Networking Basics

03a - IP: Addresses, Prefixes and Routing

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Where networks meet

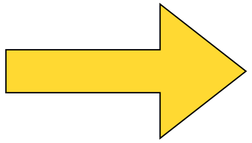
Networking Basics

DE-CIX Academy

01 - Networks, Packets, and Protocols

02 - Ethernet, 02a - VLANs

03 - IP: the Internet Protocol



03a - IP addresses, prefixes, and routing

03b - Global IP routing

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

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

06a - DNS

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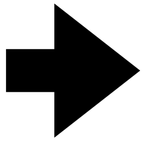
IP - the Internet Protocol

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

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IPv4 Addresses

32 bit long

- 32 bit in length
  - 4.294.967.296 possible addresses
- written as 4 decimal numbers separated by dots "."
- some addresses are reserved / not usable
- all usable IPv4 addresses have been assigned to users

IPv6

Development started: 1994
First published: 1995

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IPv6 Addresses

128 bit long

- 128 bit in length - possible addresses:
  340282366920938463463374607431768211456
- there are lots of IPv6 addresses available
- written as hexadecimal numbers separated by colons ":"
  - double-colon "::" means fill up with zeros here
- some addresses are reserved / not usable

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

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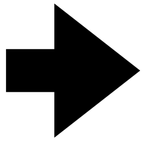
Internet Model

IP / Internet Layer

- Data units are called "Packets"
- Needs **addresses** for entities
- Provides source to destination transport
  - **End-to-End Transport**



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End-to-End Transport

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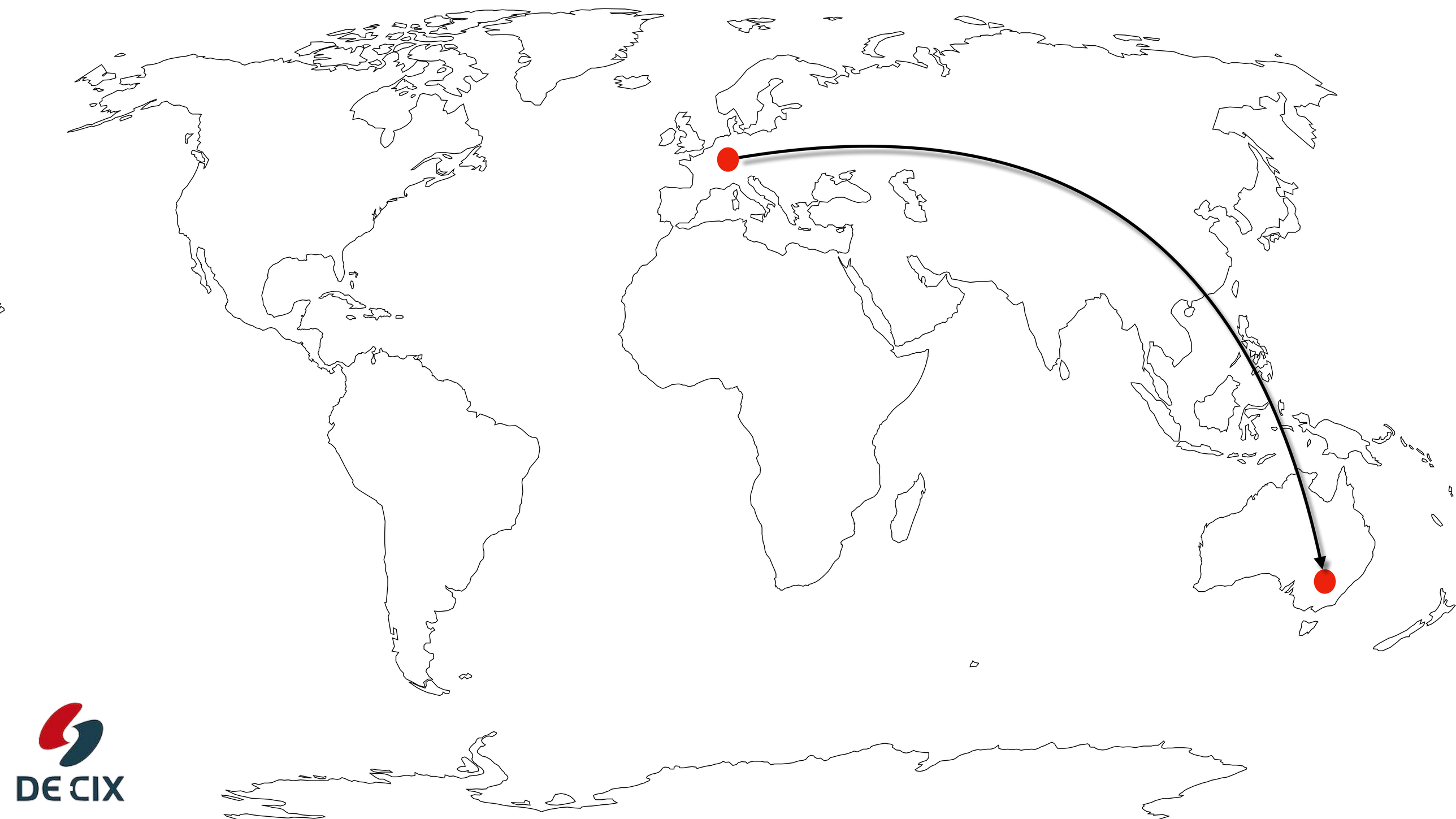

