Networking Basics

02a - Ethernet + VLANs

Wolfgang Tremmel
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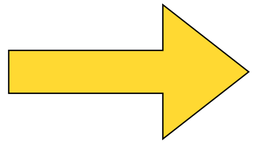
DE-CIX

Where networks meet

Networking Basics

DE-CIX Academy



01 - Networks, Packets, and Protocols

02 - Ethernet

02a - Ethernet and VLANs

03 - IP, 03a - Routing, 03b - Global routing

04a - User Datagram Protocol (UDP)

04b - TCP

04c - ICMP

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

06a - Domain Name System (DNS)

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Ethernet

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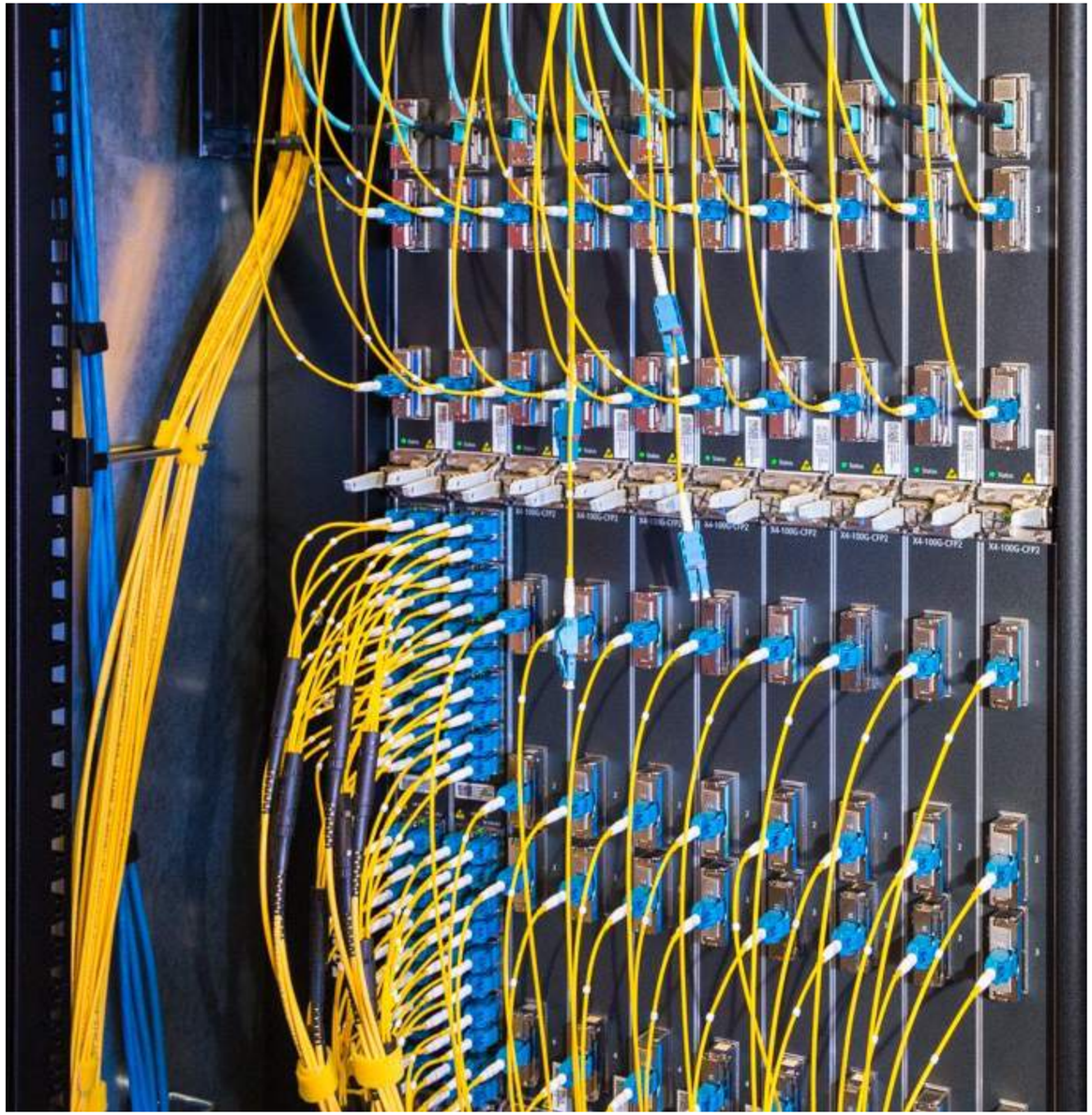
Ethernet connections

In data centers

- Usually optical fibres are used
- Various types exist (single mode, multi mode)
- Speeds are 1 GBit/s, 10 GBit/s, 100 GBit/s or 400GBit/s
- Connections are between *switches* and end devices



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Ethernet at home

10Base-T

- Only wire-based connections are in use
- Speeds are 100Mbit/s or 1Gbit/s
- With a *switch* as a center
- Wireless Ethernet - WIFI is most common

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Ethernet Switch

Ethernet today

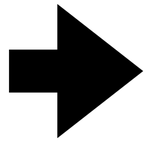
- Ethernet switches are common everywhere
- Advantage:
  - a switch learns which devices are connected to which port
  - and only sends frames on ports they are destined to
  - fallback: unknown destinations are still broadcasted on all ports

Attribution: Wolfgang Tremmel

Network layers - Internet Model

Ethernet: Link Layer

- Data units are called "Frames"
- Provides node-to-node data transfer



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

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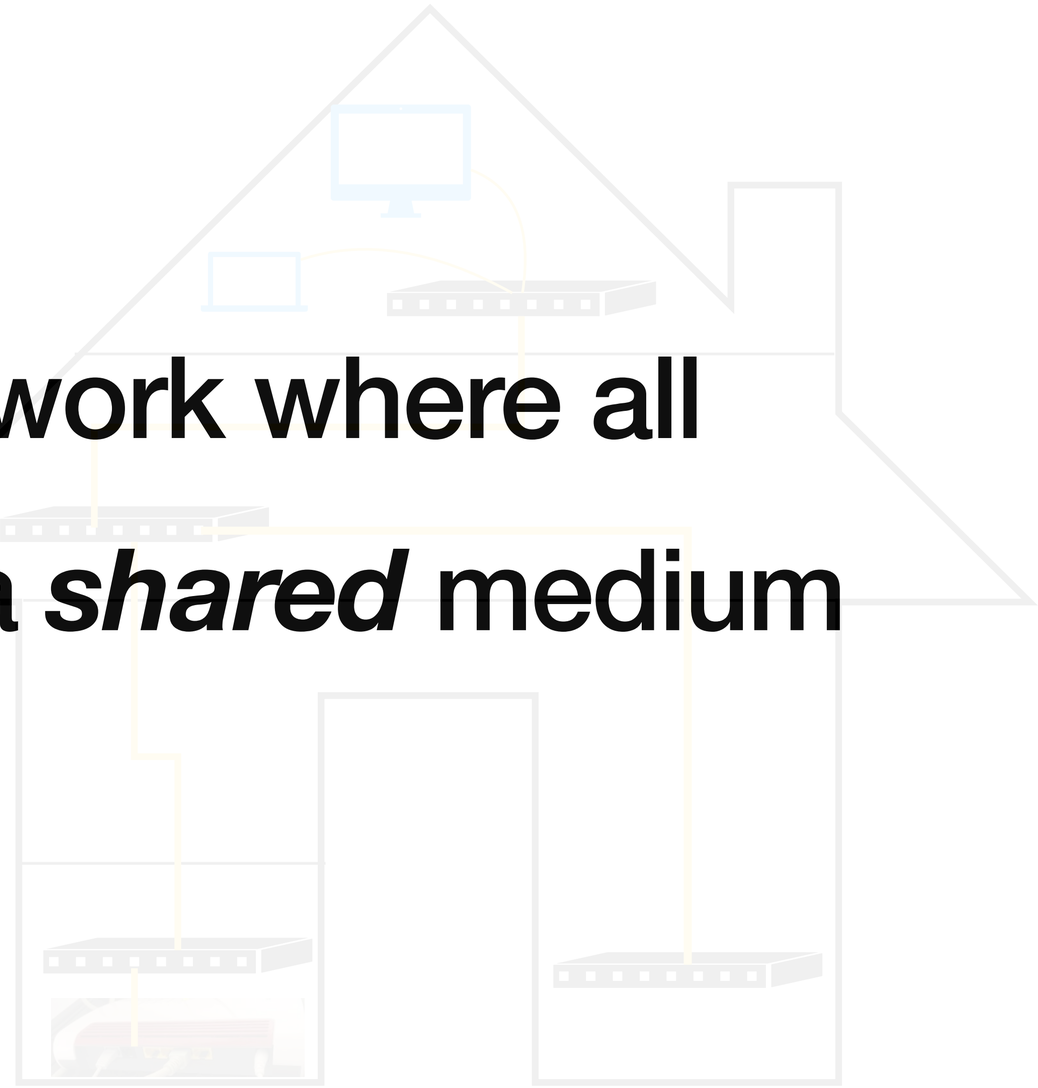
Ethernet
some facts

- ...usually has a max payload size of 1500 octets
  - "jumbo frames" with 9000 octets exist, but are not commonly used
- ...uses 48-bit addresses
- ...is a broadcast medium.

A typical Ethernet

In an office building or a home

- A router where your Internet comes in
- A switch on each floor
- Switches within large offices
- End devices (computers) connected to the switches



Ethernet is a *broadcast* network where all devices are connected to a *shared* medium

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Now you want a second network

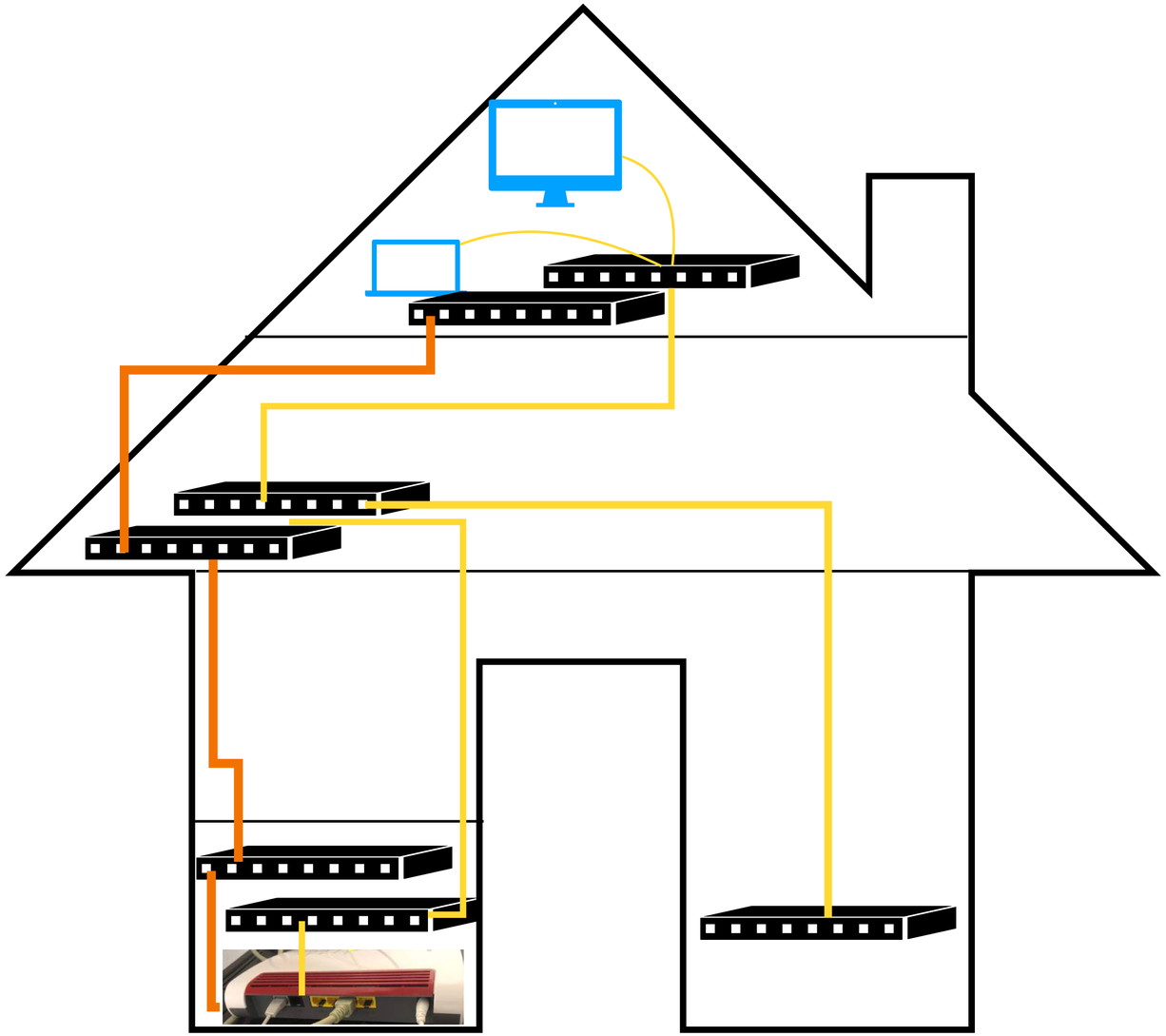
Now you want a second network

- For guests
- Or your telephones
- Or for network connected "things"

Second network

To keep separate things separate

- For example: Guest network
- Duplicate everything?
- No need - it's easier
- **VLANs** to the rescue!



