Etherchannel and L3 Redundancy

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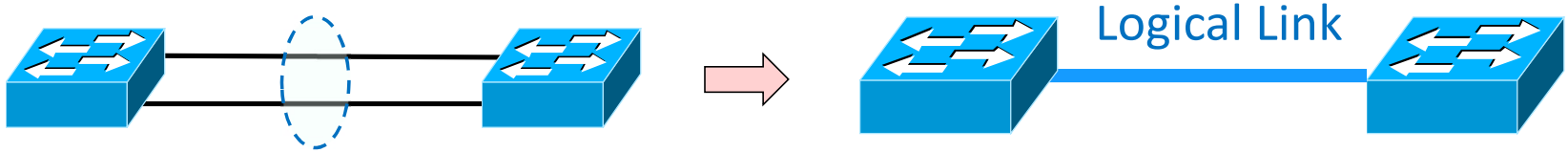
References: Cisco CCNA

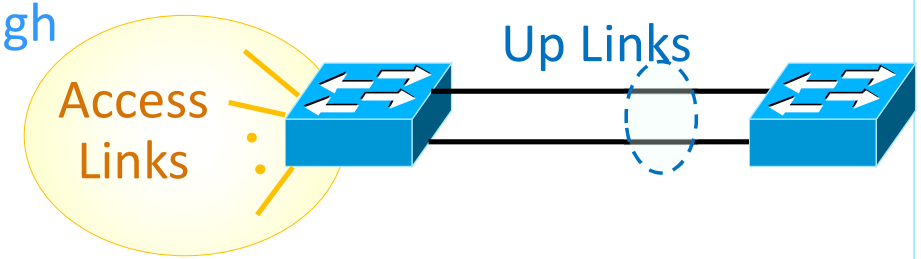
Link Aggregation

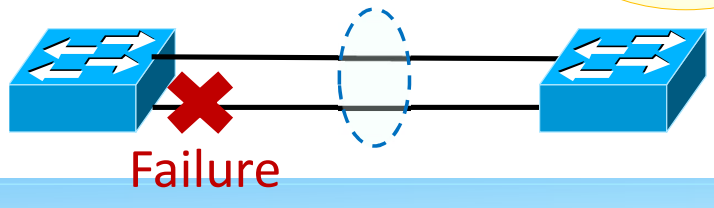
- **Link Aggregation** (aka **EtherChannel**)**:** technology that
  - **Bundles several links** between two devices and
  - Use them simultaneously as **a single** (**logical) link**.



➢Increases **bandwidth** and provides **redundancy**

- Why **EtherChanel**?
  - **Fastest possible port** is **no longer** fast enough (for traffic from all access links)
    - **Adding faster links** is **expensive**
  - Increase **availability**



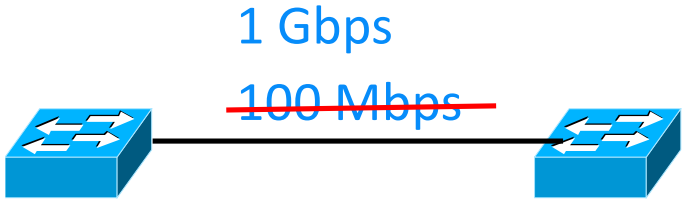


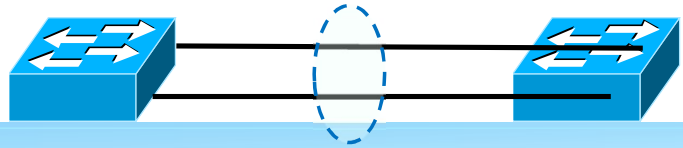
Link Aggregation and Spanning Tree Protocol

- Suppose two switches connect with each other via a 100 Mbps link

- Can we extend capability by **connecting other links** between two switches?
  - **No, Spanning-Tree Protocol** (STP) will block redundant links to prevent a loop

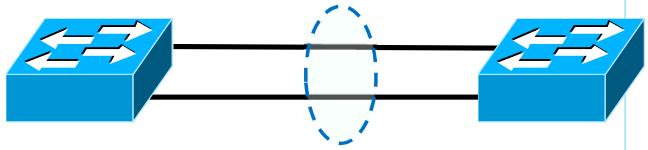
- **Alternatives** to extend the capacity of the link:
  - Deploy switches with faster interfaces (1Gbps)
    - very expensive
  - Use **Link Aggregation** to **bundle two physical links** into a bigger link
    - **STP** treats this link as **a single link**!





