

# *Networking Basics*

## 03b - Global IP routing

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*Where networks meet*

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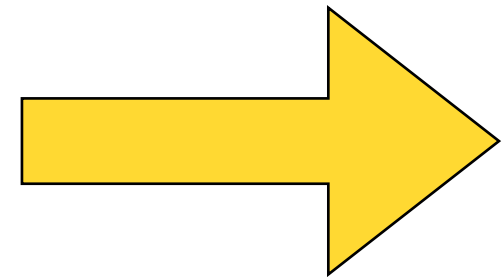
# Networking Basics

## DE-CIX Academy

01 - Networks, Packets, and Protocols

02 - Ethernet, 02a - VLANs

03 - IP, 03a - IP addresses, prefixes, and routing,



**03b - Global routing,**

03c - ARP and ND

04a - UDP, 04b - TCP, 04c - ICMP, 04d - Traceroute

05 - Uni-, Broad-, Multi-, and Anycast

06a - Domain Name System (DNS)

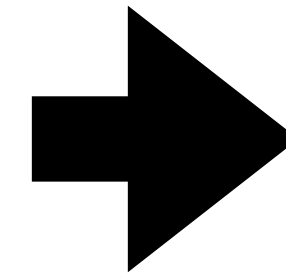
07a - Simple Mail Transfer Protocol, 07b - HTTP

# IP - the Internet Protocol

# Internet Model

## IP / Internet Layer

- Data units are called "Packets"
- Provides source to destination (**end-to-end**) transport
- Needs **addresses** for entities



| Layer | Name        |
|-------|-------------|
| 5     | Application |
| 4     | Transport   |
| 3     | Internet    |
| 2     | Link        |
| 1     | Physical    |





# IPv6 - Prefixes

Prefix-Length: 0-128

2003:de:274f:4000::/64

## Notation:

- 4 digit hex numbers (0-9,a-f)
- Separated by ":"
- "::" = fill up with zeros

Host-part all zero

128 Bits long

0 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 10 11 12 13 14 15 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35 36 37 38 39 3a 3b 3c 3d 3e 3f 40 41 42 43 44 45 46 47 48 49 4a 4b 4c 4d 4e 4f 50 51 52 53 54 55 56 57 58 59 5a 5b 5c 5d 5e 5f 60 61 62 63 64 65 66 67 68 69 6a 6b 6c 6d 6e 6f 70 71 72 73 74 75 76 77 78 79 7a 7b 7c 7d 7e 7f

# IPv4 - Prefixes

Prefix-Length: 0-32

10.3.8.0/22

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

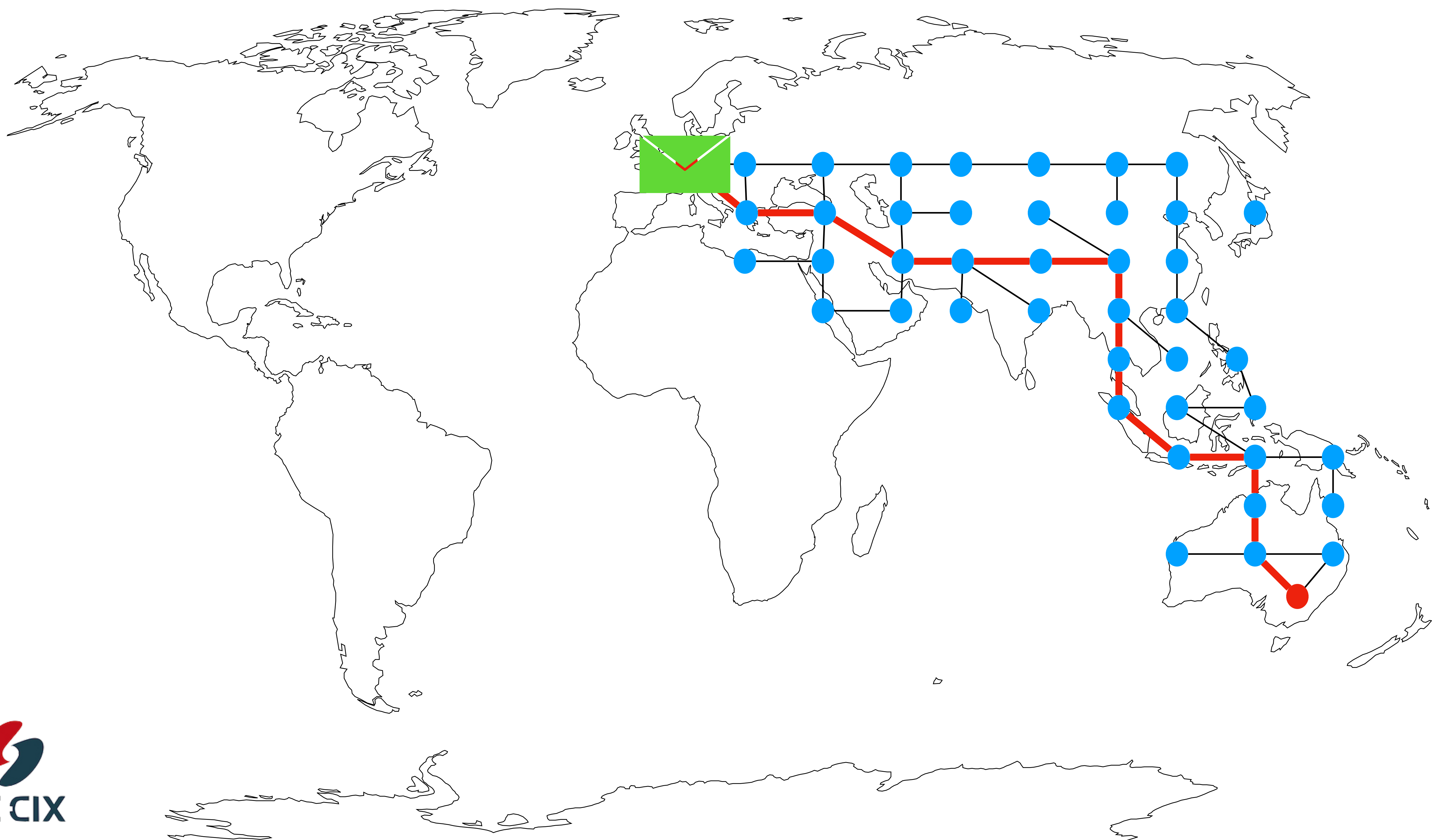
## Notation:

- 4 numbers (0-255)
- Separated by "."

