Track 2: Operations:
Data Center Architectures and Technologies

Disaster Recovery

SANOG 2006 Tutorials: 1st August 2006

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Day Agenda

- **Part I - Data Center Designs and Services (Zeeshan Naseh)**

  Data Center Architectures and Technologies Overview

  Content Switching & Application Optimization

- **Part 2 - L2 Switching Protocols (Bilal Khawaja)**
- **Part 3 - Fiber Channel and Storage Area Networks (Asim Khan)**
- **Part 4 - Data Center Disaster Recovery (Zeeshan Naseh)**

Data Center Disaster Recovery Agenda

- Distributed Data Centers
- Topologies
- DNS-BASED: Technology and Products
- ROUTE HEALTH INJECTION: Technology and Products
- HTTP REDIRECTION: Technology and Products
- Overcoming the Inherent Limitations
- Real World Deployments

DISTRIBUTED DATA-CENTERS

Why Distributed Data Centers ?

- Avoid single point of failure
- High availability of applications and data for customers, partners and employees
- Scalability
- Load distribution: better use of global resources
- Disaster recovery
- ISP redundancy
- Better response: proximity to clients
- Optimal content routing

BUSINESS CONTINUITY   And More …

Business Continuance

Business Resilience

Ability of a business to adapt, change and continue when confronted with various outside impacts

Business Continuance

Ensuring business can recover and continue after failure or disaster: recovery of data and resumption of service

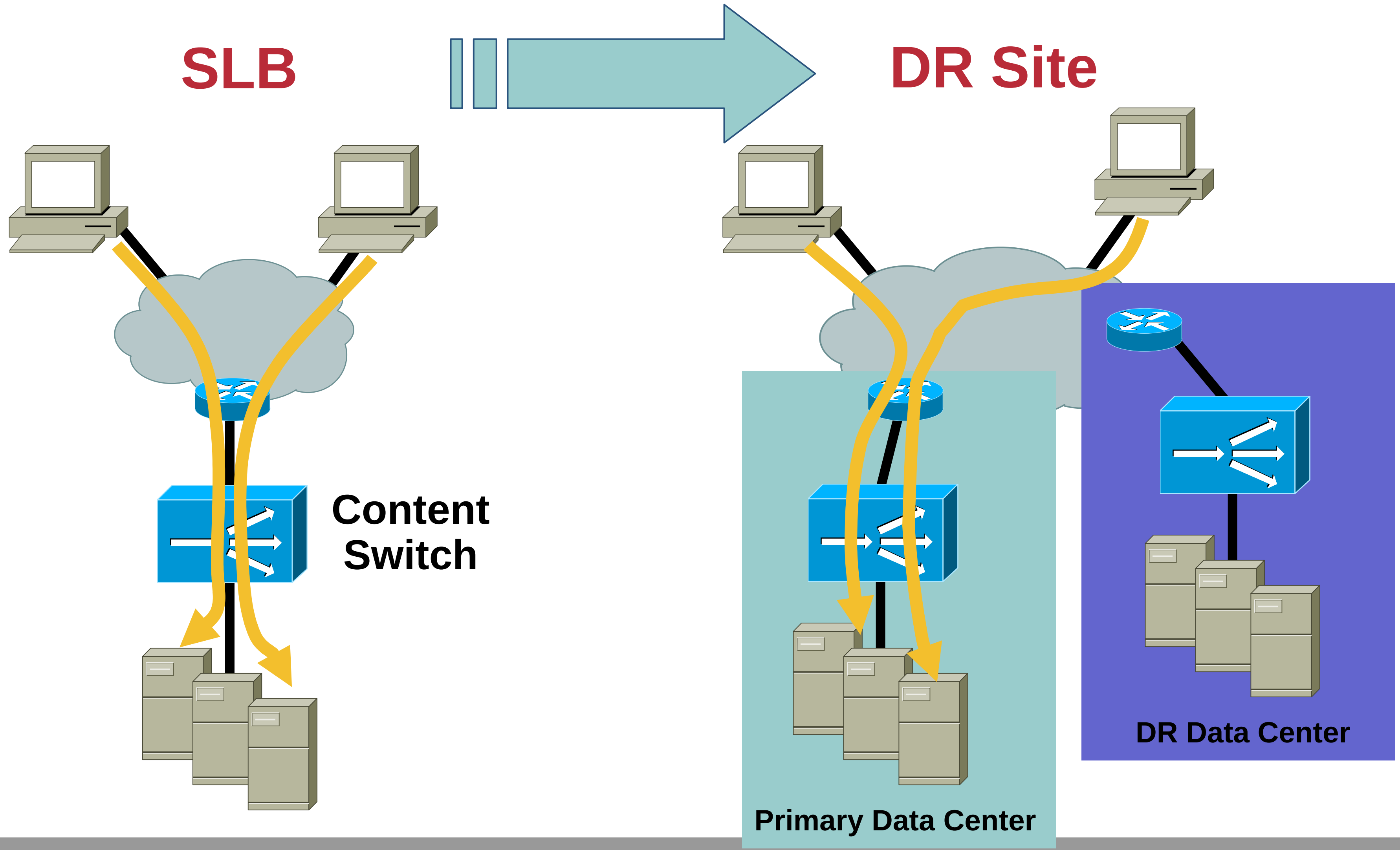
Disaster Recovery

Mitigating the impact of a disaster

Disaster Recovery

- Mechanisms used to react to a local failure by redirecting all requests to an alternate location
- Relies on data-replication
- Relies on applications being able to receive connections at any time in any location
- Typically refers to a topology with a “warm standby” data-center that only receives client requests when the primary fails

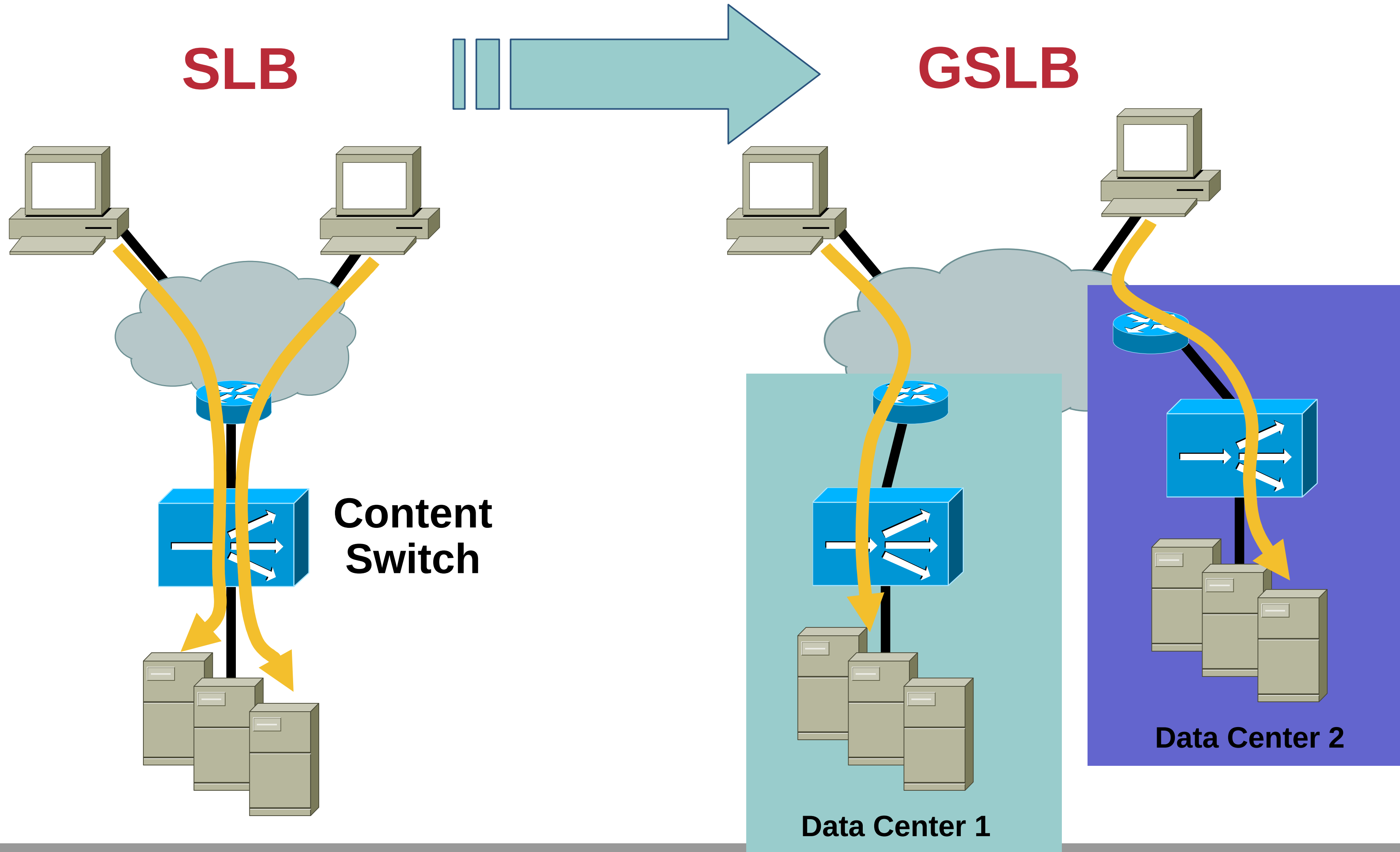
Disaster Recovery



Geographic Server Load Balancing

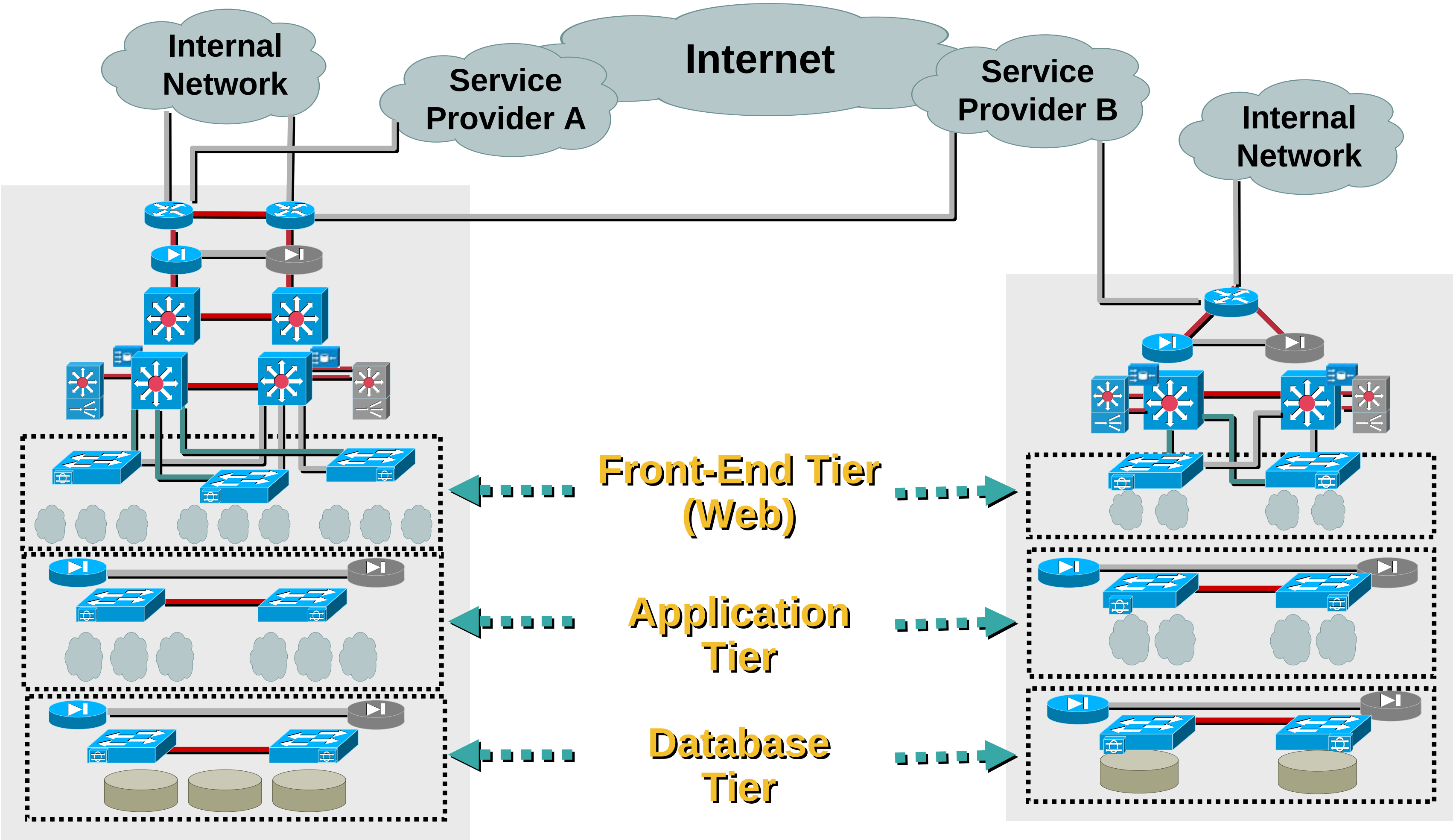
- Techniques used to distribute client traffic to servers across remote locations
- Very often deployed in conjunction with local load balancing (content switching)
- Business Continuance is the key driver
- Often associated to DNS-based deployments
- DNS is not the only solution (and has specific limitations!)
- Can rely on dedicated products or leverage content switches functions

