



# Content Networking Fundamentals

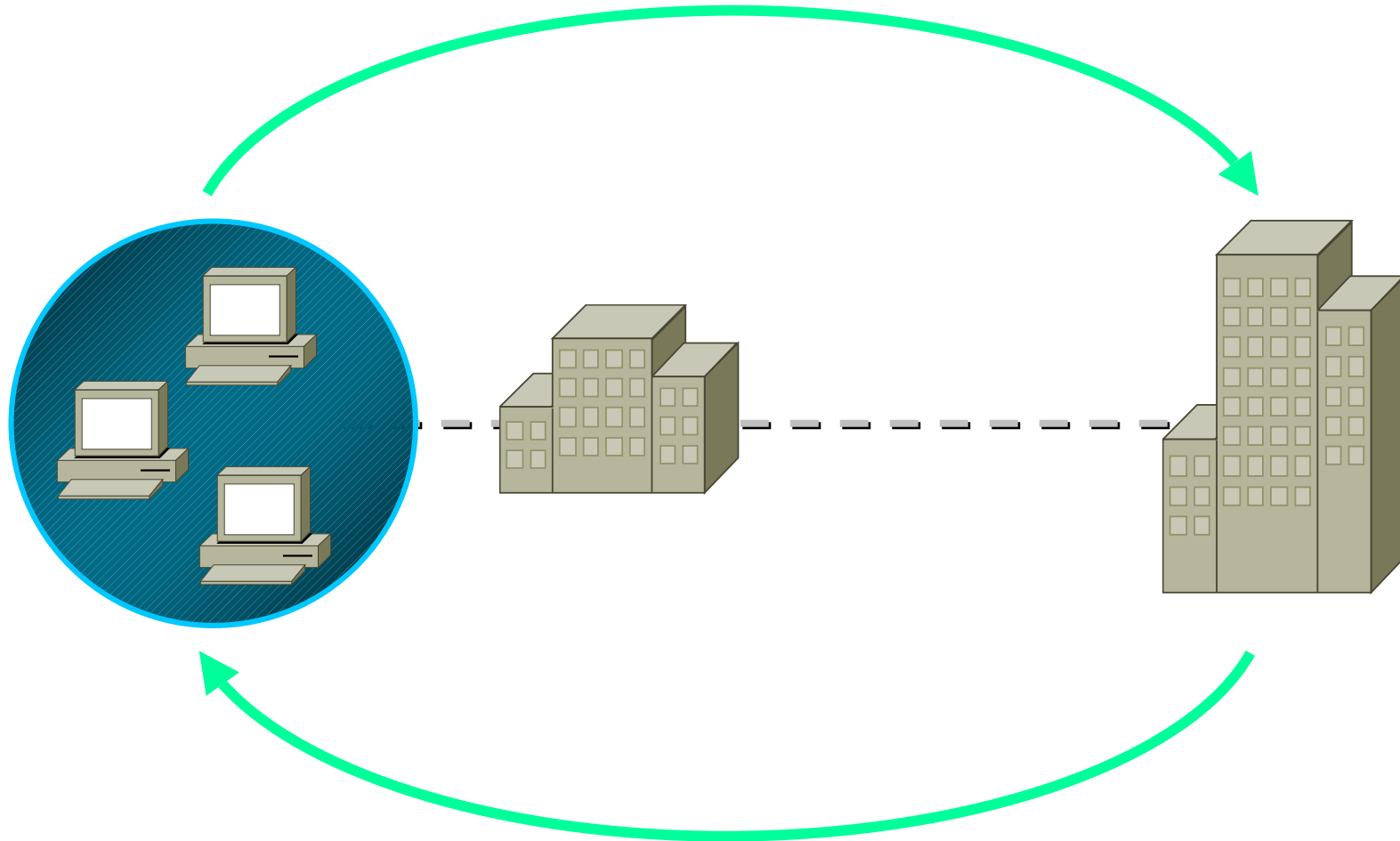


# Agenda

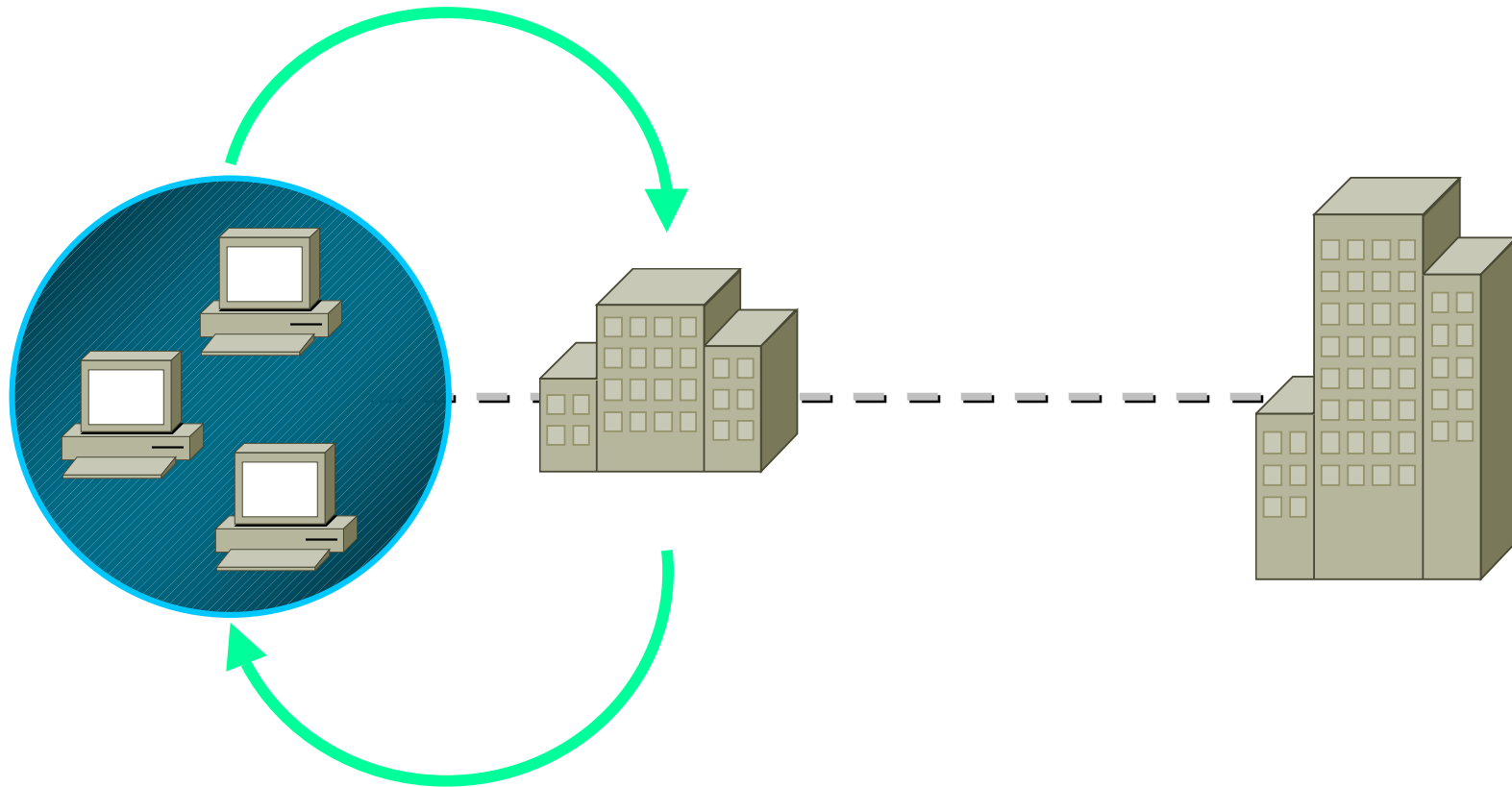
- **Caching 101**
- **Content Engines**
- **Ensuring Cache Freshness**
- **Cache Configuration**
- **Deployment Scenarios**
- **Case Studies**



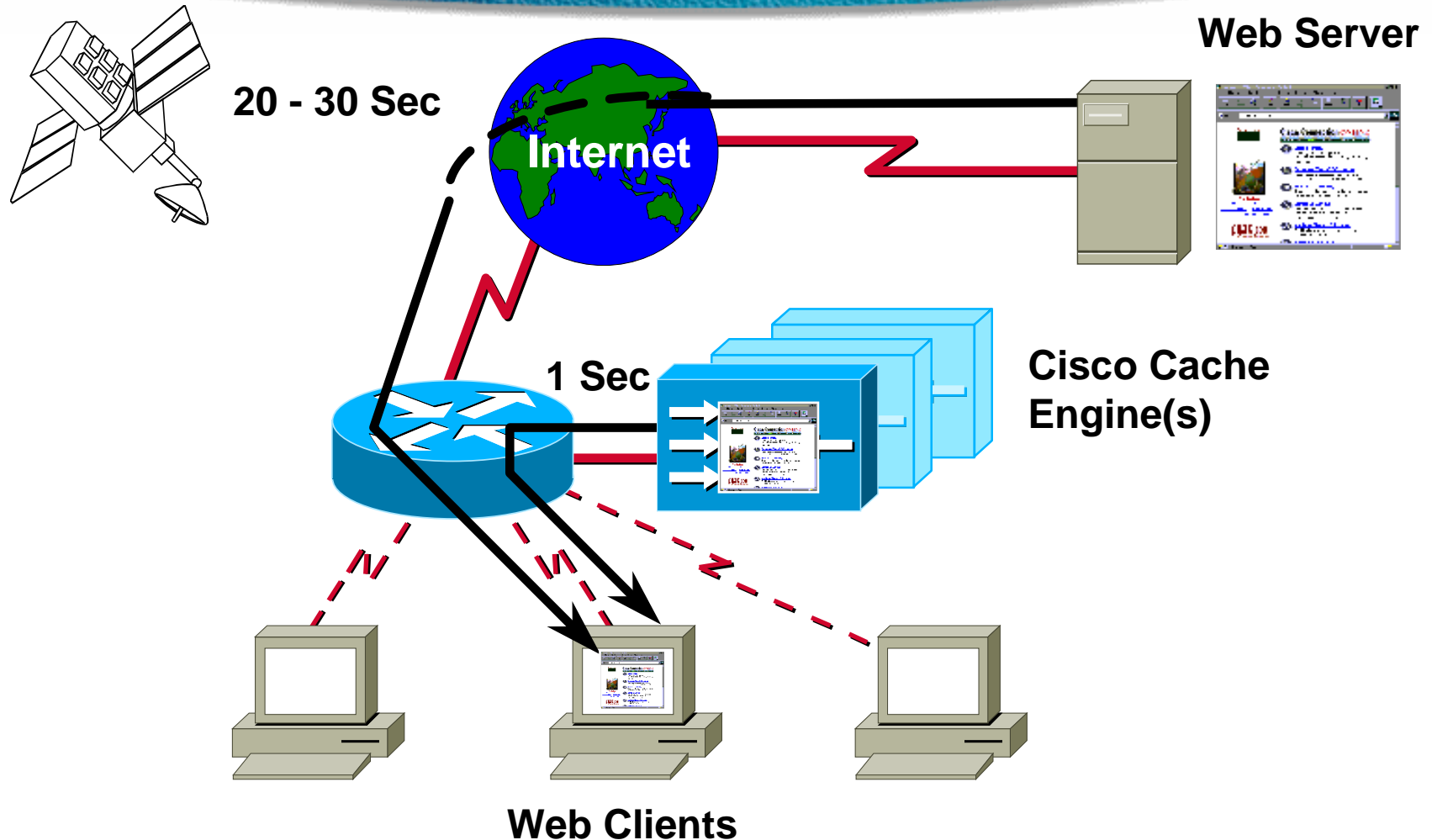
# What does caching do?



# What does caching do?



# Improved Response Time



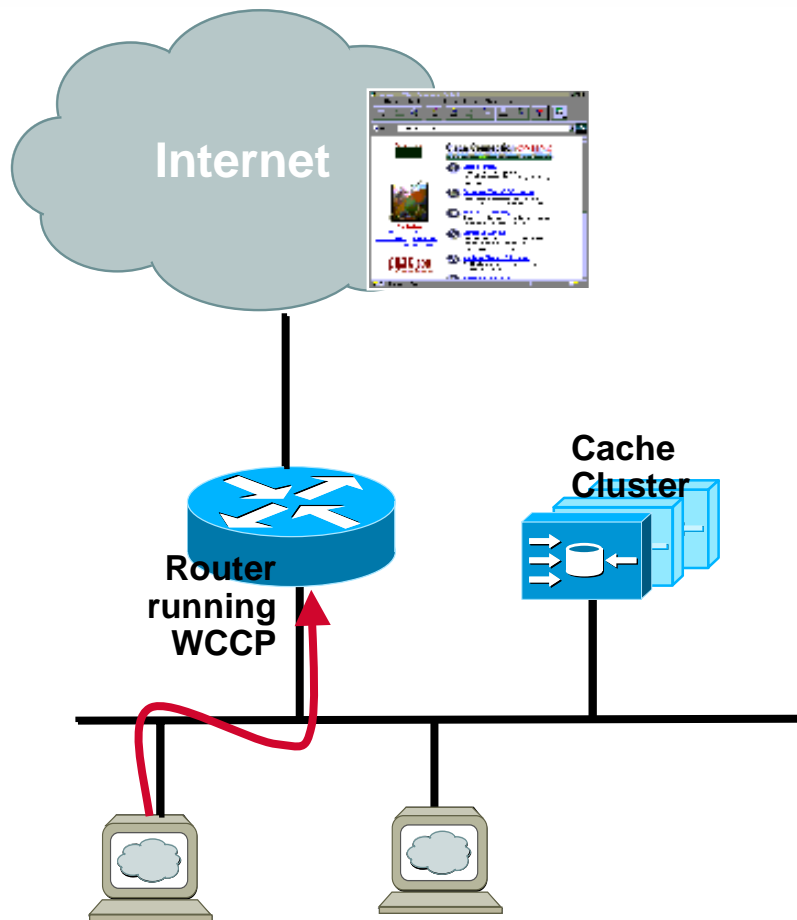
**28.8 Kbps, 56 Kbps, xDSL, trans-oceanic links**

# Reasons for Caching

- **Proxy Cache, Transparent Network Caching**  
store frequently accessed content locally closer to the end-user
- **Reverse Proxy**  
accelerate web-server performance by offloading common (static) pages from the web-server
- **Content Distribution Networks (CDNs)**  
Cache Engine → Content Engine

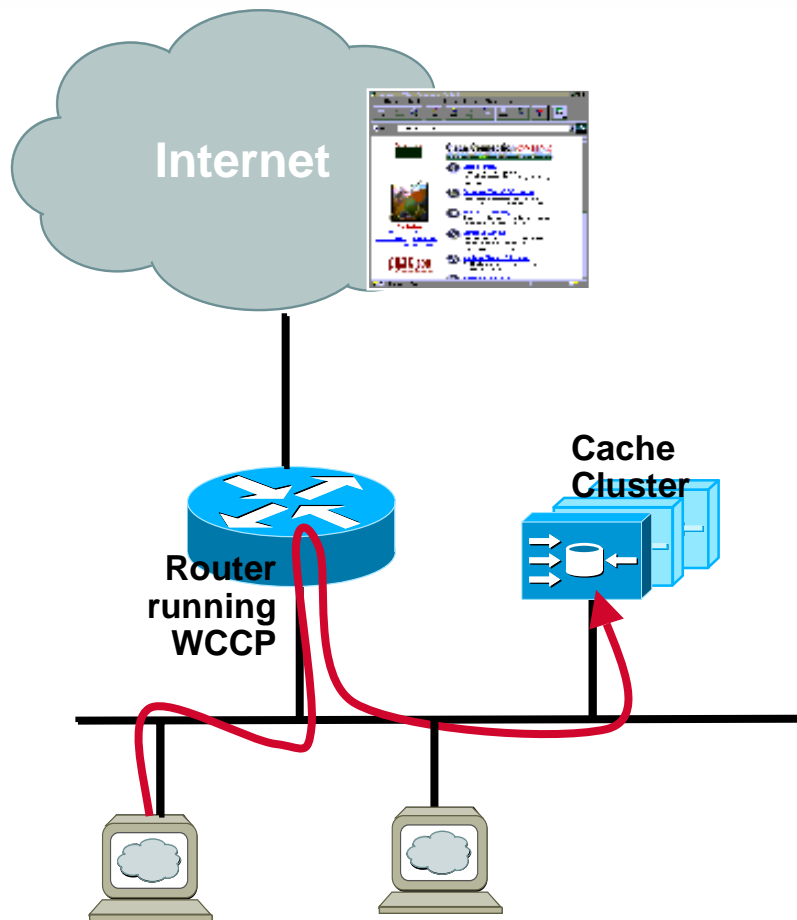
# Transparent Network Caching

- Connection initiated from web-browser





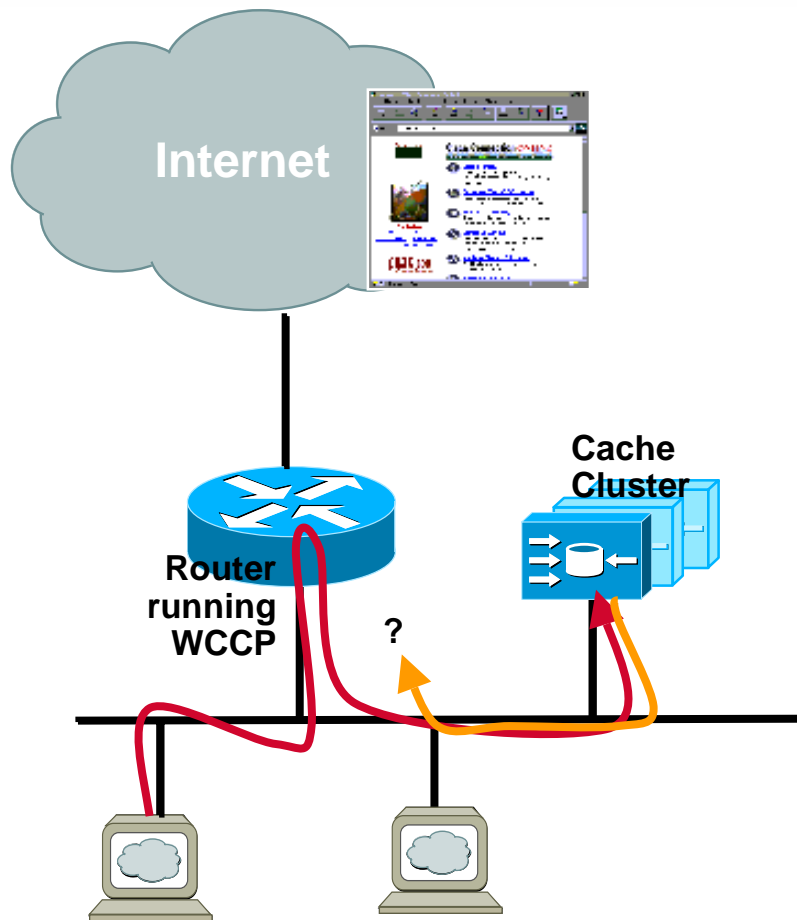
# Transparent Network Caching



- Connection initiated from web-browser
- Router ***intercepts*** flow and **redirects** it to new location (the original packet is encapsulated unchanged within a GRE frame)

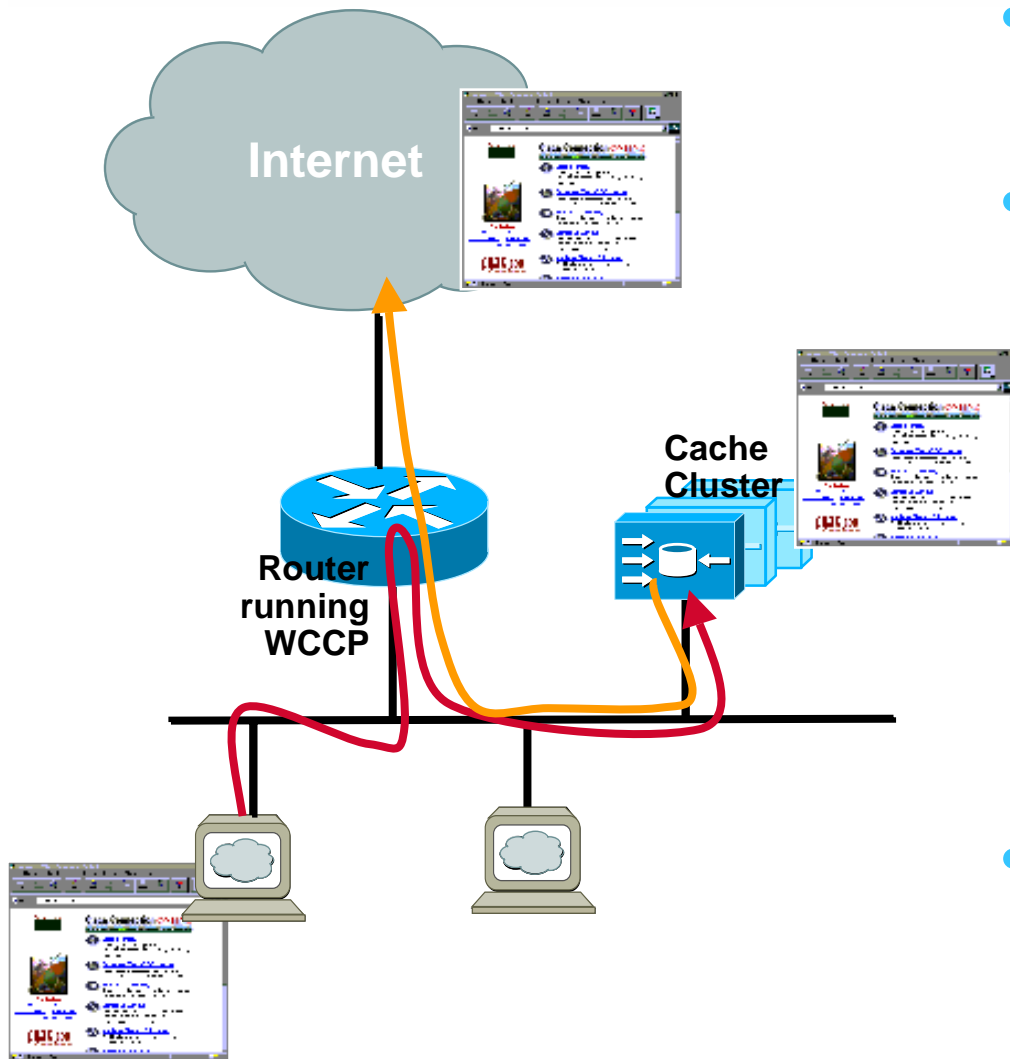


# Transparent Network Caching



- Connection initiated from web-browser
- Router intercepts flow and redirects it to new location (the original packet is encapsulated unchanged within a GRE frame)
- **Device that flow is redirected to can choose what to do with flow --**
  - send somewhere else
  - masquerade as real server

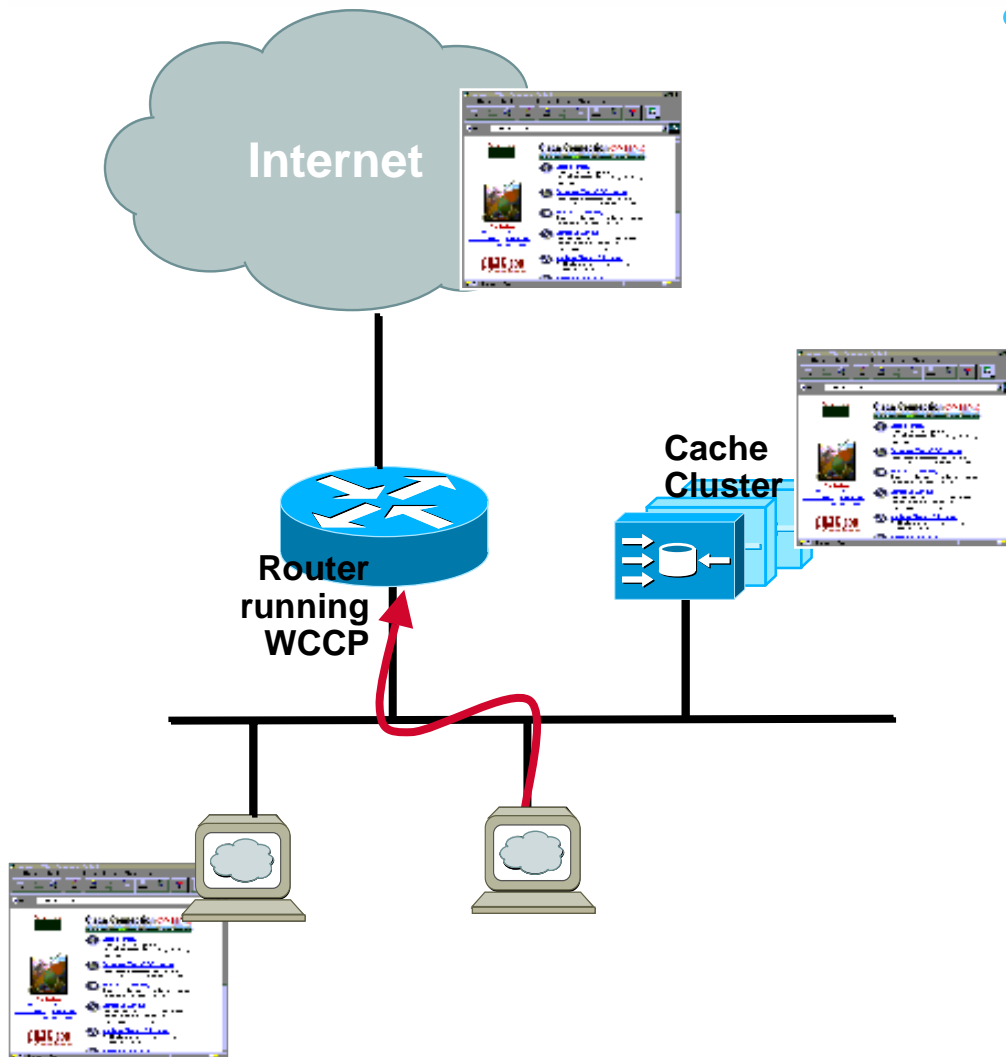
# Transparent Network Caching



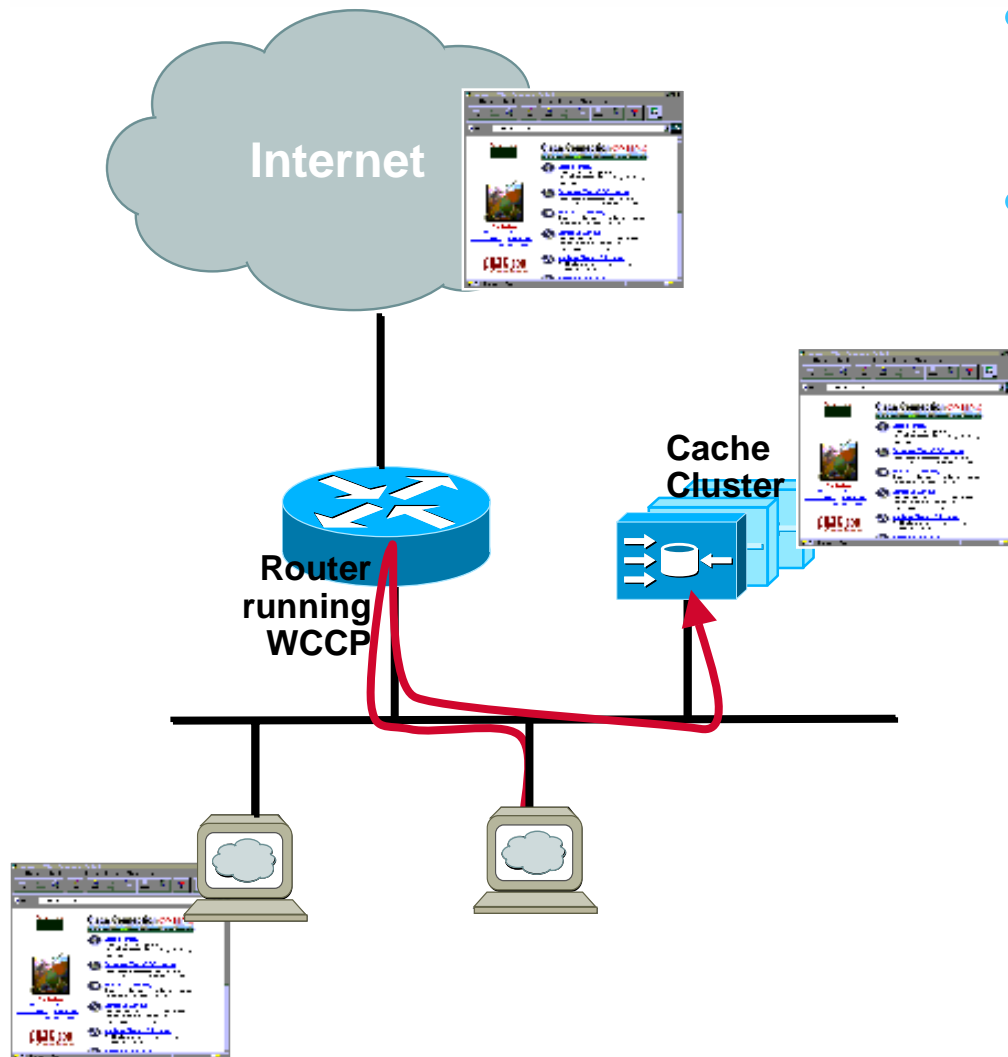
- Connection initiated from web-browser
- Router intercepts flow and redirects it to new location (the original packet is encapsulated unchanged within a GRE frame)
- Device that flow is redirected to can choose what to do with flow --
  - send somewhere else
  - masquerade as real server
- **Cache Engine will serve flow (in case of *hit*), will initiate second flow if a *miss***

# Transparent Network Caching -- subsequent requests

- Connection initiated from web-browser



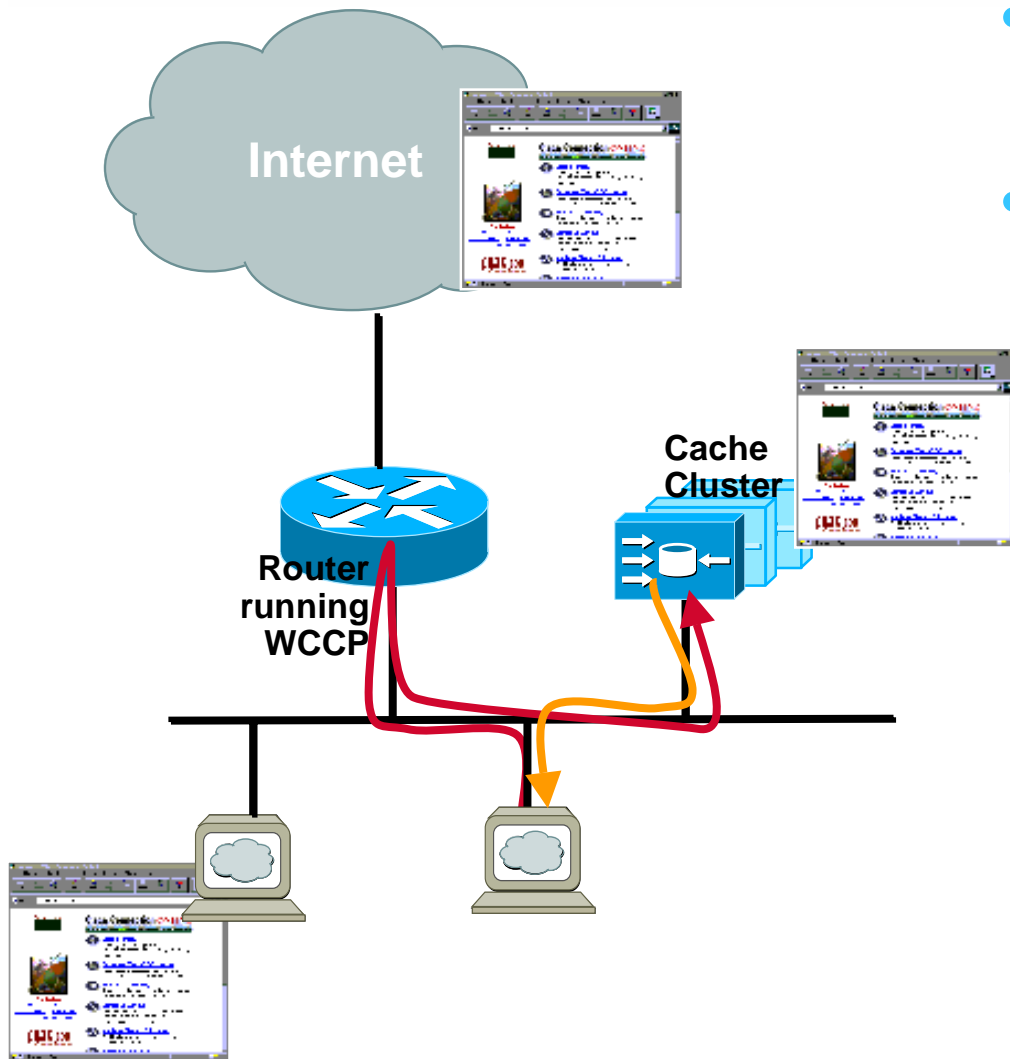
# Transparent Network Caching -- subsequent requests



- Connection initiated from web-browser
- Router ***intercepts*** flow and **redirects** it to new location (the original packet is encapsulated unchanged within a GRE frame)



