CH5 Network Layer: The Control Plane

Outline

- Routing protocols
- link-state：djiskra
- Distance vector：Bellman-Ford
- autonomous systems -> ASes
- Intra-AS Routing
- OSPF
- Hierarchical OSPF
- Internet inter-AS routing: BGP
- eBGP, iBGP connections
- BGP messages(多选，填空)
- Hot Potato Routing

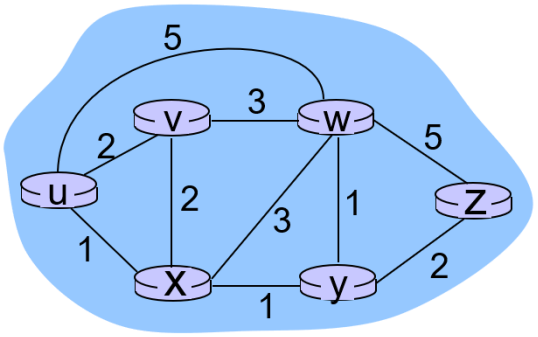
Routing protocols

- **goal**: determine “good（只是**good**）"paths (equi valently, routes), from sending hosts to receiving host, through network of routers

link-state routing algorithm: Dijkstra

- Centralized routing 中央化

Step	N'	D(v),p(v)	D(w),p(w)	D(x),p(x)	D(y),p(y)	D(z),p(z)
0	u	2,u	5,u	1,u	∞	∞
1	ux	2,u	4,x		2,x	∞
2	uxy	2,u	3,y			4,y
3	uxyv		3,y			4,y
4	uxyvw					4,y
5	uxyvwz					



Distance vector algorithm: Bellman-Ford

- Trust Neighbor
- good news travels fast，bad slow

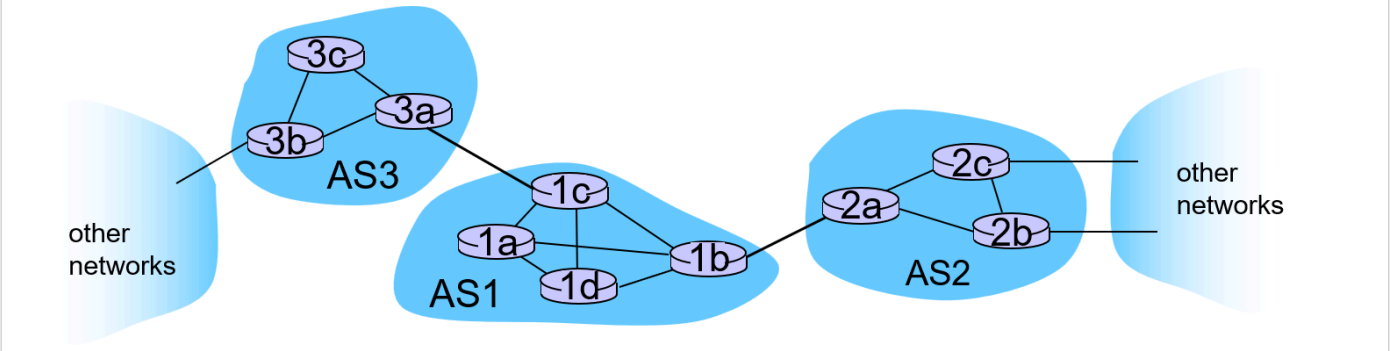
$$d_x(y) = \min_v \{c(x,v) + d_v(y)\}$$

cost from neighbor v to destination y

cost to neighbor v

min taken over all neighbors v of x

autonomous systems自治系统(AS)