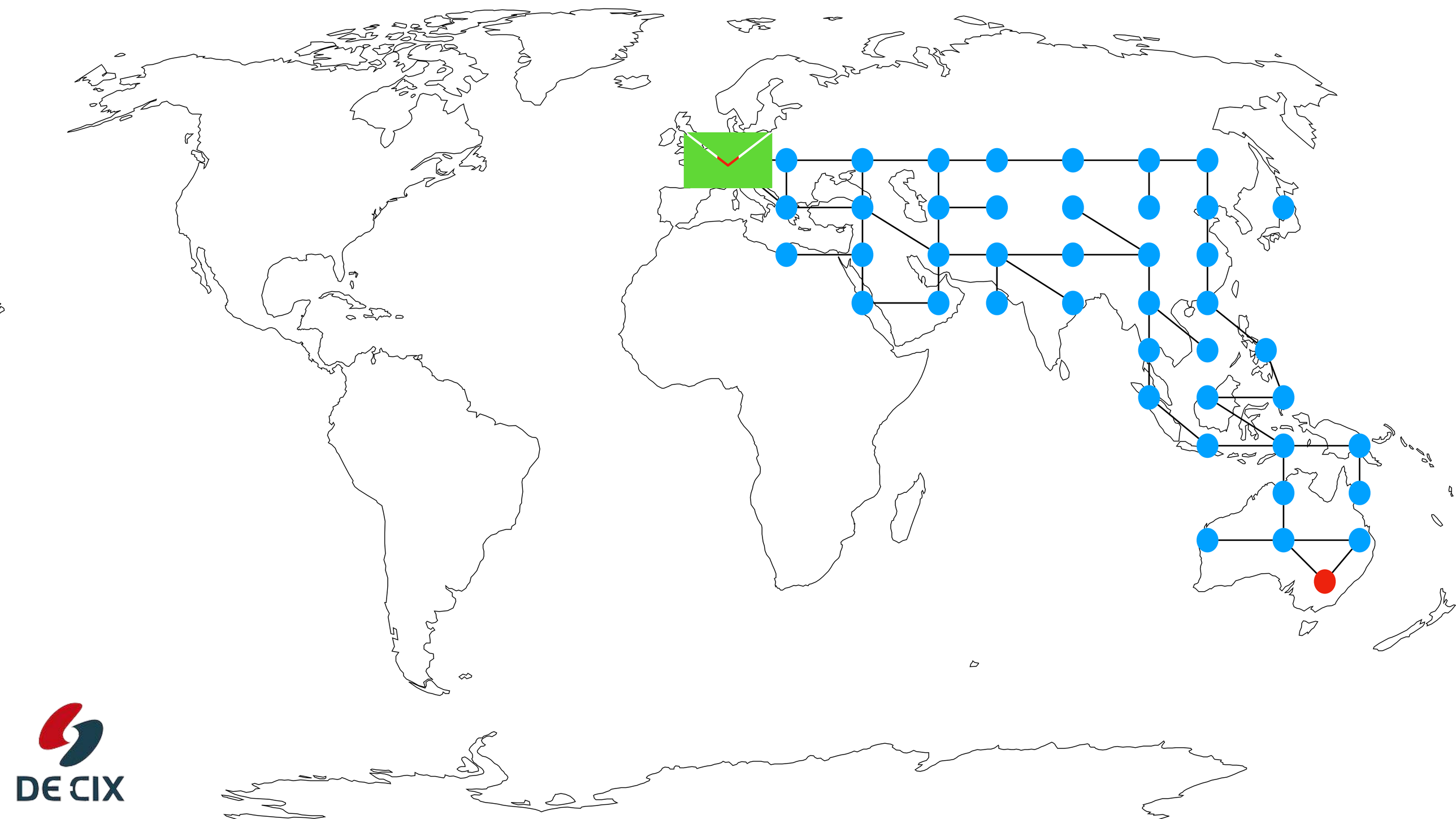
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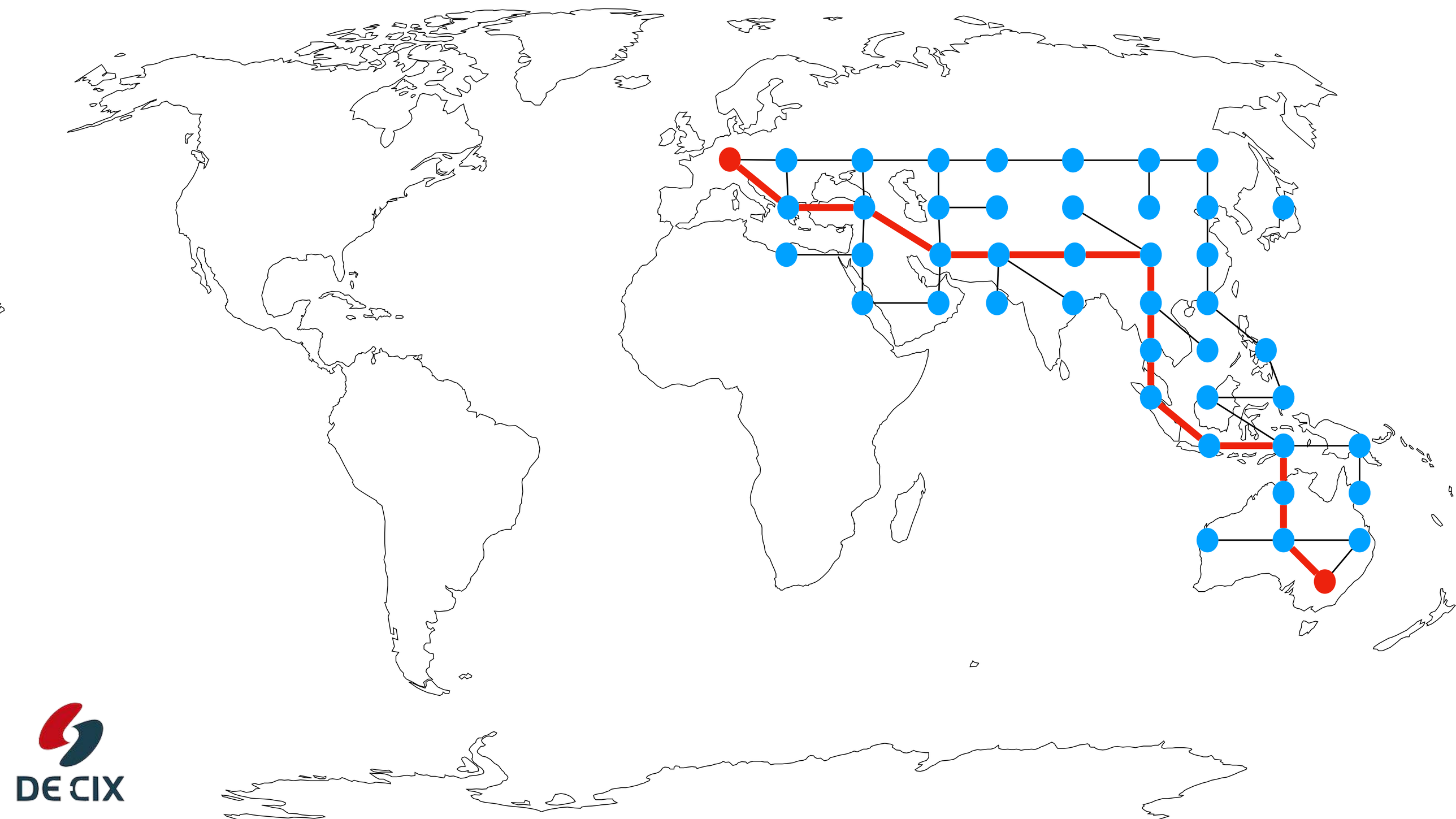