# Transparent Network Caching -- subsequent requests



- Connection initiated from web-browser
- Router intercepts flow and redirects it to new location (the original packet is encapsulated unchanged within a GRE frame)

**Cache masquerades as the web-server. Object is served locally from the cache**

# Network Caching Benefits

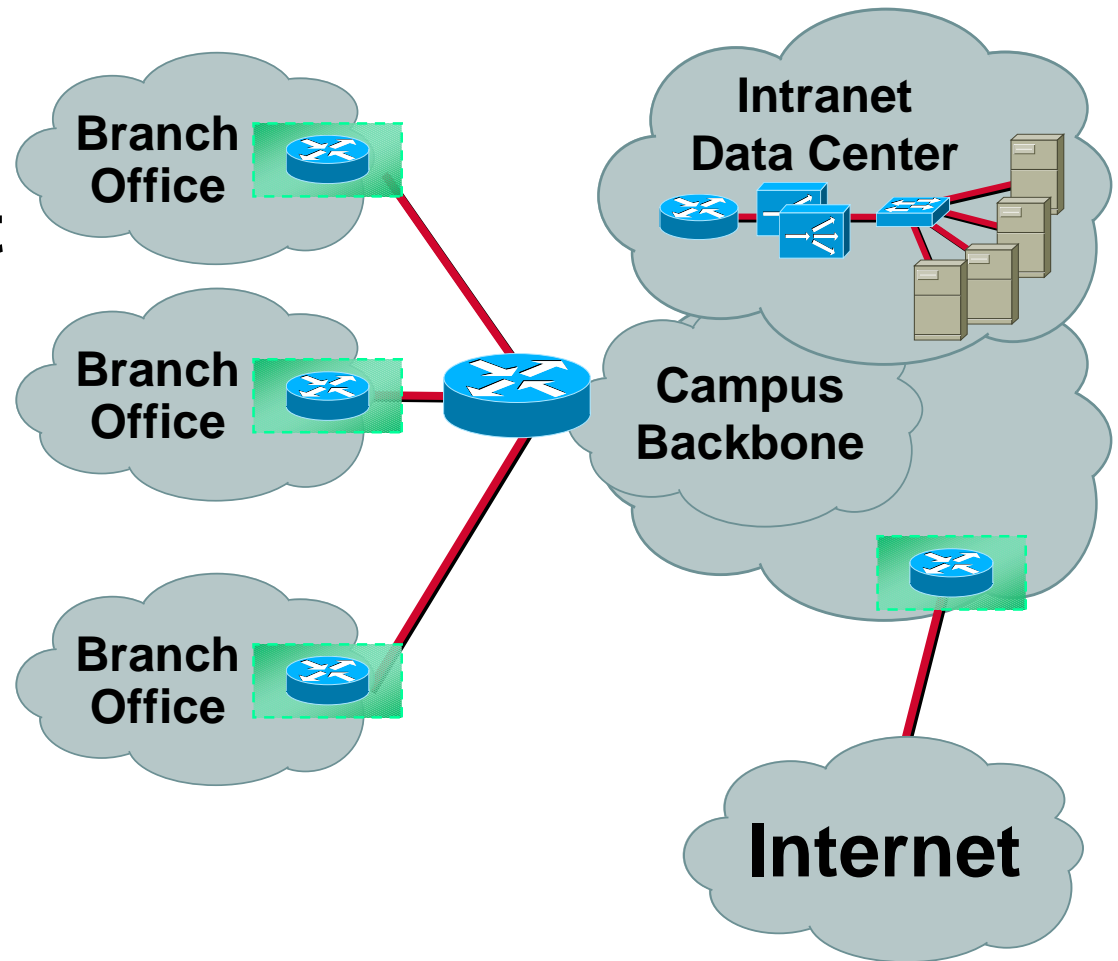
- **Minimizes redundant traffic on WAN links** (help make room for voice)
- **Significant bandwidth savings**
- **Deliver faster network response time**
- **Significant network cost savings:**

**Monthly savings = Bandwidth (Mbps) x  
Monthly BW cost/Mbps x  
Percent HTTP traffic x  
Byte hit rate**

**Payback period =  $\frac{\text{purchase price}}{\text{monthly savings}}$**

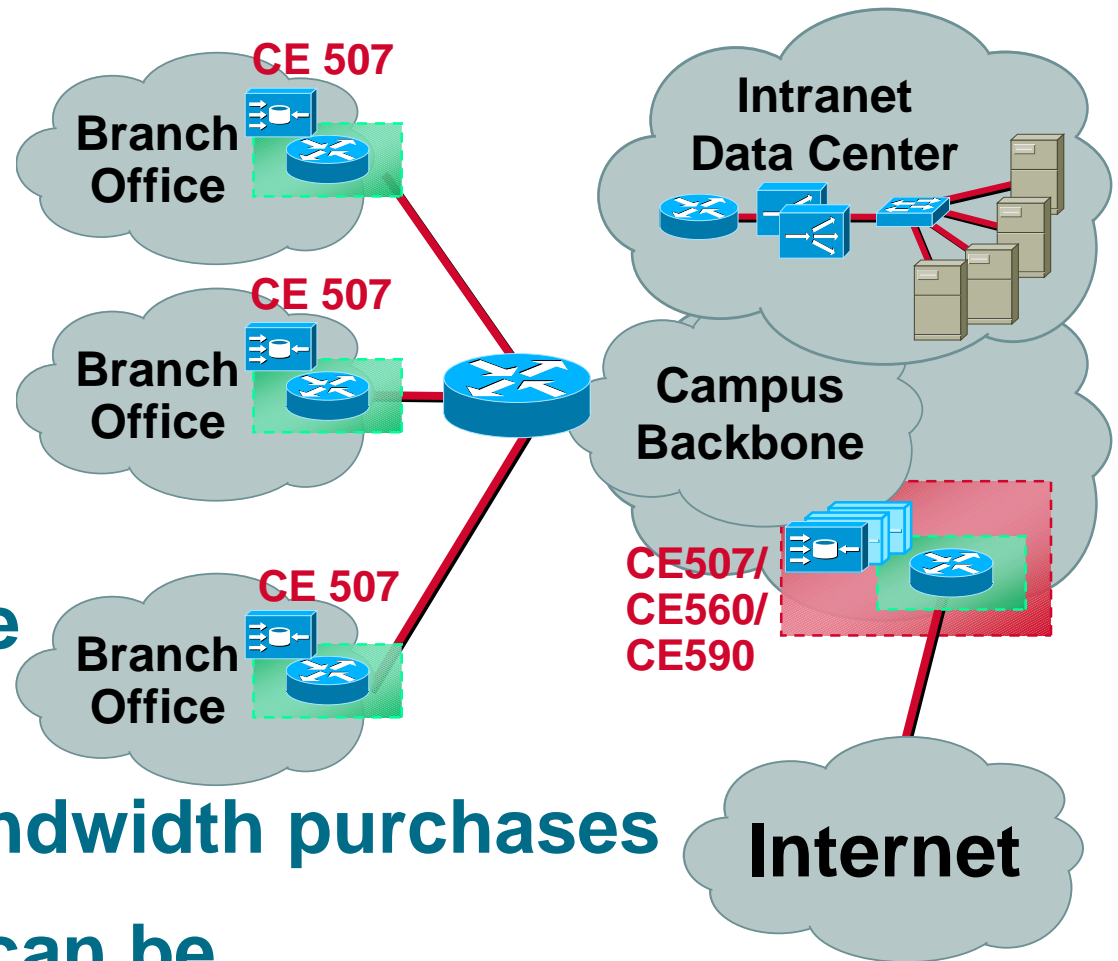
# Enterprise Challenges

- Deployment of new web-based apps
- Significant increases in amount of data traffic (VoIP, ...)
- Increasing operational complexity
- Bandwidth costs
- Slow Web access



# Enterprise Challenges

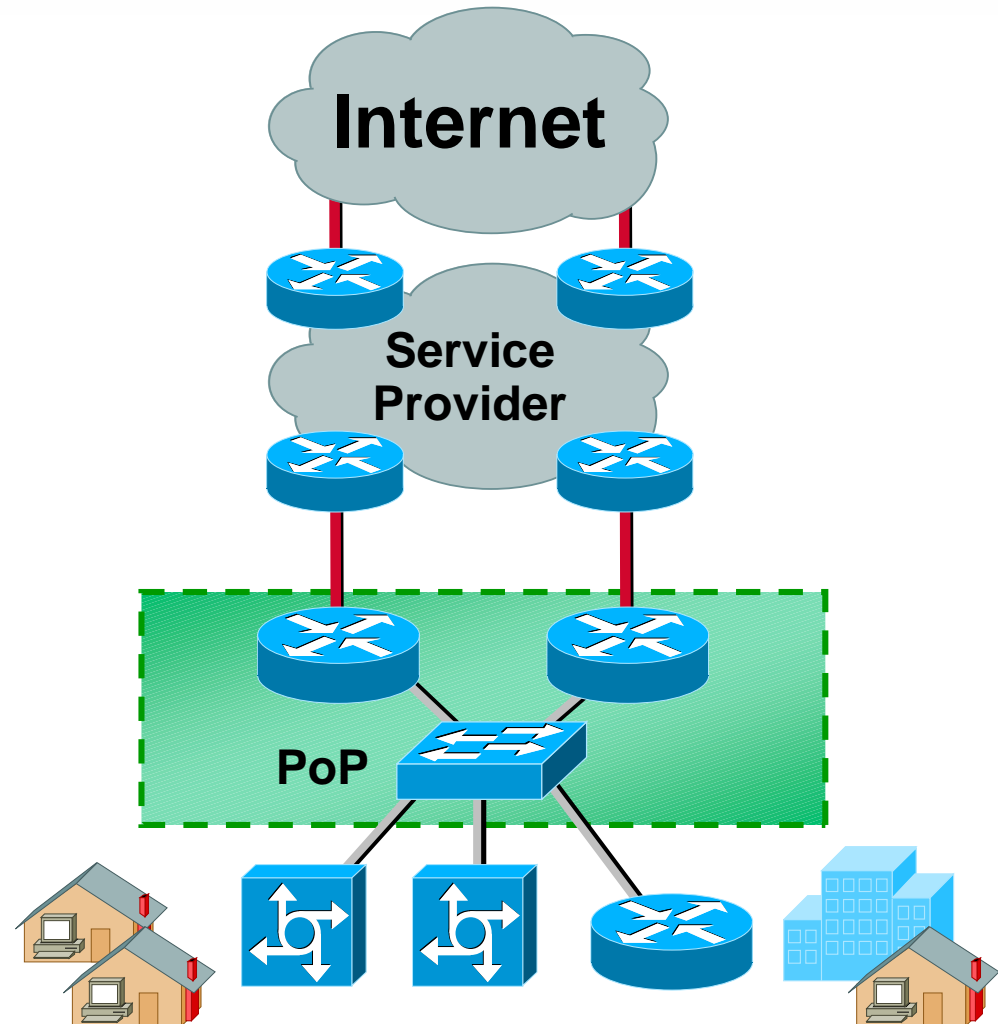
- Deployment of new web-based apps
- Minimised increase in amount of data traffic
- Network no more complex than before
- Delay expensive bandwidth purchases
- Web is as fast as it can be





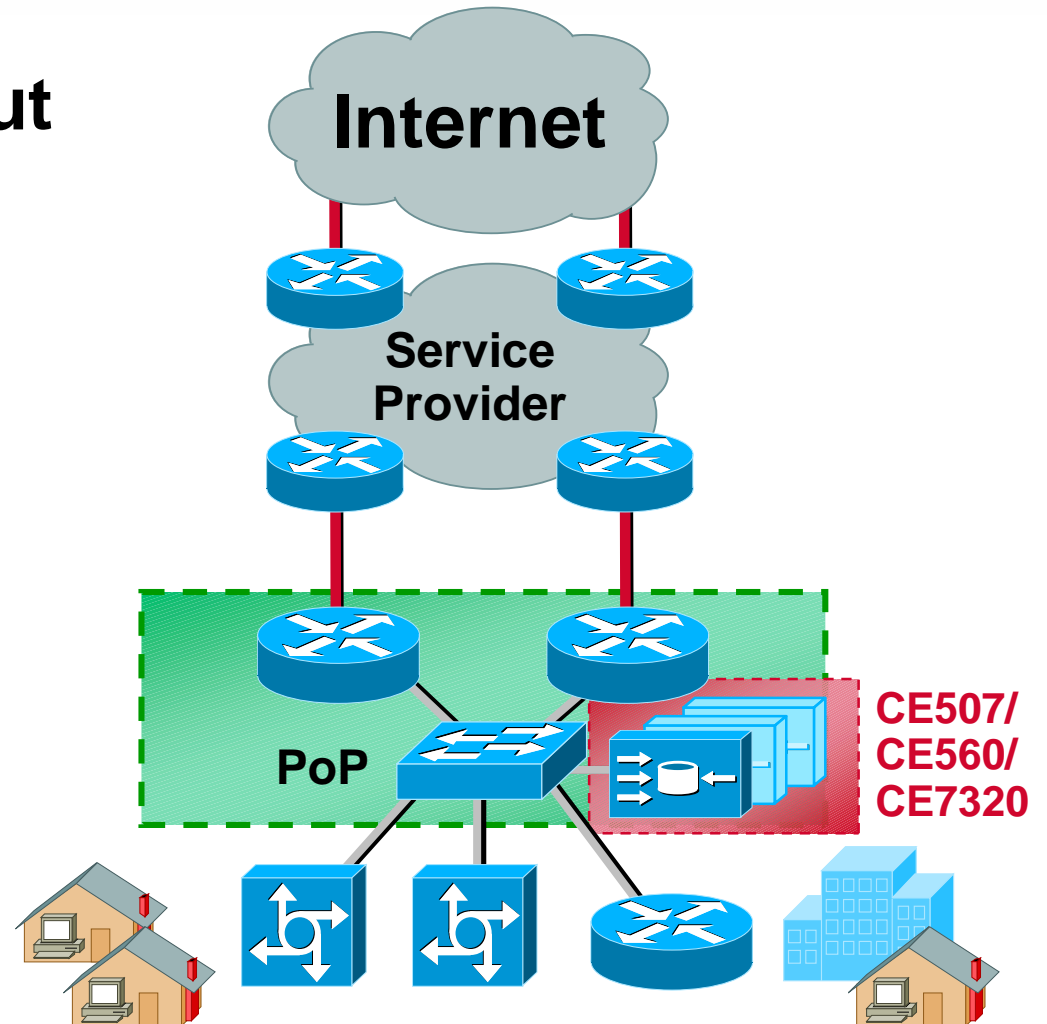
# Service Provider Challenges

- **Exponential Growth**
- **Ever-increasing demand for bandwidth**
- **Ever-increasing network complexity**



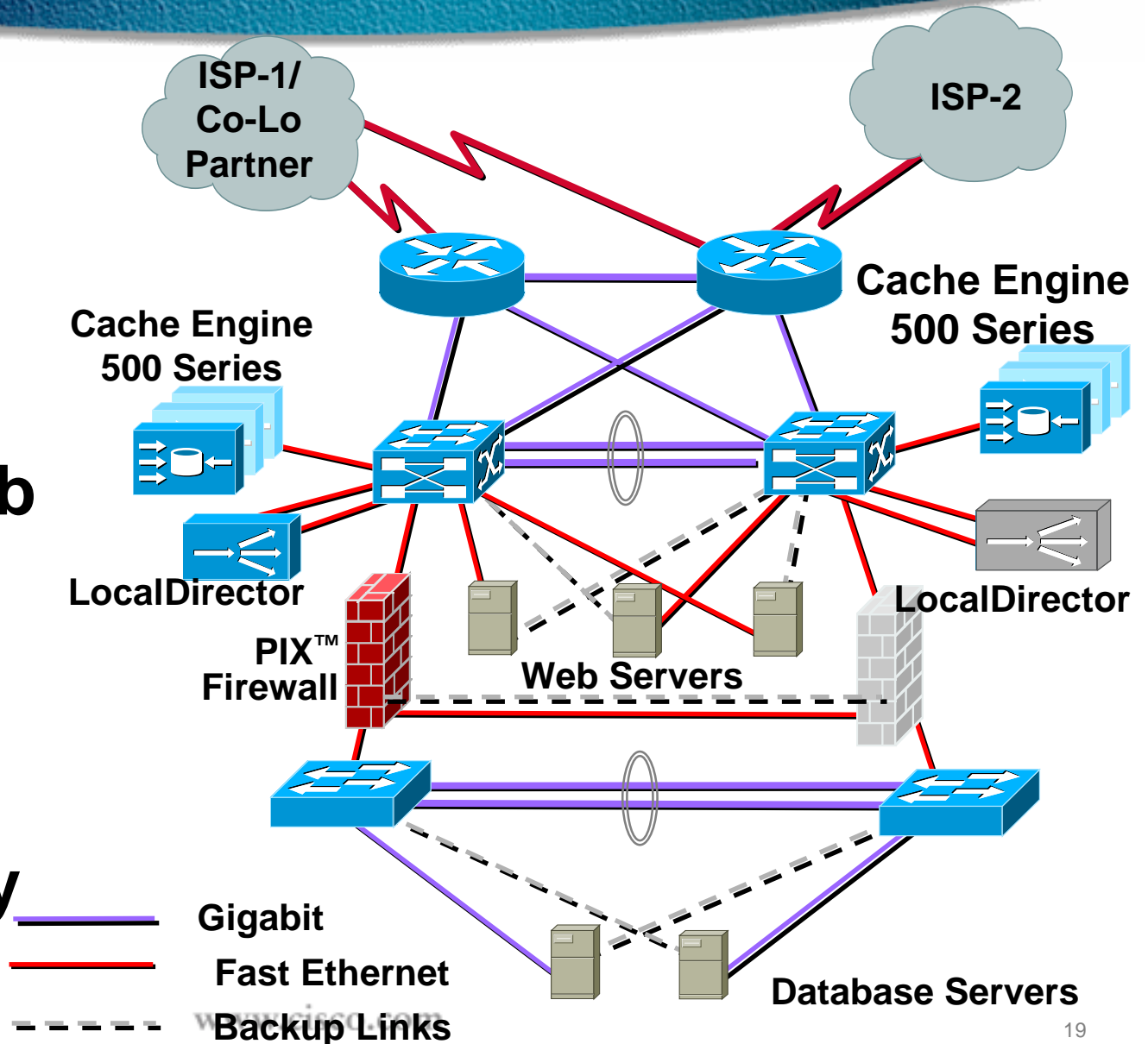
# Service Provider Challenges

- **Controlled Growth** (cut by at least 30%)
- **Network no more complex than before** (via the use of WCCP)



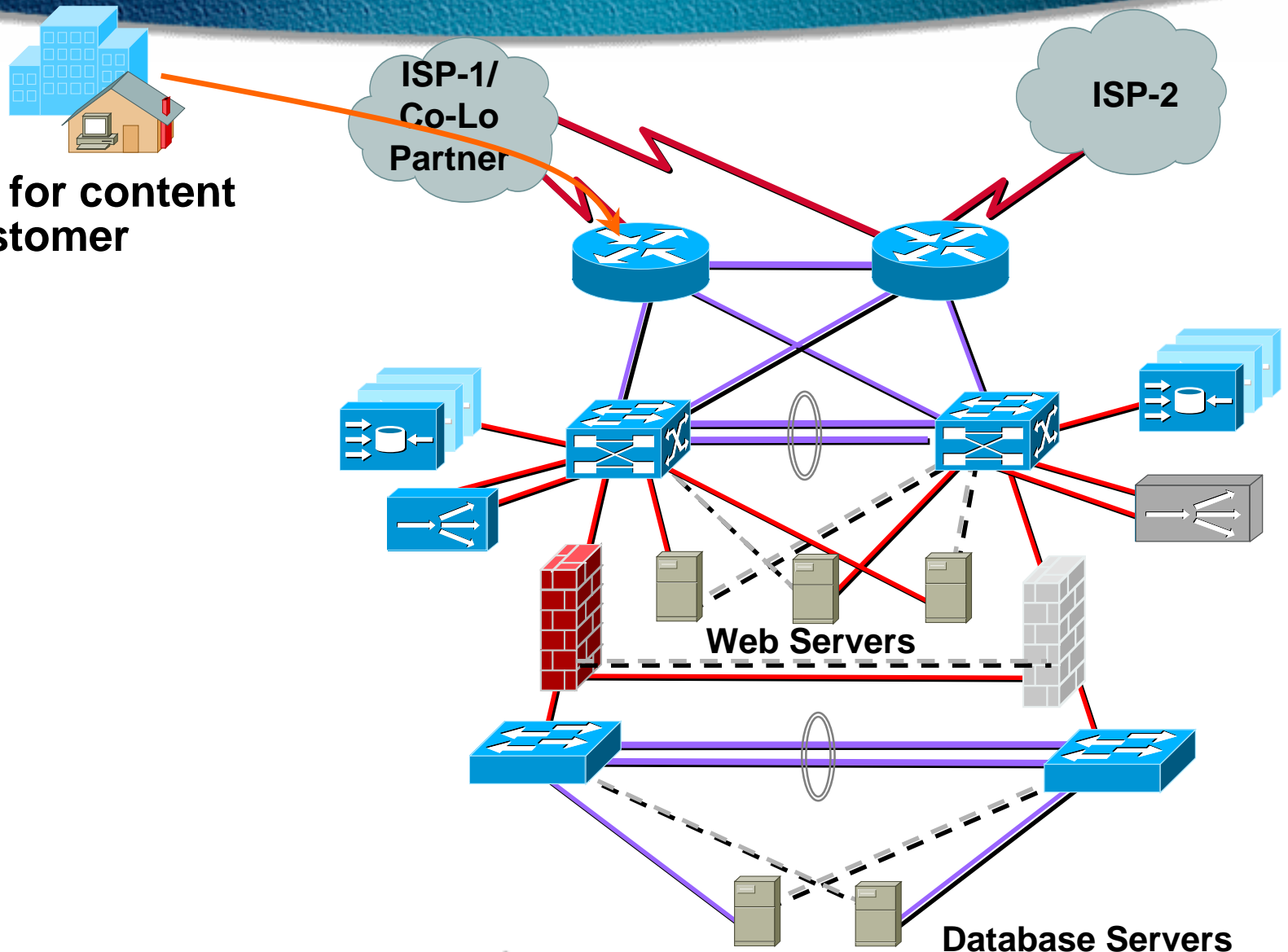
# Reverse Proxying

- Accelerate content-rich services
- Increased web site capacity
- Higher availability / security / manageability



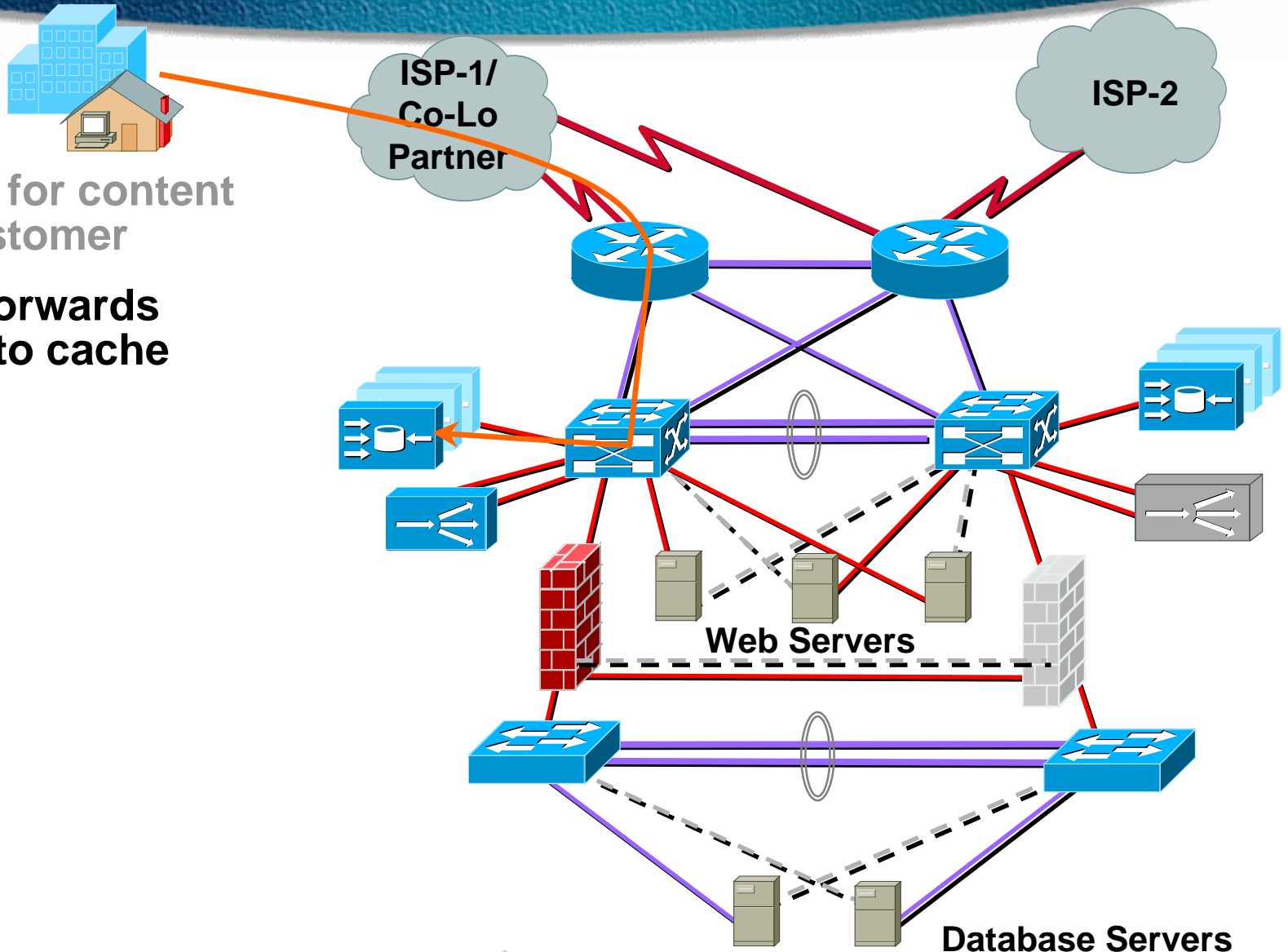
# Reverse Proxying - how it works

- Request for content from customer





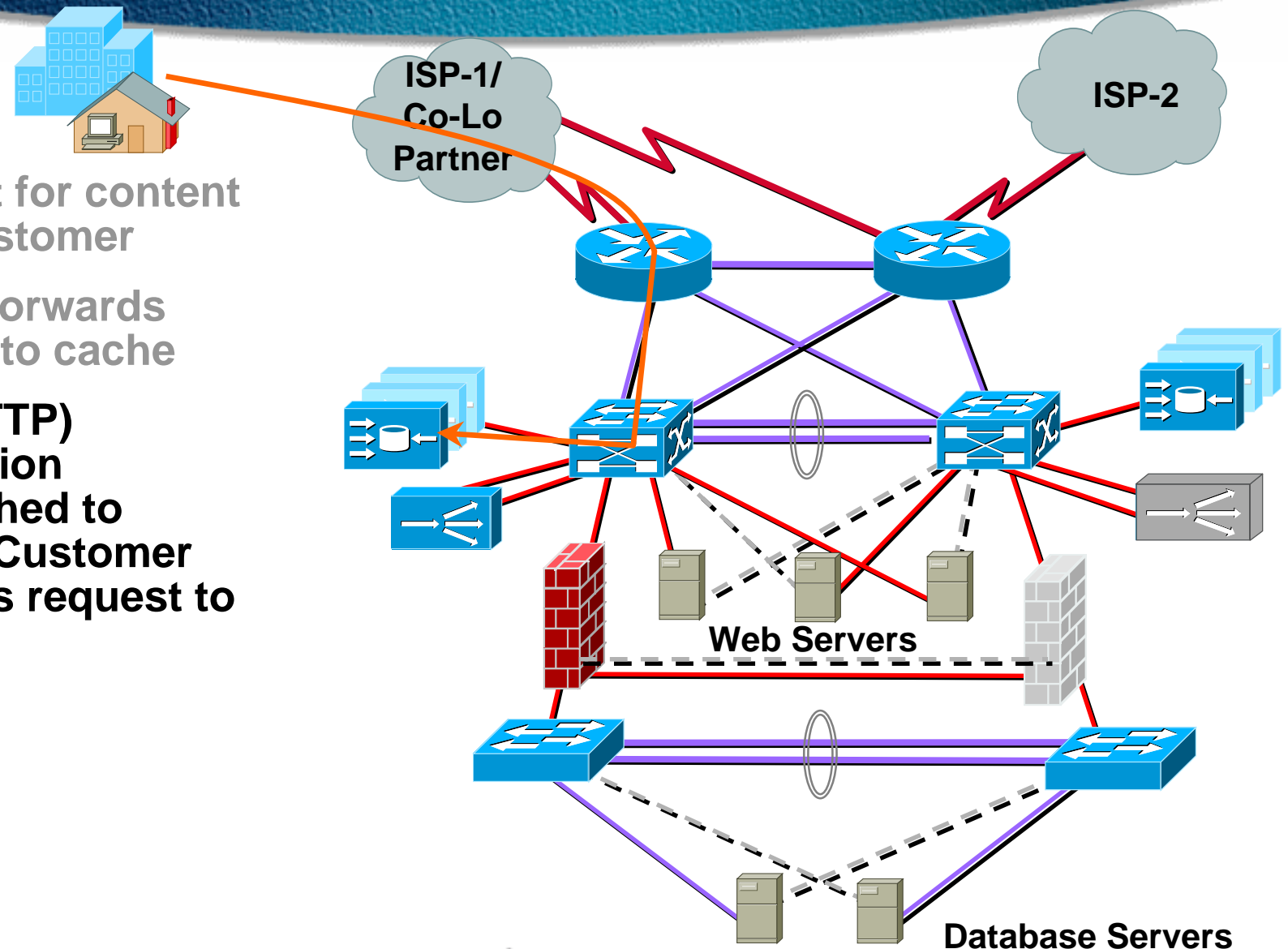
# Reverse Proxying - how it works



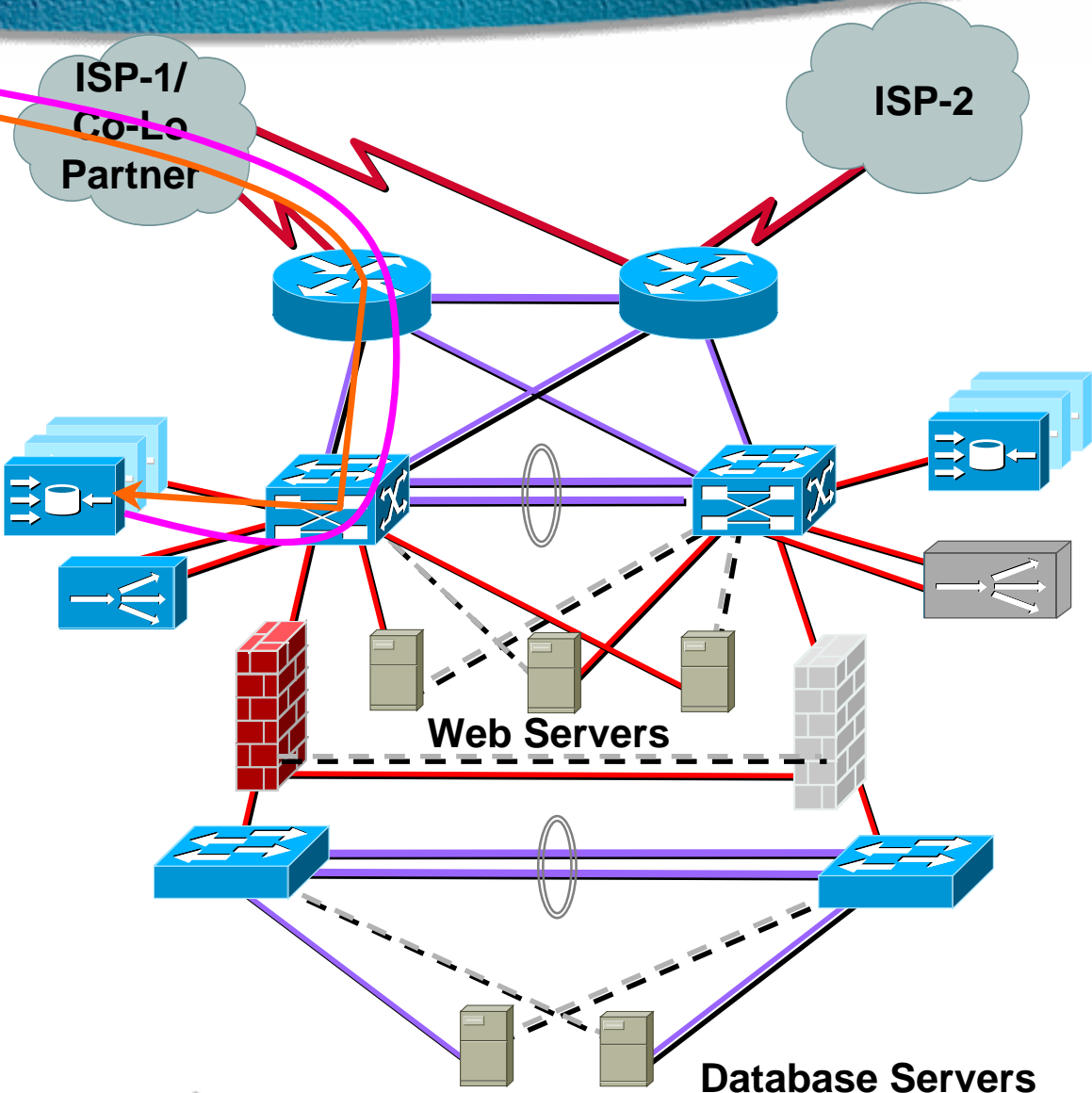
- Request for content from customer
- Router forwards request to cache

# Reverse Proxying - how it works

- Request for content from customer
- Router forwards request to cache
- **TCP (HTTP) connection established to cache. Customer forwards request to cache.**



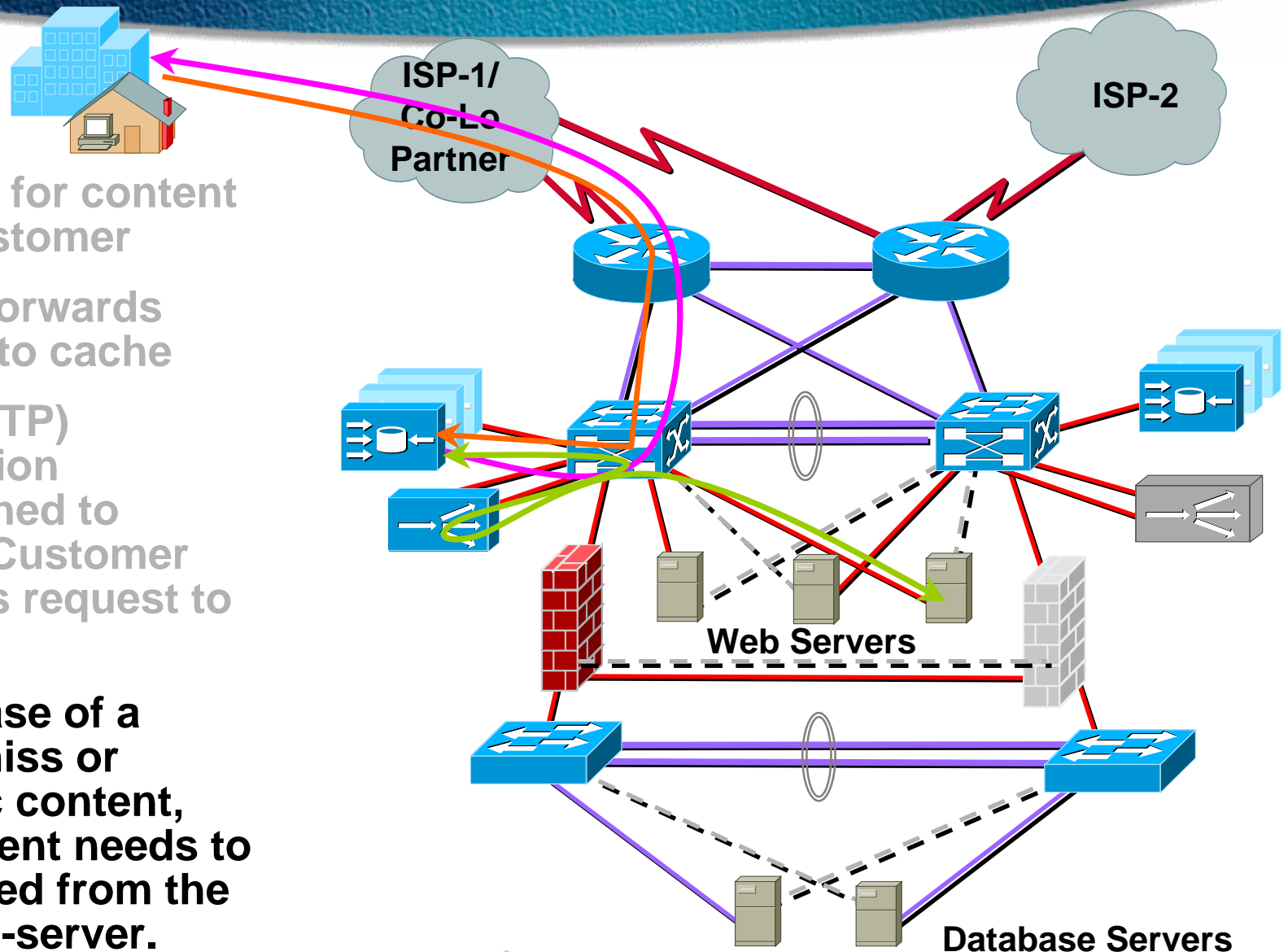
# Reverse Proxying - how it works



- Request for content from customer
- Router forwards request to cache
- TCP (HTTP) connection established to cache. Customer forwards request to cache.
- Requested content is stored on the cache (Cache Hit). Content is forwarded back to customer

# Reverse Proxying - how it works

- Request for content from customer
- Router forwards request to cache
- TCP (HTTP) connection established to cache. Customer forwards request to cache.
- In the case of a cache-miss or dynamic content, the content needs to be fetched from the real web-server.