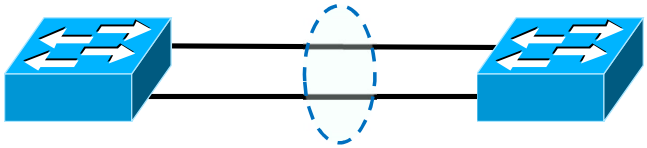
Characteristics of EtherChannel

- **High Availability –** If one link fails, traffic goes through remaining links
- **Restrictions** (for Cisco IOS switches)
  - **Interface types** cannot be mixed;
    - **Fast** (800 Mb/s) and **Gigabit** Ethernets cannot be mixed in an EtherChannel
  - **Ports** must be **compatibly-configured** on both devices
    - e.g., both sides configured as **trunks** within the **same native VLAN**
  - Up to **eight links** bundled in an **EtherChannel**
  - Up to **six EtherChannels** for a Cisco IOS switch
  - **One-to-one** connection between
    - **two switches**, or **a switch** and **an EtherChannel-enabled server**
  - Normally, for **Layer 2 ports**
    - But, layer 3 EtherChannel possible for multilayer switches



EtherChannel Configuration Mechanisms

- **By Negotiation Protocols**
  1) **Port Aggregation Protocol** (PAgP)
     - **Cisco-proprietary** protocol
     - Pronounced as “Pag – P”
  2) **Link Aggregation Control Protocol** (LACP)
     - IEEE Standard (IEEE 802.3ad)



✓Cisco switches support both protocols

✓PAgP and LACP are not compatible; both ends must use the same protocol.

- **Static Persistence** without PAgP and LACP**:**
  3) Set “on” mode in PAgP or LACP :
     - Bundles links **unconditionally**
     - **No negotiation protocol** is used.

EtherChannel Negotiation

- PAgP and PAgP Mode (Default mode is **Auto**)

Desirable	**Actively negotiates** channeling status Channel formed if **the other side** is **Auto** or **Desirable**.
Auto	Responds to **PAgP** messages but **does not aggressively negotiate** Channel formed only if the other end is **Desirable**.

- LACP and LACP Modes (Default mode is **On**)

Active	**Actively negotiates** channeling status Channel formed if the other side is **Passive** or **Active**
Passive	Responds to **LACP** messages but **does not aggressively negotiate**. Channel formed only if the other end is **Active**

- **EtherChannel formed?**

PAgP	Desirable	Auto
Desirable	Yes	Yes
Auto	Yes	No

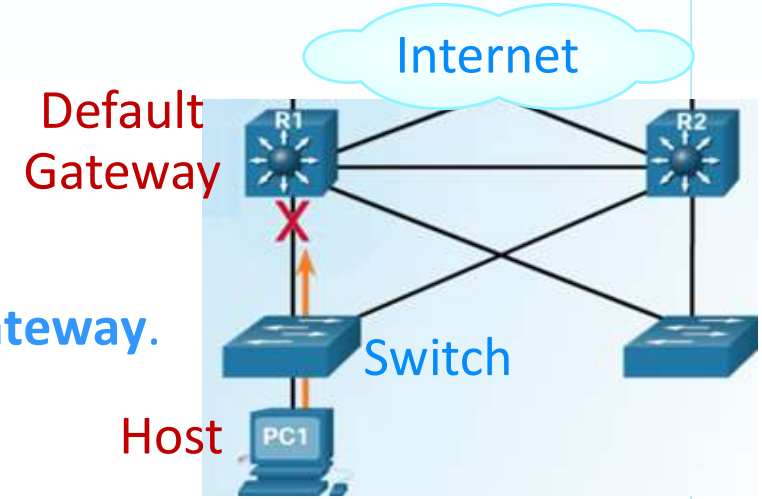
LACP	Active	Passive
Active	Yes	Yes
Passive	Yes	No

Reference: 9tut.com

First Hop Redundancy Protocols (FHRP)

Default Gateway Limitation

- **First Hop Redundancy Protocols (FHRP):**
  Redundancy technology for **transparent fail-over** at **first-hop IP router** (Default Gateway)
- **Default Gateway Limitation**
  - Host **cannot** use a **secondary gateway**, even if another gateway exists
    - Host is typically configured with **a single default gateway**.
    - **Does not change** when network topology changes

