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

CS101

Network Thinking

Network Terms
网络思维的基本名词术语

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Outline

- What is network thinking?
- Network terms
- Connectivity
  - Naming
  - Topology
- Protocol stack
  - The Web over TCP/IP stack
  - Web programming
- Network laws
  - Performance metrics
  - Network effect
- Responsible computing

These slides acknowledge sources for additional data not cited in the textbook

1. What is network thinking

- A brief history of computer networks
  - Note the never-stopping changes and evolution of
    - what are connected and what are passed (communicated)

Start Time	Milestone	Main Functions
Late 1800's	Telecommunication networks	Telephony, telegraph
1963	J. C. R. Licklider proposed the concept of Intergalactic Computer Network	A general idea of computer networks
1969	First messages sent over ARPANET (50 Kbps = 50 Kilo bits per second)	Message passing, packet switching, interface HW
1974	TCP/IP	Internetworking (Internet) with telnet, ftp, email applications
1989	World Wide Web	Even more applications enabled by global-scale hypertexting
2000	Network science, grid, cloud computing	Various networks as the object of scientific inquiry, utility computing
2007	Apple iPhone	Mobile Internet
2008	Bitcoin	Blockchain, network of trust

What is network thinking

- 通过连通性与协议栈，研究连接多个节点的网络，创造价值
- A computational process may involve not just one entity, but also a group of interconnected entities
  - Which may refer to or communicate with one another
  - Use naming to refer to entities
  - Use a protocol stack to communicate
- An entity may be an abstract or real entity regarding a computer, a person, or a thing
  - A thing could be a physical thing, a document, an idea, or a concept
- The group of interconnected entities is called a network
  - The entities are called the nodes of the network

What is network thinking

- Network: a group of interconnected entities
  - The total of nodes and interconnections 网络是节点连接或通信的整体
  - Example: all articles on computing form a network of computer science literature 全球计算机科学文献网络，连接是引用；无通信
    - Nodes (articles) are interconnected by citations
    - Note: the nodes may refer to one another, but do not necessarily communicate with one another by sending or receiving messages
- Treat a network as an *object* 网络是客体：文献网
  - E.g., study the ranks of articles in the network of computer science literature
- Treat a network as a *subject* 网络是主体：机群
  - E.g., a network of computers (cluster) is used to compute the ranks of all articles by their number of citations

    机群 算出 文献网；机群的节点之间有通信

    主语 动词 宾语
- A new perspective to look at problems and can lead to innovative solutions
  - Network thinking brings new value

Interesting phenomena

- Many interesting phenomena have been observed with network thinking
  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 is a Hungarian mathematician (1913–1996)
    - "Master of Collaboration"
    - Erdös Number = 3 → Paul Erdös is your coauthor's coauthor's coauthor

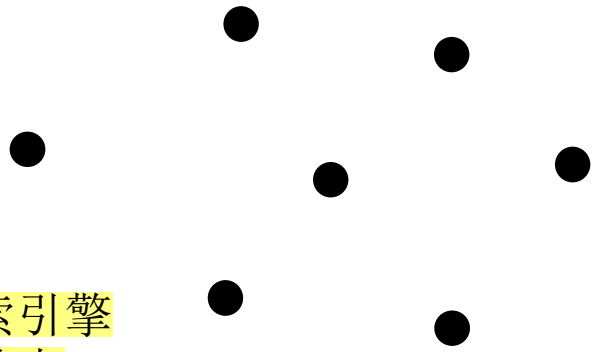
    - Zhiwei Xu: Erdös Number = ? 做计算机系统的
    - Jialin Zhang: Erdös Number = ? 做计算机理论的

Smart concepts and methods
以及很妙的新概念、新方法

- Many interesting phenomena have been observed with network thinking
  - E.g., what is your Erdös Number
    - Zhiwei Xu: 4
    - Jialin Zhang: 3
- Many smart concepts and methods have been discovered with network thinking
  - Pageranking 更有效的网络搜索方法
    - An application software example
  - Exponential backoff 解决冲突的指数退避方法
    - A network hardware example