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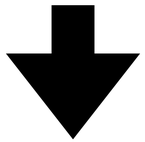
VLANs

Virtual LANs

Ethernet Frame

- Some well-known values:

0x0800	IPv4
0x86dd	IPv6
0x0806	ARP
0x8100	VLAN Tagged



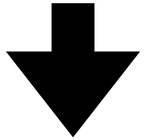
Preamble	SFD	Destination MAC Address	Source MAC Address	Ethertype	Payload	Checksum
10101010 10101010 10101010 10101010	10101011	48 Bits 6 Octets	48 Bits 6 Octets	16 Bits 2 Octets	46-1500 Octets	32 Bits 4 Octets

Ethernet Frame

VLAN tagged

- Some well-known values:

0x0800	IPv4
0x86dd	IPv6
0x0806	ARP
0x8100	VLAN Tagged



Preamble	SFD	Destination MAC Address	Source MAC Address	Ethertype	Payload	Checksum
10101010 10101010 10101010 10101010	10101011	48 Bits 6 Octets	48 Bits 6 Octets	16 Bits 2 Octets	46-1500 Octets	32 Bits 4 Octets

Preamble	SFD	Destination MAC Address	Source MAC Address	VLAN Header (801.1Q)		Ethertype	Payload	Checksum
10101010 10101010 10101010 10101010	10101011	48 Bits 6 Octets	48 Bits 6 Octets	0x8100	VLAN	16 Bits 2 Octets	42 - 1500 Octets	32 Bits 4 Octets

Ethernet

VLAN tagged frame

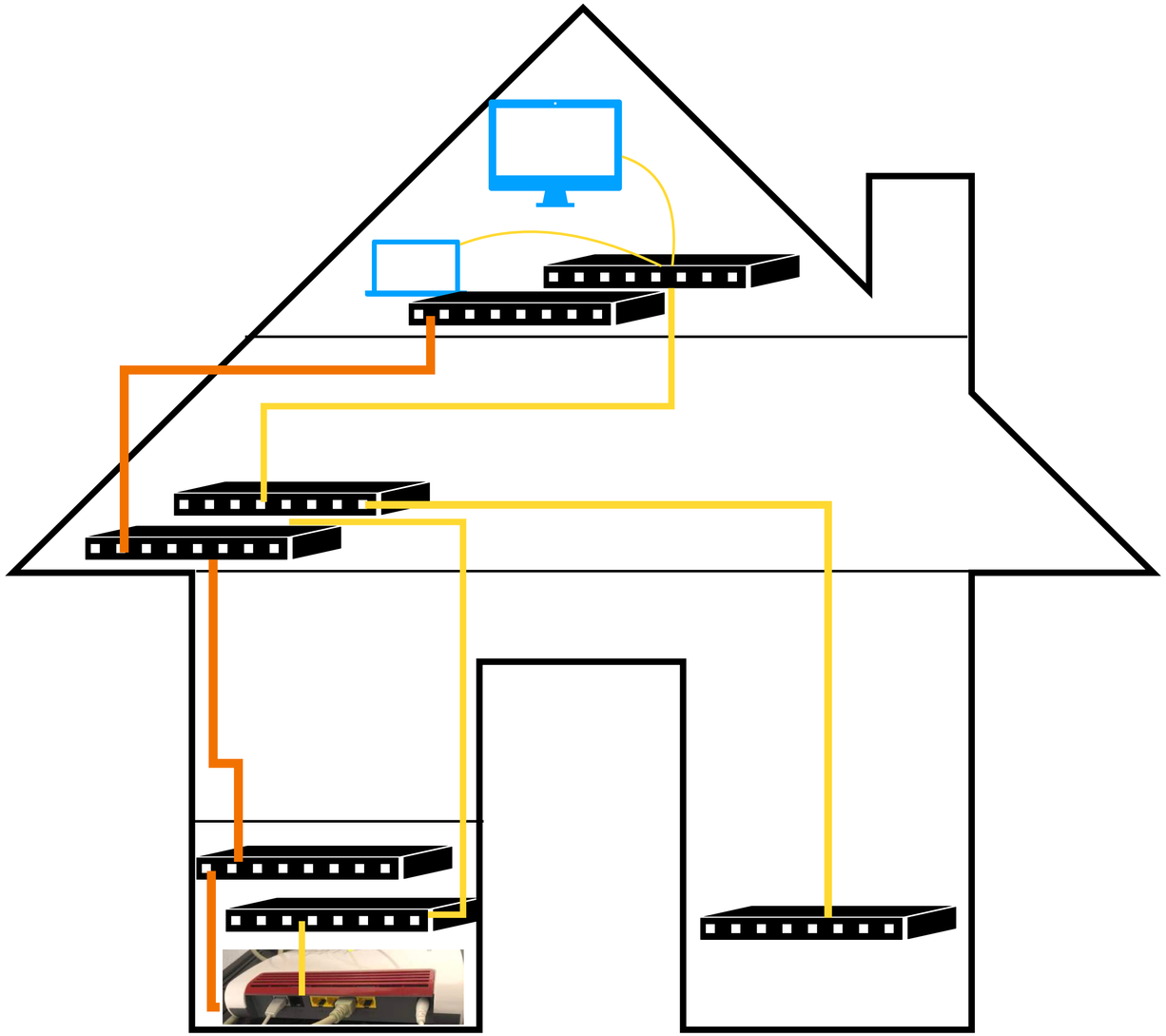
Preamble	SFD	Destination MAC Address	Source MAC Address	VLAN Header (801.1Q)		Ethertype	Payload	Checksum
10101010 10101010 10101010 10101010	10101011	48 Bits 6 Octets	48 Bits 6 Octets	0x8100	VLAN	16 Bits 2 Octets	42 - 1500 Octets	32 Bits 4 Octets

VLAN Header (801.1Q)			
16 Bits	3 Bits	1 Bit	12 Bits
0x8100	Priority	May be dropped?	VLAN ID 1-4094

Multiple networks

Use VLANs to separate

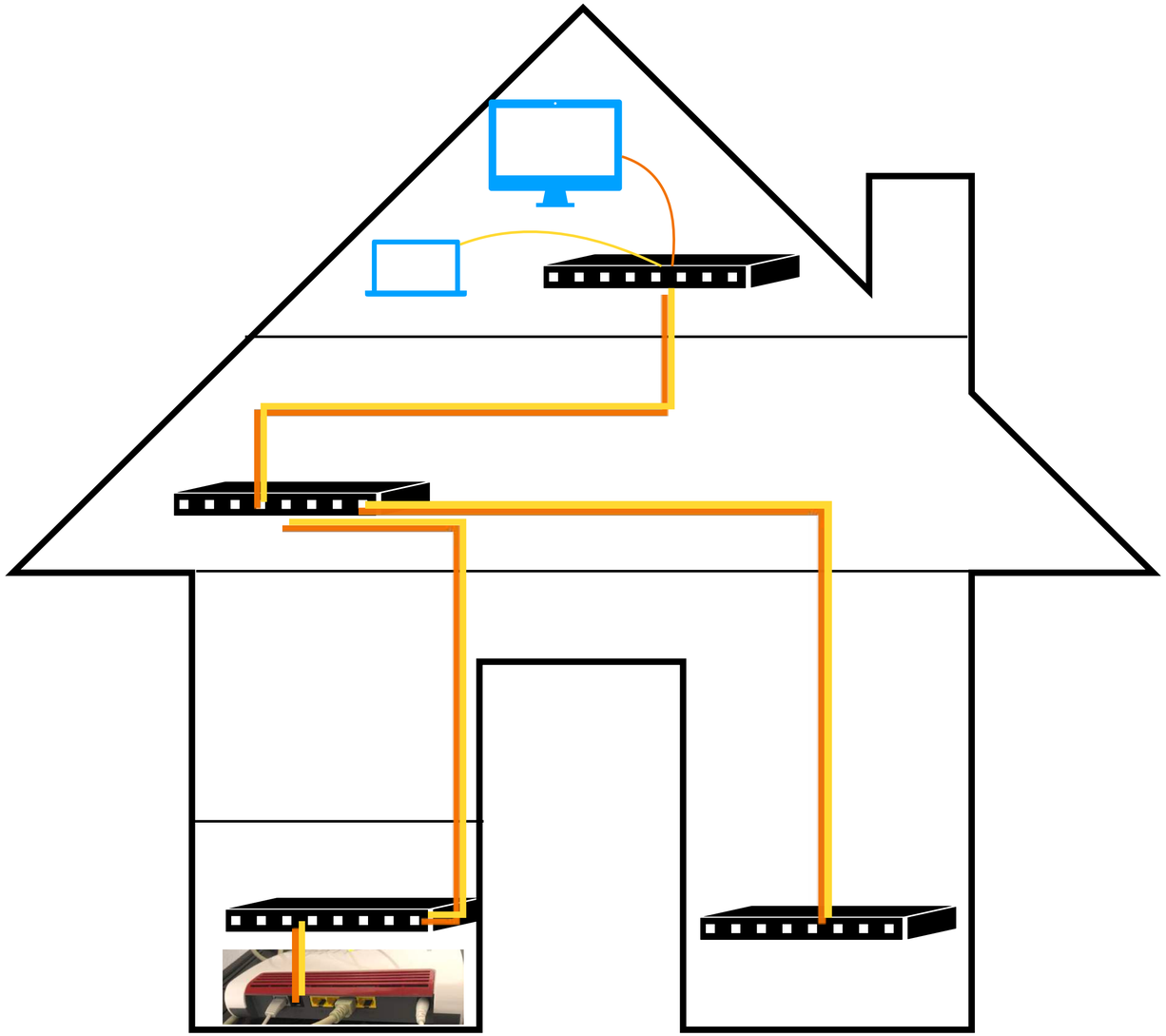
- You can have multiple VLANs on one physical infrastructure



Multiple networks

Use VLANs to separate

- You can have multiple VLANs on one physical infrastructure
- Connections can have one or multiple VLANs on them
- Connections which carry multiple VLANs are called "trunk"



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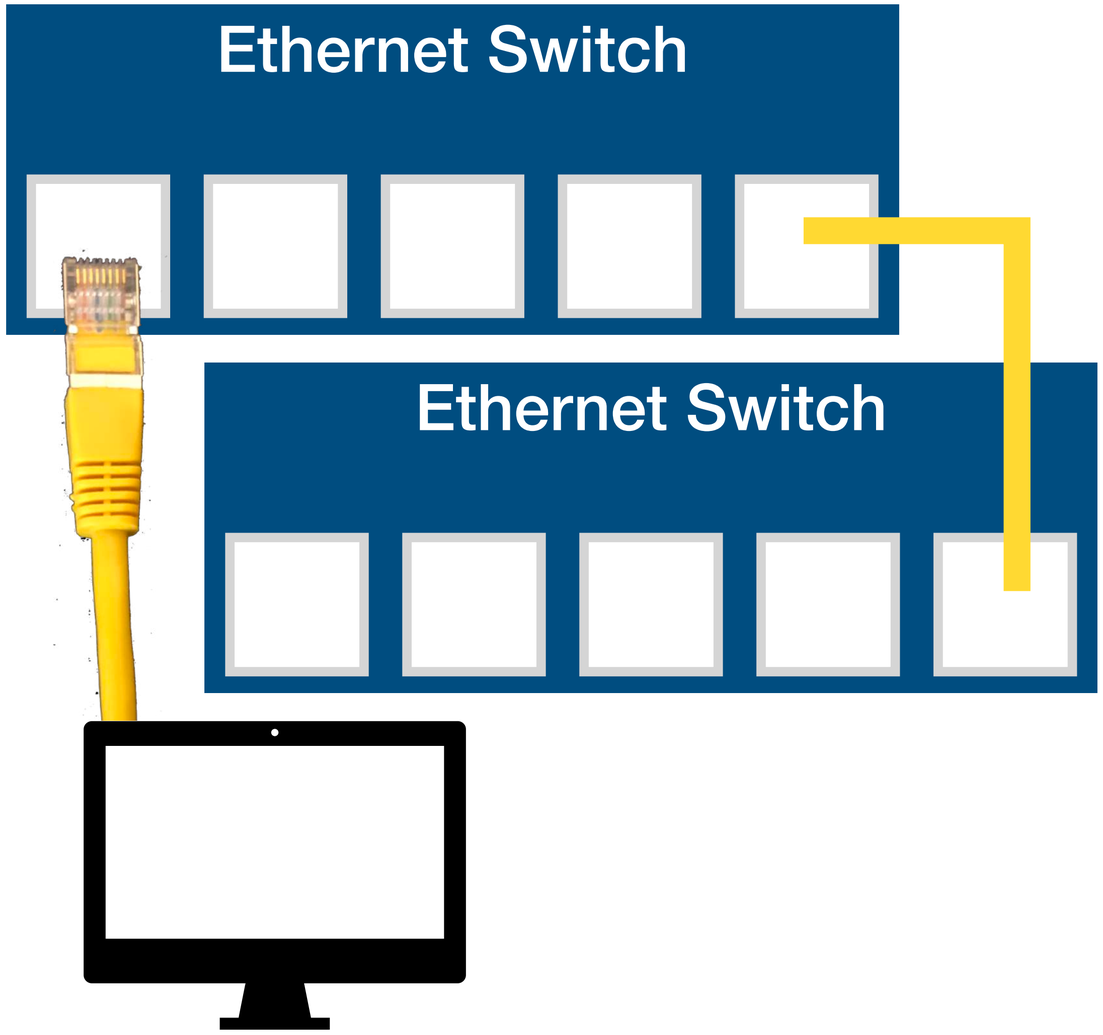
How to set it up?

How to set it up?