Geographic Server Load Balancing

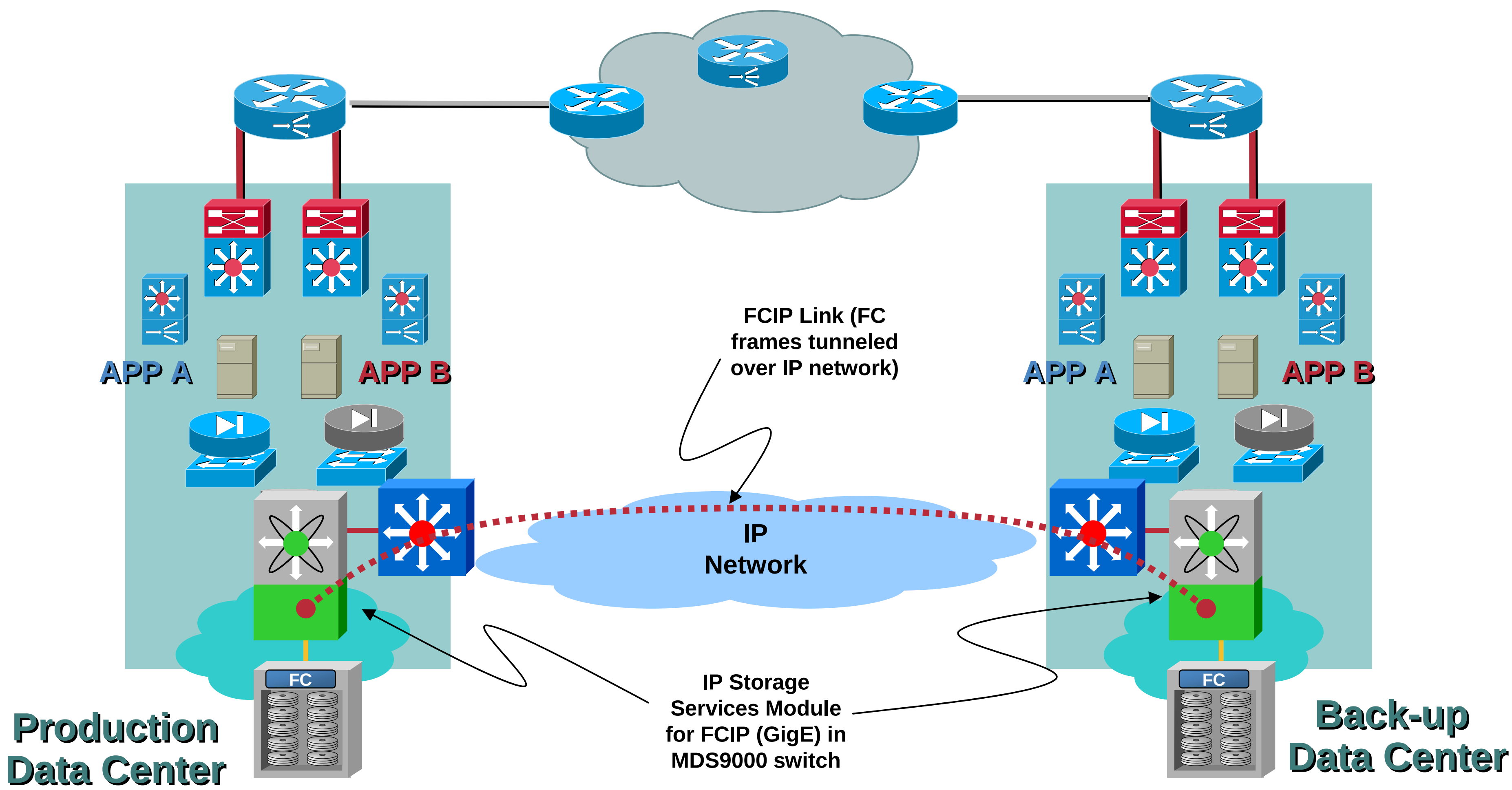


TOPOLOGIES

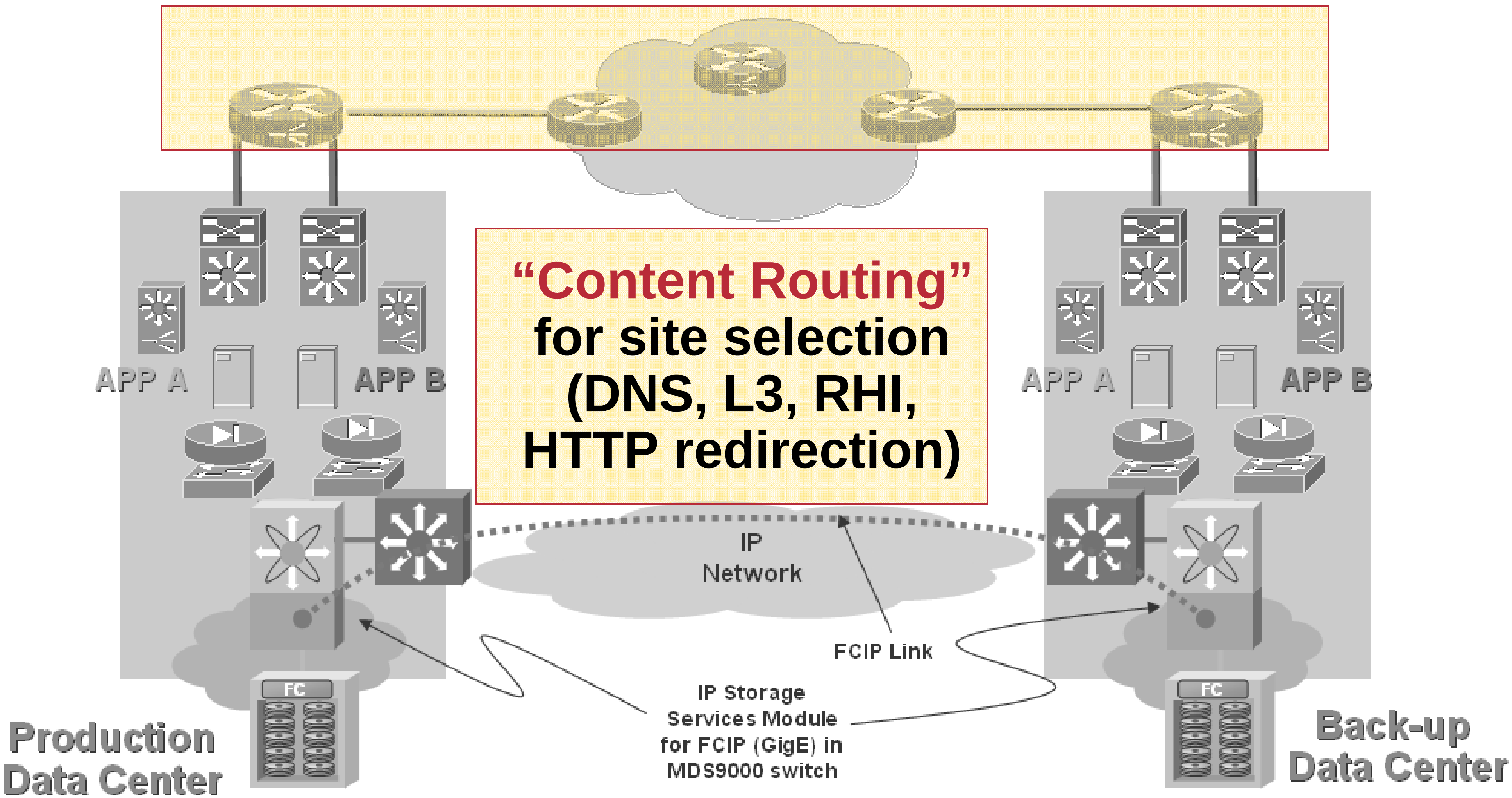
Distributed Data Center Topology



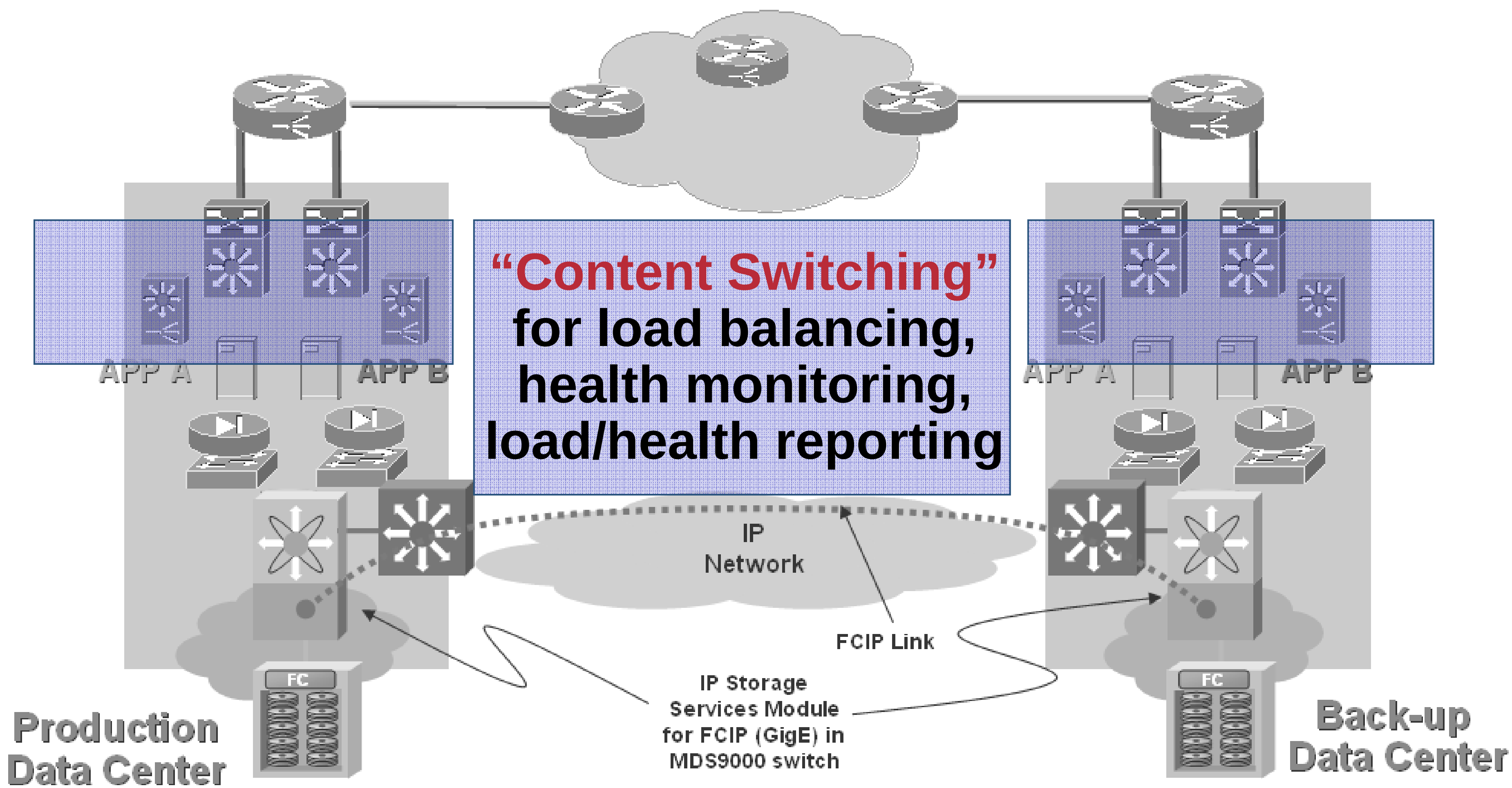
Distributed Data Center Technologies



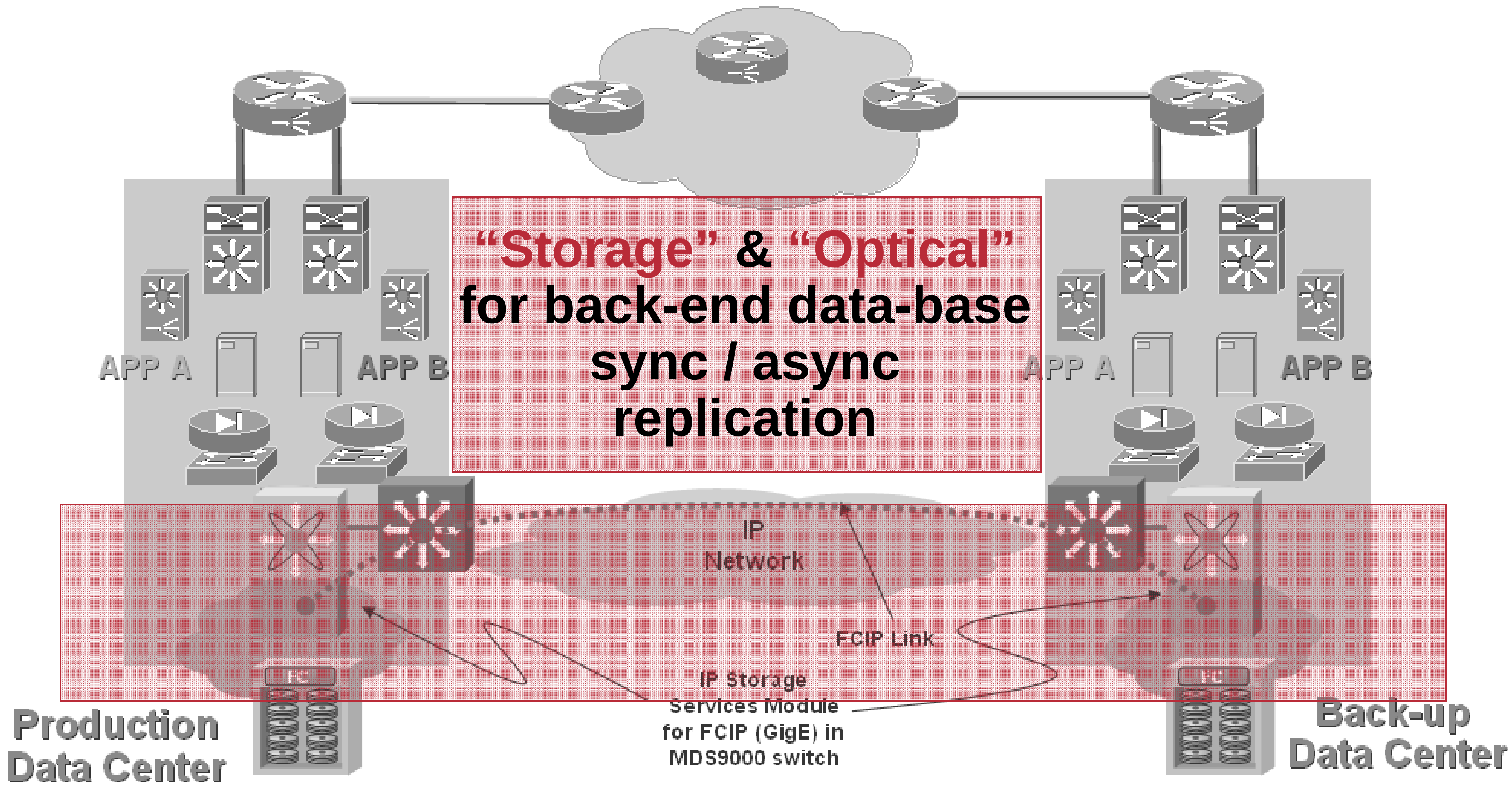
Distributed Data Center Technologies



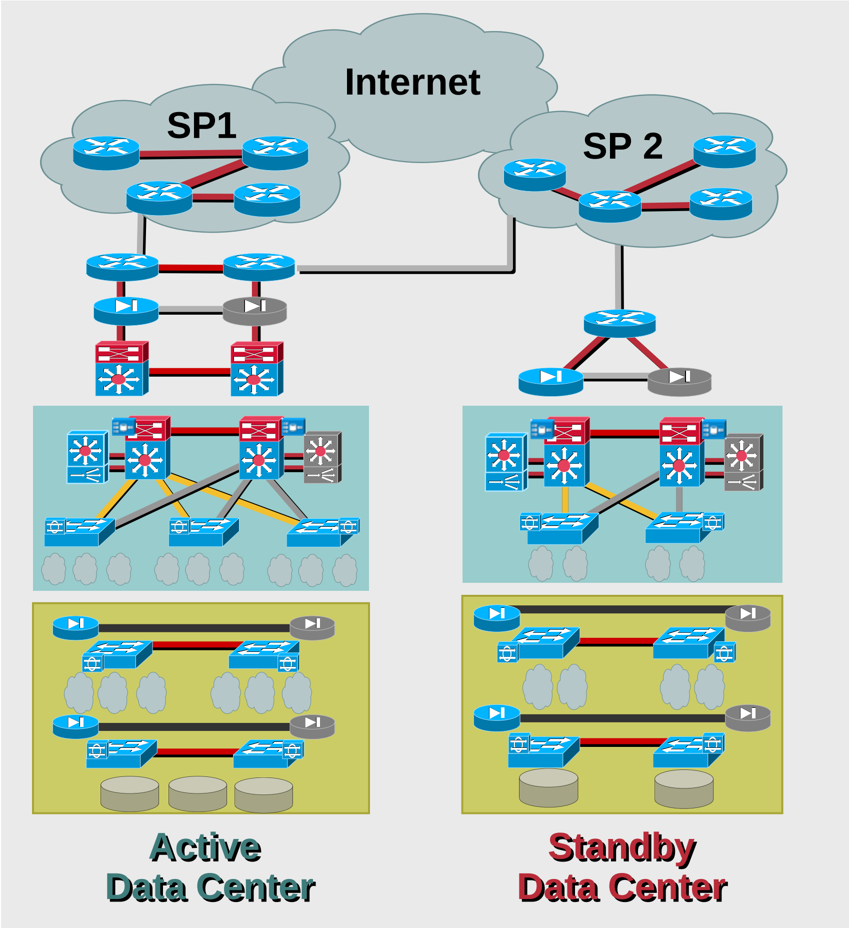
Distributed Data Center Technologies



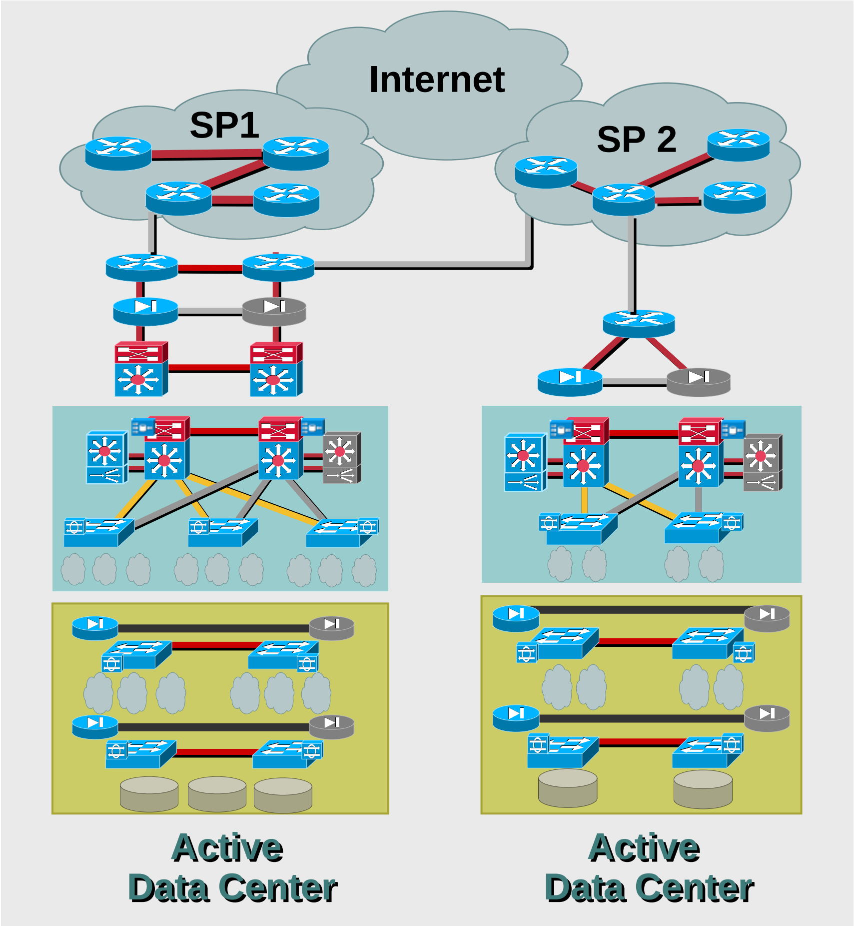
Distributed Data Center Technologies



Disaster Recovery
Data Center Configurations

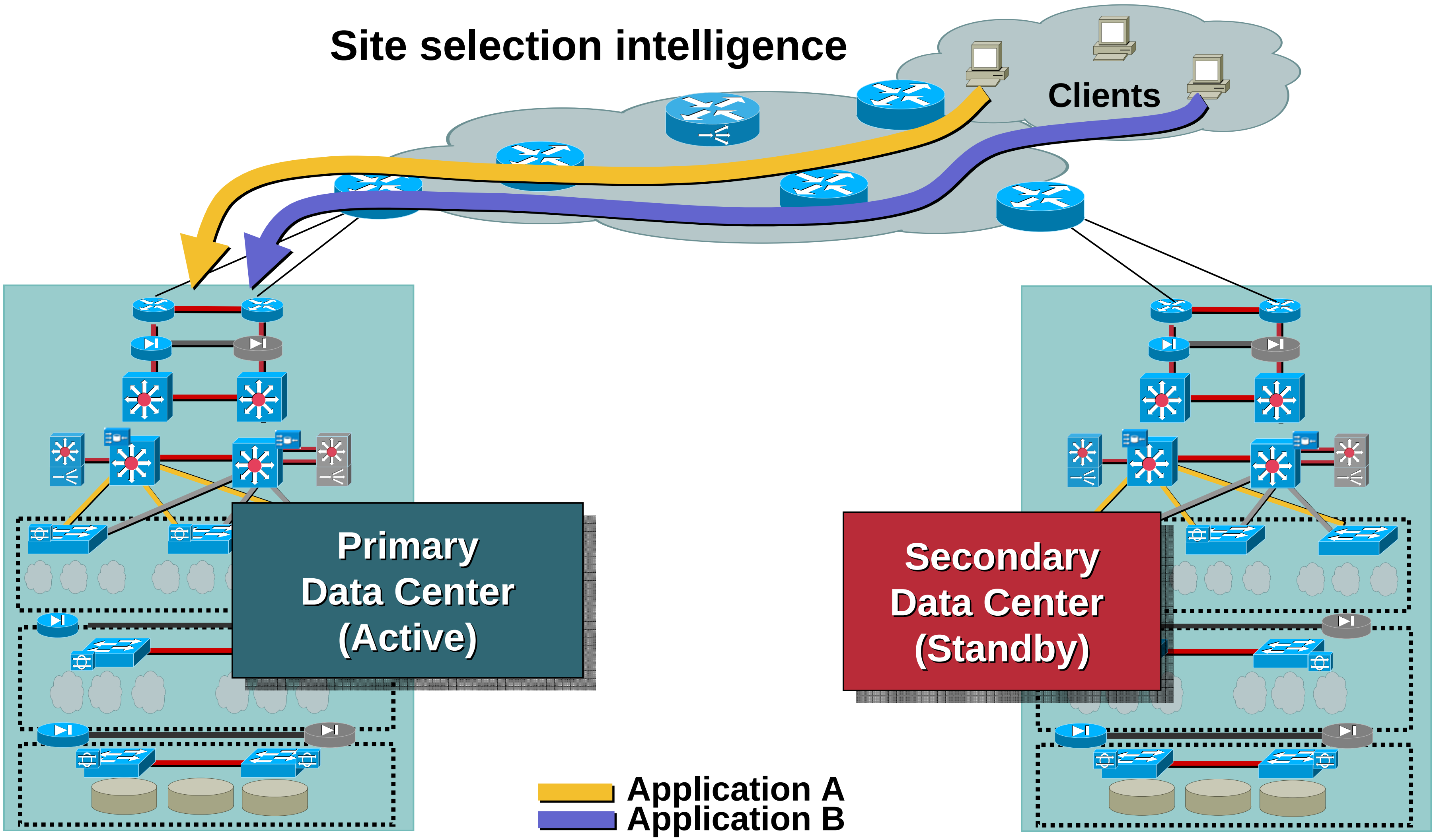


Warm Standby

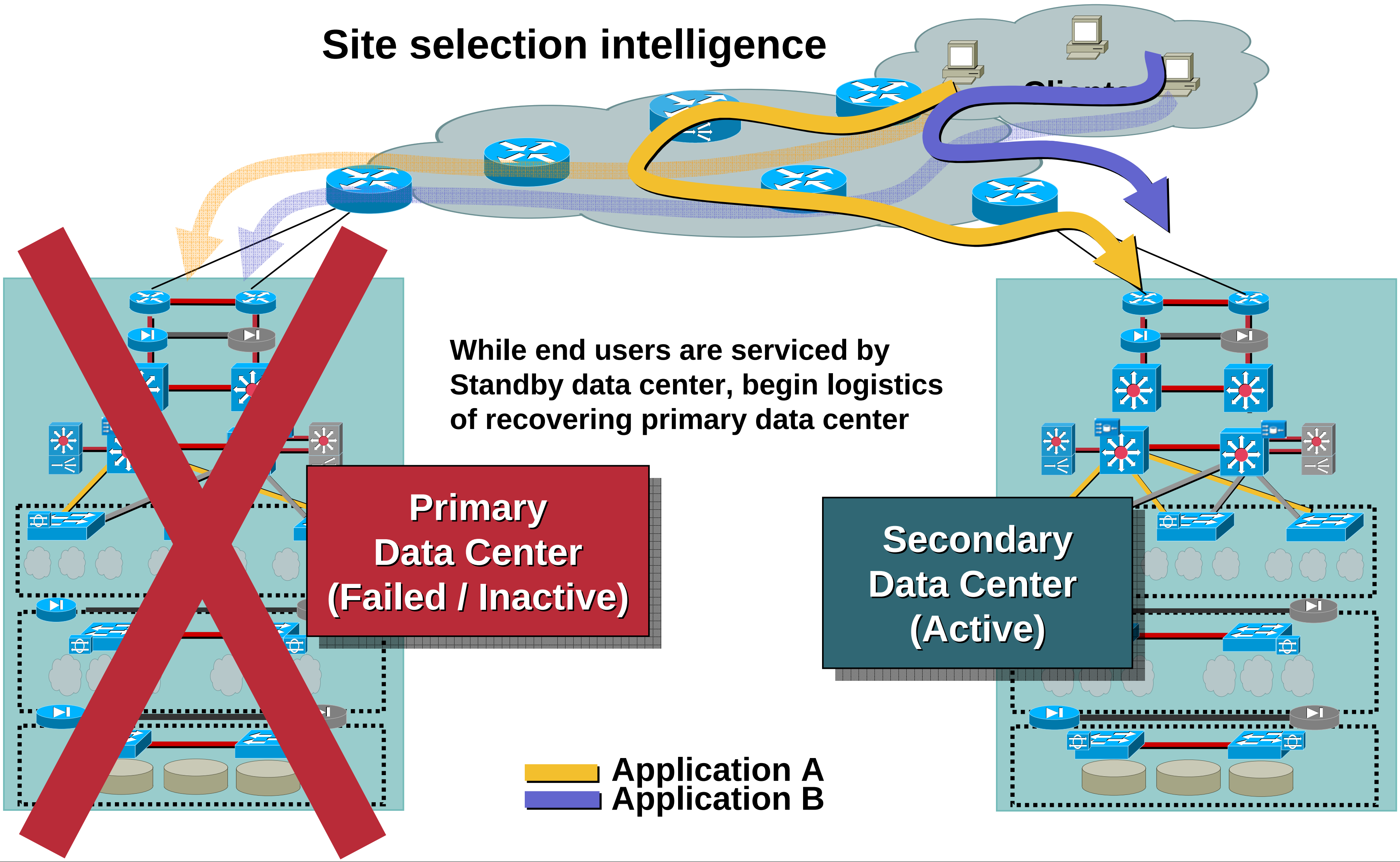


Hot Standby

Disaster Recovery
Warm Standby



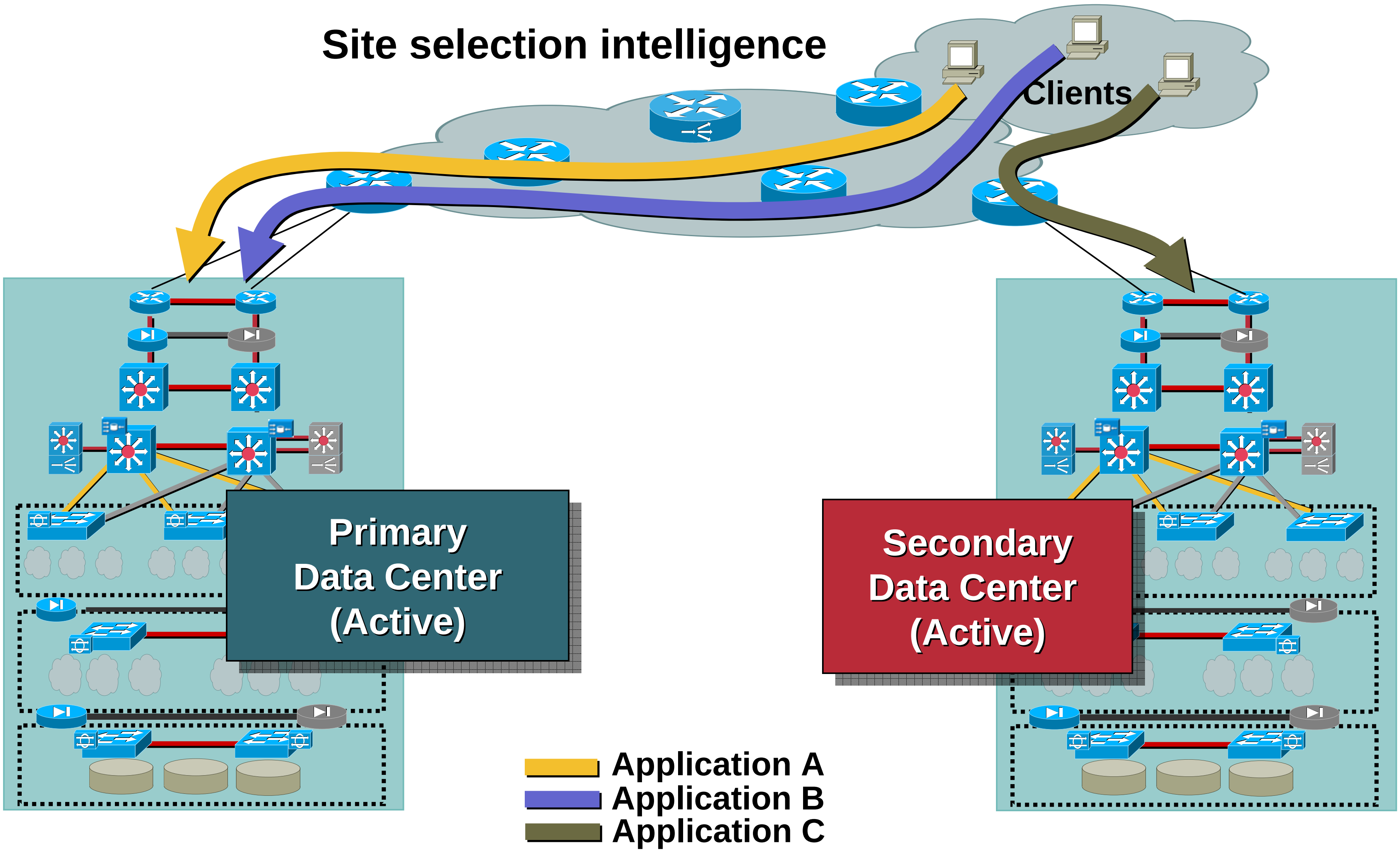
Disaster Recovery
Warm Standby



