

**caida**

# **CSE 291 INTERNET DATA SCIENCE FOR CYBERSECURITY**

**18 January 2023**

**AS Relationships  
Customer Cones**

# OVERVIEW



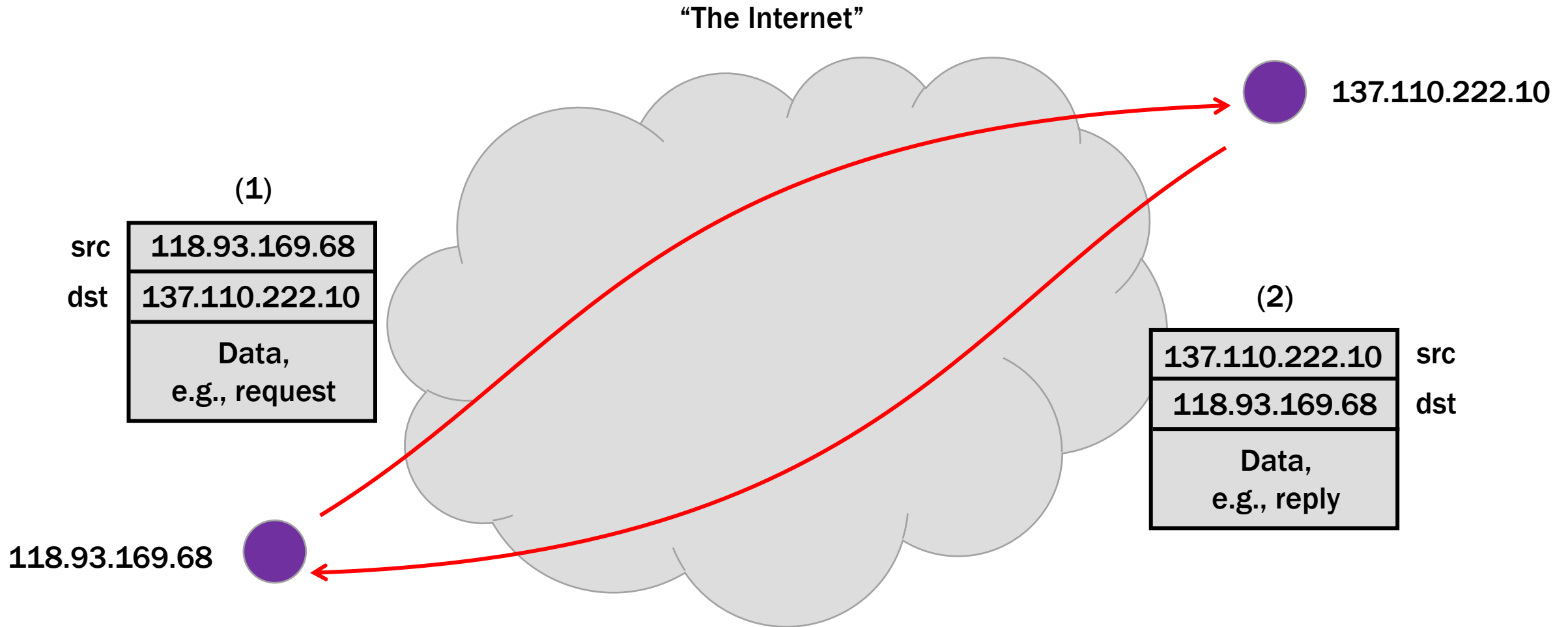
1. Background to support your reading of a research paper “*AS Relationships, Customer Cones, and Validation*” ACM IMC 2013.
2. Please read the paper and be ready to discuss it in class on Monday Jan 23<sup>rd</sup>
3. Assignment 2, which analyses *ASRank* data is due Monday Feb 6<sup>th</sup>

# LEARNING OBJECTIVES

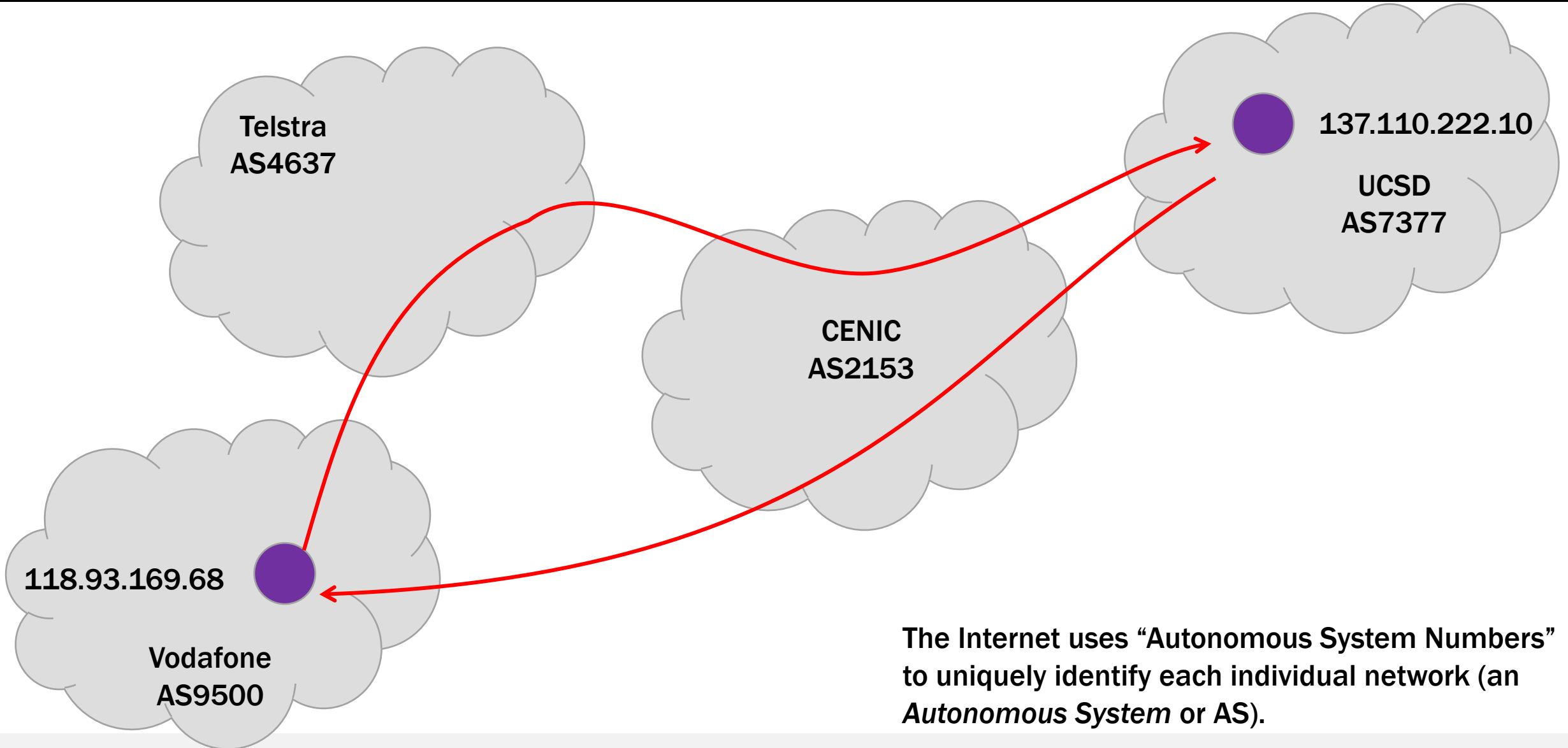


1. Be able to describe the differences between transit (customer-provider) and peering (peer-peer)
2. Understand the terms sibling, tier-1, stub, and customer-cone
3. Understand how publicly available BGP data is collected and archived