Building an Ethernet with VLANs

- You remember Ethernet switches?
- You might have one in your basement
- Ethernet switches connect devices to each other
- Ethernet switches also can connect to other switches



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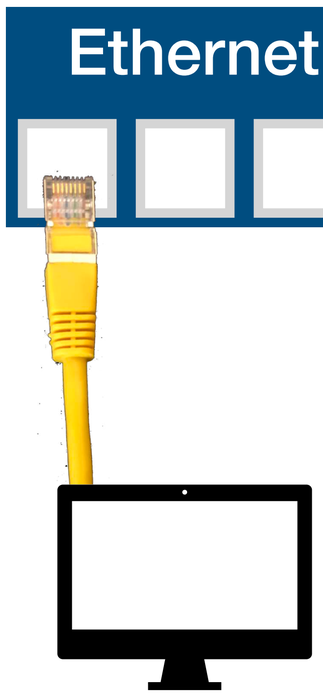
Ethernet Switch

Ethernet Switch



Ethernet Switch

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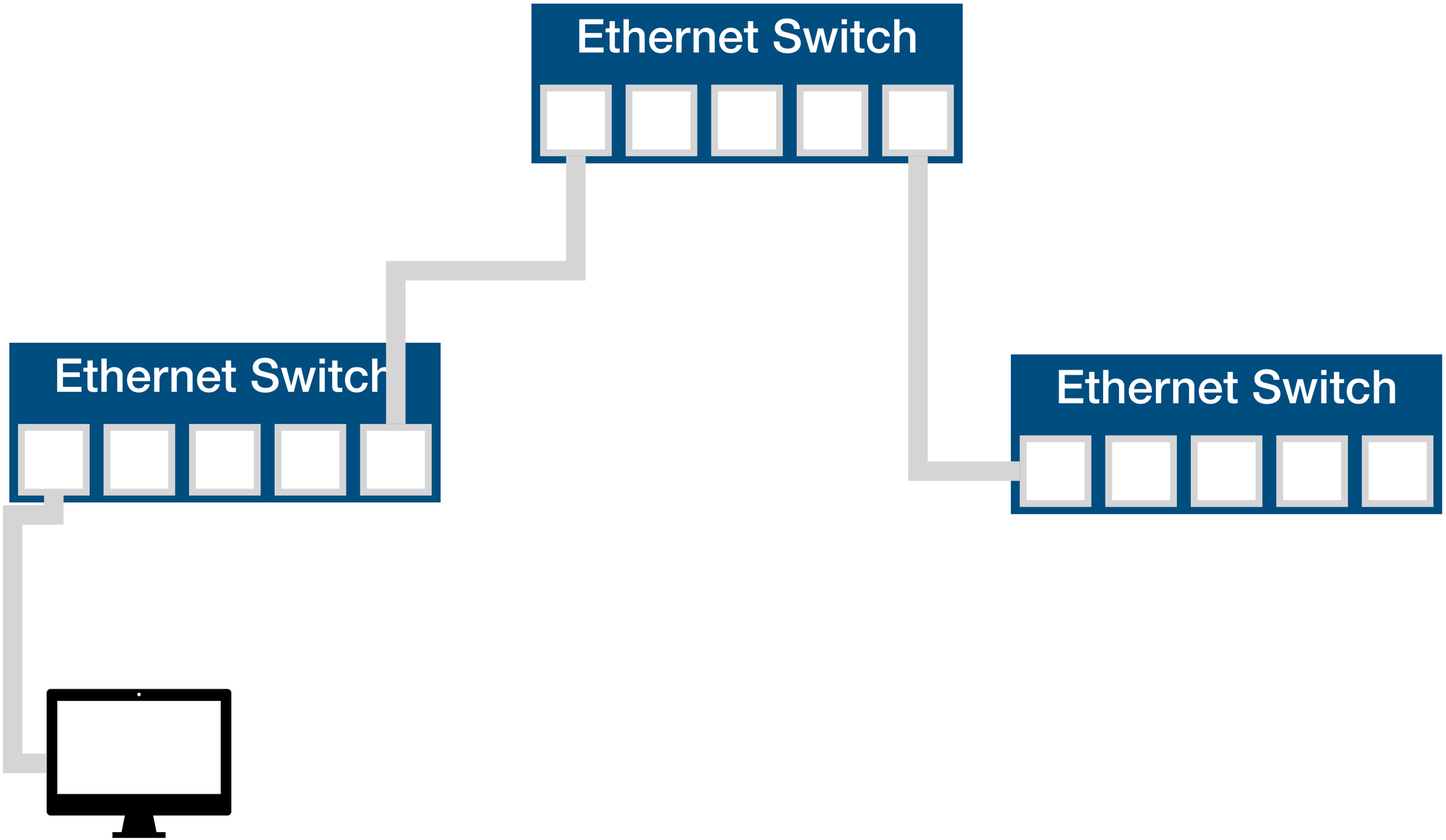
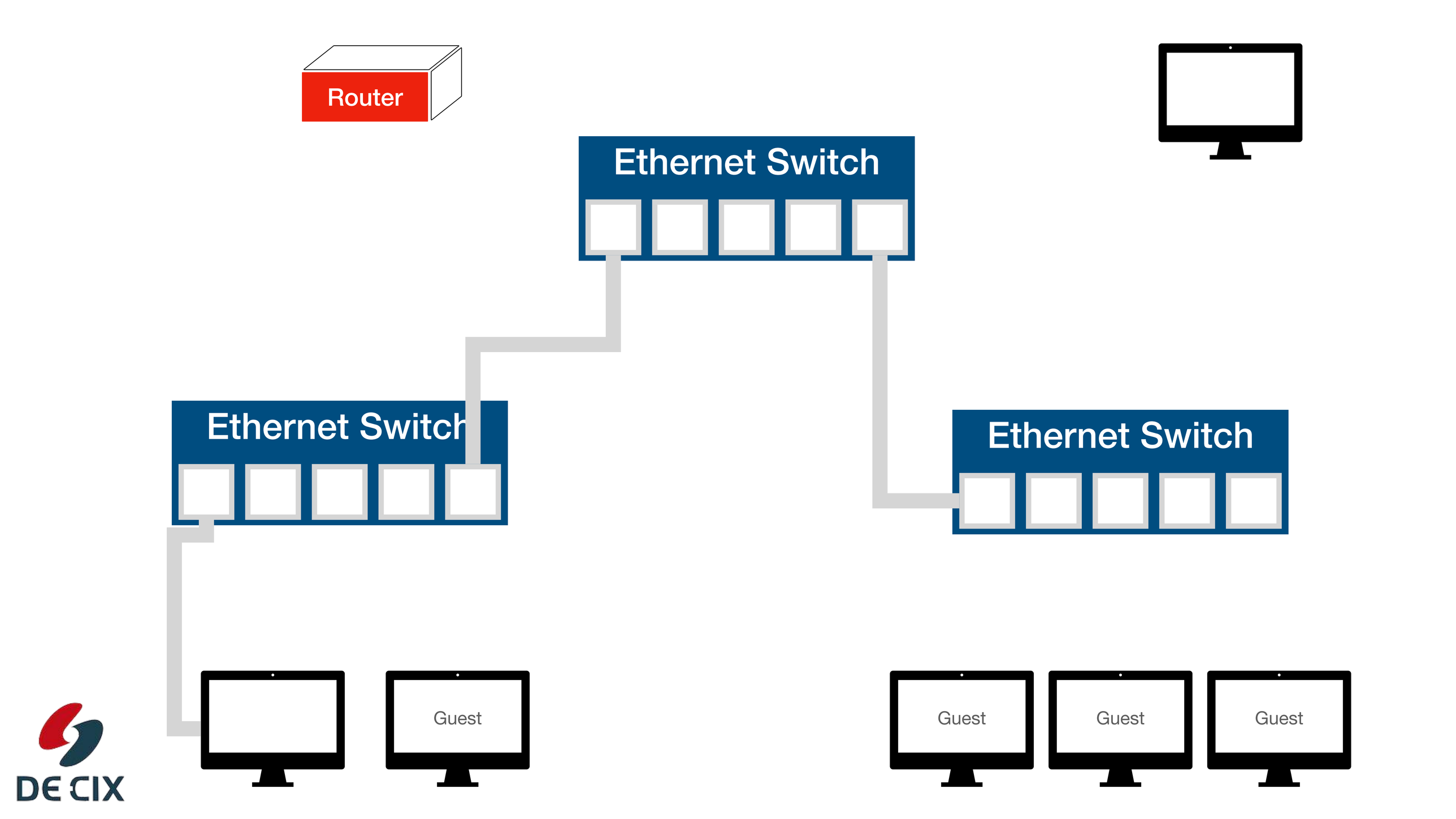
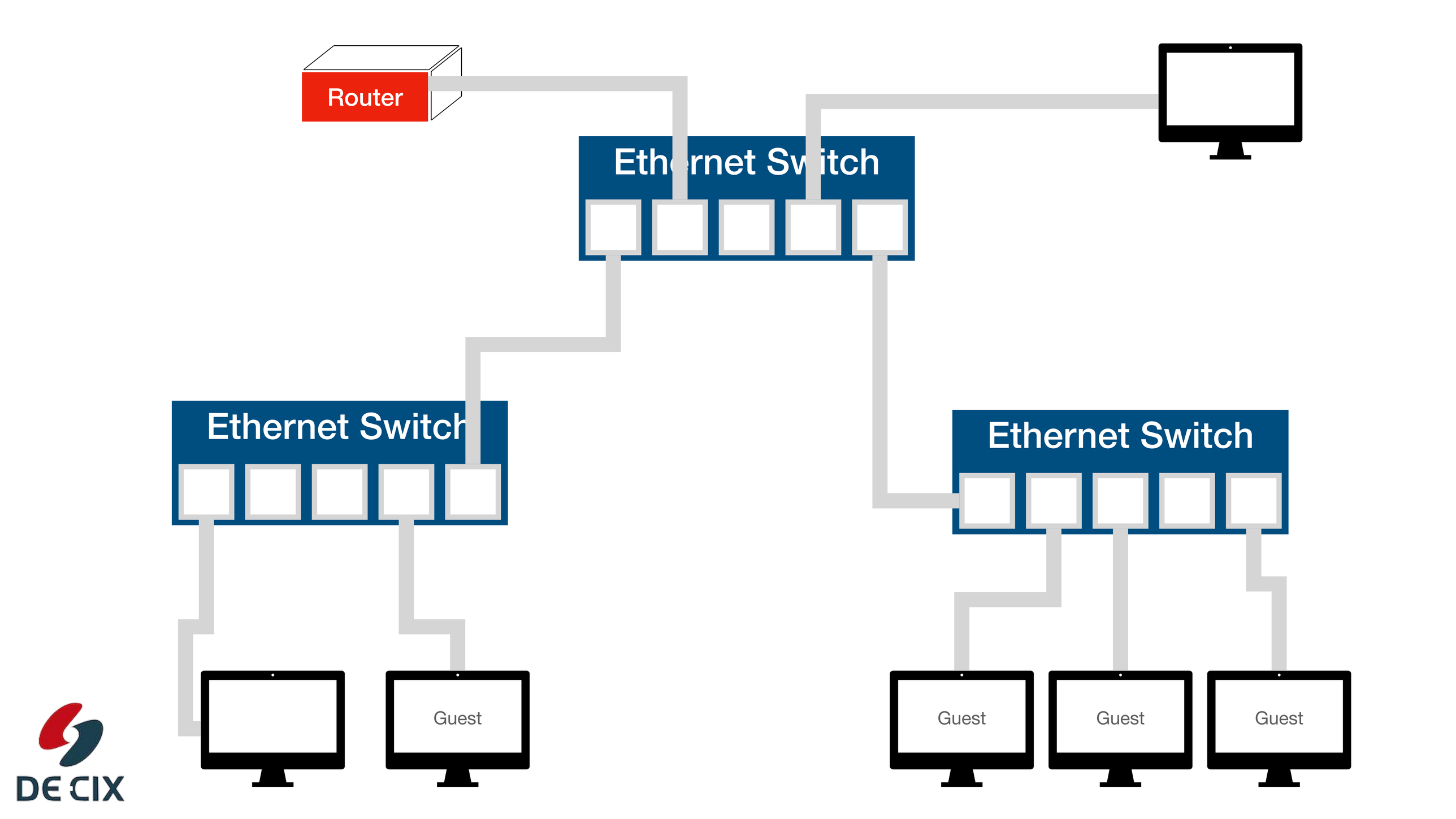
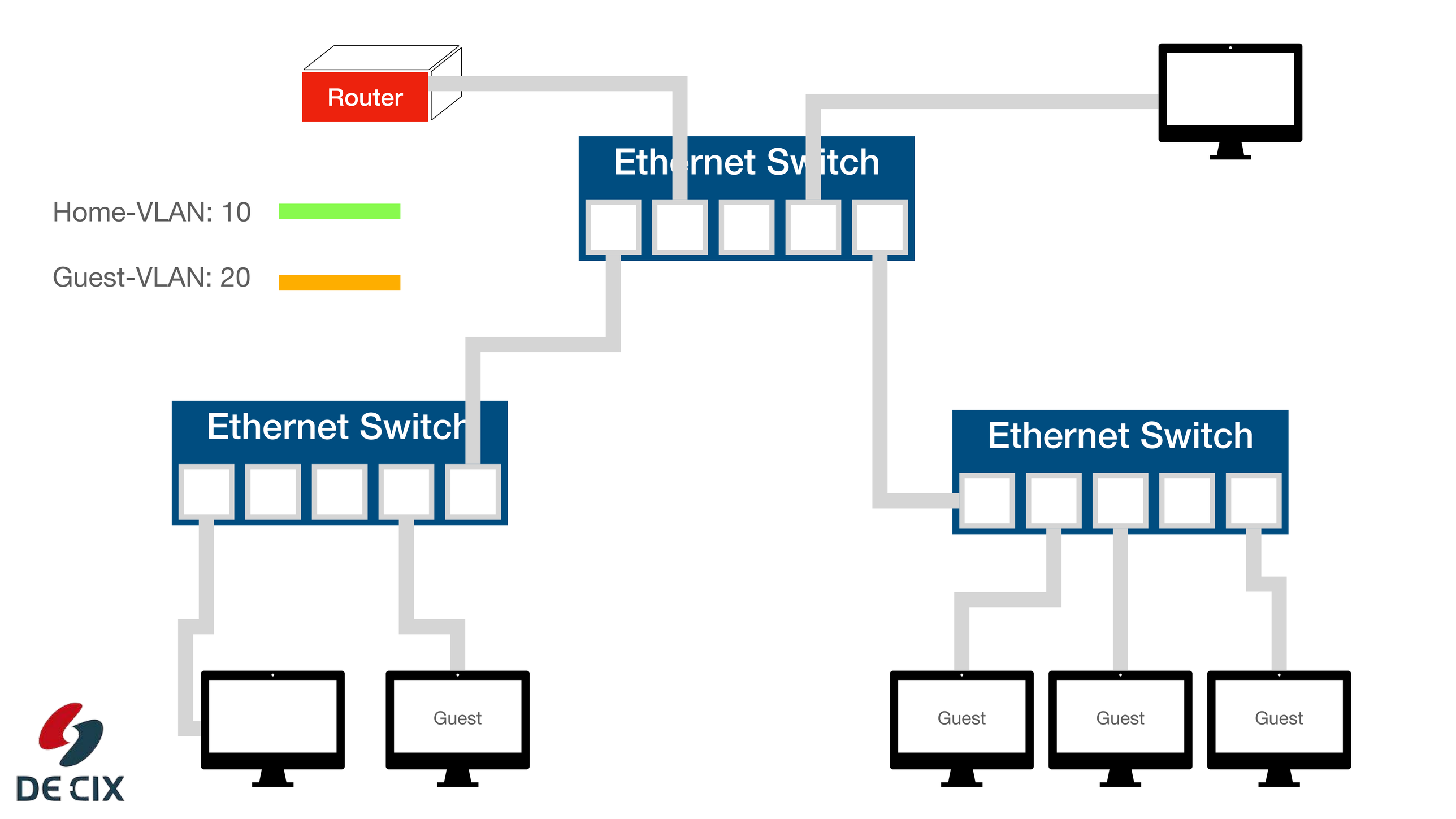
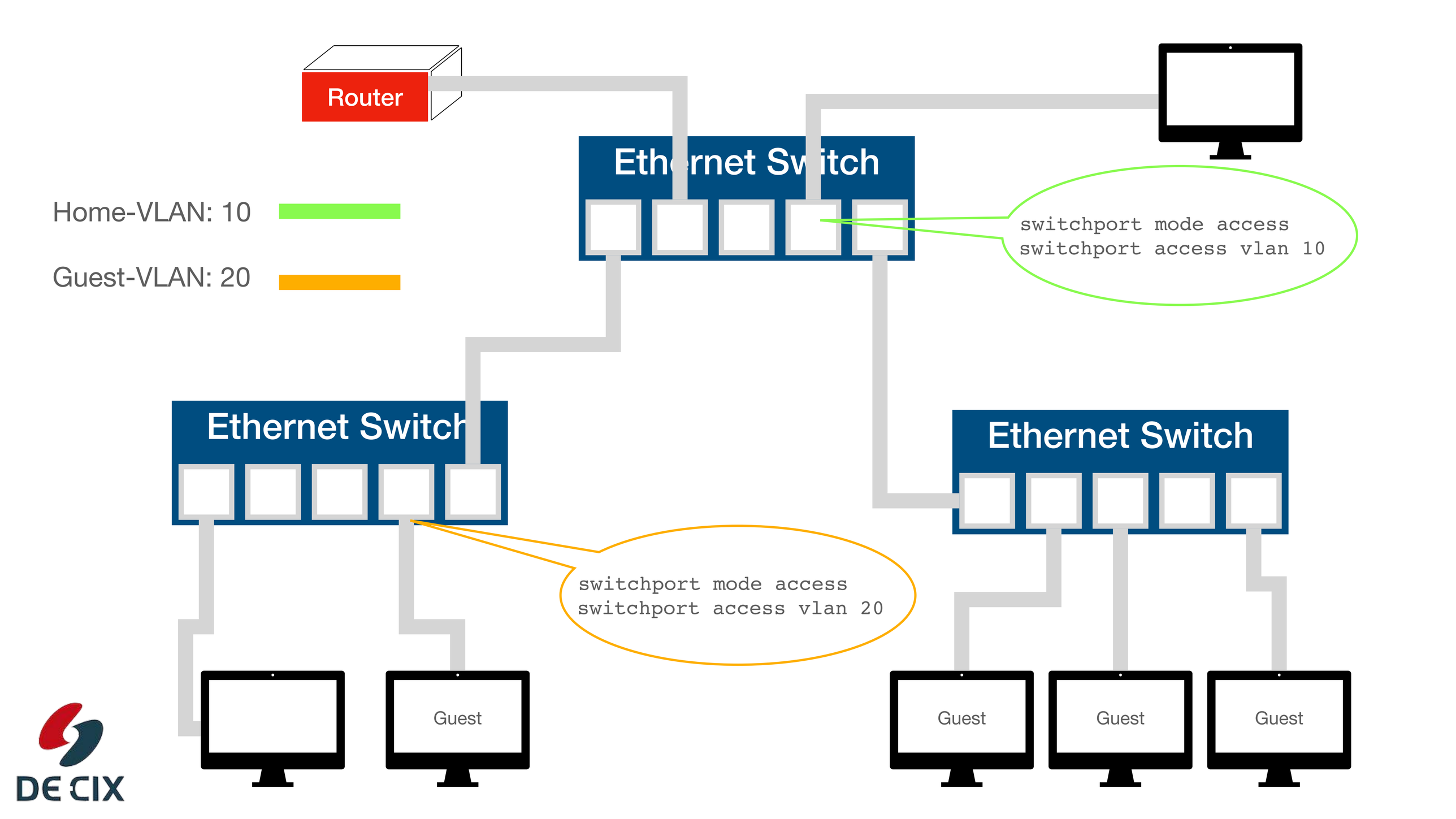