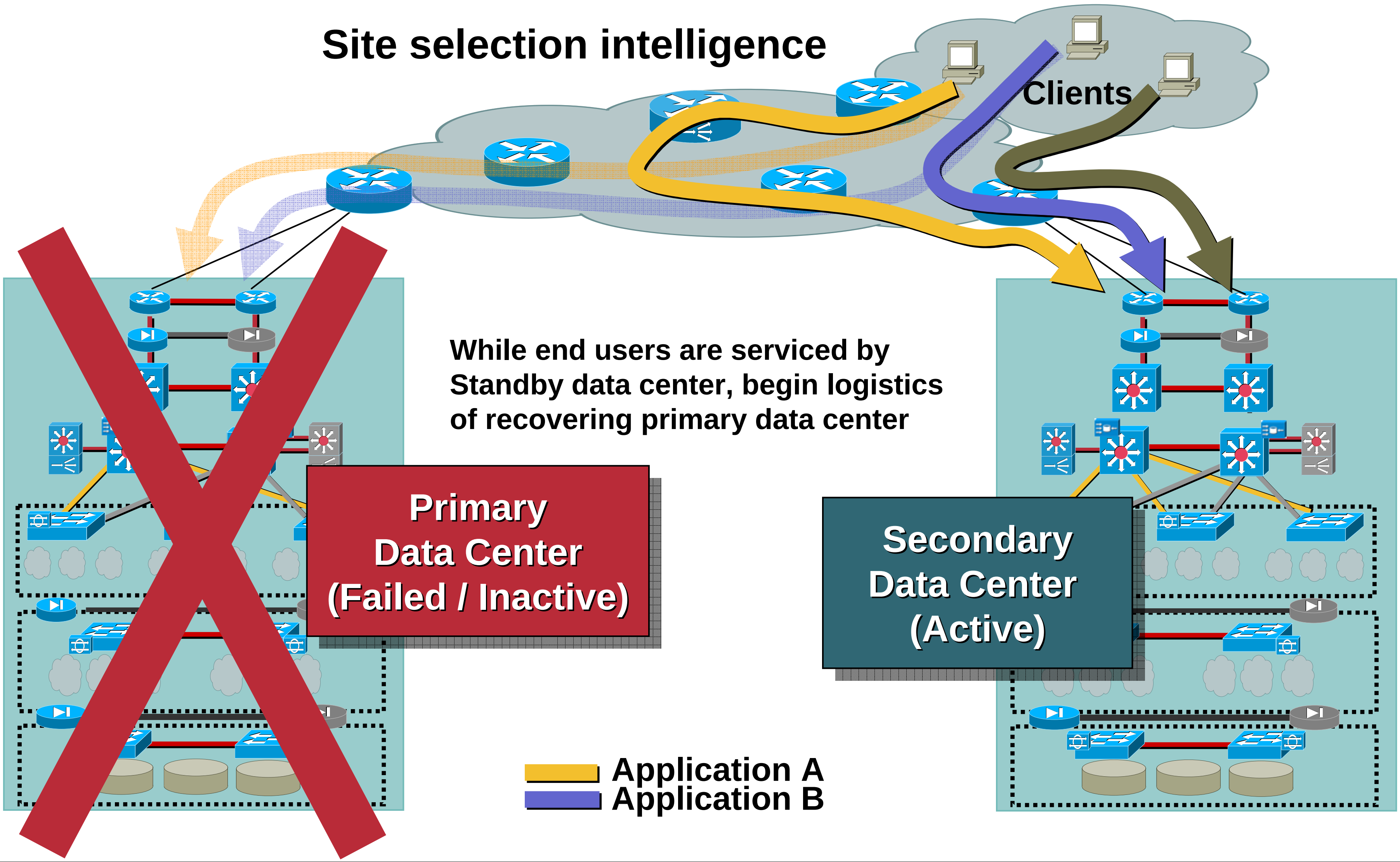
Warm Standby
Data Center Redundancy

- **Advantages**
  - **Simple design, typical Phase I deployment**
  - **Easy to build and maintain**
  - **Simple configuration**
- **Disadvantages**
  - **Under utilization of resources**
  - **Delay in failover with manual switchover**
  - **No load sharing**

Disaster Recovery
Hot Standby



Disaster Recovery
Hot Standby



Hot Standby
Data Center Redundancy

- **Advantages**
  - **Good use of resources due to load sharing**
  - **Ease of management**
- **Disadvantages**
  - **Complex, typical Phase II deployment**
  - **Data mirroring in both directions**
  - **Managing two active data centers**

Site Selection Mechanisms

- Site selection mechanisms depend on the technology or mix of technologies adopted for request routing:

  1. DNS-based
  2. Route Health Injection and L3 routing
  3. HTTP redirect

- Health of servers and applications need to be taken into account
- Optionally, also other metrics (like load and distance) can be measured and utilized for a better selection

DNS-BASED: TECHNOLOGY AND PRODUCTS

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DNS—Domain Name System

- Applications, like browsers, connect to servers using server names

- The operating system DNS resolver contacts the configured DNS server to get the IP address
- Applications use the address provided by the resolver
- When multiple addresses are provided, applications can behave differently: use first IP, use random IP, use first IP and move to the next one if unsuccessful