# The Problem ...

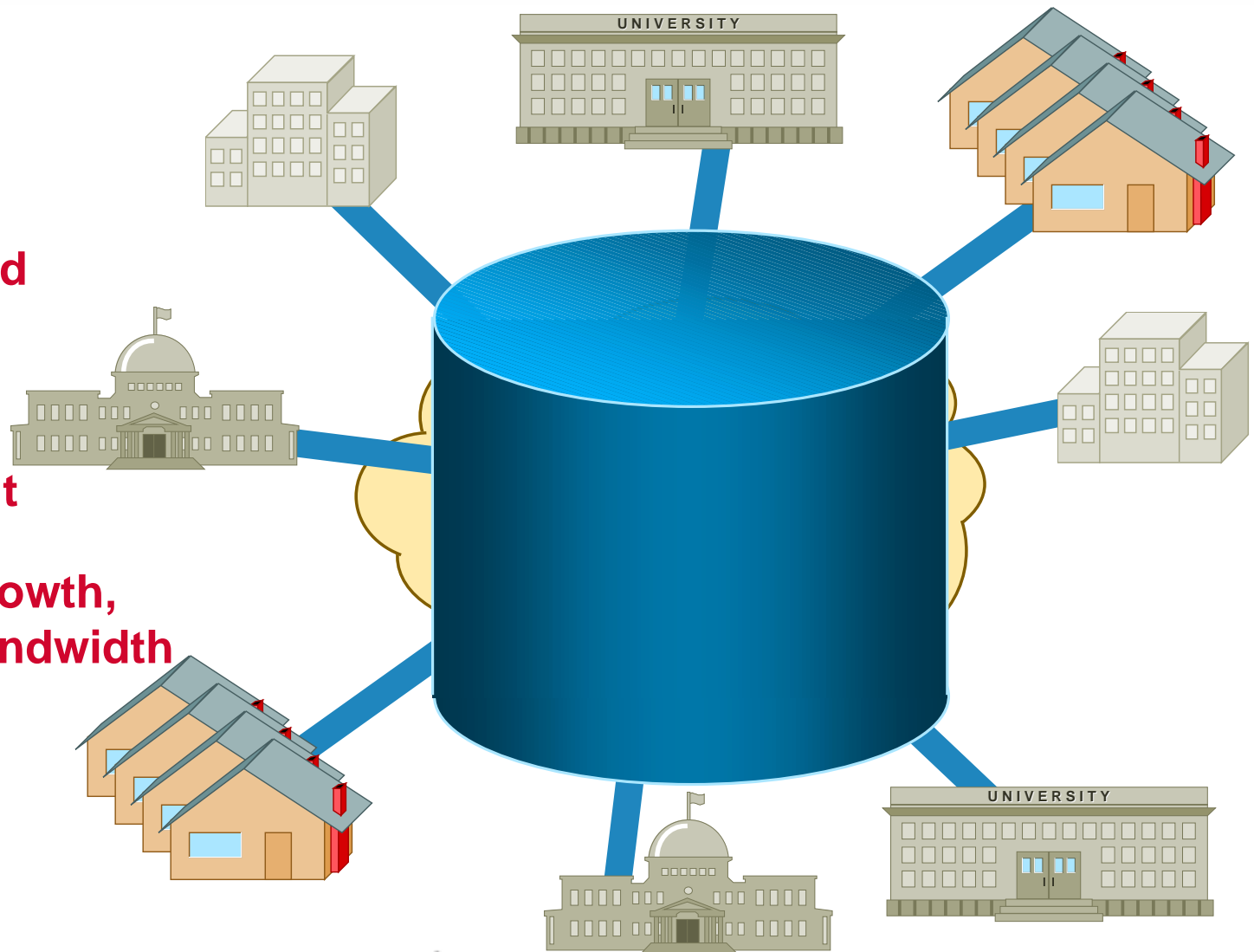
- **The last 5 years were about e-enabling relatively simple applications**
- **The next 5 years will be about moving more demanding applications on the network**
  - e-learning, e-commerce, e-communication**
- **The applications will require:**
  - High bandwidth**
  - High reliability**
  - Large scale**

# Traditional Web Growth

**Web Sites  
Are Centralized**

**Web Grows:  
More Users  
Richer Content**

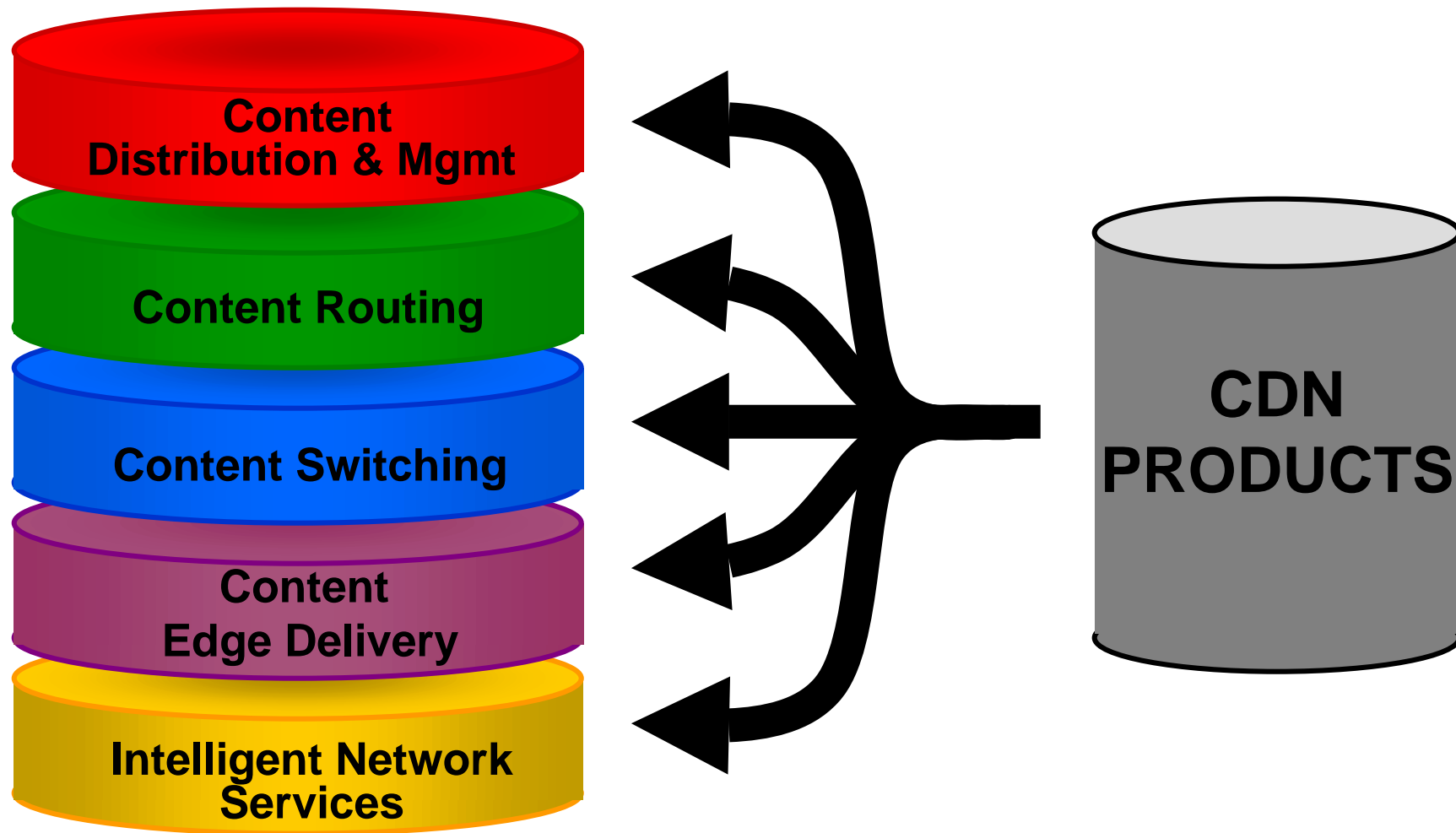
**To Manage Growth,  
Server and Bandwidth  
Are Added**



# **Solution: Content Delivery Network (CDN)**

- **Network infrastructure that cost-efficiently scales e-business applications**
- **Principles:**
  - Distributes content to the edge of the network**
  - Redirects content requests to the optimal content engine for accelerated content delivery**
  - Centrally controls content and CDN components**
- **Eliminates strain of rich content on infrastructure**
- **Increases reliability while scaling to address larger audiences**

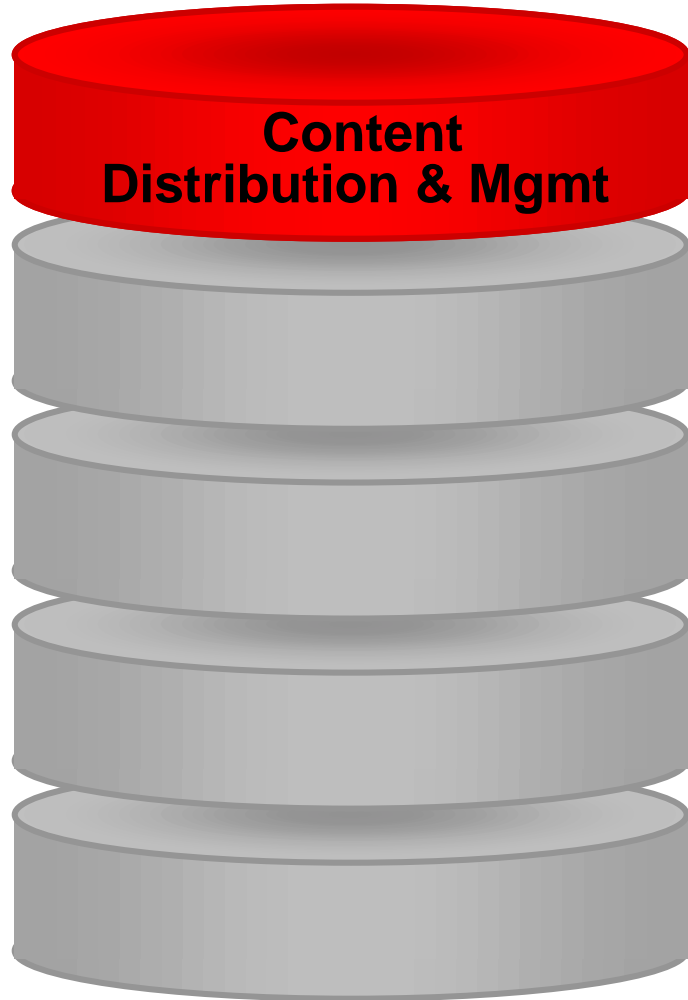
# 5 Key Service Elements of Content Delivery Networks





# 5 Key Service Elements

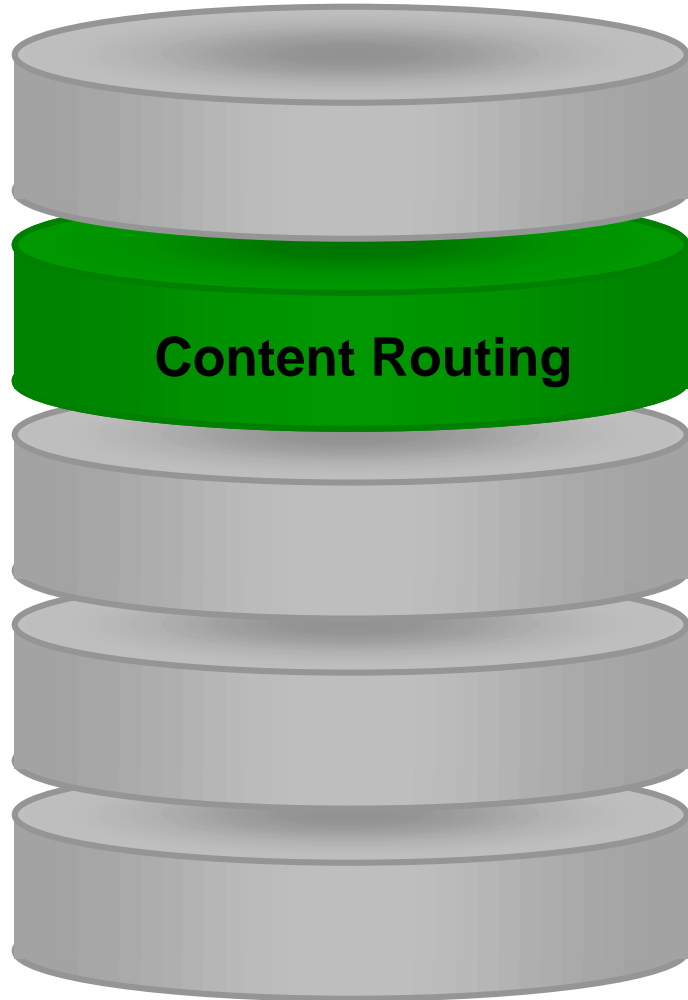
## *Content Distribution & Mgmt*



- **Global centralized provisioning for content distribution**
- **Automatically distribute content to network edge**
- **Management service for CDN monitoring**
- **Configuration management for delivery nodes at network edges**

# 5 Key Service Elements

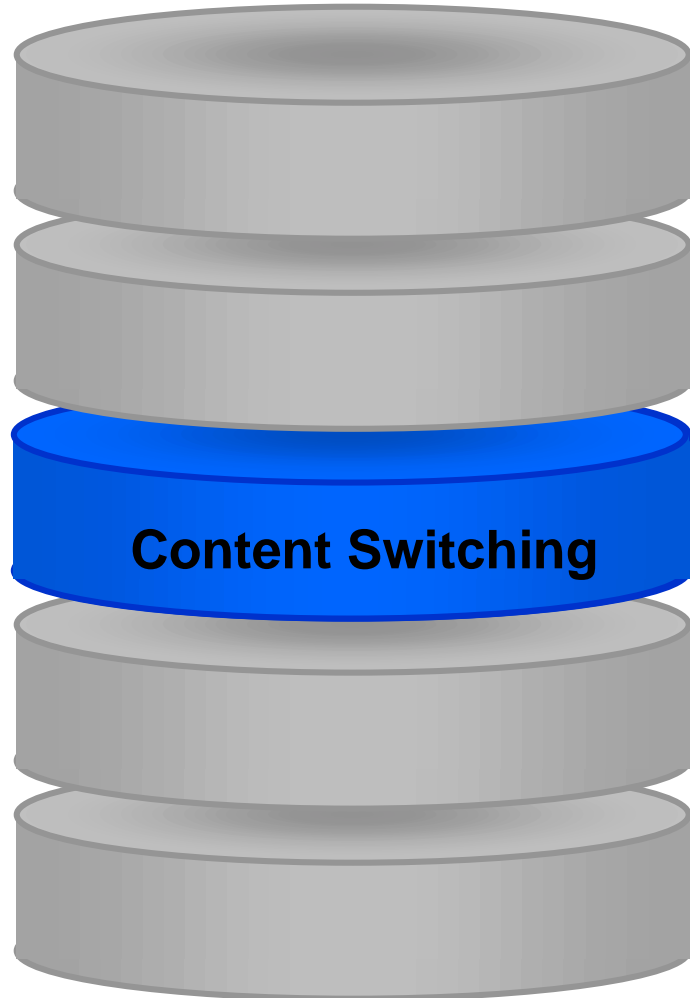
## *Content Routing*



- Reliably route user requests for content to the best site across a CDN
- Metrics include: presence of content, geographic proximity, network conditions, POP load, Content Engine load measure of performance and usage
- Adaptive routing around failures/congestion

# 5 Key Service Elements

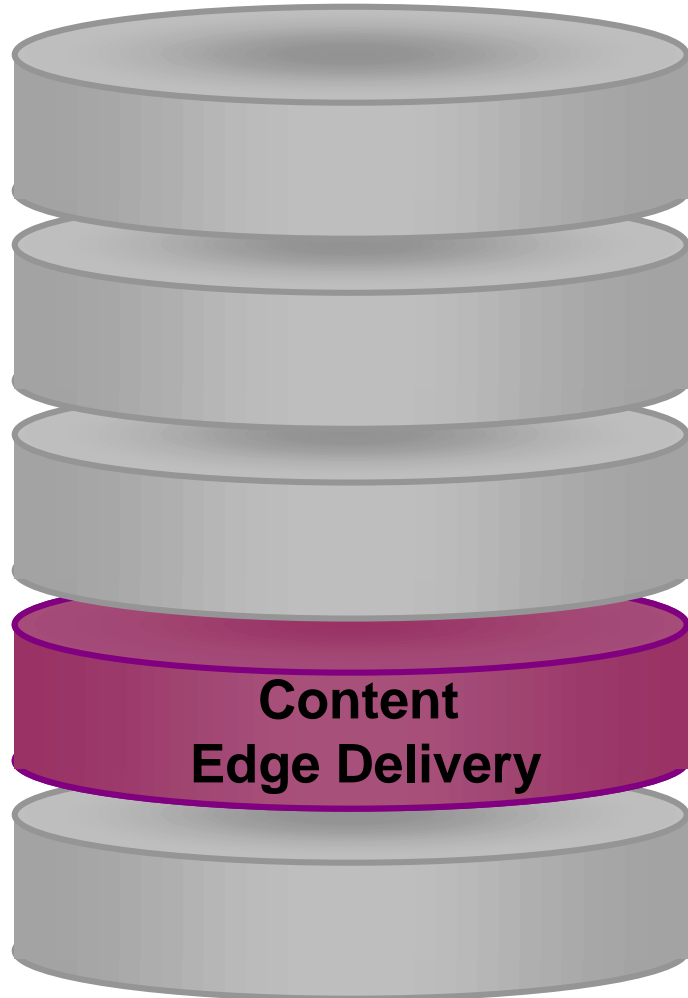
## *Content Switching*



- **Intelligently switch traffic across origin servers for load balancing**
- **Hot-spot detection for intelligent global load distribution**
- **Content verification services to ensure content validity**
- **Determine availability of content and load on server**
- **Server acceleration features to enhance user response time**

# 5 Key Service Elements

## *Content Edge Delivery*

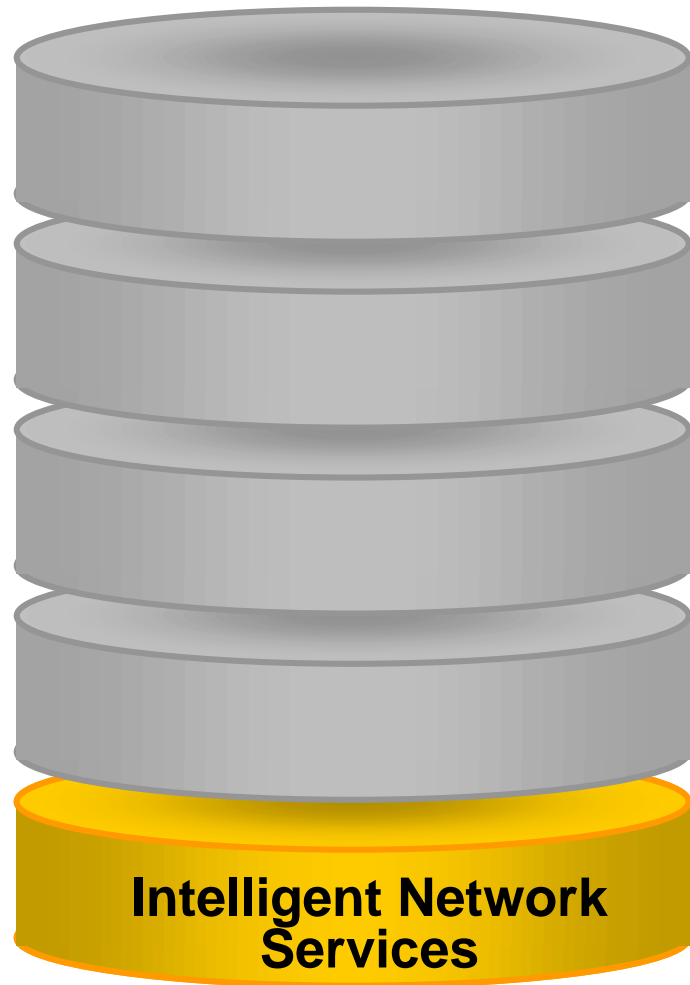


- **Import content and maintain copies at edge of network**
- **Seamlessly deliver content of any type from network edge to end user**
- **Provide content delivery service, streaming, and transparent caching all in one**
- **“Appliance” technology for ease of use and reduced administration**



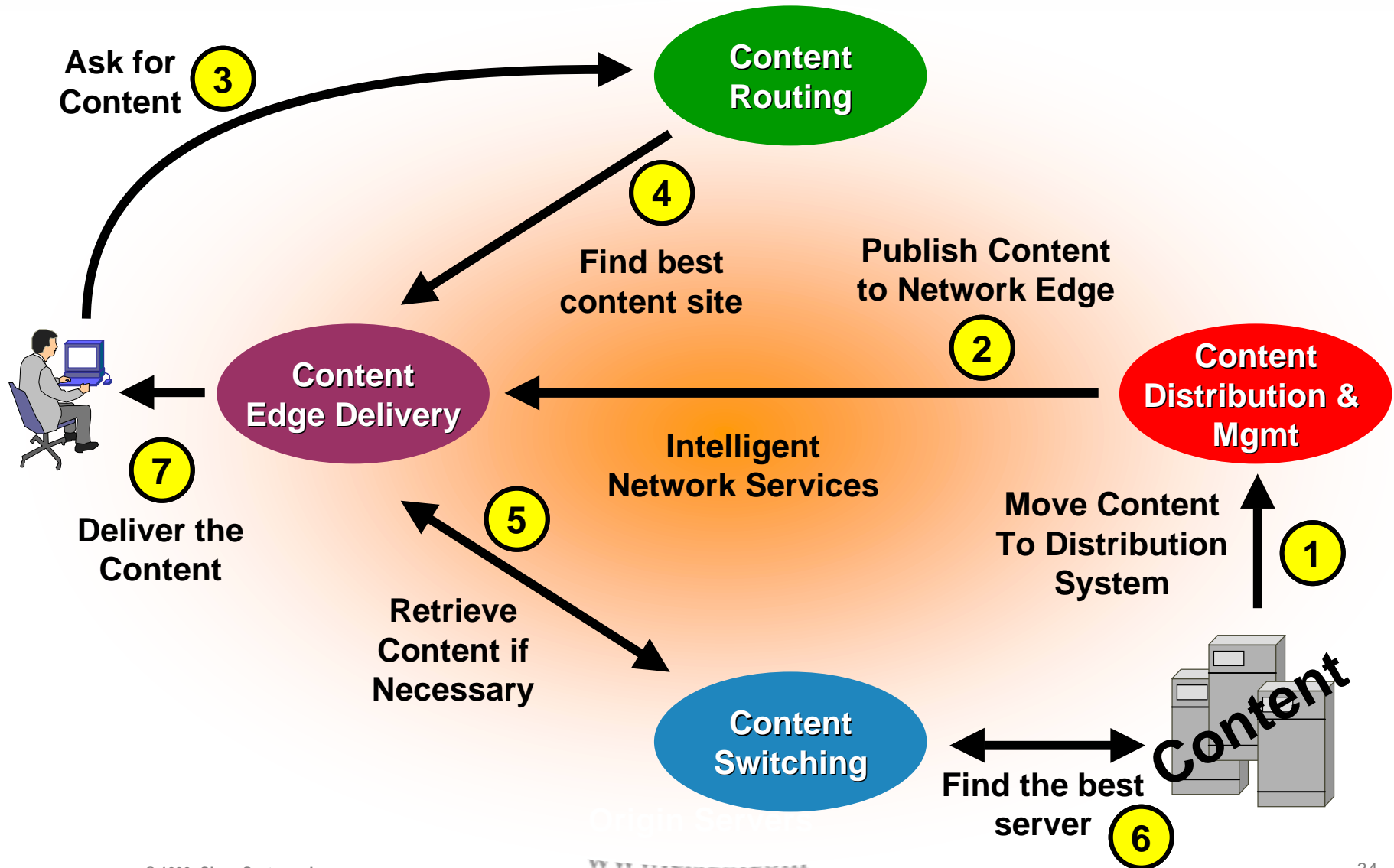
# 5 Key Elements

## *Intelligent Network Services*

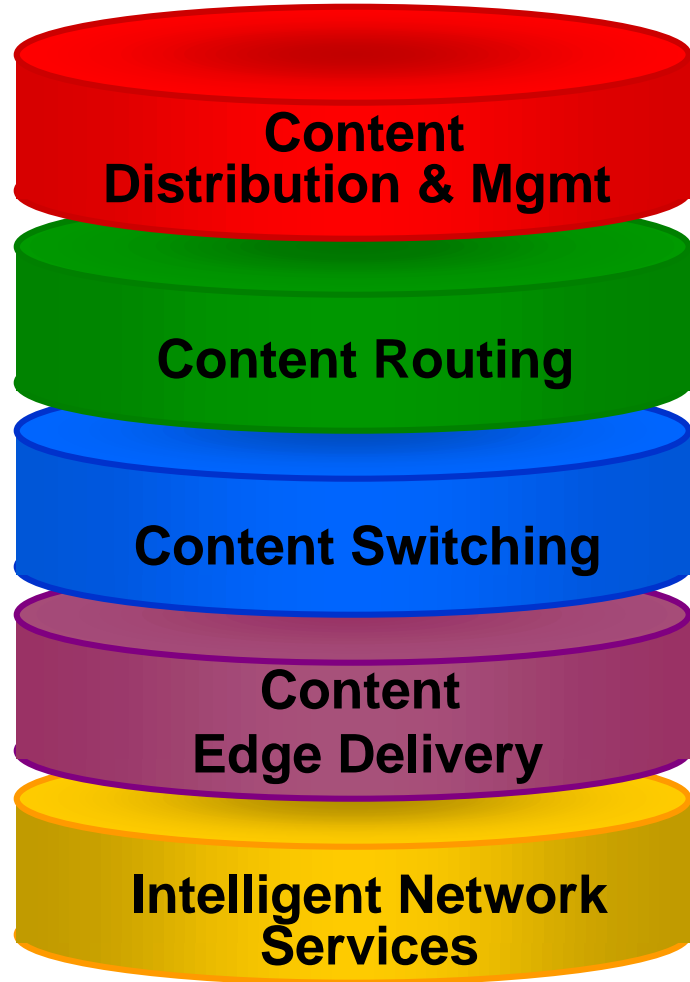


- **Cisco IOS Software: Intelligence within the Cisco IP infrastructure**
- **Required to build reliable and scalable CDNs**
- **A solid layer 2-7 intelligent and application-aware infrastructure**
- **Intelligent network services include QoS, VPNs, Security, and Multicast**

# Functional Overview of a CDN



# What's New?



- **3 Content Distribution Managers (CDM)**
  - + CDN Software, Enterprise 2.0
  - + CDN Software, Service Provider 1.0
- **3 Content Routers (CR)**
  - + CR 4400      + CR 7200
  - + CR 4450
- **3 Enhanced Content Switching Solutions**
  - + CSS-11000 with WebNS 4.0
  - + Catalyst 4840G SLB Switch
  - + LocalDirector with 4.1 software
- **5 New Content Engines (CE)**
  - + CE507, 507AV, 560, 590
  - + CE7320

*With CDN, Web Caching, and Streaming*

# Content Distribution Managers

## CDM

### CDM 4600 Series:

- Management for CDN
- CDN policy & configuration database
- Content, customer registration & domain assignment
- CDN Network monitoring
- CDN Accounting interface
- Enterprise content registry
- Peering/Billing (Future)



**CDM 4650 / 4670**



**CDM 4630**



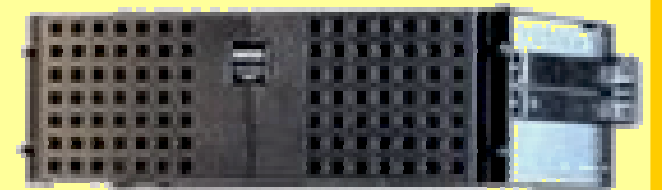
# Content Routers

CR

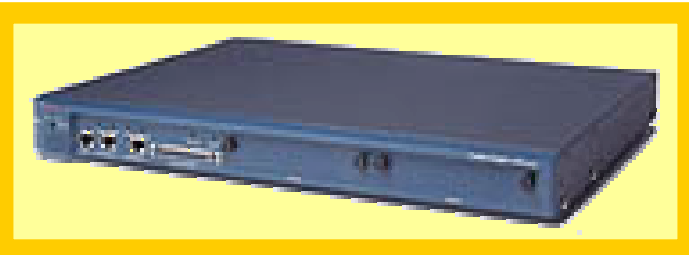
- **DistributedDirector Server Algorithm**  
Routing based on routing metrics  
BGP Route maps (policy)  
Dynamic Feedback Protocol support
- **SightPath SODA Server Algorithm**  
Scales to >10K nodes  
DNS hierarchical mechanism  
Adapts to changing network conditions
- **Boomerang Server Algorithm**  
DNS 'Triangulation' Algorithm  
Transparent Server Selection  
Server health check w/ HTTP GET



