PROTECTING AN MPLS/VPN CORE

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July 15 2009

Why Is MPLS VPN Security Important?

- **Customer buys "Internet Service":**
  - **Packets from SP are not trusted**
  - **Perception: Need for firewalls, etc.**
- **Customer buys a "VPN Service":**
  - **Packets from SP are trusted**
  - **Perception: No further security required**

SP Must Ensure Secure MPLS Operations

Agenda

Analysis of MPLS/VPN Security

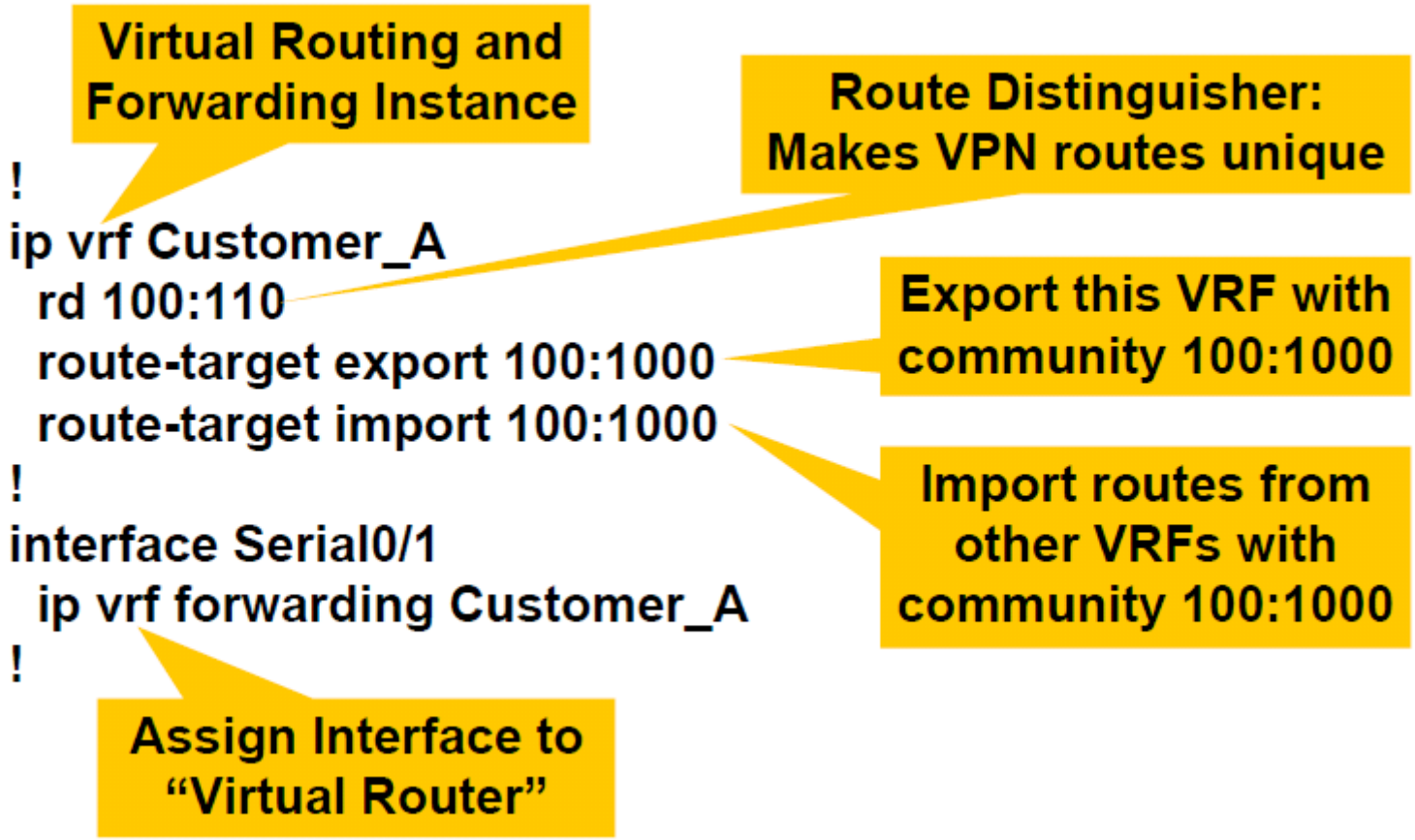
Security Recommendations

MPLS Security Architectures (Internet Access)

IPsec and MPLS

Summary

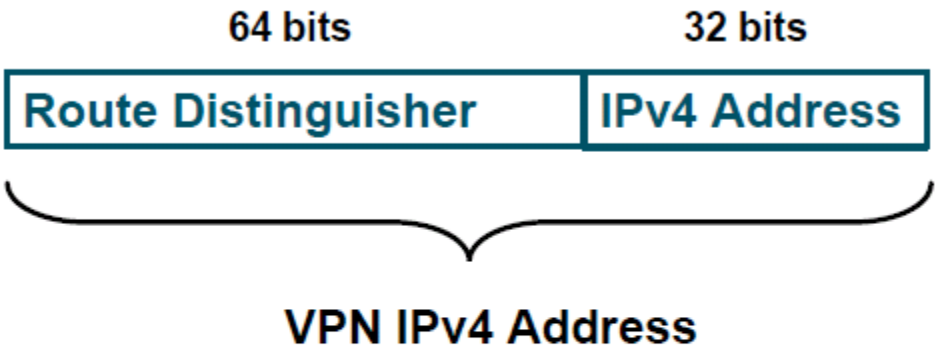
The Principle: A "Virtual Router"



General VPN Security Requirements

- **Address Space and Routing Separation**
- **Hiding of the MPLS Core Structure**
- **Resistance to Attacks**
- **Impossibility of VPN Spoofing**

