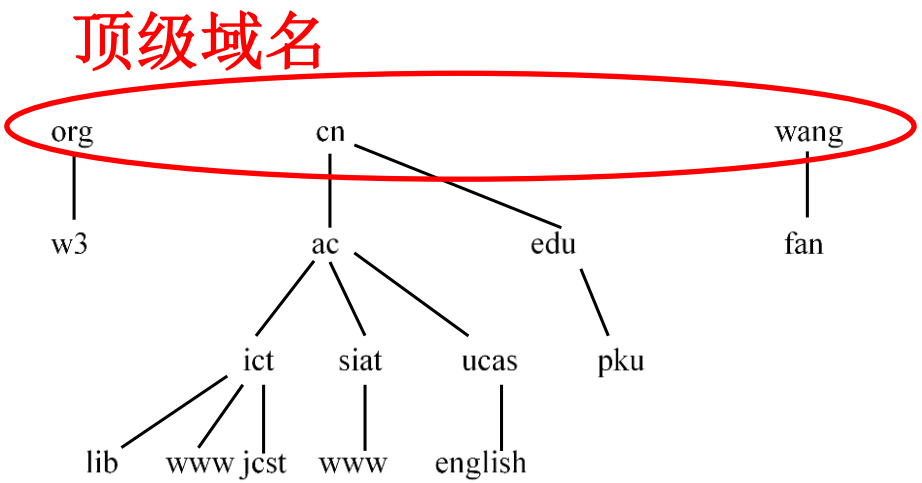
- 给定域名树，What is the URL of the homepage 首页 of the following institutions?
  - Fan Wang
  - Journal of Computer Science and Technology
  - Peking University
  - Shenzhen Institute of Advanced Technology
  - The World Wide Web Consortium
  - The University of Chinese Academy of Sciences
- Check your answers by accessing the URLs

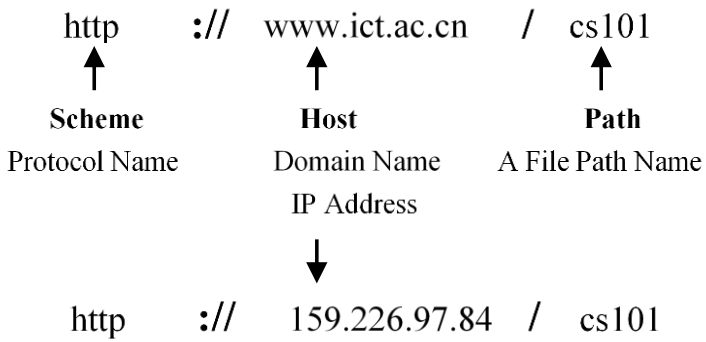




Domain name hierarchy and URL

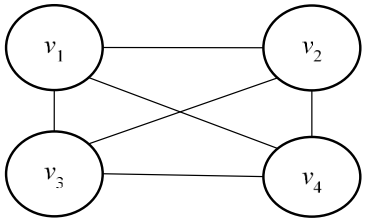
- What is the URL of the homepage of each of the following institutions? What is the top-level domain?
  - http://fan.wang/ — wang
  - http://jcst.ict.ac.cn/ — cn
  - http://pku.edu.cn/ — cn
  - http://www.siat.ac.cn/ — cn
  - http://w3.org/ — org
  - http://English.ucas.ac.cn — cn



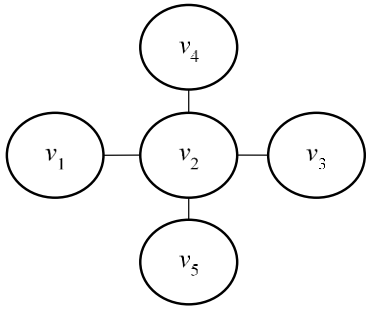


4.2 Topology 网络拓扑

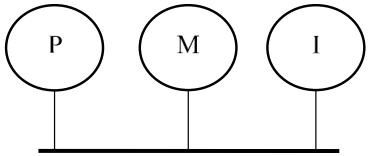
- Three types of networks 静态网络、动态网络、演化网络
  - A **static network** does not change nodes and edges
  - A **dynamic network** does not change nodes; may change edges
    - At one moment, the bus connects the processor (P) and the memory (M)
    - At the next moment, the bus connects the memory (M) and an input device (I)
      - The bus supports a *shared-media network*, while the crossbar supports a *switching network*
        总线：一对一、一对多（广播）；交叉开关：多对多
  - An **Evolutionary network** change both nodes and edges over time
    - Internet, WWW