# IP PACKET DELIVERY

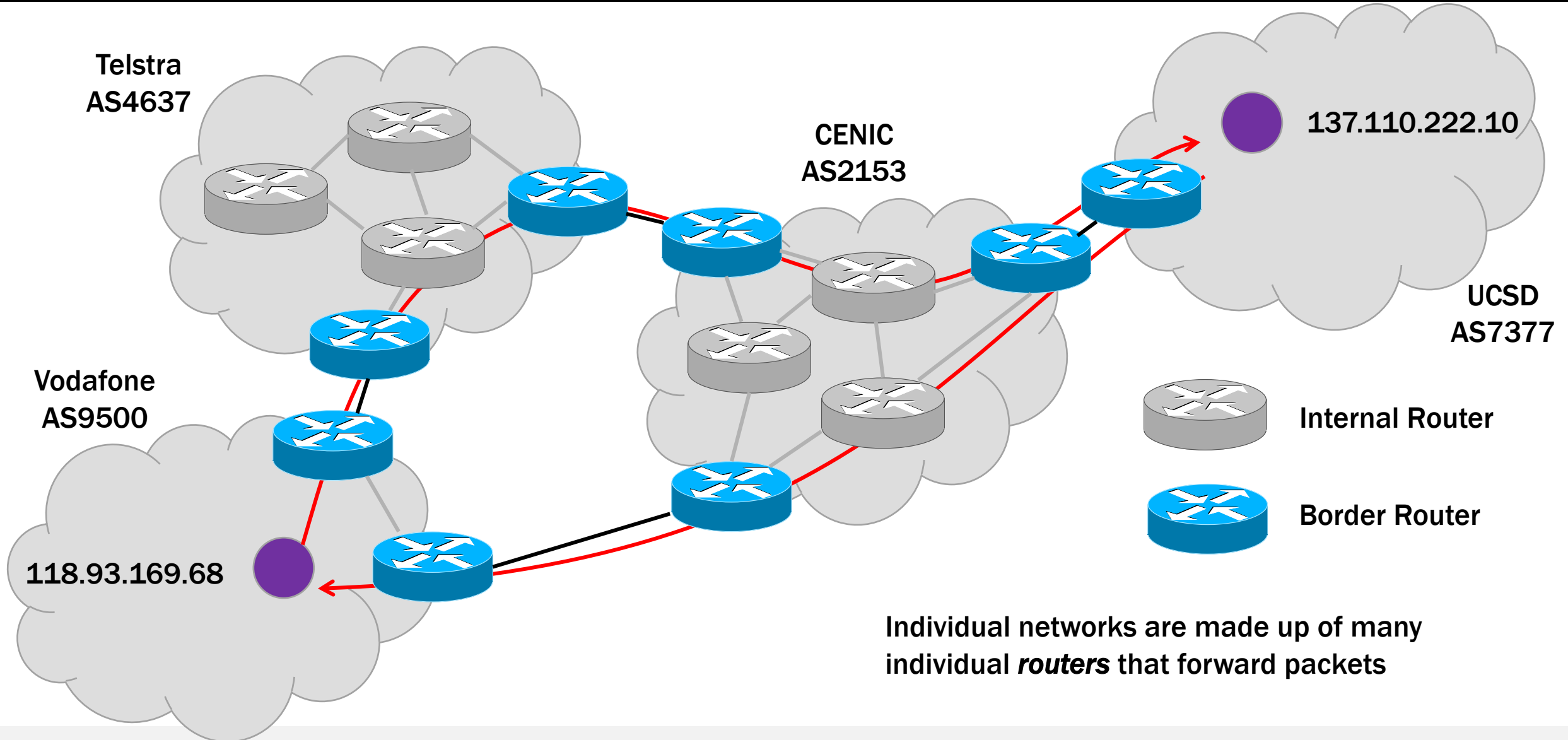


# AUTONOMOUS SYSTEMS

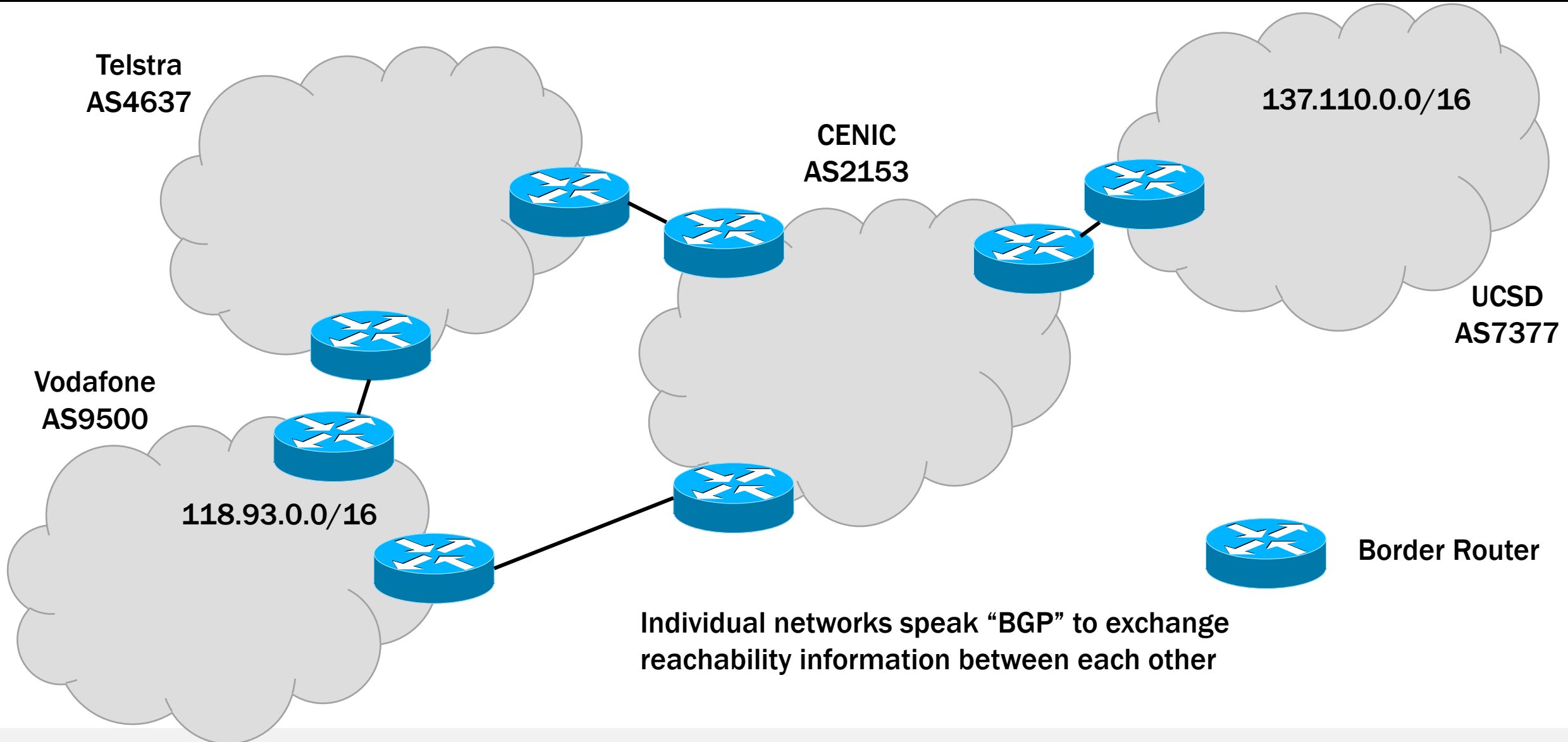


The Internet uses “Autonomous System Numbers” to uniquely identify each individual network (an *Autonomous System* or AS).