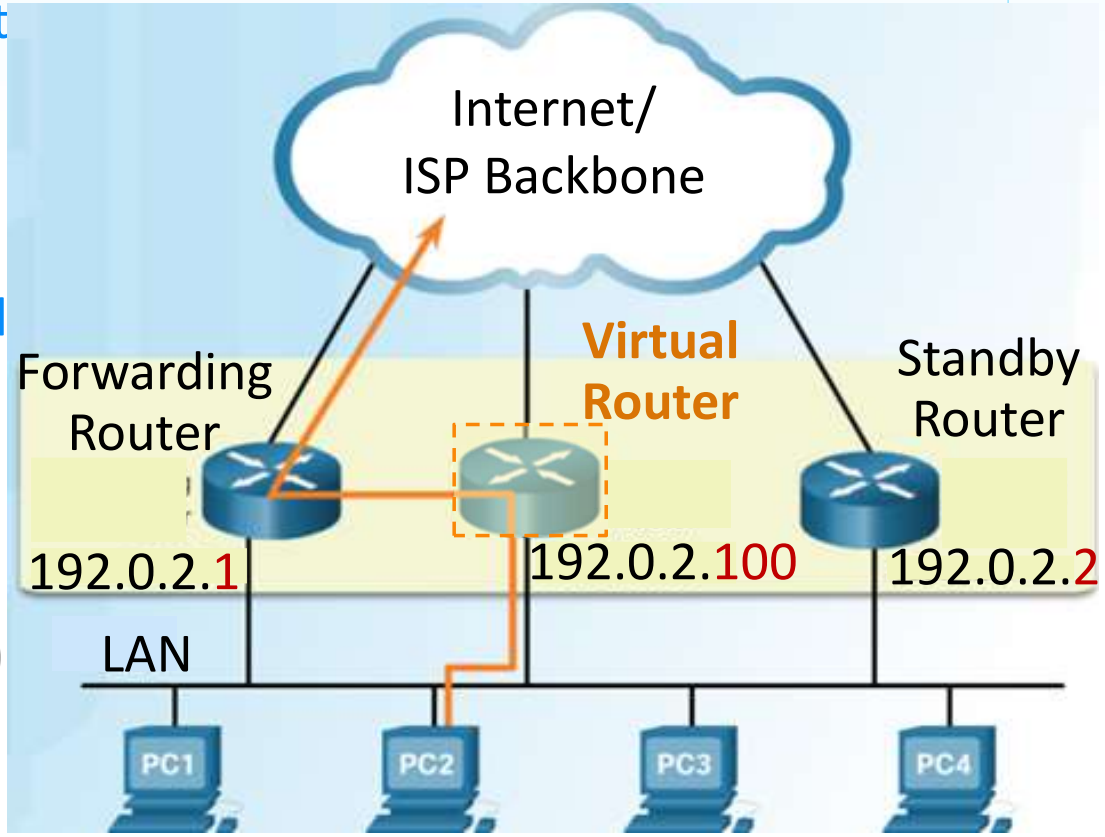


➢ If a router or a router interface that serves as a default gateway fails,
  - Hosts using the default gateway are isolated from outside networks

➢ Need a mechanism to provide **alternate default gateways**

Router Redundancy

- **Two** or **more routers** give **an illusion** of a **Virtual Router**
  - **Virtual Router** serves as the **default** gat
  - **Forwarding Router** assumes IP and MAC of **Virtual Router** (VR)
- **Need a protocol to determine**
  - **Which router** should take the **active** rol in forwarding traffic
  - **When a standby** router **takes over** forwarding role
    - Standby router assumes IP and MAC of VR (when Forwarding Router fails)
    - Transition is transparent to hosts