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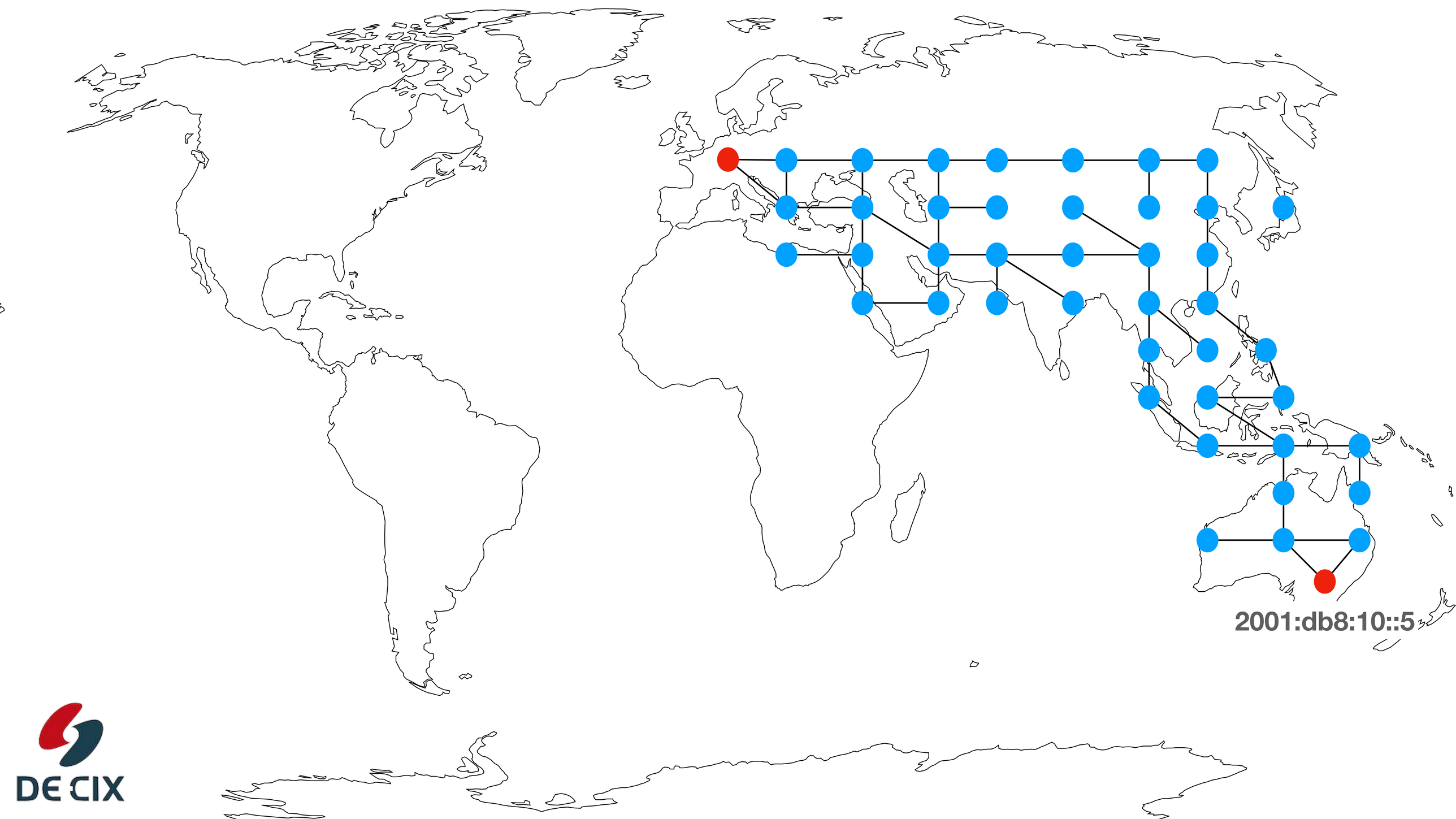
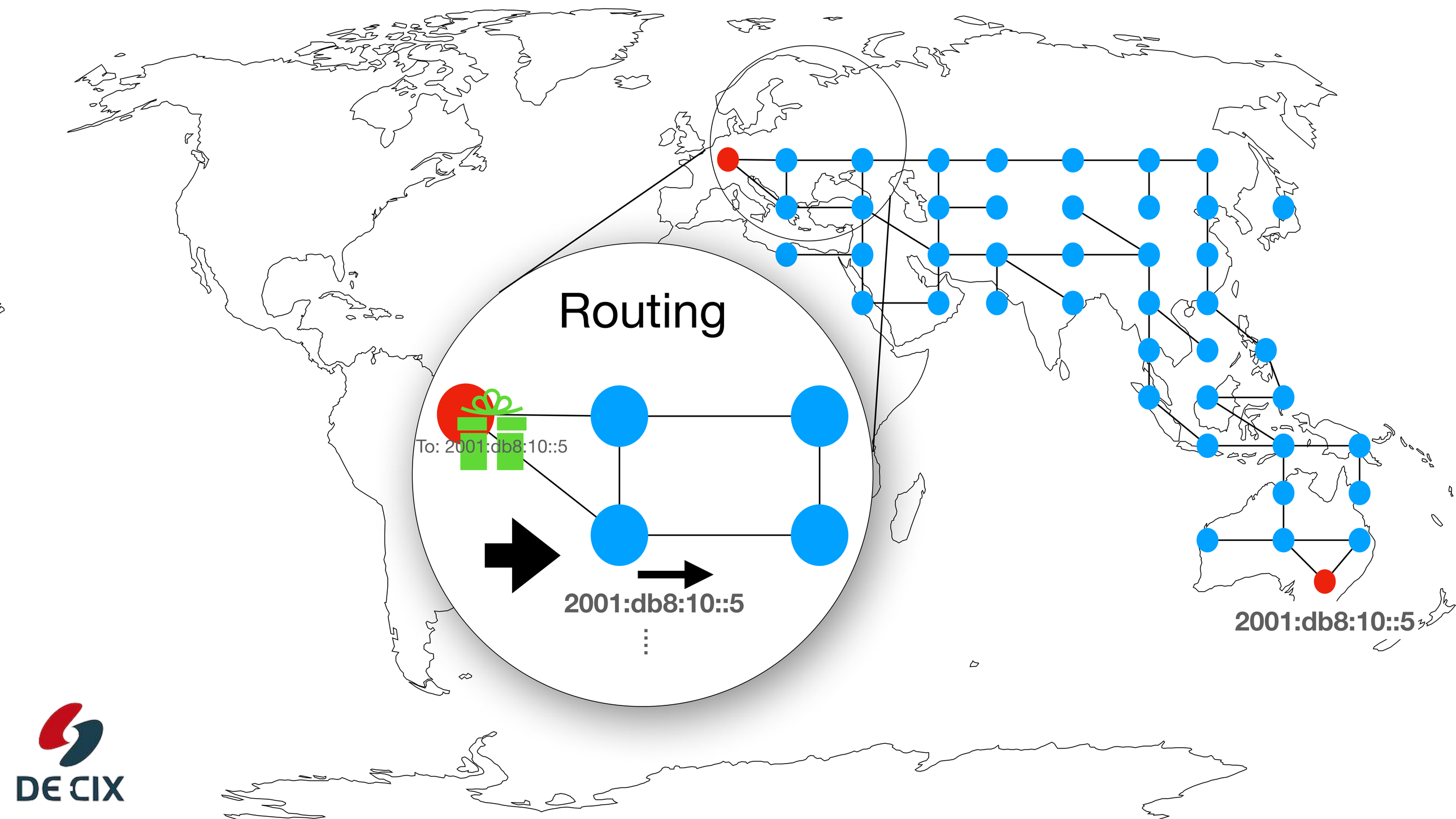