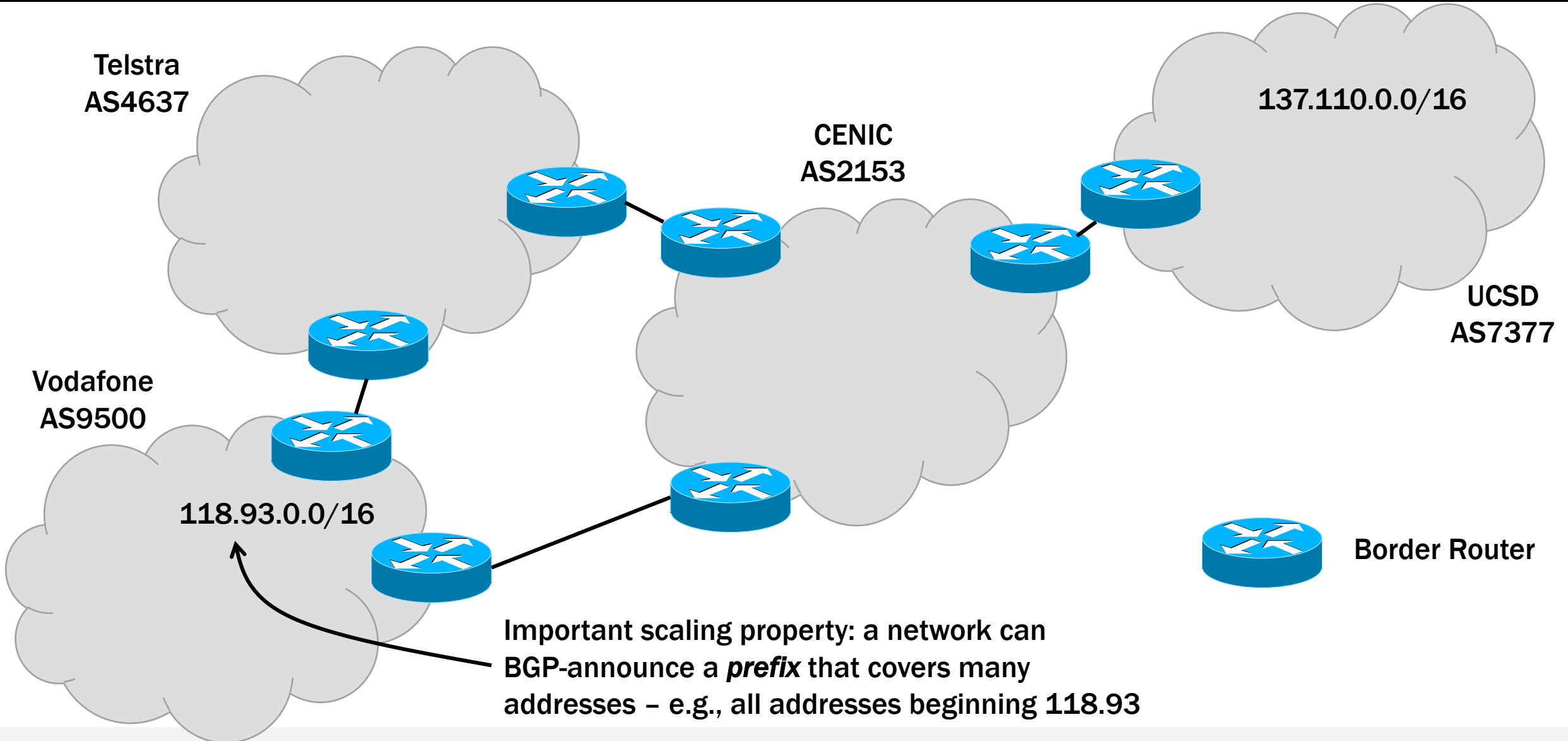
# AUTONOMOUS SYSTEMS



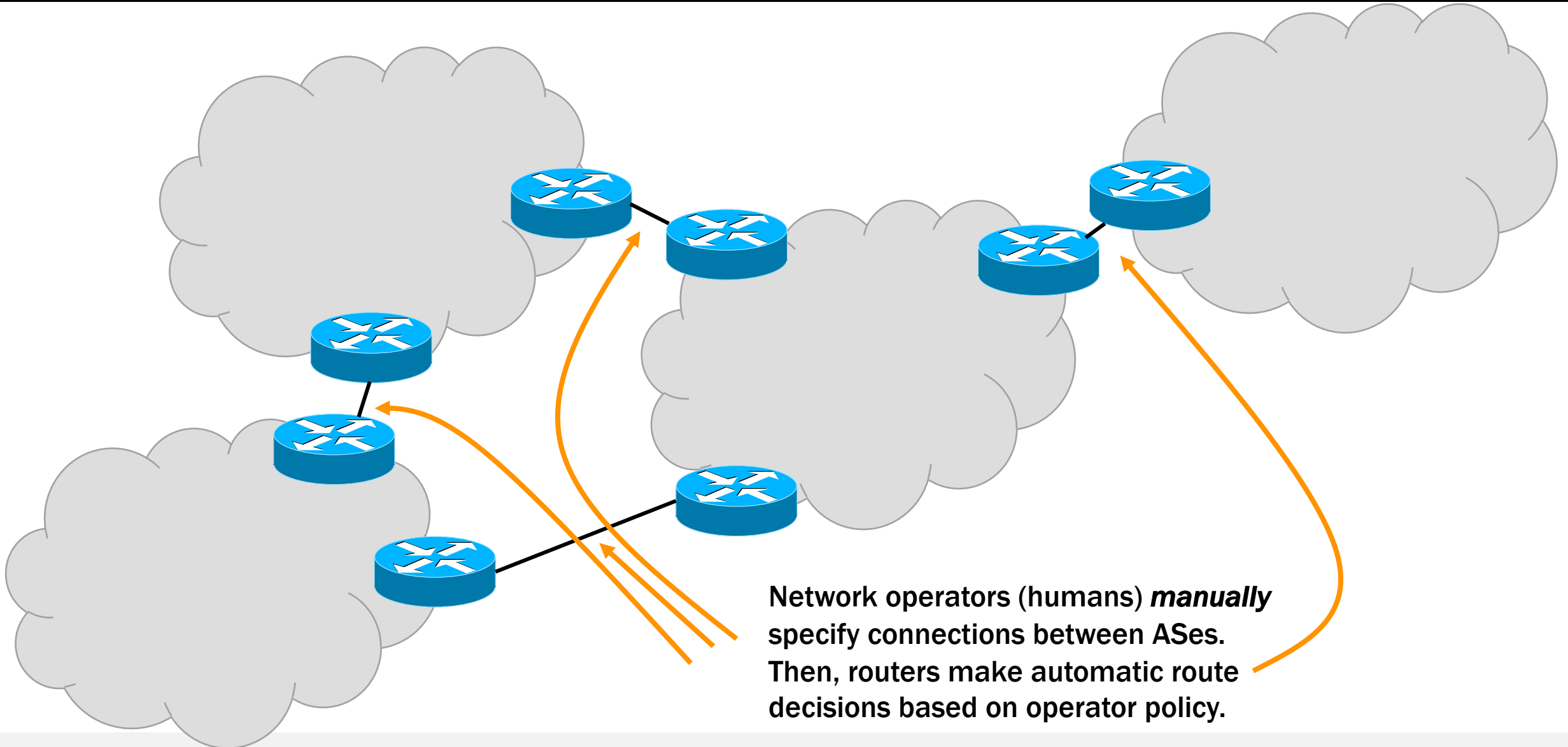
# BORDER GATEWAY PROTOCOL



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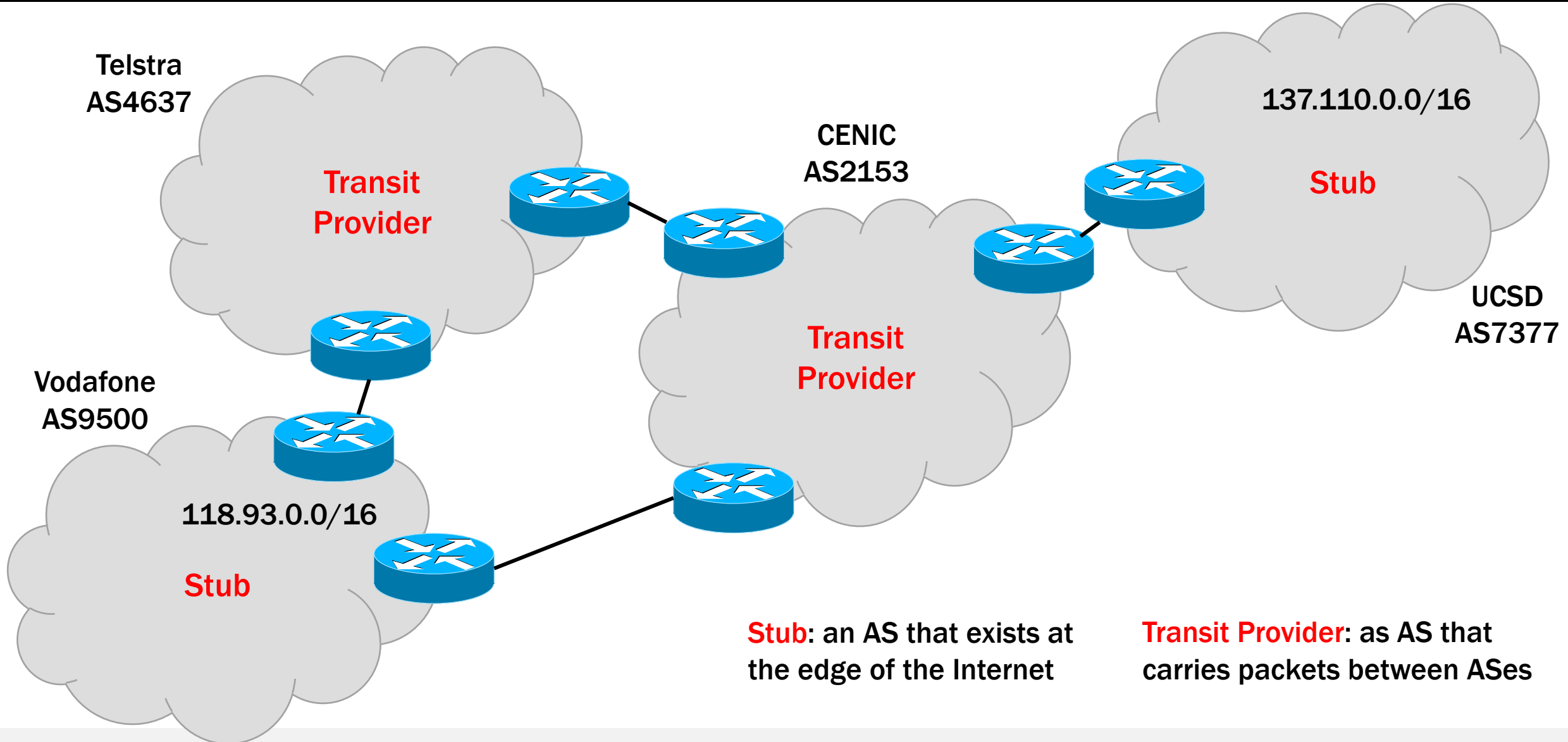


# BORDER GATEWAY PROTOCOL

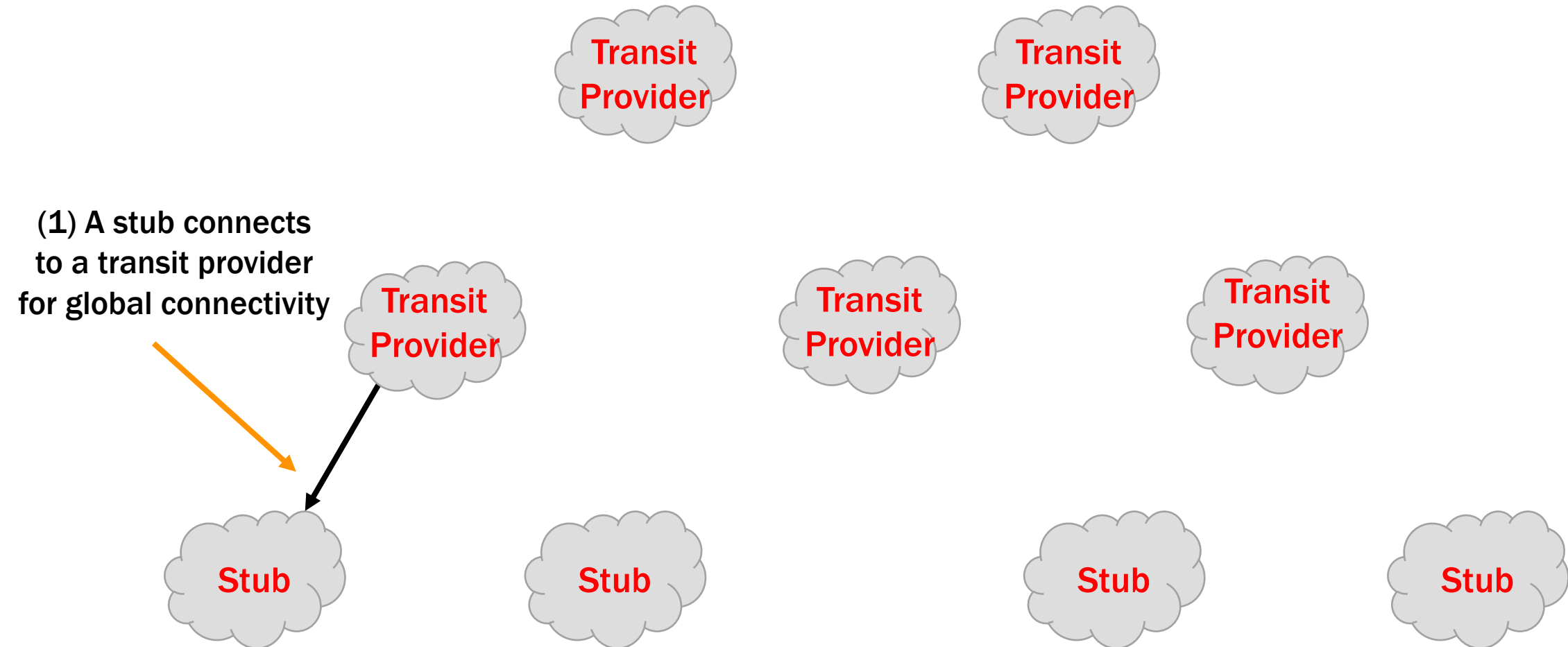


Network operators (humans) **manually** specify connections between ASes. Then, routers make automatic route decisions based on operator policy.