Ethernet Switch
Ethernet Switch
Ethernet Switch


Router
Ethernet Switch
Ethernet Switch
Ethernet Switch
Guest
Guest
Guest
Guest


Router
Ethernet Switch
Ethernet Switch
Ethernet Switch
Guest
Guest
Guest
Guest


Router
Ethernet Switch
Home-VLAN: 10
Guest-VLAN: 20
Ethernet Switch
Ethernet Switch
Guest
Guest
Guest
Guest


Router
Ethernet Switch
Home-VLAN: 10
Guest-VLAN: 20
switchport mode access
switchport access vlan 10
Ethernet Switch
Ethernet Switch
switchport mode access
switchport access vlan 20
Guest
Guest
Guest
Guest
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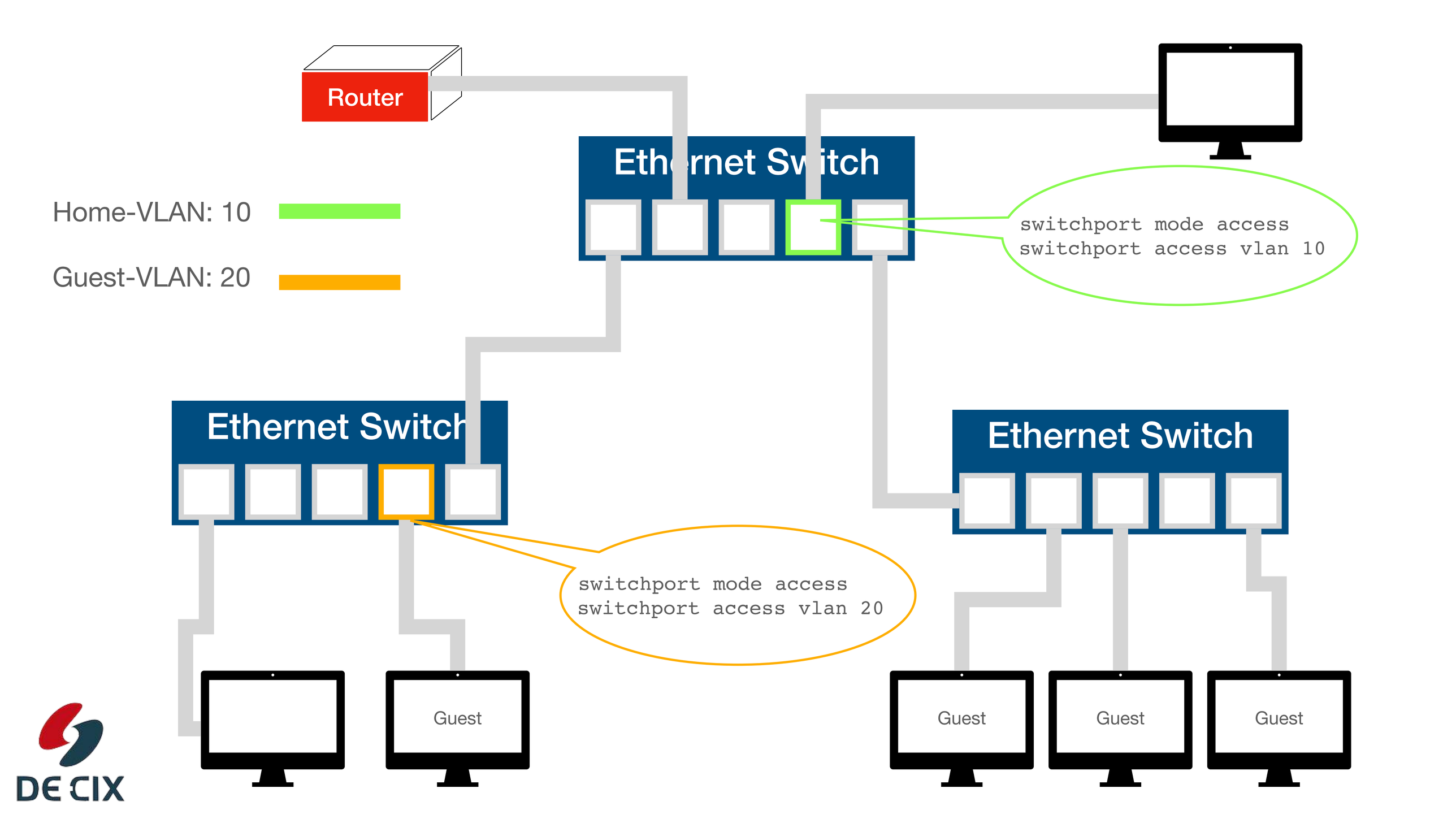
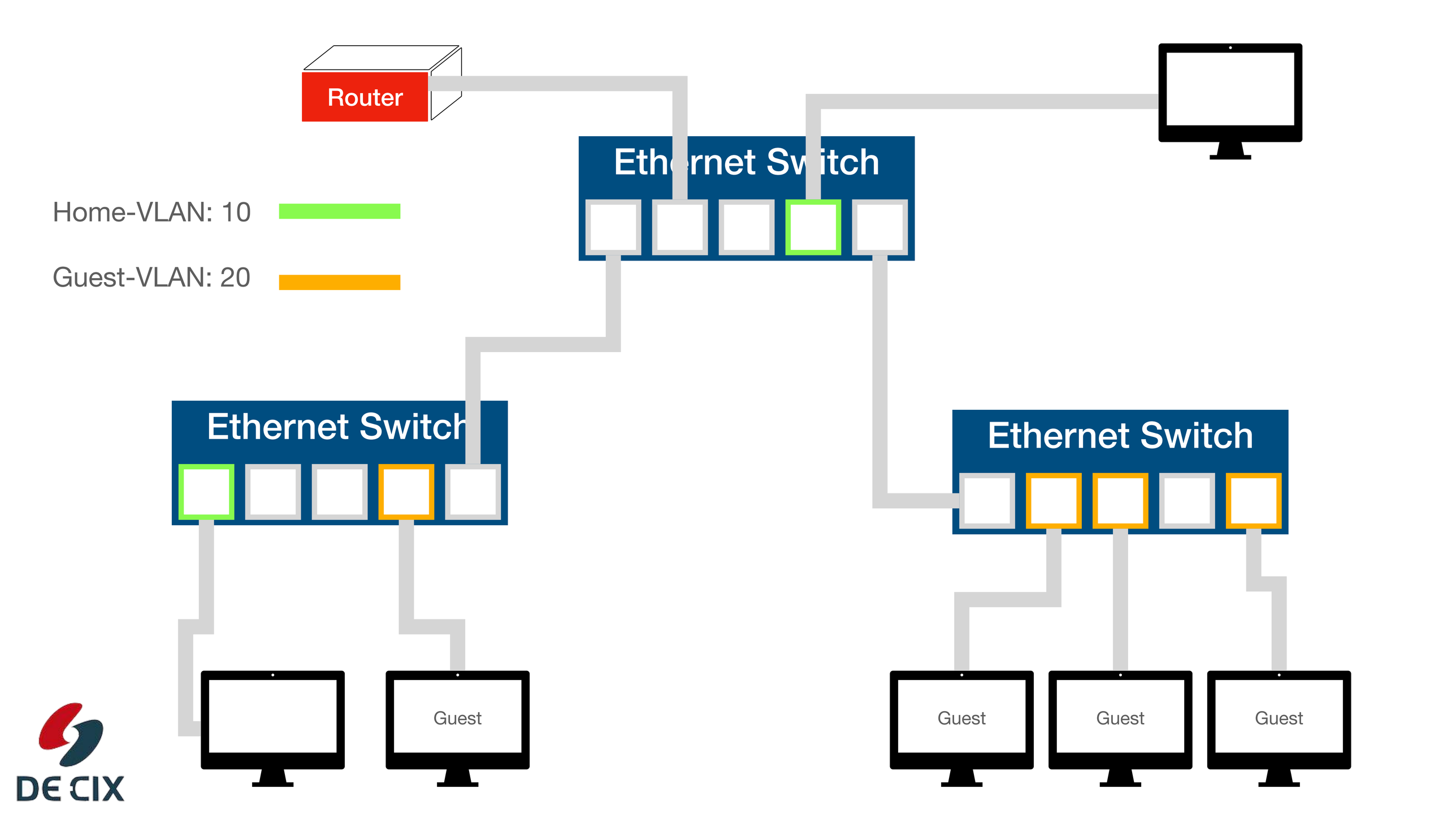
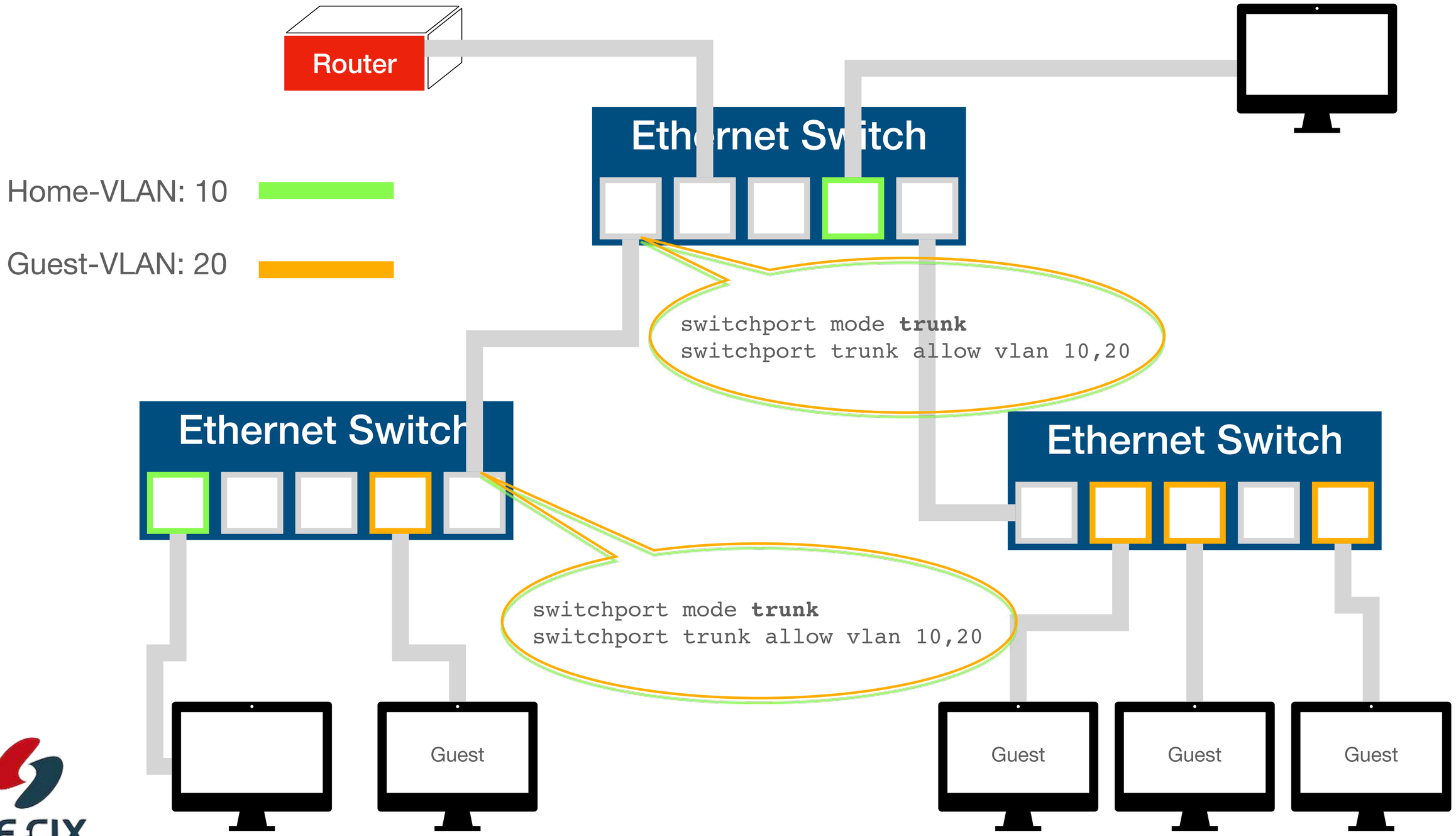
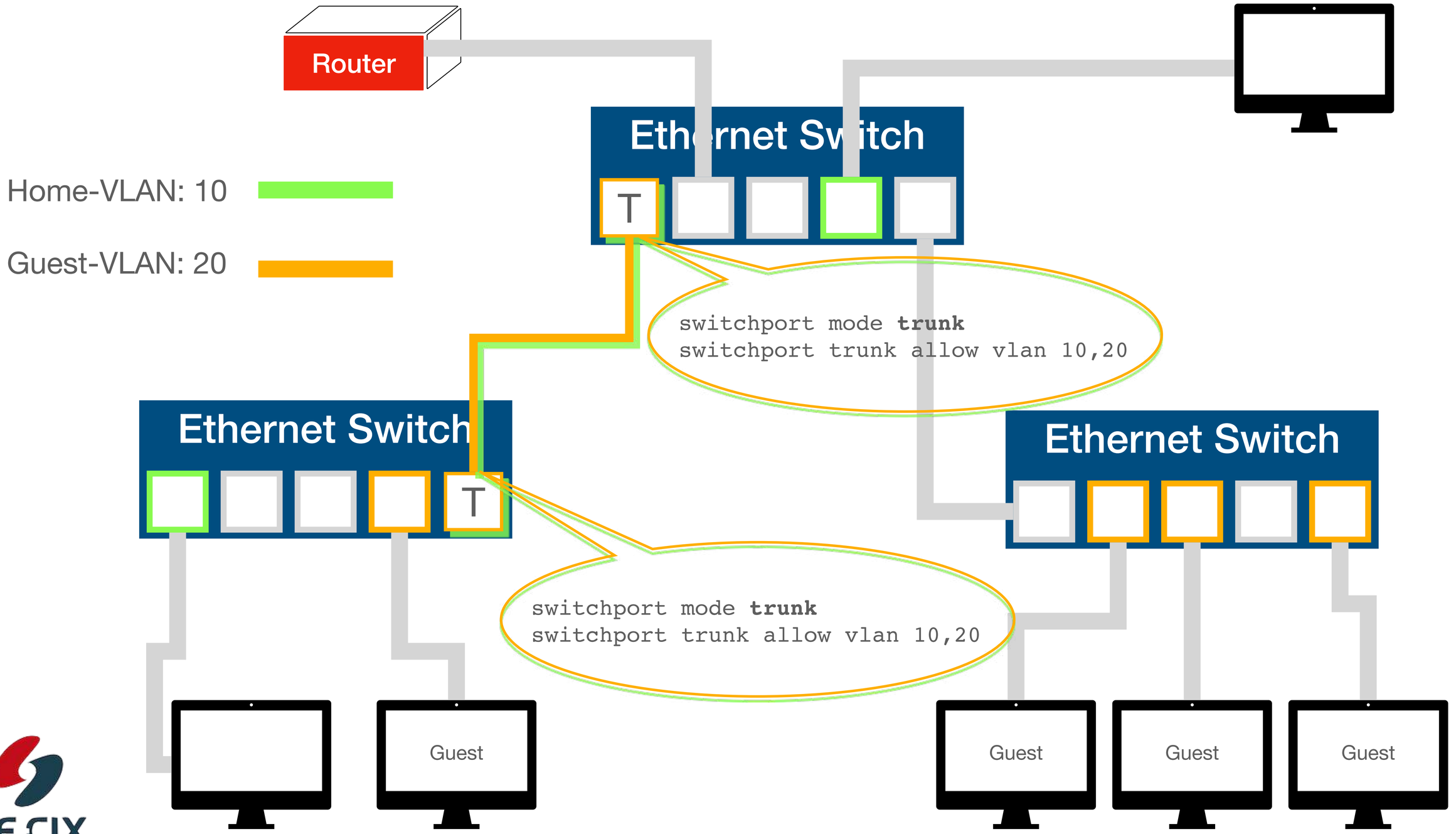