**DD 7200**



**CR 4450**



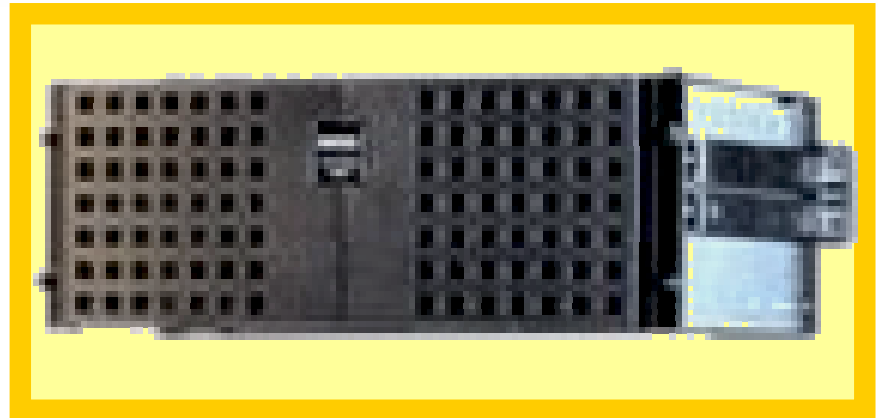
**CR 4400**

# Content Engines

CE

## Content Engine 7300 Series:

- Service Provider & Large Enterprise Deployment
- Caches Enabled Content
- Populated via Pull or Push
- Serves Requested Content



**CE 7300 Series**

## Content Engine 500 Series:

- Enterprise Deployment
- Transparent caching & content delivery software modules
- Static files, Real G2, MPEG 1 & 2 support



**CE 500 Series**

# Datacenter Acceleration with LocalDirector

**Future Enhancements in  
Local Director 4.1 and beyond:  
URL Load Balancing  
Content Routing Agents**

SSL Acceleration  
TCP Aggregation  
XML Services (peering)

**LocalDirector 430/ 416**



**Dynamic Web Page Acceleration**

**Predictive Content Replication**

## **Proven Reliability**

- **Stateful Failover**
- **Layer 7 Persistence**
- **Content Routing Protocol Support**
- **Sophisticated Content Verification**



# Content Switches - Layer 2-4

CS

- **Catalyst 6500 Family:**
  - Up to 256 Gbps switching - modular**
  - Full internet routing protocol support**
  - HW-acceleration with Cisco IOS features**
  - WAN Interfaces (T1/E1, POS, ATM)**
  - Advanced Security Services (ACL / IDS)**
- **Catalyst 4840G Switch:**
  - 22 Gbps switching / 9 Mpps - fixed**
  - Wire Speed NAT**
  - HW-acceleration with Cisco IOS Features**



**Catalyst 6500**



**Catalyst 4840G**



# Content Switches - Layer 7

CS

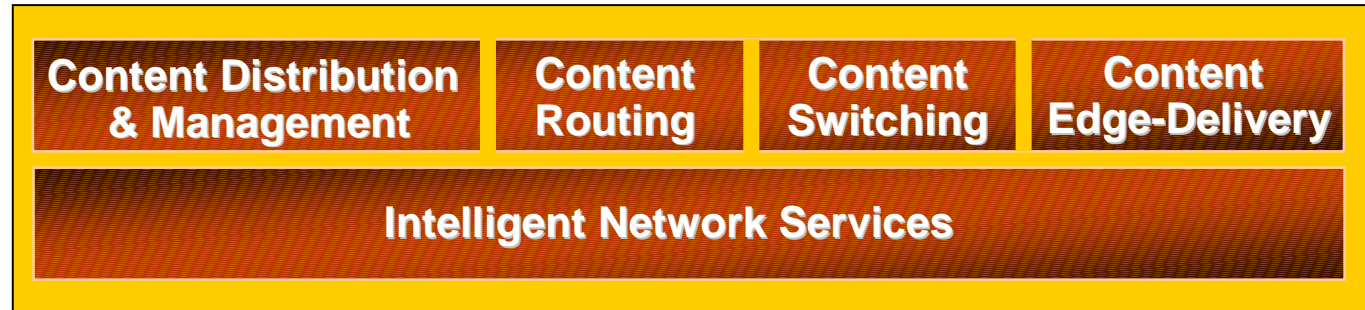
- Scalable product family
  - CSS 11050 - 8 FE, 1 GBE*
  - CSS 11150 - 12-16 FE, 2 GBE*
  - CSS 11800 - 64 FE, 32 GBE*
  - Up to 11 billion hits/day*
- Smart
  - Full content based switching using content, application, network and user level info*
  - Hot-spot or 'Flash Crowd' support*
  - Intelligent Web Cache Bypass*
- Fast
  - Up to 130,000 HTTP transactions per second*



**Content Switch  
11000 Family**

# The Cisco Difference

## Content Delivery Networks

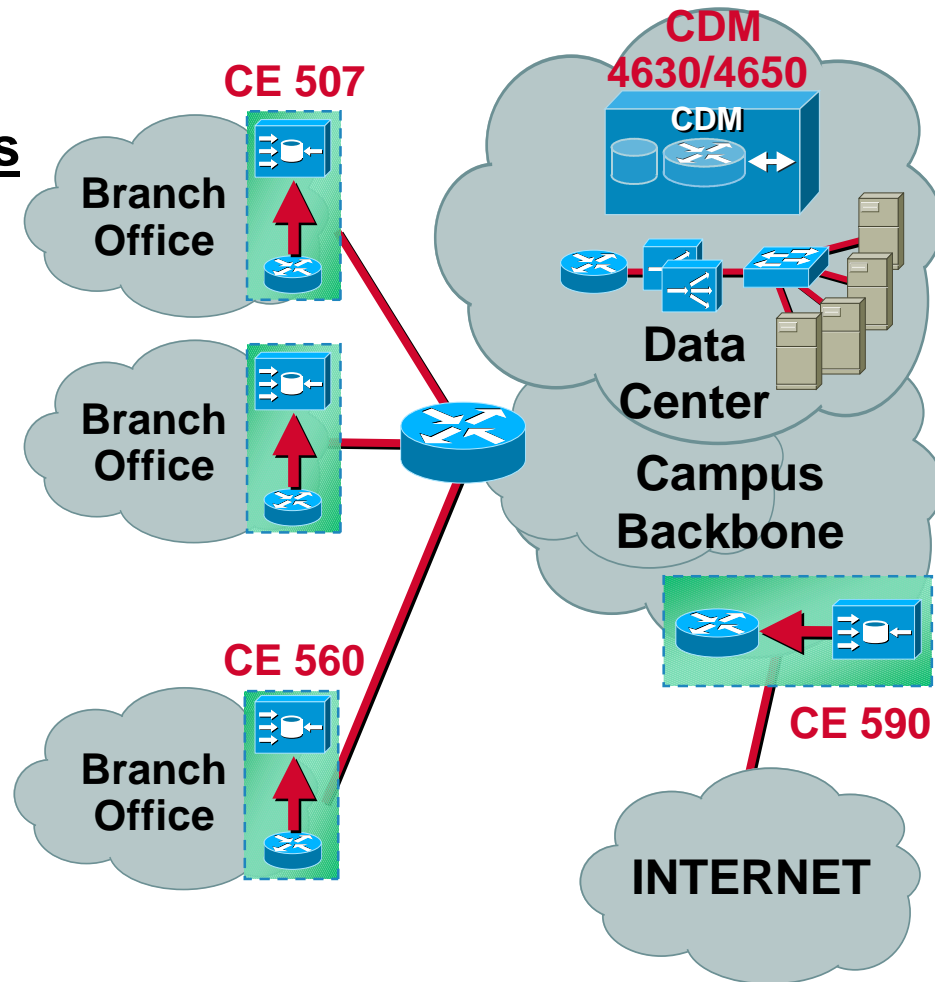


- Cisco is the first and only vendor to deliver a complete system for Content Delivery Networks and Next Generation Content Based Services
- Enables Enterprises and Dot.coms to grow brand equity and increase customer loyalty by improving end-user experience
- Enables Service Providers to build value into their networks and to deploy highly profitable content delivery services

# Enterprise Caching Service and CDN Service

## Caching Benefits

- Accelerated content delivery
- WAN bandwidth savings (25-60%)
- Protection vs. uncontrollable bottlenecks
- Higher employee productivity

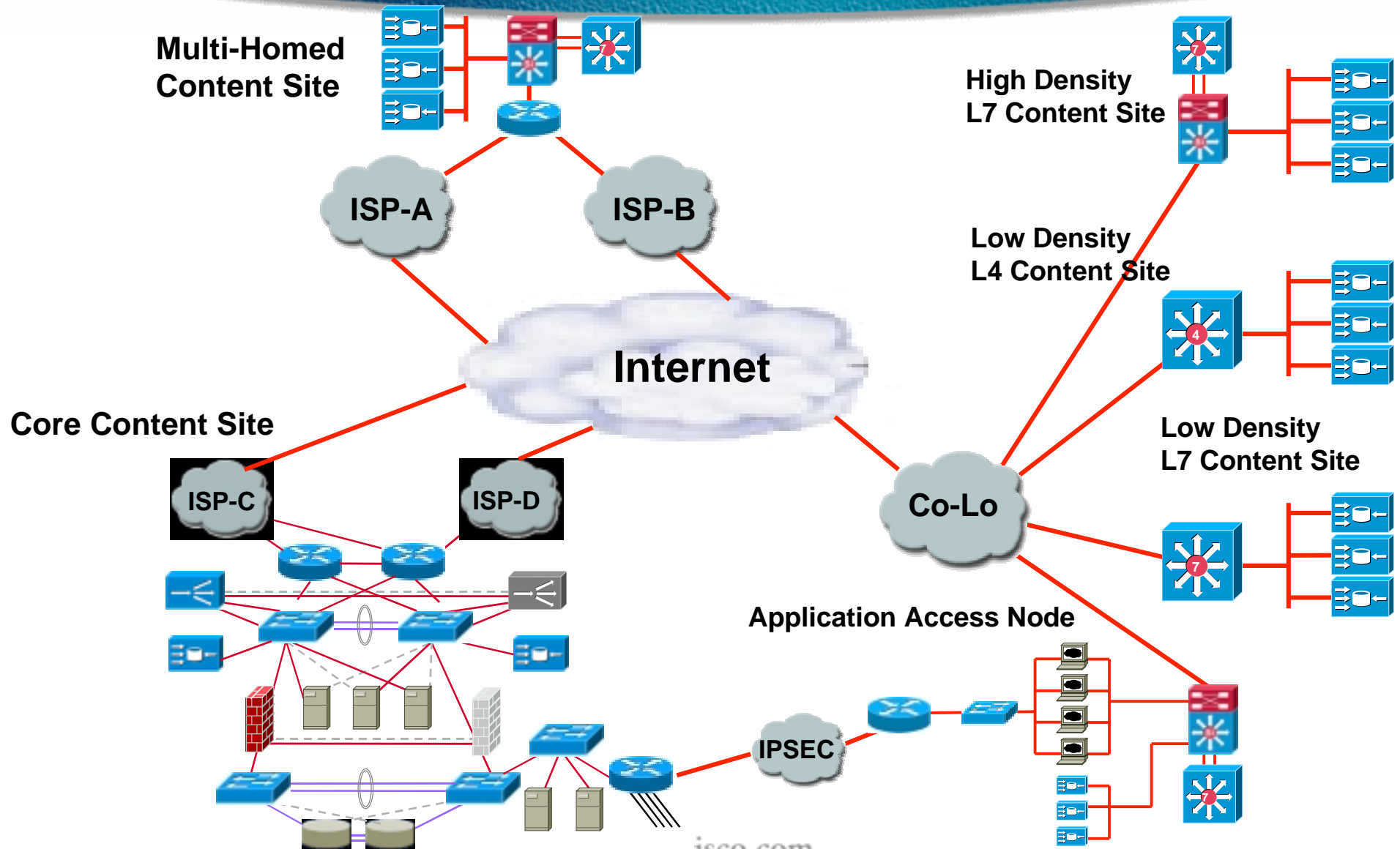


## CDN Benefits

- Enables media-rich e-learning @ branch sites
- TV-quality VoD today without a network upgrade
- Native Real Networks streaming media
- Live video: Use multicast + IP/TV products



# CDN Topology for an e-commerce site





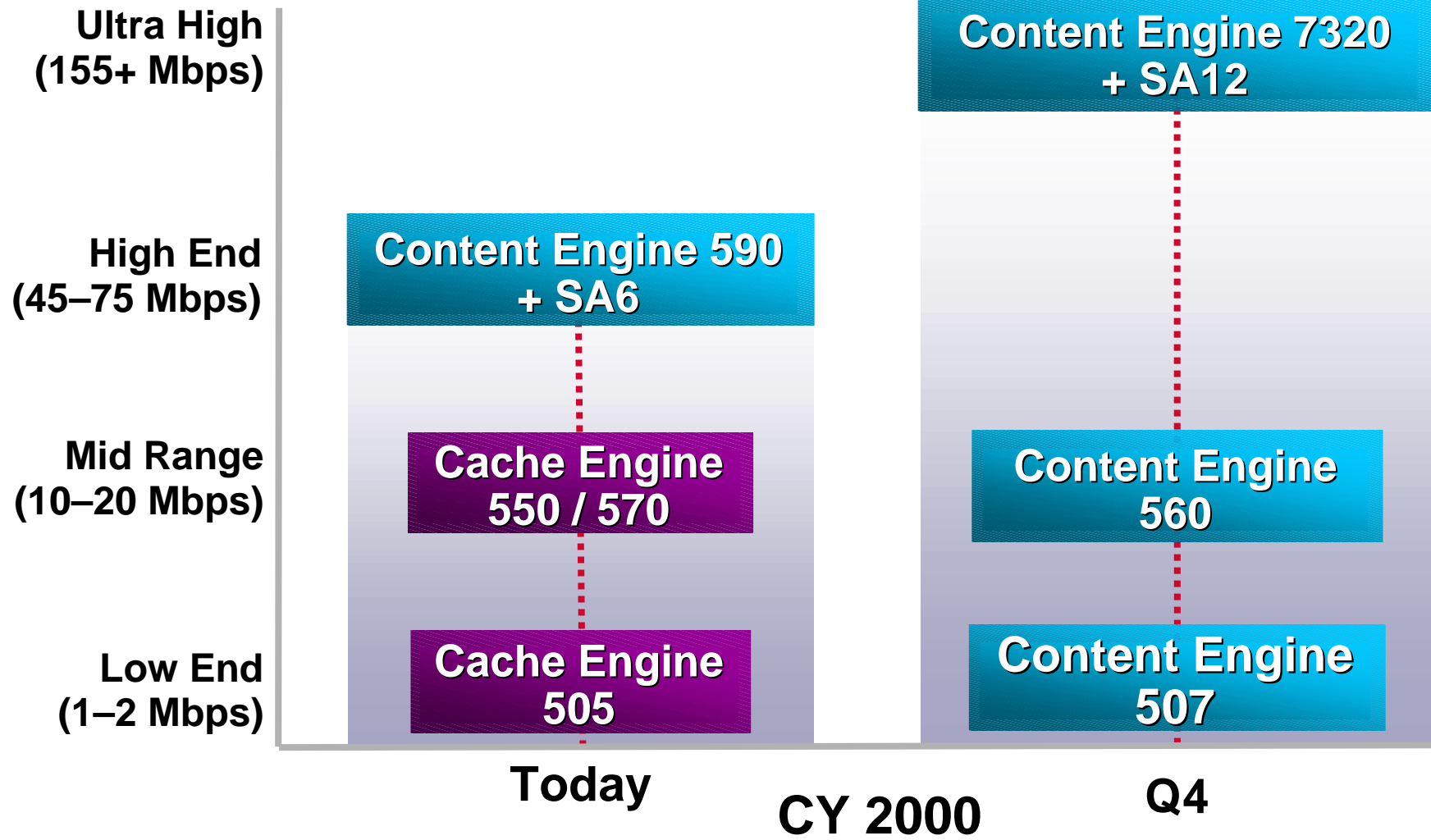
# Enterprise Intranet/Extranet Solutions

<b>Problem</b>	<b>Service Solution</b>	<b>Cisco Products</b>
Internet Access not Fast Enough, WAN Bandwidth Scalability	Caching	Content Engine WCCP Router/Switch
Unable to Deliver High-Quality Video on Demand to Clients Today	CDN	Content Engine Content Distrib. Mgr
Objectionable or Non-Business Internet Content	Employee Internet Management (EIM)	Content Engine Websense Software



# Content Engine Products

# Hardware Roadmap





# Cisco Content Engine Product Line

Customer	Solution	HTTP Performance	Rack Units	Storage (GB)	Base Price
Large Service Providers	CE 7320 (a)	155+ Mbps	4-7	180–396	\$90,000
Service Providers, Enterprises	CE 590 (a)	45+ Mbps	1-4	36–252	\$30,000
Regional Sites	CE 560 (a)	20 Mbps	1-4	36–144	\$15,000
Small Branch Sites	CE 507	T1/E1	1	18–36	\$5,500
	CE 507AV	T1/E1	1	18	\$6,995

All models have (2) 10BaseT/100BaseTX interfaces. CE 7320 also has (2) GigE (fiber) ports. AC and DC versions will be offered for the CE 590 and CE 7320.

(a) An external Cisco Storage Array is required for optimal performance.

Cisco Storage Array 6: 6x18=108 GB: \$13,000 (3 RU)

Cisco Storage Array 12: 12x18=216 GB: \$21,500 (3 RU)



# Cisco Content Engines

CDN

Transparent  
Caching

Employee Internet  
Management (EIM)

**Content Engine Hardware**

## *Content Services Platform*



© 1999, Cisco Systems, Inc.

[www.cis](http://www.cis)



# Content Engine Solutions

<b>Solution</b>	<b>Benefit</b>	<b>Orderability</b>
Enterprise Caching	Speed, Bandwidth Savings	Today
Enterprise CDN	VoD today	Q4 CY '00
Enterprise EIM	Content Control	Today
E-Commerce Caching	Scalability	Today
E-Commerce CDN	Scalability/Redundancy	Q4 CY '00
SP Caching	Speed, Bandwidth Savings	Today
SP CDN	New Hosting Service	December

# Software Releases

- **Content Engines: CDN or Cache software**  
CDN software: CDN service  
Cache 2.x, 3.x software: Caching/EIM services
- **Cache Engines: Cache 2.x software**  
Cache 2.x sw: Caching/EIM services  
(final feature release in Q4 CY '00)



# CDN and Caching

<b>Capability</b>	<b>Caching</b>	<b>CDN</b>
<b>Content Source</b>	<b>All Content Requested</b>	<b>Only Assigned Domains and Files</b>
<b>Content Population</b>	<b>Pull or Cache-Driven Prepopulation</b>	<b>Centralized Prepopulation, Based on Policies</b>
<b>Request Routing</b>	<b>Local—Intercept Traffic and Deliver From Cache</b>	<b>Global—Redirect Request to Optimal Node</b>
<b>Load Balancing</b>	<b>Local Clustering</b>	<b>Global, Across Entire CDN</b>
<b>Content Management</b>	<b>Decentralized—Automated on CEs</b>	<b>Centralized Content Management</b>
<b>Content Retention</b>	<b>Store Frequently Requested Files</b>	<b>Policy-Driven. Can Ensure 100% Hit Rate</b>



# Software Releases

## Software Release

	Cache 2.X	Cache 3.X	CDN Enterprise	CDN Service Provider
Content Engine <b>7320</b>	—	3.0+	—	1.0+
Content Engine <b>590</b>	2.2+	3.0+	—	1.0+
Content Engine <b>560</b>	2.3.4+	3.1+	Future	—
Content Engine <b>507</b>	2.3.4+	3.1+	2.0+	—
Content Engine <b>507AV</b>	—	—	2.0+	—
Cache Engine <b>505/550/570</b>	Yes	—	—	—

# Content Engine Summary

- **Leading overall performance and density**

**Density = performance / RU**

- **Cisco is the only vendor that offers the complete CDN solution**
- **Most advanced transparent caching**
- **Powerful Employee Internet Management services**
- **Scale from super PoPs to branch sites**

# Leading Overall Performance

## The Second IRCache Web Cache Bakeoff Results

### Rankings

### Raw Data from IRCache Report

Place	Product	Overall Performance Ranking	Throughput Ranking	Latency Ranking	Byte Hit Rate Ranking	Throughput (URLs/sec)	Latency (sec)	Byte Hit Rate
1	Cisco CE 7300	3.3	2	6	2	2304	1.48	57%
2	Compaq-C2500	3.7	1	5	5	2400	1.45	55%
3	iMimic-5000	5.0	4	1	10	1453	1.35	47%
4	Cisco CE 590	5.3	7	7	2	951	1.50	57%
5	Squid-2.4	6.3	16	2	1	160	1.41	58%
6	Lucent-150a	6.3	8	9	2	771	1.58	57%
7	Network Appliance	9.0	17	3	7	151	1.44	53%
8	IBM-5600	9.3	6	10	12	1306	1.65	43%
9	Lucent-100	9.7	9	13	7	675	1.71	53%
10	Swell-1000	10.0	20	3	7	77	1.44	53%

- (a) Overall performance ranking is the average of the throughput, latency, and byte hit rate rankings.
- (b) Cacheflow pulled out of this competition because their Polymix-2 benchmark numbers were lower than the 2300 TPS that they achieved with the older DataComm-1 benchmark. Results obtained on different benchmarks are not comparable.
- (c) Inktomi failed to register for the bakeoff due to scalability issues.

Source: <http://polygraph.ircache.net/Results/bakeoff-2/>  
 PolyMix-2 Benchmark: <http://polygraph.ircache.net/sources/>





# Ensuring Content Freshness



# Sample page



**CISCO SYSTEMS**  
EMPOWERING THE  
INTERNET GENERATION®

## Cisco Connection Online

The Worldwide Leader in Networking for the Internet

How to Buy | Login | Register | Map/Help | Countries/Languages

Search [More Options](#) | [Help](#)

Concept

All CCO

### Solutions for Your Network

[Overview](#), [Internet Business Solutions](#), [Large Corporations](#), [Small/Medium Business](#), [Service Providers](#), [Home Networking](#), [Government](#), [Education](#)

### Service & Support

[Technical Assistance Center](#)  
[Technical Documents](#)  
[Software Center](#)  
[Service Contract Center](#)  
[Service & Support Solutions](#)

### Training, Events, & Seminars

[Training/Certifications](#)  
[Networkers](#)  
[Seminars](#), [Events](#)  
[E-Learning](#)

### Corporate News & Information

[About Cisco](#), [Contact Cisco](#)  
[Investor Information](#)  
[Find a Job](#)  
[News/Press and Publications](#)



Powering the Internet,  
Empowering Humanity ...  
**Cisco Systems,**  
the Company  
Behind **NetAid**

### Products & Technologies

Product Families

[Products](#)  
[Technologies](#)

### Ordering


[Online Ordering](#)  
[Ordering Information & Assistance](#)  
[Finance Your Network Solutions](#)

### Partners & Resellers

[Login](#), [Become a Reseller](#)  
[Selling Value](#)  
[Find a Partner/Reseller](#)  
[Strategic Alliances](#)  
[Partner E-Learning Connection](#)



**Cisco**  
Powered Network™  
[Learn more about  
Service Providers](#)



**Cisco**  
NetWorks  
[Learn more about  
Technology Licensing](#)

### Top News

Cisco Content  
Networking [Delivers](#)  
Services Acceleration  
Improving the  
Performance of Internet  
Business Applications

### More News

Small/Medium Business  
**CISCO RESOURCE NETWORK**

### HOT JOBS @ CISCO

### YEAR 2000 Compliance

### ORDER Networking Products Online

Updated **6700** Series  
**Delivers** New World  
**Broadband & DSL**

Test your  
company's  
Internet Quotient

▶ [CLICK NOW](#)

# URLs Are Cached, Not Pages

WHAT'S NEW LOGIN REGISTER NAVIGATE HELP

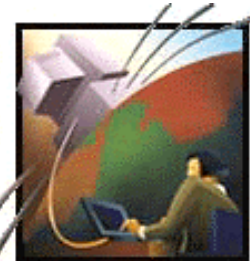
menu\_bar.gif

Cisco Connection **ONLINE**

cco\_header.gif



cisco\_powered.gif



logo2.gif



button1.gif



button2.gif



button3.gif

cisco\_connection.html

```
HREF="http://www.cis  
on_root.shtml">Cisco  
Solutions<BR>  
</A></B><FONT SIZE=-  
enterprise, small/me  
small/home office, S  
education.</FONT></T  
</TR>  
</TABLE>  
</TD>  
</TR>  
  
<TR VALIGN="Middle" .
```

# Browser Function

- Go to [www.cisco.com](http://www.cisco.com)
- Pull down index (HTML) file
- Fetch individual objects specified in the index file
- HTTP 1.0: one object/TCP connection
- HTTP 1.1: multiple objects/connection



# Dynamic Content

- **Banner ads, stock quotes**

**Marked as noncacheable to overcome every browser's cache**

- **Active server pages (.asp)**

**Dynamically builds a Web page of objects**

**Index file is noncacheable**

**But most objects will be static**



# Content Freshness

- HTTP 1.0: cache/no cache header
- HTTP 1.1: expiration tag header
- When object is cached,  
Time To Live (TTL) value =

**(Today—Modified) \* Freshness Factor**

# Content Freshness

- Revalidate content freshness with If-Modified-Since (IMS) feature

Issued upon a request for expired content or when client browser issues an IMS

(to web-server)

GET /index.html HTTP/1.1

Server: www.cisco.com

Connection: keep-alive

If-Modified-Since: Tue 12 Sep 2000 10:07:04 GMT

Accept: \*/\*

(web-server response)

304 Not Modified OR 200 OK

(end-of-request)

(response headers)

(data)

www.cisco.com (end-of-request)



# CE Configuration

# Cache Engine Configuration

**Cache just like any other Cisco device as far as setup**

- **Initial cache configuration in less than 10 commands.**
- **User can have Cache operational in less than 15 minutes.**



# Initial Cache installation

- Power on cache. Cache boots up ..

Initial configuration dialog on console:

---- System Configuration Dialog ----

You may use Ctrl-D to abort Configuration Dialog at any prompt.

Would you like to enter the initial configuration? [yes]: **yes**

host name: **sj-cache1**

domain name: **mysite.com**

admin password: **reallysecret**

cache IP address: **192.168.10.40**

IP network mask: **255.255.255.0**

gateway IP address: **192.168.10.1**

DNS server: **171.69.2.132**

---- System Configuration Complete ----

- Cache *services* may now be configured:

Username: **admin**

Password: **reallysecret**

sj-cache1# **conf t**

Enter configuration commands, one per line. End with CNTL/Z

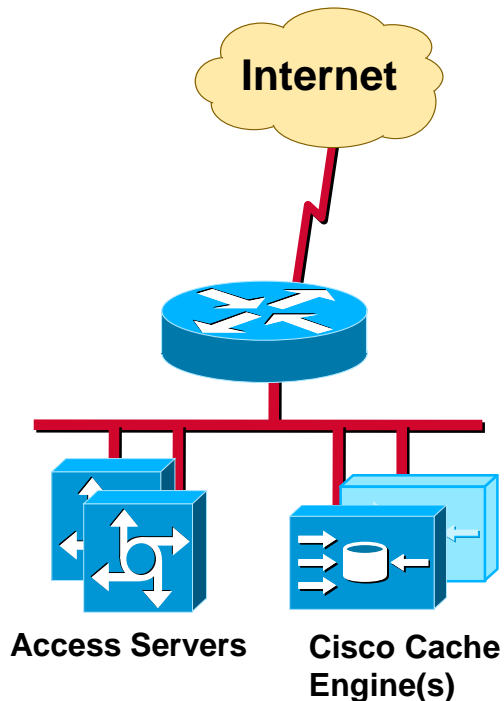
sj-cache1(config)# **wccp router-list 1 192.168.10.1**

sj-cache1(config)# **wccp web-cache router-list-num 1 password secretcache**

sj-cache1(config)# **^Z**

- Cache operational in only 9 commands!

# WCCP transparent proxying



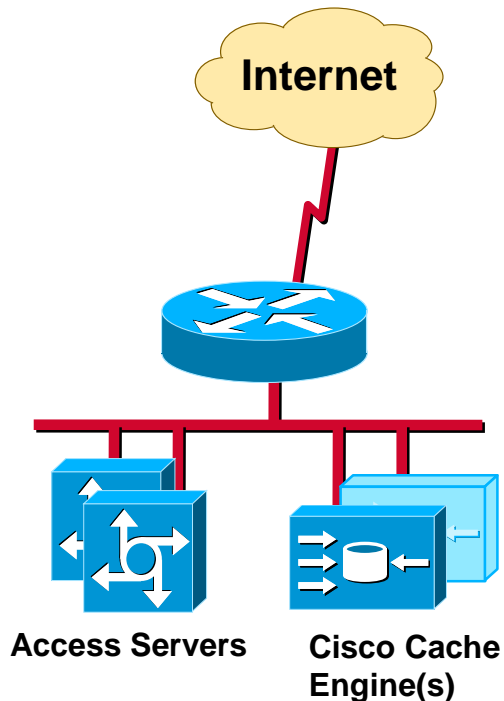
## ROUTER

```
ip wccp version {1,2}
ip wccp web-cache password <pass>
!
interface <internet-I/face>
  ip wccp web-cache redirect out
!
```

## CACHE(s)

```
wccp version {1,2}
wccp router-list 1 <router ip addr>
wccp web-cache router-list-num 1 pass <pass>
```

# WCCP transparent proxying on ports other than 80



## ROUTER

```
ip wccp version 2
ip wccp 98 password <pass>
!
interface <internet-l/face>
 ip wccp 98 redirect out
!
```

## CACHE(s)

```
wccp version 2
wccp router-list 1 <router ip addr>
wccp custom-web-cache router-list-num 1
 port 8080 pass <pass>
```

# Cache Engine Configuration

- **Configurable via IOS CLI**  
(telnet, console port)
- **Configurable via web-based GUI**  
(<http://cache:8001/>)
- **Monitoring via SNMP, SNMP traps, syslog, web-based GUI, CLI**



# **[new] Rules Template Feature**

- **Client request pattern match (pick one)**
  - URL regular expression
  - Destination domain name
  - Source/destination IP address
  - Destination port number
  - MIME type
- **Action (pick one)**
  - Do not cache
  - Only cache objects that match the pattern, nothing else
  - On a cache miss, go to a specified server or proxy
  - Do not use upstream proxy, do internal DNS resolution
  - Revalidate content via IMS
  - Do not authenticate
  - Block it



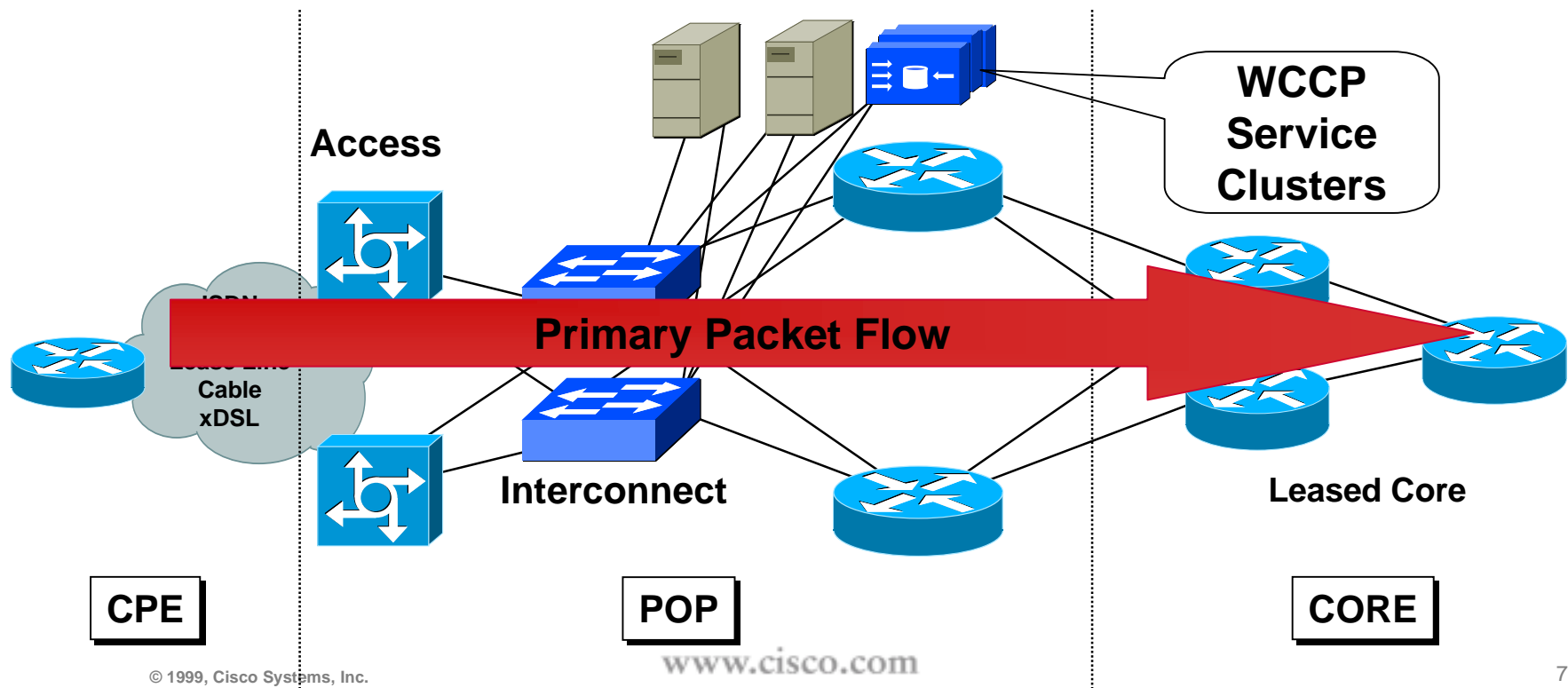
# **CE Deployment Scenarios with WCCP**

# Design Objectives for the ISP

- Transparent *Redirection* of a IP flow based on source, destination, and/or port number.
- Transparent *Integration* - no rebuilding the POP to add this service.
- Failed open - if the service fails, it should not effect the core IP service nor any other services.