# BROAD AS CLASSIFICATION



# AS HIERARCHY: TRANSIT

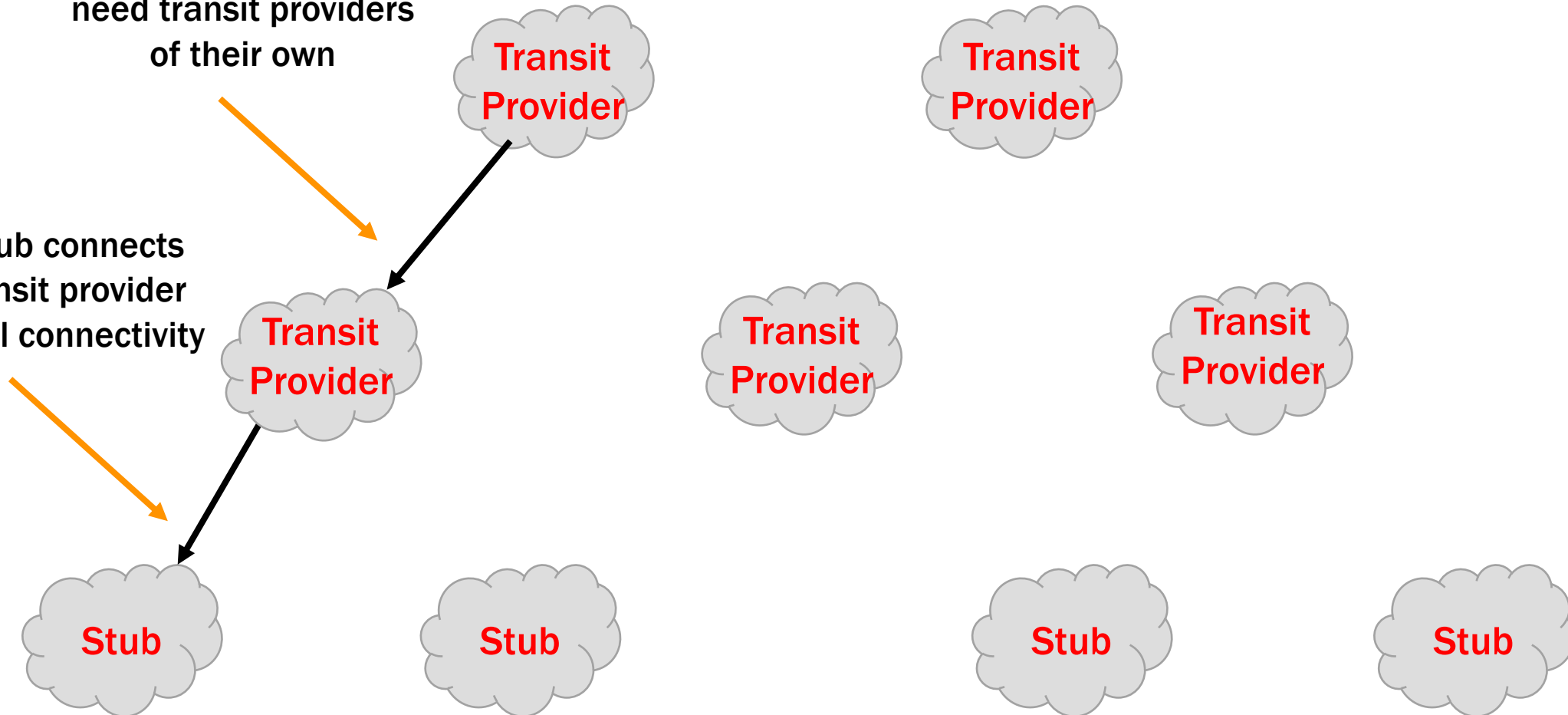


# AS HIERARCHY: TRANSIT

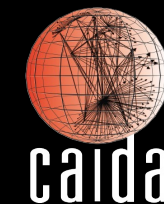


(2) Most transit providers need transit providers of their own

(1) A stub connects to a transit provider for global connectivity

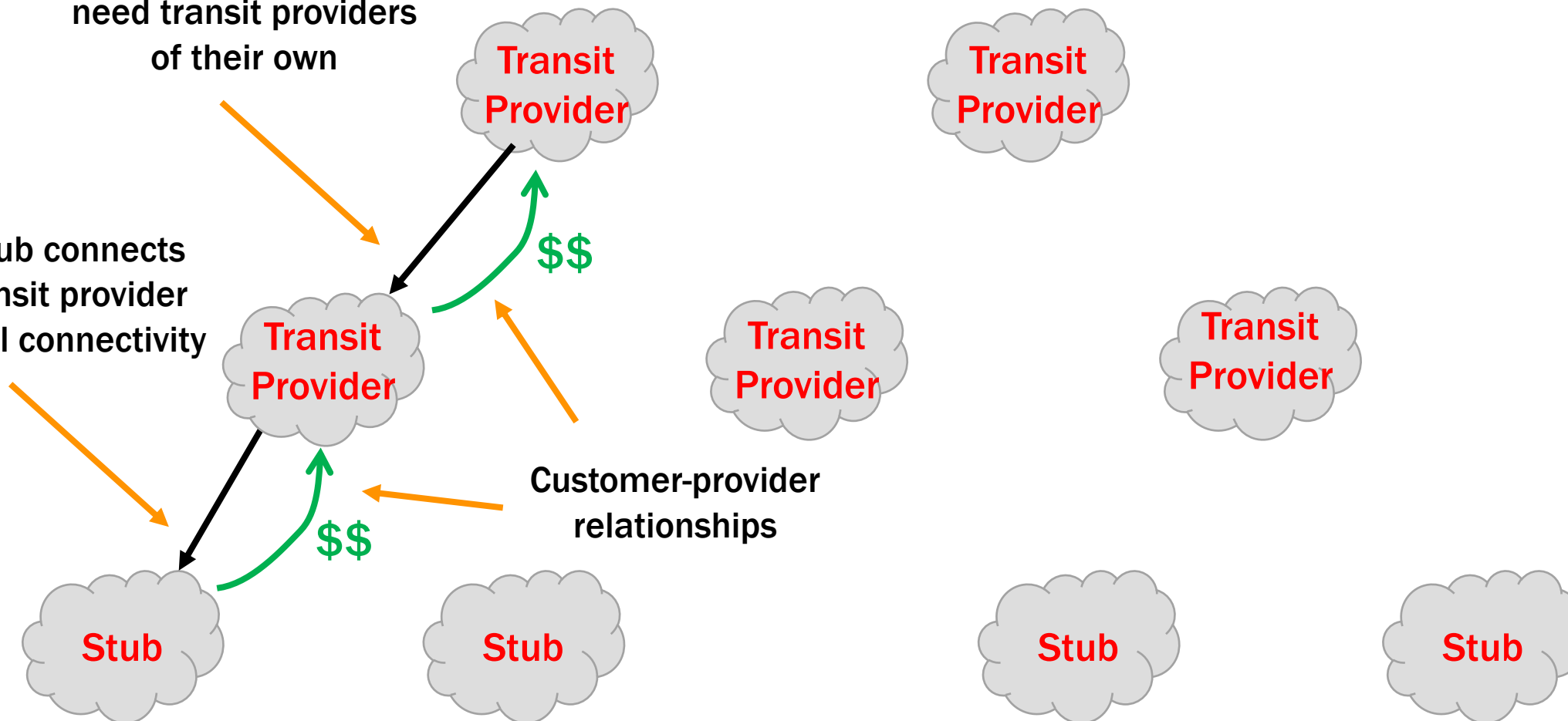


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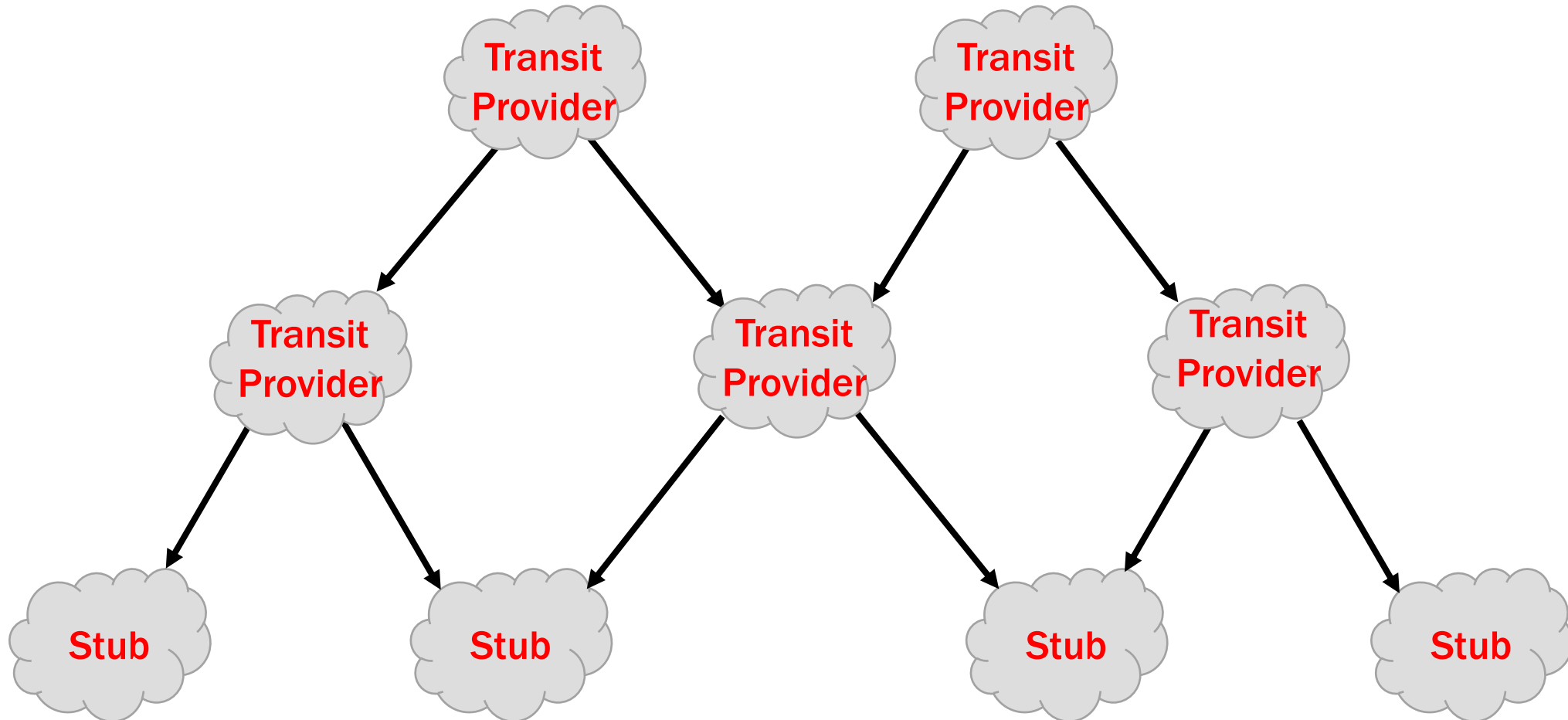


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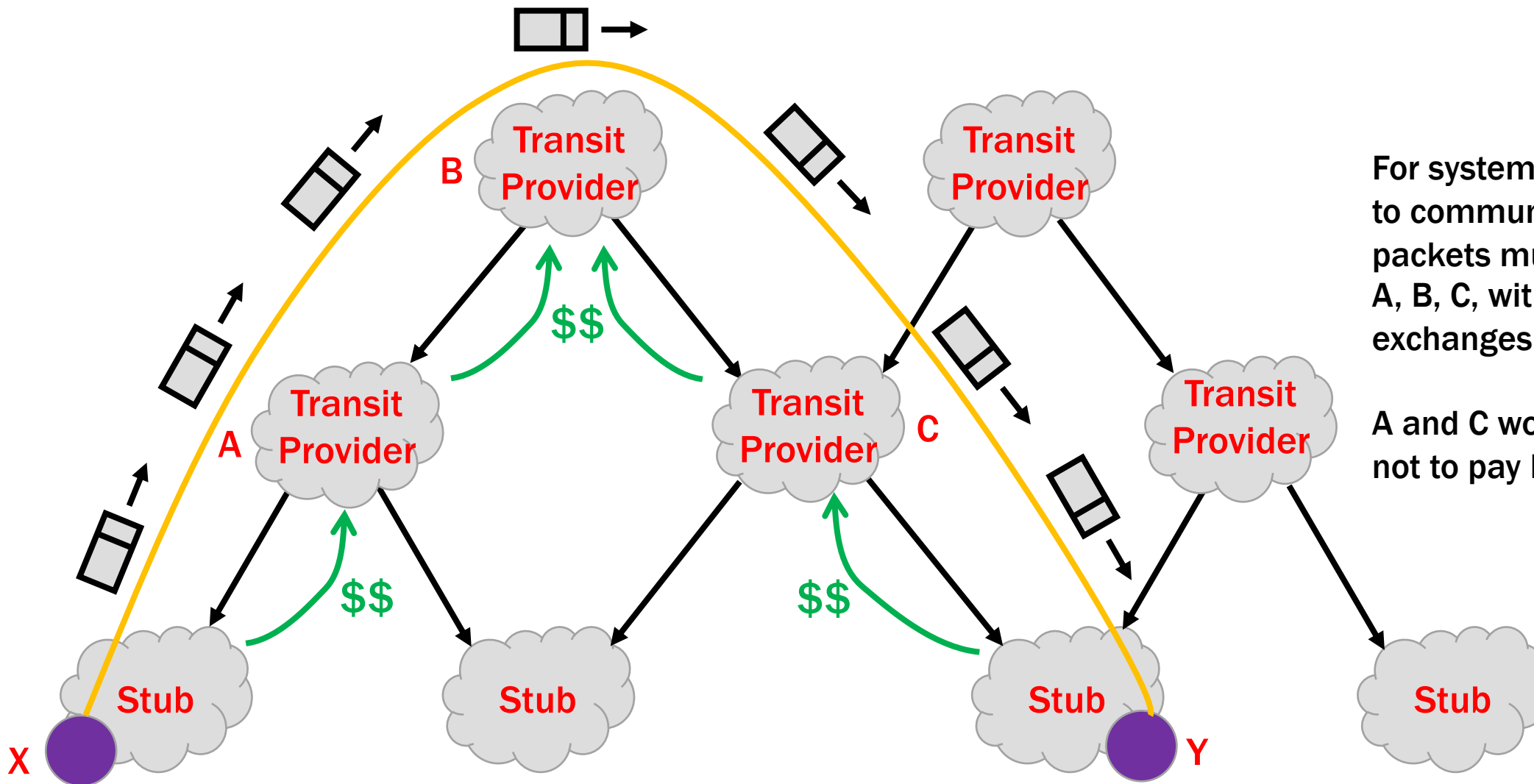
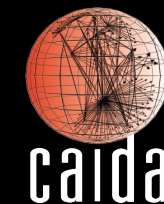
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# AS HIERARCHY: TRANSIT