➢ **First-Hop Redundancy** protocols

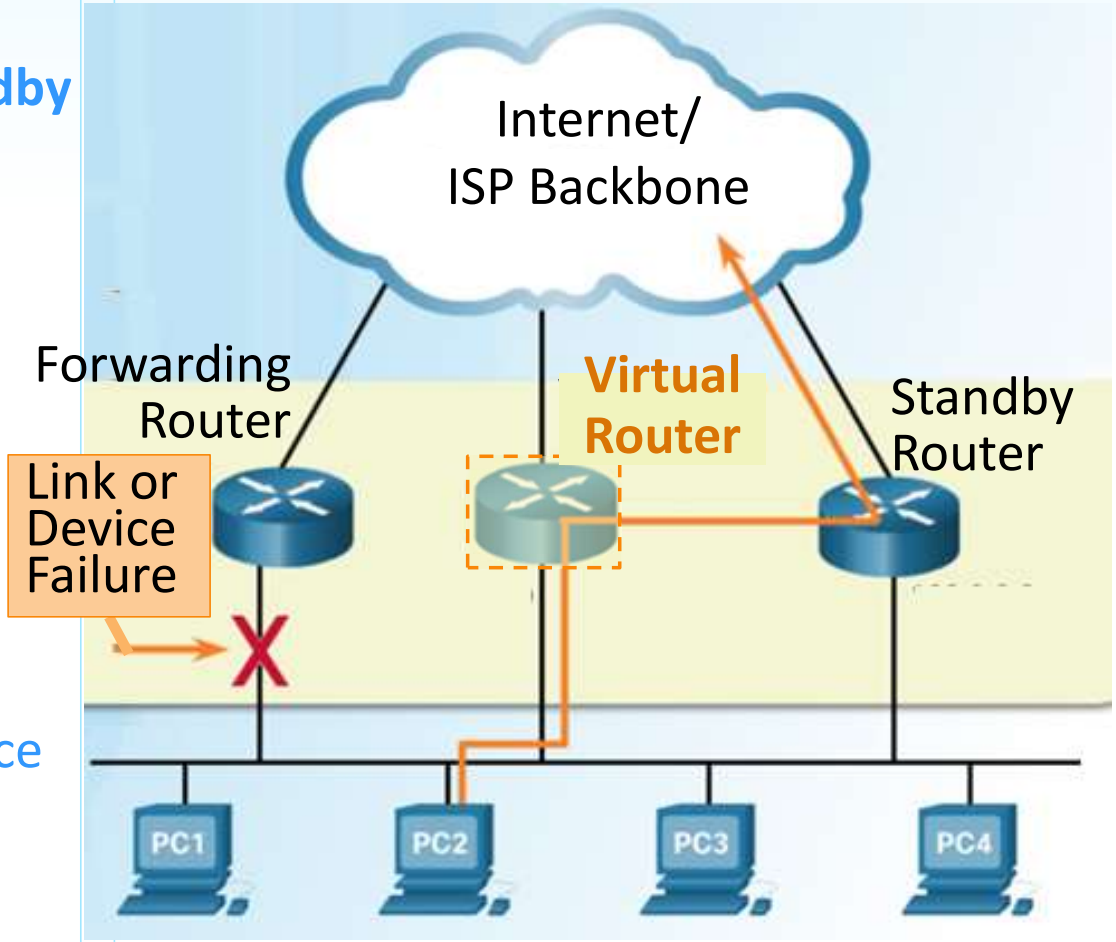
Provides the ability of networks to dynamically recover from the **default gateway failure**

Steps for Router Failover

- When Active (Forwarding) Router fails,
  - **Redundancy protocol** transitions **Standby Router** to new **Active Router** role
- **Steps for Router Failover**:
  1. **Standby Router** stops seeing Hello messages from **Forwarding Router**
  2. **Standby Router** assumes the role of **Forwarding Router**
     - Standby Router assumes IP and MAC Virtual Router

➢ Host devices see no disruption in service

- No change in IP and MAC (of VR) addresses of **default gateway**



First-Hop Redundancy Protocols (FHRPs)

- **Hot Standby Router Protocol** (HSRP):
  - Cisco's initial, proprietary standard
  - Developed in 1998
- **Virtual Router Redundancy Protocol** (VRRP):
  - An open standard protocol
    - Albeit patent encumbered
- **Gateway Load Balancing Protocol** (GLBP):
  - A more recent proprietary standard from Cisco
  - Permits **load balancing** as well as **redundancy**
- Etc.

Hot Standby Router Protocol (HSRP)

- A CISCO proprietary protocol, which provides redundancy for a local subnet.
- **HSRP Group** or a **Standby Group**
  - A set of routers works in concert to present the **illusion of a single virtual router**
    - One Active router
    - One Standby router
    - One or more Listening router
  - An **HSRP election process** determines the roles of routers
  - **HSRP Group** has **a single**, **well-known MAC** addr and **IP** addr for ***Virtual Router***
    - **Each interface of routers** has its **own MAC** and **IP** addresses
      - Different from **HSRP Group MAC** and **IP** addresses.
- **Hosts** assume **Virtual Router** as the **default gateway**
- Only **Active Router** forwards packets sent to **Virtual Router**.
- If ***Active Router*** fails, ***Standby Router*** assumes the role of **Active Router**

Important Terminologies of HSRP

- **Virtual IP address:**
  IP address from local subnet assigned as **default gateway** to all local hosts.
- **Virtual MAC address:**
  MAC address is generated automatically by HSRP.
  - First 24 bits: **Cisco address** (i.e., 00.00.0c).
  - Next 16 bits: ***HSRP ID***, i.e., 07.ac
  - Next 8 bits: **group number** in hexadecimal.
  - e.g., group number is 10 (= 0a).

    Virtual MAC address: 00.00.0c.07.ac.0a
- **Hello messages:**
  Messages exchanged periodically by **Active** and **Standby** Routers.
  - exchanged every 3 seconds,
  - telling the state of a router.

https://www.geeksforgeeks.org/hot-standby-router-protocol-hsrp/

Important Terminologies of HSRP (cont.)