- intra-AS routing域内路由
- inter-AS routing域间路由
- 域内自治
- 真实的Internet - ASes

Intra-AS Routing域内路由

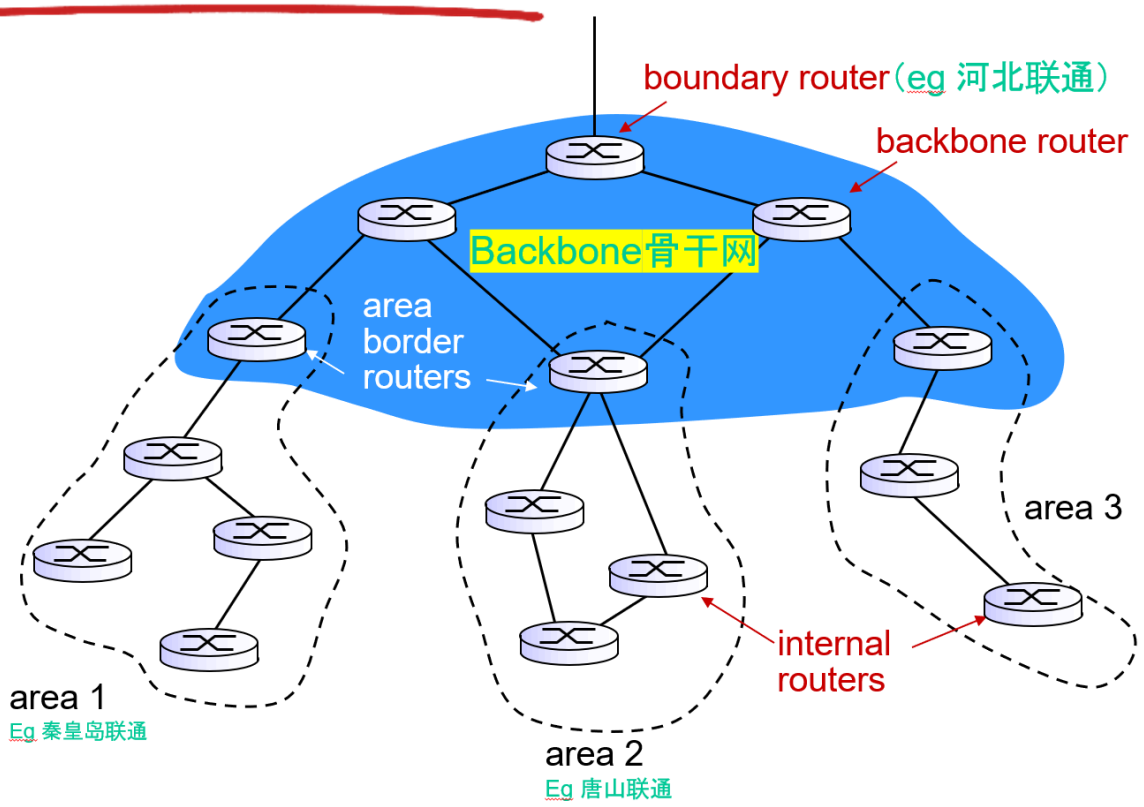
- also known as interior gateway protocols (IGP)
- most common intra-AS routing protocols:
  - RIP 简单
  - OSPF 主流
  - IGRP

OSPF (Open Shortest Path First)

OSPF 是一种基于链路状态的内部网关协议（IGP），用于在单一自治系统（AS）内决策路由。OSPF 路由器通过交换链路状态信息来建立网络拓扑，然后使用 Dijkstra 算法计算到达所有目的地的最短路径。

- for each link, multiple cost metrics for different TOS
- “open”: publicly available
- uses link-state algorithm

Hierarchical OSPF



三个主要类型（要能在图里填空出来）

- **area border routers**:“summarize” distances to nets in own area, advertise to other Area Border routers.
- **backbone routers**: run OSPF routing limited to backbone.
- **boundary routers**: connect to other AS’es.