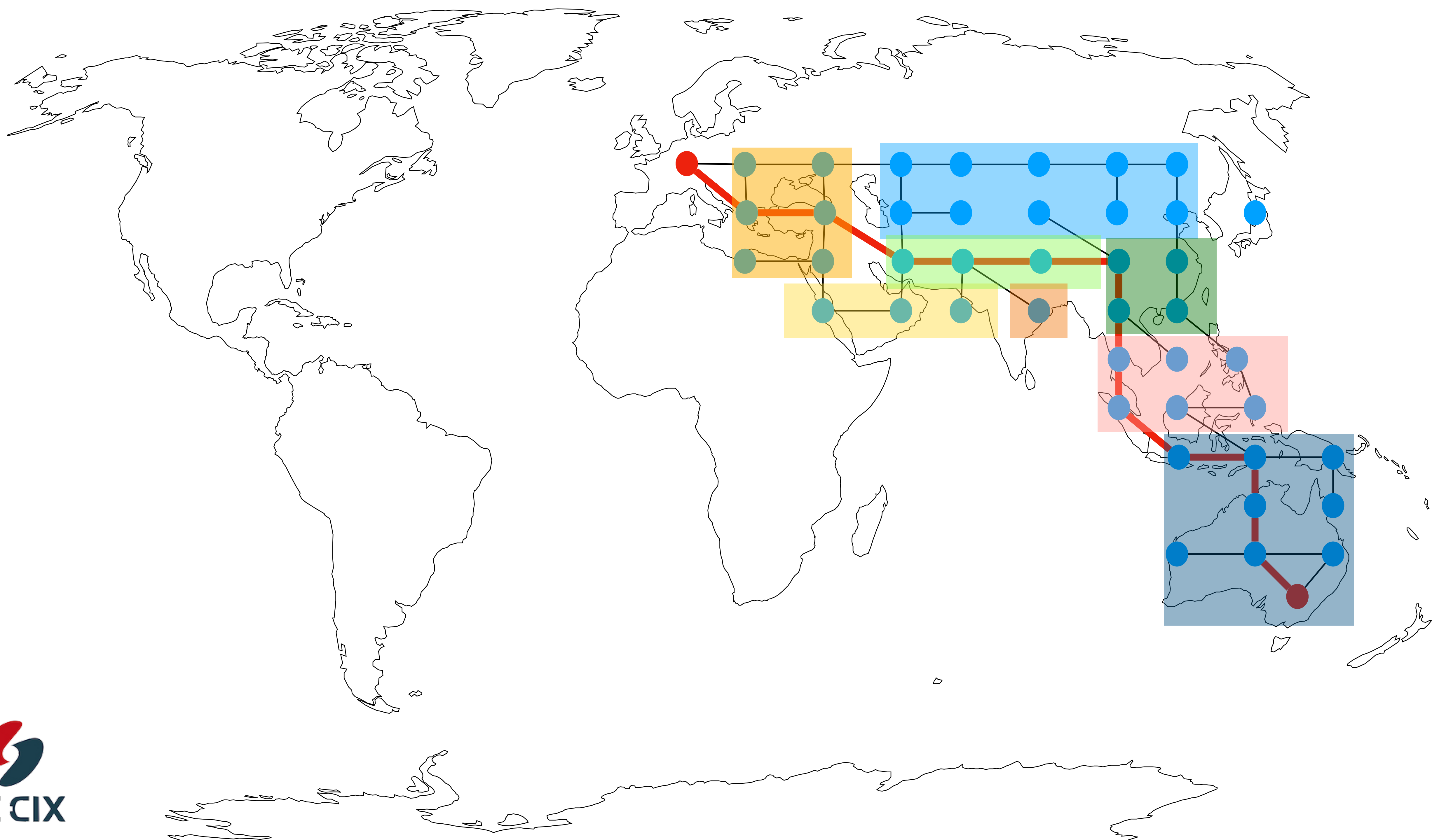
Host-part all zero

32 Bits long

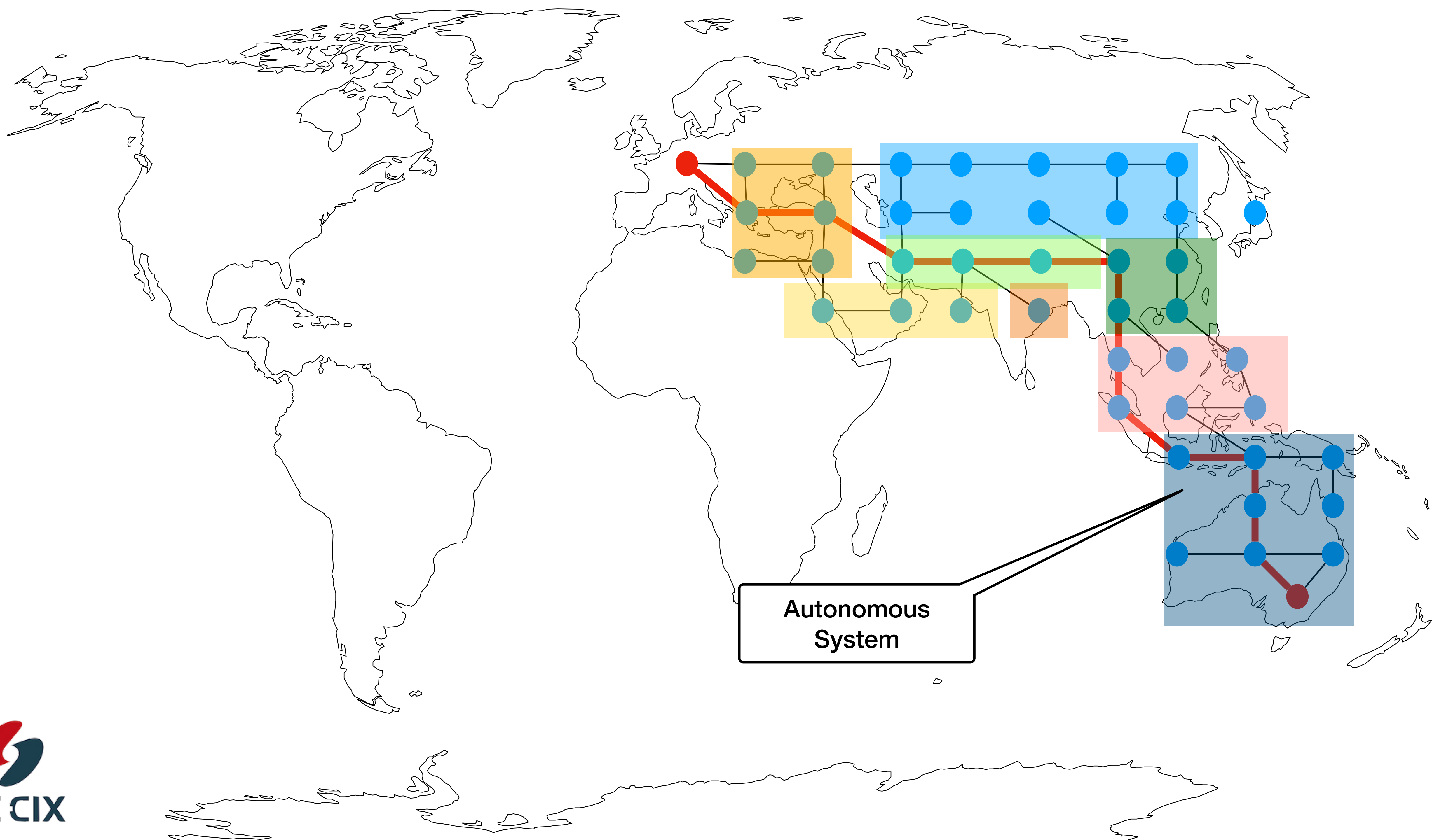




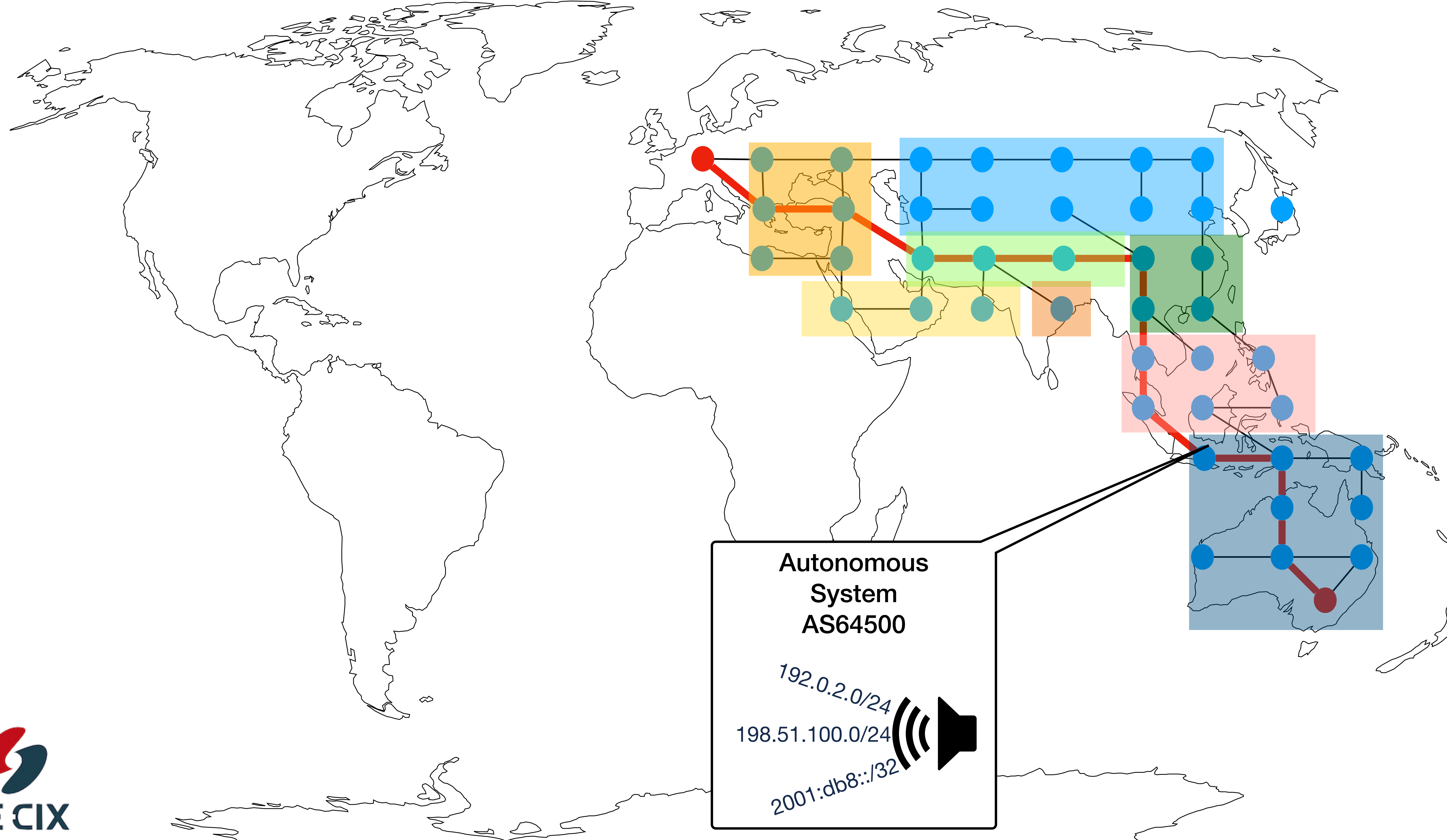








Autonomous  
System



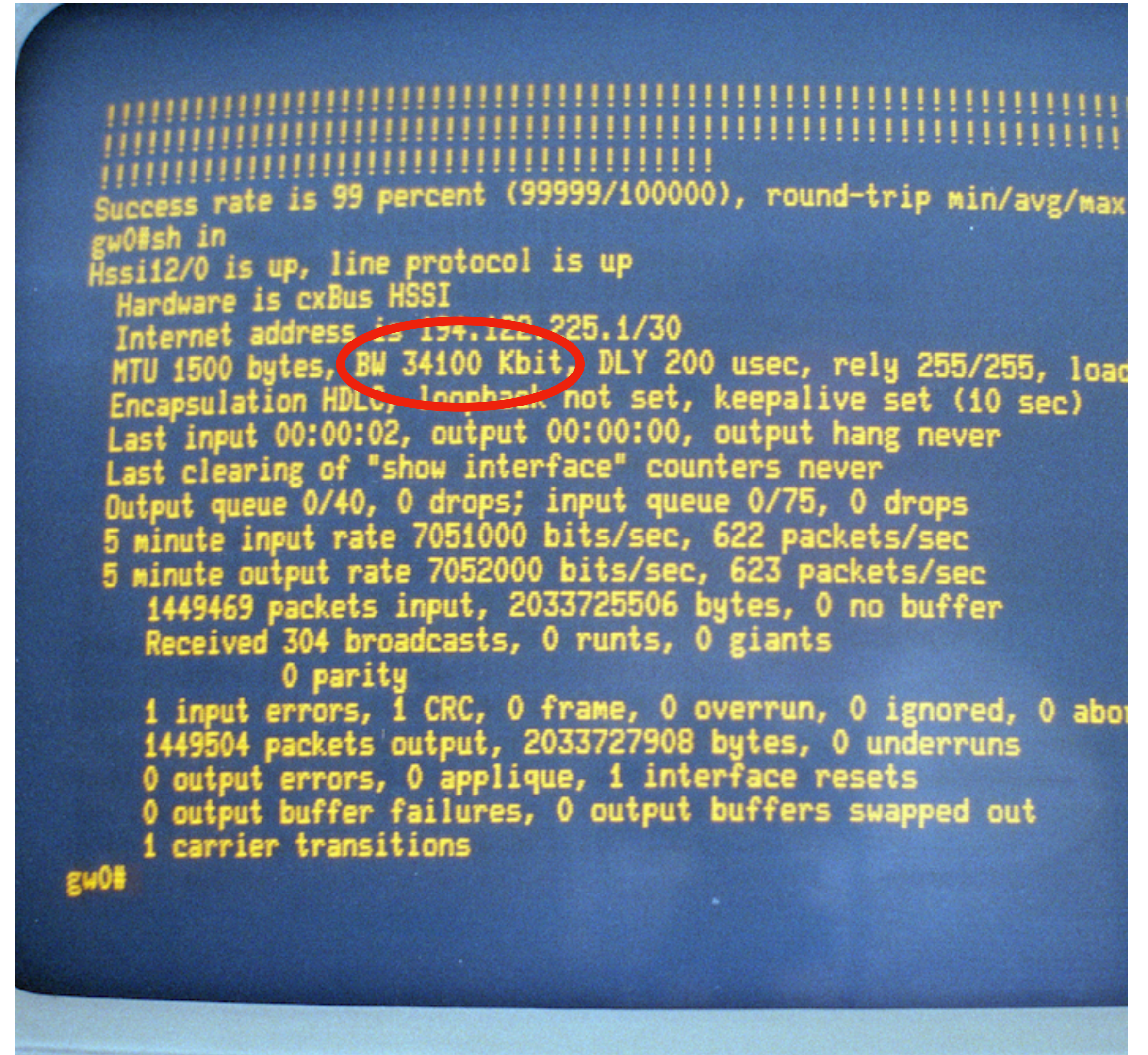


# How did it start?



## Also some personal history

- 2Mbit/s was a "fast connection"
- Backbone networks were 34Mbit/s
- End customers connected via ISDN (modern) or telephone modems