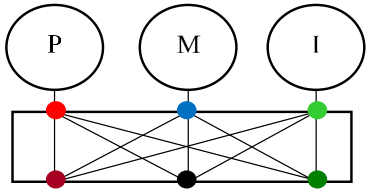
(a) A fully connected graph



(b) A star network



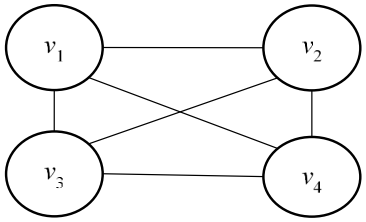
Nodes connected by (c) a bus



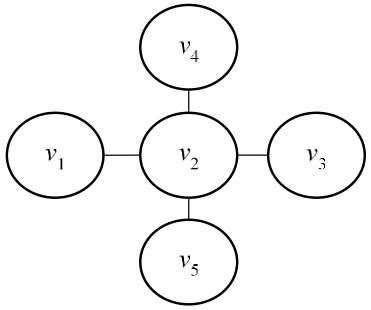
(d) a crossbar switch

***哪个网络的连通性强？

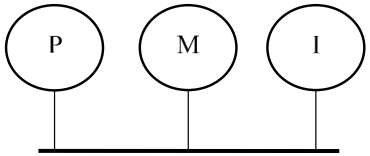
- Three types of networks　静态网络、动态网络、演化网络
  - A **static network** does not change nodes and edges
  - A **dynamic network** does not change nodes; may change edges
    - At one moment, the bus connects the processor (P) and the memory (M)
    - At the next moment, the bus connects the memory (M) and an input device (I)
      - The bus supports a *shared-media network*, while the crossbar supports a *switching network*
        总线：一对一、一对多（广播）；交叉开关：多对多
  - An **Evolutionary network** change both nodes and edges over time
    - Internet, WWW