2001:db8:10::5


Routing
To: 2001:db8:10::5
2001:db8:10::5
2001:db8:10::5

Routing

Intermission: Language

Routing

"A method of finding paths from origins to destinations in a network such as the Internet, along which information can be passed."

https://en.wiktionary.org/wiki/routing

UK /ˈɹuːtɪŋ/

US /ˈɹutɪŋ/

/ˈɹaʊtɪŋ/

Routing

"A method of finding paths from origins to destinations in a network such as the Internet, along which information can be passed."

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routing /ˈɹaʊtɪŋ/

root

rooting "A hole formed by a pig when it roots in the ground"

https://en.wiktionary.org/wiki/rooting

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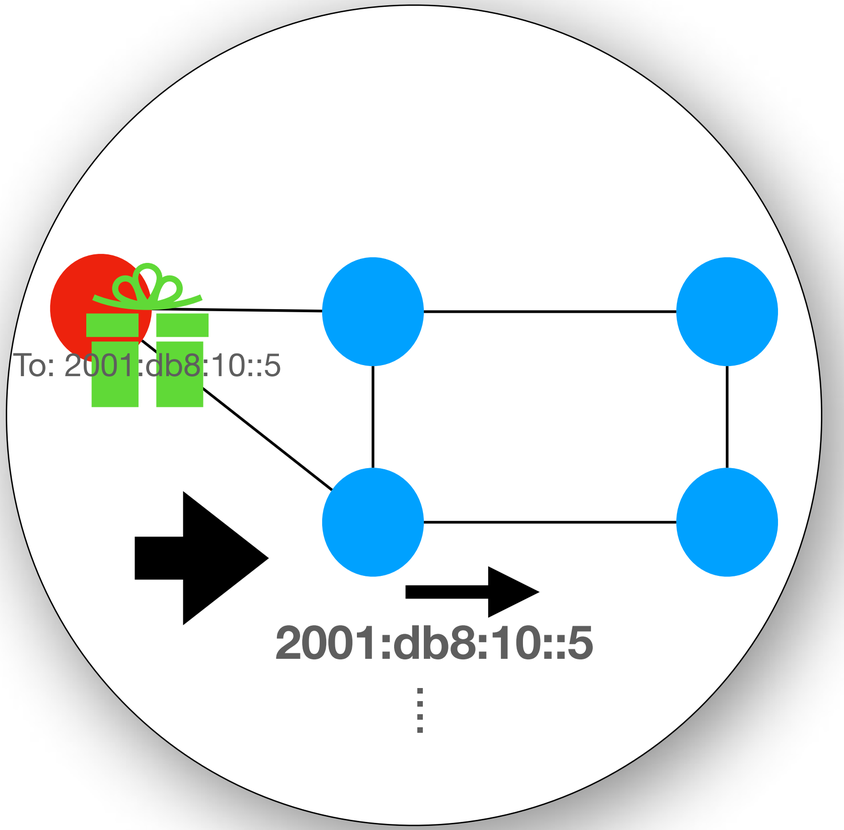
Routing