Address Space Separation



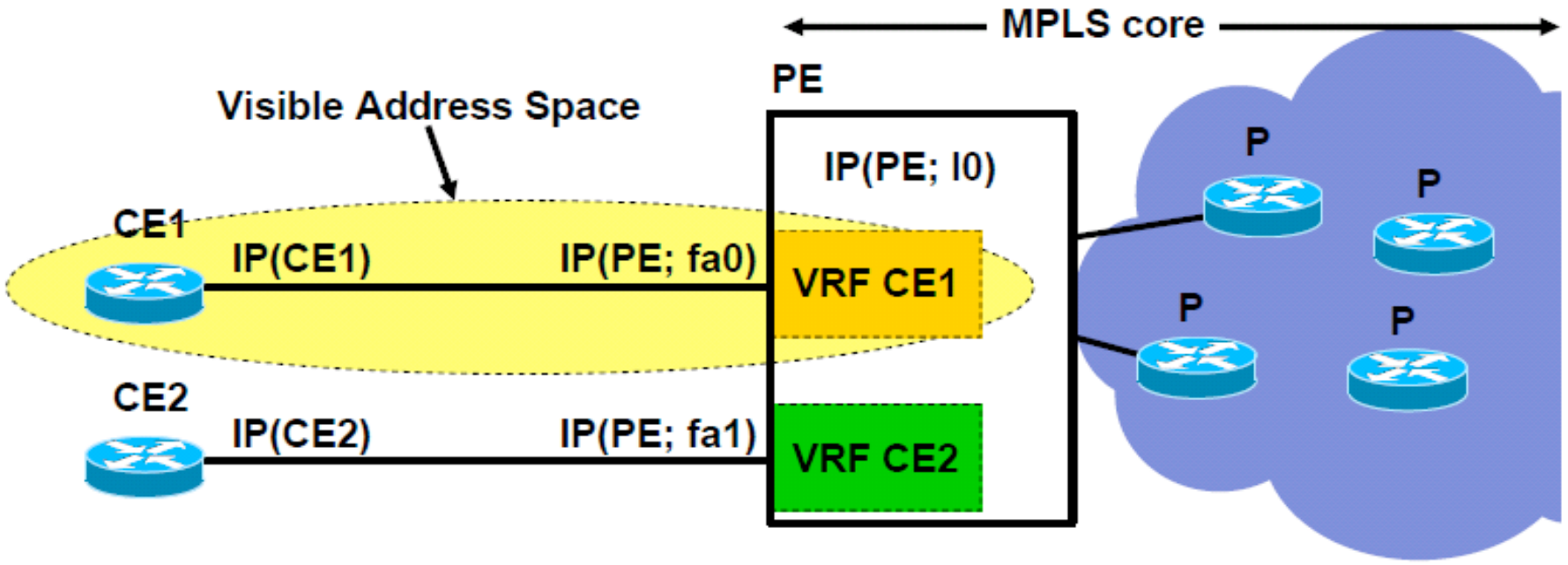
Within the MPLS core all addresses are unique due to the Route Distinguisher

Routing Separation

- Each (sub-) interface is assigned to a VRF
- Each VRF has a RD (route distinguisher)
- Routing instance: within one RD
  -> within one VRF

  -> Routing Separation

Hiding of the MPLS Core Structure



- VRF contains MPLS IPv4 addresses
- Only peering Interface (on PE) exposed (-> CE)!
  -> ACL or unnumbered

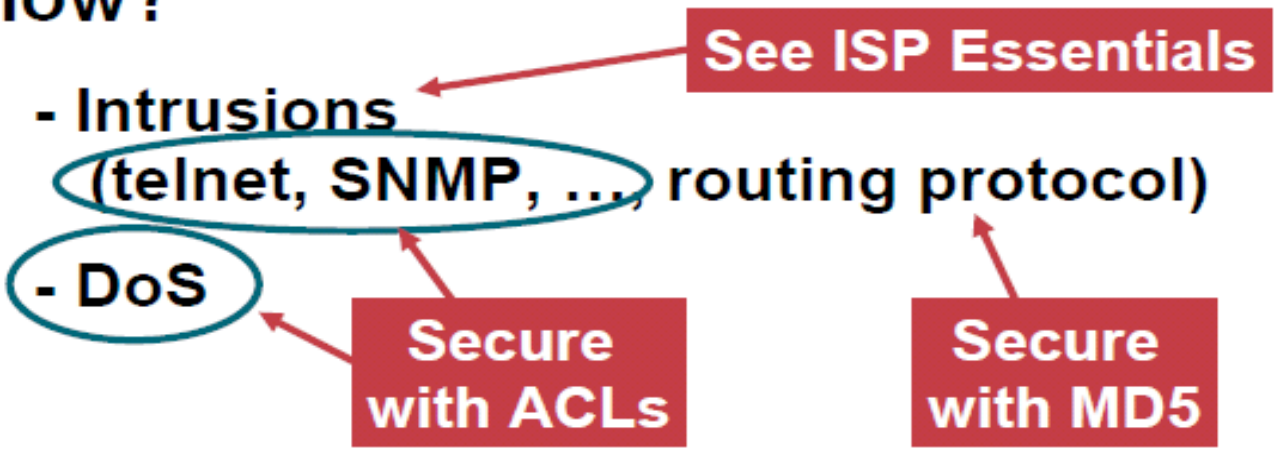
Resistance to Attacks: Where and How?

- Where can you attack?

  Address and Routing Separation, thus:

  Only Attack point: peering PE

- How?