Router
Ethernet Switch
Home-VLAN: 10
Guest-VLAN: 20
switchport mode access
switchport access vlan 10
Ethernet Switch
switchport mode access
switchport access vlan 20
Ethernet Switch
Guest
Guest
Guest
Guest
DE CIX


Router
Ethernet Switch
Home-VLAN: 10
Guest-VLAN: 20
Ethernet Switch
Ethernet Switch
Guest
Guest
Guest
Guest


Router
Ethernet Switch
Home-VLAN: 10
Guest-VLAN: 20
switchport mode trunk
switchport trunk allow vlan 10,20
Ethernet Switch
Ethernet Switch
switchport mode trunk
switchport trunk allow vlan 10,20
Guest
Guest
Guest
Guest


Router
Ethernet Switch
T
Home-VLAN: 10
Guest-VLAN: 20
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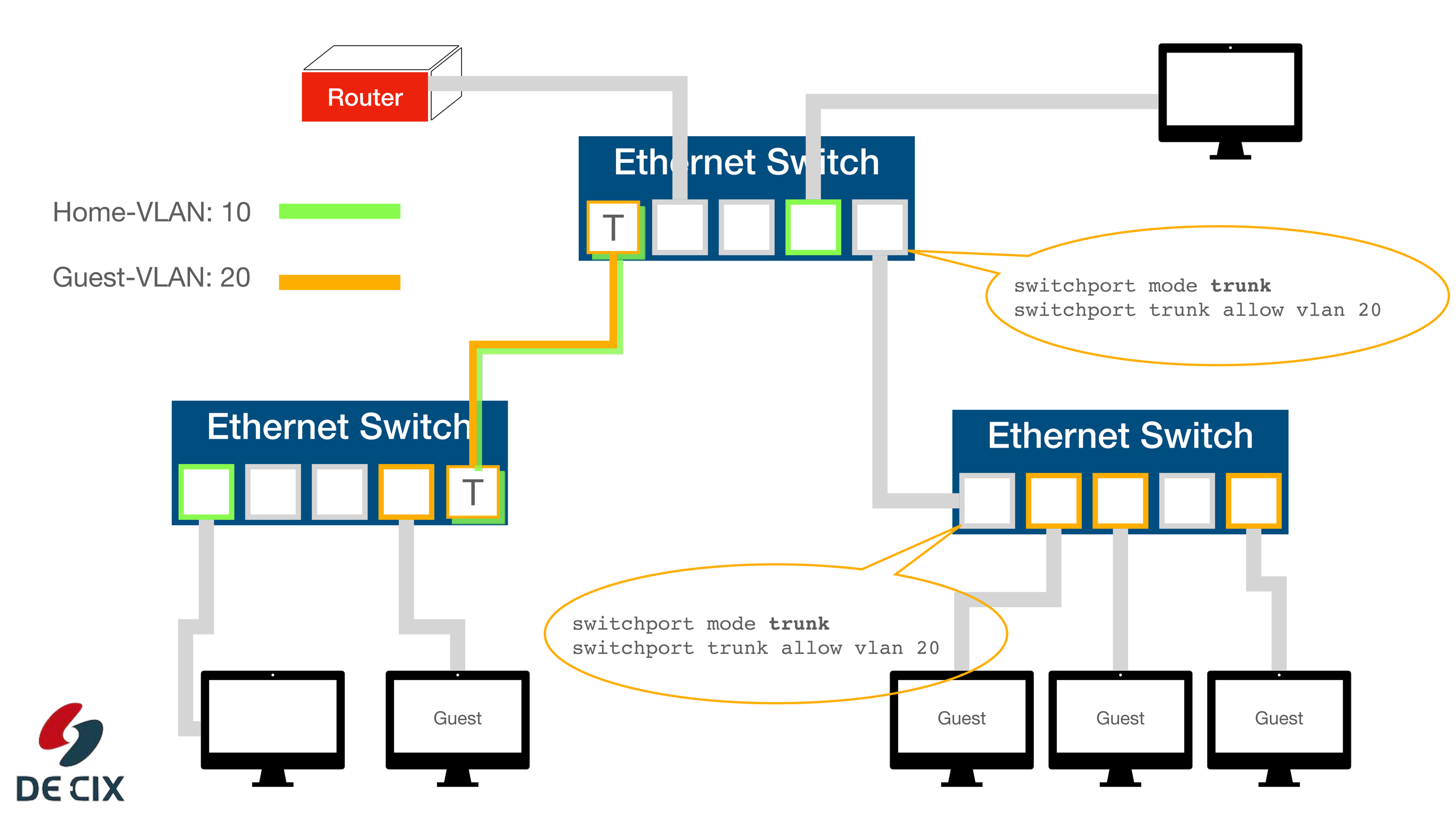
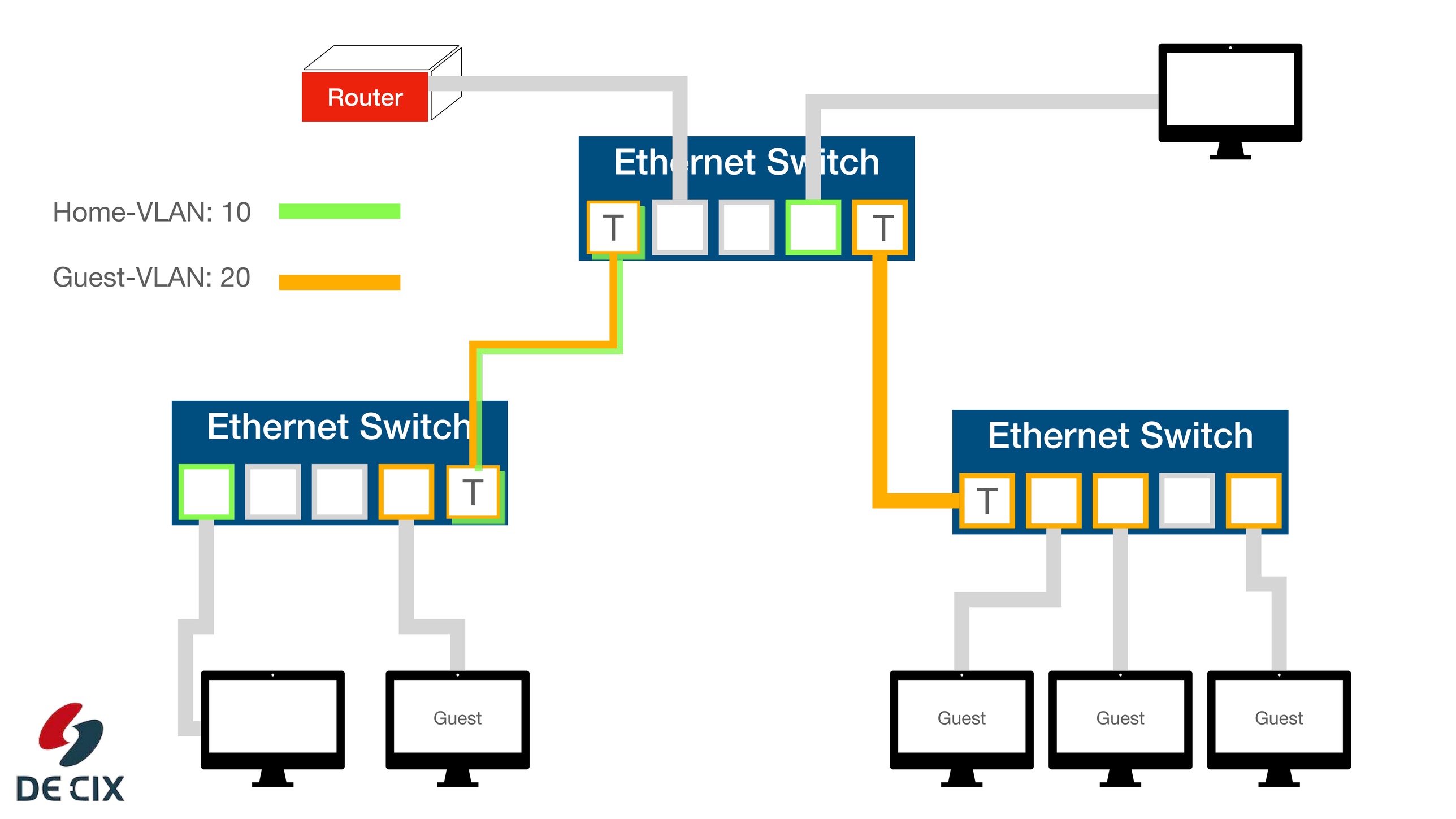
Ethernet Switch
T
Ethernet Switch
switchport mode trunk
switchport trunk allow vlan 10,20
Guest
Guest
Guest
Guest


Router
Ethernet Switch
T
Home-VLAN: 10
Guest-VLAN: 20
switchport mode trunk
switchport trunk allow vlan 20
Ethernet Switch
T
Ethernet Switch
switchport mode trunk
switchport trunk allow vlan 20
Guest
Guest
Guest
Guest


