CPSC 317 COMPUTER NETWORKING

Module 5: Network Layer – Day 1 – History and ASes

READING

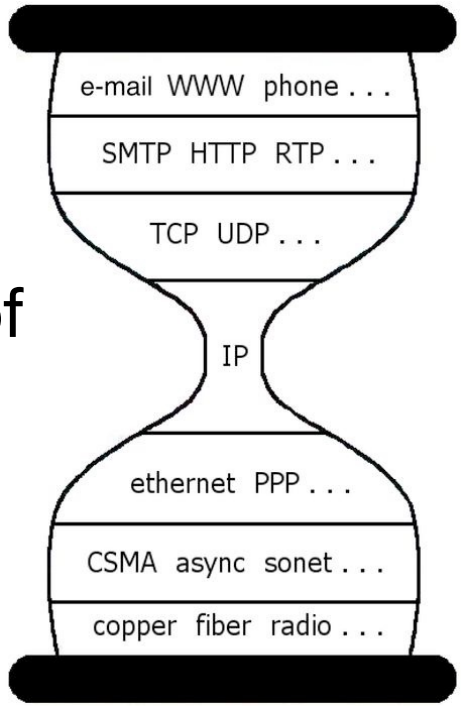
- Reading: Chapter 5 Intro, 5.3, 5.4

LEARNING GOALS (INTERNET STRUCTURE)

- Explain how “a network of networks” led to the current notion of Autonomous Systems
- Describe the notion of “tiers” of ASes
- Explain the relationship between ASes and organizations
- Explain why addresses are assigned to interfaces and not hosts
- Define a network

TCP/IP HOURGLASS

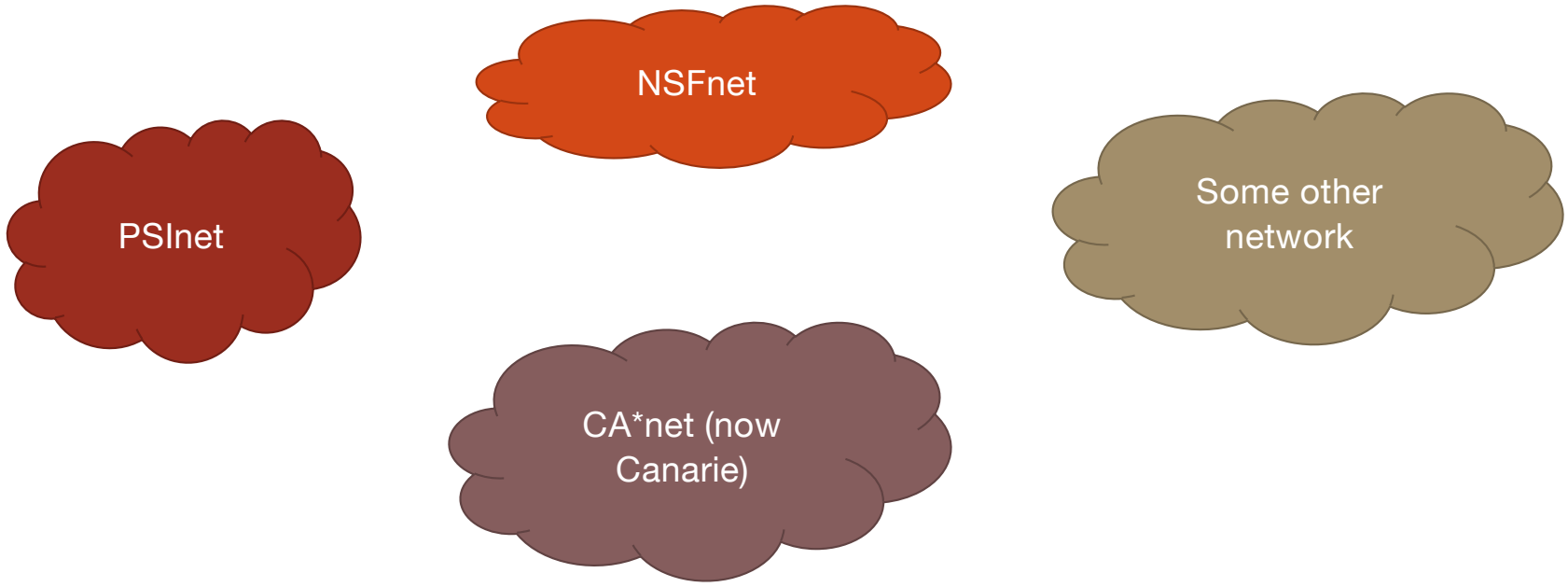
The waist of the Internet



IP sends packets (Datagrams) from source to destination…

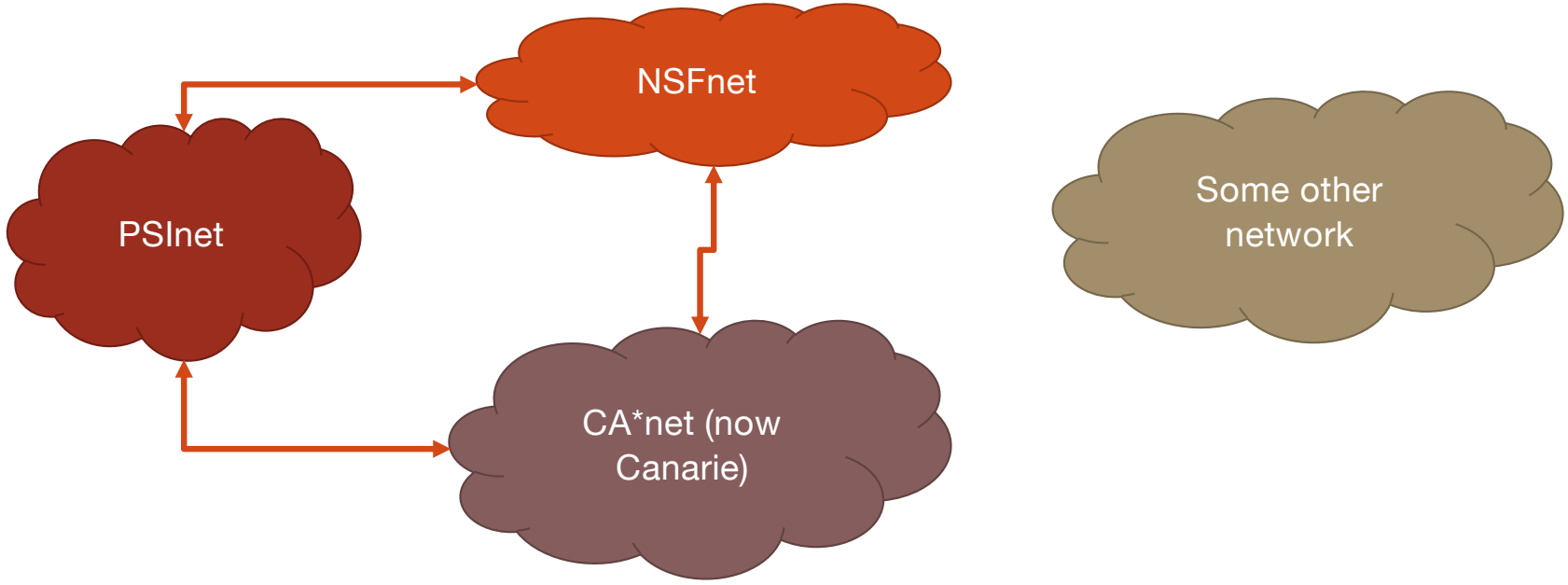
IN THE BEGINNING...