Example: 1G vs. 2G search engines

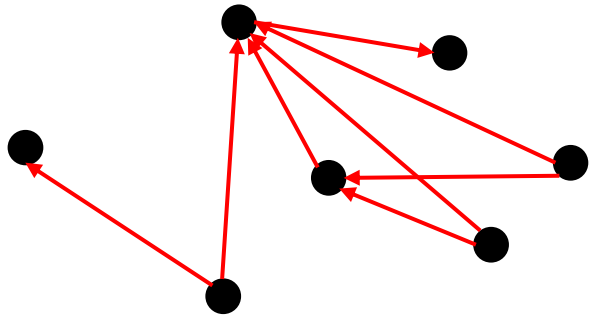
- 1st generation search engines
  - Computed search results by matching the keywords in search queries to the contents of webpages (*nodes*)
  - Only utilized nodes of the network of webpages



第一代搜索引擎
只利用了节点

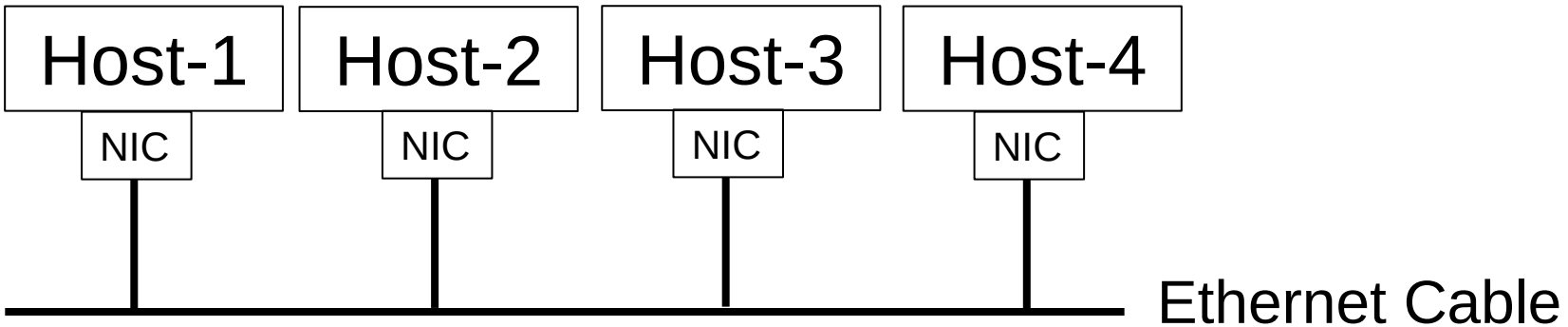
- 2nd generation search engines
  - Around 1996, Jon Kleinberg, Robin Li (李彦宏), and Larry Page observed a phenomenon:
    - Web links also significantly influence the relevance of search results
  - Utilized both nodes and interconnections to develop the 2G search engines with better results
    - More fully utilizes network thinking and created Google and Baidu, serving billions of users and generating annual revenue over $100 billion