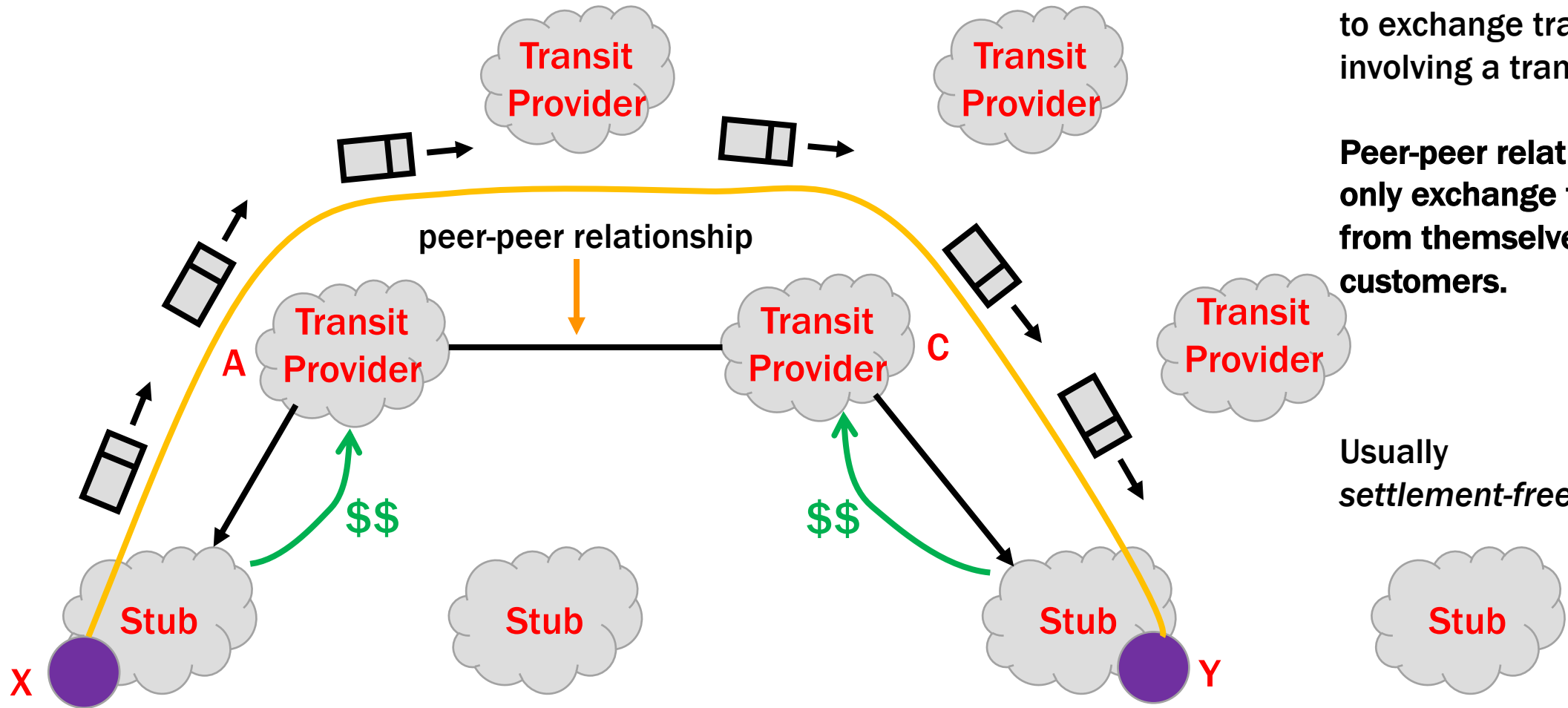
# AS HIERARCHY: TRANSIT



For system X in stub AS to communicate with Y, packets must transit A, B, C, with money exchanges (two w/ B).

A and C would prefer not to pay B for transit.

# AS HIERARCHY: PEERING

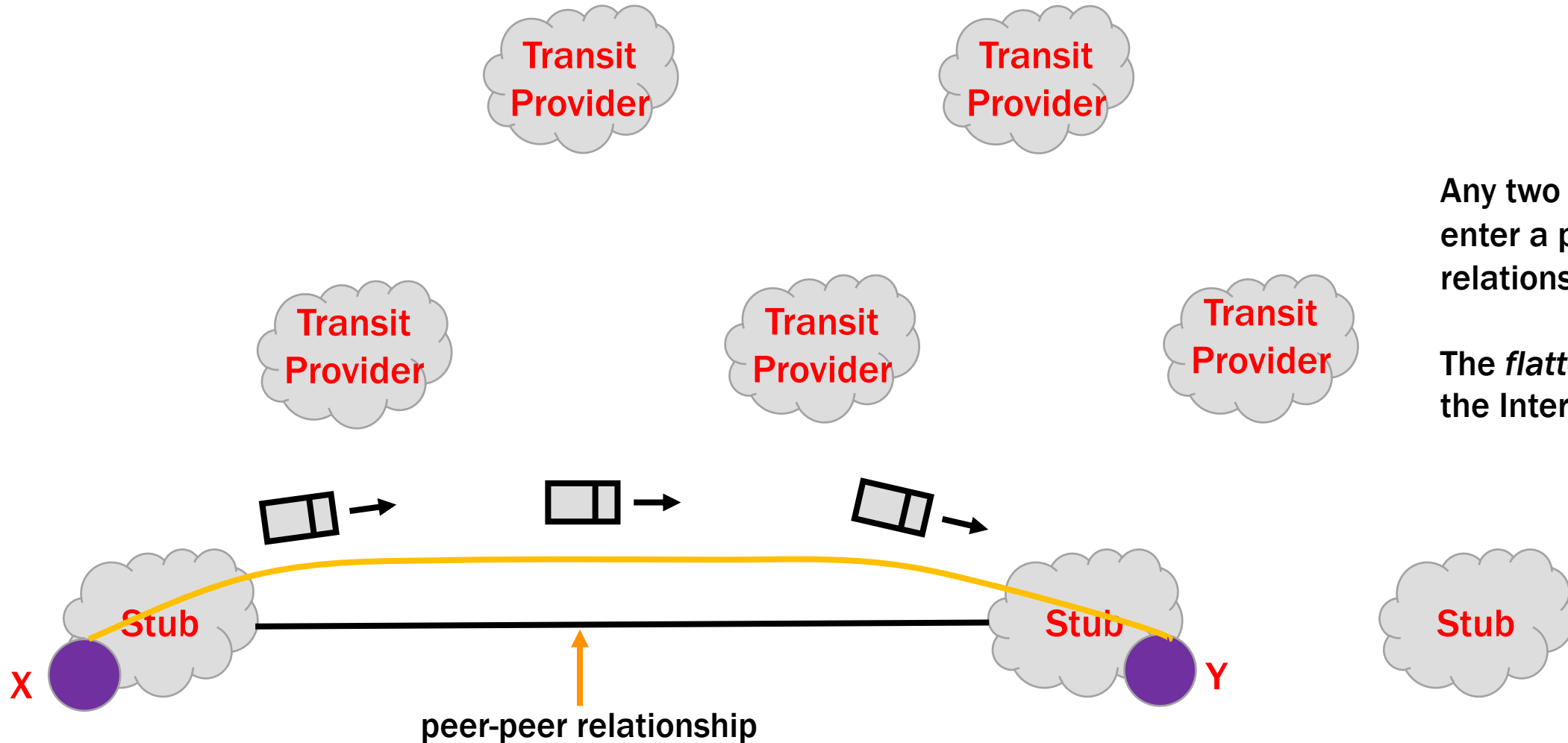


Two ASes may choose to exchange traffic without involving a transit provider.

**Peer-peer relationship:** only exchange traffic from themselves or their customers.

Usually settlement-free.

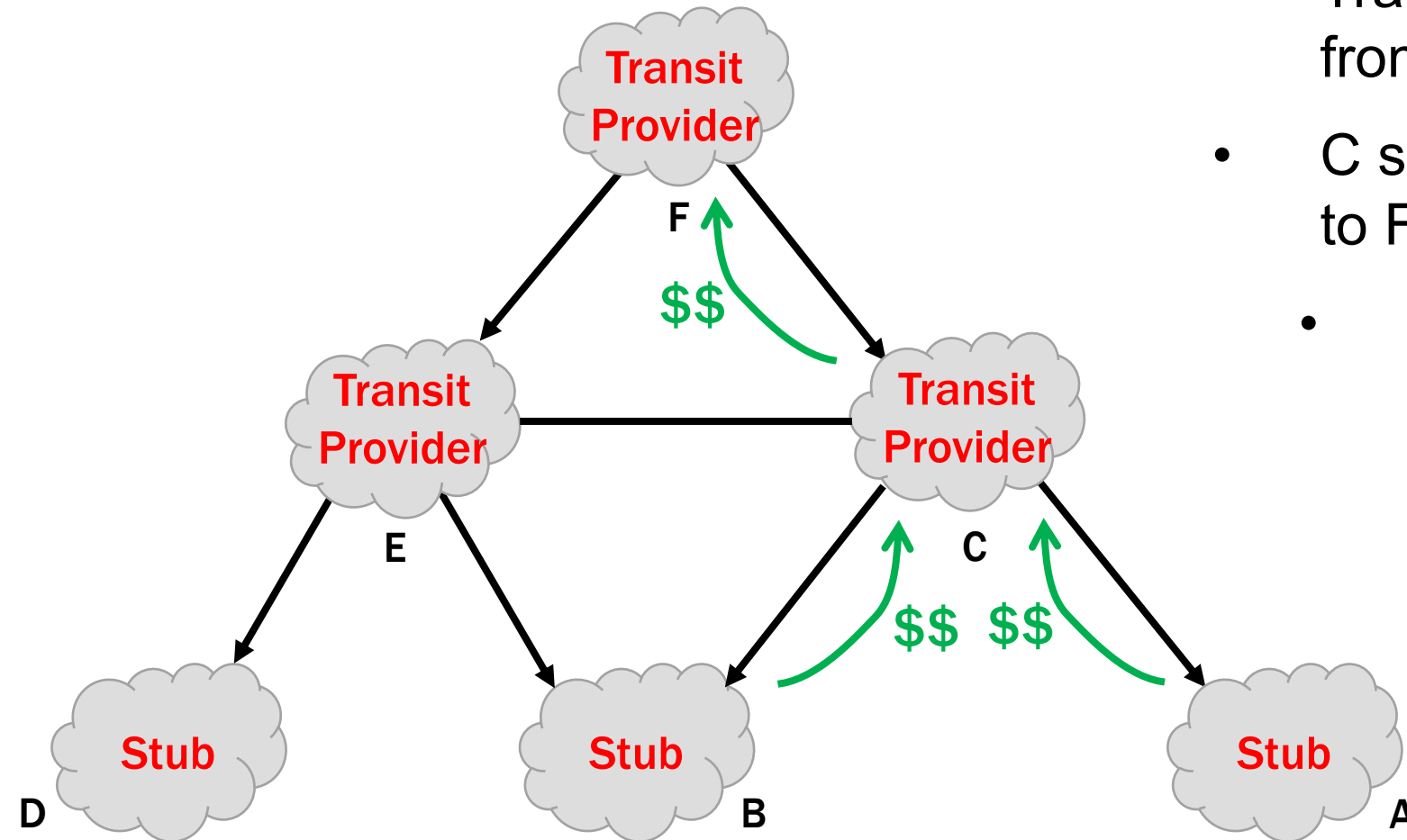
# AS HIERARCHY: PEERING



Any two ASes may enter a peer-peer relationship.