- Standard end customer speed was 64kBit/s

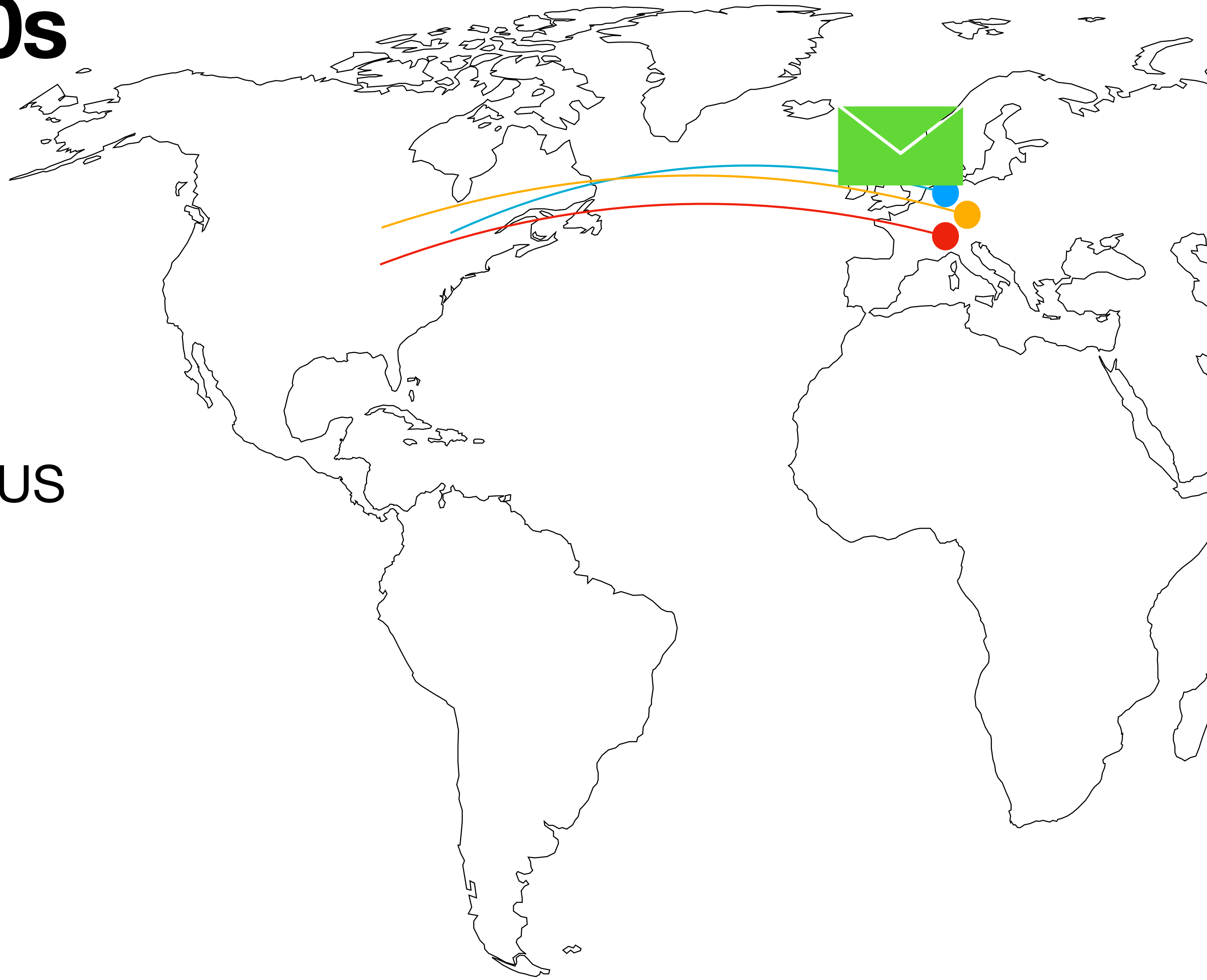




# Internet in the 1990s

## Situation in Germany

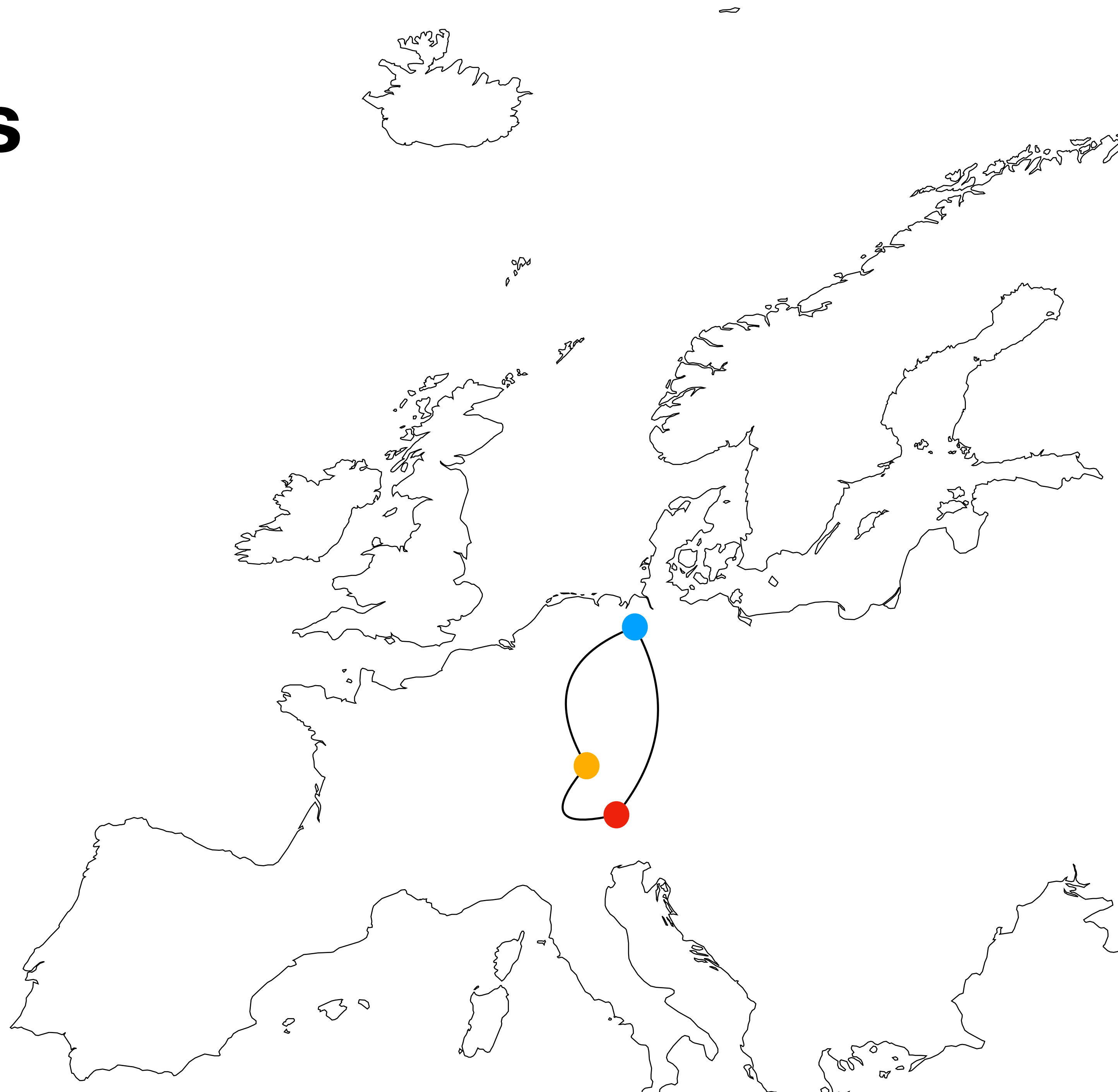
- In the early 1990s there were three commercial ISPs in Germany
- Each had a connection to the US
- So traffic had to go via the Atlantic twice in worst case
- And was expensive