第二代搜索引擎
利用了节点和边



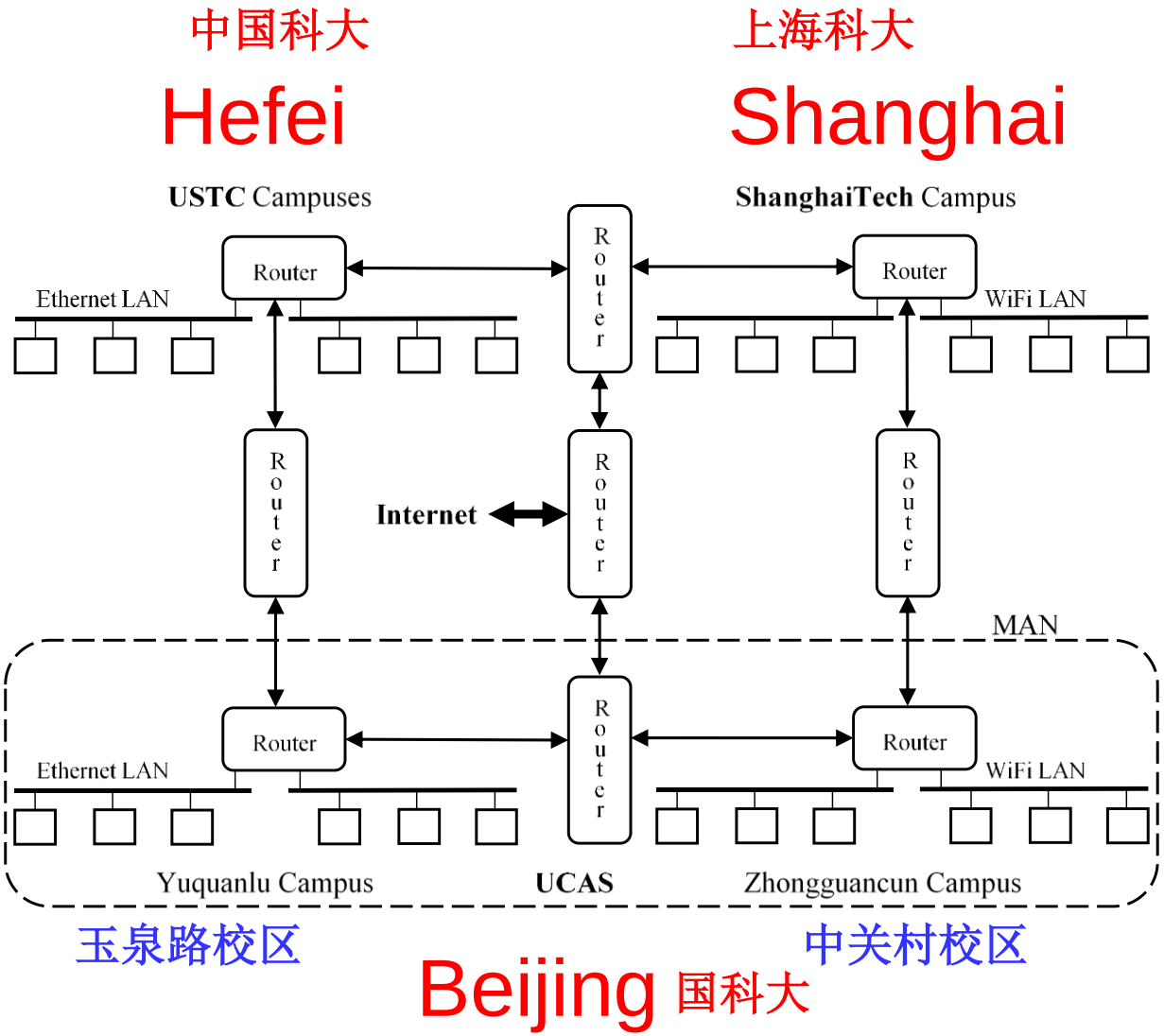
A smart way to resolve conflicts

- 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]