DNS—Query

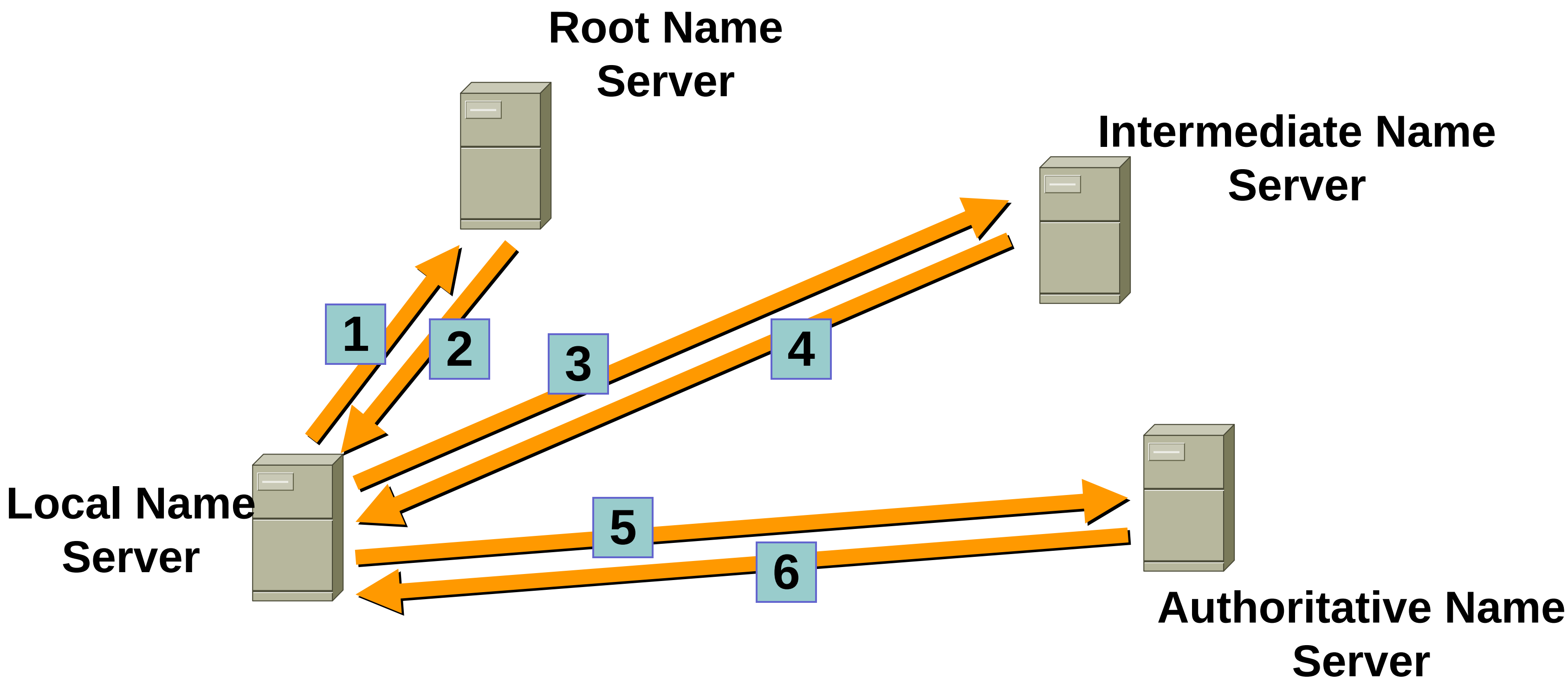

```
User Datagram Protocol, Src Port: 1302 (1302), Dst Port: domain (53)
Domain Name System (query)
    Transaction ID: 0x002a
    Flags: 0x0100 (Standard query)
        0... .... .... .... = Response: Message is a query
        .000 0... .... .... = Opcode: Standard query (0)
        .... ..0. .... .... = Truncated: Message is not truncated
        .... ...1 .... .... = Recursion desired: Do query recursively
        .... .... ...0 .... = Non-authenticated data is unacceptable
    Questions: 1
    Answer RRs: 0
    Authority RRs: 0
    Additional RRs: 0
    Queries
        www.cisco.com: type A, class inet
            Name: www.cisco.com
            Type: Host address
            Class: inet
```

DNS—Query Response


```
User Datagram Protocol, Src Port: domain (53), Dst Port: 1302 (1302)
Domain Name System (response)
    Transaction ID: 0x002a
    Flags: 0x8580 (Standard query response, No error)
Questions: 1
    Answer RRs: 1
    Authority RRs: 2
    Additional RRs: 2
    Queries <--snipped-->
    Answers
        www.cisco.com: type A, class inet, addr 198.133.219.25
            Name: www.cisco.com
            Type: Host address
            Class: inet
            Time to live: 1 day
            Data length: 4
            Addr: 198.133.219.25
    Authoritative nameservers <--snipped-->
    Additional records <--snipped-->
```

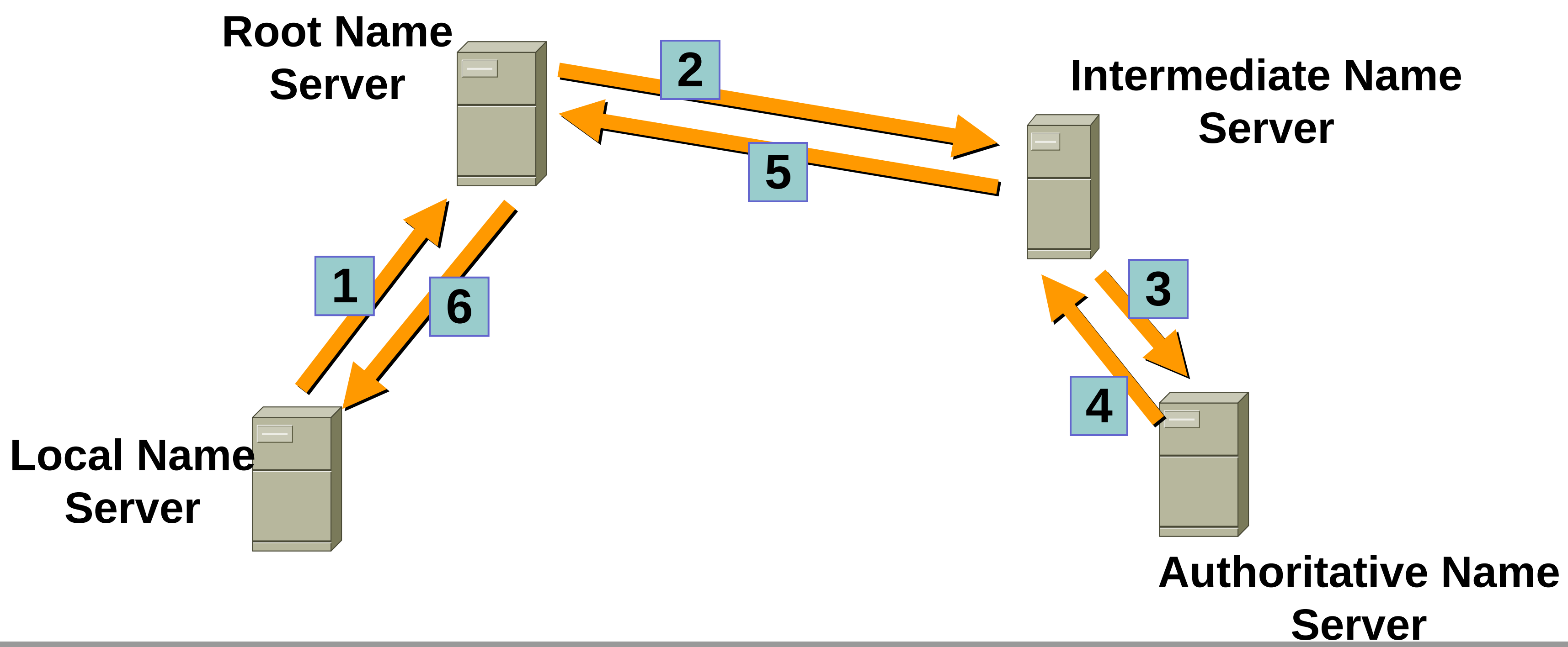
Iterative Requests

If the name server does not have a cached response, it provides a pointer to another name server



Recursive Requests

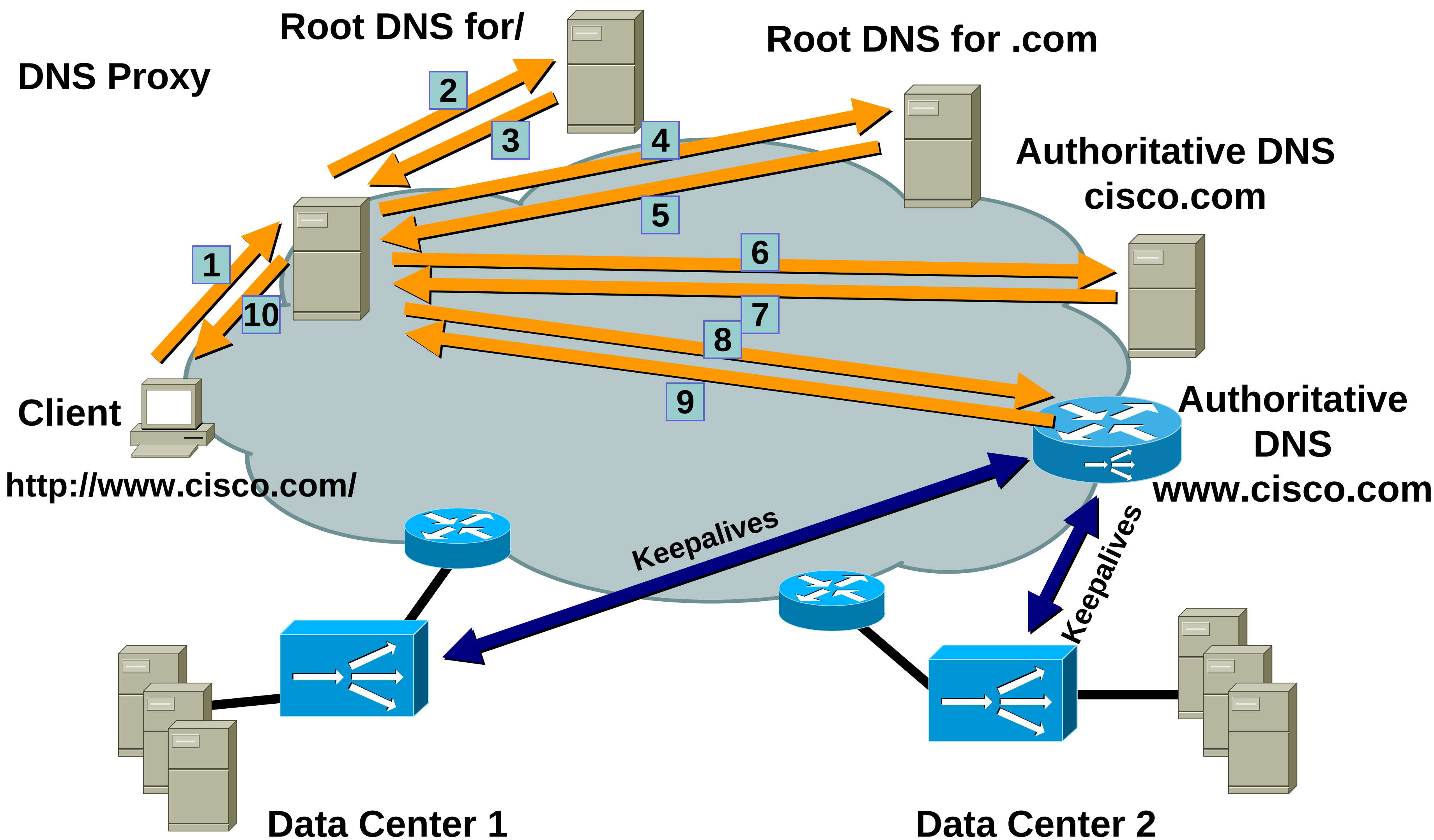
If the name server assumes the full responsibility for providing a full answer



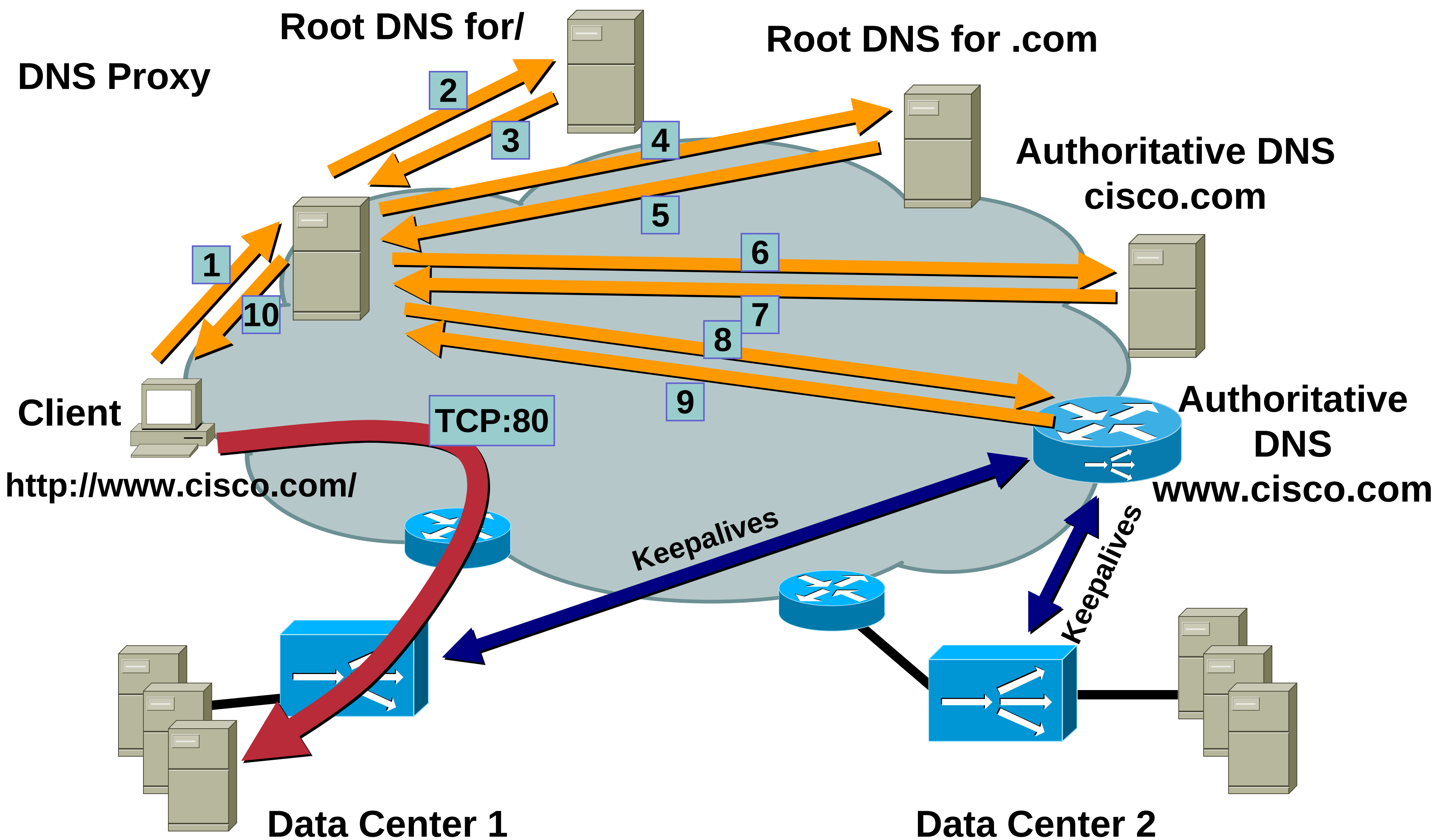
DNS-Based Site Selection

- The client DNS resolver (implemented as part of the client OS) typically sends a recursive query
- The client D-proxy typically performs iterative queries, then returns the final result to the client
- The device which acts as “site selector” is the authoritative DNS server for the domain hosted in multiple locations
- The “site selector” sends keepalives to servers or content switches in the local and remote locations
- The client connects to the selected location
- All the devices involved might cache the information