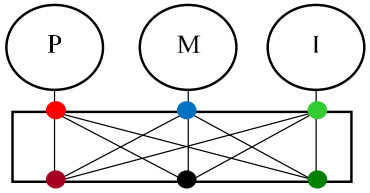
(a) A fully connected graph



(b) A star network



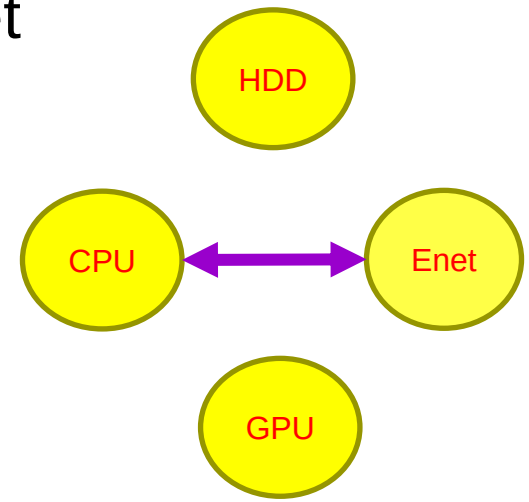
Nodes connected by (c) a bus

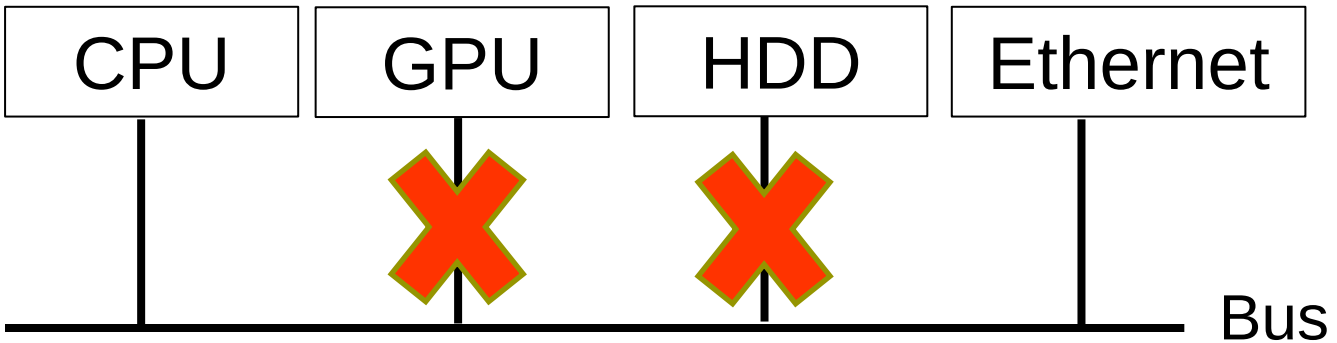


(d) a crossbar switch

How does a dynamic network work?

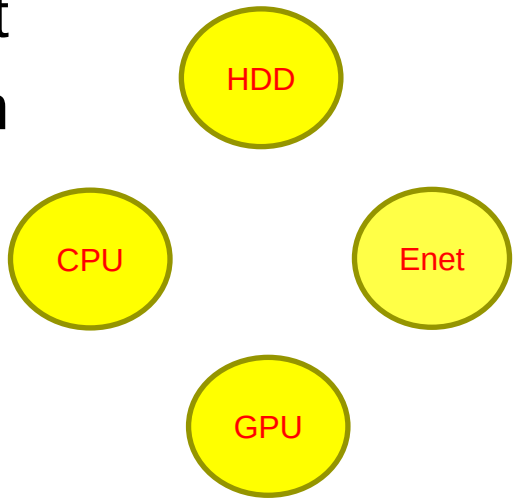
- Bus arbitration 总线仲裁例子
  - Time interval 1: CPU connects to Ethernet

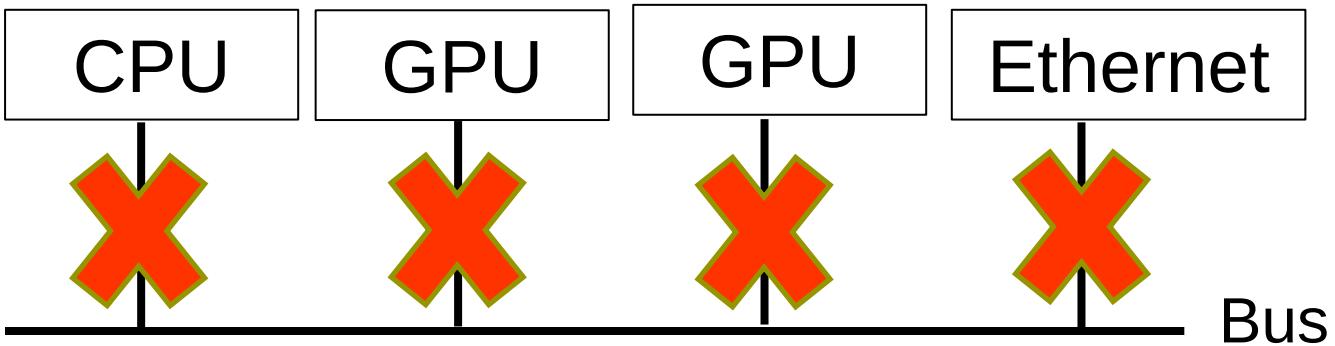




How does a dynamic network work?