# Design Objectives for the ISP

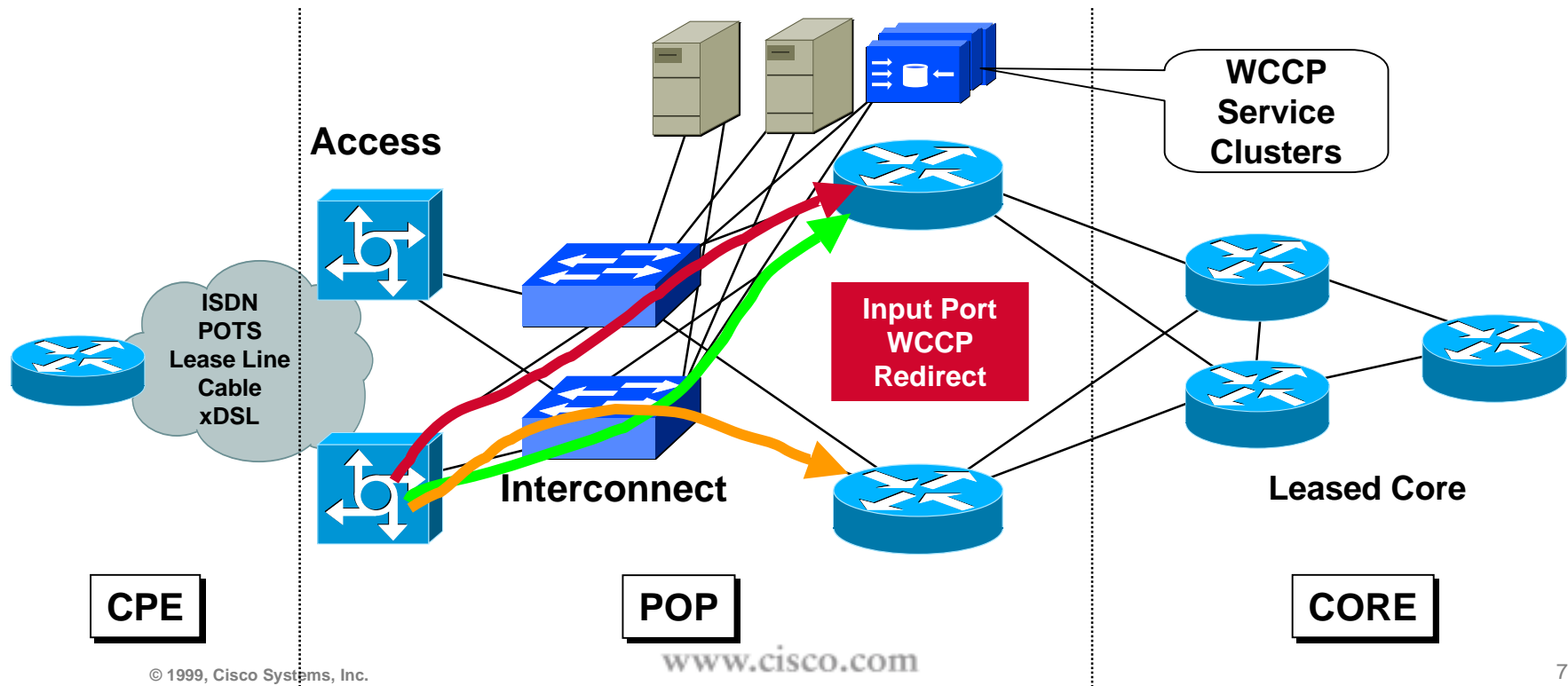
- Not to effect the primary packet flow of the POP - if not redirected - then is CEF/dCEF Switched!





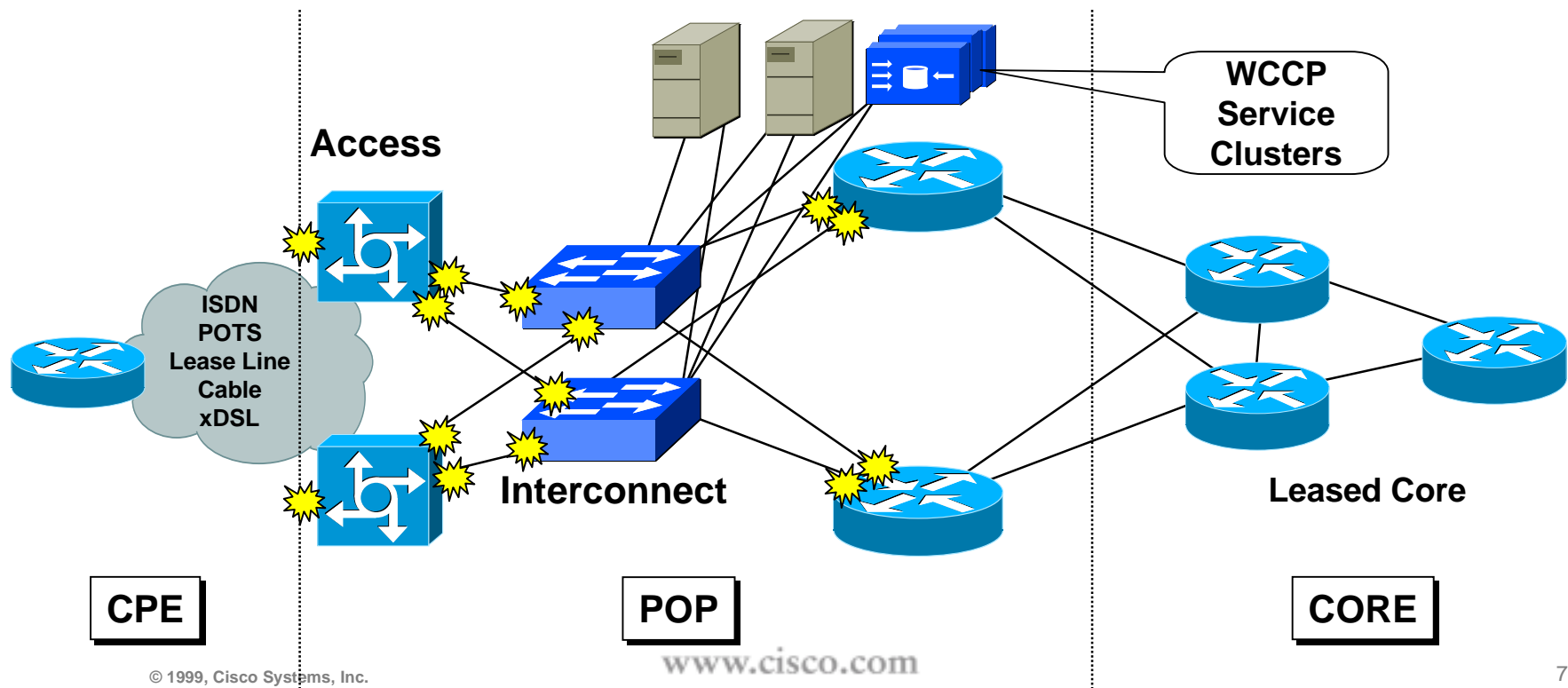
# Design Objectives for the ISP

- Work with the multi-level L2/L3 redundancy of the ISP POP. Equal paths in the IGP + CEF leads packet asymmetry.



# Design Objectives for the ISP

- Provide the ISP with Flexibility on the point of redirection.

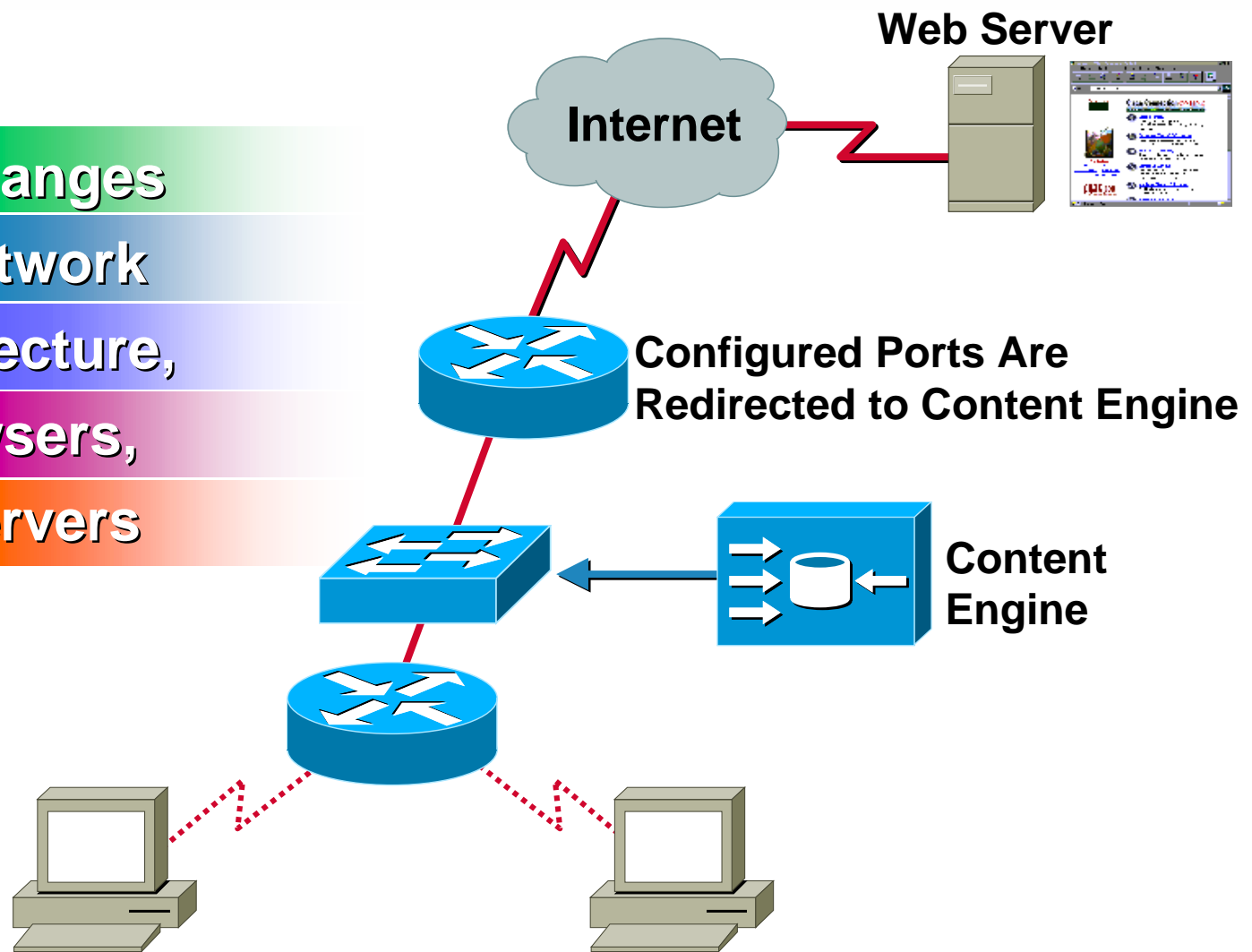


# Design Objectives for the Service Group

- **Linear Scalability with the Cache - minimize object replication.**
- **Fault Tolerance and Maintenance.**
- **“Joe Smith the Telco Tech” test.**

# Basic Transparency

No Changes  
to Network  
Architecture,  
Browsers,  
or Servers





# WCCP's Features

- **WCCP's Features are in two parts:**
  - Router Based - Benefiting the operation of the ISP Edge (POP) or Enterprise Gateway.**
  - Service Group - Benefiting the applications WCCP is servicing**

# WCCP's Features (Router)

- **Transparent Integration**
- **Fail Open on the Service Group Failure**
- **On-line Maintenance of the Service Group**
- **Multiple Router Support in one Service Group MD5 Authentication between Router and Service Group**

# WCCP's Features (Router)

- **CEF and dCEF Switched**
- **Multiple Service Groups**
- **Options on where the redirections happens**

# WCCP's Features (Service Group)

- **Fault Tolerance of the Service Group**
- **On-line Maintenance of the Service Group**
- **Linear Scalability of the of the Service Group**
- **WCCP Slow Start**

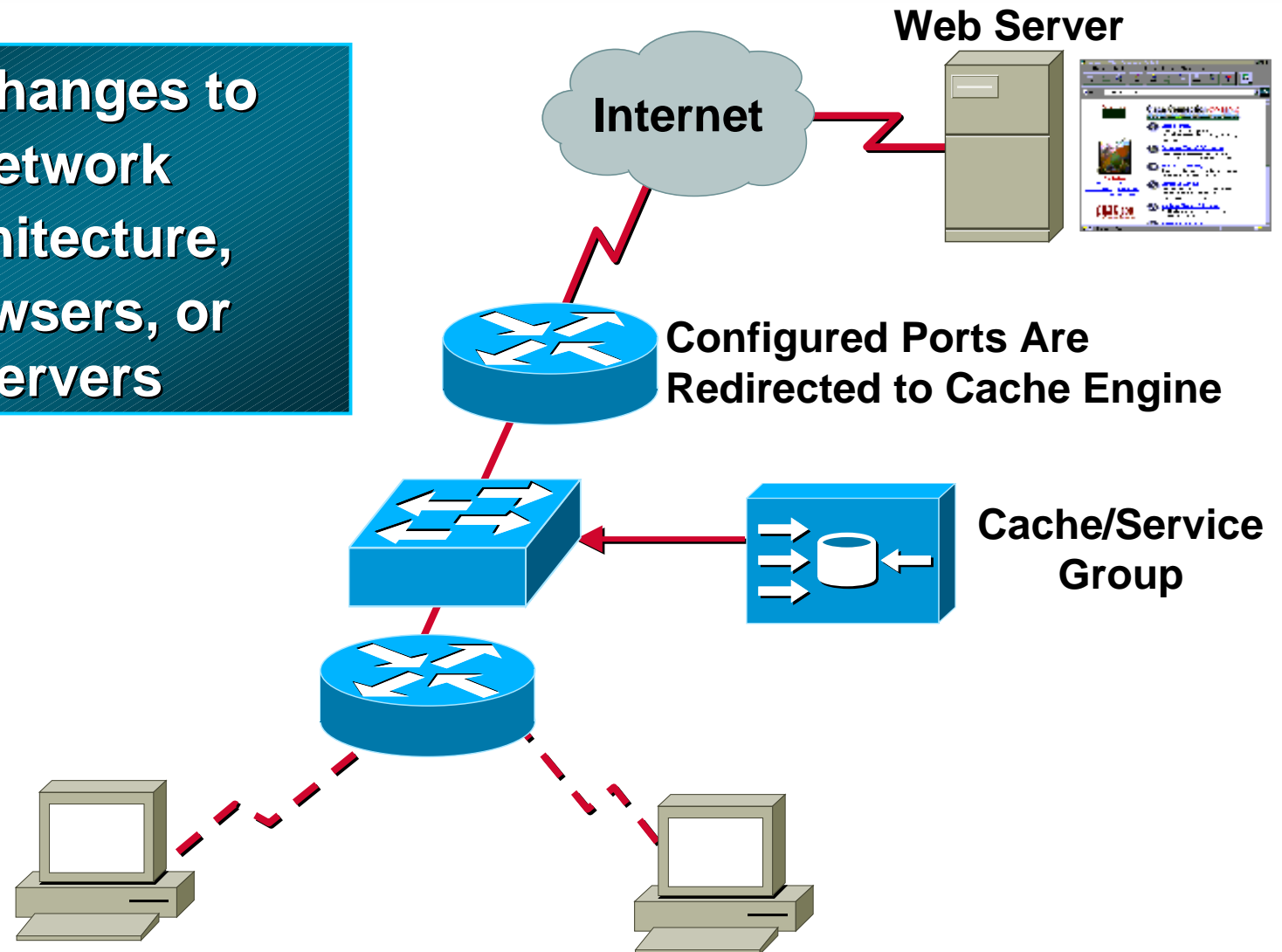


# WCCP's Features (Service Group)

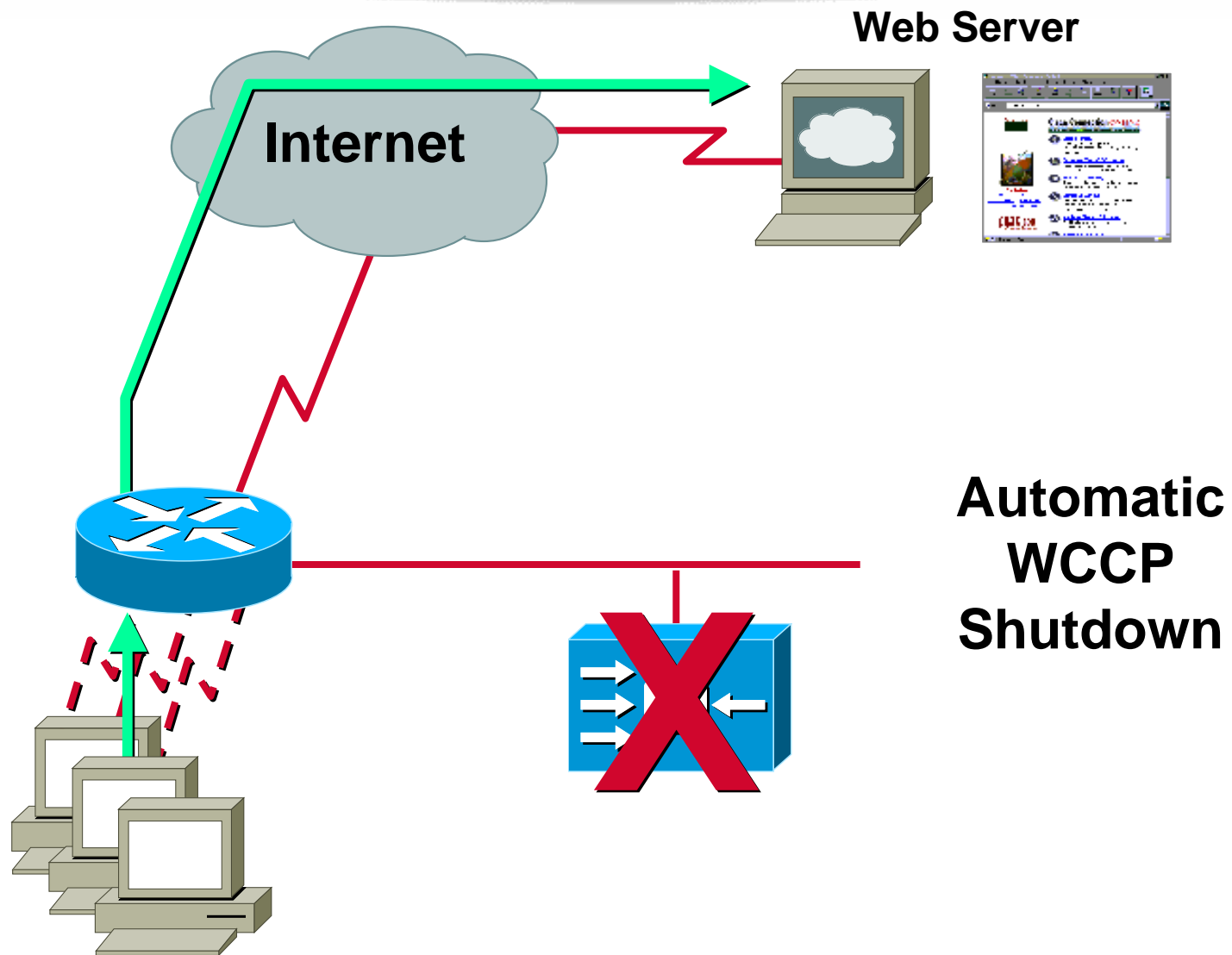
- **Fault Prevention - Packet Return Feature (Overload and Bypass)**
- **Load Distribution (Hot Spots)**
- **Fail Open on the Service Group Failure**
- **Authentication By-pass**

# Transparent Integration

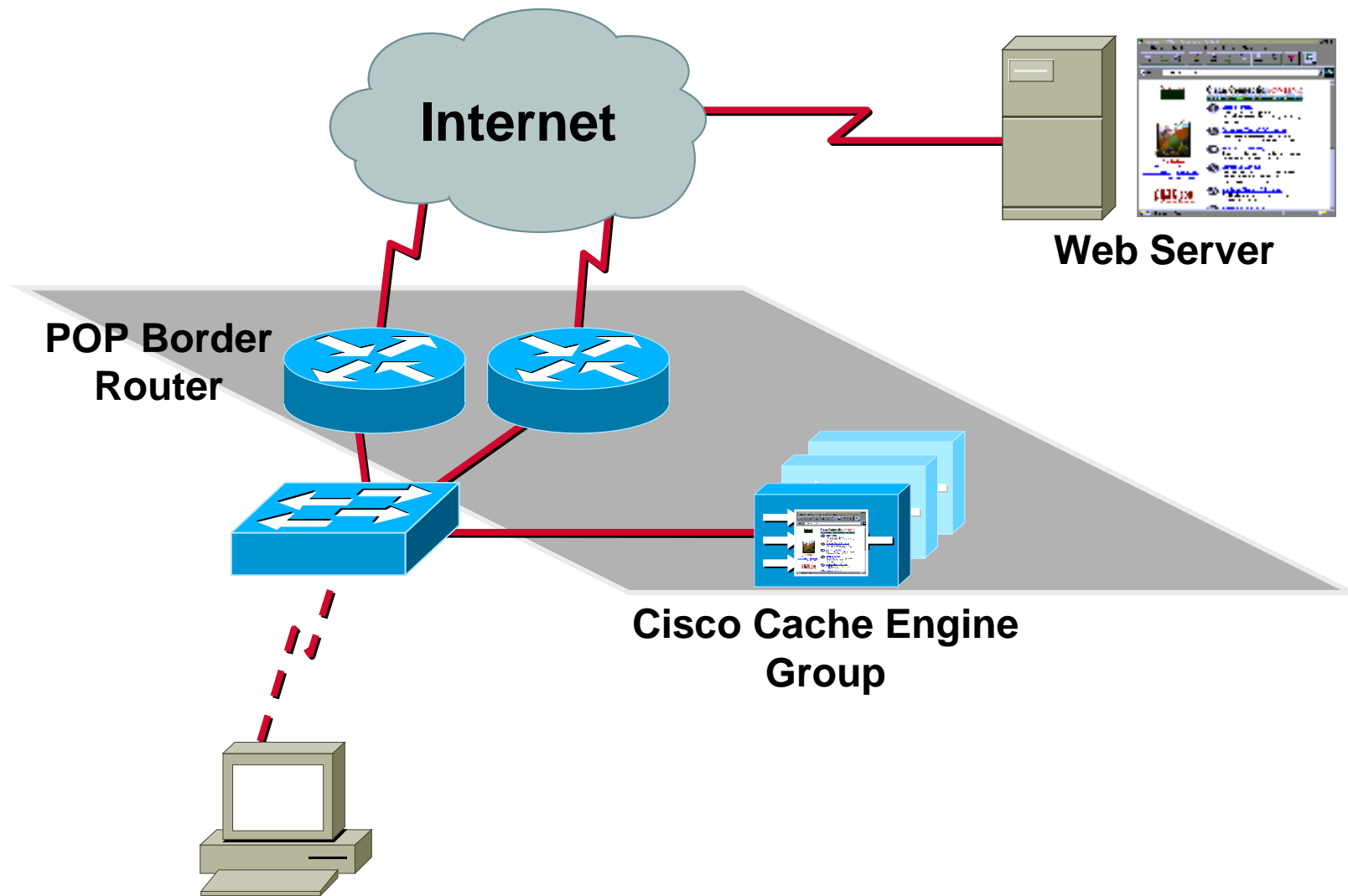
**No Changes to  
Network  
Architecture,  
Browsers, or  
Servers**



# Fail Open

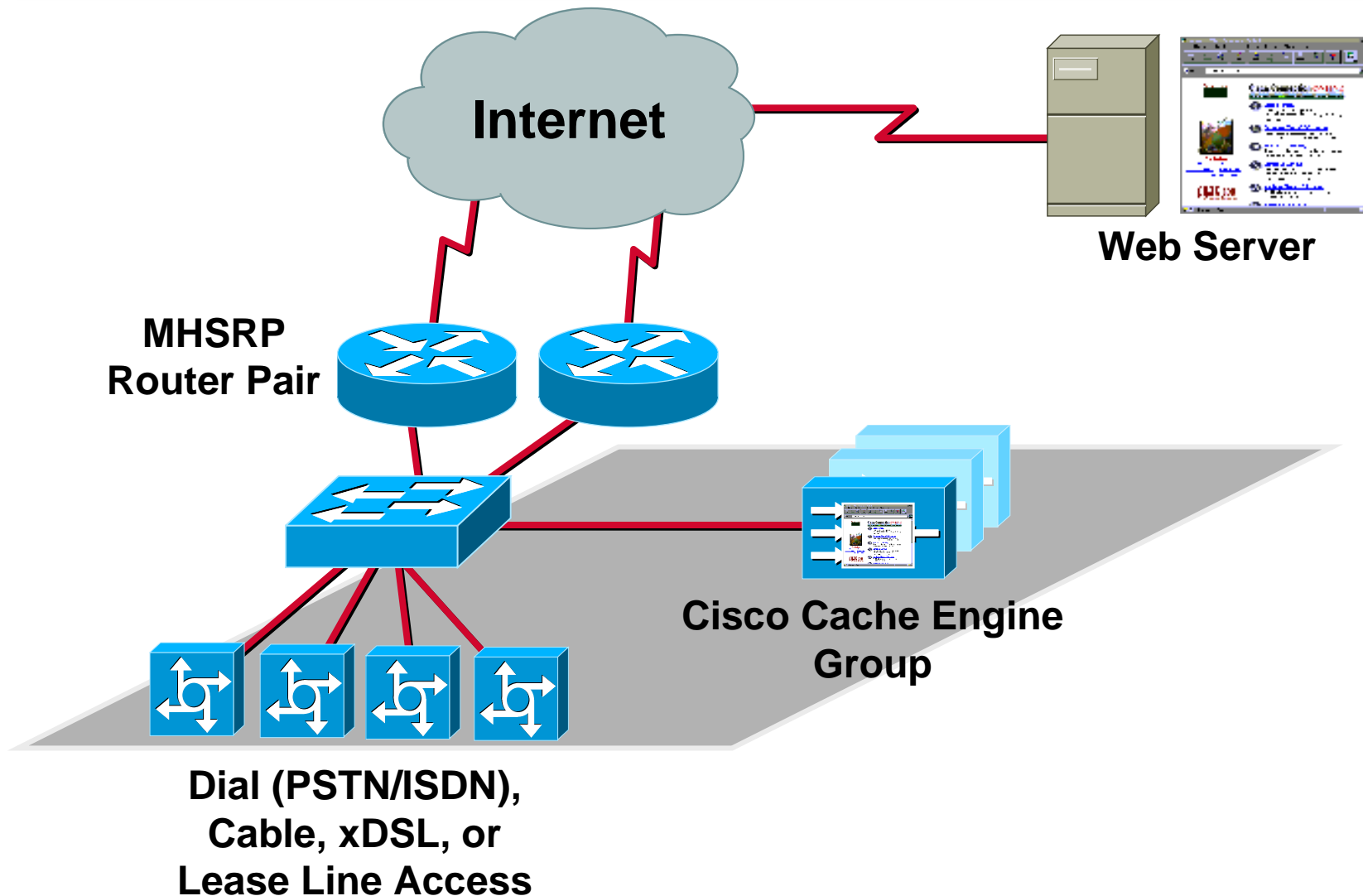


# Multi Router - POP Border Routers

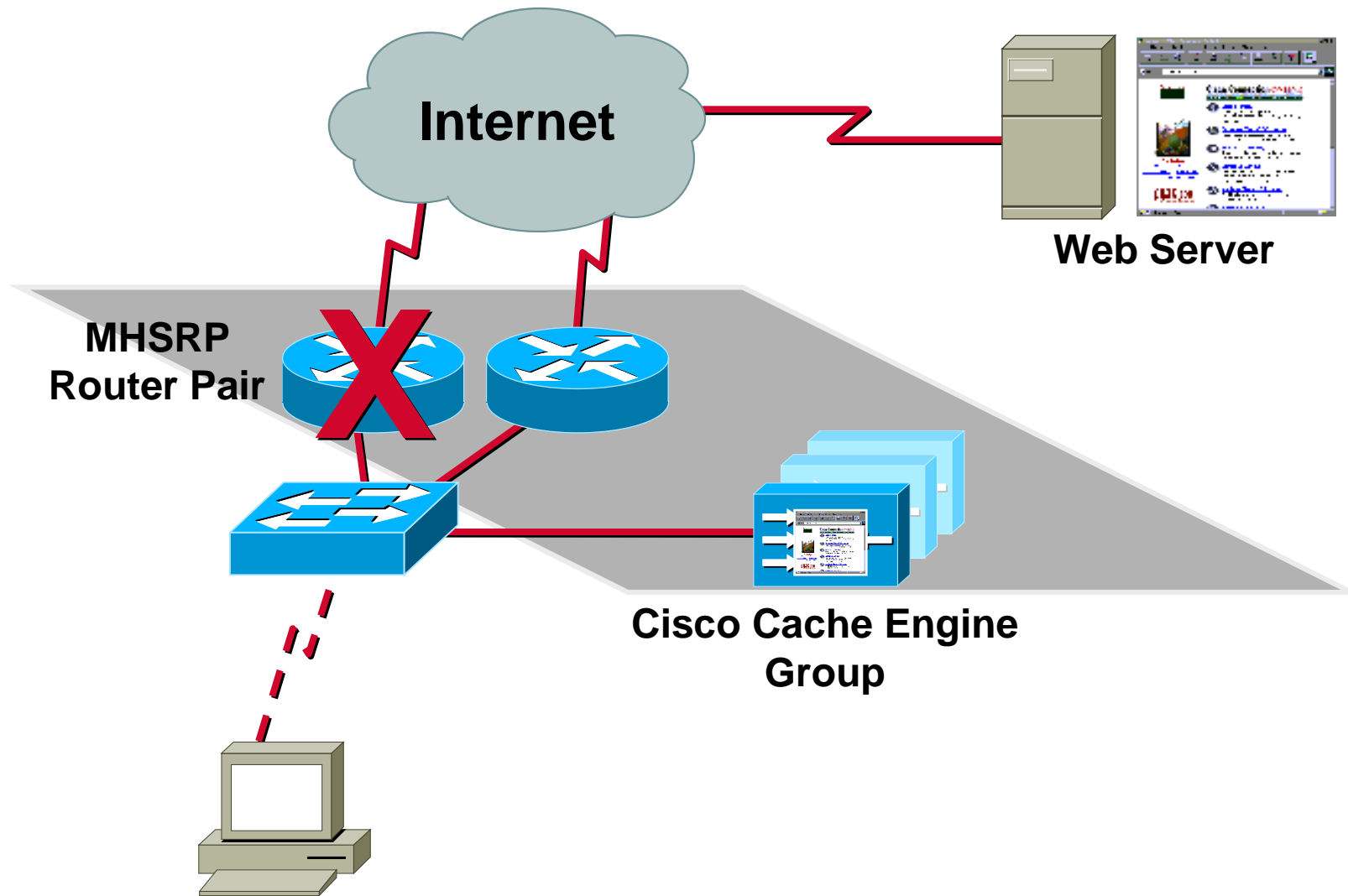




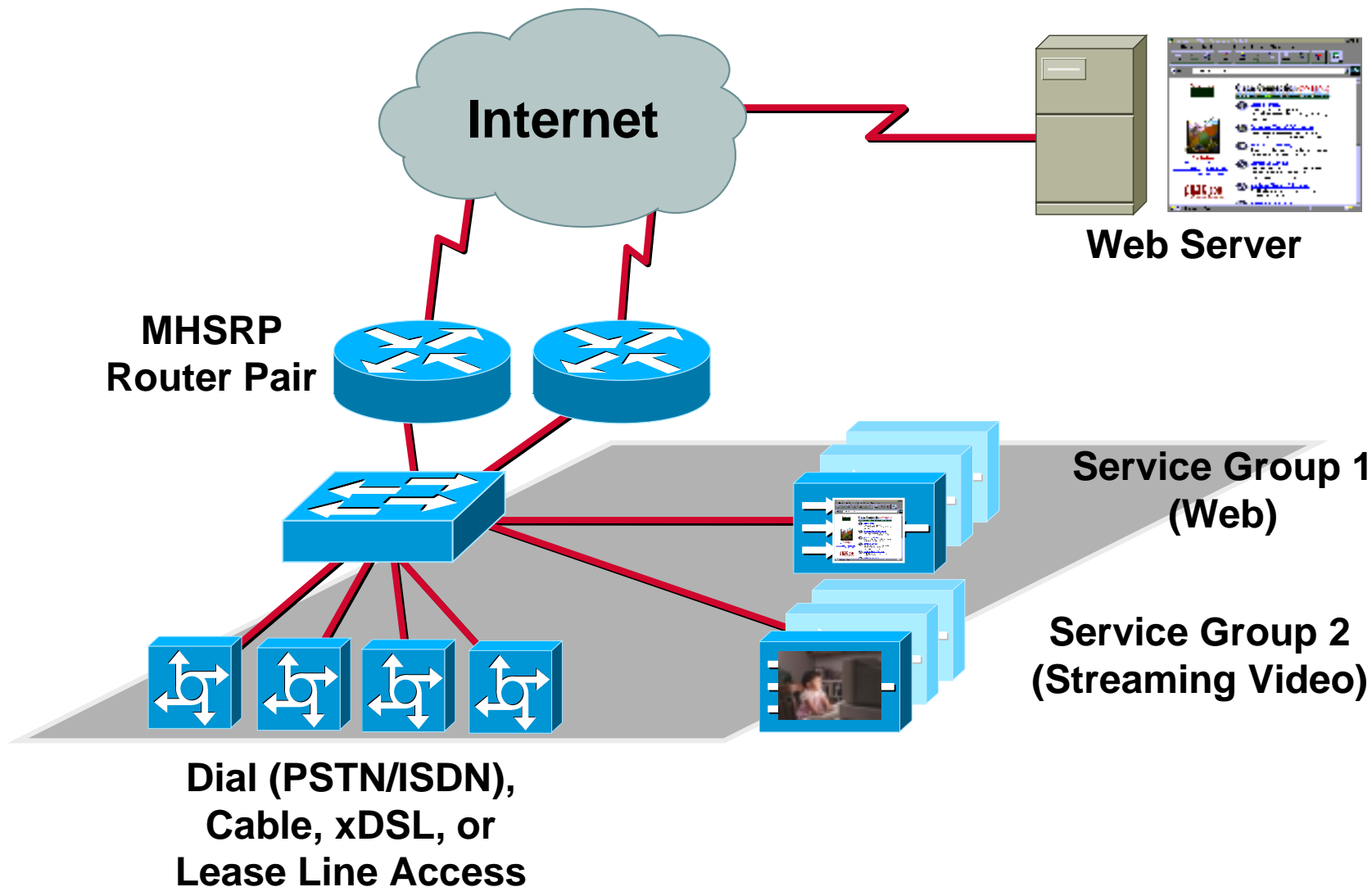
# Multi Router Support - POP Edge Devices