- Imagine a bunch of private networks



NETWORKS START TO INTERCONNECT

- Internet: Network of networks

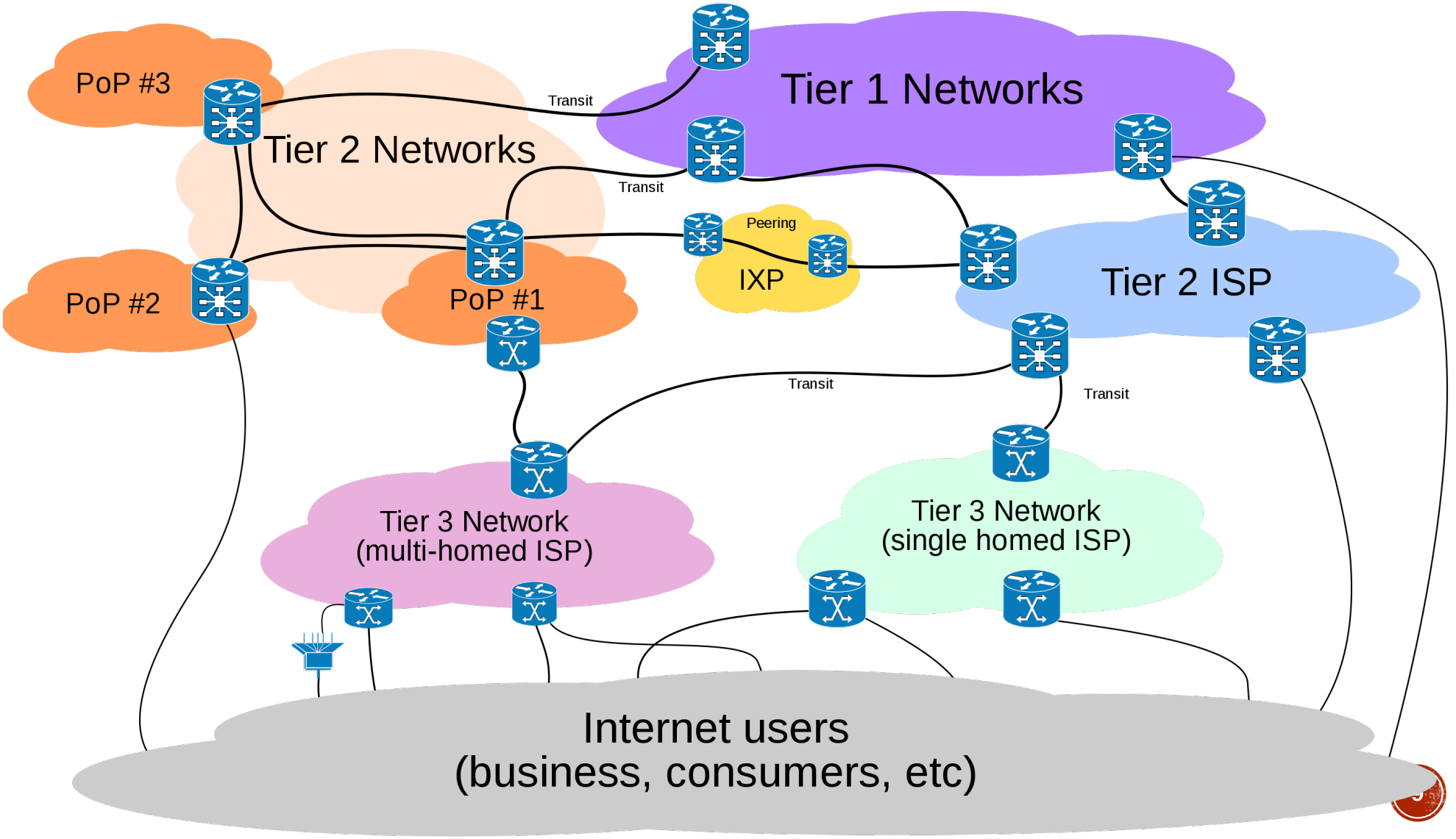


INTERNET ORGANIZATION STRUCTURE

- Organized into entities called autonomous systems (ASes)
  - Remnant of old private networks
- Each autonomous system:
  - is assigned a range/collection of IP addresses
  - is responsible for routing to addresses it “owns”
  - is responsible for routing to addresses that are not its responsibility
- Why keep ASes?
  - Autonomy!

WHO CONTROLS AN AS?