Label Spoofing

- Label spoofing is the ability of the upstream router to replace or insert a label into a packet that was not originally allocated by the downstream router
- PE router expects IP packet from CE
- Labelled packets will be dropped Thus no spoofing possible
- Cisco router does not accept labelled packets on an interface that is NOT enabled for label switching
- CE router can spoof source or destination address before packet arrives at the PE, but this would only affect the customer's own VPN (address separation attribute)
- Customer would be spoofing self

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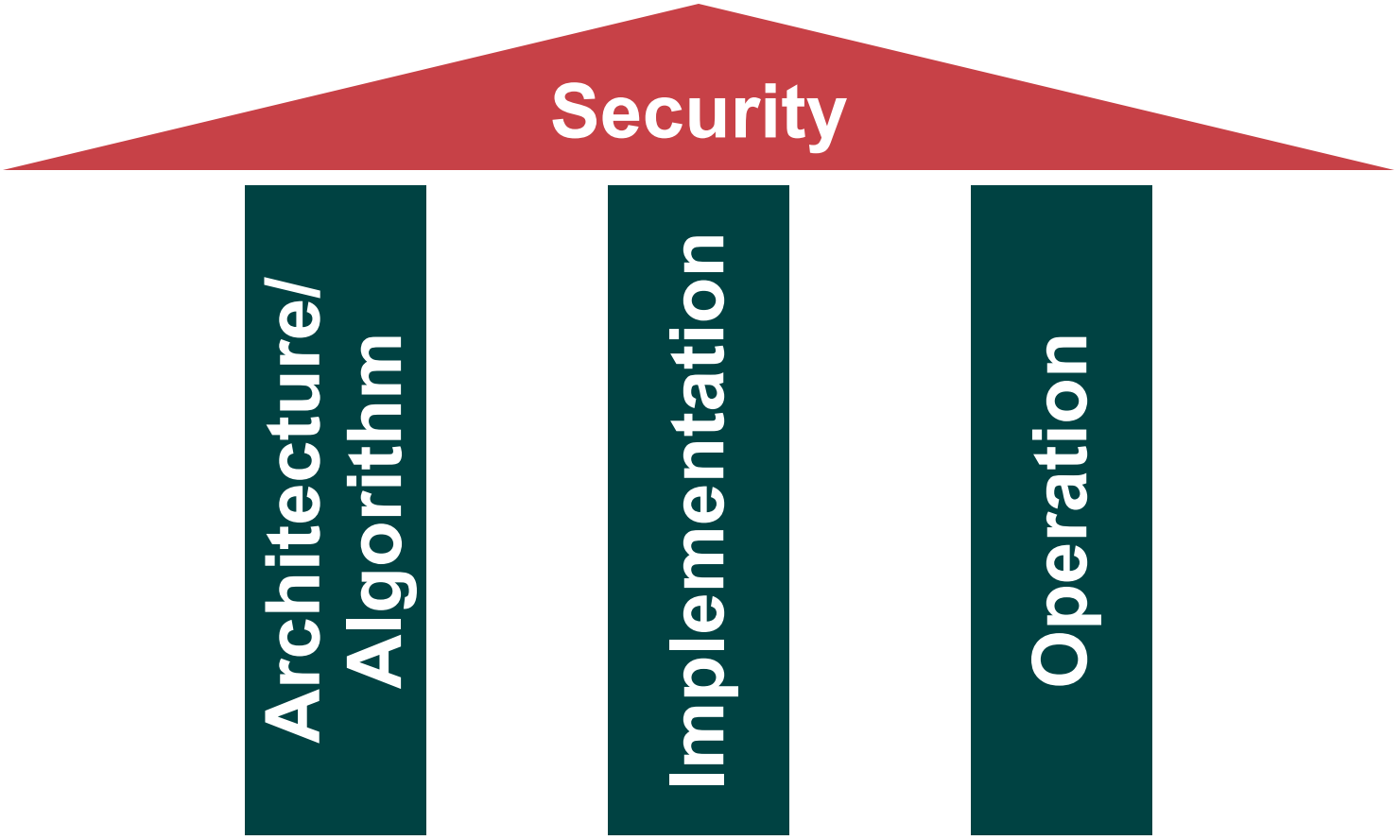
Security Relies on Three Pillars



Break One, and All Security Is Gone!

Security Recommendations for ISPs

- Secure devices (PE, P): They are trusted!
- CE-PE interface: Secure with ACLs
- Static PE-CE routing where possible
- If routing: Use authentication (MD5)
- Separation of CE-PE links where possible (Internet / VPN)
- LDP authentication (MD5)
- VRF: Define maximum number of routes

PE-CE Routing Security

In order of security preference:

1. Static: **If no dynamic routing required (no security implications)**
2. BGP: **For redundancy and dynamic updates (many security features)**
3. IGPs: **If BGP not supported (limited security features)**

Neighbor Authentication

- **Router "knows" his neighbors**
  - **Verification through shared MD5 secret**
- **Verifies updates it receives from neighbor**
- **Supported: BGP, ISIS, OSPF, EIGRP, RIPv2**
- **Key chains supported for ISIS, EIGRP, RIP**
  - **Use them where available**
  - **Easier key roll-over**
- **Config easy**

Neighbor Authentication

router bgp 13

address-family ipv4 vrf Peabody1

neighbor 1.1.1.1 remote-as 14

neighbor 1.1.1.1 update-source loopback 0

neighbor 1.1.1.1 password 5 1Sherman2 (establishes use of MD5 password “1Sherman2” for this neighbor)