DNS-Based Site Selection



DNS-Based Site Selection



GSLB Methods

1. **Ordered List**

   Prefers first entry in the list.
   Uses next VIPs when all previous VIPs are overloaded or down
   Used for active-standby scenarios

2. **Static Proximity Based on Client's DNS Address**

   Maps IP address of client's DNS proxy to available VIPs

3. **Round Robin**

   Cycles through available VIPs in order

4. **Weighted Round Robin**

   Weighting causes repeat hits (up to 10) to a VIP

GSLB Methods

5. **Least Loaded**

   Least connections on CSM and least loaded on CSS

   Load communicated through Content and Application Peering Protocol (CAPP) User Datagram Protocol (UDP)

6. **Source Address and Domain hash**

   IP address of client’s DNS proxy and domain used

   Always sticks same client to same VIP

7. **DNS Race**

   Initiates race of A-record responses to client

   Finds closest SLB to client’s D-proxy

8. **Drop**

   Silently discards request

Advantages of the DNS Approach

- Protocol independent: works with any application
- Easy to implement, with minimal configuration changes in the DNS authoritative server
- Can take load or data center size into account
- Can make the decision based on source IP (D-proxy)

Limitations of the DNS-Based Approach

- Visibility limited to the D-proxy (not the client)
- DNS caching in the D-proxy
- DNS caching in the client application (browsers defaulting to 15 or 30 minutes timeouts)
- D-proxy ignoring TTL
- Order of multiple A-record answers can be altered by D-proxies

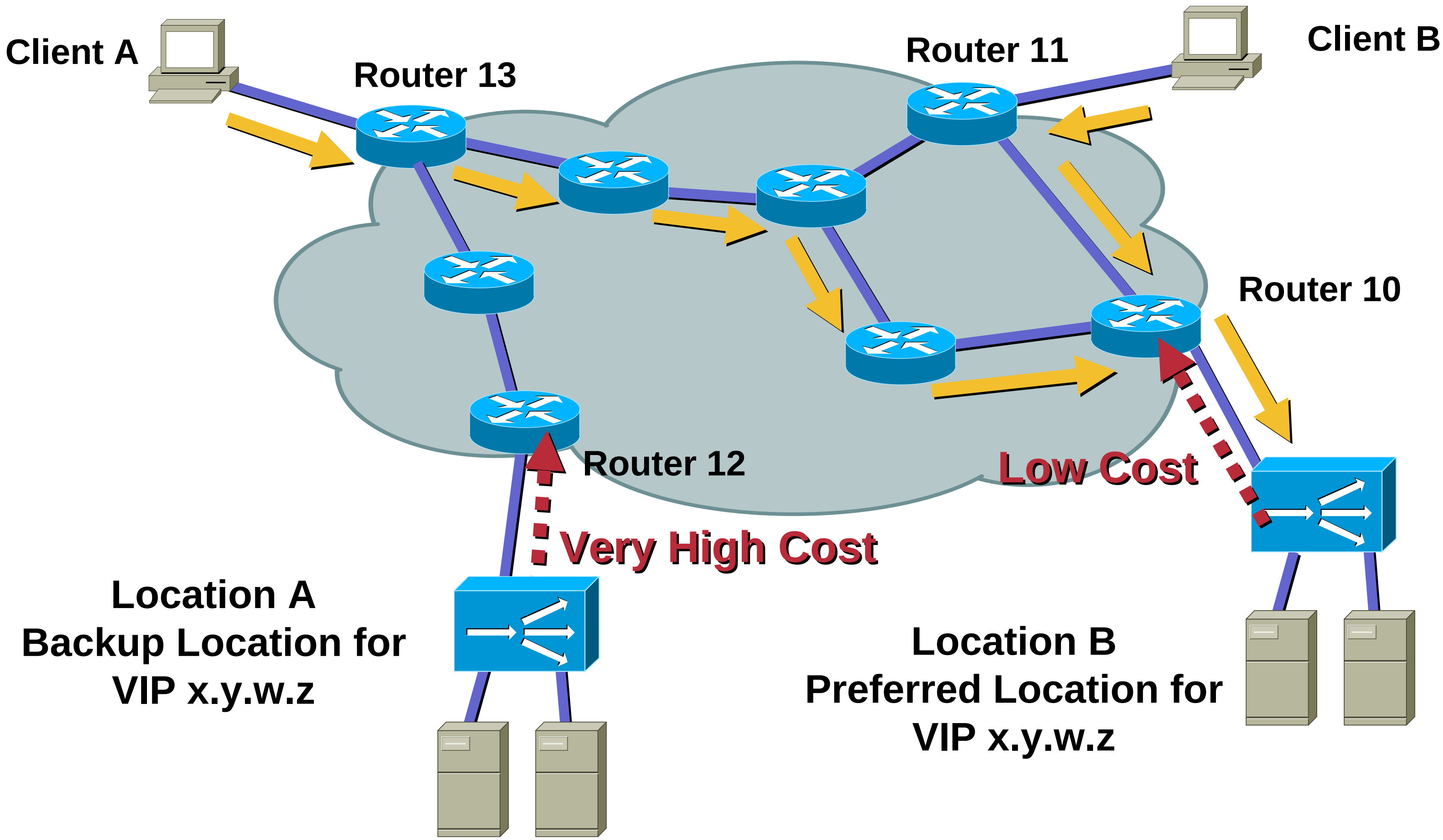
ROUTE HEALTH INJECTION: TECHNOLOGY AND PRODUCTS

Route Health Injection

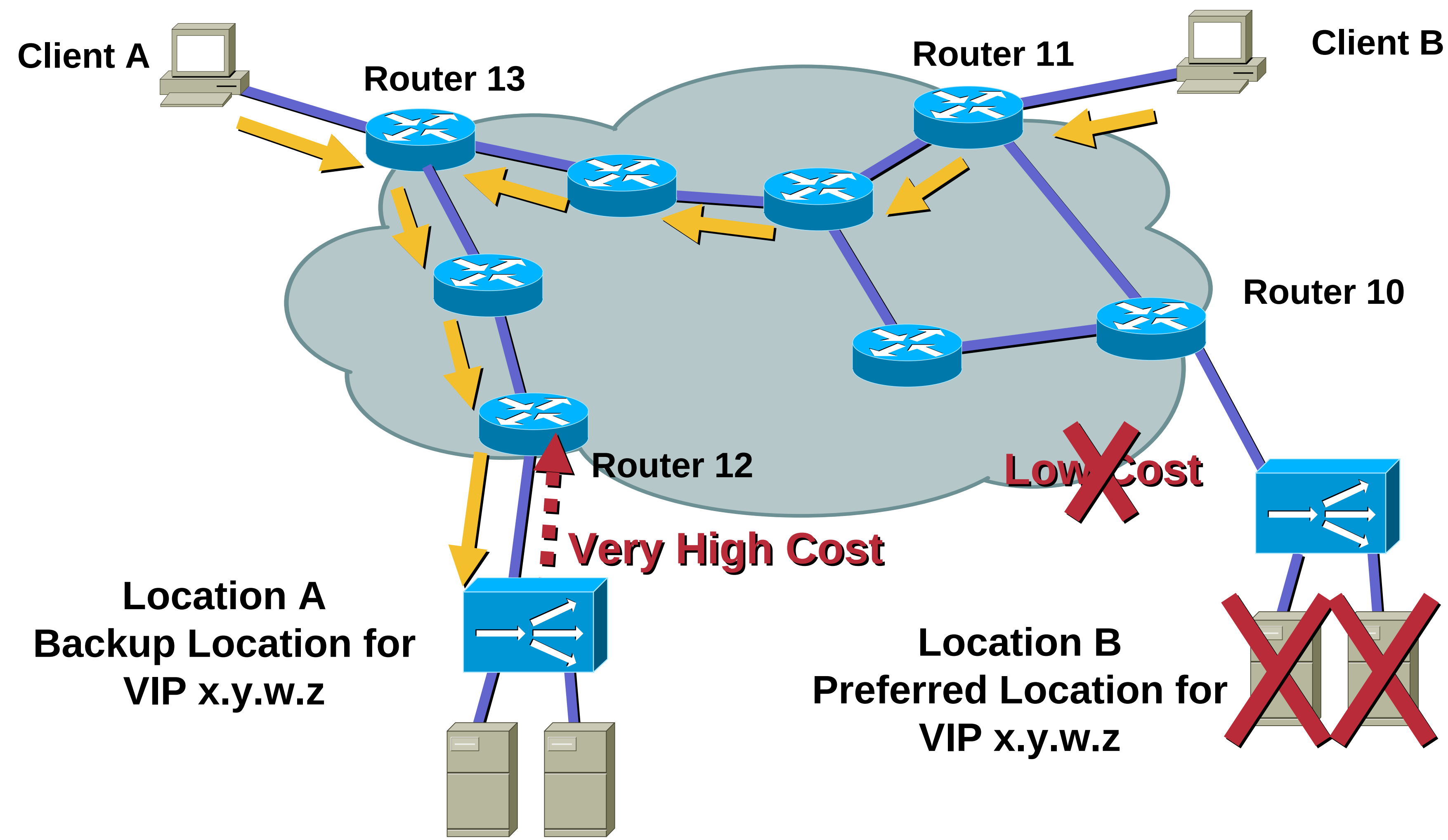
The Main Idea

- **Rely on L3 protocols for request routing**
- **Advertise the same VIP address from two or more different data center**
- **For Disaster Recovery advertise the preferred data center's VIP with better metrics**
- **The upstream routers select the best route**
- **The content switches at each location provide server and application health monitoring**
- **In case of virtual server failure at the primary site, the route is withdrawn and network converges**

Route Health Injection

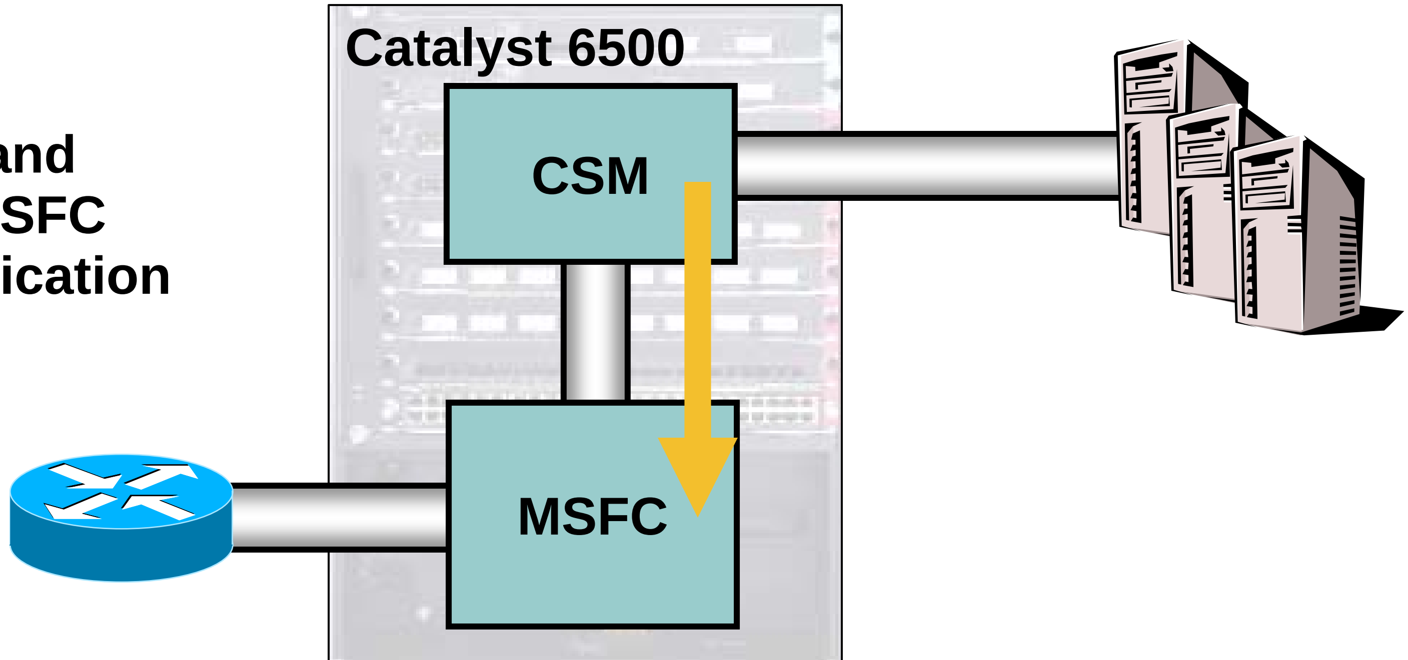


Route Health Injection



Products for Route Health Injection CSM + MSFC

- The Content Switching Module (CSM) can be configured to "inject" a 32-bit host route as a static route in the MSFC routing table
- The CSM injects or remove the route based on the health of the back-end servers (checked with L3-7 probes or inband health monitoring)
- Out of band CSM – MSFC communication