- Some companies do the end systems (last mile)
- Some companies do long haul lines (backbones)
  - within a country or region
  - around the world
- Some do a mix of both
- Some companies are consortiums
- Networks often connect to each other at Internet Exchanges


PoP #3
Tier 2 Networks
Transit
Tier 1 Networks
Transit
Peering
IXP
PoP #2
PoP #1
Tier 2 ISP
Transit
Transit
Tier 3 Network
(multi-homed ISP)
Tier 3 Network
(single homed ISP)
Internet users
(business, consumers, etc)

CLICKER QUESTION

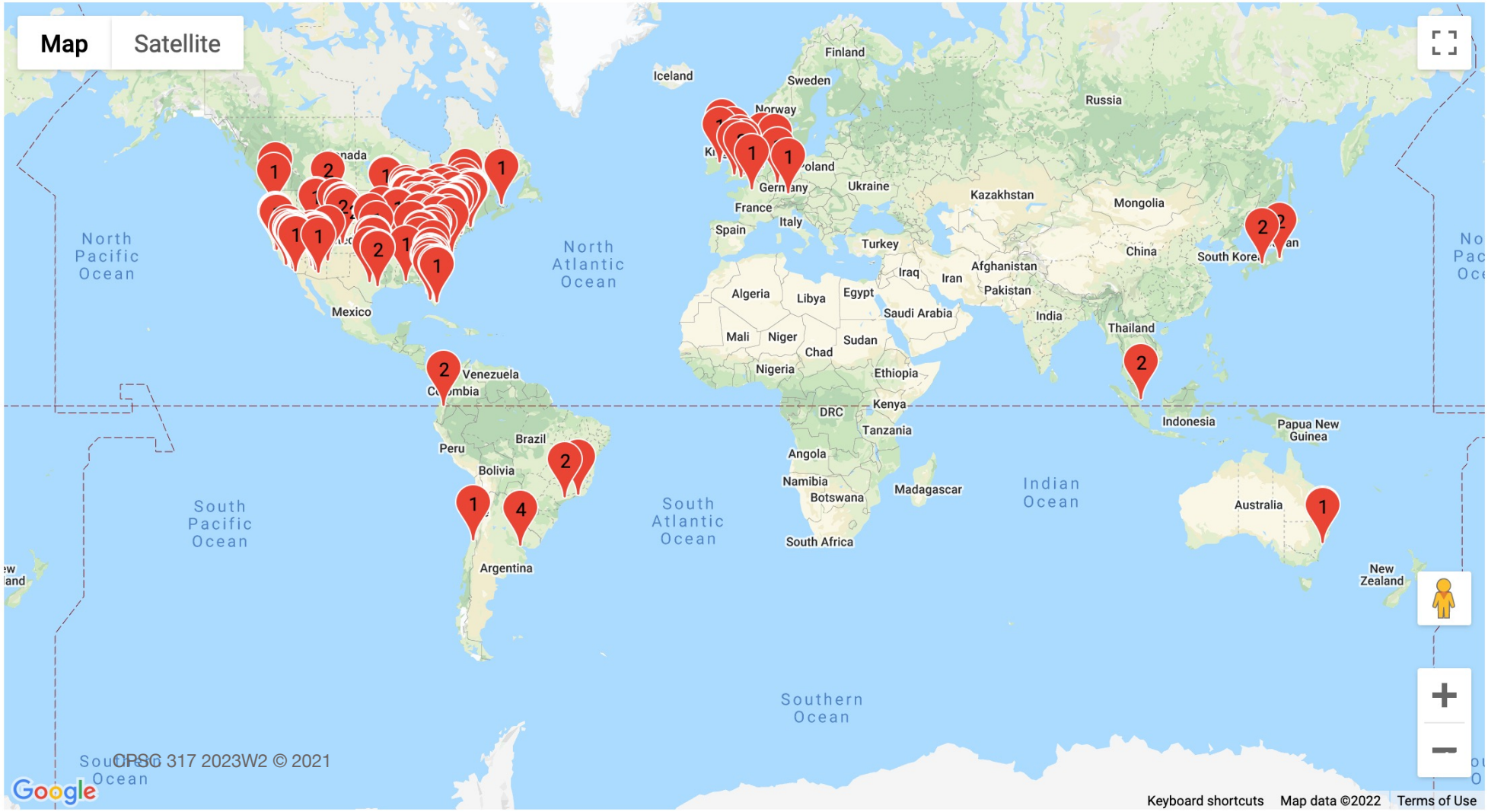
- How many autonomous systems (networks) are there in the Internet today?