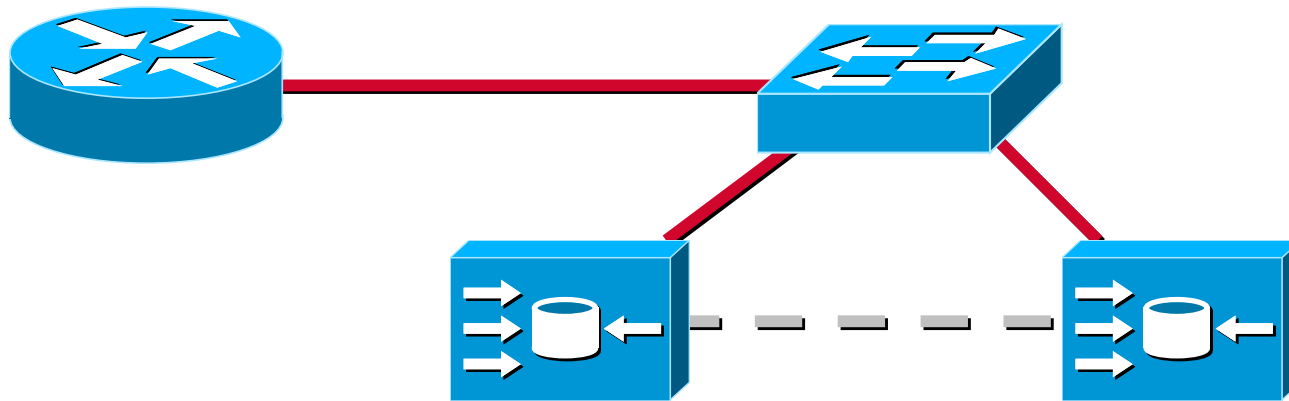
# Multihome Router via HSRP



# Multi-Service Group Support



# Scalable Grouping

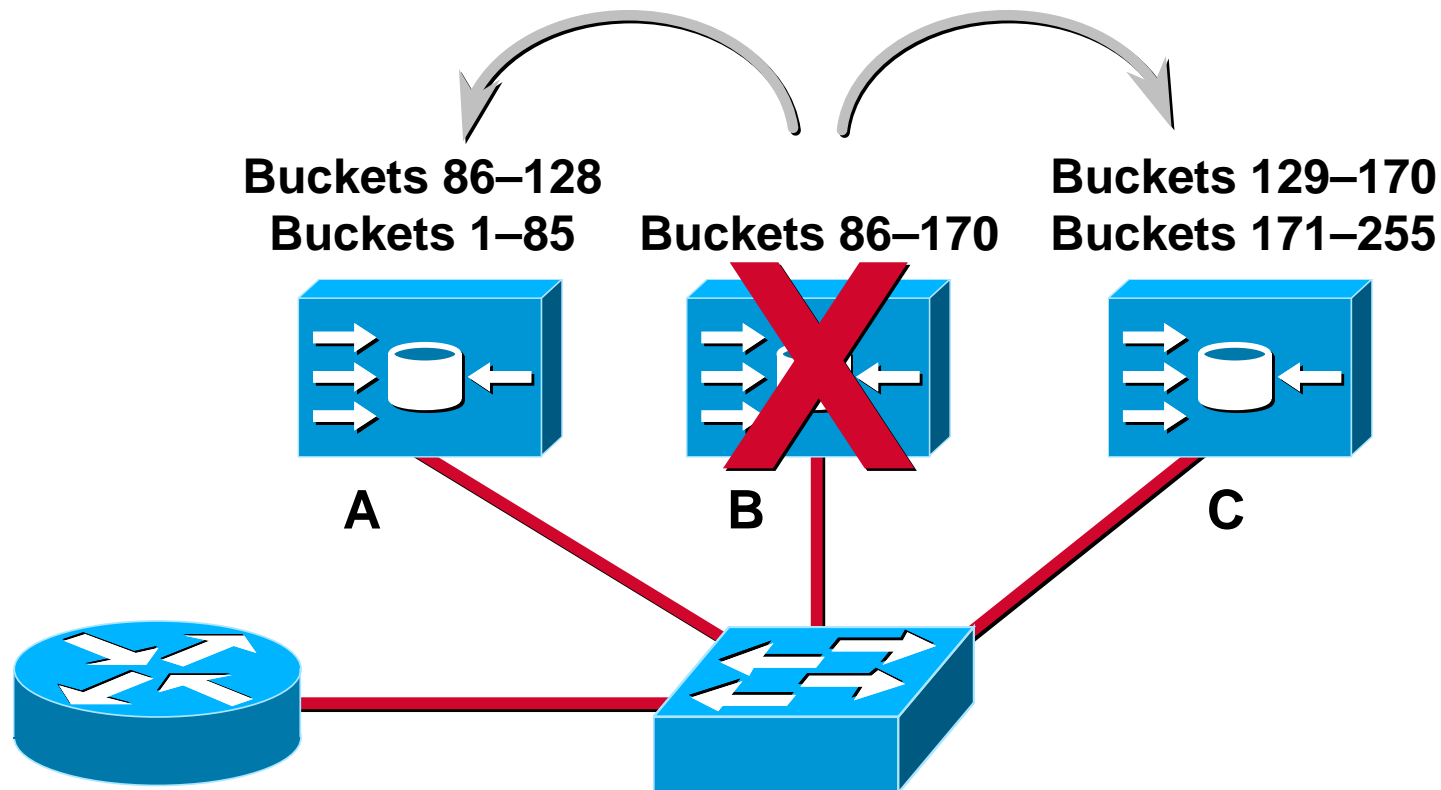


- **Load balancing by hashing on destination IP address**
- **Linear, incremental scalability**
- **Hot insertion**
- **High availability, redundancy**

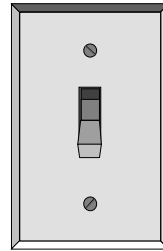


# Fault Tolerance

## Automatic Redistribution

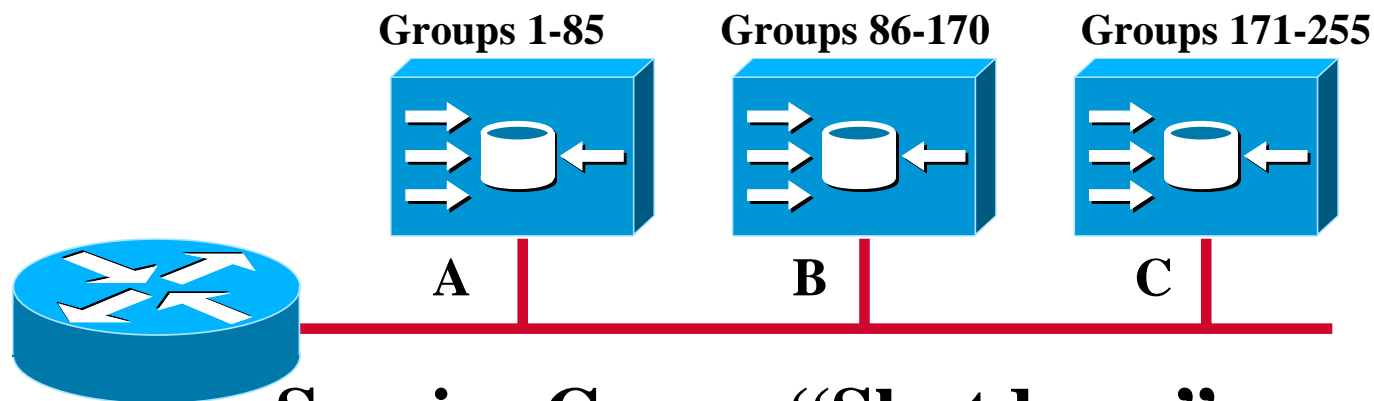


# Service Group Maintenance



## N + 2 Group Sizing

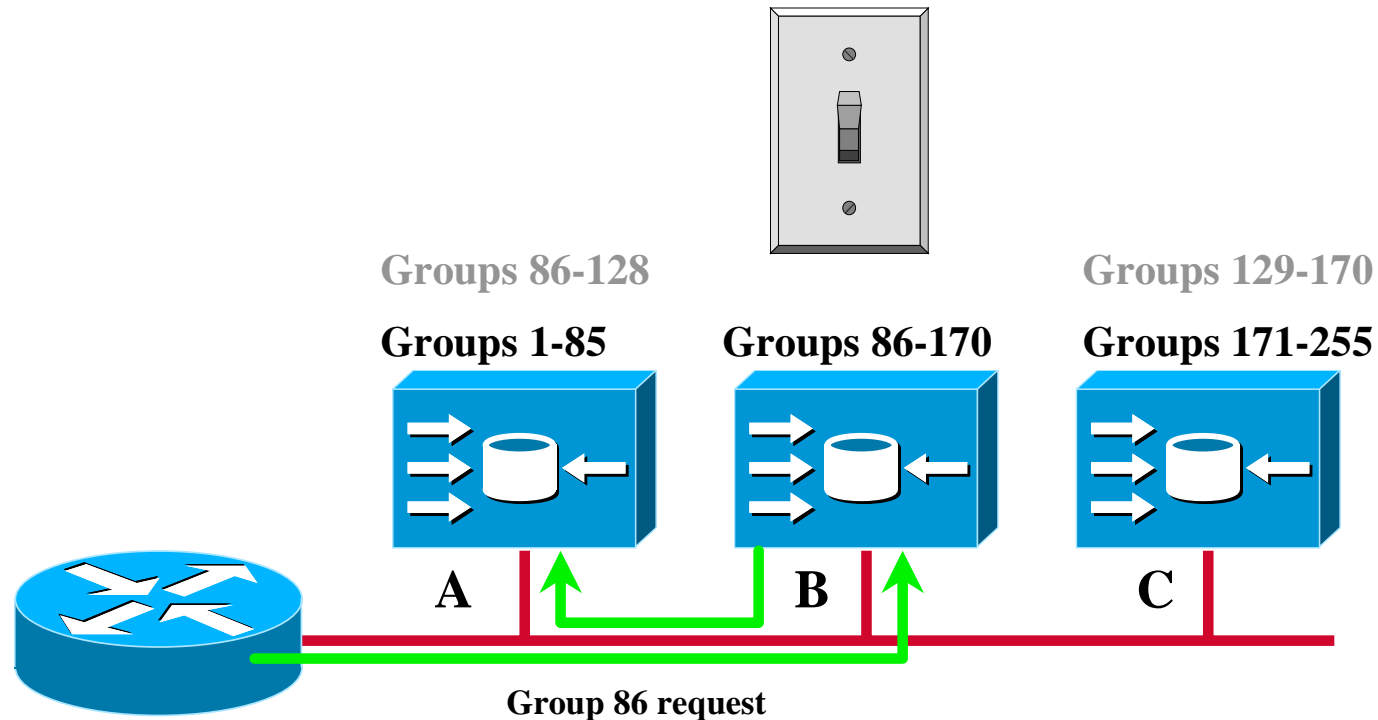
- ⇒ One for failure
- ⇒ One for Maintenance



- **Service Group “Shutdown”**

- ✓ Stops accepting connections from WCCP
- ✓ Tells WCCPv2 to stop sending flows

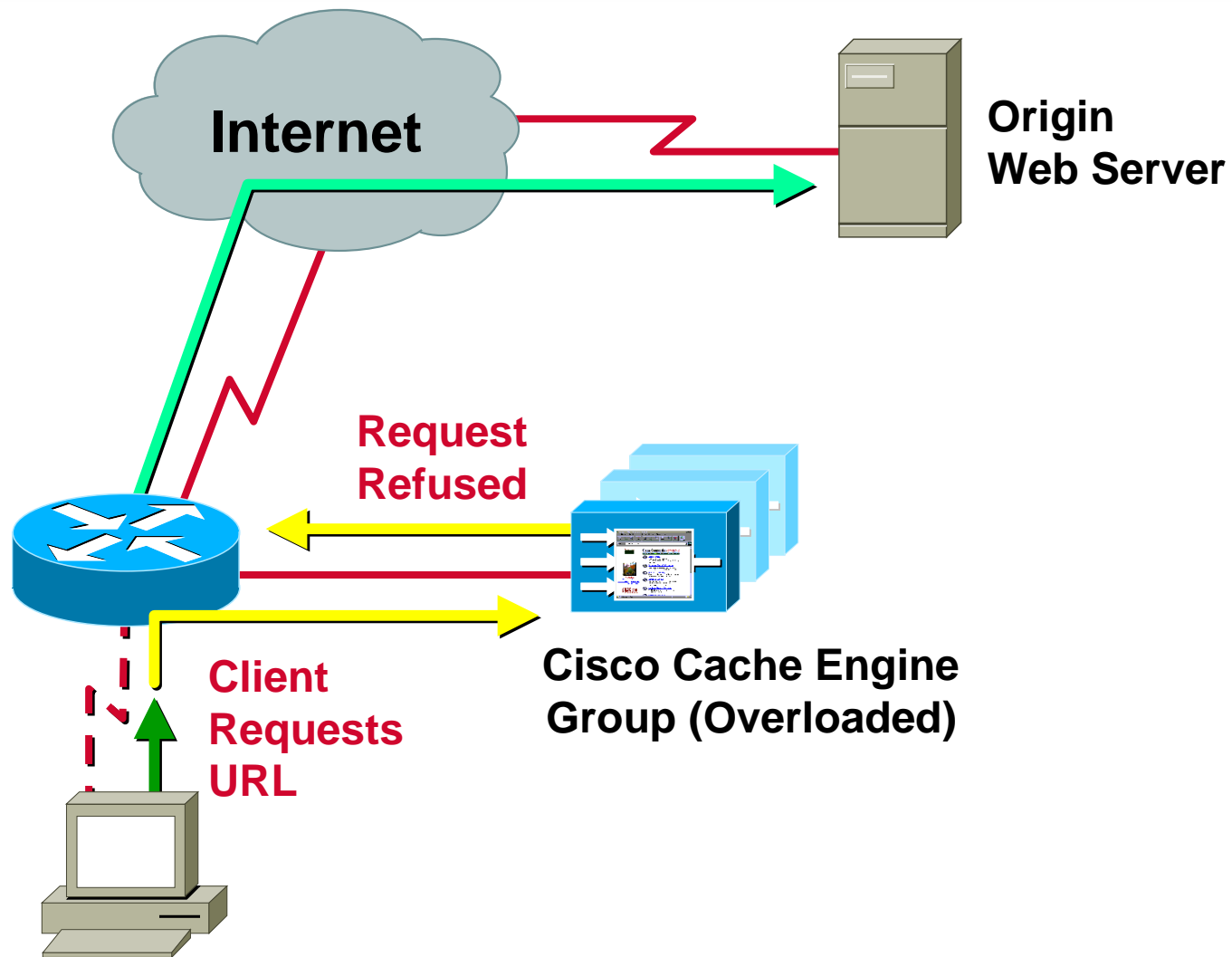
# Service Group Maintenance



- **Service Group Convergence**

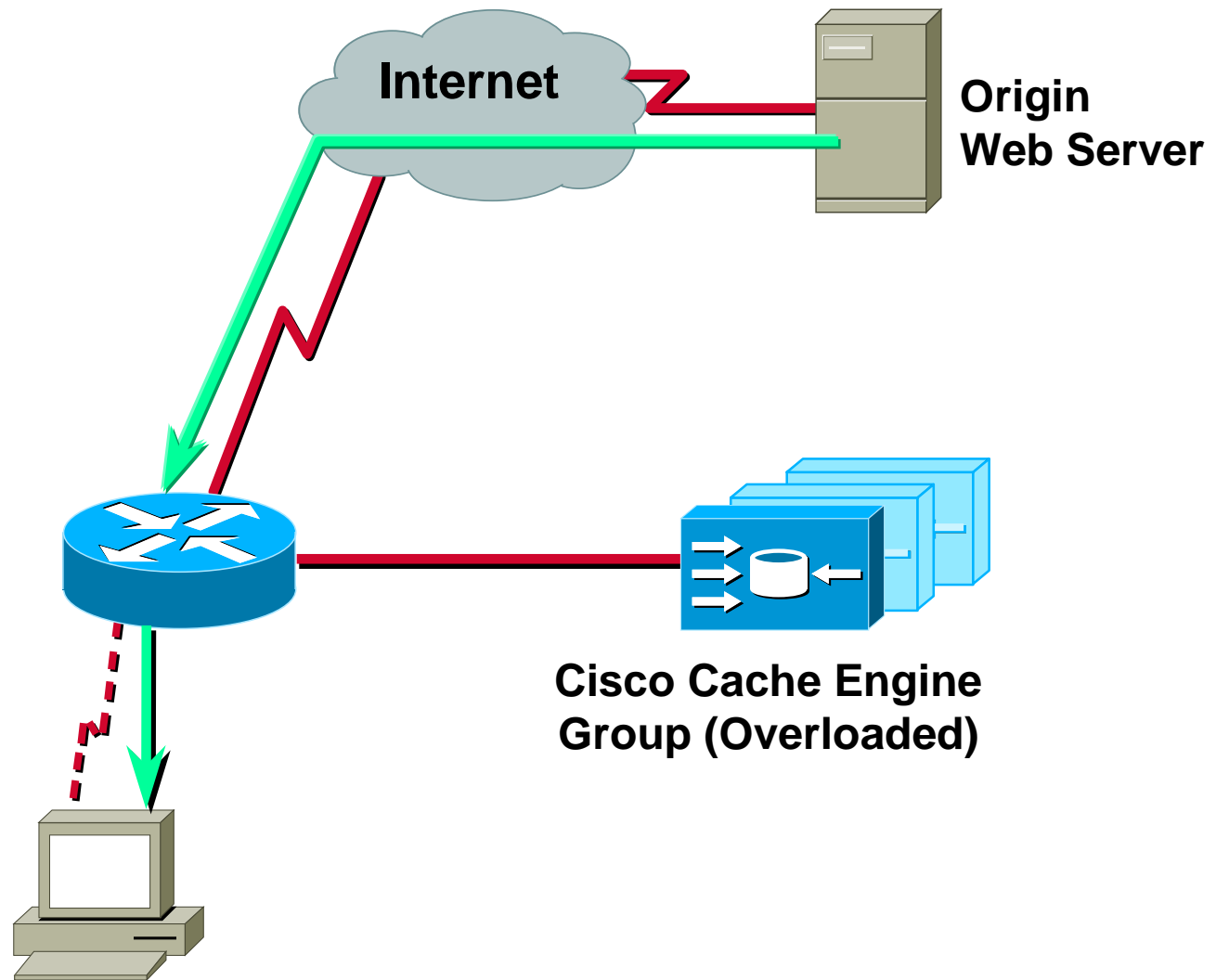
- ✓ Tells WCCPv2 to start sending flows
- ✓ Gradual hand off from other units in Group

# Fault Prevention: Overload

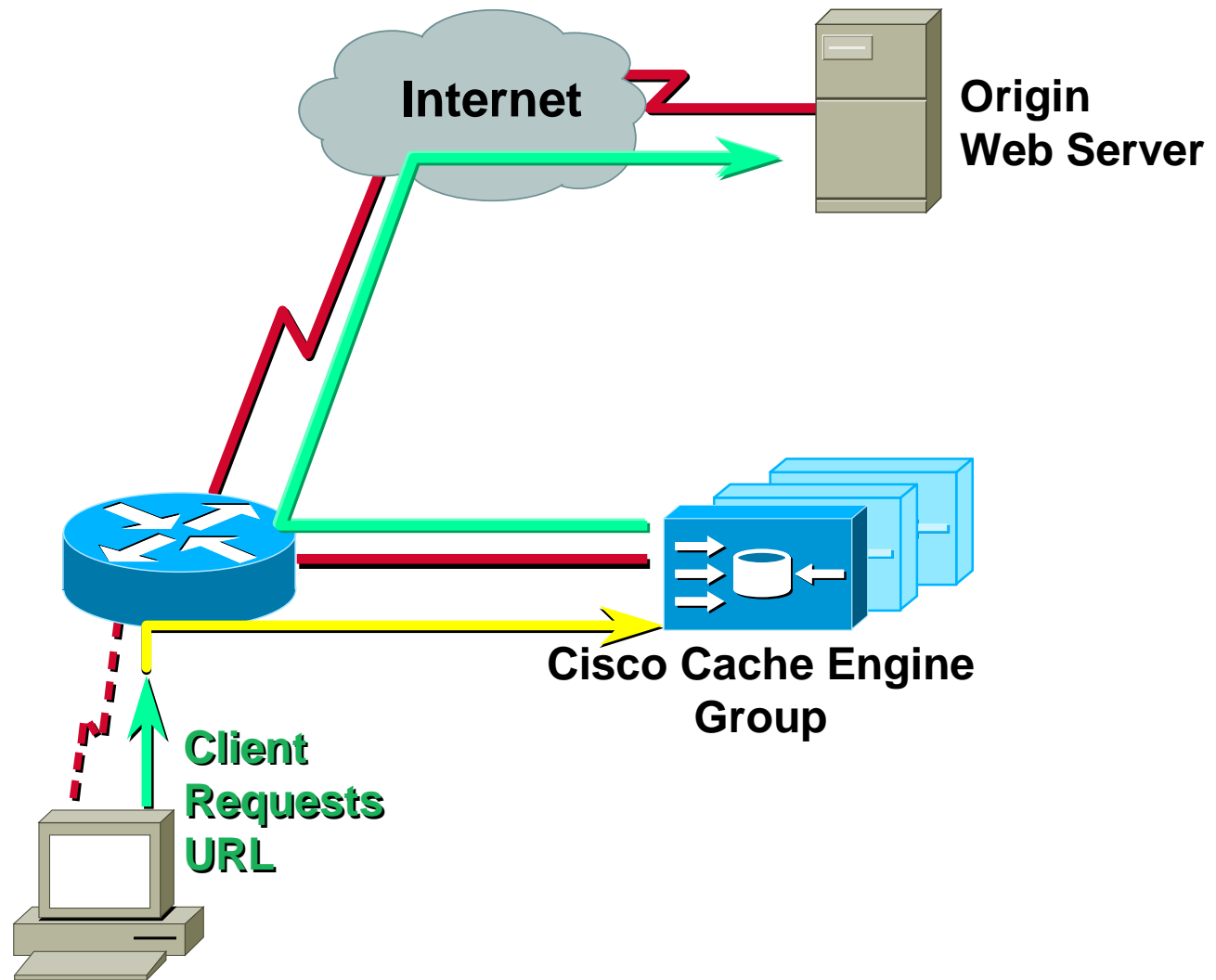




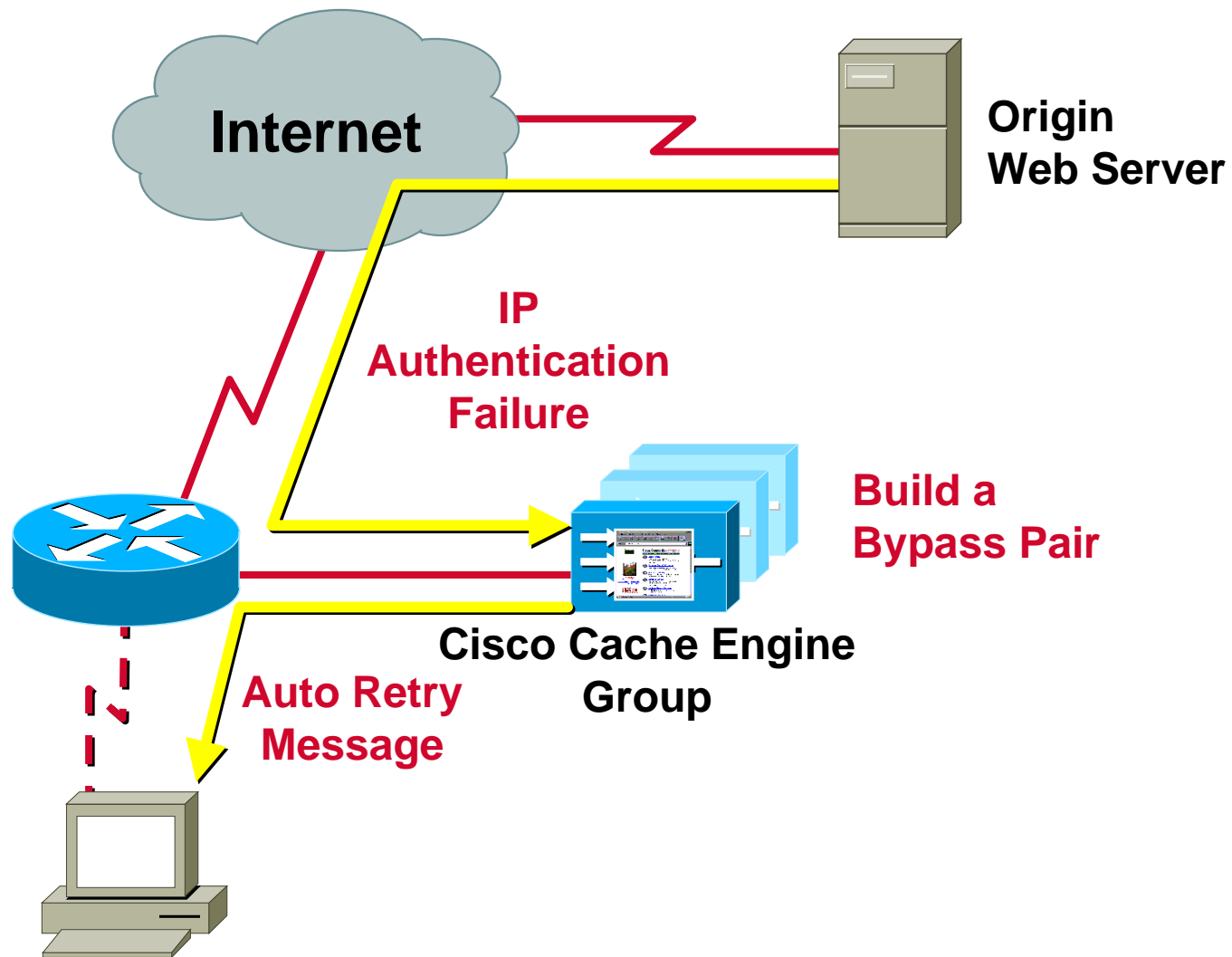
# Fault Prevention: Overload



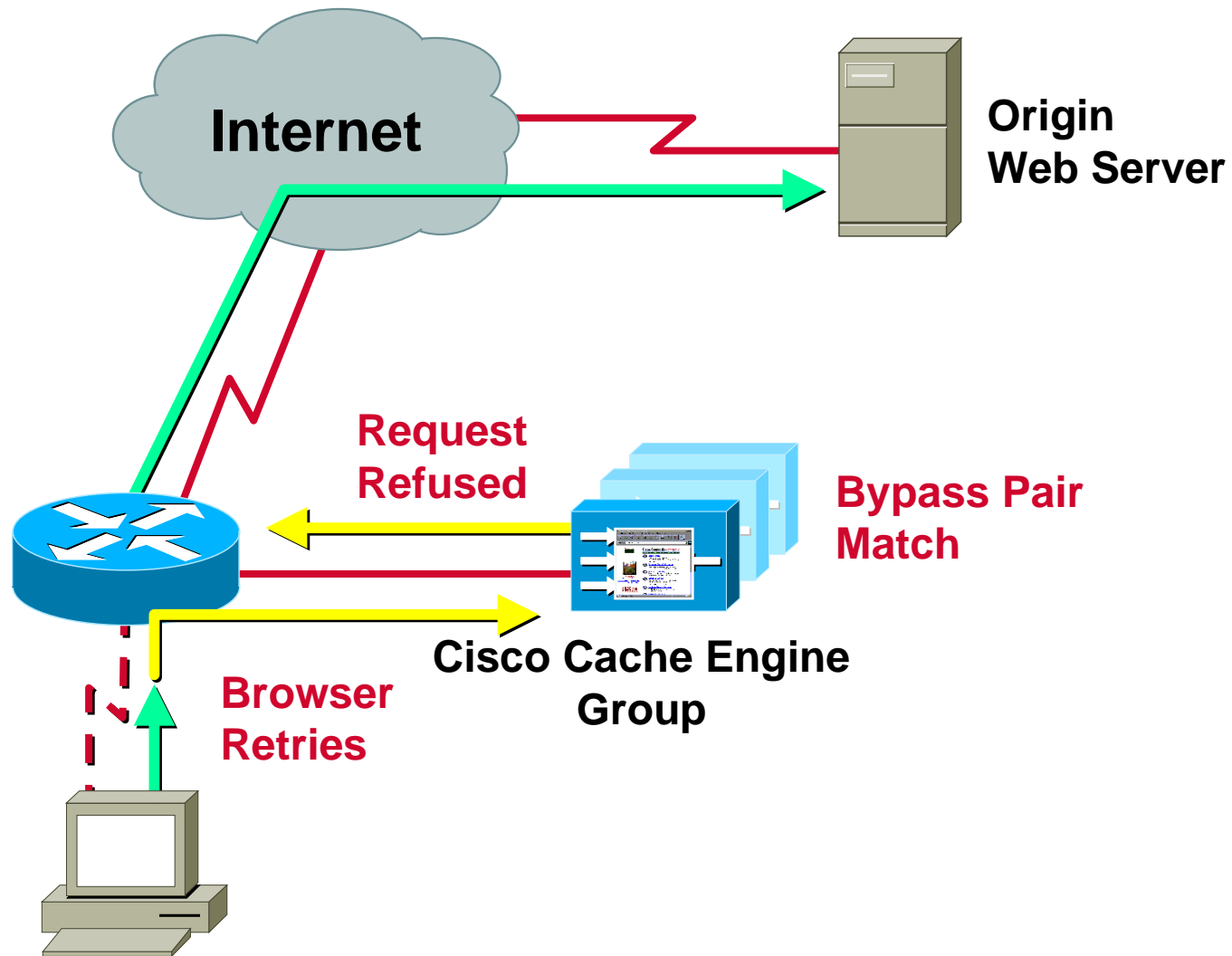
# Fault Prevention: IP Authentication



# Fault Prevention: IP Authentication



# Fault Prevention: IP Authentication





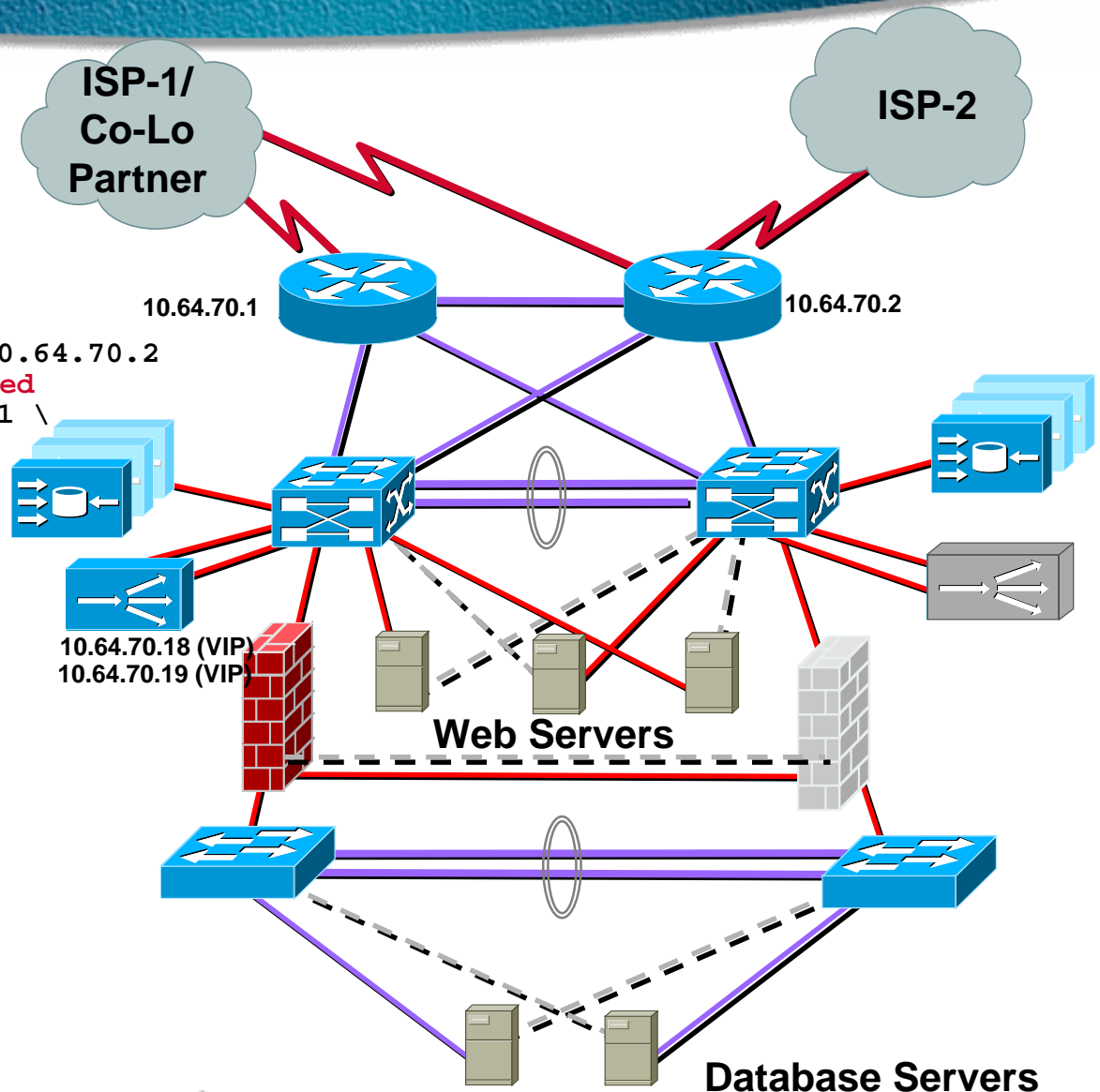
# Reverse Proxying via WCCP

## Routers

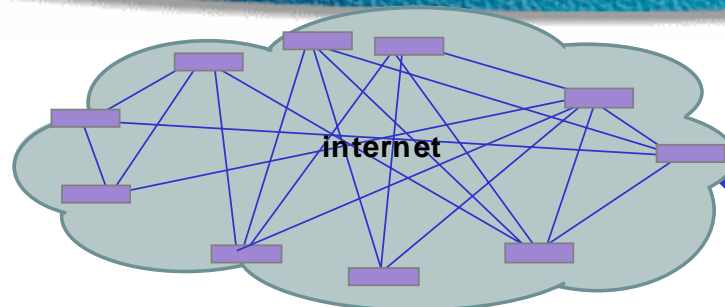
```
ip wccp 99 password pass1
!  
interface fastethernetX/Y  
ip wccp 99 redirect out
```