- **Hold Down Timer:**

  Elapsed time **Standby Router** will wait for **Hello message** (before assuming Active Router is down)
  - Default value is 10 seconds (roughly **3 times** of elapsed time of **Hello messages**.)
- **Priority:** *router having higher priority will become the active router*
  - Default 100, but changeable
- **(Standby) Preempt** state**:**
  - **A state** allows a **Standby Router** (whose priority has become higher) to take over the role of the **Active Router**
    - A **Standby Router** not at the **Standby Preempt** state will not preempt the **Active Router** even if the **Standby Router** has a higher priority.
  - Often combined with **Standby Track**
- **Standby Track: Active Router** tracks an interface and **decreases priority** when the interface goes down (make priority lower than the Standby Router priority)

Active Router Election – HSRP Priority

- Recall: **HSRP election process** determines the roles of **Active** and **Standby Routers**
- HSRP Priority:

  Used to determine **Active Router**
  - Range: 0 to 255
  - Default 100
- May use **`standby priority`** **interface command** to configure priority

- The router with the highest HSRP priority will become the **Active Router**
  - If equal,

    the router with the numerically **highest IP address** is elected as **Active Router**

Active Router Election – HSRP Preemption

- By default, after a router becomes the **Active Router**, it will **remain Active** even if **another router** comes online **with a higher HSRP priority**
- **To force a new HSRP election process**,
  - Use **`standby preempt`** command to enable preemption of **Active Router**
  - If not configured:
    local router assumes the role of **Active Router** only if it receives information indicating **no Active Router exists**.
  - If configured:

    Standby Router preempts an Active Router only if it has a higher priority
    - with equal priority, but a higher IP address will not preempt the **Active Router**
- **Note**:

  With **preemption disabled**, the **router** that **boots up first** will become the **Active Router** if no other routers are online **during the election process**