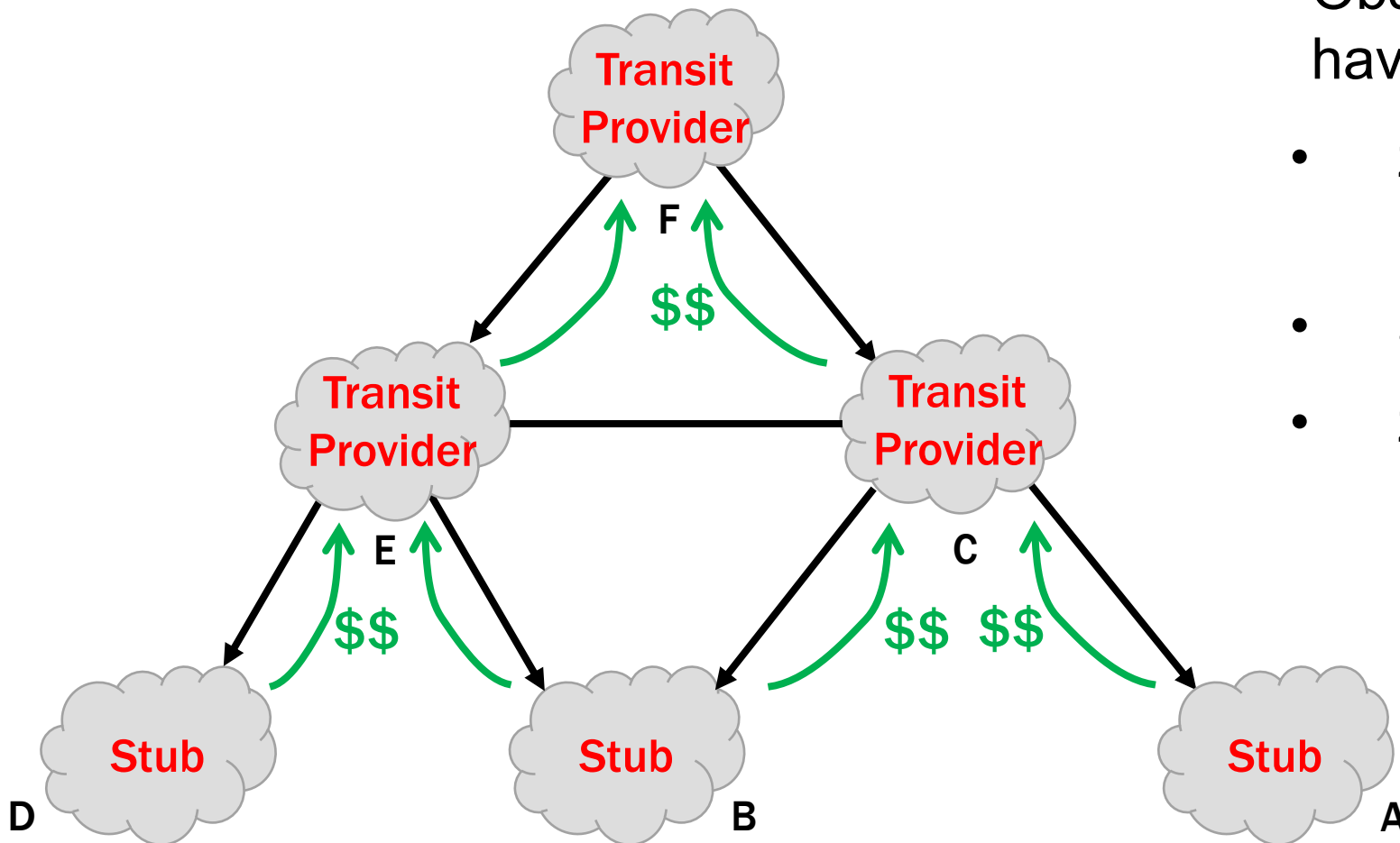
The *flattening* of the Internet.

# ROUTE EXPORT POLICY



- Transit Provider C receives routes from A, B, F, and E.
- C should not provide routes from E to F, or routes from F to E
- C would be paying F to carry traffic for E, for which C does not receive payment

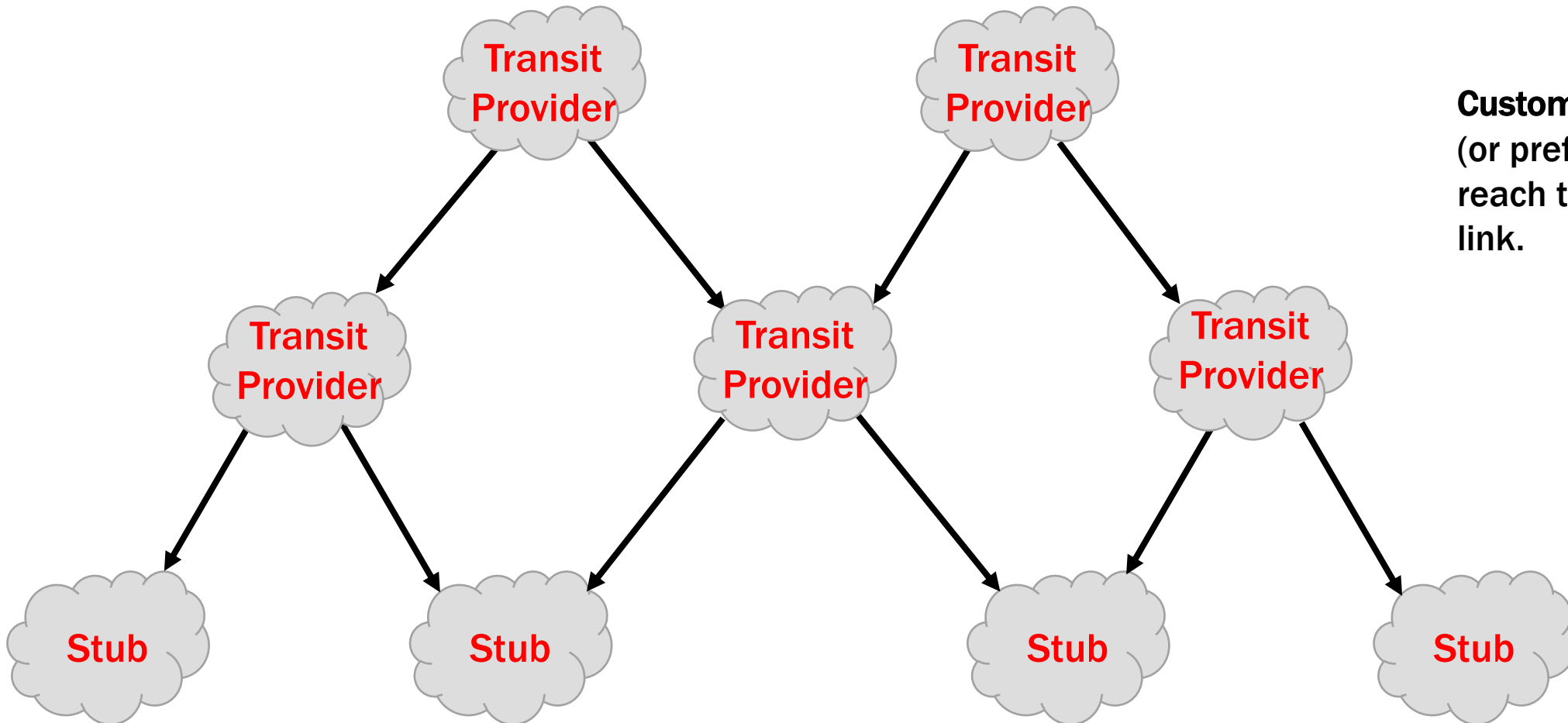
# VALLEY FREE PROPERTY



- Observation: BGP paths generally have a “valley free” property:
  - zero or more (uphill) customer-provider (c2p) links,
  - an optional peer-peer (p2p) link,
  - zero or more (downhill) provider-customer (p2c) links.

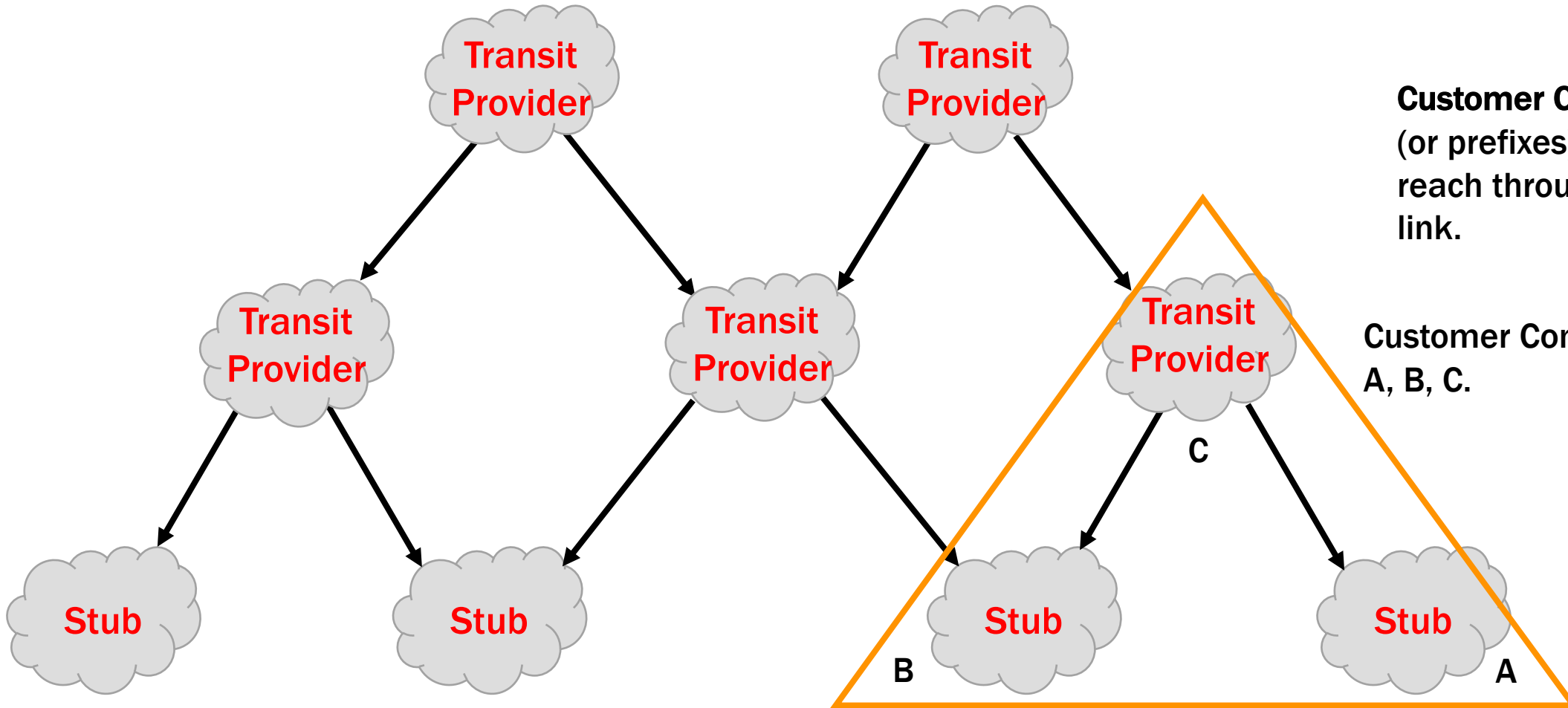
D		E		F		C		A
D		E		C		A		
E		C		B				
C		B						