How a *router* works

- All IP packets have a *destination IP address*
- Depending on the destination IP address a *next hop* is chosen
- For this, each router has a large lookup-table
  - This is called the *routing table*
- It contains not single IP addresses, but *Prefixes*



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IP Prefixes

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IPv6 - Addresses

2003:de:274f:400:226:b0ff:fed8:3d8a

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IPv6 - Addresses

2003:de:274f:400:2266:b0ff:fed8:3d8a

Notation:

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

128 Bits long

IPv6 - Prefixes

Prefix-Length: 0-128

2003:de:274f:400::/64

Host-part all zero

128 Bits long

Notation:

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

IPv4 - Addresses

10.3.8.17

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IPv4 - Addresses

10.3.8.0/22

Notation:

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

32 Bits long

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IPv4 - Prefixes

Prefix-Length: 0-32

10.3.8.0/22

Notation:

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

Host-part all zero

32 Bits long

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IP Addresses and Prefixes

Prefix or not?

	IPv4	IPv6
Length	32 Bit	128 Bit
	0-32 Prefix Length	0-128 Prefix Length
Notation	4 Numbers, 0-255	8 Numbers, 0-fffff
Separator	.	:
Prefix: Host part	all zero	
Address: Host part	**not** all zero / **not** all one	
Example (Prefix)	198.51.100.0/24	2001:db8:4f30::/48

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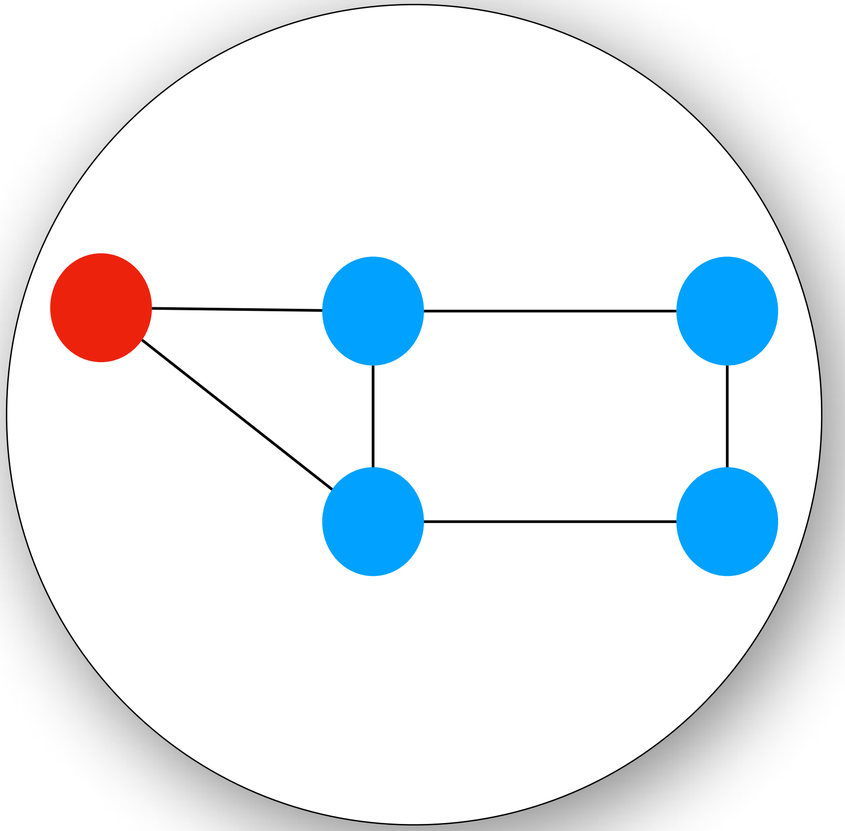
IP Routing