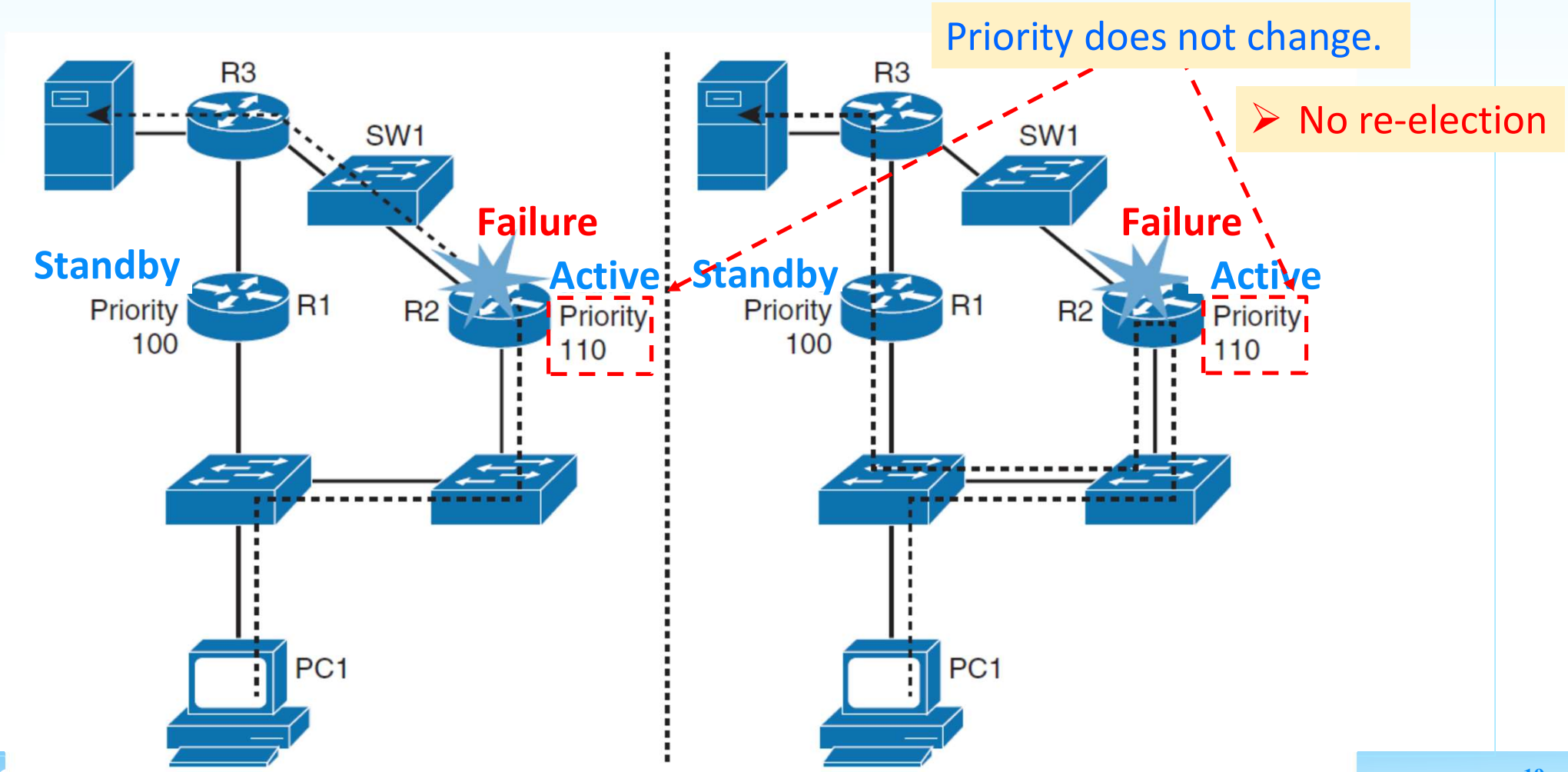
HSRP Message Exchange

- Once the election process protocol completes,
  only **Active** and **Standby** routers send **periodic HSRP messages**
- If the **Active Router fails,** the **Standby router** takes over as the **Active router**.
- If the **Standby Router** fails or becomes **Active**, another router is elected as **Standby**.
- **Hot Standby Router Protocol (HSRP) has 2-versions :**
  - **Version 1:**
    - Messages are multicast at 224.0.0.2
    - Uses UDP port 1985.
    - Allows **group numbers** to range from 0 to 255.
  - **Version 2:**
    - Messages are multicast at 224.0.0.102
    - Uses UDP port 1985.
    - Allow **group numbers** to range from 0 to 4095.