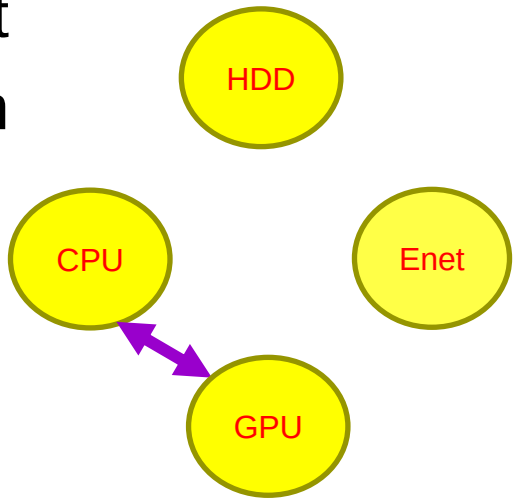
- Bus arbitration
  - Time interval 1: CPU connects to Ethernet
  - End of interval 1: Bus arbitration operation
    - Switch to a new connection

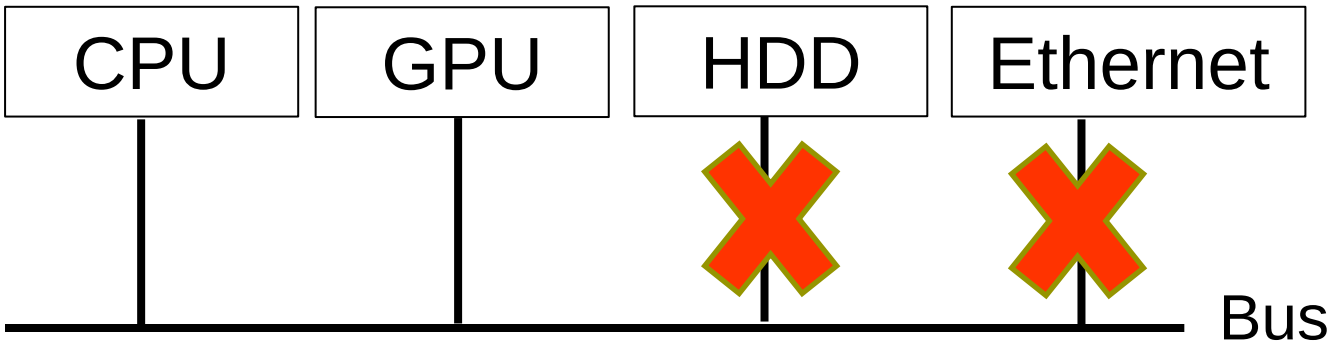




How does a dynamic network work?

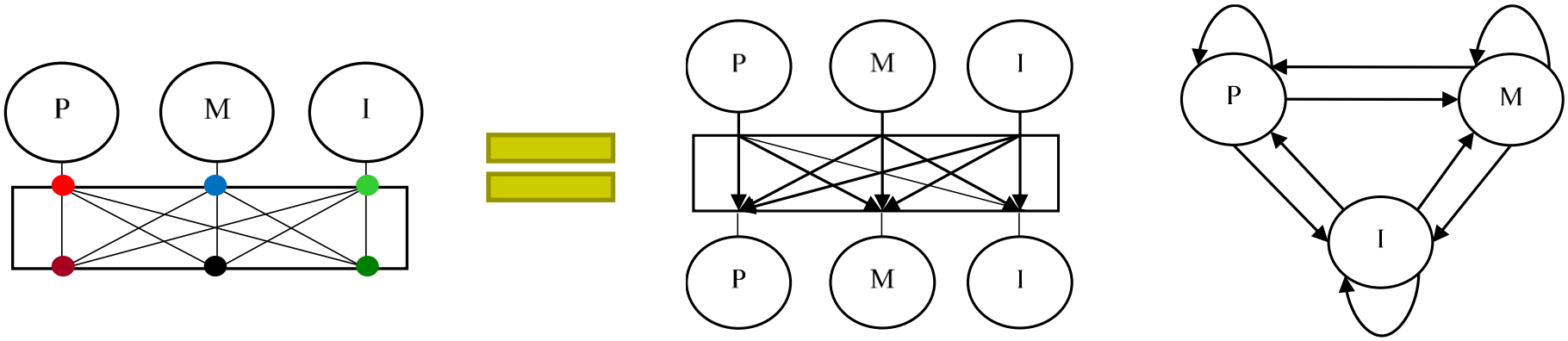
- Bus arbitration
  - Time interval 1: CPU connects to Ethernet
  - End of interval 1: Bus arbitration operation
    - Switch to a new connection
  - Time interval 2: CPU connects to GPU