Router
Ethernet Switch
T
T
Home-VLAN: 10
Guest-VLAN: 20
Ethernet Switch
T
Ethernet Switch
T
Guest
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Guest
Guest
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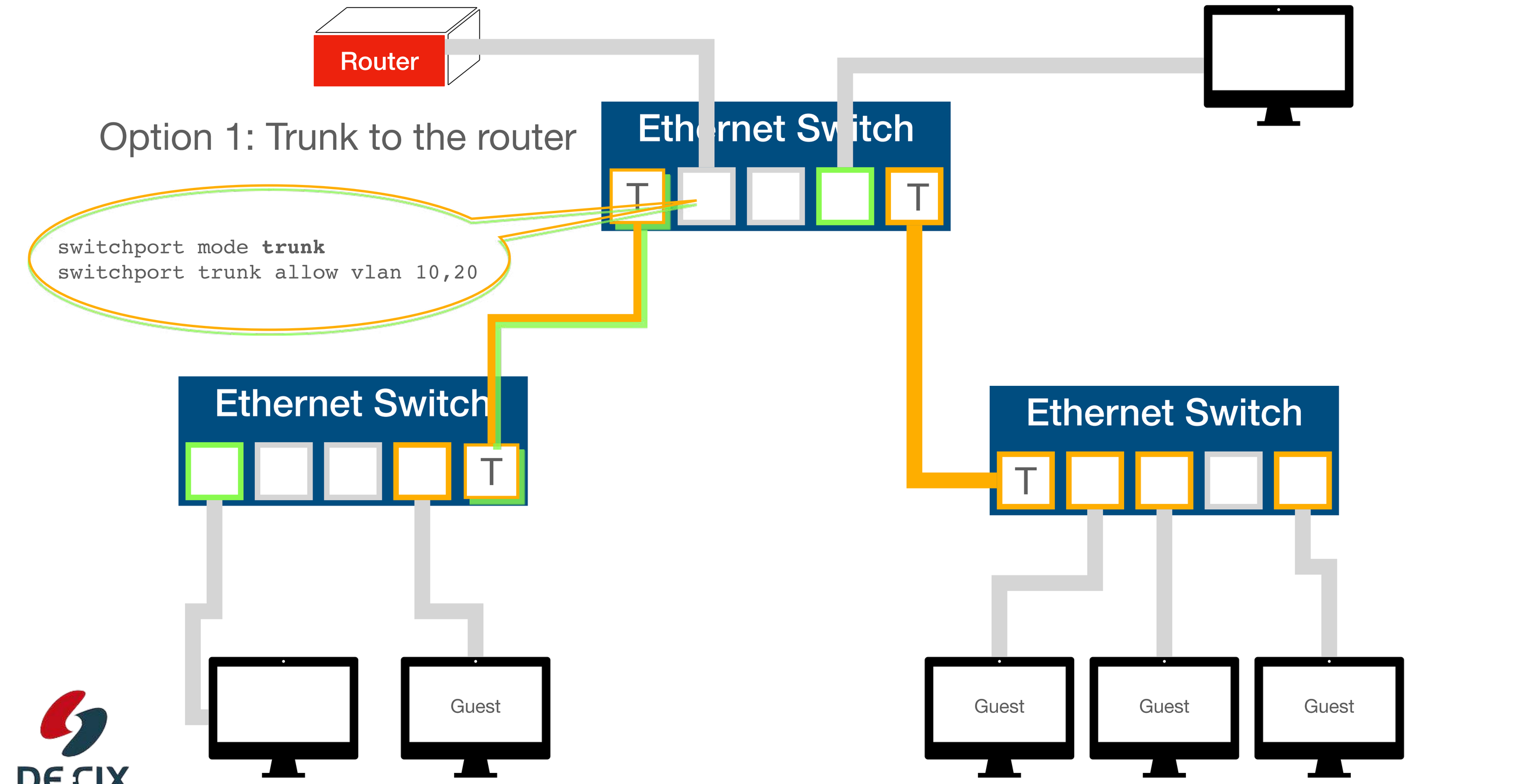
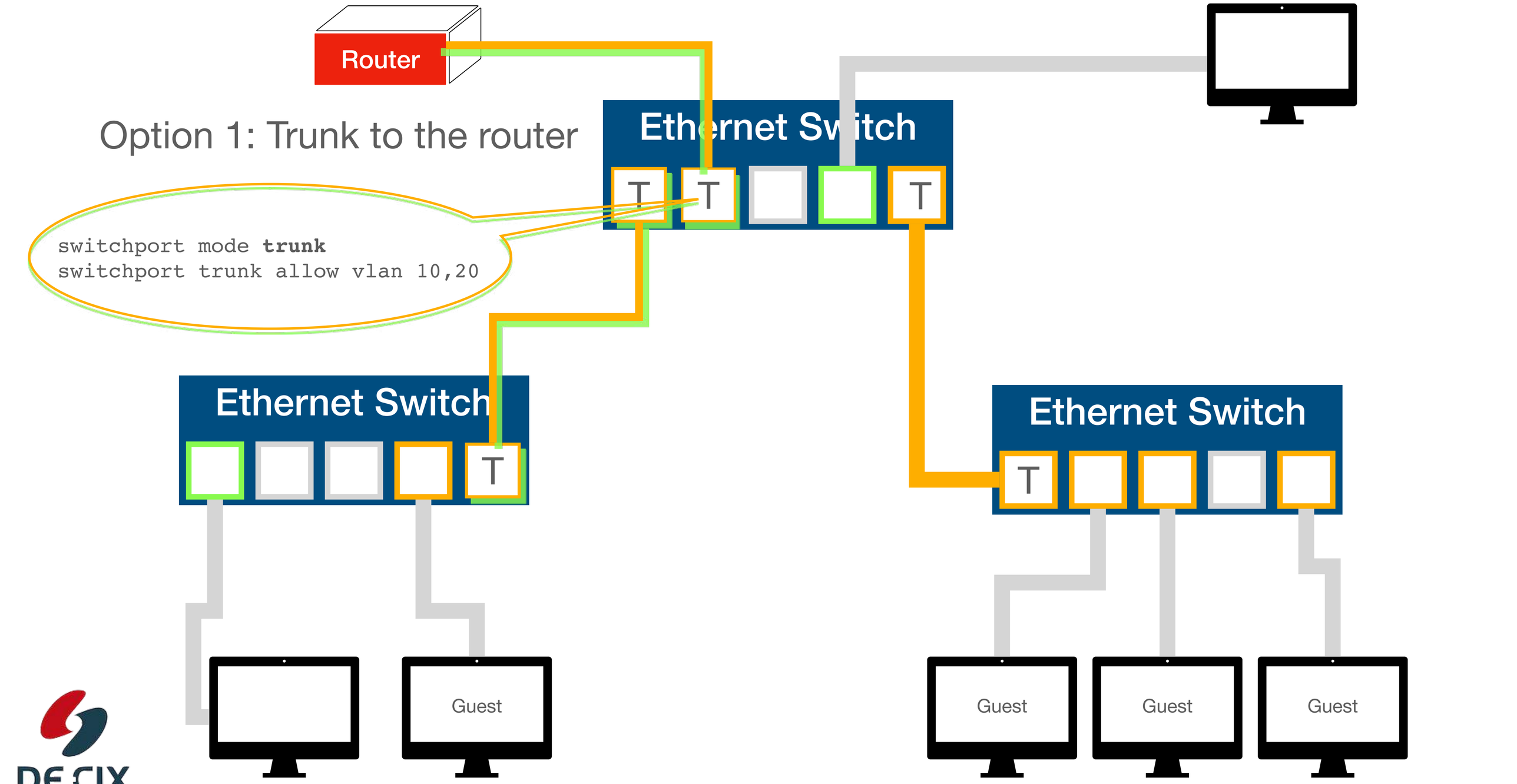
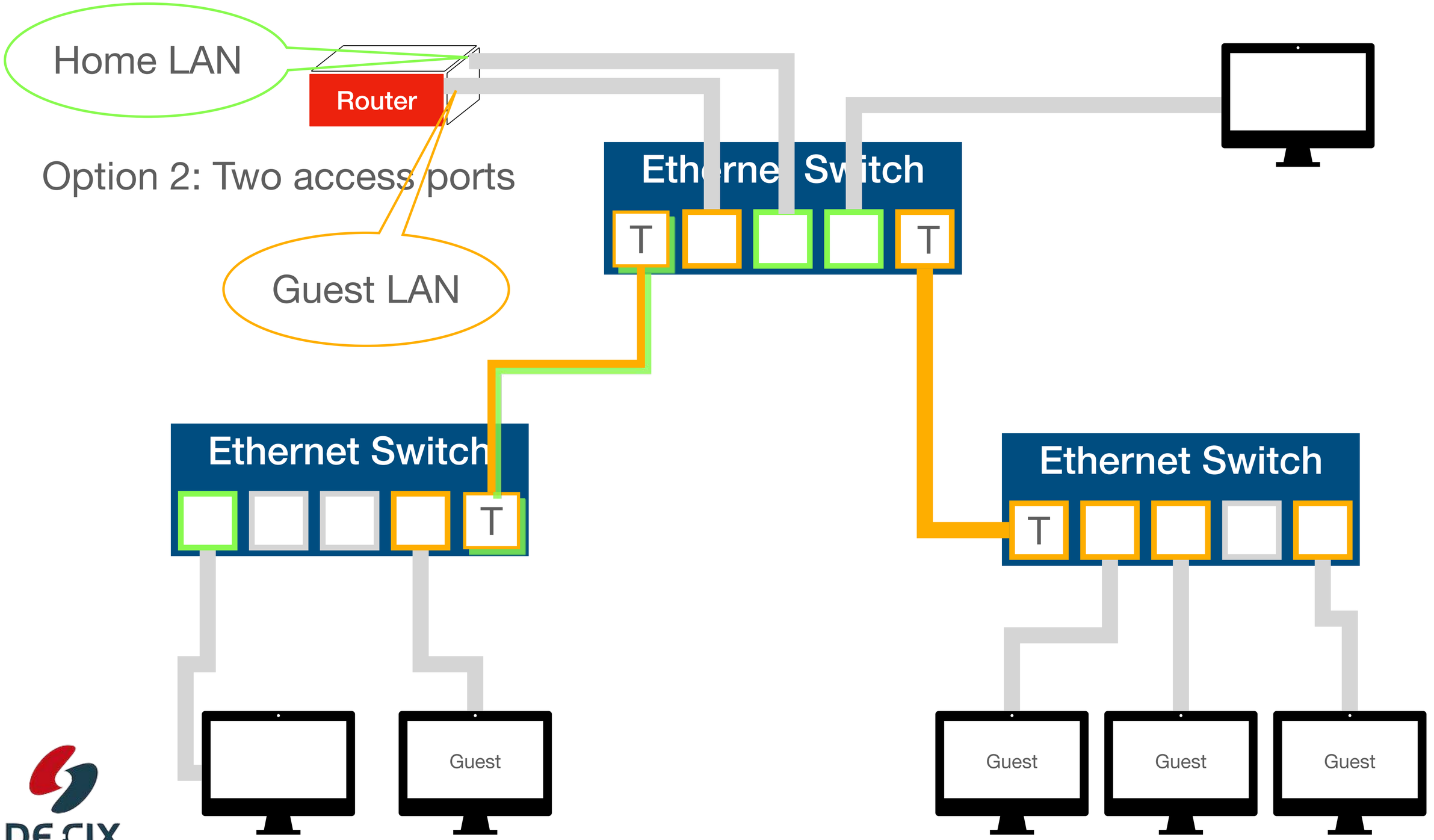
Option 1: Trunk to the router

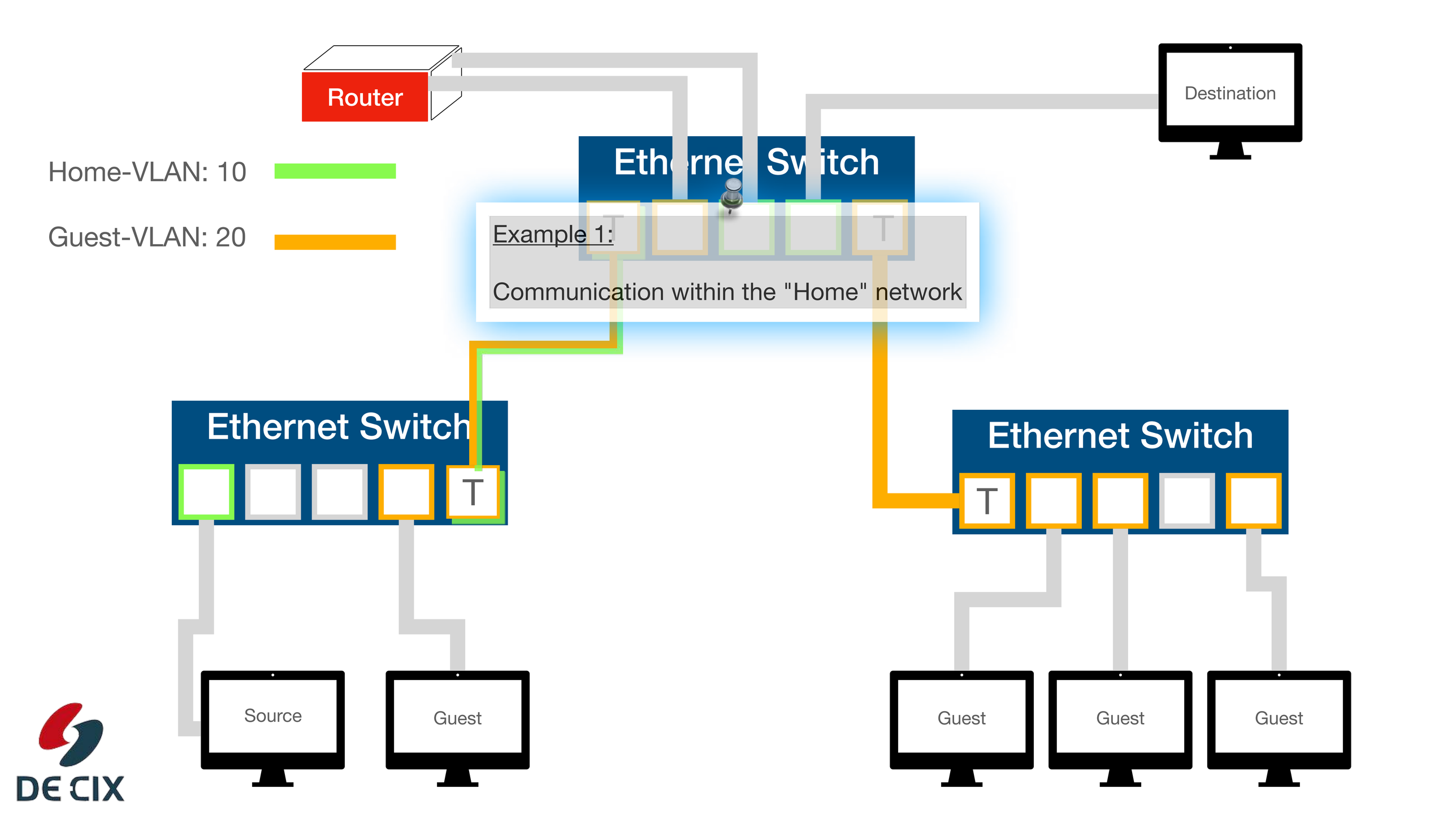


Option 1: Trunk to the router




Home LAN
Router
Option 2: Two access ports
Guest LAN
Ethernet Switch
T
T
Ethernet Switch
T
Ethernet Switch
T
Guest
Guest
Guest
Guest

And how does it work?