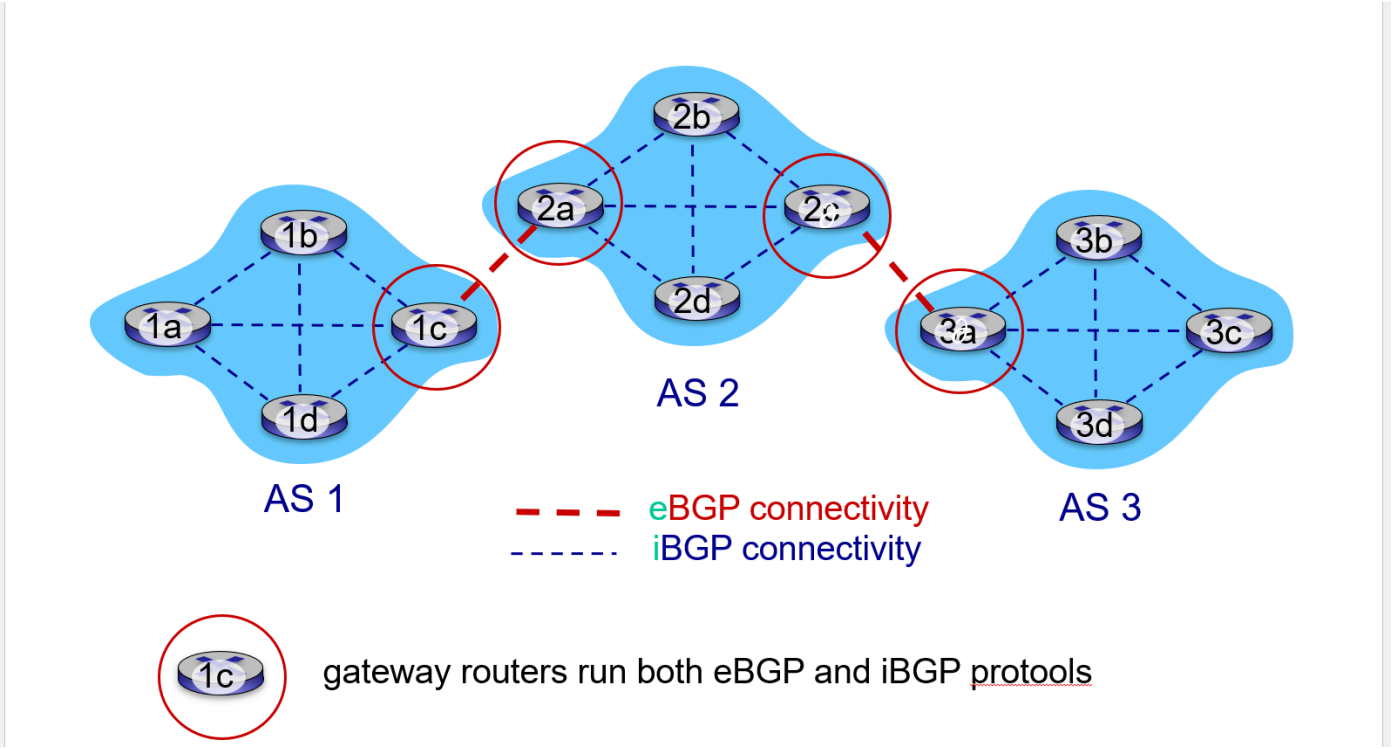
Internet inter-AS routing: BGP（Border Gateway Protocol）

考判断题

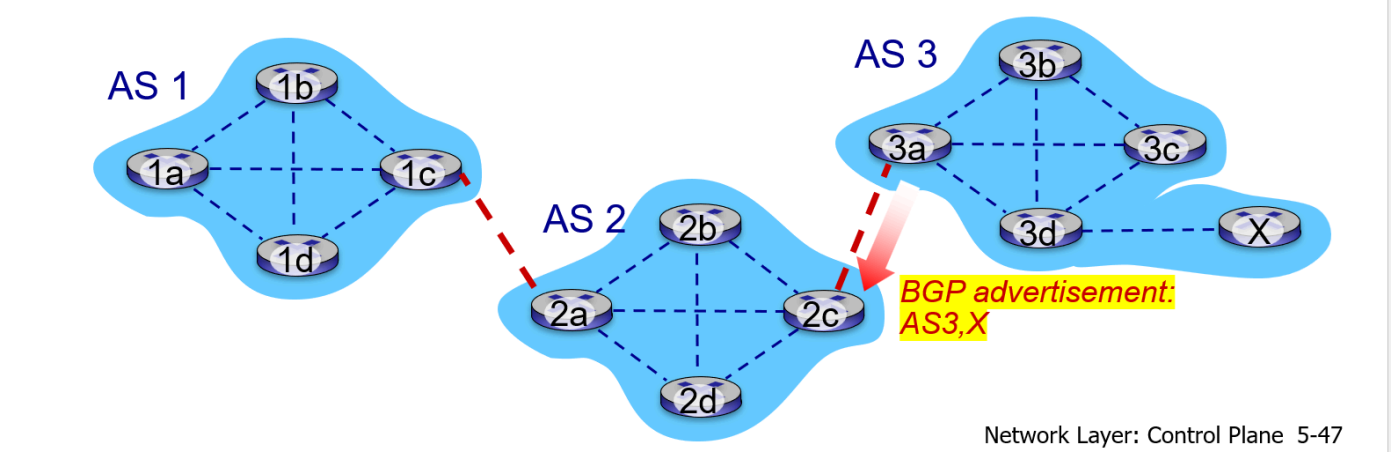
BGP是一种用于互联网自治系统（AS）之间进行路由选择和交换路由信息的协议。BGP是互联网中最常用的外部网关协议，被用于在不同自治系统之间交换路由信息，以确定最佳的路径来转发数据包。