address- family ipv4 vrf Dudley1

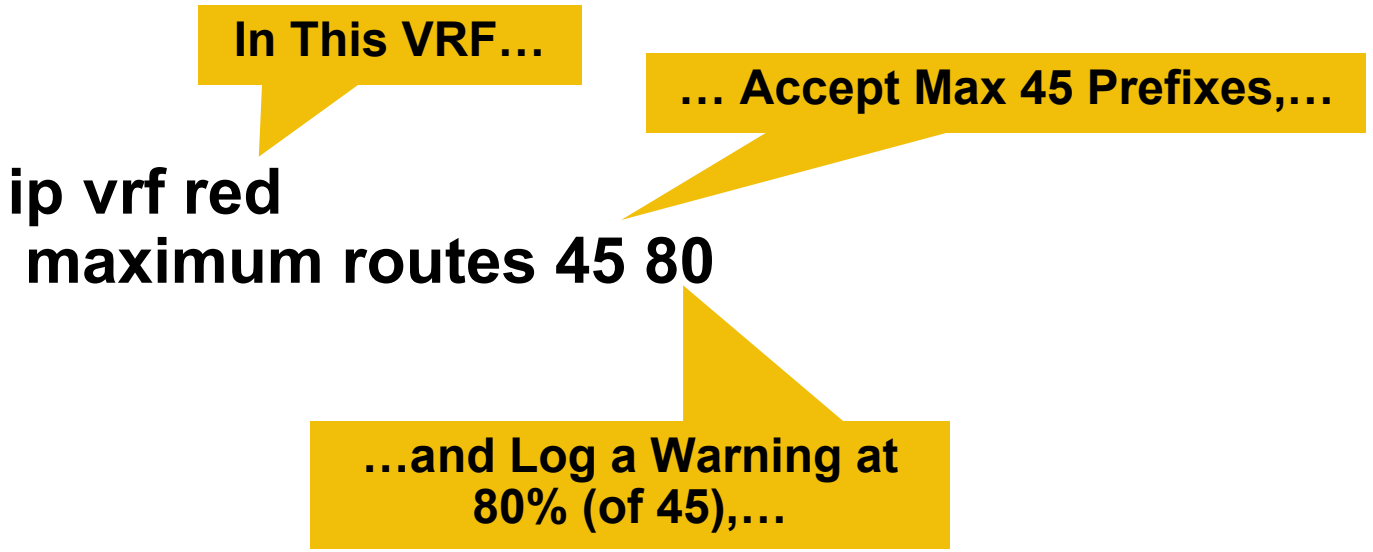
neighbor 2.2.2.2 remote-as 15

neighbor 2.2.2.2 update-source loopback 0

neighbor 2.2.2.2 password 5 77doright2 (# establishes use of MD5 password “77doright2” for this neighbor)

VRF Maximum Prefix Number

- **Injection of too many routes:**
  - **Potential memory overflow**
  - **Potential DoS attack**
- **For a VRF: Specify the maximum number of routes allowed**



P to P/PE Security

- Routing authentication: IGP BGP and MPBGP MD5 Authentication

- Label Distribution Protocol [LDP] MD5 authentication:
  The LDP can also be secured with MD5 authentication across the MPLS cloud. This scenario prevents hackers from introducing bogus routers, which would participate in the LDP.

- Hide the addressing structure of the MPLS core to the outside world

  no mpls ip propagate-ttl forwarded on PE (mitigate traceroute results)

Configuring IP TTL Propagation—Extended Options

router(config)#

no mpls ip propagate-ttl [forwarded | local]

Cisco IOS Release 12.1(5)T

Selectively disables IP TTL propagation for:

- **Forwarded traffic (traceroute does not work for transit traffic labeled by this router)**
- **Local traffic (traceroute does not work from the router but works for transit traffic labeled by this router)**

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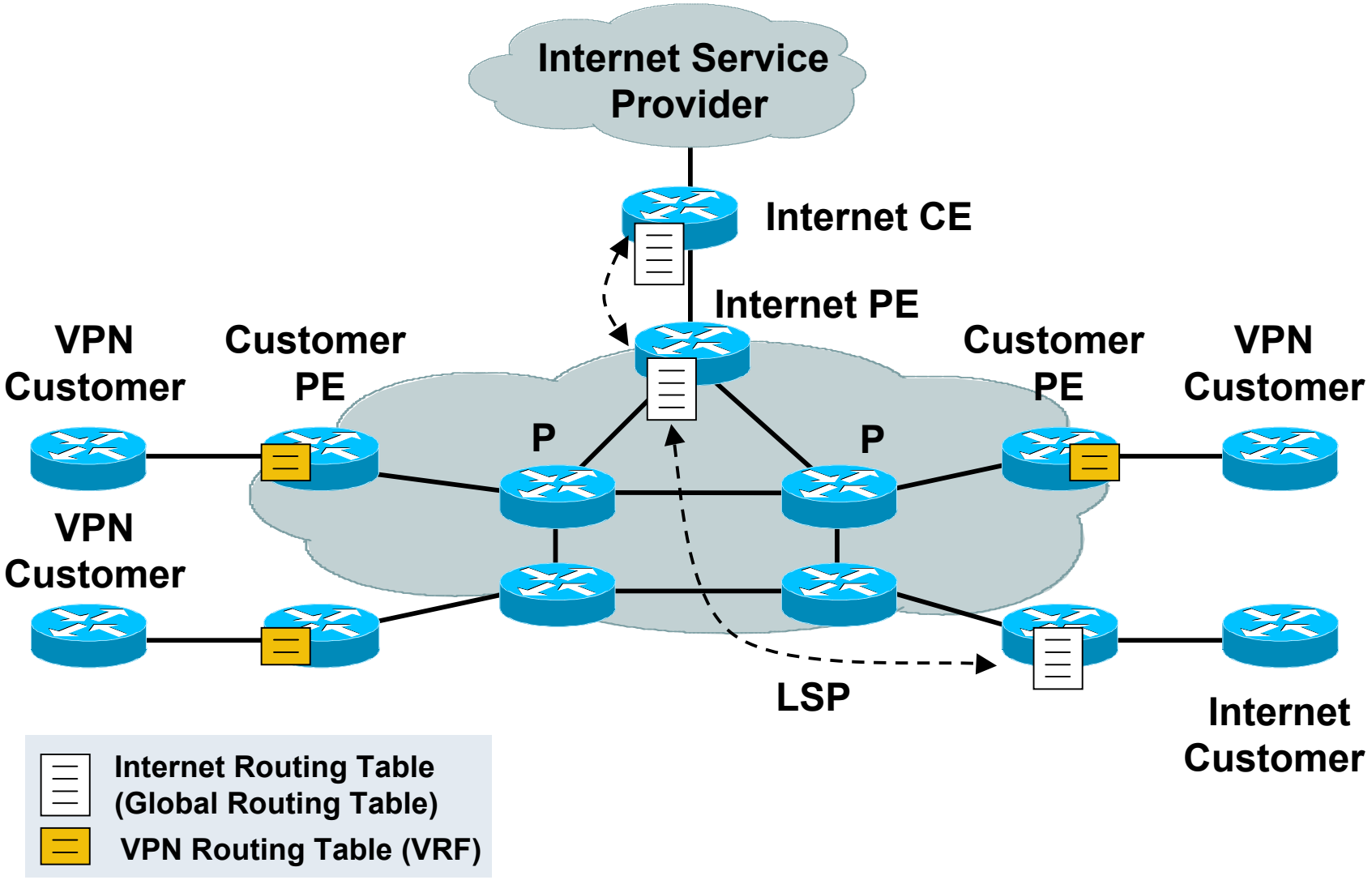
Internet Provisioning on an MPLS Core