## Cache

```
..  
wccp router-list-num 1 10.64.70.1 10.64.70.2  
! both WCCP-enabled routers listed  
wccp reverse-proxy router-list-num 1 \  
password pass1  
! enable reverse-proxy service  
..  
rule enable  
rule use-proxy 10.64.70.18 80 \  
domain site.com  
! send cache misses to  
! LocalDirector  
! VIP 10.64.70.18  
http proxy outgoing 10.64.70.19 80  
! send all other [non-listed]  
! Domains to a cache-all VIP  
! on LD that tells user that  
! the domain does not exist
```



# Reverse Proxying via WebNS



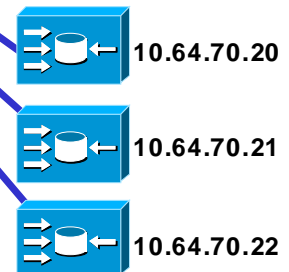
HTTP requests distributed to VIP 10.64.70.19

www.site.com

CSS11xxx

Cache misses distributed to VIP 10.64.70.18

CE5xx or CE73xx's



Server 10.64.70.46 Server 10.64.70.47

## WebNS

```
owner www.site.com
content reverse_proxy_rule
vip address 10.64.70.19
protocol tcp
port 80
url "/" eql cachable
add service cachel
add service cache2
add service cache3
```

```
content web-server-rule
vip address 10.64.70.19
protocol tcp
port 80
url "/"
add service webserver1
add service webserver2
```

```
content cache-request-rule
vip address 10.64.70.18
add service webserver1
add service webserver2
```

## Cache

```
no bypass load enable
! we always want to serve requests
! offered to us
http l4-switch enable
! we wish to operate in transparent mode
rule enable
rule use-proxy 10.64.70.18 80 \
domain site.com
! send cache misses to
! WebNS VIP 10.64.70.18
http proxy outgoing 10.64.70.17 80
! send all other [non-listed]
! Domains to a cache-all VIP
! that tells user that
! the domain does not exist
```

# Sizing correct cache

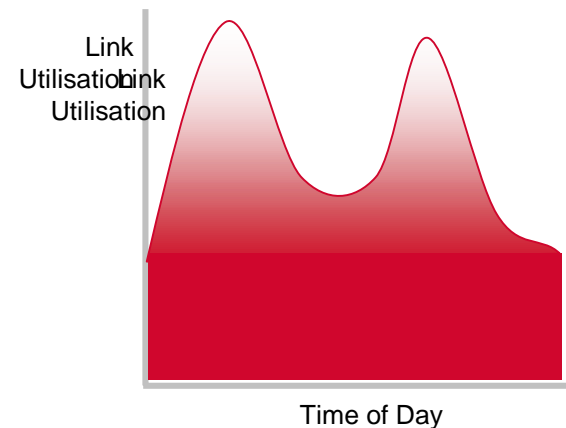
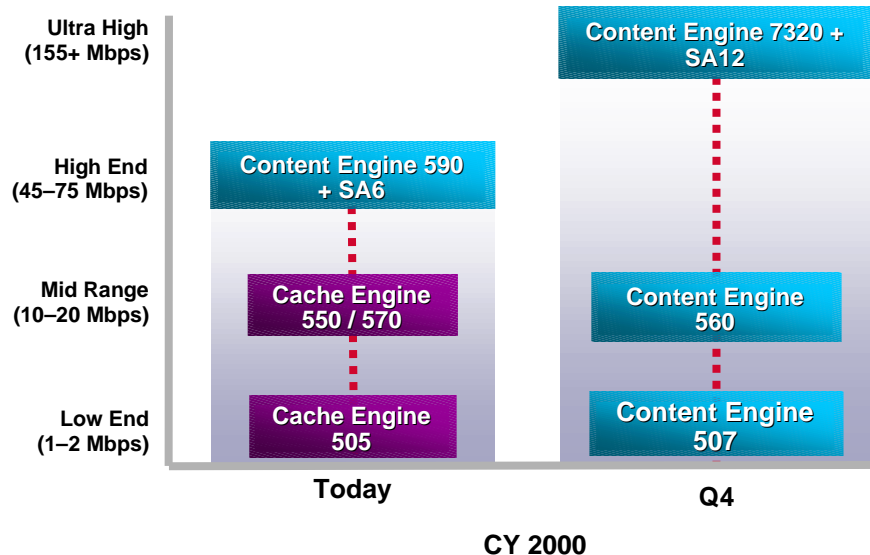
## 3 important parameters for sizing a cache:

- Transactions/sec (aka req/sec, URLs/sec)
- Concurrent # TCP conns.
- Cache Disk capacity

All are sized appropriately in CE560/590/7320 for typical “Service Provider” traffic

If traffic patterns are not “typical”, then consult Deployment Guide.

(see <http://bock-bock/~ltd/cache/>)



# Accelerated WCCPv2 for Catalyst 6x00

**WCCPv2: GRE Encap, CEF/DCEF Switched**  
**Accelerated WCCPv2: L2 Rewrites, No GRE**

Supervisor 1				Supervisor 2	
				MSFC 2	MSFC 2
				GRE	L2
Conns/sec	MSFC 1 GRE 50K	MSFC 1 L2 50K	MSFC 2 GRE 150K	MSFC 2 L2 150K	MSFC 2 GRE 150K
Throughput	170 Kpps	15 Mpps	510 Kpps	15 Mpps	510 Kpps
					30 Mpps

**Caches need to be L2-connected to switch**



# Accelerated WCCPv2 for Catalyst 6x00

- **Today: Supervisor 1 support**

**CE 590+SA6: Cache 2.2 software**

**Catalyst 6000: Catalyst OS 5.5, MSFC:  
Cisco IOS 12.1(2)E**

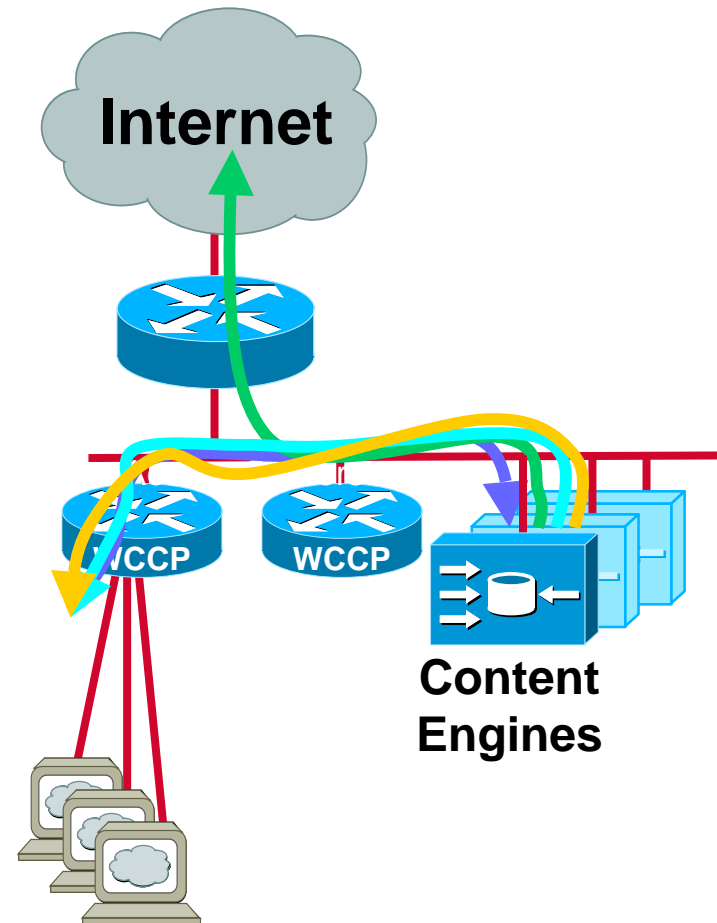
- **Q1 CY '01: Supervisor 2 support**

**CE 7320+SA12 or CE 590+SA6: Cache 3.2 software**

**Catalyst 6000: Catalyst OS 6.1, MSFC:  
Cisco IOS 12.1(4+)E**

# WCCP: where to enable it?

- CEF switched in 12.0(4)T
- In 12.0(11)S
  - Input interface feature
  - 7500+VIP DCEF switched
  - Flow acceleration
  - BGP Policy Propagation
  - => **Minimal CPU increase**
- Run WCCPv2 on access routers and attach Content Engines to a switch
- Load is distributed across multiple routers, no increase in number of packets



# WCCP in 12.0(11)S

- **Ability to define traffic which can be intercepted via route-map.**

**Very powerful -- provides for selective inclusion in cache eligibility**

- **‘Premium’ hosting**

**Service Providers can offer transparent backbone caching. Peers/customers can choose to participate by setting bgp community/MED**

- **Cache-only-dial-pool**

**Provider only wants to cache dial or DSL pool, yet address space is segregated.**

- **Selective intercept based on administrative pref**

**Only cache traffic which is due to go out an expensive path (eg. International)**



# Policy Propagation with WCCP

## *Using MTRES vs ACLs*



# BGP Policy Propagation for WCCP

- **Problem: Caching is an *operational* savings. What ISPs and Co-Lo Providers are looking for is a new revenue stream - CDNs**
- **Problem: How to maintain redirection ACLs and Route-Maps that will point redirected packets to the correct CDN service? (think 1000s of devices w/ ACLs)**

# BGP Policy Propagation for WCCP

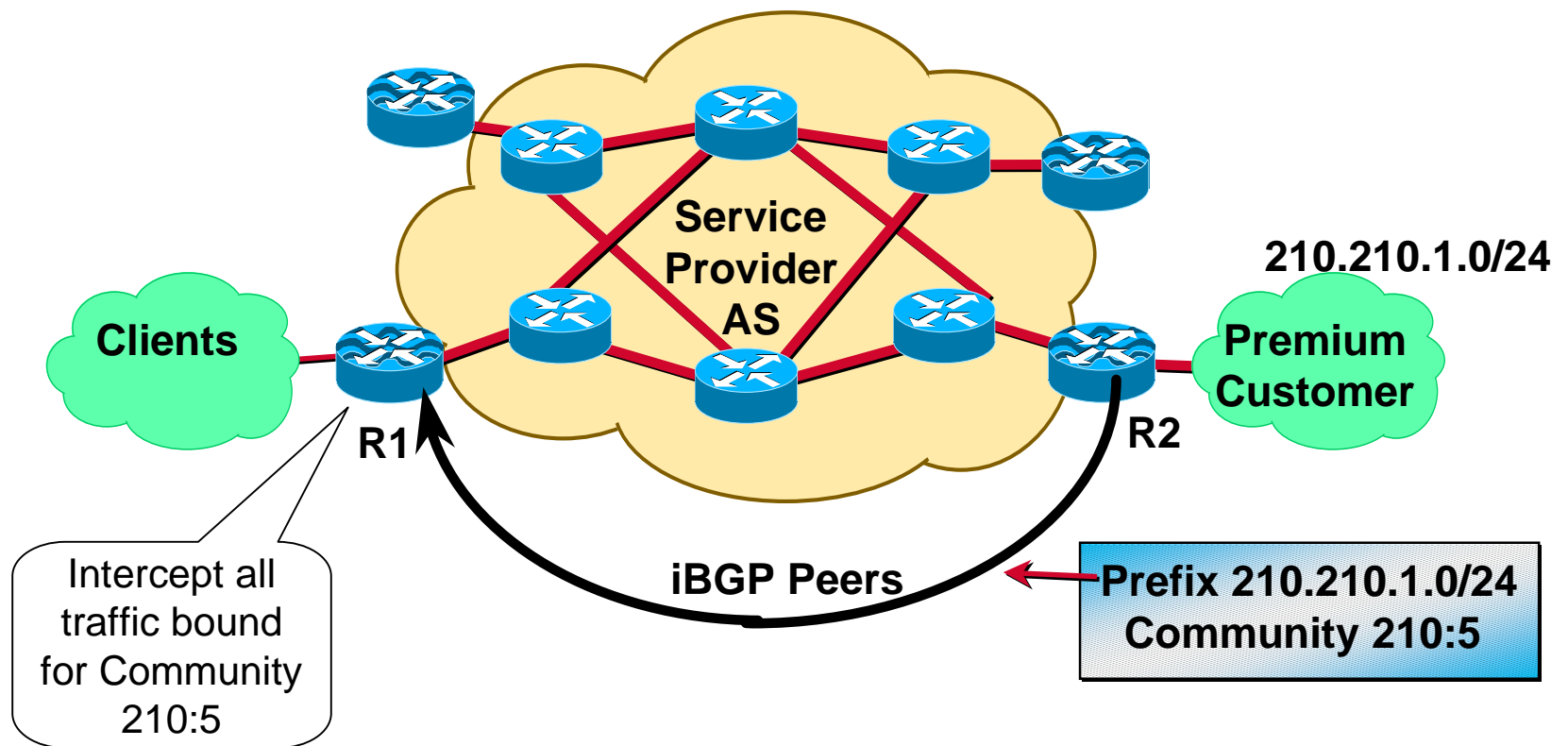
- **Answer - use the FIB!**

**The FIB has the capability to add extra fields to describe a prefix.**

**Currently (12.0(11)S) there are four extra FIB fields - precedence, qos\_group, traffic\_index, and *wccp\_tag***

**Features would use a MTRE look-up in the FIB to get information on what to redirect.**

# BGP Policy Propagation for WCCP



# Example - Step 1

## Step 1- Router R2 (or another Router) mark the prefix with a community

```
!  
router bgp 210  
  neighbor 210.210.14.1 remote-as 210  
  neighbor 210.210.14.1 route-map comm-relay-prec out  
  neighbor 210.210.14.1 send-community  
!  
ip bgp-community new-format  
!  
access-list 1 permit 210.210.1.0 0.0.0.255  
!  
route-map comm-relay-prec permit 10  
  match ip address 1  
  set community 210:5  
!  
route-map comm-relay-prec permit 20  
  set community 210:0  
!
```



## Example - Step 2

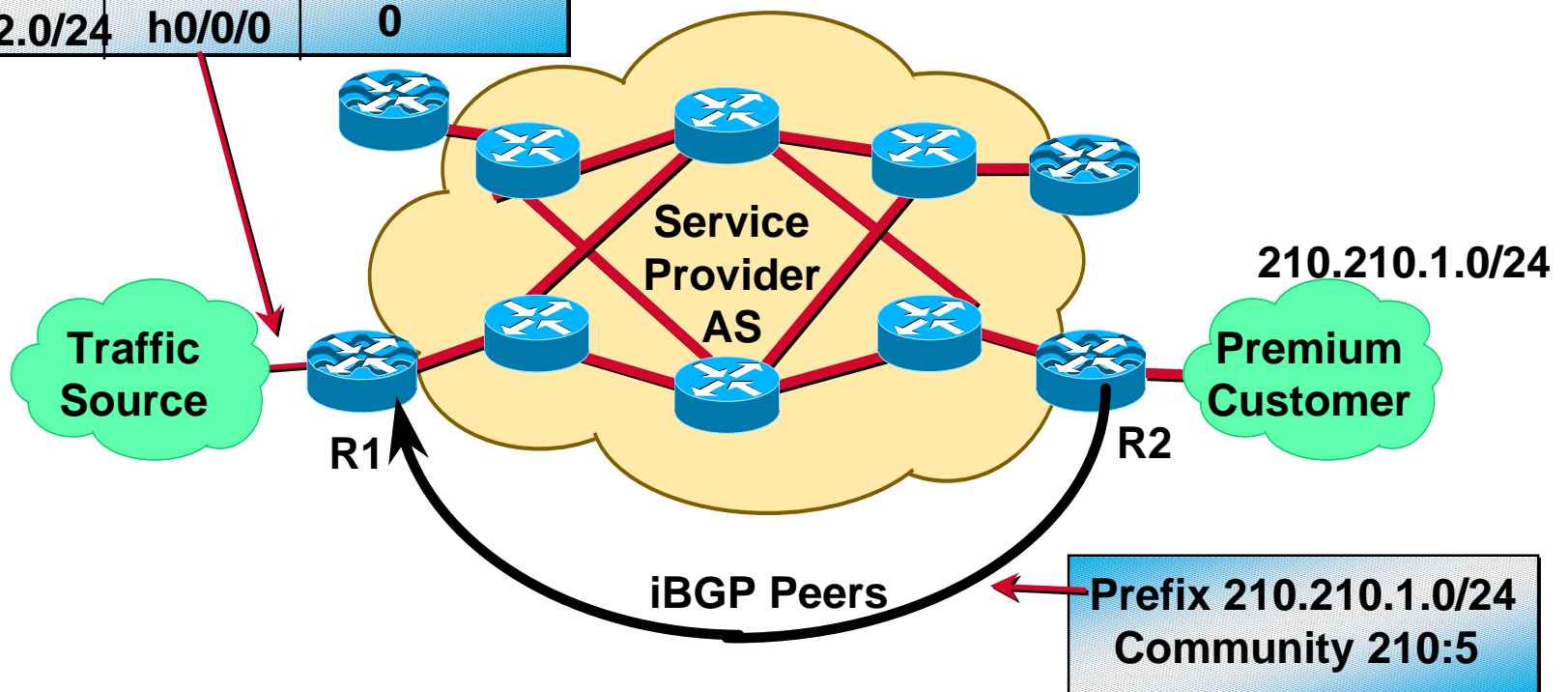
**Step 2 - Use the BGP Update to match the community and set the value in the FIB**

```
!  
router bgp 210  
  table-map precedence-map  
  neighbor 200.200.14.4 remote-as 210  
  neighbor 200.200.14.4 update-source Loopback0  
!  
ip bgp-community new-format  
!  
ip community-list 1 permit 210:5  
!  
route-map precedence-map permit 10  
  match community 1  
  set ip wccp 50  
!  
route-map precedence-map permit 20  
!
```

# Example - Status

R1's FIB Table

Prefix	Next-hop	WCCP_TAG
210.210.1.0/24	h0/0/0	50
210.210.2.0/24	h0/0/0	0



## Example - Step 3

**Step 3 - WCCP used the a FIB lookup to get the WCCP\_TAG. It then redirected based on the WCCP\_TAG value.**

!

```
ip wccp version 2
```

```
ip wccp web-cache password <pass> policy source 50
```

!

```
interface <xyz>
```

```
ip wccp web-cache redirect in
```

!

# BGP Policy Propagation for WCCP

- **Very powerful -- provides for selective inclusion in cache eligibility**

## **'Premium' hosting**

**Service Providers can offer transparent backbone caching. Peers/customers can choose to participate by setting bgp community/MED**

## **Cache-only-dial-pool**

**Provider only wants to cache dial or DSL pool, yet address space is segregated.**

## **Selective intercept based on administrative pref**

**Only cache traffic which is due to go out an expensive path (eg. International)**

## **Redirects into CDN Services**



# Another Example

- **The following example shows only "premium" traffic being cached.**

**"Premium" traffic is defined as traffic which has:**

**The policy defined below is:**

**any traffic with community 4433:1050 set,  
any traffic with community 4433:1055 set,  
any traffic originating from directly-connected AS 65521,  
any traffic passing thru directly-connected AS 65522,  
any traffic passing thru AS 65523**

**is eligible for intercept.**

**Standard "web-cache" service is used -- which is a standard assignment of 'match tcp destination port 80', distribute traffic among participating caches as hashed by destination ip address.**

# Another Example

```
!  
ip cef distributed          # ensure Distributed CEF is enabled  
!  
ip wccp version 2         # enable WCCPv2  
ip wccp web-cache password <pass> policy source 50  
                           # enable WCCP standard web-cache service, apply policy  
                           # "source"- match on WCCP route-tag 50  
!  
interface <xyz>            # incoming i/face  
  ip wccp web-cache redirect in  # redirect on input traffic  
!  
router bgp XXXX  
  table-map neighbor-xyz-in  # BGP Updates the FIB's WCCP_TAG field  
!  
ip bgp-community new-format  
ip community-list 3 permit 4433:1050  # AS4433 community 1050 is premium  
ip community-list 3 permit 4433:1055  # AS4433 community 1055 is premium  
!  
ip as-path access-list 121 permit ^65521$  # only traffic from AS65521 is premium  
ip as-path access-list 121 permit ^65522  # any traffic thru AS65522 premium  
!  
route-map neighbor-xyz-in permit 10      # incoming route filter on  
  match as-path 121  
  set ip wccp 50  
!  
route-map neighbor-xyz-in permit 15  
  match community 3  
  set ip wccp 50
```

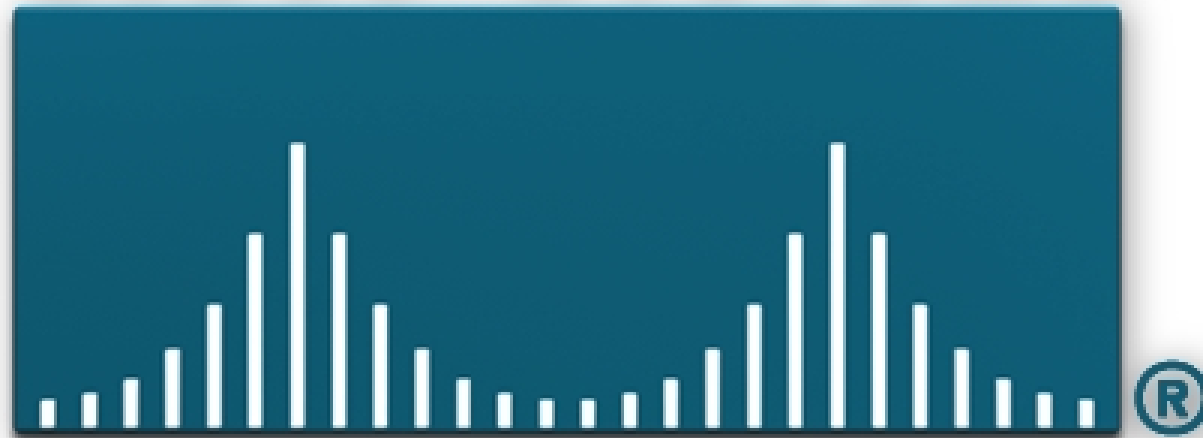
## *The Caveat*

- **BGP Policy Propagation for WCCP was only committed to 12.0(11)S.**

**Hence it is currently in 12.0(11)S and it's children - 12.0SC and 12.0SL**

- **Work is underway to have this committed to 12.1T and find ways for it to work on the EARL and GSR architecture (*issue is the MTRE for the source address*).**

# CISCO SYSTEMS



EMPOWERING THE  
INTERNET GENERATION<sup>SM</sup>



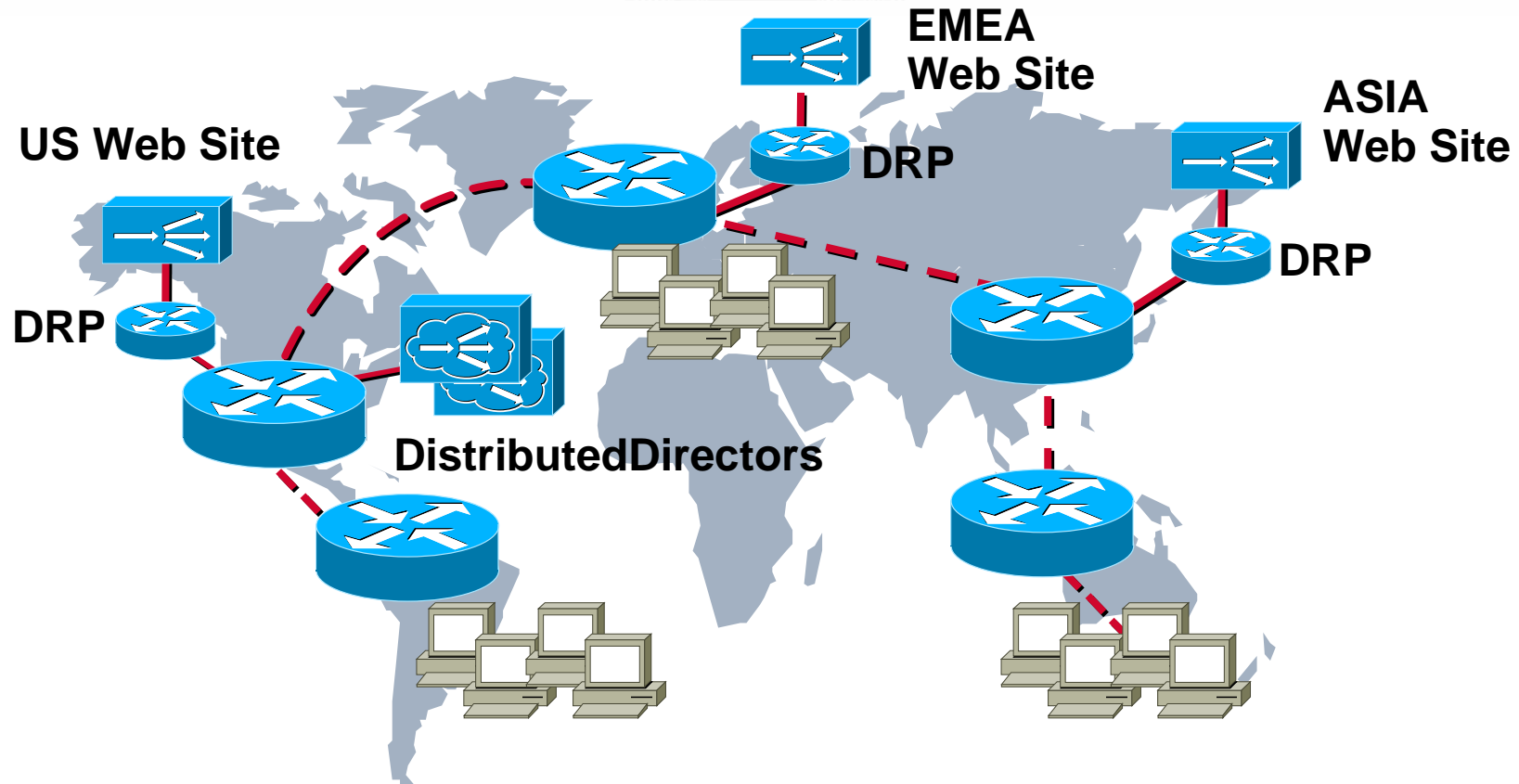


# Content Routing

# Content Routing

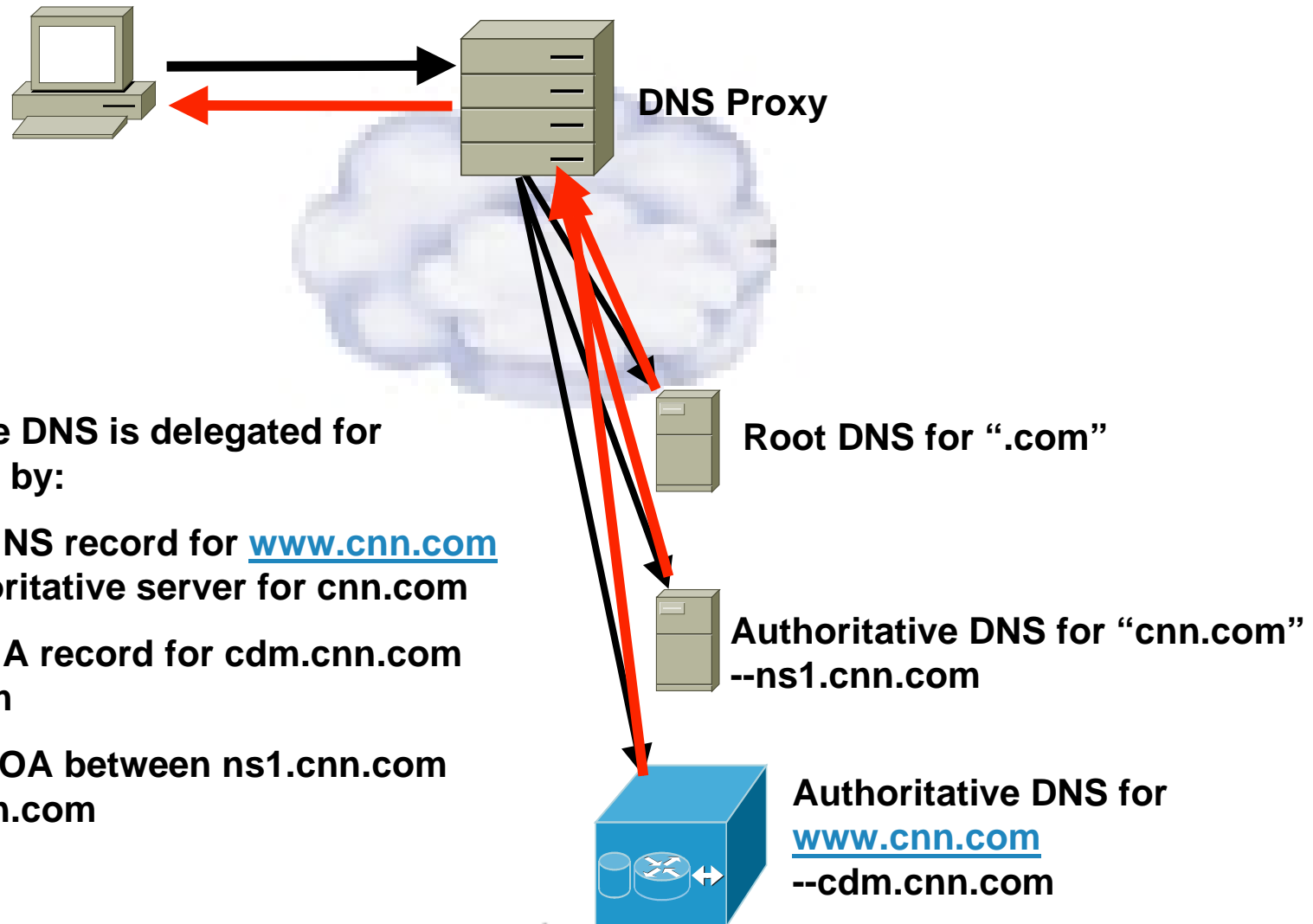
- **The goal of content routing is to direct a user request to the closest, available content delivery site that has the content the user is requesting.**