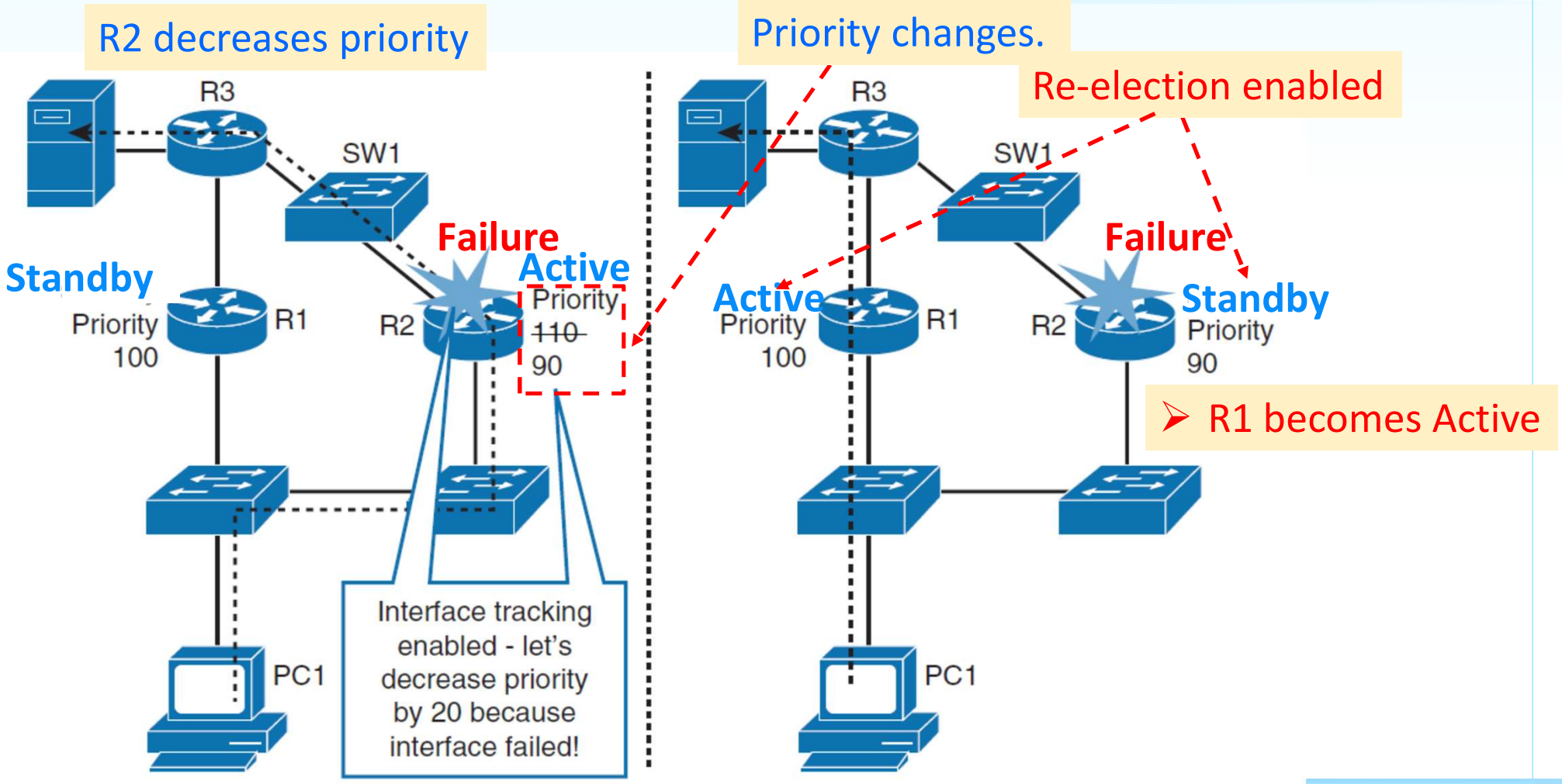
HSRP Interface Tracking

- **Interface Tracking**
  - Allowing us to **specify an interface** on a router for HSRP to **monitor**
  - If the **specified interface** goes down, HSRP reduces the router's HSRP priority (for the given group)
    - Allowing another HSRP router with higher priority to become the **Active** router

Example – Without Interface Tracking



HSRP Interface Tracking



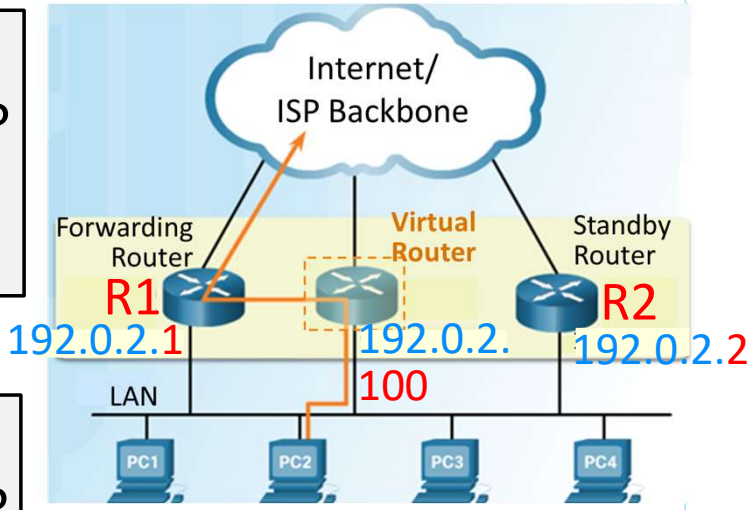
HSRP – Example Configuration

- Consider a given topology with 2 routers, **R1** and **R2**.
  - IP addresses: R1 (f 0/0) is 192.0.2.1/24, R2 (f 0/0) is 192.0.2.2/24.
- **Example: Virtual IP**: 192.0.2.100, **Group Name**: HSRP_GROUP, Group Number: 1
  - **R1** Configuration: **Priority 110**. Preempt enabled

```
R1#(config-if) standby 1 ip 192.0.2.100
R1#(config-if) standby 1 name HSRP_GROUP
R1#(config-if) standby 1 priority 110
R1#(config-if) standby 1 preempt
```

  - **R2** Configuration: **Priority 100**. Preempt enabled

```
R2#(config-if) standby 1 ip 192.0.2.100
R2#(config-if) standby 1 name HSRP_GROUP
R2#(config-if) standby 1 priority 100
R2#(config-if) standby 1 preempt
```