# Internet in the 1990s

## The idea

- Idea: Exchange traffic directly
- Via cables?
  - Each of this early ISPs was in a different city
  - Cables / leased lines were expensive
  - Meet in the middle!

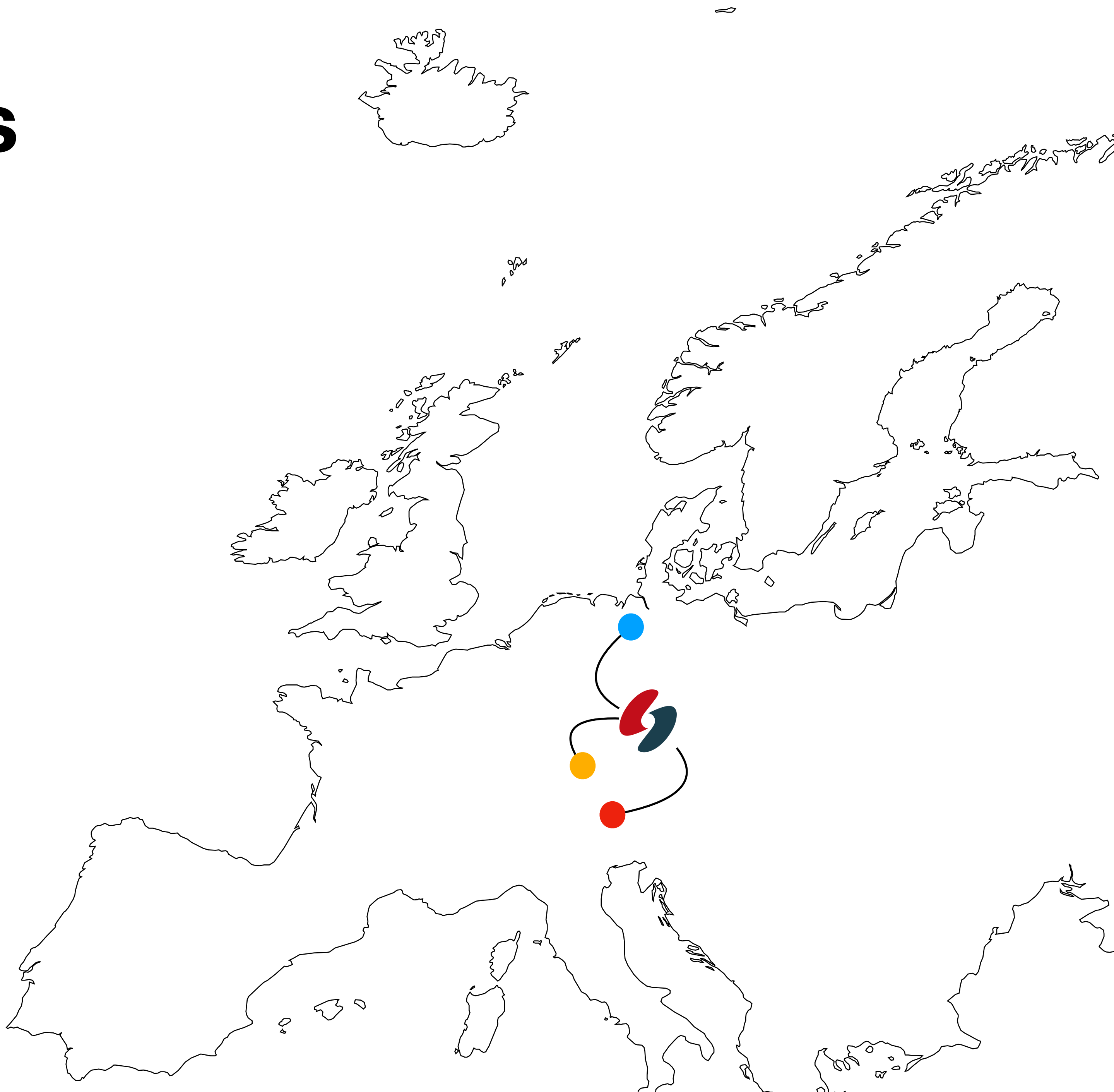




# Internet in the 1990s

## The solution

- Meet in the middle!
  - DE-CIX was born
- Direct connection between commercial providers
- To exchange traffic
  - Only their own and their own customers
- This is Peering!



# Peering

Noun

**peering** (*plural* peerings)

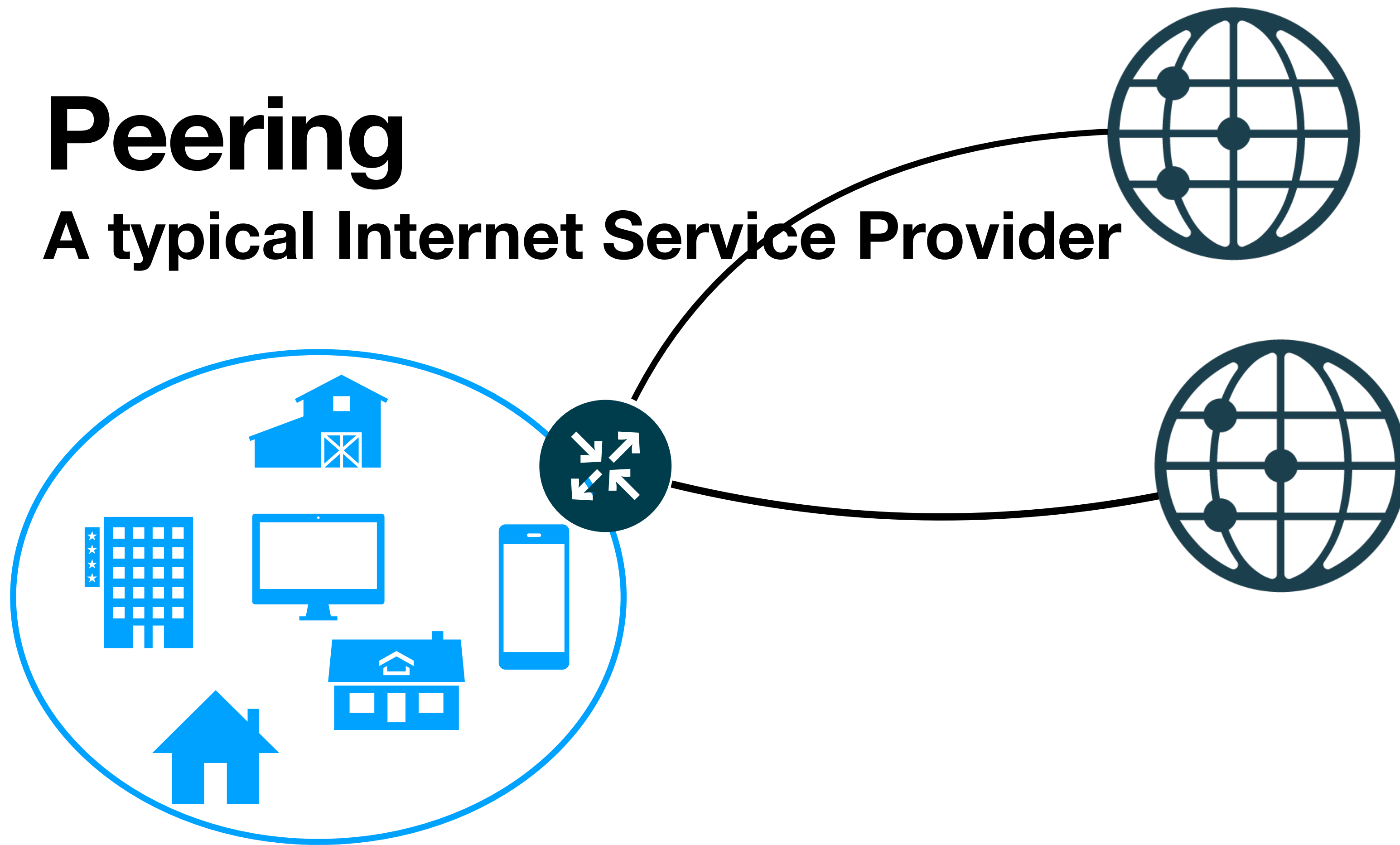
1. The act of one who peers; a looking around.
2. (*Internet*) The act of carrying communications traffic terminating on one's own network on an equivalency basis to and from another network, usually without charge or payment.