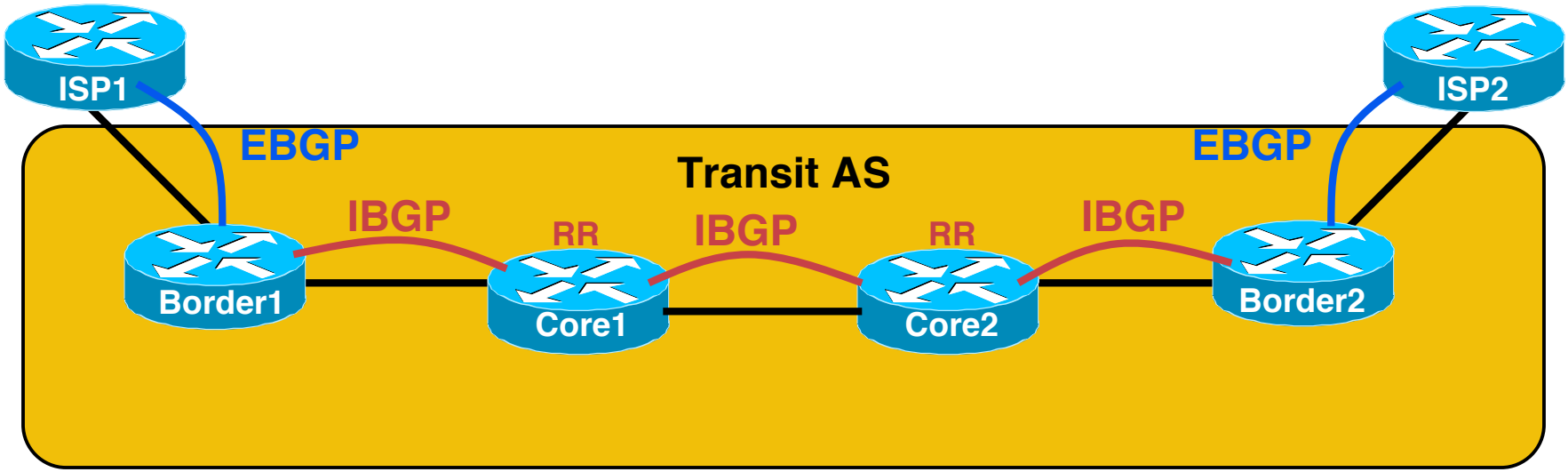
Two basic possibilities:

1. **Internet in global table, either:**
   - 1a) Internet-free core (using LSPs between PEs)
   - 1b) hop-by-hop routing
2. **Internet in VRF**
   - Internet carried as a VPN on the core