2. Network terms

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



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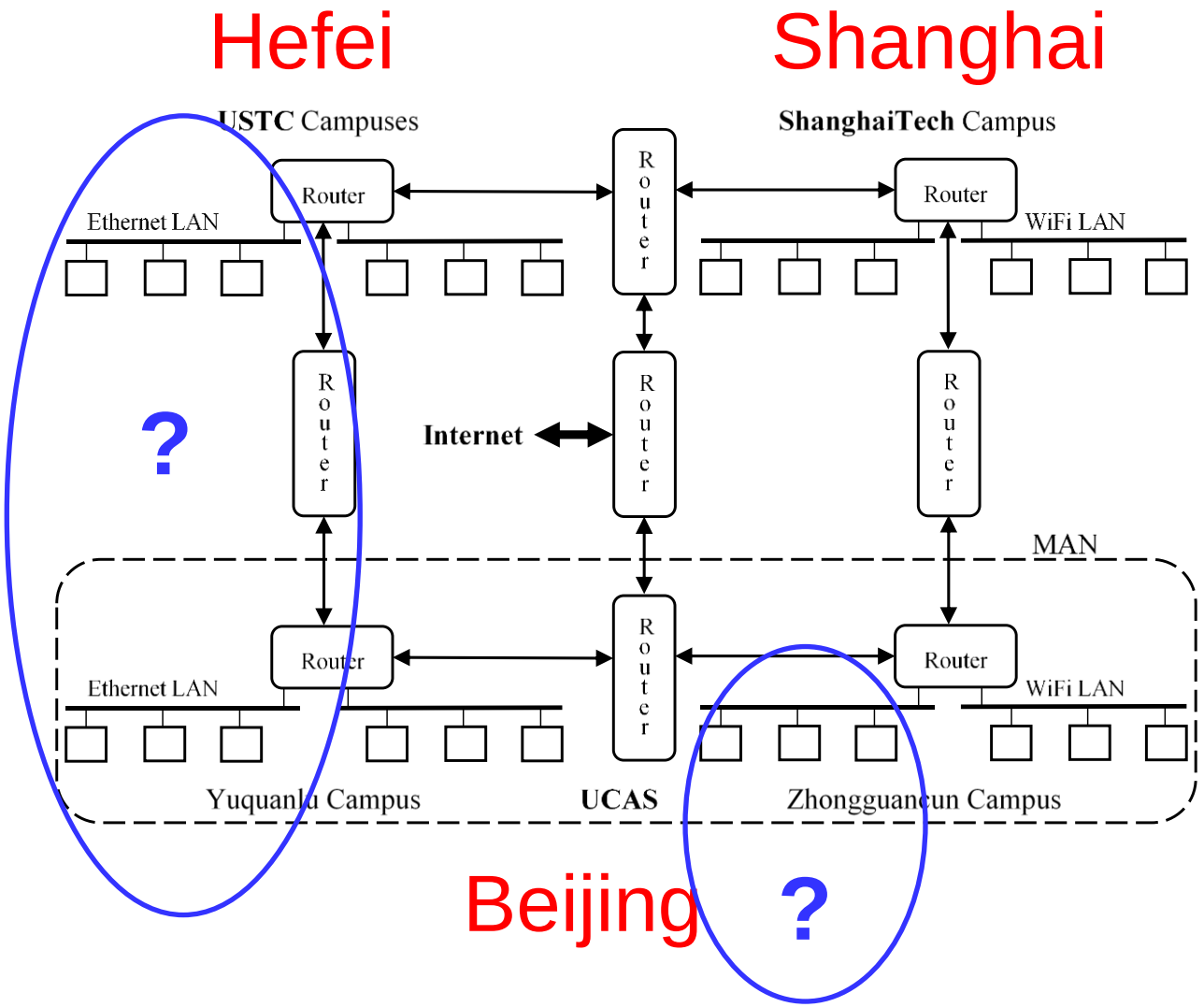
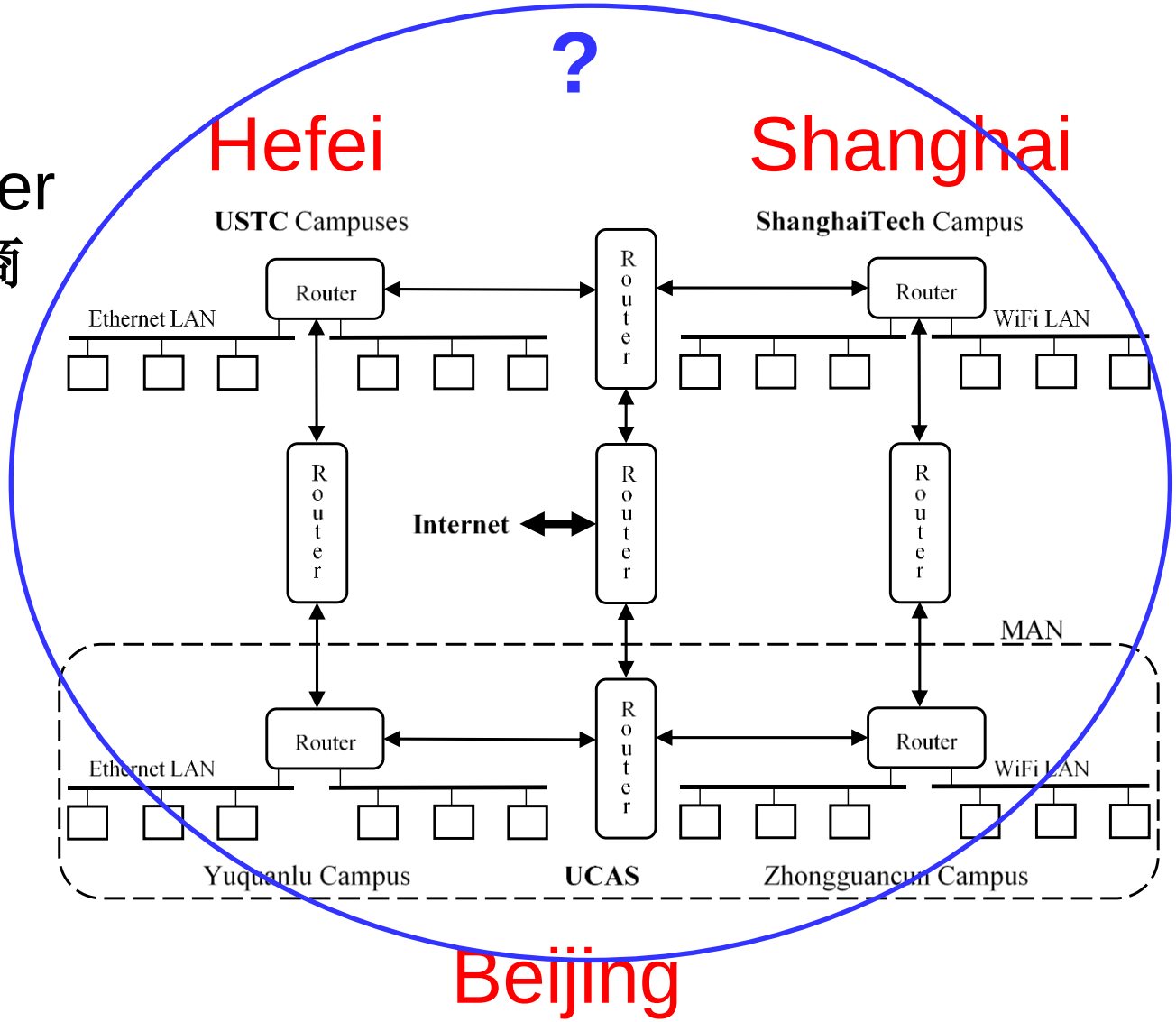