Router
Destination
Home-VLAN: 10
Guest-VLAN: 20
Ethernet Switch
Example 1:
Communication within the "Home" network
T
T
Ethernet Switch
T
Ethernet Switch
T
Source
Guest
Guest
Guest
Guest
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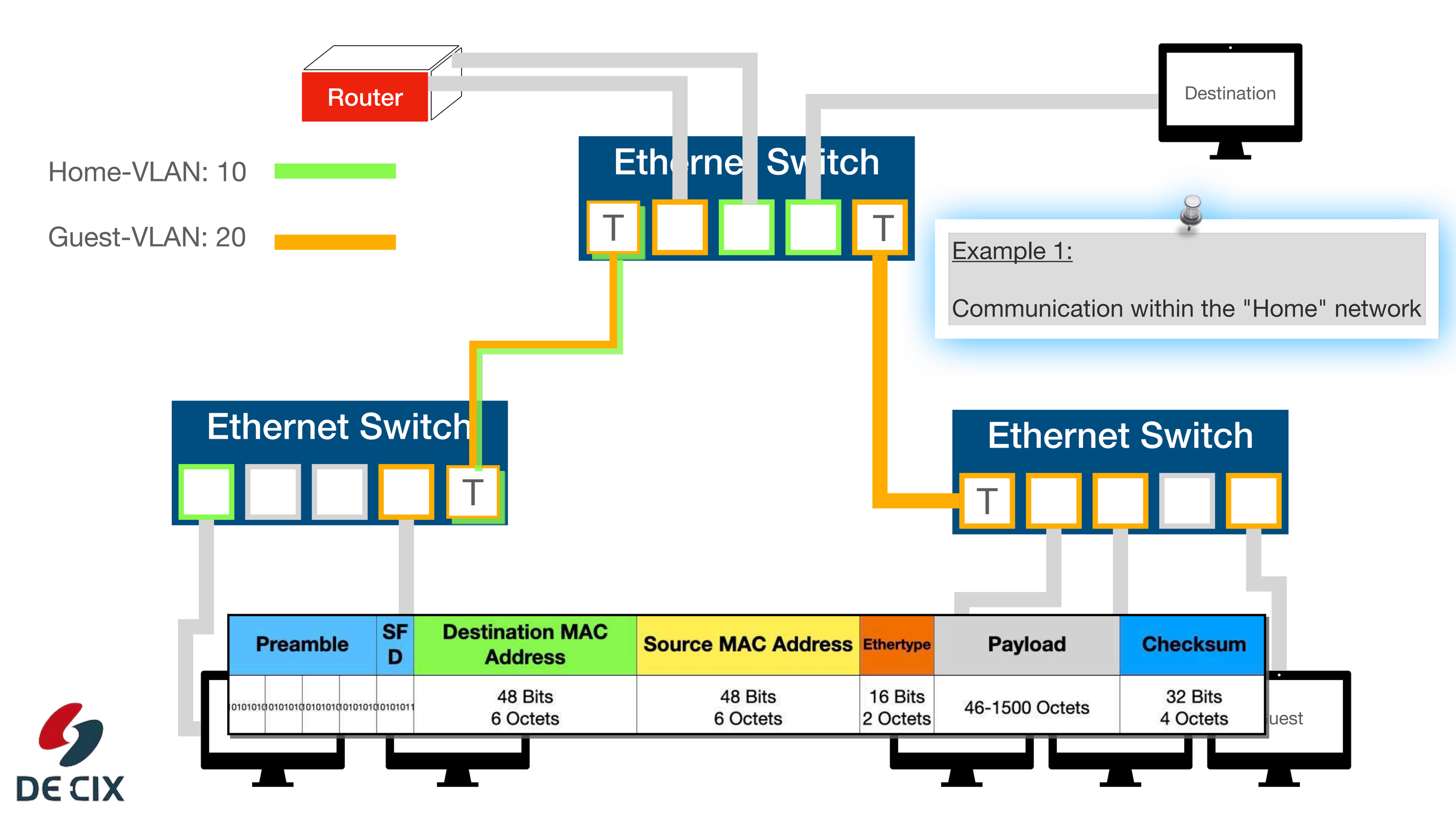
Router
Destination
Home-VLAN: 10
Guest-VLAN: 20
Ethernet Switch
T
T
Example 1:
Communication within the "Home" network
Ethernet Switch
T
Ethernet Switch
T
Preamble
SFD
Destination MAC Address
Source MAC Address
Ethertype
Payload
Checksum
48 Bits
6 Octets
48 Bits
6 Octets
16 Bits
2 Octets
46-1500 Octets
32 Bits
4 Octets
uest

Router

Destination

Home-VLAN: 10

Guest-VLAN: 20

Ethernet Switch

T

T

Example 1:

Communication within the "Home" network

Ethernet Switch

T

Ethernet Switch

T

Source

Guest

Guest

Guest

Guest

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Destination

Router

Home-VLAN: 10

Guest-VLAN: 20

Ethernet Switch

T

T

Ethernet Switch

T

Ethernet Switch

T

Example 2:

Preamble	SFD	Destination MAC Address	Source MAC Address	Ethertype	Payload	Checksum
01010101010101010101010101010101		48 Bits 6 Octets	48 Bits 6 Octets	16 Bits 2 Octets	46-1500 Octets	32 Bits 4 Octets

uest

Source

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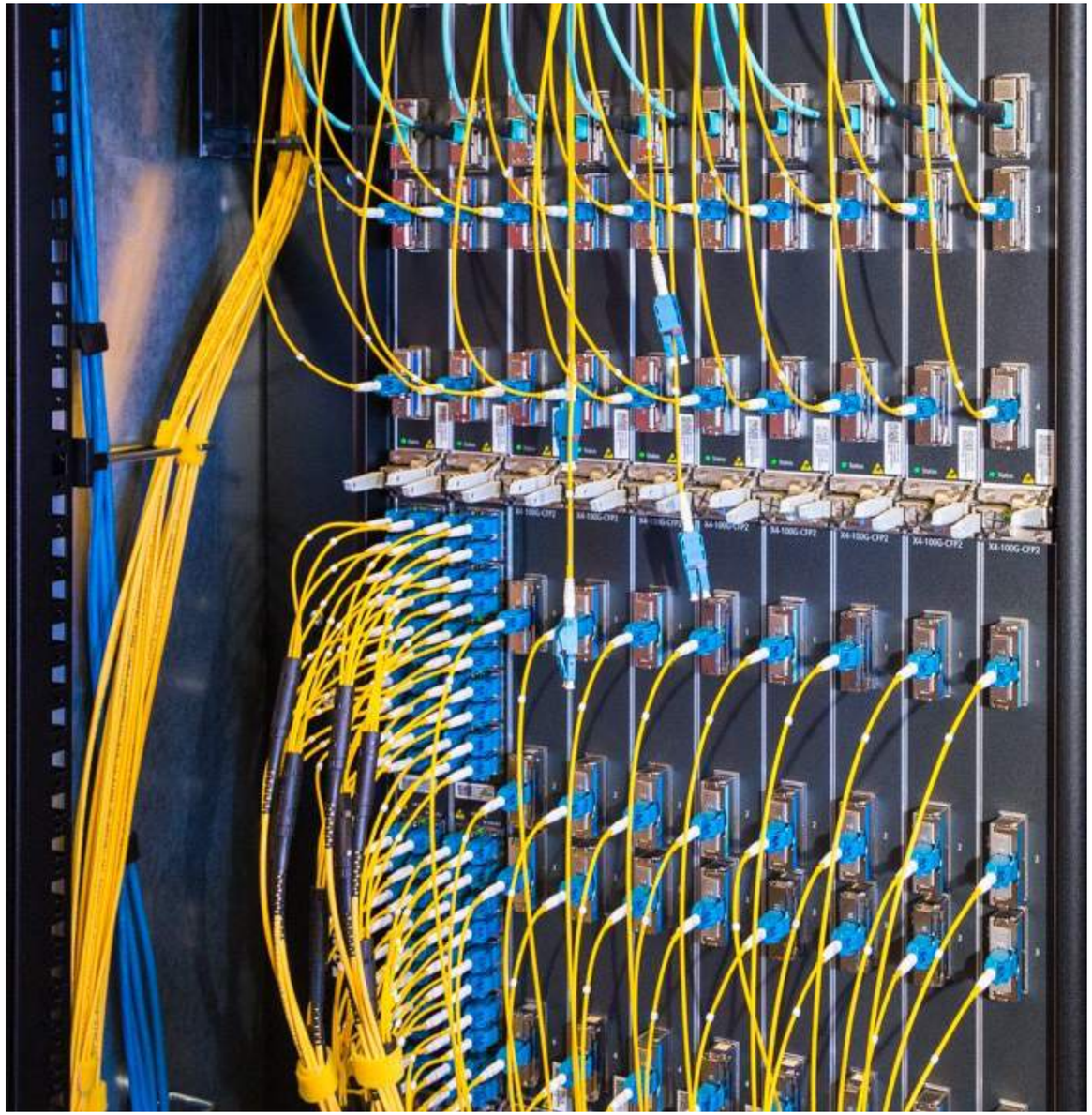
VLANs at DE-CIX

VLANs at DE-CIX

How we use them

- VLANs can deliver multiple LANs on one trunked port
- Each tagged with a different VLAN ID
- Like we used to separate "Home" and "Guest" network



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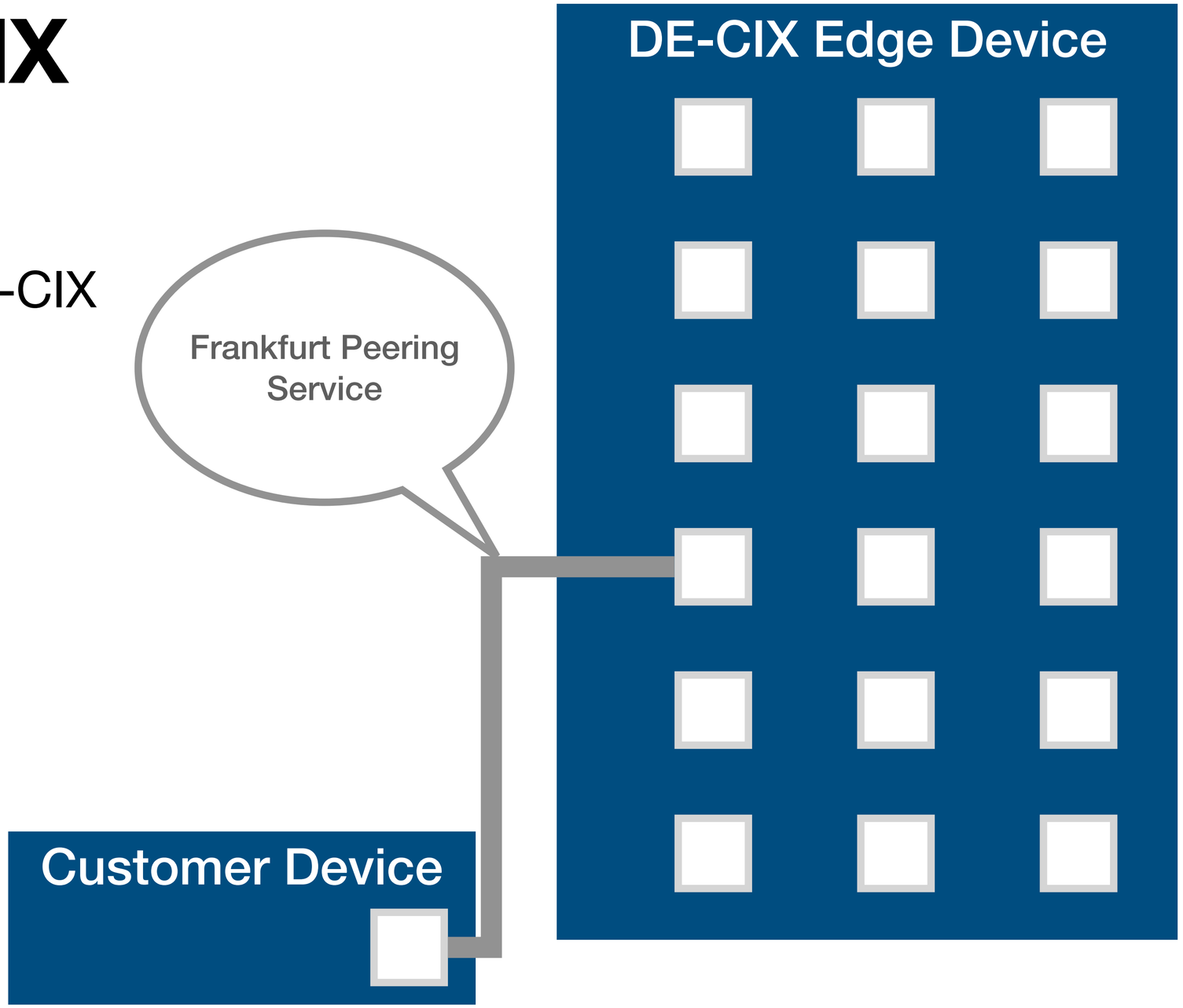
VLANs at DE-CIX