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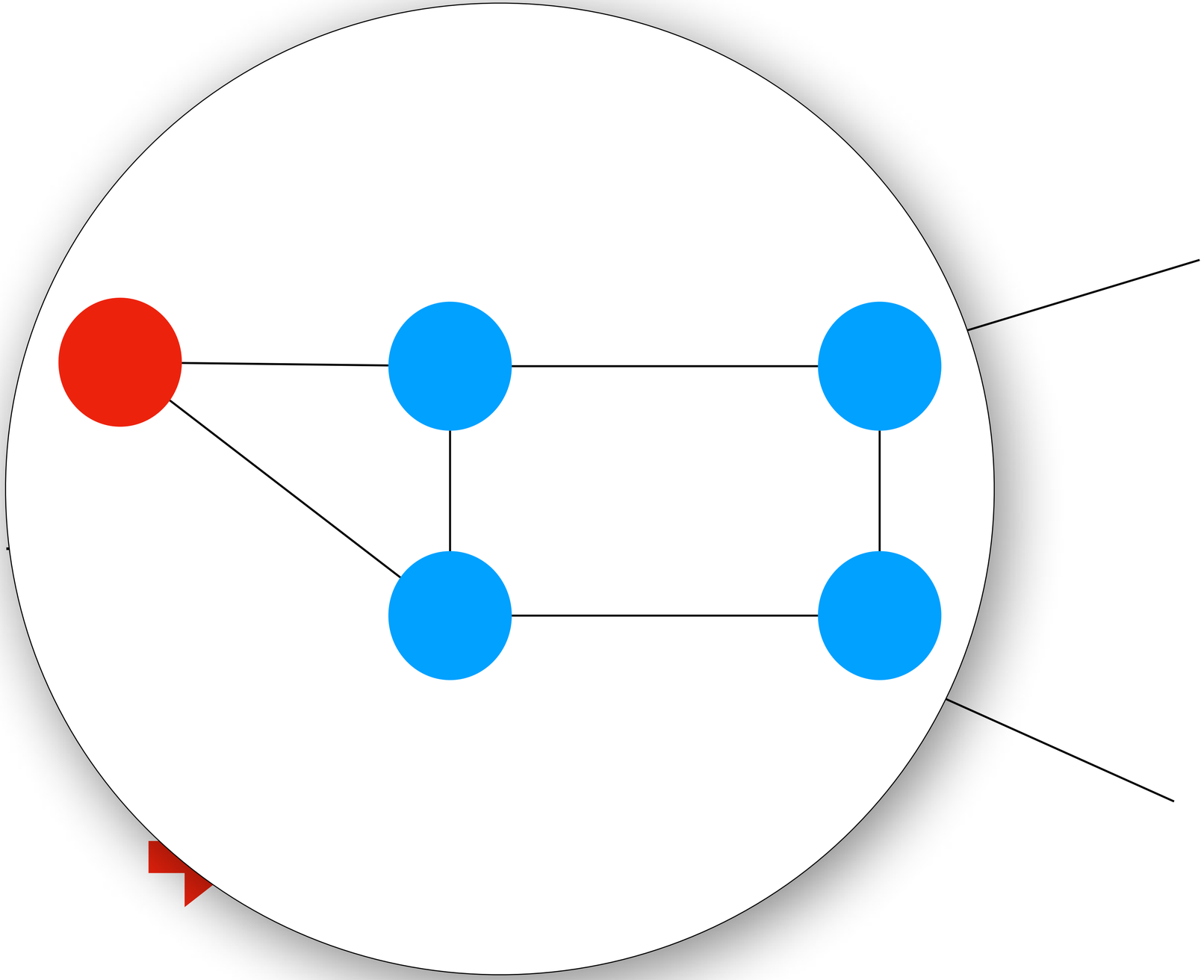
IP Routing



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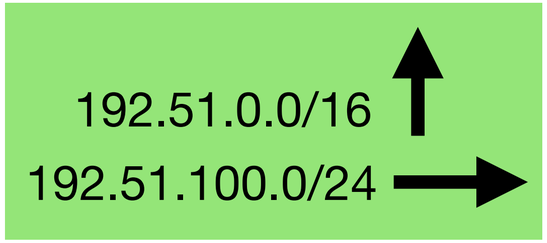
IP Routing