<https://en.wiktionary.org/wiki/peering>



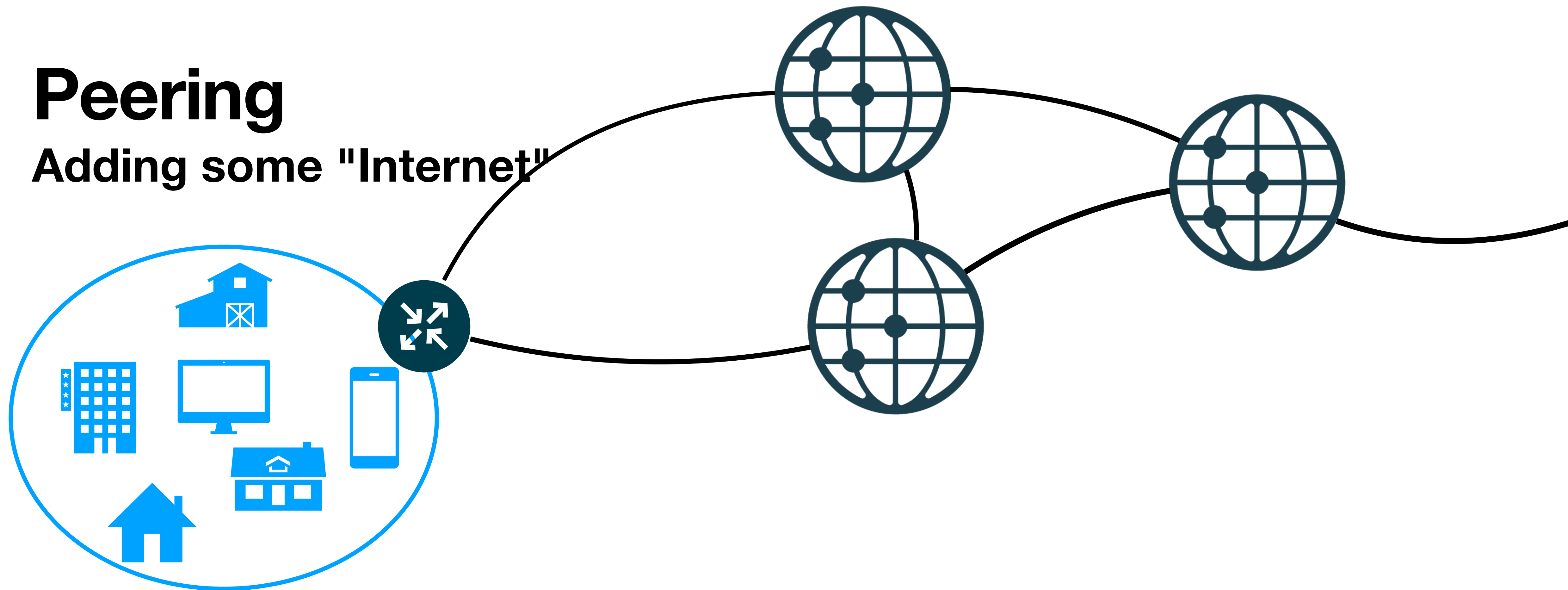
# Peering

A typical Internet Service Provider



# Peering

Adding some "Internet"