Internet in the Global Routing Table Using LSPs Between PEs

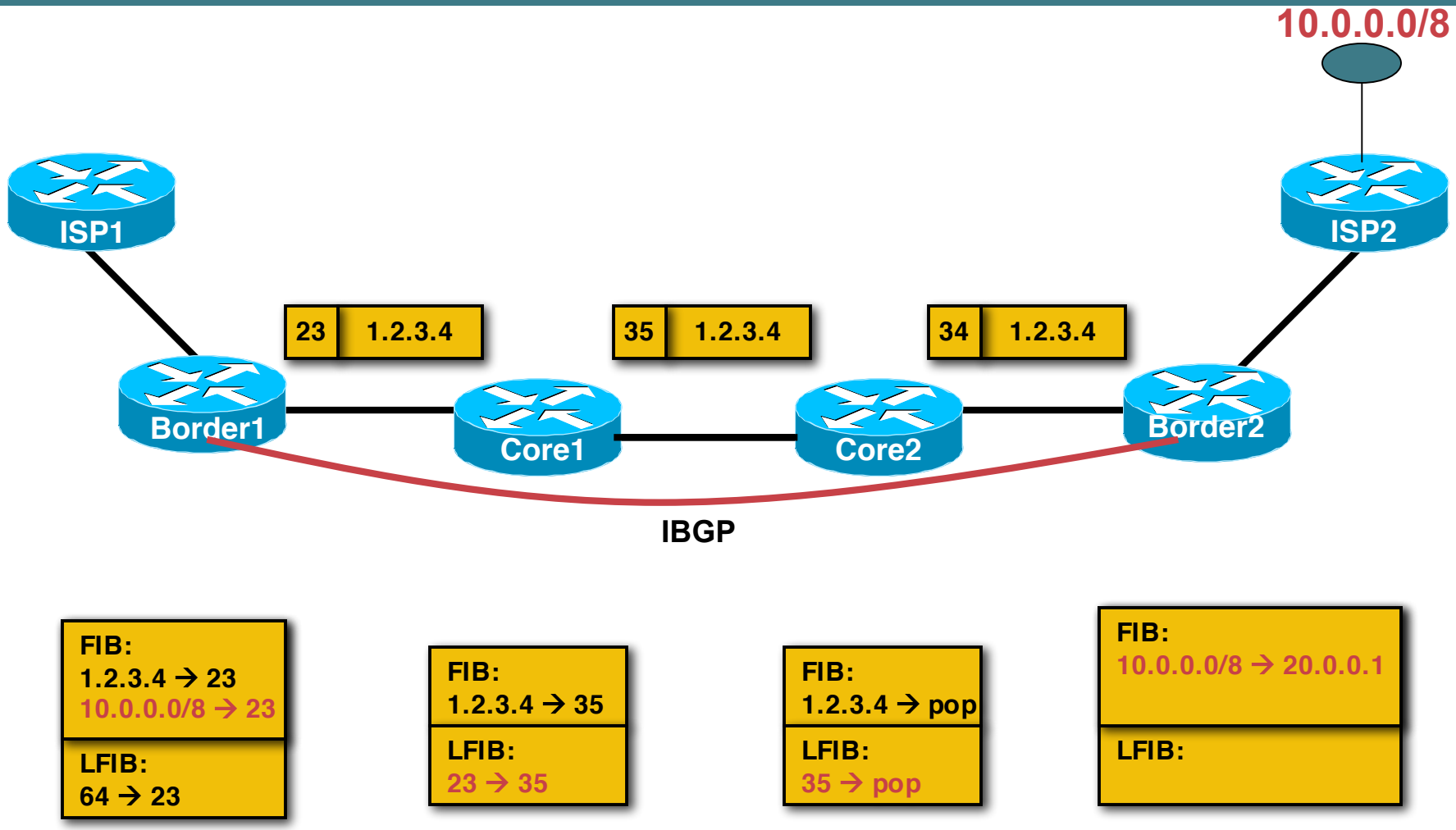


Traditional BGP AS System Design Requirements



- **All core routers are required to run BGP.**
- **All core routers require full Internet routing information (more than 100,000 networks) to be able to forward IP packets between ISP1 and ISP2.**

MPLS-Based Transit AS Packet Propagation



Internet in the Global Routing Table Using LSPs Between PEs

- **Default behavior, if Internet in global table!!**
  - **On ingress PE: BGP next hop: Egress PE loopback**
  - **Next hop to egress usually has label!**
  - **LSP is used to reach egress PE**
  - **P routers do not need to know Internet routes (nor run BGP)**
- **Security consequence:**
  - **PE routers are fully reachable from Internet, by default (bi-directional)**
  - **P routers are also by default reachable from Internet; but only uni-directional, they don't know the way back!**

Internet in the Global Routing Table Using LSPs Between PEs

Recommendations:

- **Fully secure each router!**
- **Do not advertise IGP routes outside**

  (This is a general security recommendation for all cores!)

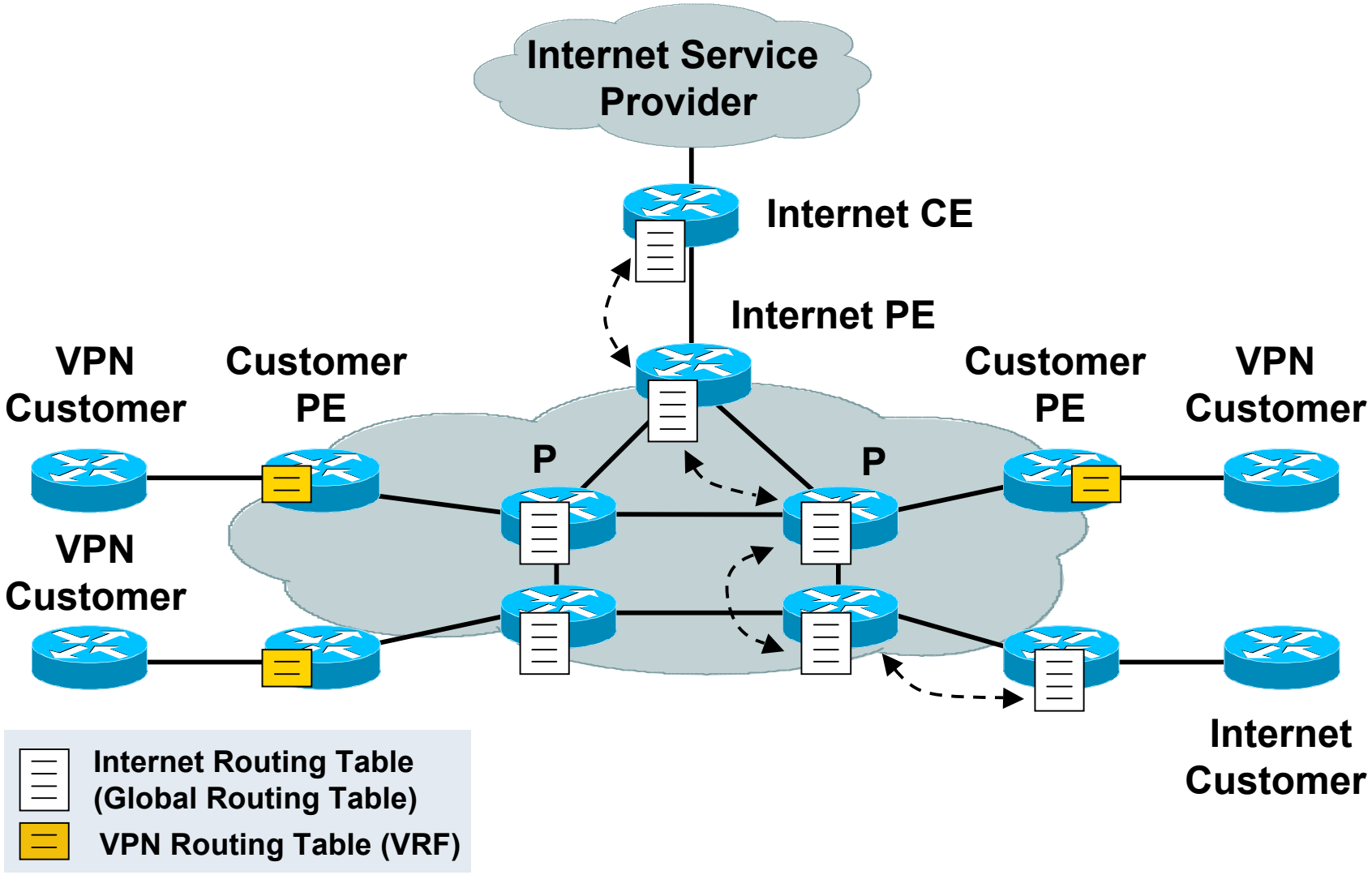
  P routers not reachable (unless someone defaults to you)