Switch

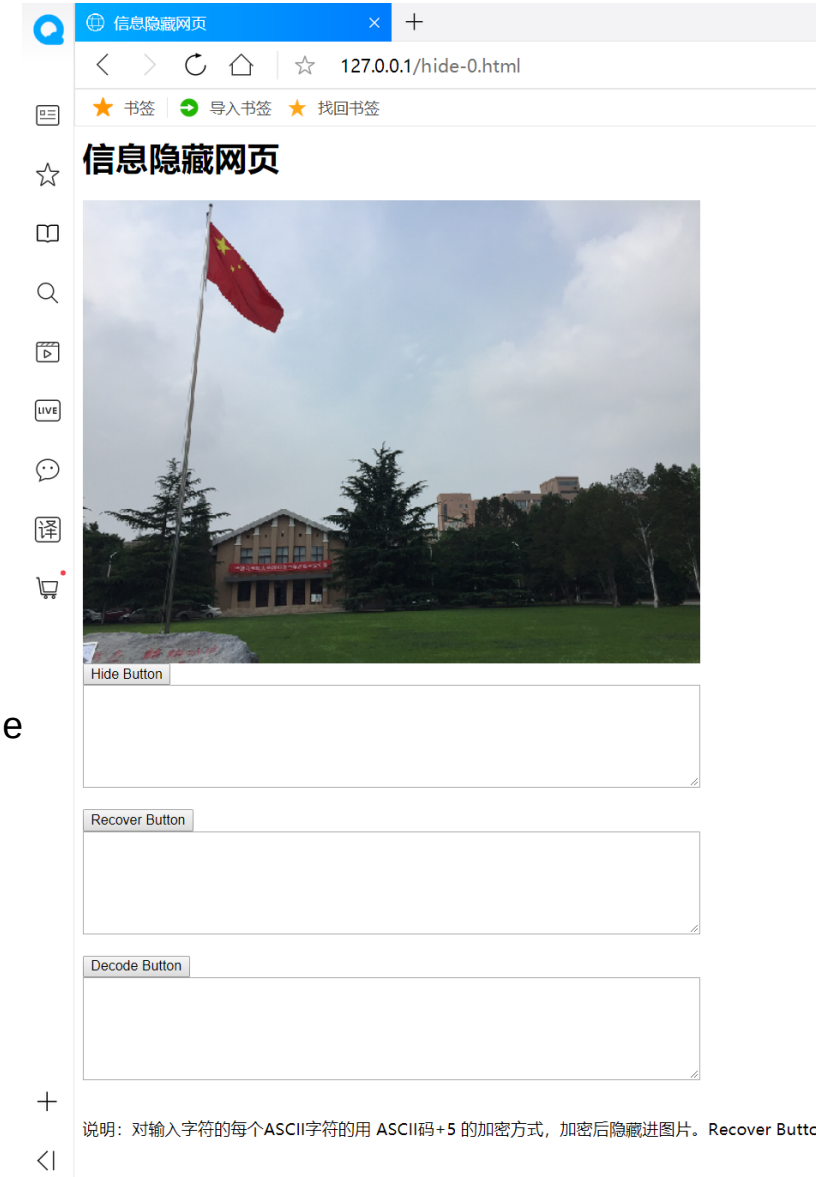
- All nodes of the network are dynamically connected
  - Switch = dynamic fully-connected network
- Can be configured to realize any connection
  - Interval 1: Permutation, {P→M, M→I, I→P}
  - Interval 2: Broadcast, {P→P, P→M, P→I}
  - Interval 3: Point-to-point, {P→M}



Other HTML elements besides paragraph

- Canvas to draw a picture

```
<body>
……
    <canvas id="myCanvas" width="600" height="450" >
    </canvas><br/>
    <input type="button" value="Hide Button"
    onclick="hide_info();"><br/>
    <textarea id="hide_text" style="width: 600; height: 100px;">
    </textarea><br/><br/>
……
    <script>
      // load the image
      var img = new Image();
      var context1 = document.getElementById("myCanvas").ge
      img.onload = function(){context1.drawImage(img,0,0);}
      img.src="./ucas.bmp";
……
    </script>
</body>
```



网页作品例子：信息隐藏

初始界面

网页作品例子：信息隐藏

输入文字后点击**Hide**按钮

图像貌似没有变化
文字确实被隐藏了

网页作品例子：信息隐藏

信息隐藏网页

127.0.0.1/hide-0.html

书签 导入书签 找回书签

信息隐藏网页

Hide Button

Your friend is your needs answered.
He is your field which you sow with love and reap with thanksgiving.
And he is your board and your fireside.
For you come to him with your hunger, and you seek him for peace.