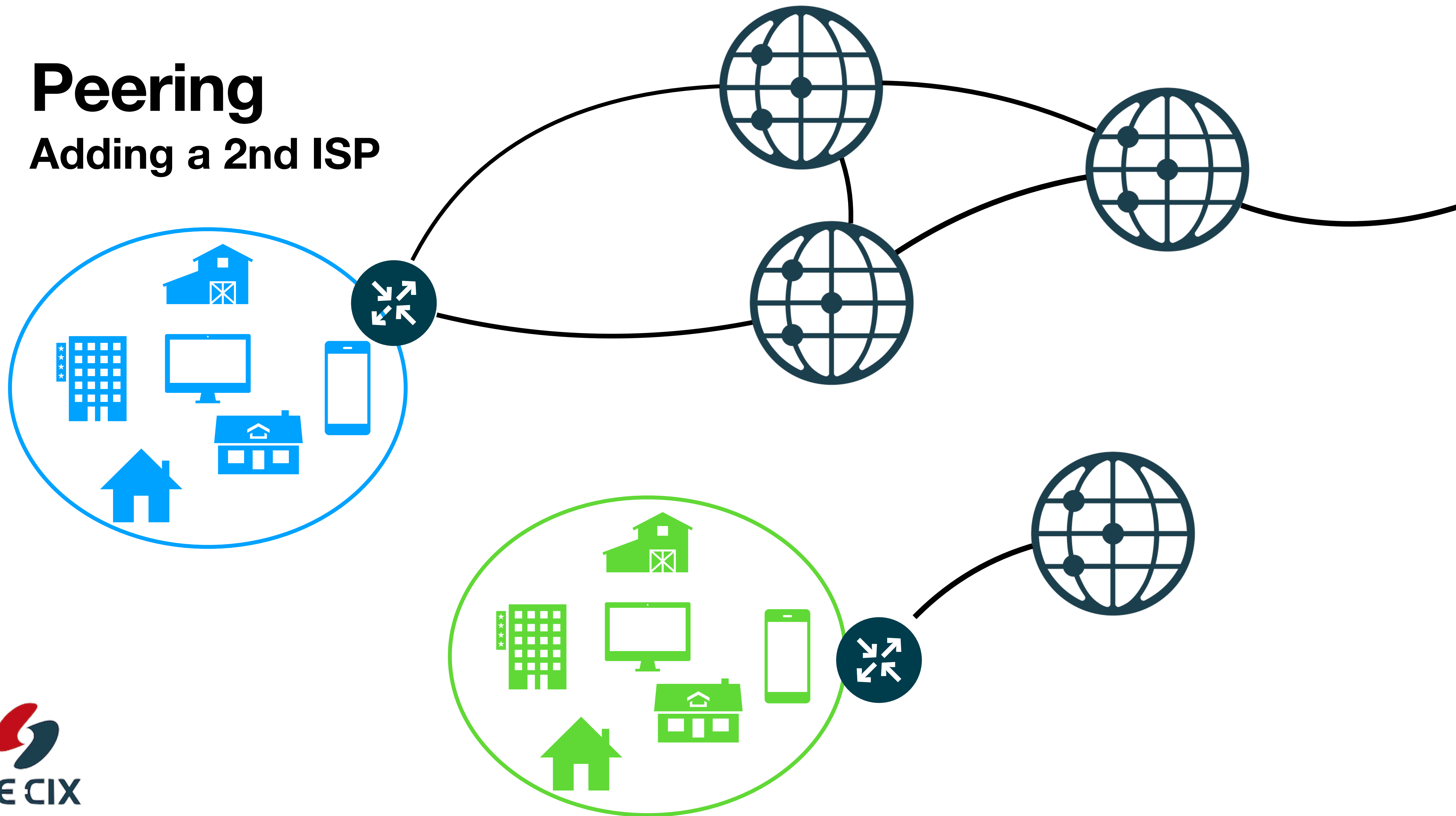


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# Peering

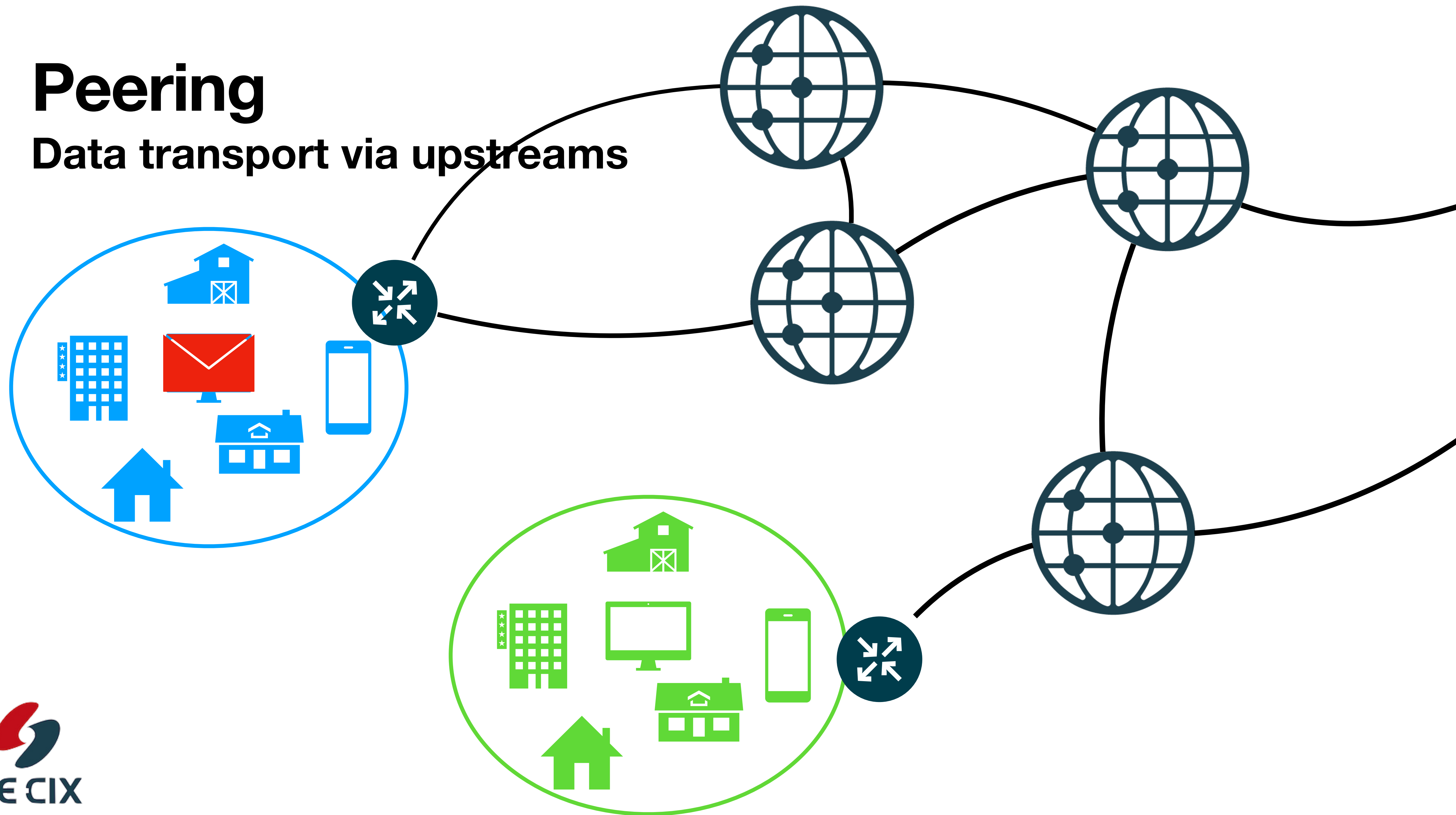
Adding a 2nd ISP



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# Peering

Data transport via upstreams

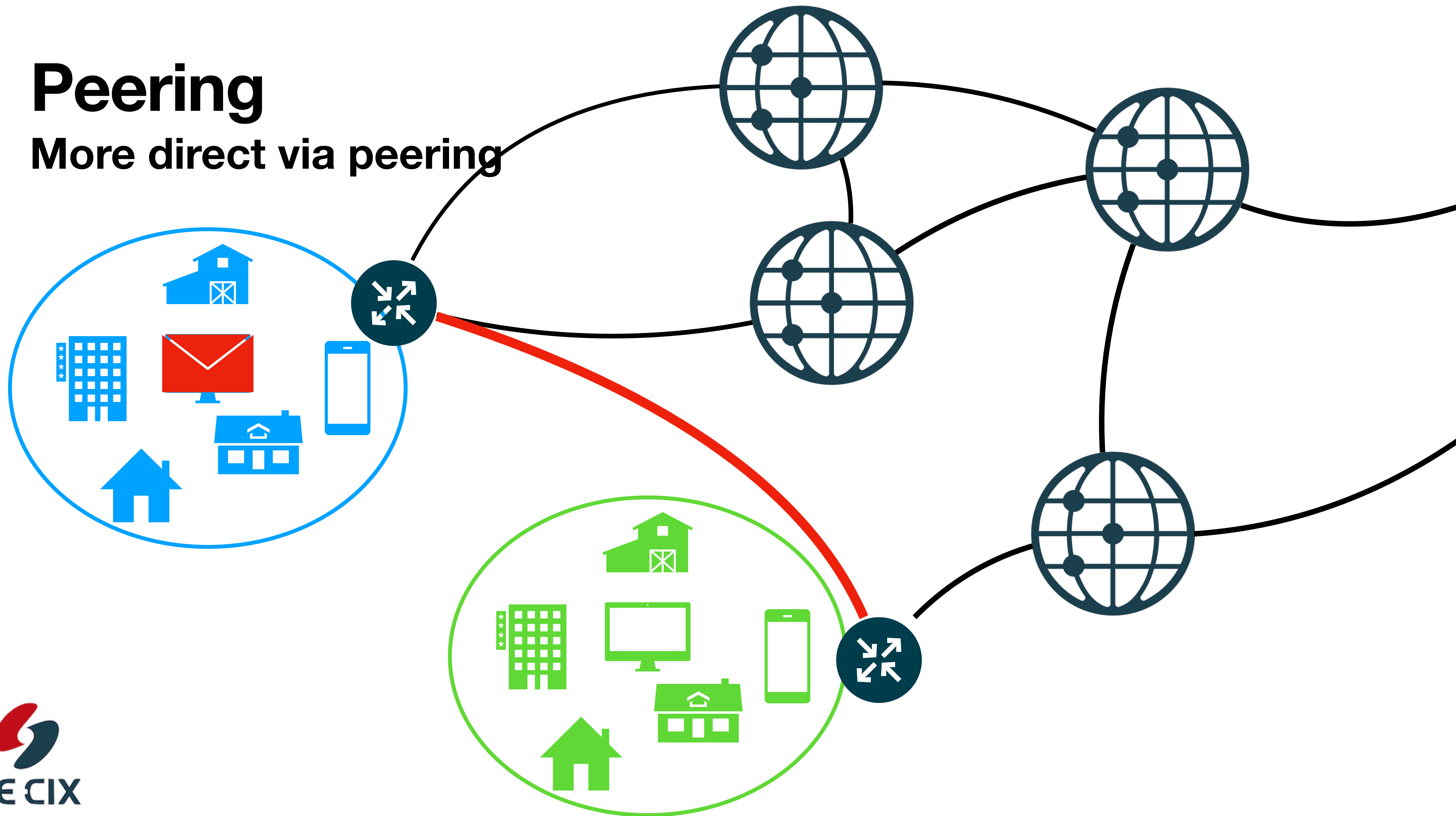


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# Peering

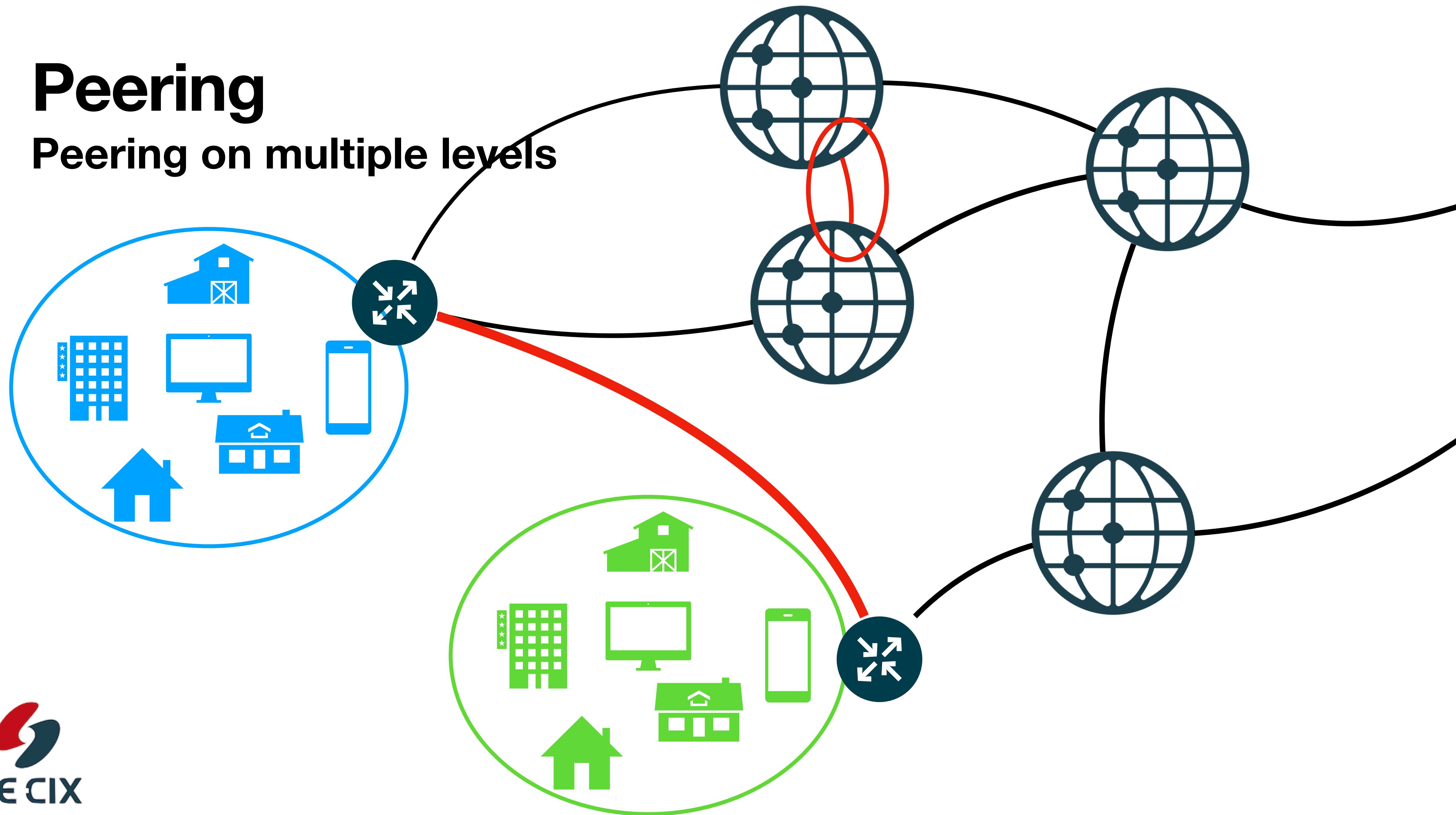