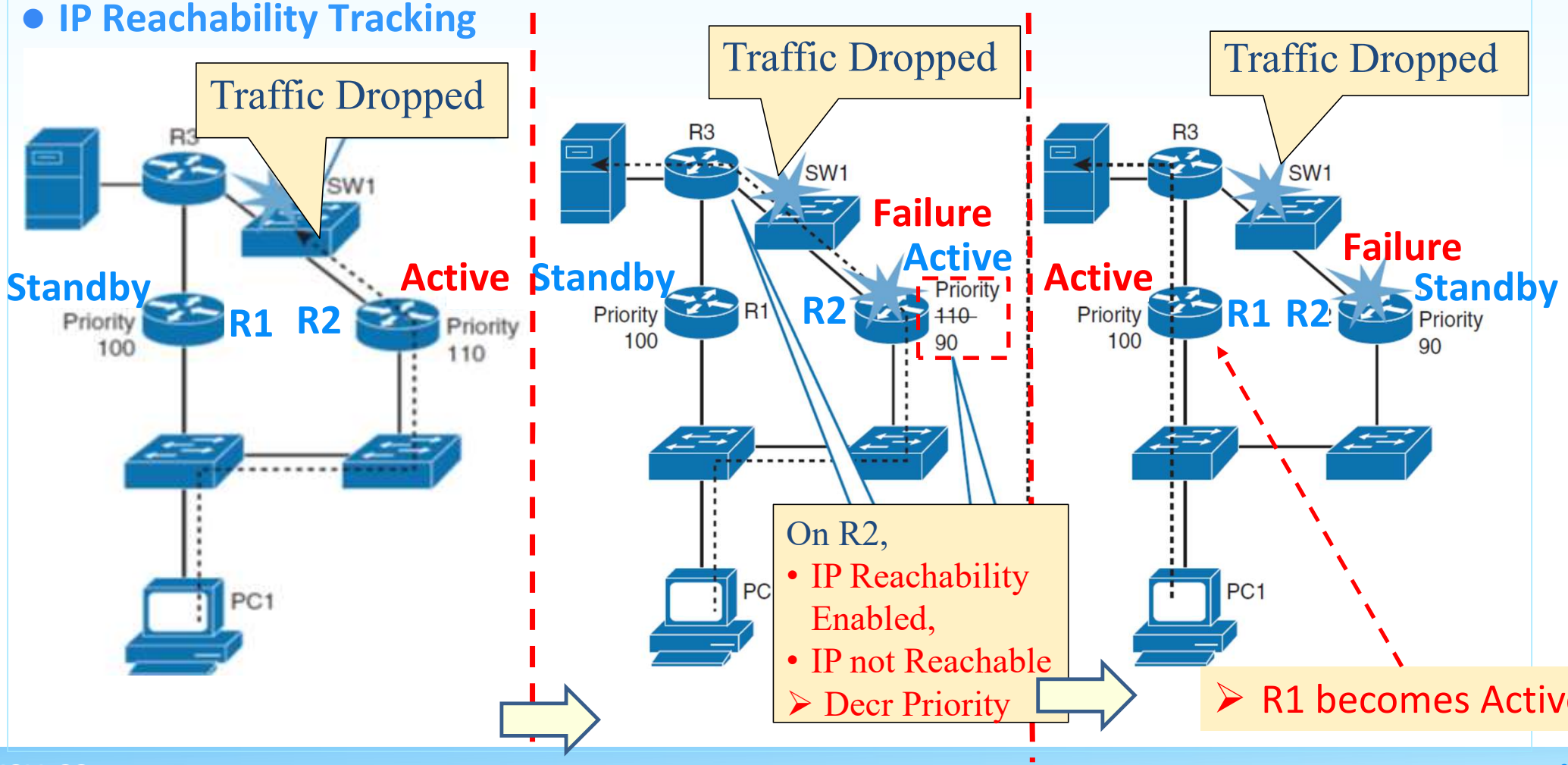
HSRP Enhanced Object Tracking

- HSRP has a mechanism for tracking the **Interface Line-**protocol state.
- **Enhanced Object Tracking**
  - **Separates** tracking mechanism from HSRP.
  - Creates **a separate, standalone tracking process** (other than HSRP).
    - Allows **tracking of other objects** in addition to the **Interface Line-**protocol state.
  - **Client process**, such as HSRP, can **register** an interest in **tracking objects**
    - To request **notification** when the **tracked object** changes state.
  - Several clients can track the same object but take different actions when the object changes state.
- Advantages:
  - Increases **availability** and **speed of recovery** of a router system and
  - Decreases **outages** and **outage duration**.

Ref: http://www.cisco.com/en/US/products/sw/iosswrel/ps1839/products_feature_guide09186a00801541be.html

Example of HSRP Object Tracking

- IP Reachability Tracking



Virtual Router Redundancy Protocol (VRRP)

- An open (albeit patent encumbered) standard protocol (RFC 5798)
- Difference between **HSRP** and **VRRP**

Features	HSRP	VRRP
Standard	Cisco Proprietary	IETF open standard
Components	1 Active, 1 Standby, 1 or more Listening	1 Master, 1 or more Backup
IP of virtual router	Virtual IP	**Highest IP of Interfaces**
Packet Period / Hold-down Timer	3 Sec Hold-down Timer 10 sec	1 Sec Hold-down Timer 3 sec
Preempt Default	not enabled	**enabled**
Multicast Address	224.0.0.2 (V1), 224.0.0.102 (V2)	224.0.0.18
Transport	UDP Port 1985	UDP Port 112