To: 198.51.100.17

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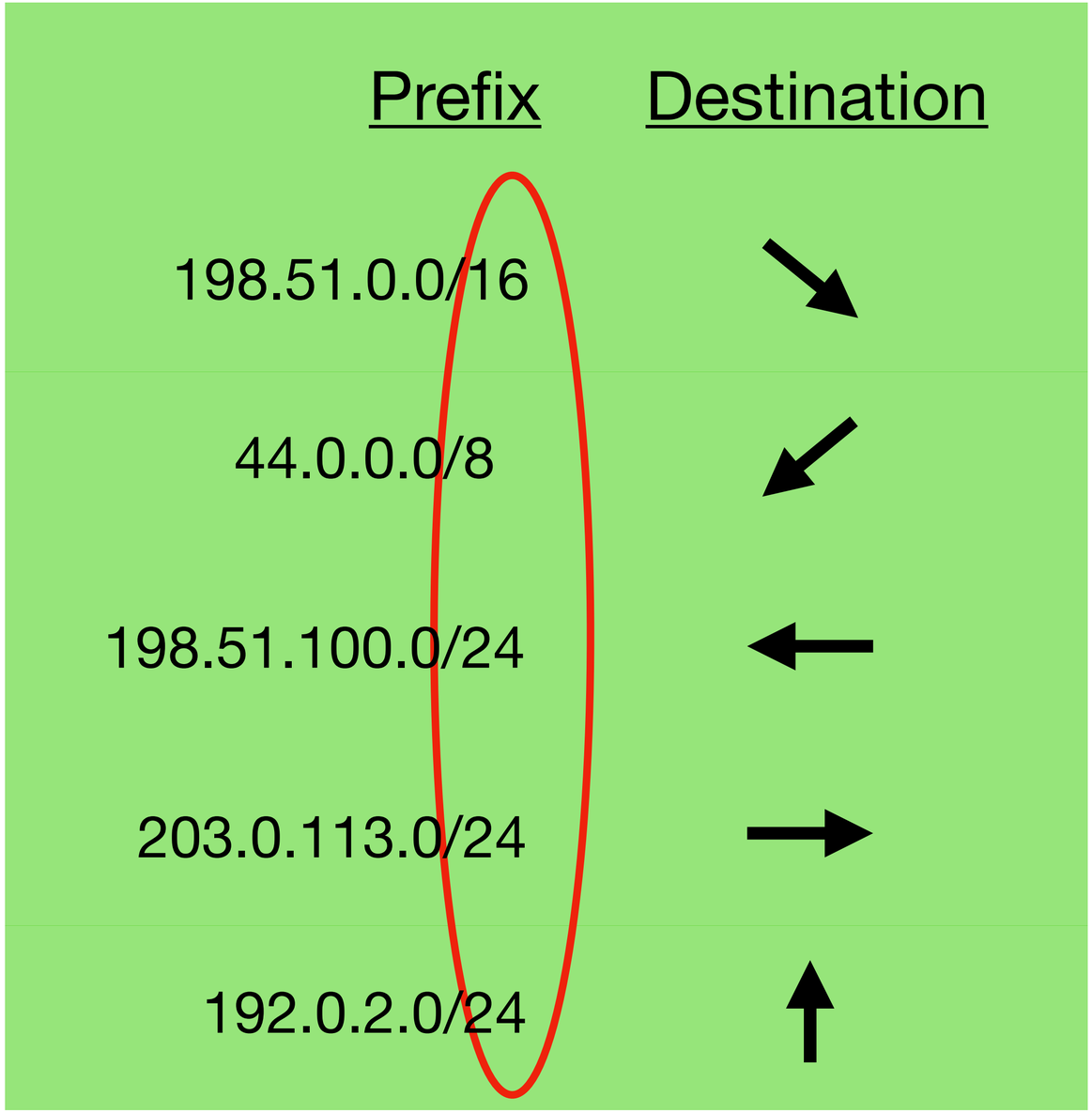
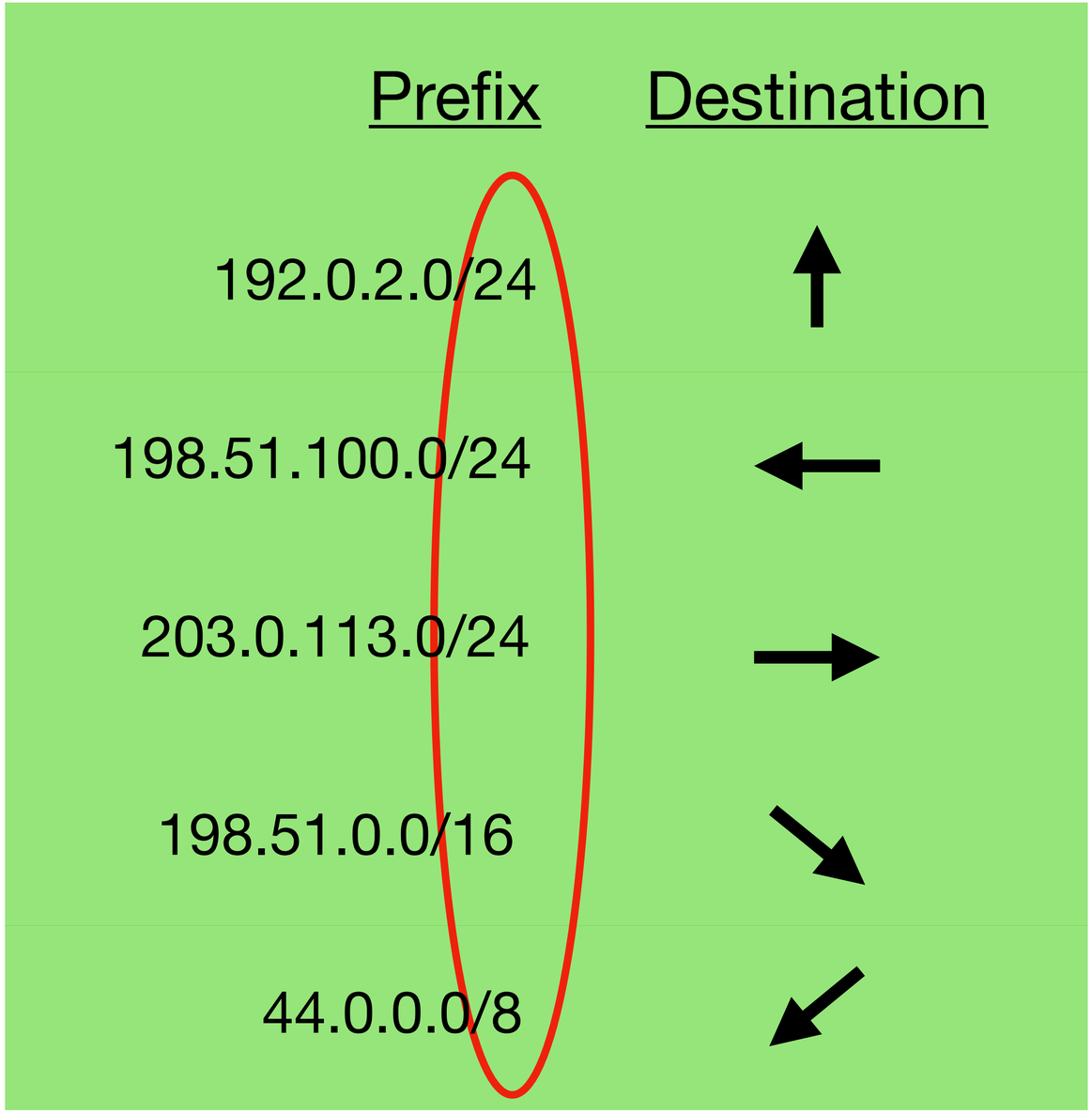
IP Routing

To: 198.51.100.17



IP Routing

To: 198.51.100.17



IP Routing

To: 198.51.100.17

Apply the netmask: /24

/24 = 24 bits in network part
11111111 11111111 11111111 00000000

255.255.255.0
"bitwise logical and" with IP address

198.051.100.017
255.255.255.000
=
198.051.100.000 ≠

Prefix	Destination
192.0.2.0/24	↑
198.51.100.0/24	←
203.0.113.0/24	→
198.51.0.0/16	↘
44.0.0.0/8	↙