A. 100s
B. 1,000s
C. 10,000s
D. 100,000s
E. 1,000,000s

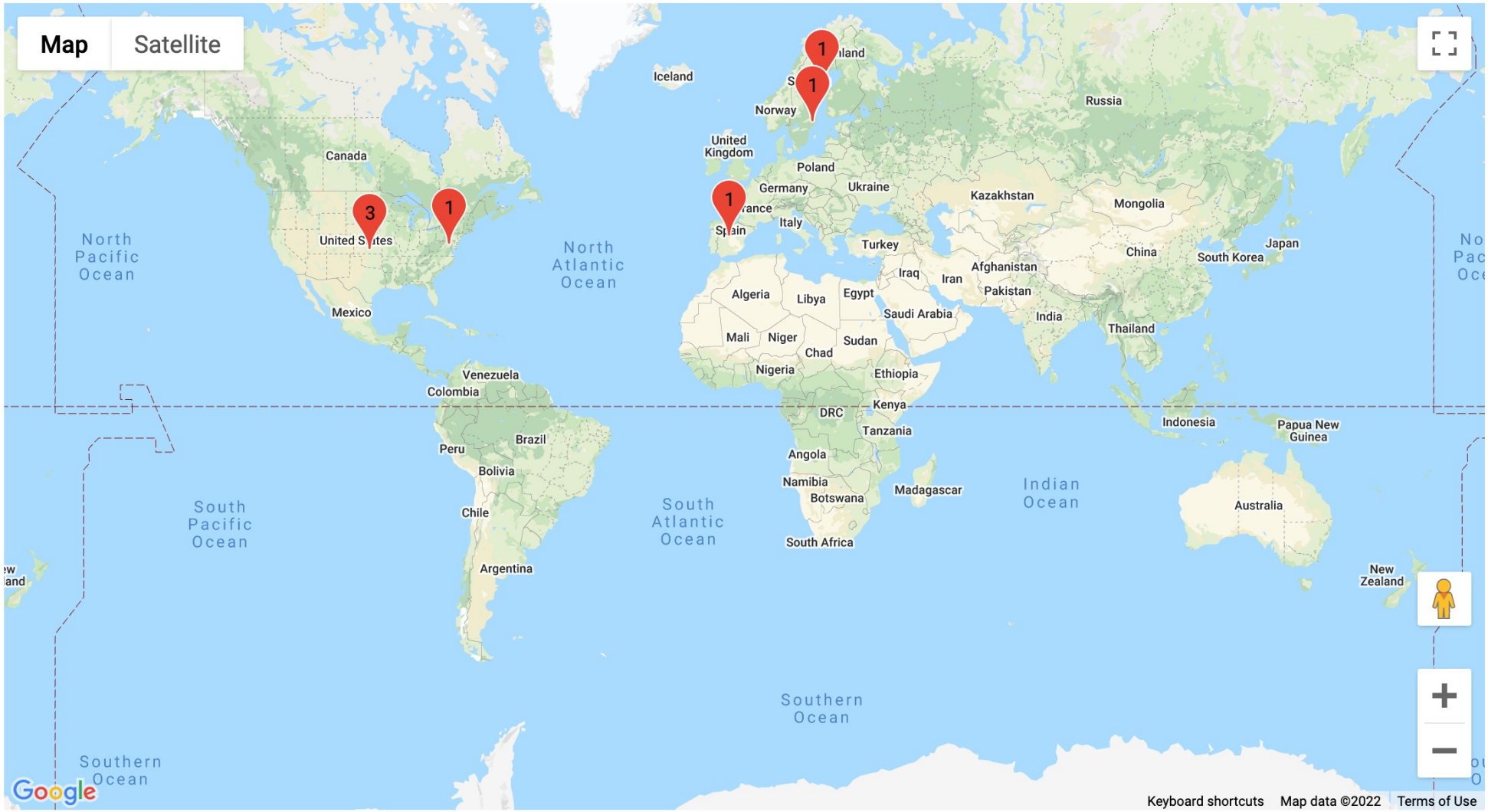
TIER 1 NETWORKS

- https://en.wikipedia.org/wiki/Tier_1_network
  - Lumen (formerly Level 3) (USA)
  - Arelion (formerly Telia) (Sweden)
  - GTT (USA)
  - NTT (Japan)
  - Telecom Italia Sparkle (Italy)
  - Tata (India)
  - Zayo (USA)

Map of ASN 3356 LEVEL3 (2856 samples 207 locations)



Map of ASN 1299 Telia Company AB (20 samples 8 locations)



Map of ASN 3257 GTT Communications Inc. (285 samples 86 locations)

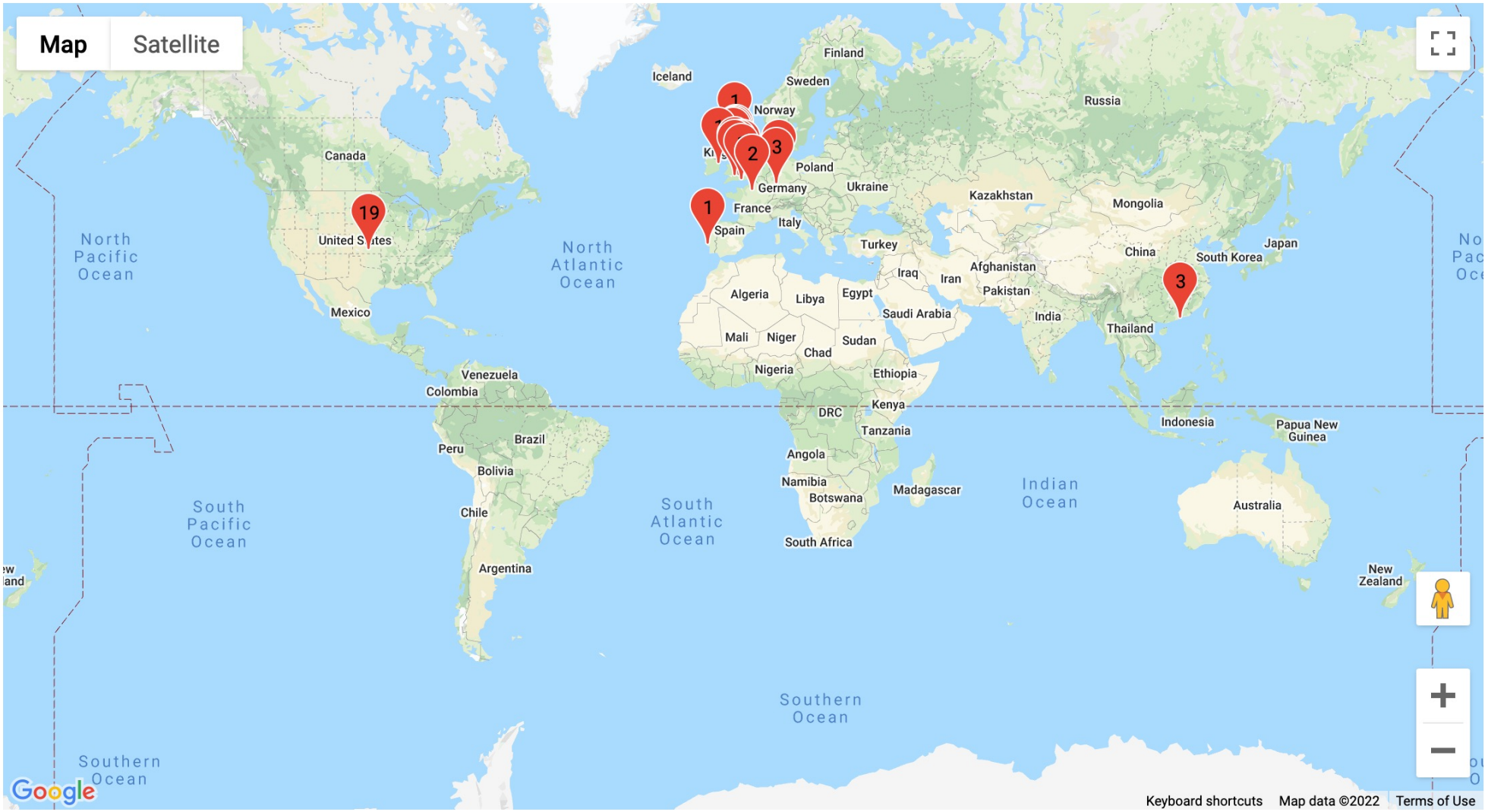
TIER 2 NETWORKS

- https://en.wikipedia.org/wiki/Tier_2_network
  - Hurricane Electric
  - Sprint
  - Korea Telecom
  - Vodaphone
  - China Telecom
  - British Telecom
  - Comcast
  - And lots, lots more