More direct via peering



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# Peering

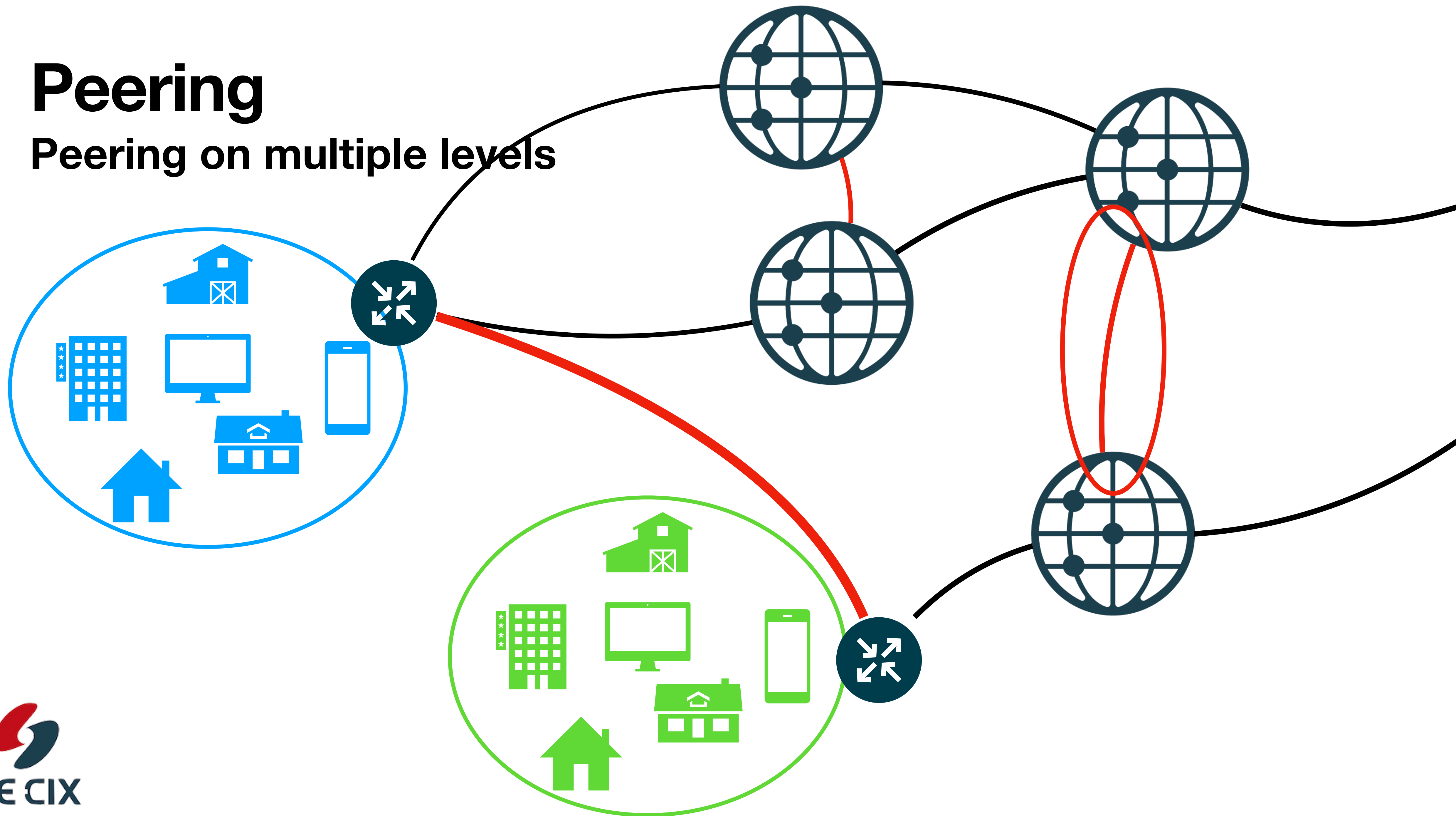
Peering on multiple levels



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# Peering

Peering on multiple levels



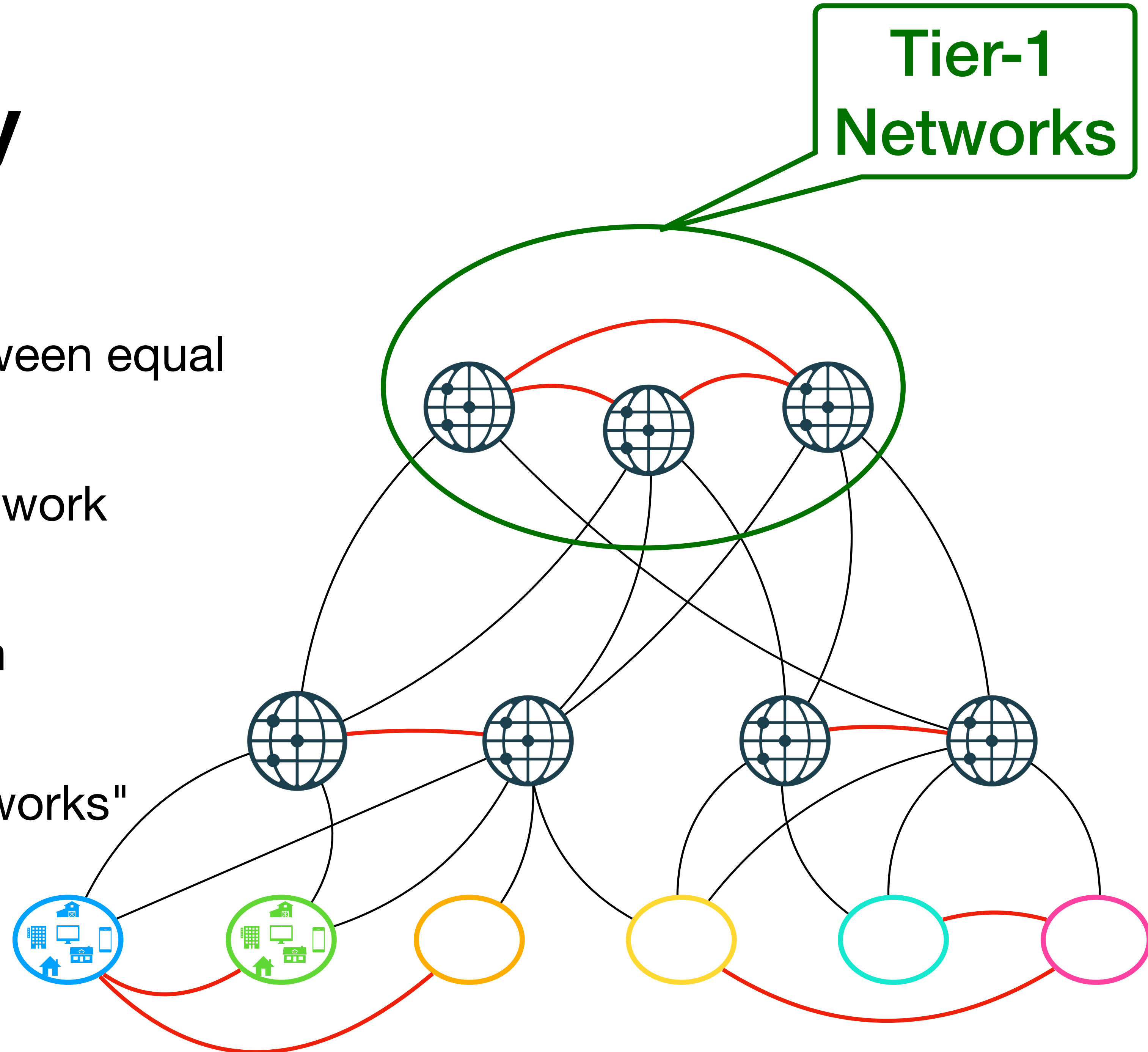
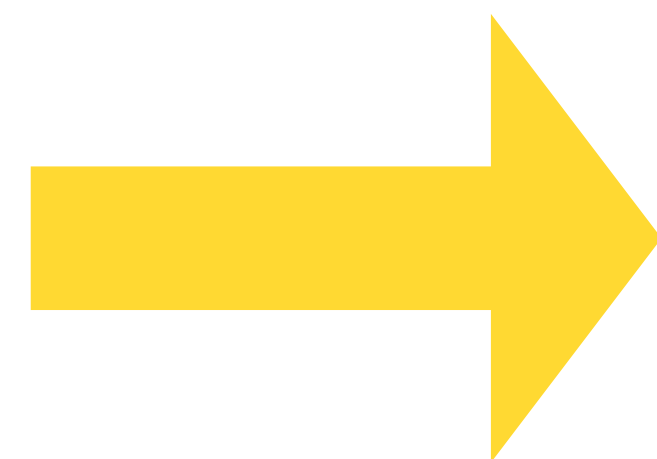
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# Peering Hierarchy