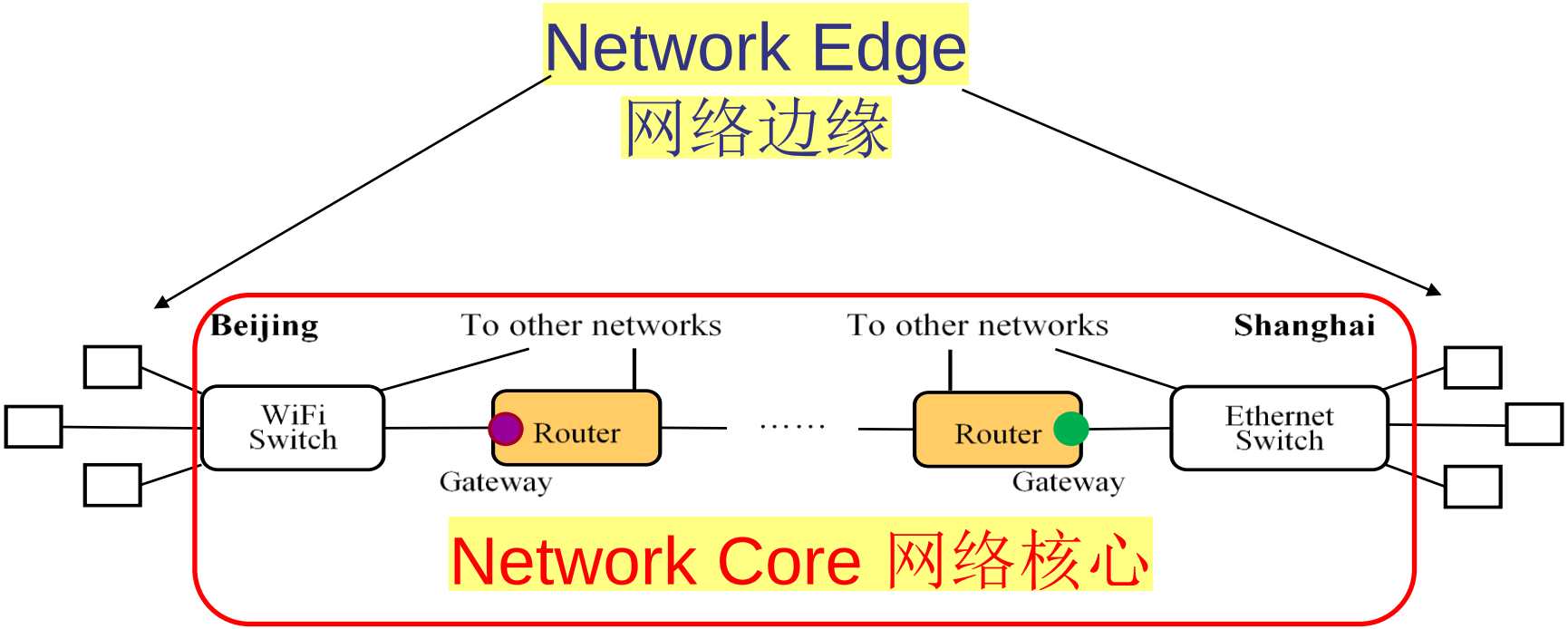
Network terms

- **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



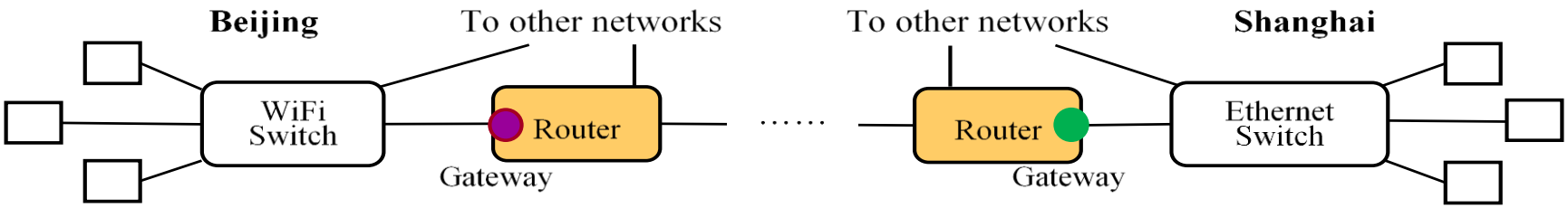
Two types of network devices (nodes)
宿主节点（宿主机）、组网设备节点

- Hosts: client nodes and server nodes at the network edge
  - 6 edge devices (hosts) are shown
  - 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



What devices are used?

- 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
  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)