# AS CUSTOMER CONES



**Customer Cone:** set of ASes (or prefixes) that an AS can reach through a customer link.

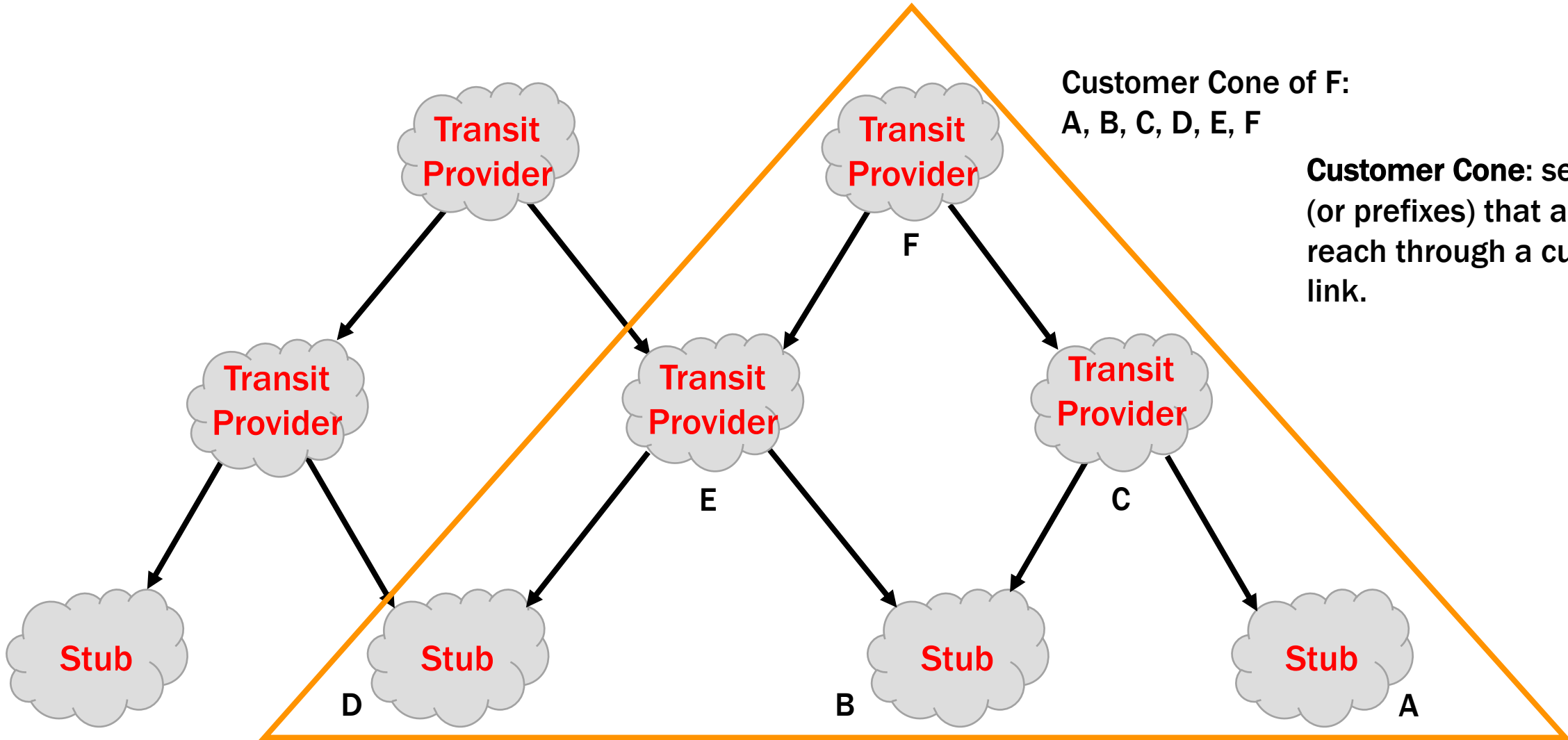
# AS CUSTOMER CONES



**Customer Cone:** set of ASes (or prefixes) that an AS can reach through a customer link.

**Customer Cone of C:** A, B, C.

# AS CUSTOMER CONES



Customer Cone of F:  
A, B, C, D, E, F

**Customer Cone:** set of ASes (or prefixes) that an AS can reach through a customer link.

# SIBLINGS



- Some organizations operate multiple ASes
  - by design (operate different parts with diff ASes)
    - e.g., Comcast has a different ASN for each regional network in the U.S. that they operate
  - by acquisition (they purchase other networks)
    - e.g., Verizon (AS701) purchased EdgeCast (AS15133)

# SIBLINGS



- WHOIS database operated by RIRs includes OrgId for ASNs that are held by the same organization

```
$ whois -h whois.arin.net AS7922
ASNumber:      7922
ASName:        COMCAST-7922
ASHandle:      AS7922
RegDate:       1997-02-14
Updated:       2021-01-25

OrgName:       Comcast Cable Communications, LLC
OrgId:         CCCS
```

```
$ whois -h whois.arin.net AS33662
ASNumber:      33662
ASName:        CMCS
ASHandle:      AS33662
RegDate:       2005-02-16
Updated:       2021-01-25

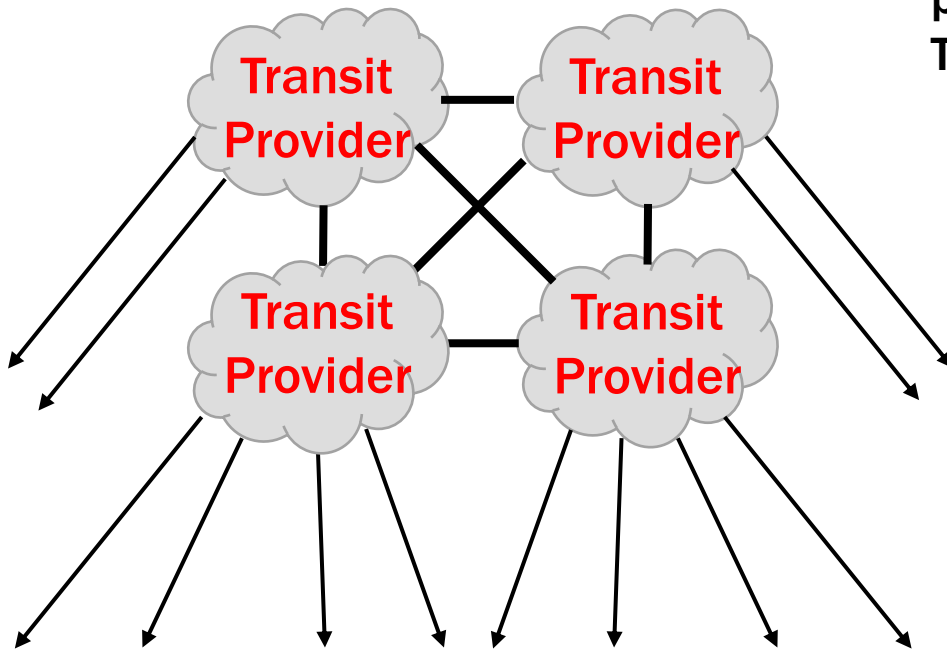
OrgName:       Comcast Cable Communications, LLC
OrgId:         CCCS
```

# AS HIERARCHY: TIER-1



A *clique* of peering ASes exists at the top of the AS hierarchy, exchanging routes to provide global reachability