How we use them

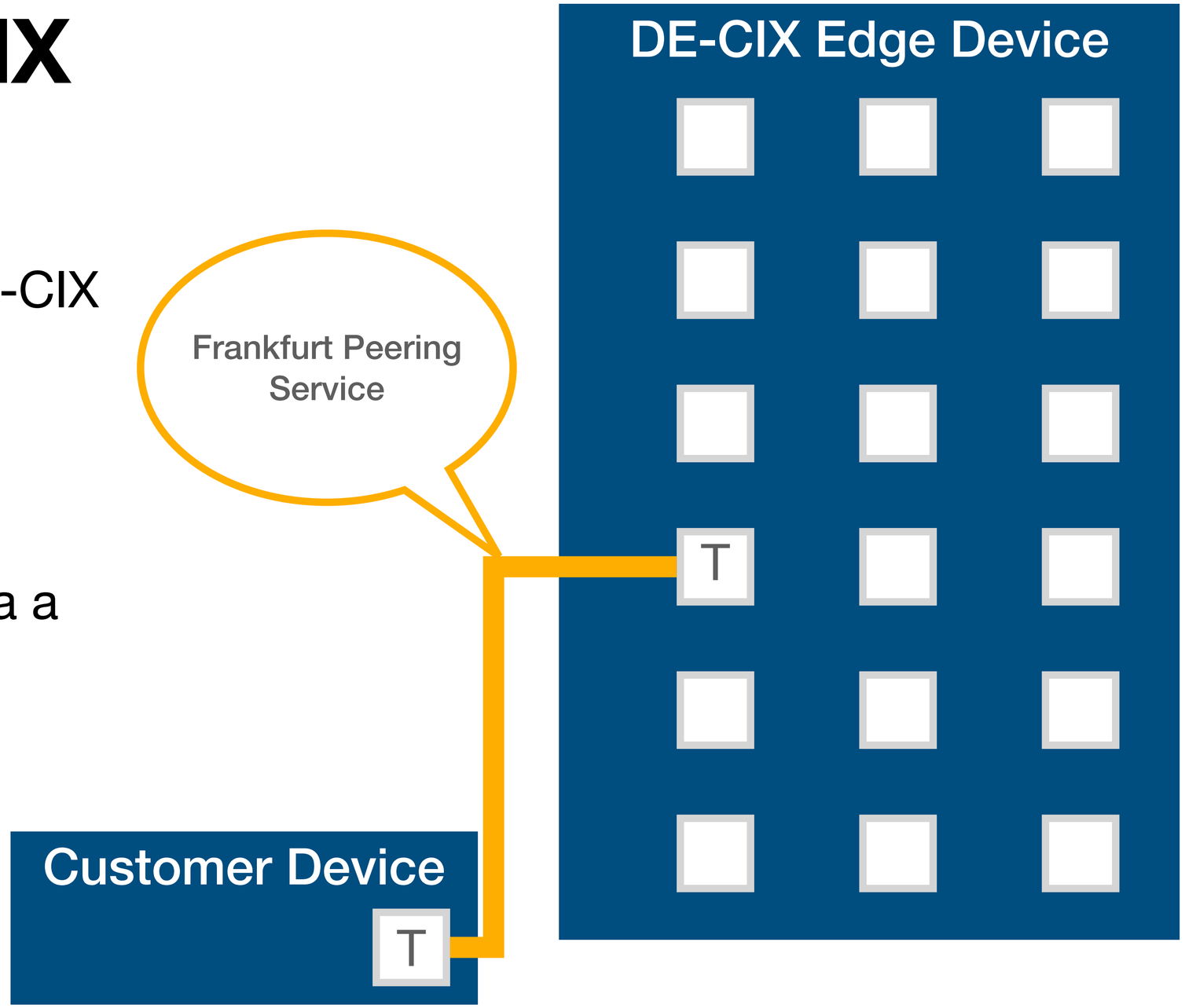
- Customers connect to DE-CIX via Ethernet
- Standard connection is a untagged access port



VLANs at DE-CIX

How we use them

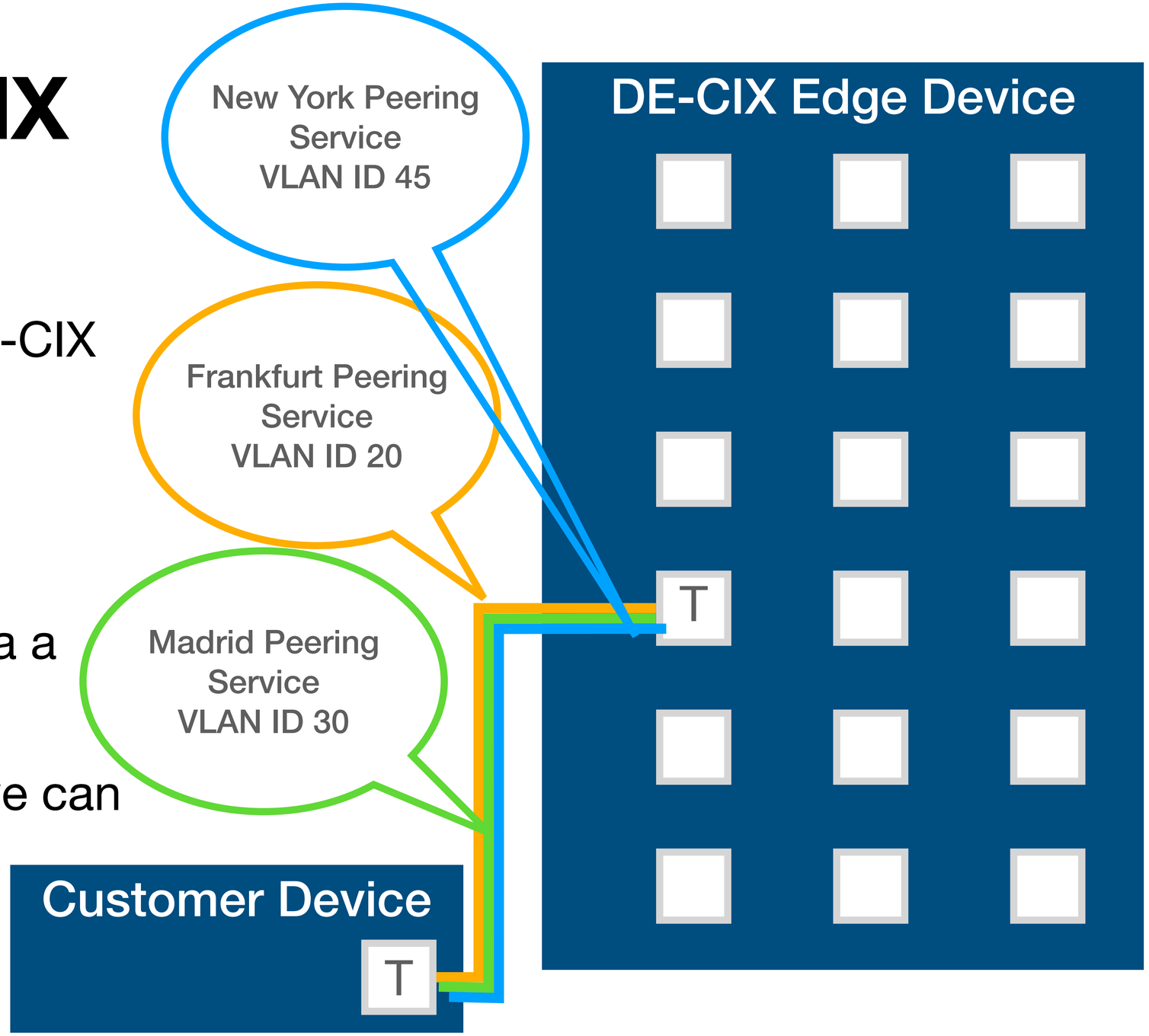
- Customers connect to DE-CIX via Ethernet
- Standard connection is a untagged access port
- But we can also deliver via a tagged trunk-like port



VLANs at DE-CIX

How we use them

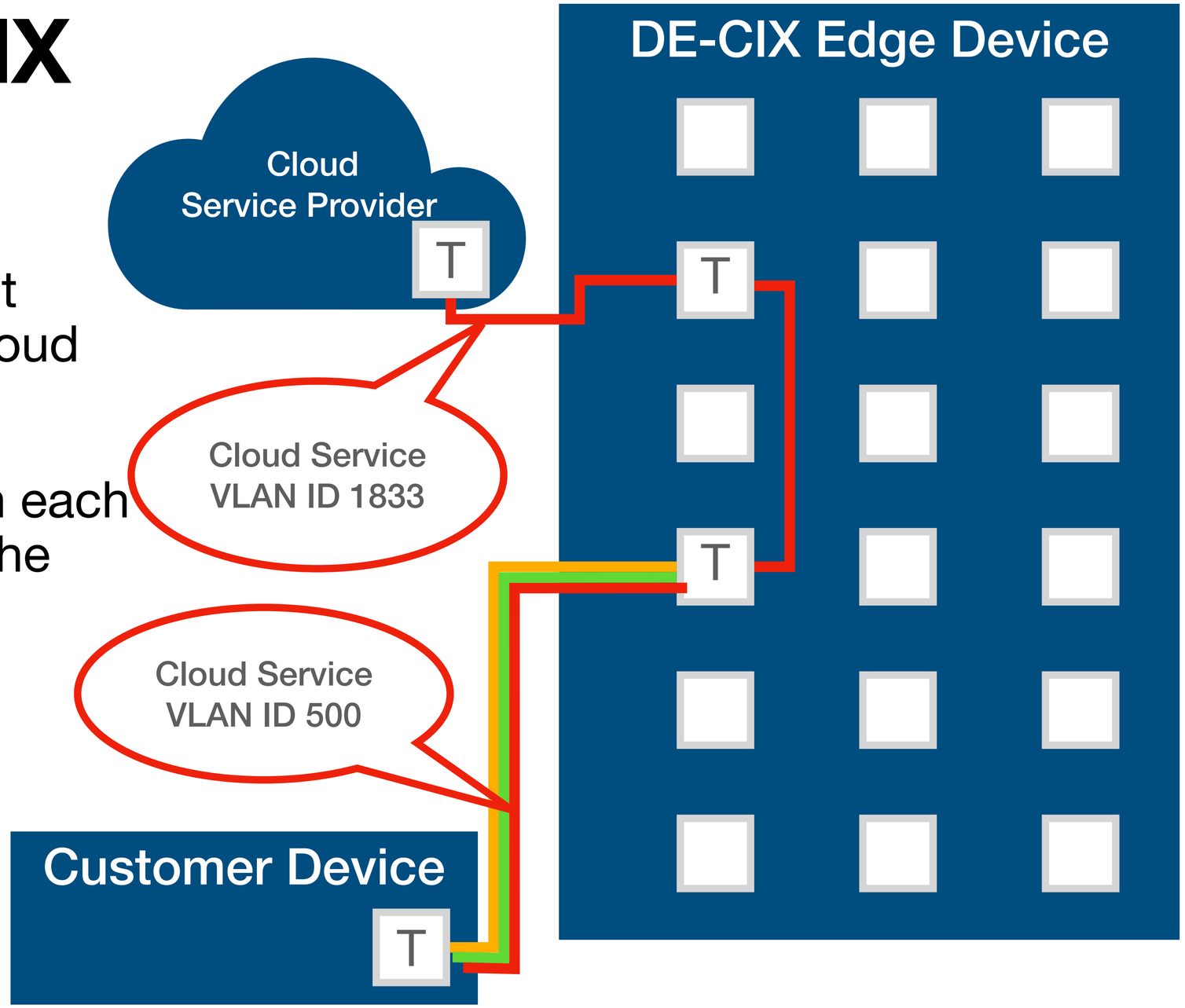
- Customers connect to DE-CIX via Ethernet
- Standard connection is a untagged access port
- But we can also deliver via a tagged trunk-like port
- And on a trunk-like port we can deliver multiple services



VLANs at DE-CIX

Connect to the Cloud

- The same way we connect customers to (multiple) Cloud service providers
- At DE-CIX the VLAN ID on each end does not have to be the same!



Conclusion

Please remember....

Facts about VLANs

- Ethernet is a **broadcast** network
- VLANs set up **virtual LANs** on a **common physical infrastructure**
- VLAN **IDs** run from 1 - 4094
  - It is recommended to **not use VLAN 1** (if possible)
- DE-CIX uses VLANs for multiple service delivery on one physical port

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Thank you!

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Links used in the presentation

Ethernet today

- Ethernet
  - Wikipedia entry for Ethernet
  - IEEE Standard for Ethernet
- Various types of Ethernet
  - 10Base5
  - 10Base2
  - 10Base-T
- more speed
  - FastEthernet - 100Mbit/s
  - GigabitEthernet - 1000Mbit/s / 1GBit/s
  - 10 Gigabit Ethernet - 10GBit/s
  - 100 Gigabit Ethernet (and 40 Gigabit Ethernet)
- Currently used hardware
  - Twisted pair cables: Cat5, Cat6, RJ45 connector
  - Optical fibres: Single-mode and multi-mode
  - Ethernet switch

VLANs

- Wikipedia entry for
  - VLANs: https://en.wikipedia.org/wiki/Virtual_LAN
  - IEEE 802.1Q (VLAN standard): https://en.wikipedia.org/wiki/IEEE_802.1Q
  - IEEE 802.1ad (nested VLANs): https://en.wikipedia.org/wiki/IEEE_802.1ad
  - Private VLAN (port isolation): https://en.wikipedia.org/wiki/Private_VLAN
- Some RFCs (Request for comment = Internet standards) about VLANs:
  - RFC3069 VLAN Aggregation for Efficient IP Address Allocation
  - RFC4554 Use of VLANs for IPv4-IPv6 Coexistence in Enterprise Networks
- IEEE Standards (may not be freely available):
  - IEEE 802.1Q-2014: https://ieeexplore.ieee.org/servlet/opac?punumber=6991460
  - IEEE 802.1ad: http://www.ieee802.org/1/pages/802.1ad.html

Standards

- IEEE standards
  - 802.3-2018 current standard, also here
  - IEEE 802 committee website

- Registered information:
  Ethertype list at IANA, Public register at IEEE

- Some Internet RFCs regarding Ethernet
  - IP over Ethernet: RFC894, RFC895
  - IPv6 over Ethernet: RFC1972, RFC2464

Software

- Wireshark
- TCPDump