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IP Routing

To: 198.51.100.17

Apply the netmask: /24

/24 = 24 bits in network part
11111111 11111111 11111111 00000000

255.255.255.0
"bitwise logical and" with IP address

198.051.100.017
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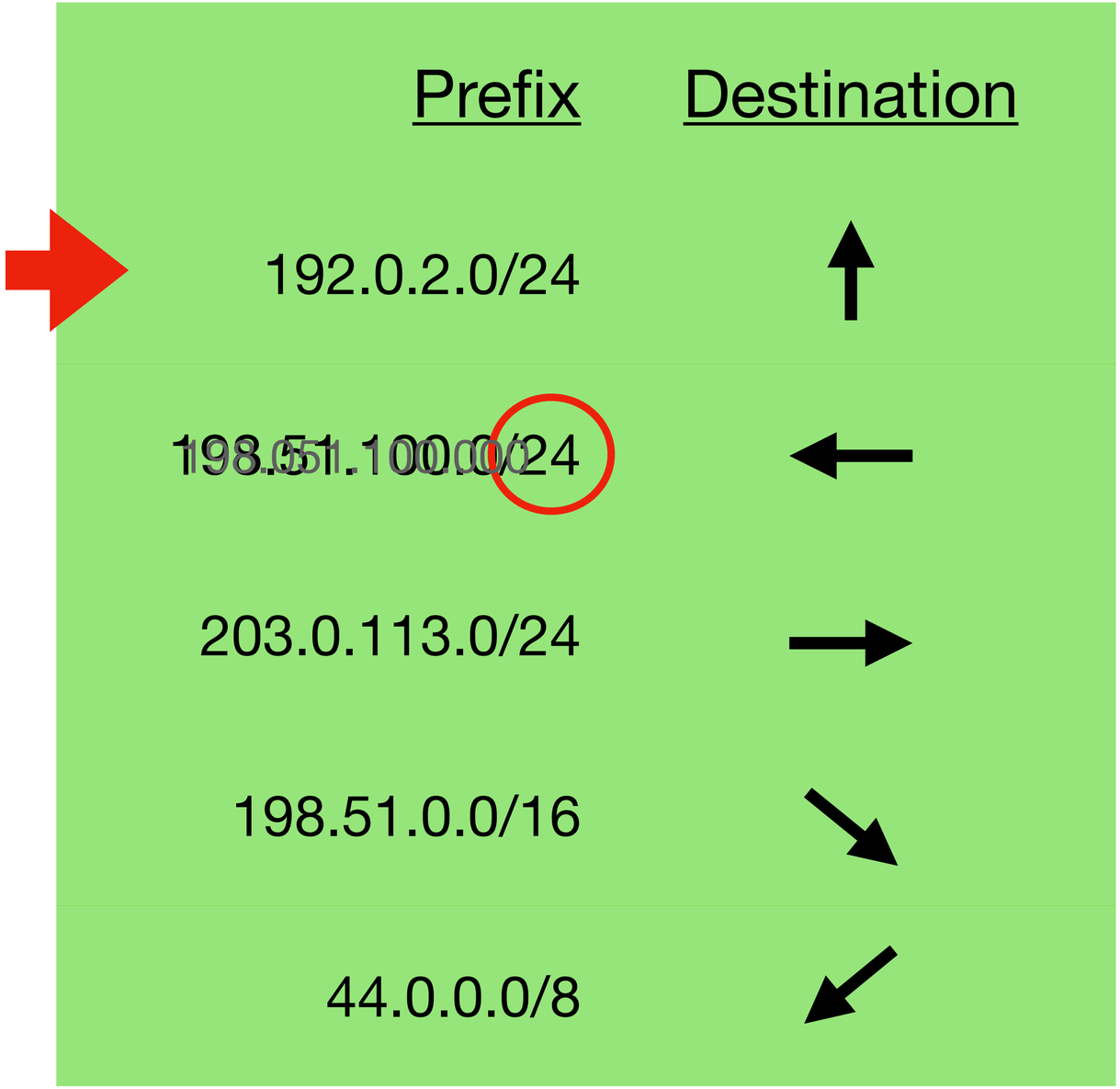

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IP Routing

- You now know how routing works
  - The router has a routing table with IP prefixes
  - The destination address is used to select a best matching prefix
  - The routing table tells the router the "next hop"

But how does the information get into the routing table?

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IP Routing

But how does the information get into the routing table?

- Someone types it in
  - This is called "*static routing*"
  - Simple, often used, but does not scale
- Routers "talk" to each other
  - This is called "*dynamic routing*"
  - And the *protocols* used are called "*routing protocols*"
  - Examples of such protocols are **BGP**, OSPF, IS-IS, RIP, EIGRP

Conclusion

Conclusion

We introduced a lot of new terms in this webinar

- "Routing"
  - "A method of finding paths from origins to destinations in a network such as the Internet, along which information can be passed."
    https://en.wiktionary.org/wiki/routing
- "Router"
  - A device which routes
- "IP Prefix"
  - A network address and a prefix length
- "Routing Table"
  - A table of IP prefixes and a next hop addresses

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Thank you!

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Links and further reading

Links and further reading

- Internet protocol - https://en.wikipedia.org/wiki/Internet_Protocol
- Protocol stack - https://en.wikipedia.org/wiki/Protocol_stack
- IP Network Model: 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
  - 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
  - IPv6 addresses - https://en.wikipedia.org/wiki/IPv6_address
  - First standard: RFC1884, current standard: RFC8200
- Routing
  - Packet forwarding - https://en.wikipedia.org/wiki/Packet_forwarding
  - Routing - https://en.wikipedia.org/wiki/Routing

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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