Products for Route Health Injection CSM + MSFC (Cont.)

```
module ContentSwitchingModule 5
 variable ADVERTISE_RHI_FREQ 3
!
 vlan 3 client
  ip address 10.3.3.20 255.255.255.0
  alias 10.3.3.21 255.255.255.0
```

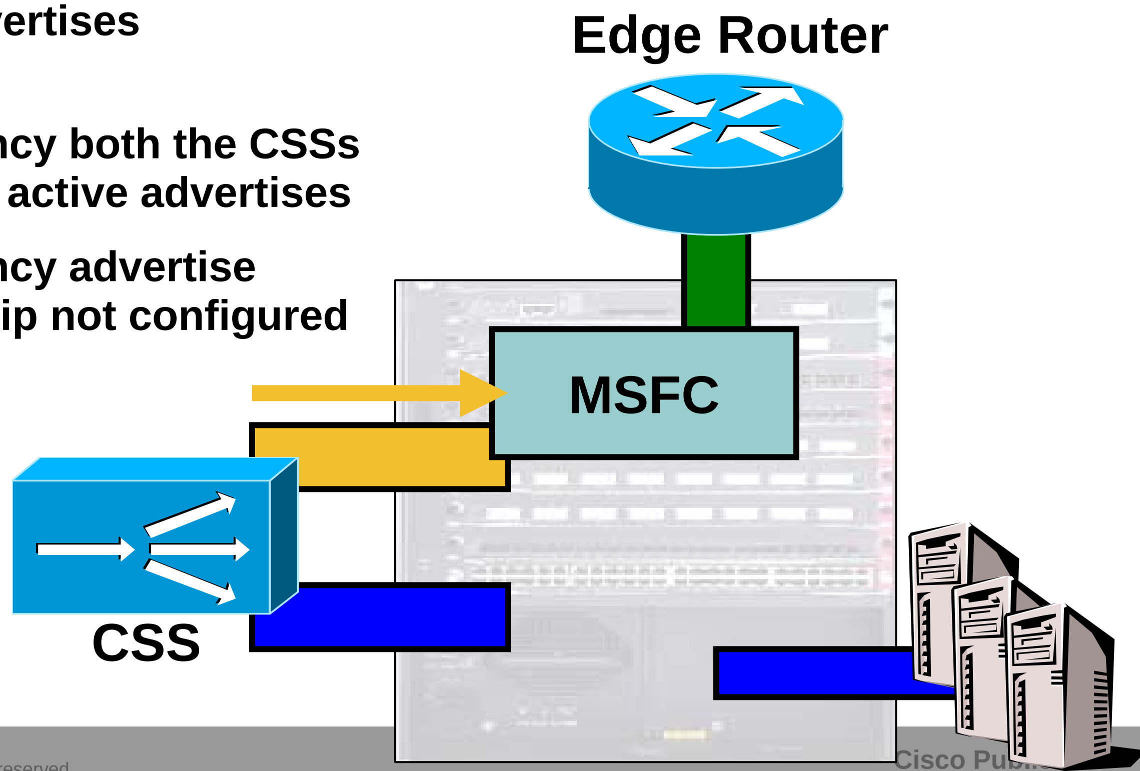
```
 vserver RHIVIP
  virtual 100.100.100.100 tcp www
  vlan 3
  serverfarm FARM1
  advertise active
  persistent rebalance
  inservice
```

```
Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP

     100.0.0.0/32 is subnetted, 1 subnets
S       100.100.100.100 [1/0] via 10.3.3.21, Vlan3
     10.0.0.0/24 is subnetted, 1 subnets
C       10.3.3.0 is directly connected, Vlan3
S*   0.0.0.0/0 [1/0] via 10.20.196.193
```

RHI on CSS using OSPF
Topology

- OSPF can be used on the Content Services Switch to achieve Route Health Injection
- CSS advertises host routes to the neighbor for the Active Virtual IP addresses
- In Box-to-Box Redundancy, the active CSS forms adjacency and advertises operational VIPs
- In VIP/Interface Redundancy both the CSSs forms adjacency but only active advertises
- In VIP/Interface Redundancy advertise always when redundant-vip not configured



RHI on CSS using OSPF
Box to Box Redundancy

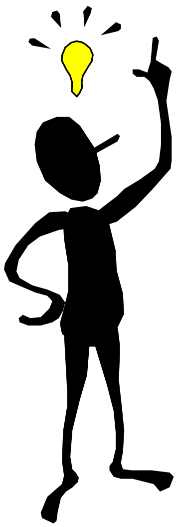
```
ip redundancy
app
app session 10.33.133.2

ospf router-id 10.115.1.12
ospf as-boundary
ospf area 0.0.0.2
ospf enable
ospf advertise 10.115.1.101 255.255.255.255 metric 200
ospf advertise 10.115.1.102 255.255.255.255 metric 200
ospf advertise 10.116.1.101 255.255.255.255
```

```
circuit VLAN115
  description "CLIENT VLAN"
  redundancy
  ip address 10.115.1.12 255.255.255.0
    ospf
    ospf enable
    ospf area 0.0.0.2
!
owner znaseh
  content app1
    vip address 10.115.1.101
    protocol tcp
    port 8081
    add service s1
    active
```

```
MSFC
  O E2    10.116.1.101/32 [110/1] via 10.115.1.12, 00:04:15, Vlan115
  O E2    10.115.1.101/32 [110/200] via 10.115.1.12, 00:04:15, Vlan115
  O E2    10.115.1.102/32 [110/200] via 10.115.1.12, 00:04:15, Vlan115
```

Advantages of the RHI Approach



- Support legacy application, that do not rely on a DNS infrastructure
- Very good re-convergence time, especially in Intranets where L3 protocols can be fine tuned appropriately
- Protocol-independent: works with any application
- Robust protocols and proven features

Limitations of the RHI Approach

- **Relies on host routes (32 bits), which cannot be propagated all over the internet**
- **Requires tight integration between the application-aware devices and the L3 routers**
- **Internet deployments require route summarization**
  (more on this later …)

HTTP REDIRECTION: TECHNOLOGY AND PRODUCTS

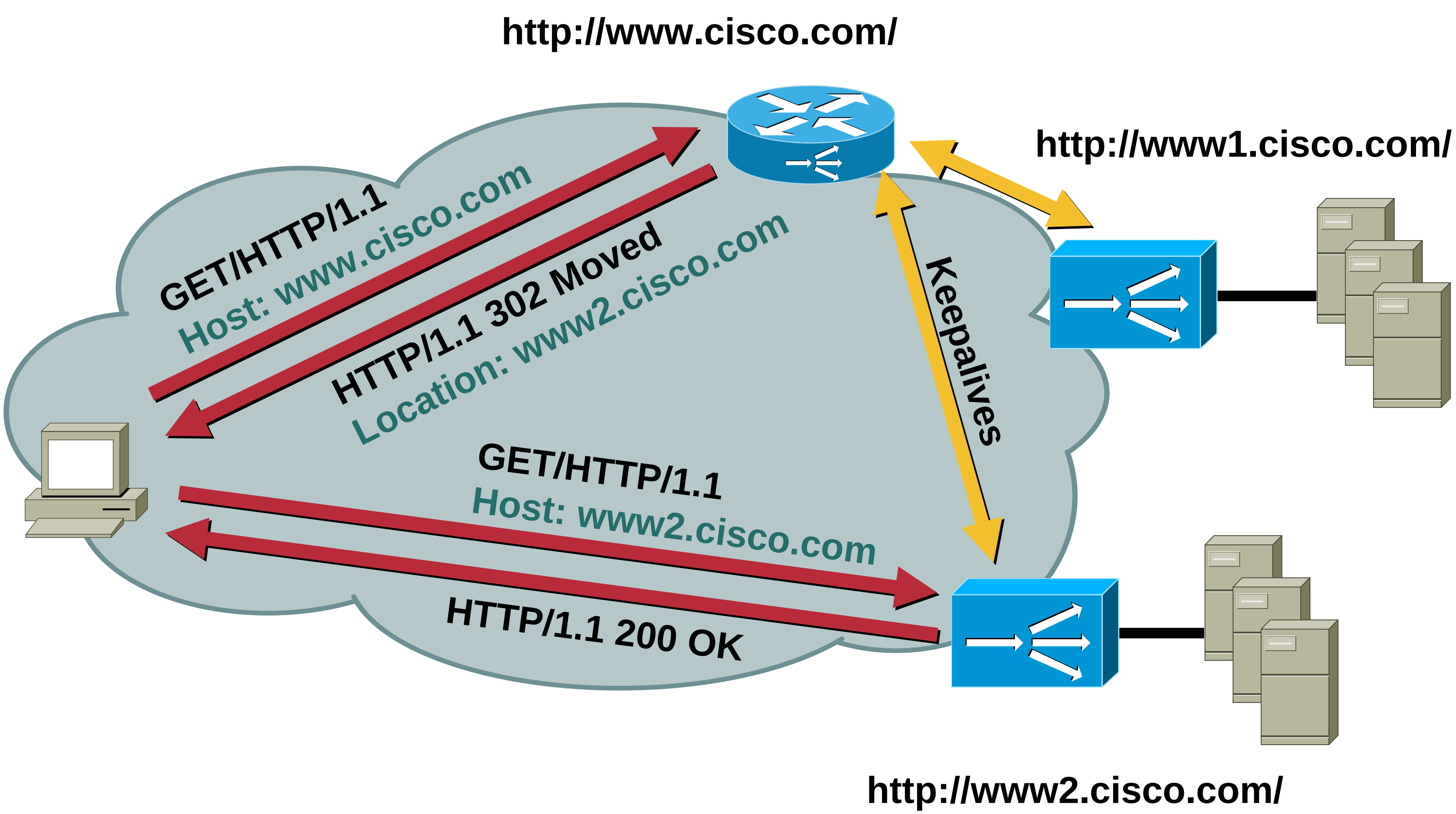
HTTP Redirection

The Main Idea

- Leverages the HTTP redirect function
  HTTP return codes 301 and 302
- Incoming client requests are redirected to the selected location
- The balancing decision happens after the DNS resolution and the L3 routing of the initial request has been completed
- Can be used in conjunction with other site selection mechanisms

HTTP-Redirect

After the DNS Resolution



HTTP-Redirect Example

```
10.20.211.100.80 > 10.20.1.100.34589: FP 1:56(55) ack 287 win 2048 (DF)
0x0000   4500 005f 763c 4000 3e06 dd6c 0a14 d364      E.._v<@.>..l...d
0x0010   0a14 0164 0050 871d 7b57 aead ec1d 6b04      ...d.P..{W....k.
0x0020   5019 0800 8b1a 0000 4854 5450 2f31 2e30      P.......HTTP/1.0
0x0030   2033 3031 2046 6f75 6e64 200d 0a4c 6f63      .301.Found...Loc
0x0040   6174 696f 6e3a 2068 7474 703a 2f2f 7777      ation:.http://ww
0x0050   7732 2e74 6573 742e 636f 6d0d 0a0d 0a        w2.test.com....
```

Advantages of the HTTP Redirect Approach

- **Visibility into the client IP address**
- **Visibility into the request**
  Possibility to distinguish:
  http://www.example.com/app1
  http://www.example.com/app2
- **Inherent persistence to the selected location**

Limitations of the HTTP Redirect Approach

- It is protocol specific (HTTP)
- Requires redirection to fully qualified additional names (www2, www3, …)
- Clients can bookmark a specific location

OVERCOMING THE INHERENT LIMITATIONS

GSLB and Disaster Recovery

	DNS	HTTP Redirect	Route Health Injection
How Does It Work?	Device Is Authoritative DNS	Device Returns HTTP 302	L3 Routing and Reconvergence
Advantages	• Protocol Independent • Also GSLB	Visibility into Client IP and Request	• Protocol Independent • No Need for DNS • Can Work w/ DNS
Caveats	• Hard coded IPs • Subject to DNS Implementation • DNS Caching	• HTTP only • Bookmarks • Resource Intensive	• Only Disaster Recovery • Host Routes Dropped at Edge