Map of ASN 6939 HURRICANE (34 samples 6 locations)

Map of ASN 4766 Korea Telecom (4512 samples 255 locations)

Map of ASN 1273 CW Vodafone Group PLC (214 samples 17 locations)



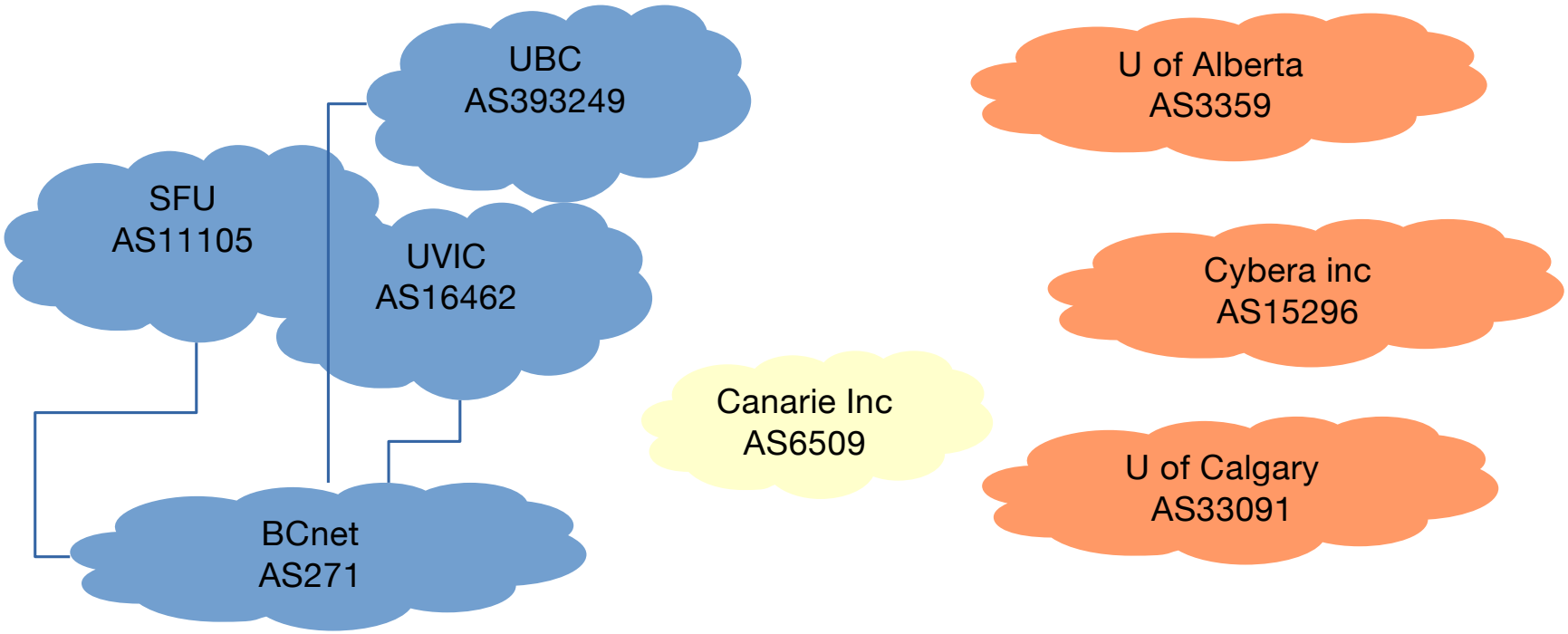
Map of ASN 4134 Chinanet (10935 samples 697 locations)

TIER 3 NETWORKS (STUBS)

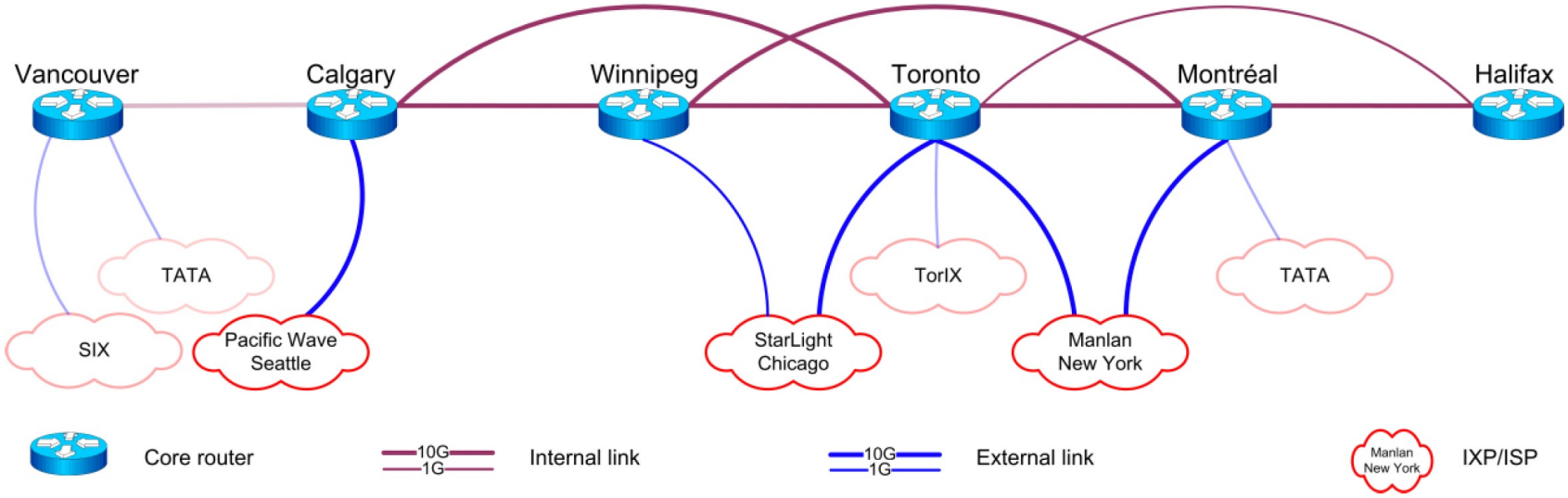
- Everybody else

Map of ASN 393249 UBC (48 samples 17 locations)