- “glue that holds the Internet together”
- eBGP: obtain subnet reachability information from neighboring ASes
- iBGP: propagate reachability information to all AS-internal routers.

eBGP, iBGP connections 🚀



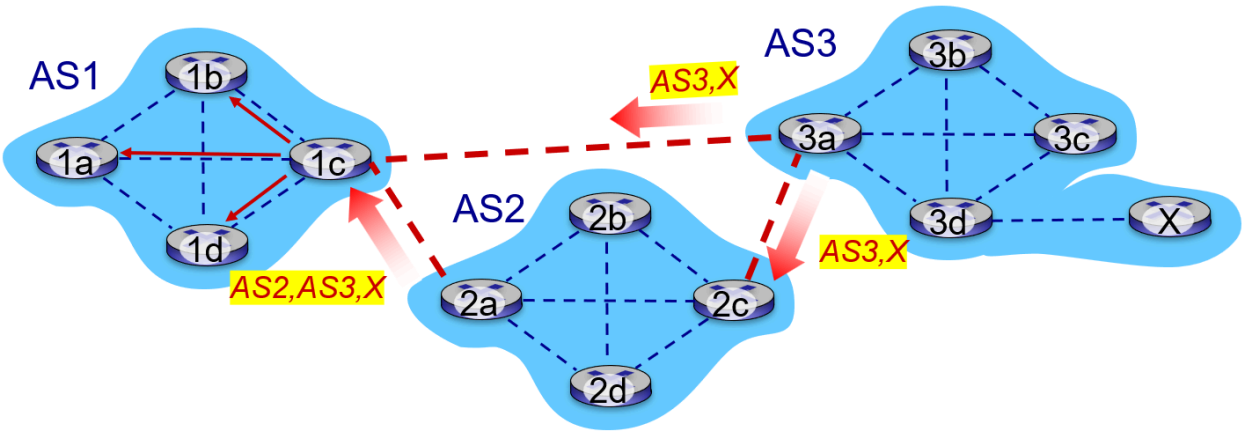
BGP basics



- prefix + attributes = “route”

在BGP中，"advertised prefix”是指通过BGP协议向其他自治系统宣告的IP地址前缀，而"BGPattributes"则是与该前缀相关联的属性信息。当这两者结合在一起时，形成了一个完整的路由，通常被称为"route”。

BGP path advertisement 🚀



gateway router may learn about **multiple paths** to destination:

- AS1 gateway router 1c learns path AS2,AS3,X from 2a
- AS1 gateway router 1c learns path AS3,X from 3a
- **Based on policy**, AS1 gateway router 1c chooses path AS3,X, andadvertises path within AS1 via iBGP

BGP messages(多选，填空)

- BGP messages : **NO UK**
  - OPEN
  - UPDATE
  - KEEPALIVE
  - NOTIFICATION
- Hot Potato Routing
  - choose local gateway that has least intra-domain cost
- 为了节省自己的资源，各个运营商可能会留个心眼，不让别的运营商的数据包via自己