## Peering on multiple levels

- Peering happens usually between equal size networks
- Peering takes place on all network levels
- The "top ones" only peer with each other
  - They are called "Tier-1 networks"



# Why Peering?



# Historical view

- In the early days, peering was cheaper than routing traffic via upstream providers
- Also, it kept traffic from crossing the Atlantic twice

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!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
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!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
s rate is 99 percent (99999/100000), round-trip min/avg/max = 16/
in
/0 is up, line protocol is up
ware is cxBus HSSI
net address is 194.122.225.1/30
500 bytes, BW 34100 Kbit, DLY 200 usec, rely 255/255, load 52/2
sulation HDLC, loopback not set, keepalive set (10 sec)
input 00:00:02, output 00:00:00, output hang never
clearing of "show interface" counters never
t queue 0/40, 0 drops; input queue 0/75, 0 drops
ute input rate 7051000 bits/sec, 622 packets/sec
ute output rate 7052000 bits/sec, 623 packets/sec
49469 packets input, 2033725506 bytes, 0 no buffer
ceived 304 broadcasts, 0 runts, 0 giants
    0 parity
input errors, 1 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
9504 packets output, 2033727908 bytes, 0 underruns
output errors, 0 applique, 1 interface resets
output buffer failures, 0 output buffers swapped out
carrier transitions

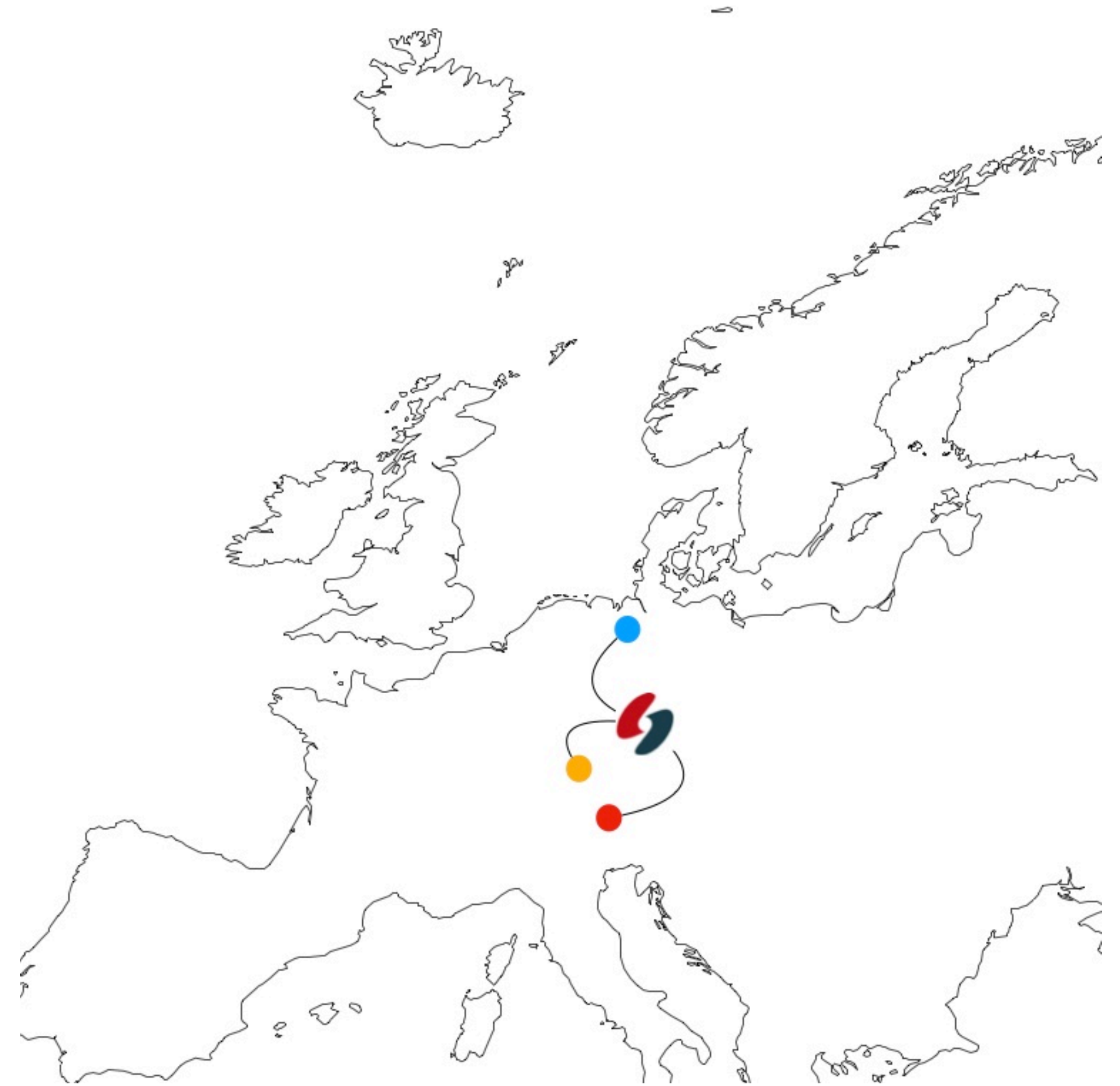
```



# Why Peering?

## Peering today

- Upstream prices are down
- But peering is still important
  - Keeping local traffic local
  - Reducing latency
  - Keep your traffic under control
- At an Internet Exchange (IXP) you can peer with multiple networks via one common infrastructure



# Conclusion



# Conclusion

## Global IP routing

- Networks (Internet Service Providers) announce IP Prefixes
- IP Packets are routed to these prefixes by using their IP destination address
- Peering is exchanging traffic between similar sized networks
  - Peering in the past was mainly done to reduce cost
  - Today peering decreases latency and enhances control
  - Internet Exchanges are places where many networks meet and can peer with each other

# Thank you!

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# Links and further reading



# Links and further reading

- Internet protocol - [https://en.wikipedia.org/wiki/Internet\\_Protocol](https://en.wikipedia.org/wiki/Internet_Protocol)
- Protocol stack - [https://en.wikipedia.org/wiki/Protocol\\_stack](https://en.wikipedia.org/wiki/Protocol_stack)
- IP Network Model: [https://en.wikipedia.org/wiki/Internet\\_protocol\\_suite](https://en.wikipedia.org/wiki/Internet_protocol_suite)
- IP Version Numbers <https://www.iana.org/assignments/version-numbers/version-numbers.xhtml#version-numbers-1>
- IPv4
  - IPv4 - <https://en.wikipedia.org/wiki/IPv4>
  - IPv4 address exhaustion - [https://en.wikipedia.org/wiki/IPv4\\_address\\_exhaustion](https://en.wikipedia.org/wiki/IPv4_address_exhaustion)
  - Map of IPv4 addresses in [2006](#), [2011](#)
- IPv6
  - IPv6 itself - <https://en.wikipedia.org/wiki/IPv6>
  - IPv6 header - [https://en.wikipedia.org/wiki/IPv6\\_packet](https://en.wikipedia.org/wiki/IPv6_packet)
  - IPv6 addresses - [https://en.wikipedia.org/wiki/IPv6\\_address](https://en.wikipedia.org/wiki/IPv6_address)
  - First standard: [RFC1884](#), current standard: [RFC8200](#)
- Routing
  - Packet forwarding - [https://en.wikipedia.org/wiki/Packet\\_forwarding](https://en.wikipedia.org/wiki/Packet_forwarding)
  - Routing - <https://en.wikipedia.org/wiki/Routing>

# Links and further reading

- History of Internet in Germany:
  - <https://www.isoc.de/roots-of-the-net/index.html>
  - <https://www.heise.de/hintergrund/Missing-Link-Abschied-vom-Herrn-der-Routen-dem-Internetpionier-der-Telekom-4980616.html>
  - <https://www.heise.de/hintergrund/Missing-Link-Von-der-Un-Sicherheit-in-der-Informationstechnik-4999925.html>
- History of Internet:
  - <https://www.internethalloffame.org/brief-history-internet>
- Network Hierarchies
  - Tier-1 networks: [https://en.wikipedia.org/wiki/Tier\\_1\\_network](https://en.wikipedia.org/wiki/Tier_1_network)
  - Internet Backbone: [https://en.wikipedia.org/wiki/Internet\\_backbone](https://en.wikipedia.org/wiki/Internet_backbone)
- Internet Exchanges: [https://en.wikipedia.org/wiki/Internet\\_exchange\\_point](https://en.wikipedia.org/wiki/Internet_exchange_point)
  - DE-CIX Locations: <https://www.de-cix.net/en/locations>
  - European Internet Exchange Association: <https://www.euro-ix.net/>
- THE place for networks who peer: <https://www.peeringdb.com>

# Internet RFCs (Standards)

- There are too many RFCs dealing with IPv4, IPv6, and routing to be listed here
- Just go to <https://tools.ietf.org/html/> and use the search field
- How does something become RFC? <https://www.rfc-editor.org/pubprocess/>
- The [IETF](#) - Internet Engineering Task Force





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