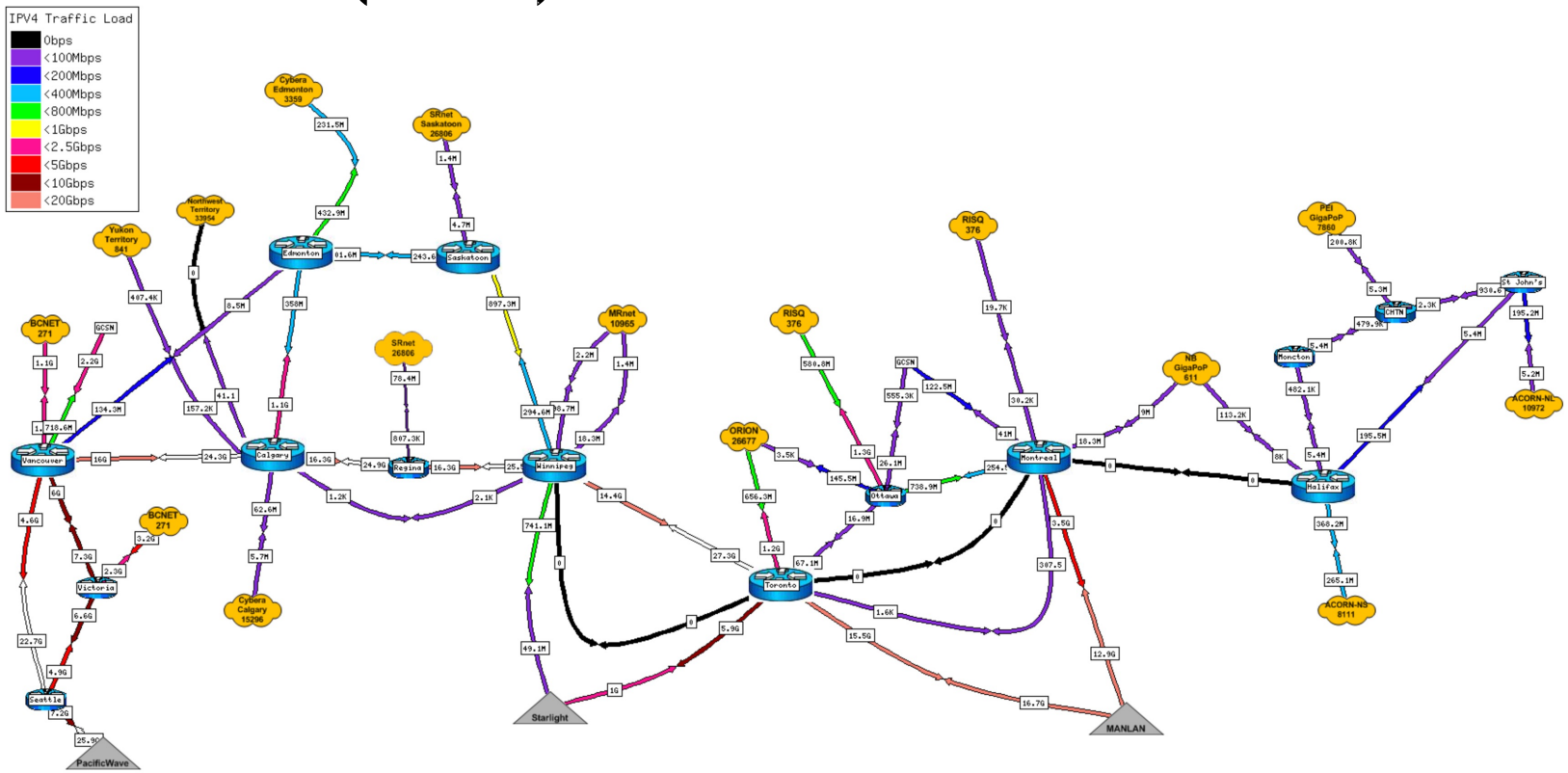
EXAMPLE: A COLLECTION OF REAL AUTONOMOUS SYSTEMS



CANARIE (CIRCA 2010)



CANARIE (NOW)


IPV4 Traffic Load
0bps
<100Mbps
<200Mbps
<400Mbps
<800Mbps
<1Gbps
<2.5Gbps
<5Gbps
<10Gbps
<20Gbps
Vancouver
Calgary
Edmonton
Saskatoon
Regina
Winnipeg
Toronto
Ottawa
Montreal
Halifax
Victoria
Seattle
Starlight
MANLAN
PacificWave

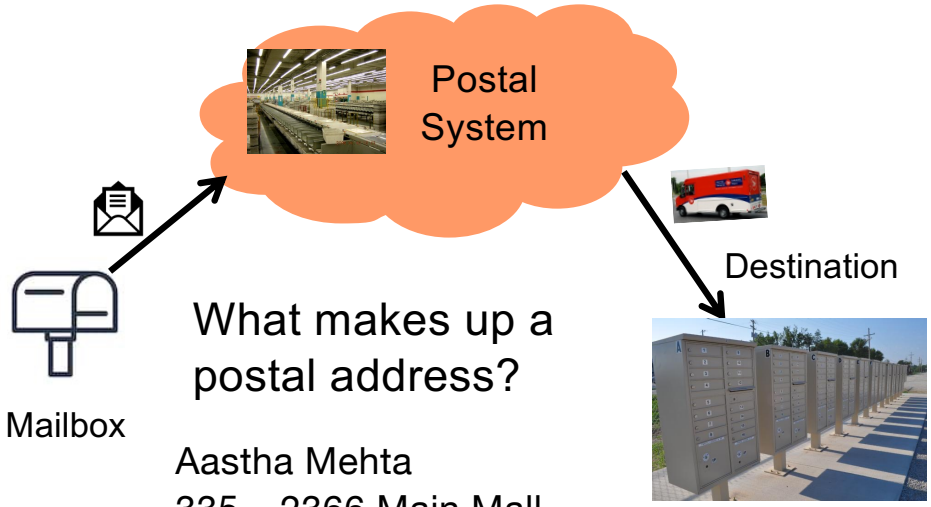
SO, HOW DOES DATA MOVE?