  PE routers not reachable (possible exception: Peering PE)
- **Infrastructure ACLs to block core space:**

  Additional security mechanism

  Even if someone defaults to you, he cannot reach the core

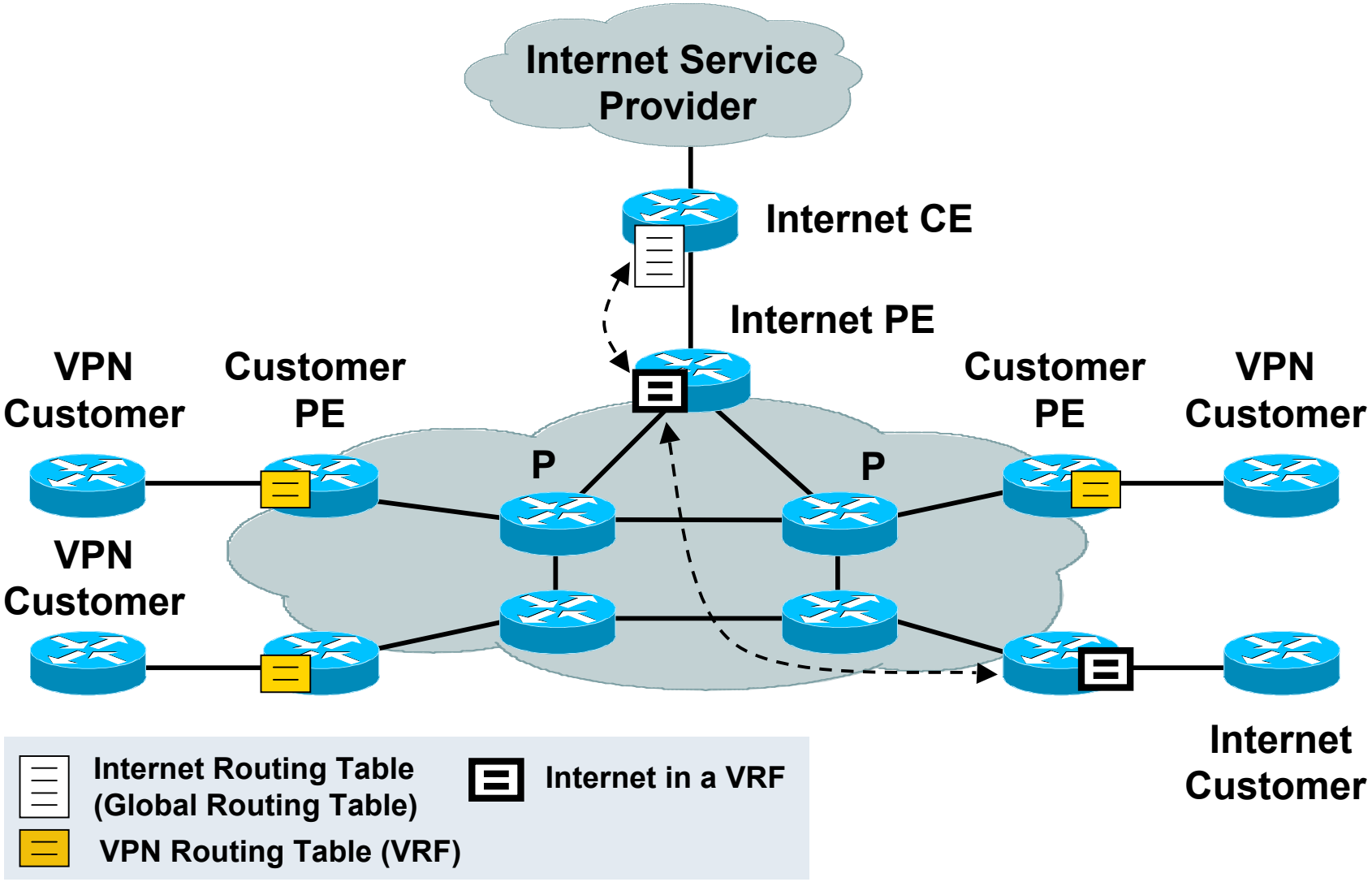
Internet in the Global Routing Table
Hop-by-Hop Routing



Internet in the Global Routing Table Hop-by-Hop Routing

- **Like in standard IP core**
  - **Each router speaks BGP, and carries Internet routes**
  - **Not default, must be configured!**
- **Security consequence:**
  - **P and PE routers by default fully reachable from Internet**
- **Recommendations: (like before)**
  - **Fully secure each router!**
  - **Do not advertise IGP routes outside**
  - **Infrastructure ACLs**

Internet in a VRF



Internet in a VRF

- **Internet is a VPN on the core**
  - **Full separation to other VPNs, and the core, by default!**
  - **“Connection” between Internet and a VPN (for service) must be specifically configured**
- **Security consequence:**
  - **P routers not reachable from anywhere!**
  - **PE routers only reachable on outbound facing interfaces;**
  - **Very limited**
  - **Much easier to secure**
- **But!!!**
  - **Routes in a VRF take more memory!!**
  - **Convergence times increase**