System Level Approach

- Each application and its respective user base varies
- Complete solution can be achieved by combining multiple technologies
    - DNS
    - Route Health Injection
    - BGP / IP Anycast
    - HTTP Redirect

REAL-WORLD DEPLOYMENTS

Real-World Deployments
Coast-to-Coast Fast Disaster Recovery

- **Goal**

  Very fast disaster recovery between 2 remote data centers; minimize possibility of data center down

  Non-DNS based application; client configuration cannot be changed

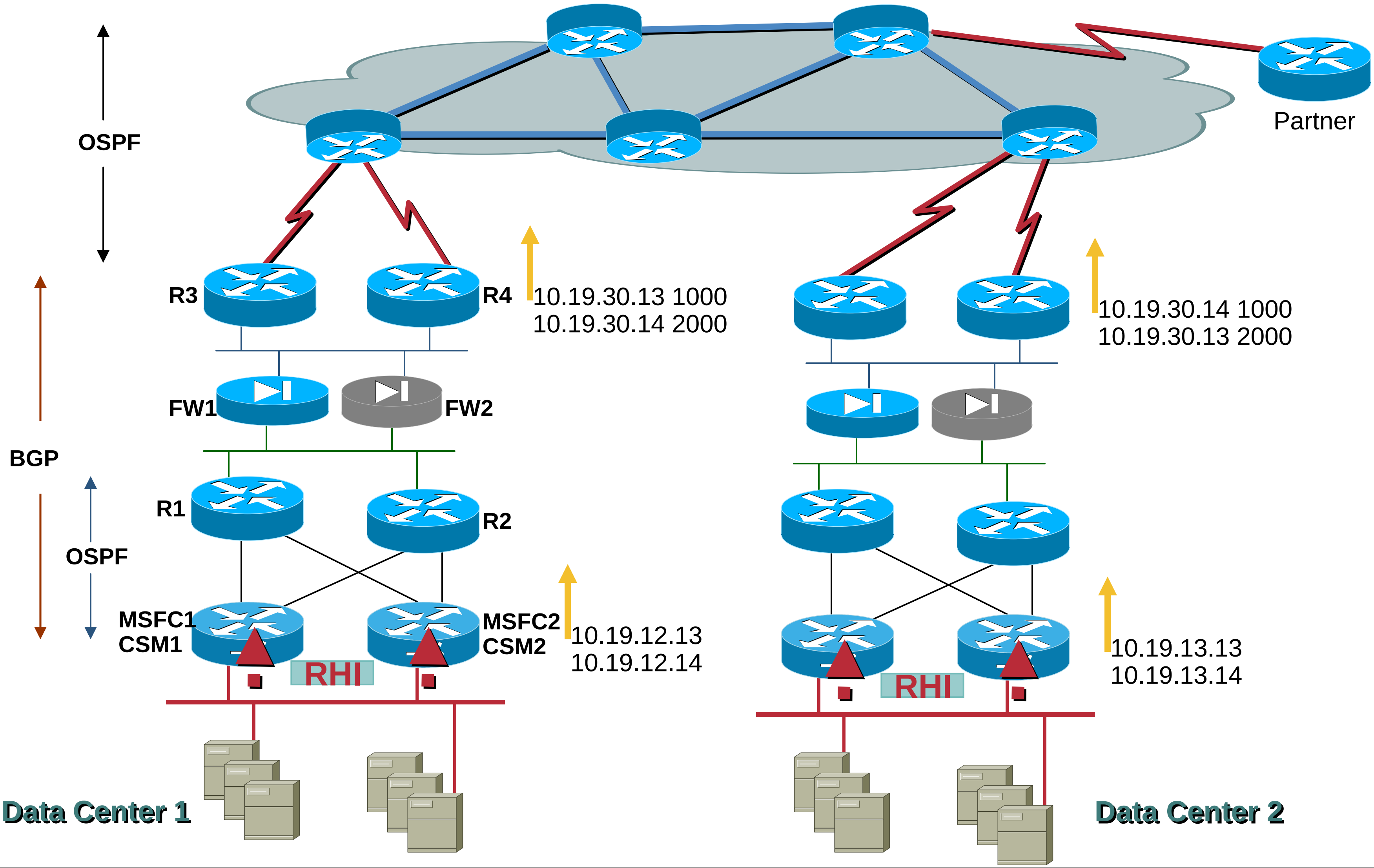
  Support proprietary protocol: very long connections

- **Solution**

  Active-standby content switches in each data-center; RHI across data centers

  Active and passive health monitoring tuned to react as fast as possible

Real-World Deployments
Coast-to-Coast Fast Disaster Recovery



Real-World Deployments
Coast-to-Coast Fast Disaster Recovery

Implementation Details

- Route Health Injection is used on the CSM to dynamically announce VIPs to the MSFC
- MSFC running OSPF; other switches within the data center part of OSPF domain
- MSFC running BGP to connect to edge routers; EBGP peers across firewalls [Between MSFC and Edge routers]
- EBGP runs between edge routers of primary and secondary data center
- Firewall rules adjusted to allow BGP peers; TCP port 179
- OSPF in the Core
- Hold down timer will be used to prevent a failed center from immediately coming back on-line if the servers become active (probe failed value)

Real-World Deployments
Coast-to-Coast Fast Disaster Recovery

```
vlan 61 client
  ip address 10.19.71.12 255.255.255.0
  gateway 10.19.71.1
  alias 10.19.71.11 255.255.255.0
vlan 73 server
  ip address 10.23.71.12 255.255.255.0
  alias 10.23.71.11 255.255.255.0
!
probe ICMP icmp
 interval 2
 retries 3
 receive 2
 failed 65535
!
serverfarm APP_1
 nat server
 no nat client
  real 10.23.71.113
   inservice
  real 10.23.71.114
   inservice
 probe ICMP
```

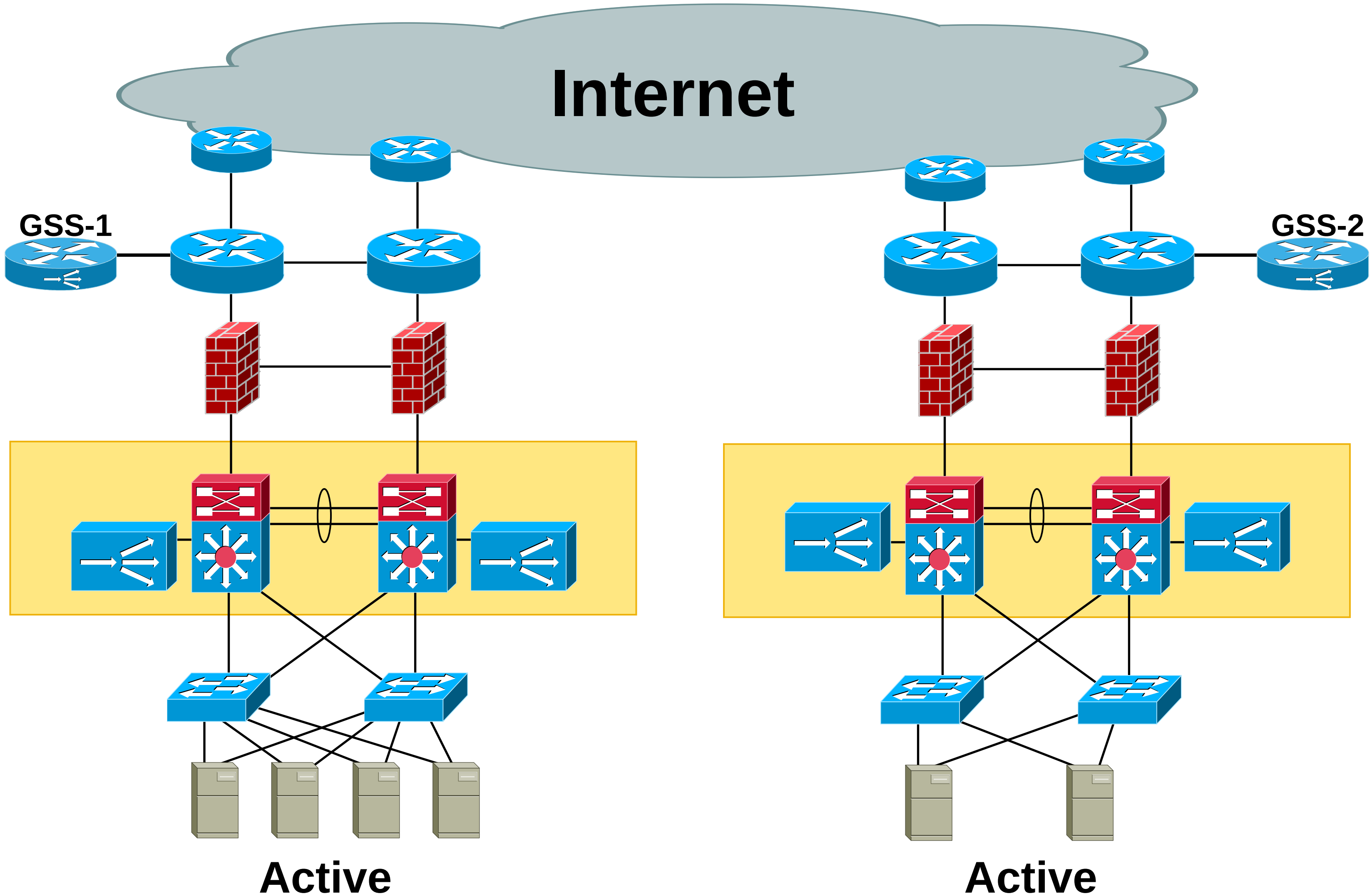
```
vserver APP_1_VIP1
  virtual 10.19.12.13 tcp 0
  vlan 61
  serverfarm APP_1
  advertise active
  inservice
!
vserver APP_1_VIP2
  virtual 10.19.30.13 tcp 0
  vlan 61
  serverfarm APP_1
  advertise active
  inservice
```

```
router ospf 25
  network 10.19.0.0 0.0.255.255 area 0
  log-adjacency-changes
  redistribute static metric-type 1 subnets route-map
     Internal-Static
!
router bgp 6117
  no synchronization
  bgp router-id 10.19.2.1
  bgp log-neighbor-changes
  bgp scan-time 5
  network 10.19.30.13 mask 255.255.255.255
  network 10.19.30.14 mask 255.255.255.255
  timers bgp 5 15
  neighbor  10.19.2.12 remote-as 6114
  neighbor  10.19.2.12  ebgp-multihop
  neighbor  10.19.2.12 update-source loopback0
  <SNIP>
!
```

Real-World Deployments
Varying Capacity Data Centers

- **Goal**
  - Load balance applications within and across regions using DNS information
  - Load balance a single APP across Sites based on availability and load
  - High-volume, resilient and scaleable server farm for both static content
  - Datacenters with different server capacity
  - Max connections for servers needed
  - Least Loaded required (ap-kal keep alive from GSS to CSS)
- **Solution**
  - CSS deployed within the data centers for SLB
  - One GSS deployed at each datacenter with ap-kal to the CSS

Real-World Deployments
Varying Capacity Data Centers



Real-World Deployments
Varying Capacity Data Centers

Implementation Details

- ACLs used on the GSS for protection against unauthorized access and attacks
- NS forwarder configured for unsupported record types – for example MX, AAAA etc
- Primary balance method is Round Robin
- For applications requiring site stickiness Source IP hash is used

  D-Proxy hopping (location cookies with SSL termination)

  Mega Proxy and large enterprises cause uneven load on the sites
- Static Proximity used for Intranet clients
- Firewall rules updated to allow kal-ap probe (UDP/5002) to go through between GSS and CSS
- Secondary clause used within the GSS rule with keepalive type to send a response to the client in case of both data center failure. This protects against negative caching

Real-World Deployments
Varying Capacity Data Centers

```
!
  app-udp
  app-udp secure
  app-udp options 10.14.80.21 encrypt-md5hash somepsswd
  app-udp options 10.4.92.21 encrypt-md5hash somepsswd
!
owner customer.com
  content web
    add service server3
    add service server4
    protocol tcp
    port 80
    vip address 10.18.80.155
    add dns www.customer.com
    advanced-balance sticky-srcip
    active
```

```
vserver HR_JOBS_80
  virtual 10.14.80.31 tcp www
  serverfarm HR_JOBS
  replicate csrp connection
  domain jobs.hr.customer.com
  inservice
!
 vserver HR_REVIEW_80
  virtual 10.14.80.35 tcp www
  serverfarm HR_REVIEW
  replicate csrp connection
  domain review.hr.customer.com
  inservice
!
 capp udp
  secure
  options 10.14.80.21 encryption md5 somepsswd
  options 10.4.92.21 encryption md5 somepsswd
!
```

Q and A

Recommended Reading

- **Designing Content Switching Solutions: ISBN: 158705213X**

  By Zeeshan Naseh,
  Haroon Khan