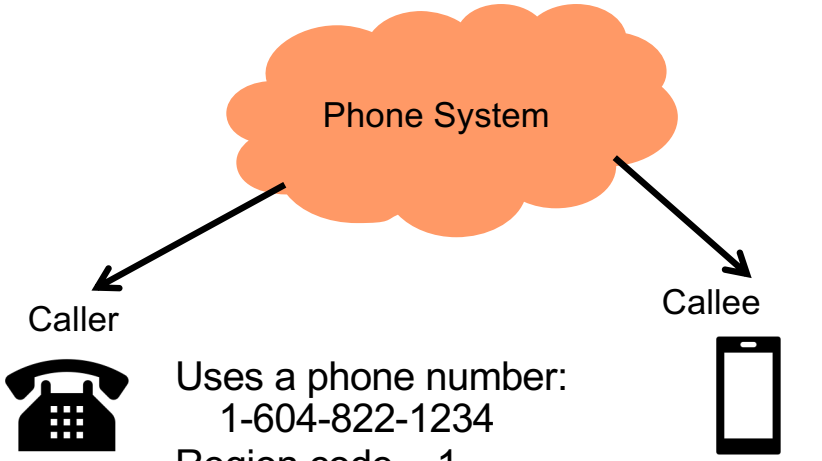
- We need to think about names (or addresses)
- We need to think about deciding where to send data

NAMING

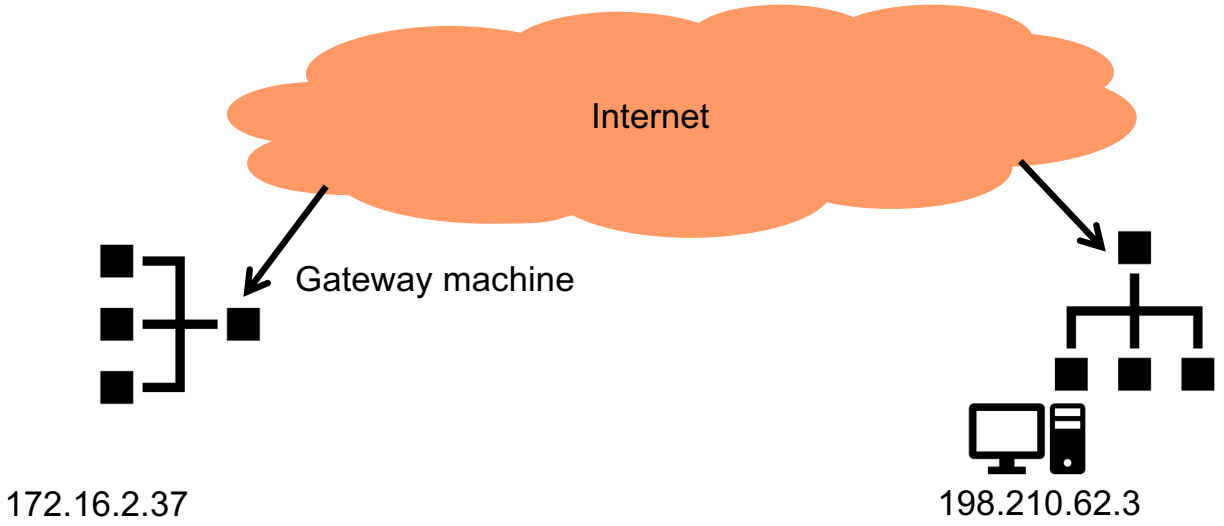
- Purpose of the network layer is to route messages from source machine to destination machine.
- What's in a Name?
  - Format
  - Semantics
  - Properties
- What is an "address"?

ADDRESSING IN DIFFERENT SYSTEMS

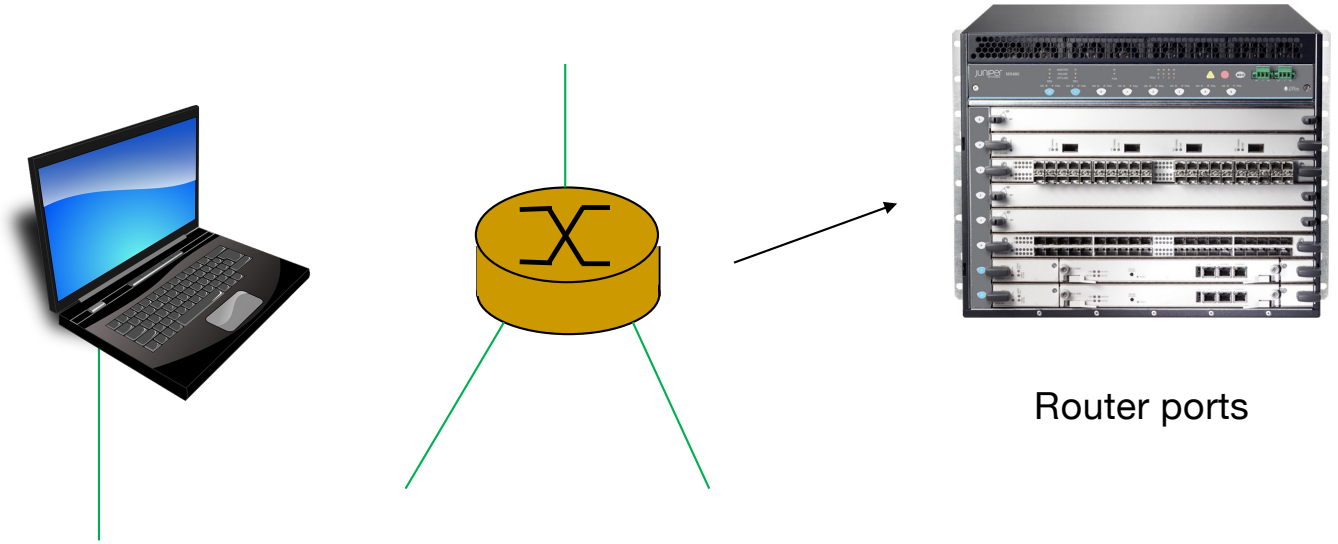




ADDRESSING IN COMPUTER NETWORKS



ADDRESSES NAME INTERFACES NOT HOSTS



Router ports

WHY NAME INTERFACES?