Fixed in IOS XR
(fast convergence)

Internet in a VRF

Recommendations:

- **Fully secure each router (you never know…)**
- **Secure external facing PE interfaces!**

  Use Infrastructure ACLs for this (see earlier)

  (Internal PE i/f and P cannot be reached from outside)

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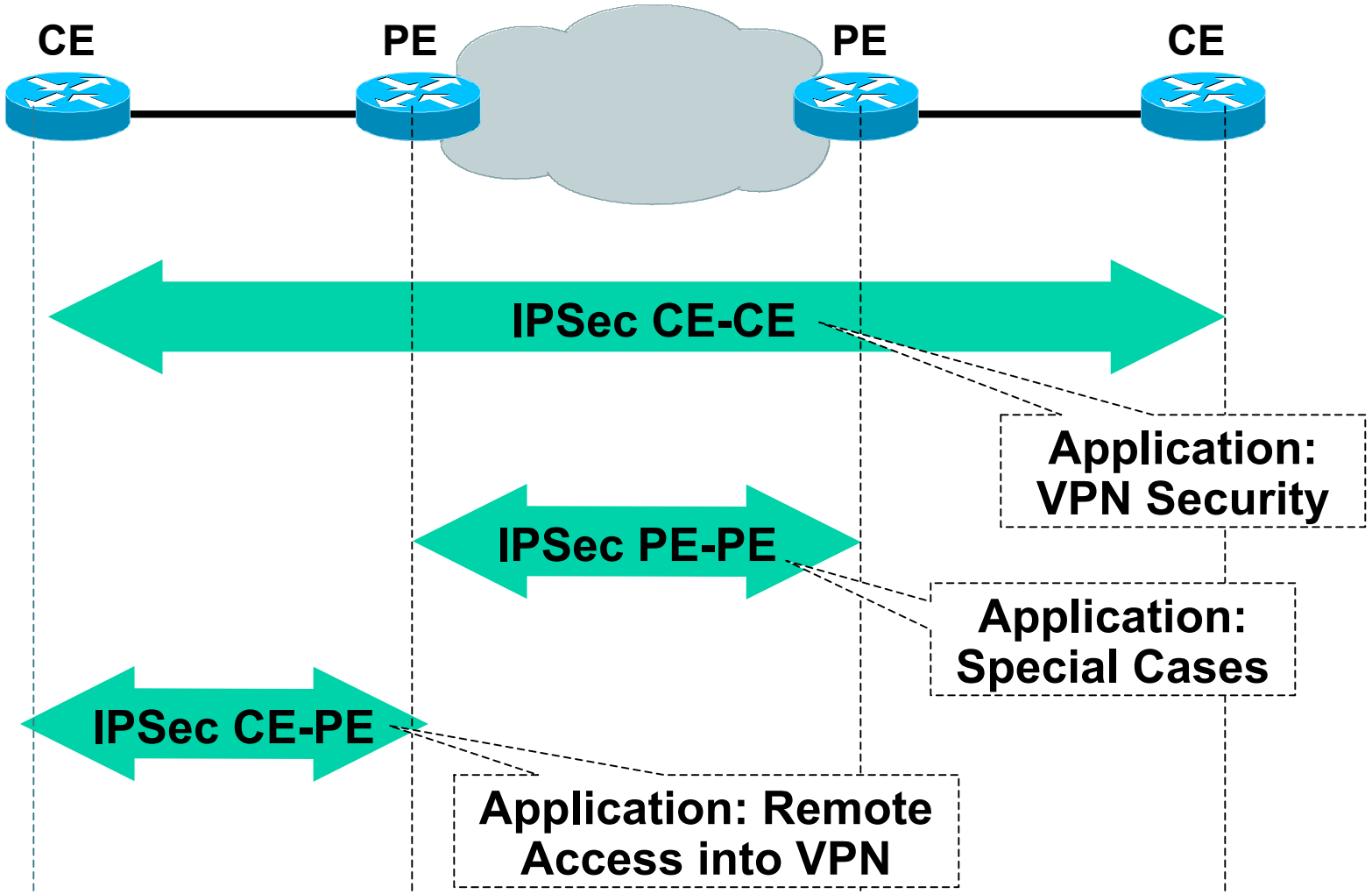
Use IPSec If You Need:

- **Encryption of traffic**
- **Direct authentication of CEs**
- **Integrity of traffic**
- **Replay detection**

- **Or: If you don't want to trust your ISP for traffic separation!**

Where to Apply IPSec



How to Establish IPSec: Options

- **Option 1: Static IPSec**
  - Pre-configure static IPSec tunnels
  - Works, but does not scale well
- **Option 2: Dynamic Cryptomap/ Tunnel Endpoint Discovery**
  - Scaling improvements over 1).
- **Option 3: DMVPN**
  - Dynamic tunnel establishment
  - Easy to configure and maintain
  - Some scaling issues
- **Option 4: GET VPN**
  - Easy to configure and maintain
  - Scales well

Dynamic Multipoint VPN

Group Encrypted Transport

RECOMMENDED

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MPLS doesn't provide:

- **Protection against mis-configurations in the core**
- **Protection against attacks from within the core**
- **Confidentiality, authentication, integrity, anti-replay -> Use IPsec if required**
- **Customer network security**

Summary

- **MPLS VPNs can be secured as well as ATM/FR VPNs**
- **Security depends on correct operation and implementation (everywhere!)**
- **MPLS backbones can be more secure than “normal” IP backbones**

  Core not accessible from outside

  Separate control and data plane
- **Key: PE security**

  Advantage: Only PE-CE interfaces accessible from outside

  Makes security easier than in “normal” networks

THANKS