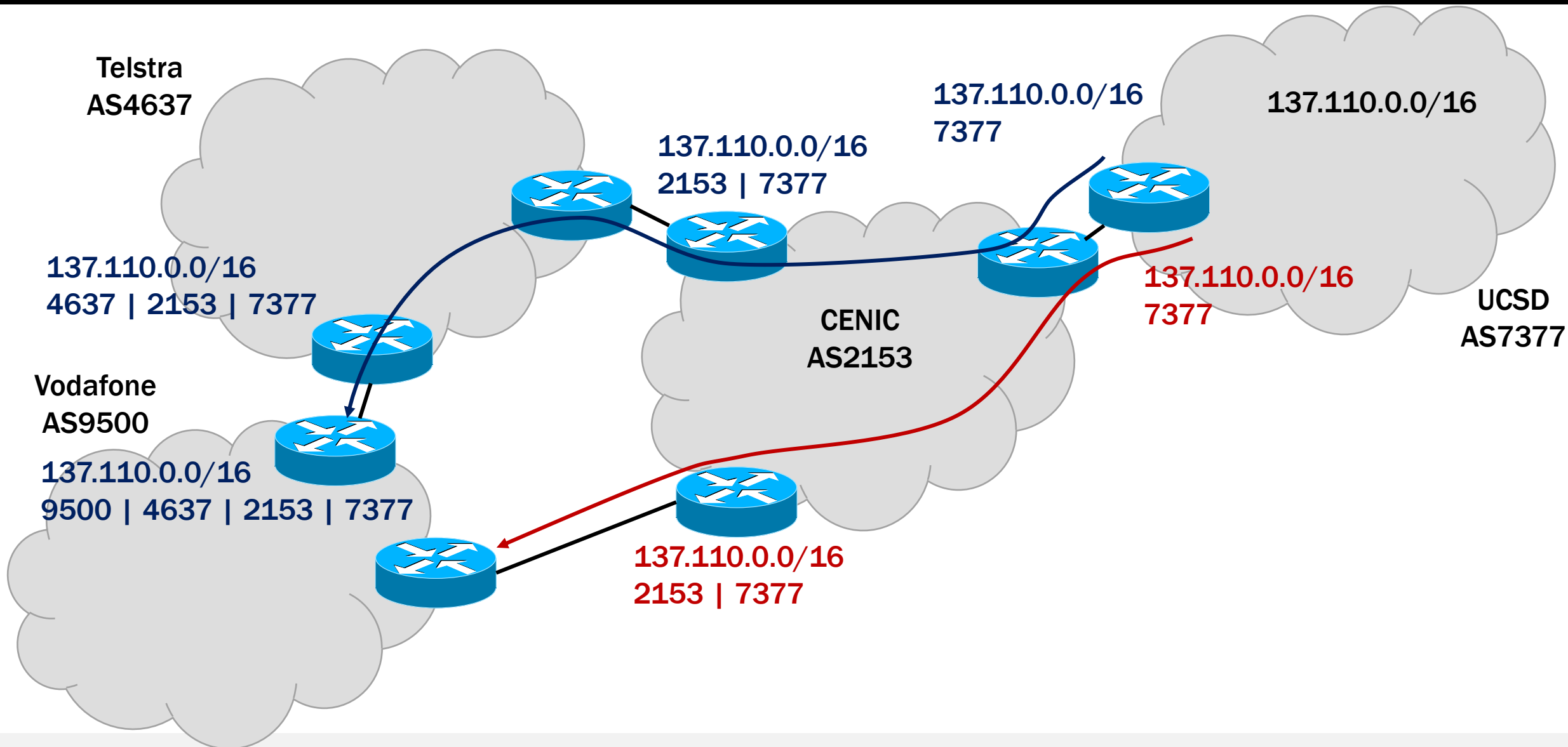
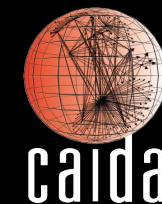
A *Tier-1 AS* is an AS that does not pay any neighbor AS; exactly which ASes in the peering clique are Tier-1 is unknown.



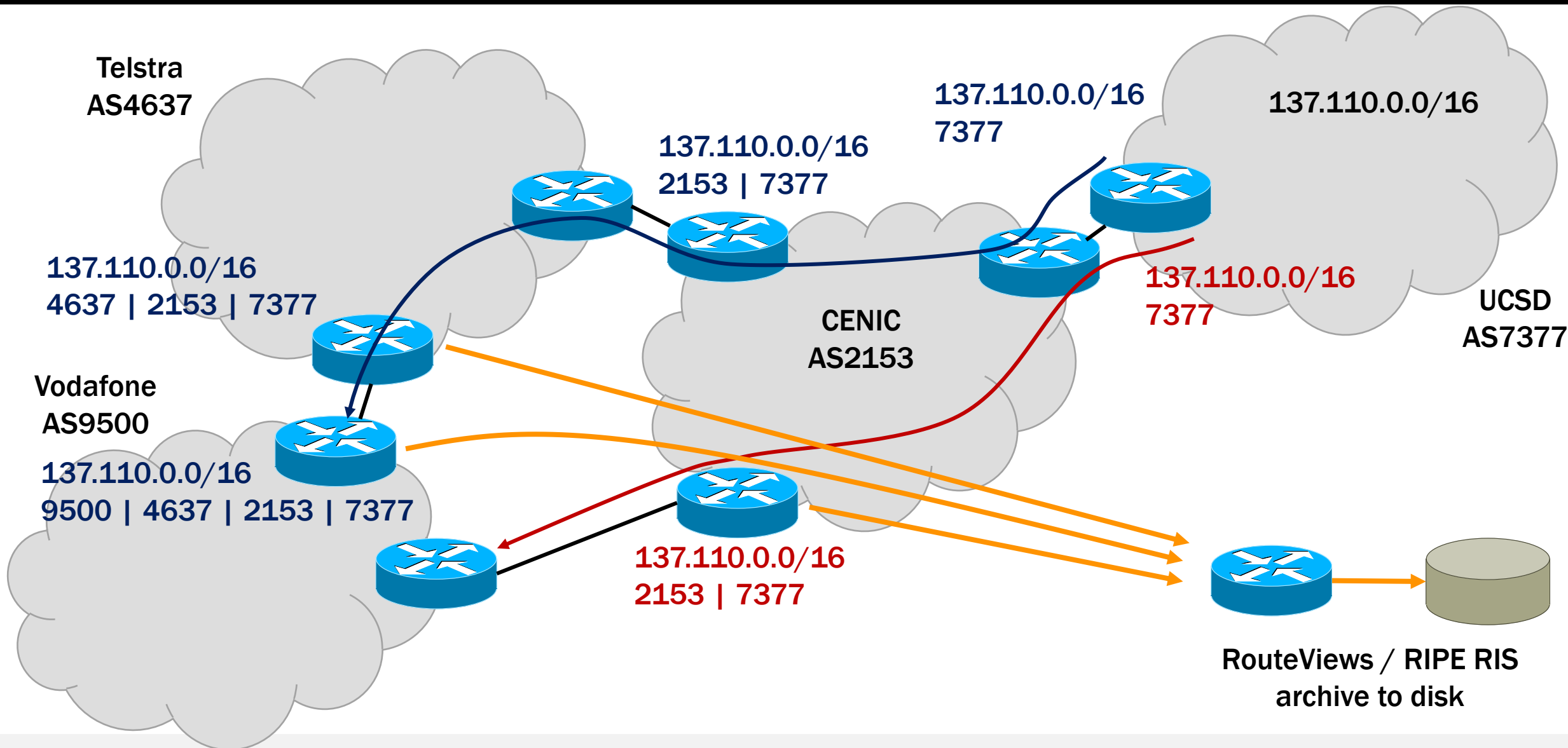
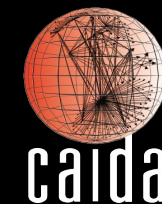
Clique ASes (Wikipedia, 2023):

- 174 (Cogent)
- 701 (Verizon)
- 1239 (Sprint/T-Mobile)
- 1299 (Arelion)
- 2914 (NTT)
- 3257 (GTT)
- 3320 (Deutsche Telekom)
- 3356 (Lumen)
- 3491 (PCCW)
- 5511 (Orange)
- 6453 (TATA)
- 6461 (Zayo)
- 6762 (Telecom Italia)
- 6830 (Liberty Global)
- 7018 (AT&T)
- 12956 (Telxius)

# BGP COLLECTORS



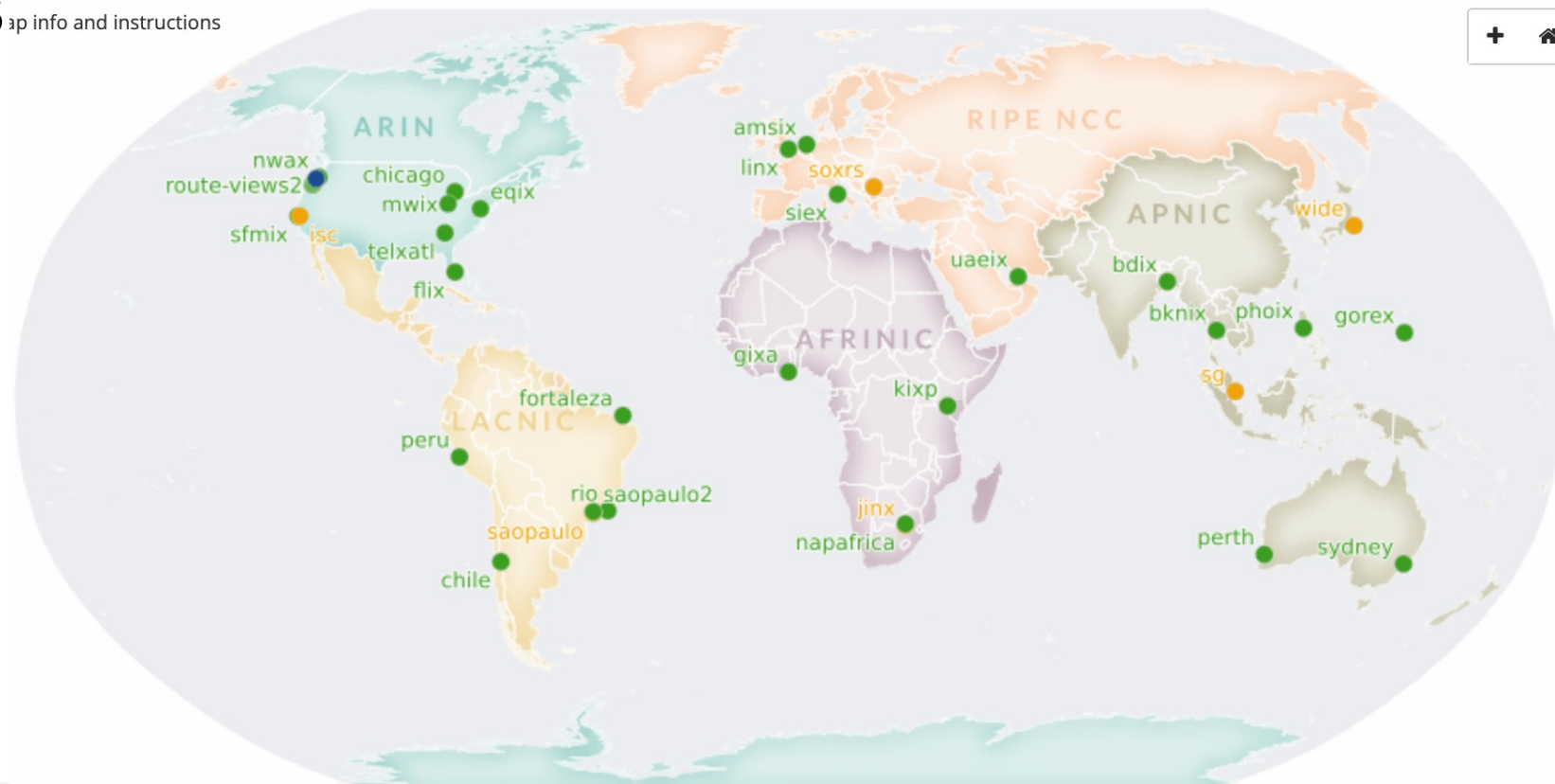
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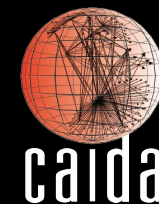


- RIPE RIS and RouteViews each operate ~30 collectors, each collector records BGP routing data from ~30 routers ap info and instructions



<https://www.routeviews.org/>  
<https://ris.ripe.net/>

# AS RELATIONSHIPS



- CENIC: 2153 | 7377 137.110.0.0/16  
Telstra: 4637 | 2153 | 7377 137.110.0.0/16  
Vodafone: 9500 | 4637 | 2153 | 7377 137.110.0.0/16
- RouteViews and RIPE RIS observe >300M routes
- Paths provide constraints on which links could be c2p, p2p, or p2c.
- Paper provides a description of an algorithm to infer AS relationships given observed paths.