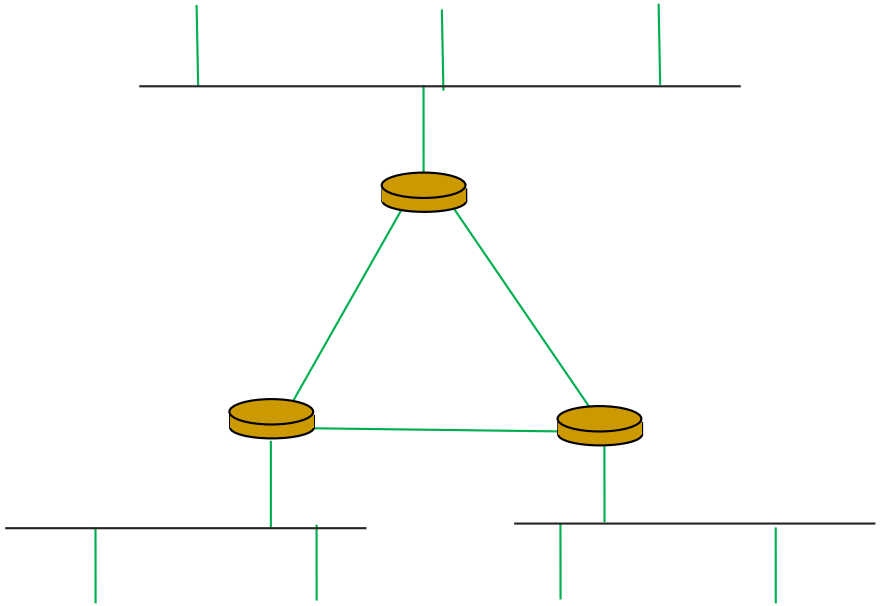
- Consider a cell phone
  - It has multiple interfaces
    - WIFI
    - Cellular data
  - When you make a connection using one of these interfaces, you expect the data to come back on the same interface
  - So the address has to identify the interface, not just the cell phone
- Your laptop
  - Has at least one “real” network interface 142.103.10.41
  - And at least one “loopback” network interface 127.0.0.1

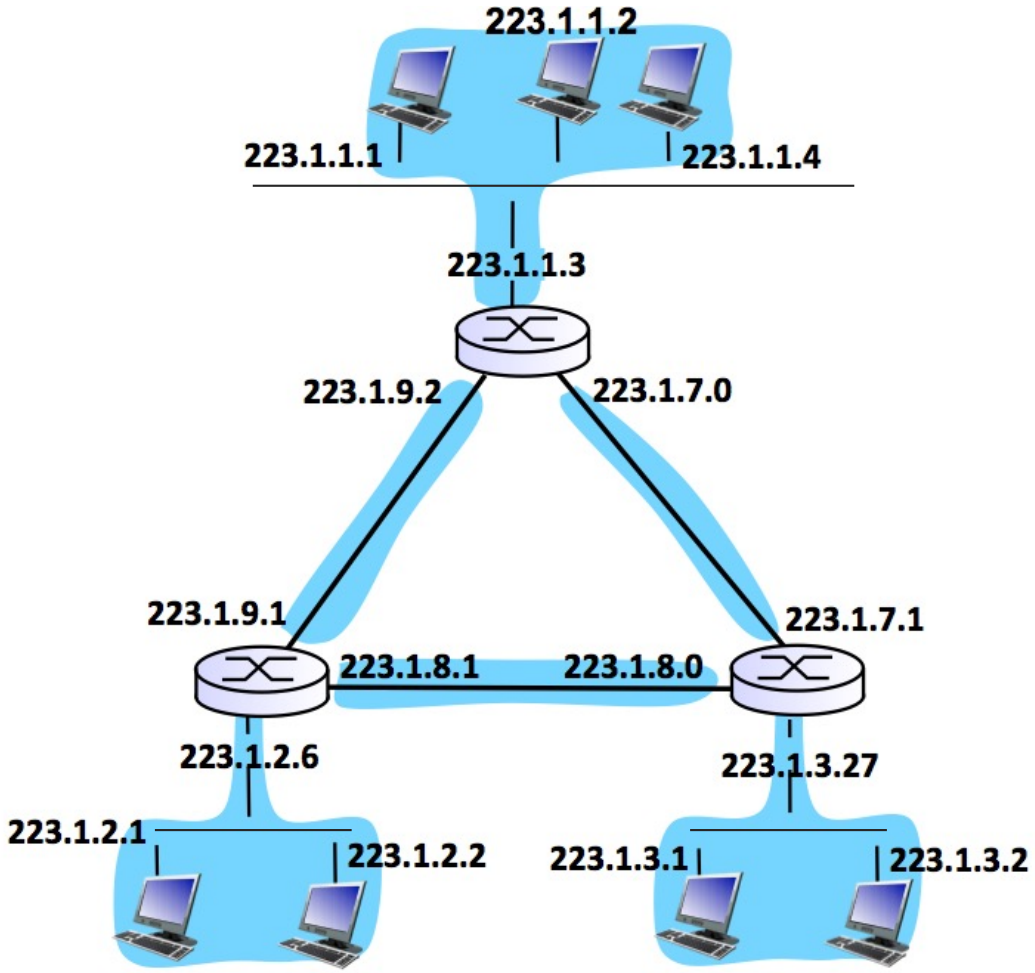
WHAT EXACTLY IS A "NETWORK"?

- At the network layer, we use the term "network" in (at least) 2 different ways:
  - In the early part of today's lecture, we talked about ASes as networks
    - A collection of computers and routers owned and administered by a single organization
  - When we talk about forwarding, we talk about a network as a single shared communication medium connected to at least 2 interfaces

CLICKER QUESTION

How many (1st level) networks (shared medium with some interfaces attached to it) are in this picture?




223.1.1.2
223.1.1.1
223.1.1.4
223.1.1.3
223.1.9.2
223.1.7.0
223.1.9.1
223.1.7.1
223.1.8.1
223.1.8.0
223.1.2.6
223.1.3.27
223.1.2.1
223.1.2.2
223.1.3.1
223.1.3.2

IN-CLASS ACTIVITY

- ICA51