Recover Button

^tzw%kwnjsi%nx%~tzw%sjjix%fsx|jwji3□Mj%nx%~tzw%knjqi%|mnhm%~tz%xt|%|nym%qt(j%fsi%wjfu%|nym%ymfspxln{ns17□Fsi%mj%nx%~tzw%gtfwi%fsi%~tzw%knwjxnij3□Ktw%~tz%htrj%yt%mnr%|nym%~tzw%mzsljw1%fsi%~tz%xjjp%mnr%ktw%ujfhj7□

Decode Button

点击Recover按钮
显示密文

说明：对输入字符的每个ASCII字符的用 ASCII码+5 的加密方式，加密后隐藏进图片。Recover Button显示从图片里提取出的加密后的文本；Decode Button显示从图片里提取出的解密后的文本。

网页作品例子：信息隐藏

127.0.0.1/hide-0.html

书签 导入书签 找回书签

信息隐藏网页

Hide Button

```
Your friend is your needs answered.
He is your field which you sow with love and reap with thanksgiving.
And he is your board and your fireside.
For you come to him with your hunger, and you seek him for peace.
```

Recover Button

```
^tzw%kwnjsi%nx%^tzw%sjjix%fsx|jwji3□Mj%nx%^tzw%knjqi%|mnhm%^tz%xt|%|nym%qt{j%fsi%wjfu%|nym%ymfspxln{ns17□Fsi%mj%nx%^tzw%gtfwi%fsi%^tzw%knwjxnij3□Ktw%^tz%htrj%yt%mnr%|nym%^tzw%mzsljwl%fsi%^tz%xjjp%mnr%ktw%ujfhj7□
```

Decode Button

```
Your friend is your needs answered.
He is your field which you sow with love and reap with thanksgiving2
And he is your board and your fireside.
For you come to him with your hunger, and you seek him for peace2
```

点击Decode按钮
恢复明文

127.0.0.1/hide-0.html

书签 | 导入书签 | 找回书签

信息隐藏网页

Hide Button

```
Your friend is your needs answered.
He is your field which you sow with love and reap with thanksgiving.
And he is your board and your fireside.
For you come to him with your hunger, and you seek him for peace.
```

Recover Button

```
`tzw%kwnjsi%nx%~tzw%sjjix%fsx|jwji3□Mj%nx%~tzw%knjqi%|mnhm%~tz%xt|%|nym%qt{j%fsi%wjfu%|nym%ymfspx1n{ns17□Fsi%mj%nx%~tzw%gtfwi%fsi%~tzw%knwjxnij3□Ktw%~tz%htrj%yt%mnr%|nym%~tzw%mzsljwl%fsi%~tz%xjjp%mnr%ktw%ujfhj7□
```

Decode Button

```
Your friend is your needs answered.
He is your field which you sow with love and reap with thanksgiving2
And he is your board and your fireside.
For you come to him with your hunger, and you seek him for peace2
```

```
<html>
  <head>
    <meta charset="UTF-8">
    <title>信息隐藏网页</title>
  </head>
  <body>
    <h1>信息隐藏网页</h1>
    <canvas id="myCanvas" width="600" height="450" ></canvas><br/>
    <input type="button" value="Hide Button" onclick="hide_info();"><br/>
    <textarea id="hide_text" style="width: 600; height: 100px;"></textarea><br/><br/>
    <input type="button" value="Recover Button" onclick="show_info(0);"><br/>
    <textarea id="show_info_0" style="width: 600px; height:
100px;"></textarea><br/><br/>
    <input type="button" value="Decode Button" onclick="show_info(1);"><br/>
    <textarea id="show_info_1" style="width: 600px; height:
100px;"></textarea><br/><br/>
    <p>
      说明：对输入字符的每个ASCII字符用 ASCII码+5 的加密方式，加密后隐藏进图片。Recover Button显示从图片里提取出的加密后的文本；Decode Button显示从图片里提取出的解密后的文本。
    </p>
    <script>
      // load the image
      var img = new Image();
      var context1 = document.getElementById("myCanvas").getContext("2d");
      img.onload = function(){context1.drawImage(img,0,0);}
      img.src="./ucas.bmp";
……
    </script>
  </body>
</html>
```

More details on next page

说明：对输入字符的每个ASCII字符的用 ASCII码+5 的加密方式，加密后隐藏进图片。Recover Button显示从图片里提取出的加密后的文本；Decode Button显示从图片里提取出的解密后的文本。

```
func modify(data int, array []byte, size int) {
  for i := 0; i < size; i++ {
     v := byte(data & 0x3)
     array[i] = array[i] & 0xFC
     array[i] = array[i] | v
     data = data >> 2
  }
}
```

Go Code

```
func main() {
  txt_path                          := "./Richard_Karp.txt"
  src_img_path                      := "./ucas.bmp"
  dest_img_path                     := "./modified_ucas.bmp"
  d, _ := ioutil.ReadFile(src_img_path)              // read ucas.bmp into d
  t, _ := ioutil.ReadFile(txt_path)  // read Richard_Karp.txt into t
  modify(len(t), d[S : S+T], T)      // hide   length of Richard_Karp.txt
  for i:=0; i<len(t); i++{           // hide contents of Richard_Karp.txt
     offset := S+T+(i*4)
     modify(int(t[i]),d[offset:offset+C],C)
  }
  ioutil.WriteFile(dest_img_path, d, 0666)  // output to mofified_ucas.bmp
}
```

Go Code

书签 | 导入书签

信息隐藏网页

Hide Button

```
Your friend is your needs answered.
He is your field which you sow with love and reap with thanksgiving.
And he is your board and your fireside.
For you come to him with your hunger, and you seek him for peace.
```

Recover Button

```
^tzw%kwnjsi%nx%~tzw%sjjix%fsx|jwji3□Mj%nx%~tzw%knjqi%|mnhm%~tz%xt|%|nym%qt{j%fsi%wjfu%|nym%ymfspx1n{ns17□Fsi%mj%nx%~tzw%gtfwi%fsi%~tzw%knwjxnij3□Ktw%~tz%htrj%yt%mnr%|nym%~tzw%mzsljwl%fsi%~tz%xjjp%mnr%ktw%ujfhj7□
```

Decode Button

```
Your friend is your needs answered.
He is your field which you sow with love and reap with thanksgiving2
And he is your board and your fireside.
For you come to him with your hunger, and you seek him for peace2
```

```
function hide_info(){
   // 1. get original pixel_array
   var context1 = document.getElementById("myCanvas").getContext("2d");
   var img_data = context1.getImageData(0,0,600,450);
   var pixel_array = img_data.data;
   // 2. get input string
   var str = document.getElementById("hide_text").value;
   // 3. hide length
   modify(str.length, pixel_array, 16, 0);
   // 4. hide string
   for(var i=0;i<str.length; i++){
      var ch = str[i].charCodeAt() + 5;       // +5是加密操作
      modify(ch, pixel_array, 4, 16+4*i);
   }
   // 5. show modified image
   context1.putImageData(img_data,0,0);
}
function modify(data, array, size, left) {
   for (var i = left; i < left+size; i++) {
      var v = data & 0x3;              // retain last 2 bits of data
      array[i] = array[i] & 252;       // clear last 2 bits of array[i]
      array[i] = array[i] | v;         // set last 2 bits of array[i] with those of data
      data = data >> 2;                // repeat with the next 2 bits
   }
}
```

JavaScript Code

说明：对输入字符的每个ASCII字符的用 ASCII码+5 的加密方式，加密后隐藏进图片。Recover Button显示从图片里提取出的加密后的文本；Decode Button显示从图片里提取出的解密后的文本。