# Content Routing



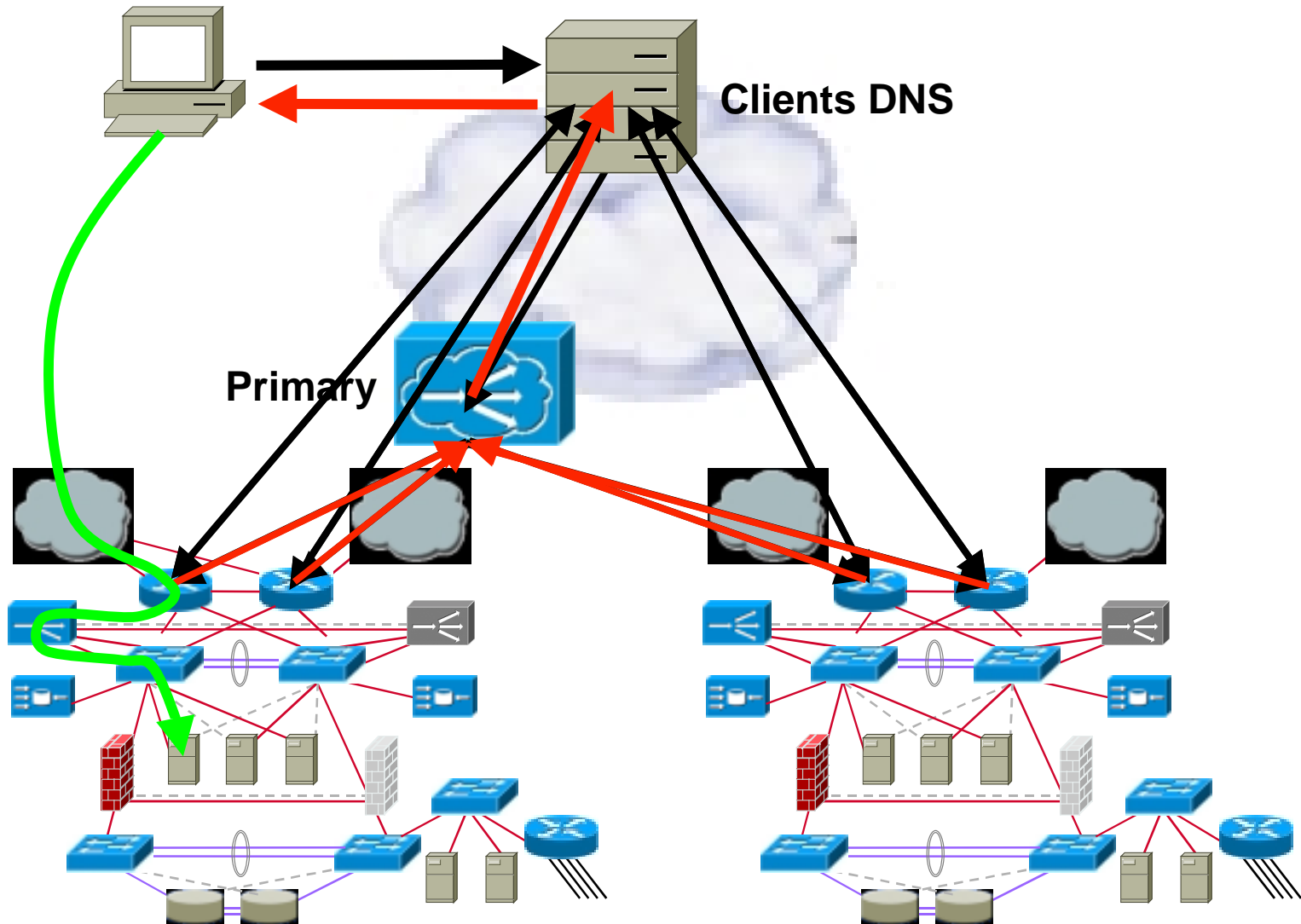
- DNS Based Technology
- Dynamically returns the “best” IP address for DNS queries
- Load Distribution Decisions include Network Topology and/or Link Latency

# DNS Lookup Process

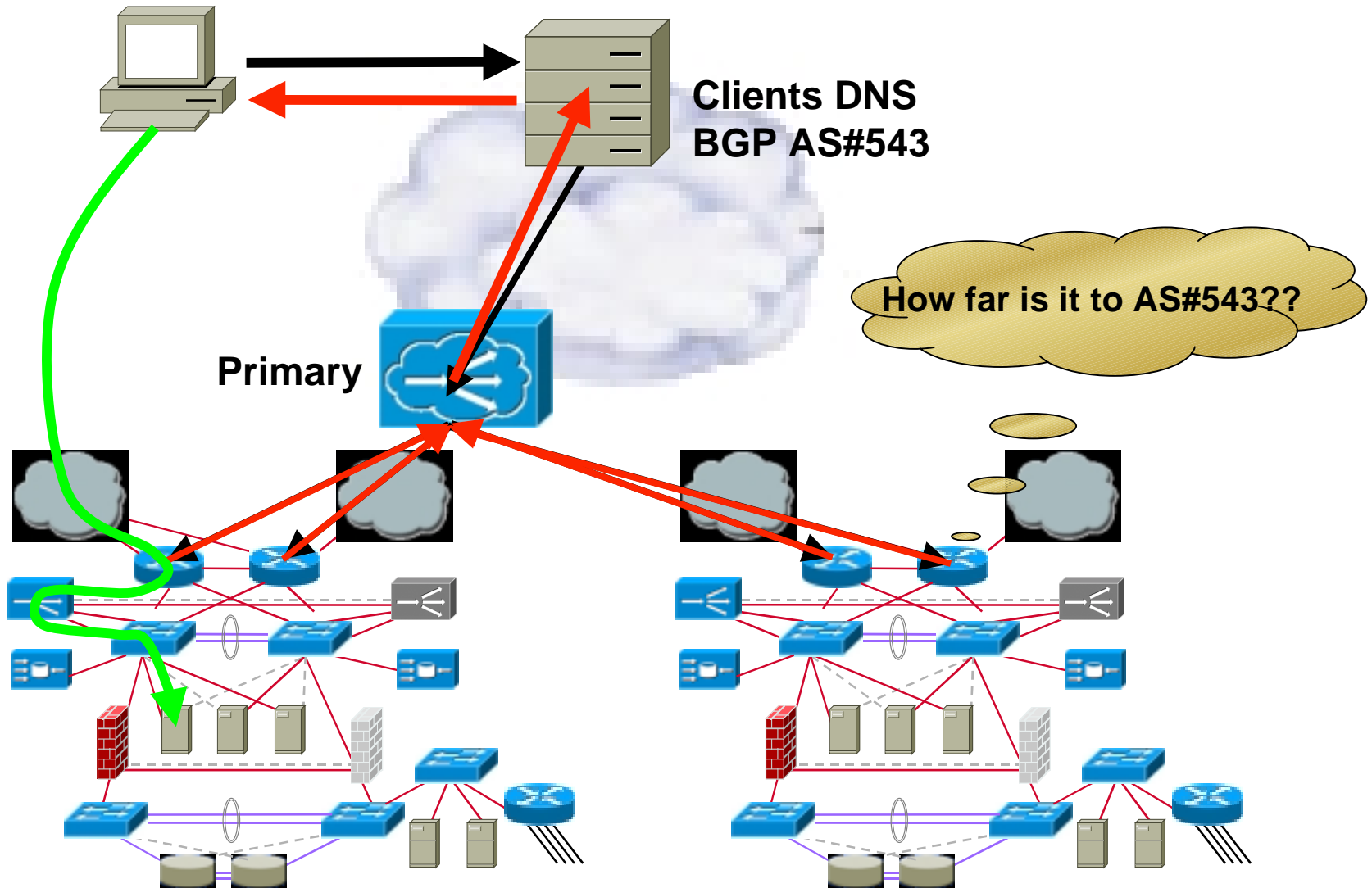




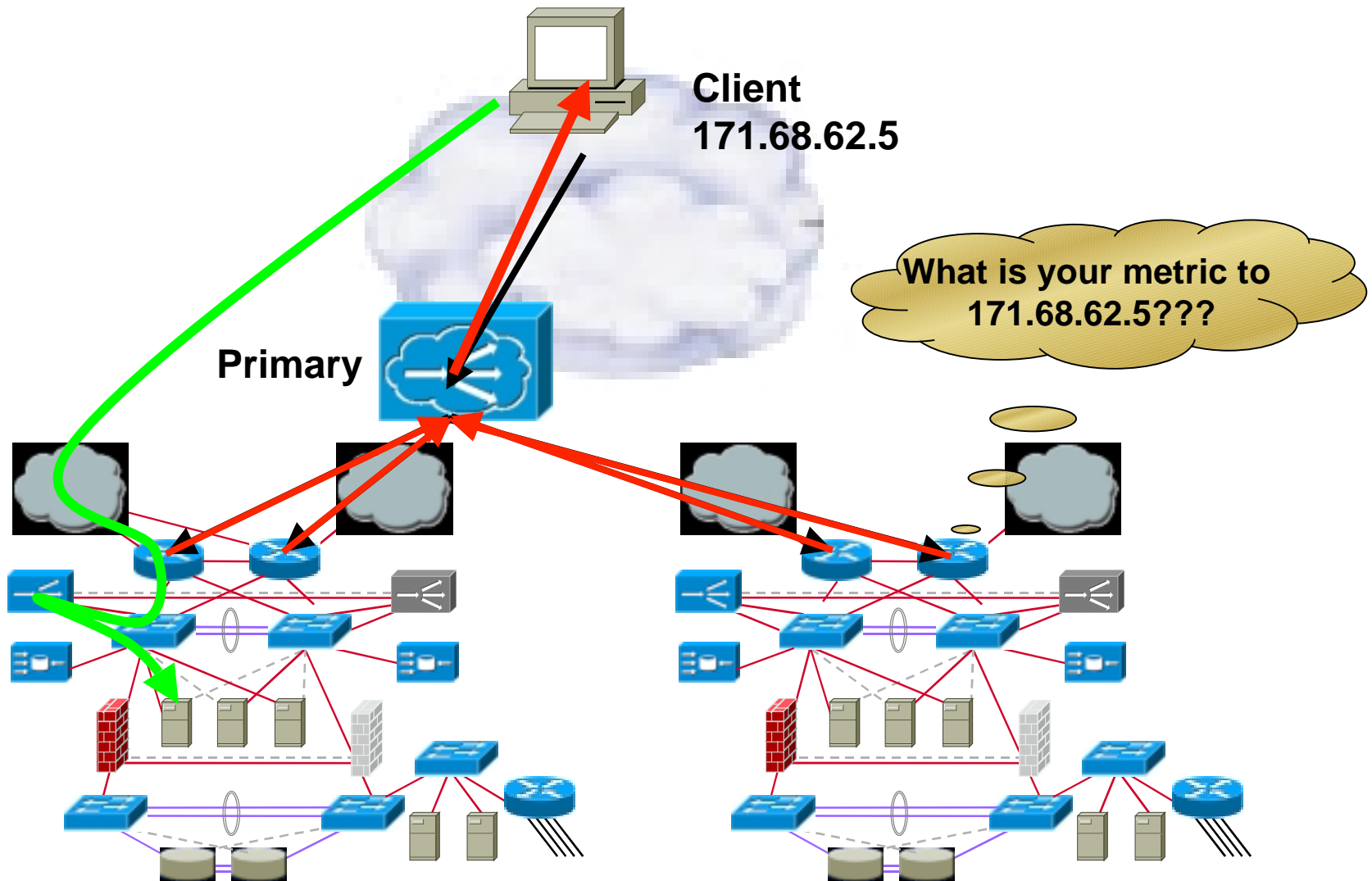
# RTT Metric



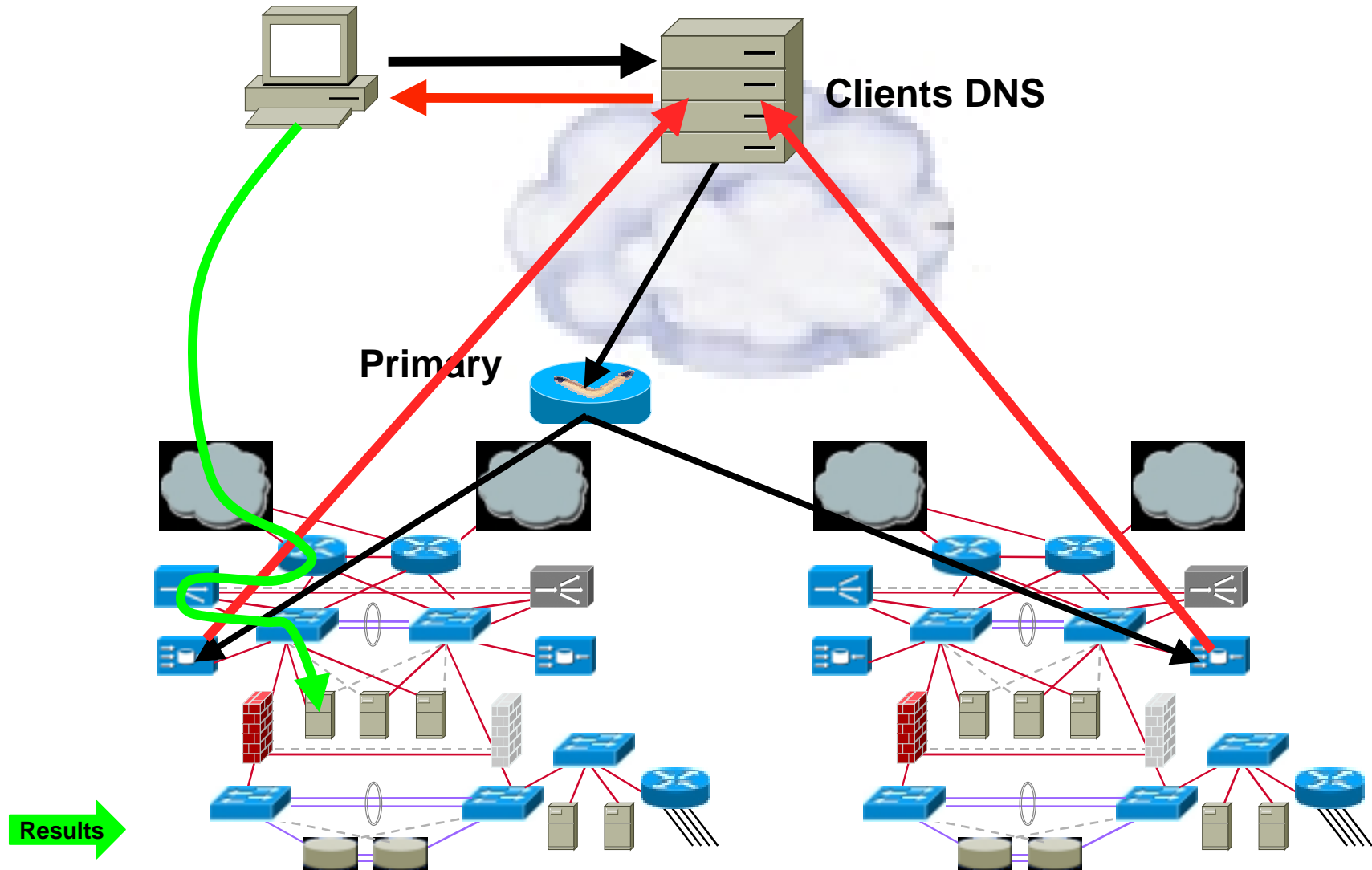
# BGP-External Metric



# IGP-Internal Metric

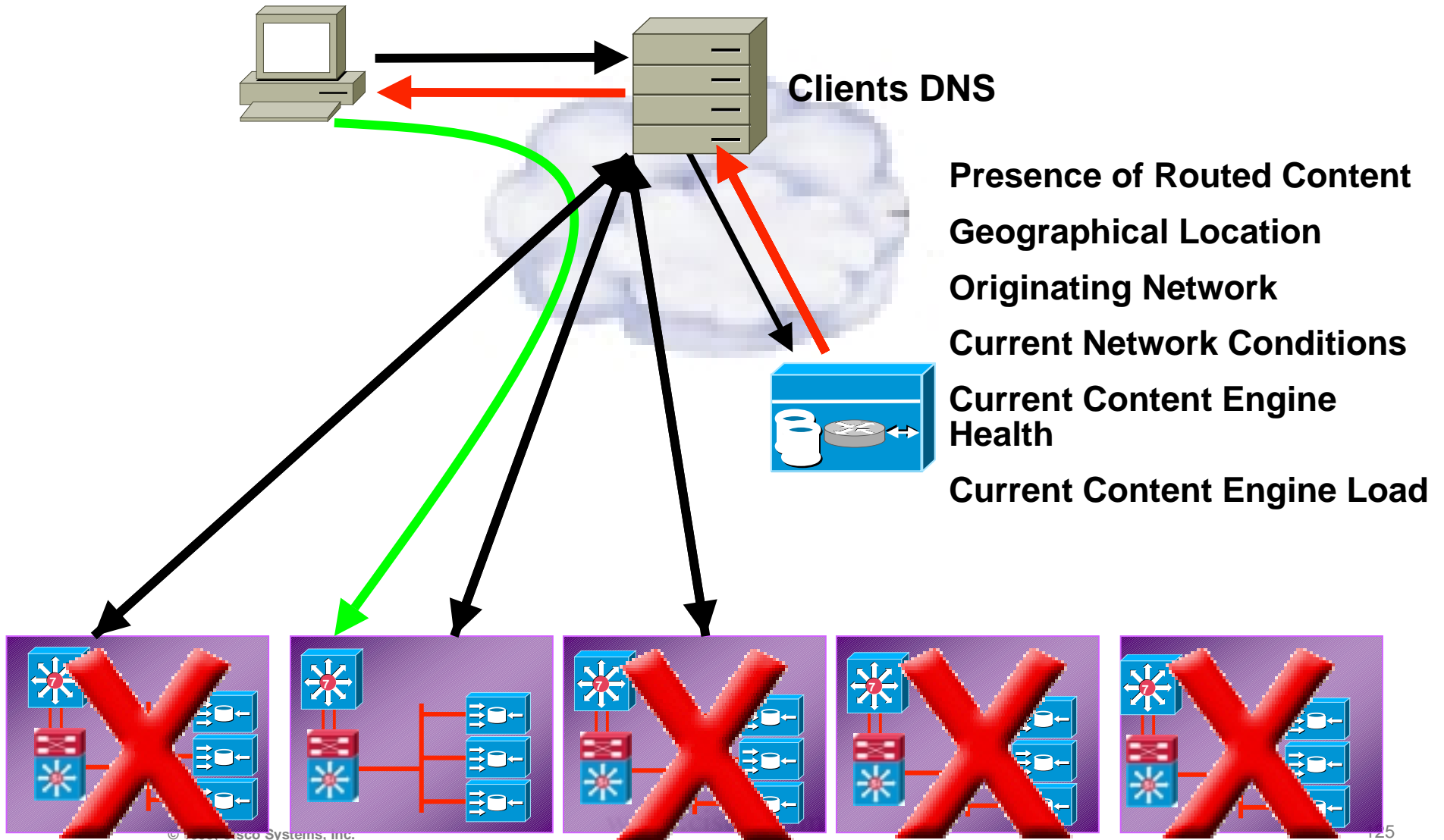


# Race Condition (Boomerang)



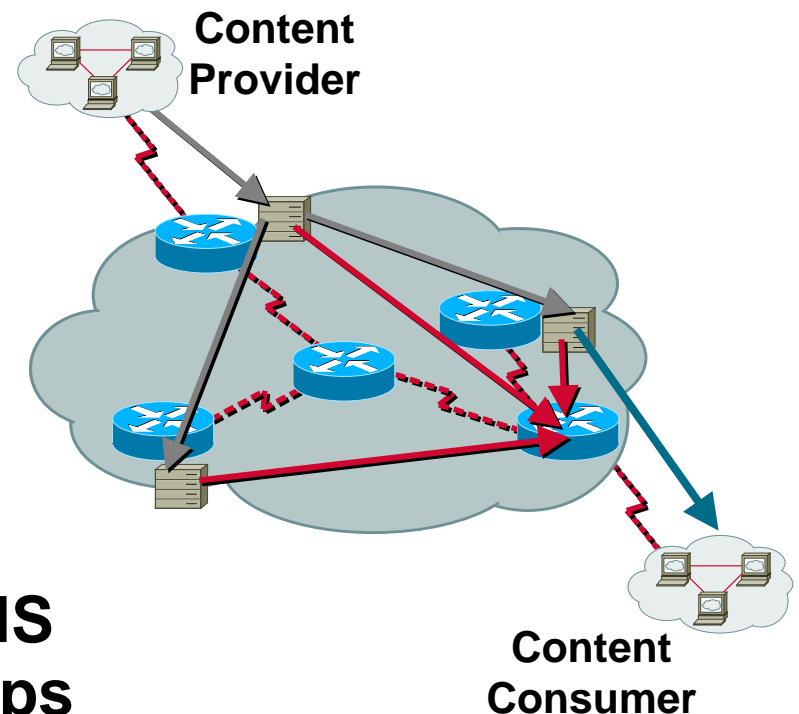


# CDM 2.0 Multiple NS-Record System (CR4450)



# Sandpiper/Digital Island Approach

- **Content provider contracts with Sandpiper for web hosting**
- **Sandpiper/Digital Island**
  - Deploys content servers,
  - Maps Internet
  - Dynamically optimizes routing
  - Minimizes delay, congestion
- **Content server selected at DNS lookup, based on network maps**



# Akamai Approach

- **Content provider contracts with Akamai for content replication**

Provider hosts content

Some content replicated in network

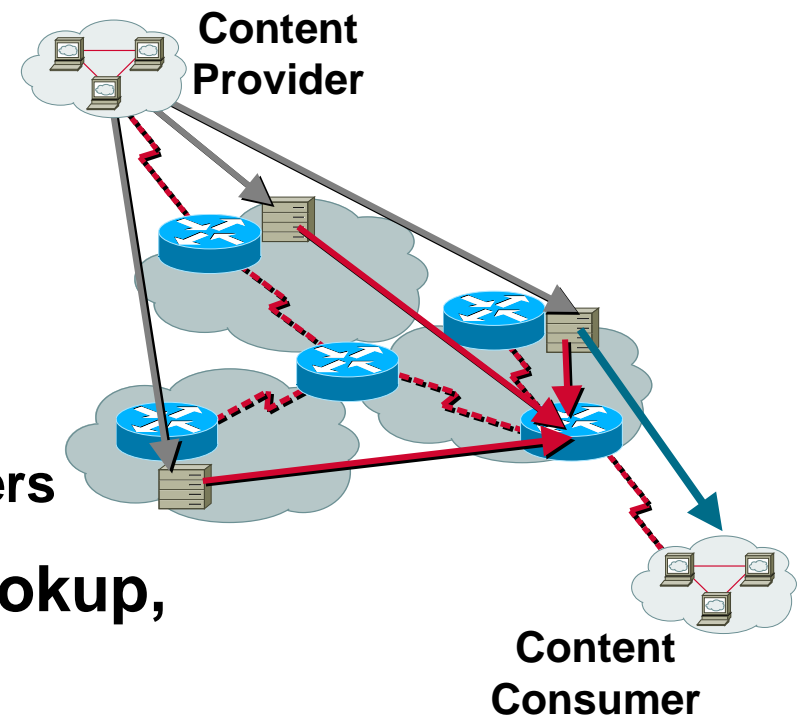
- **Akamai**

Deploys content servers,

Maps Internet

Maps potential clients to Akamai servers

- **Content server selected at DNS lookup, based on network maps**



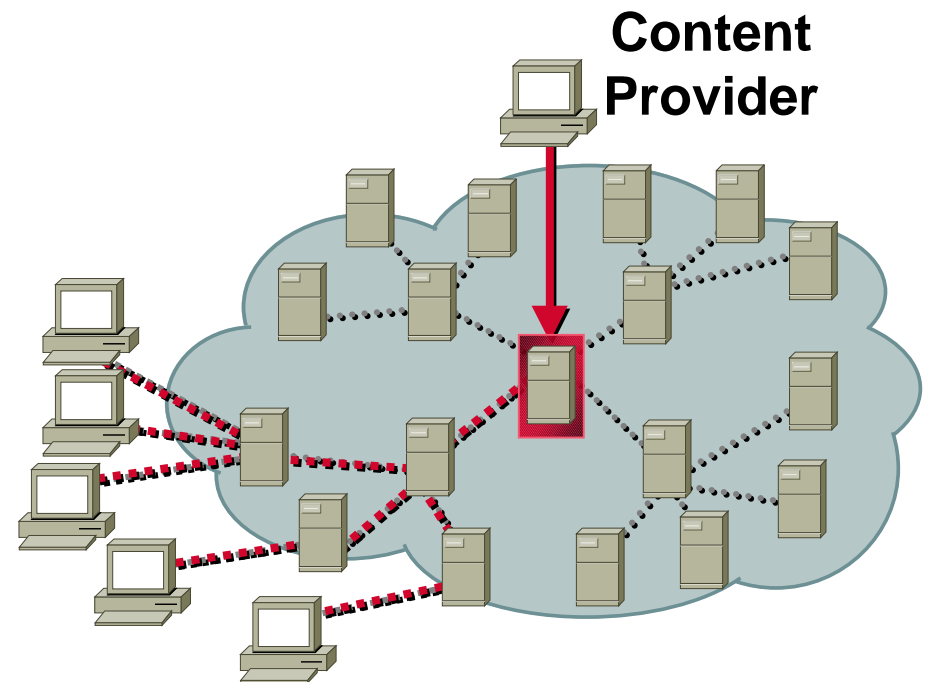
# Sightpath Approach

- **Corporation or service provider deploys content servers, markets service**

- **Service offered:**

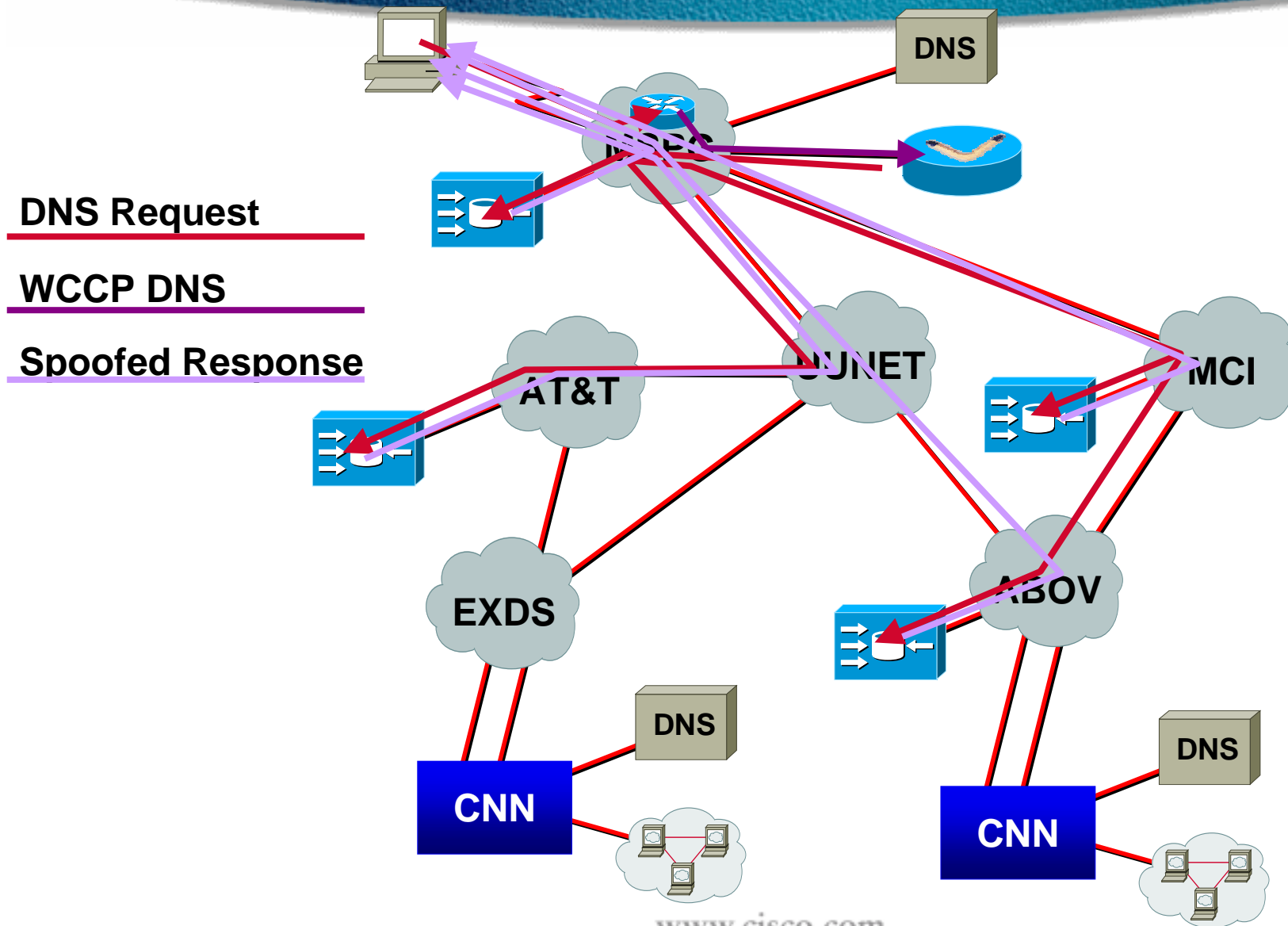
**Dynamic application layer path testing and routing minimizes loss, delay**

**Content server selected at setup time, route varies during delivery**

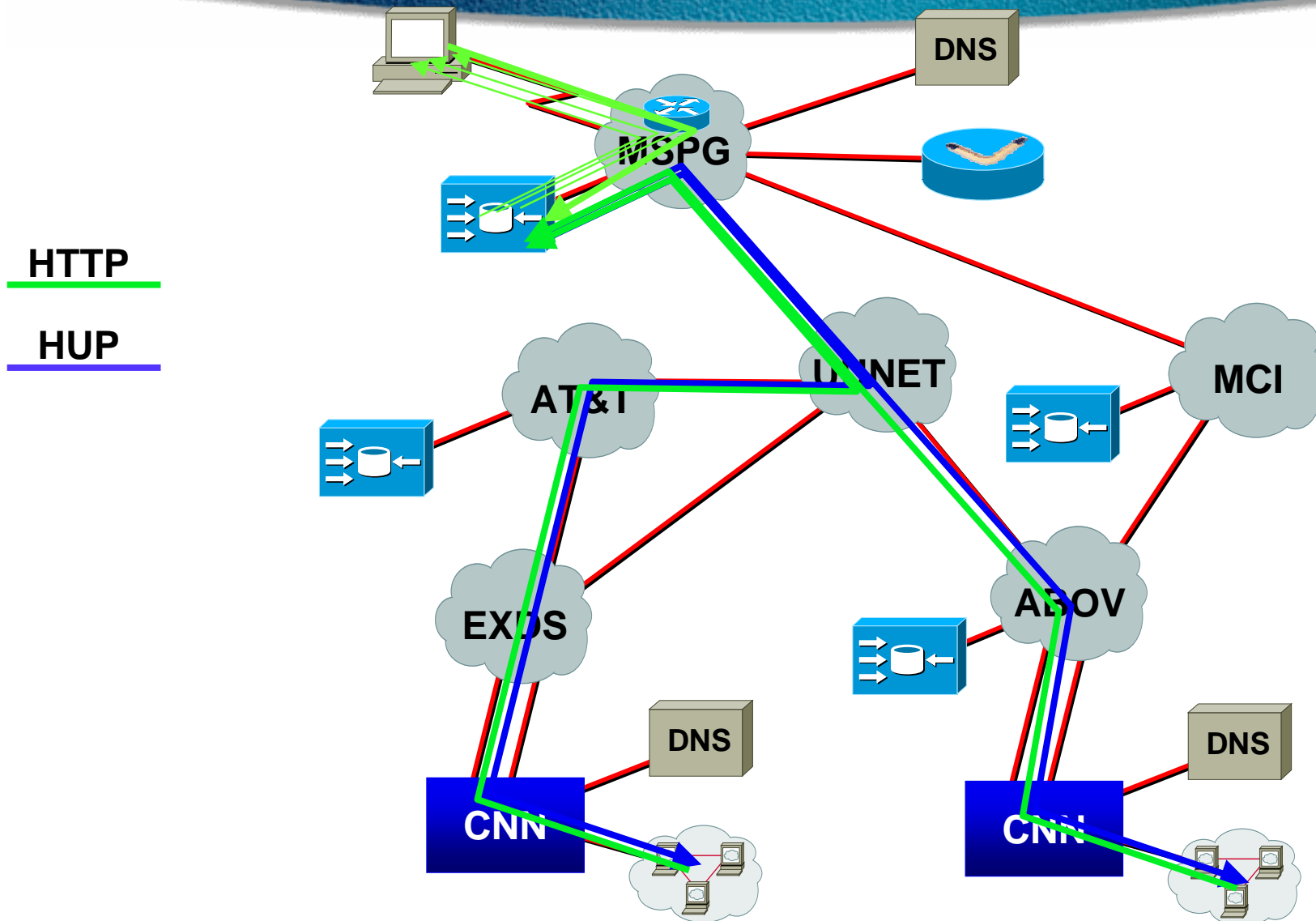




# Boomerang - CR4400



# Potential Solution



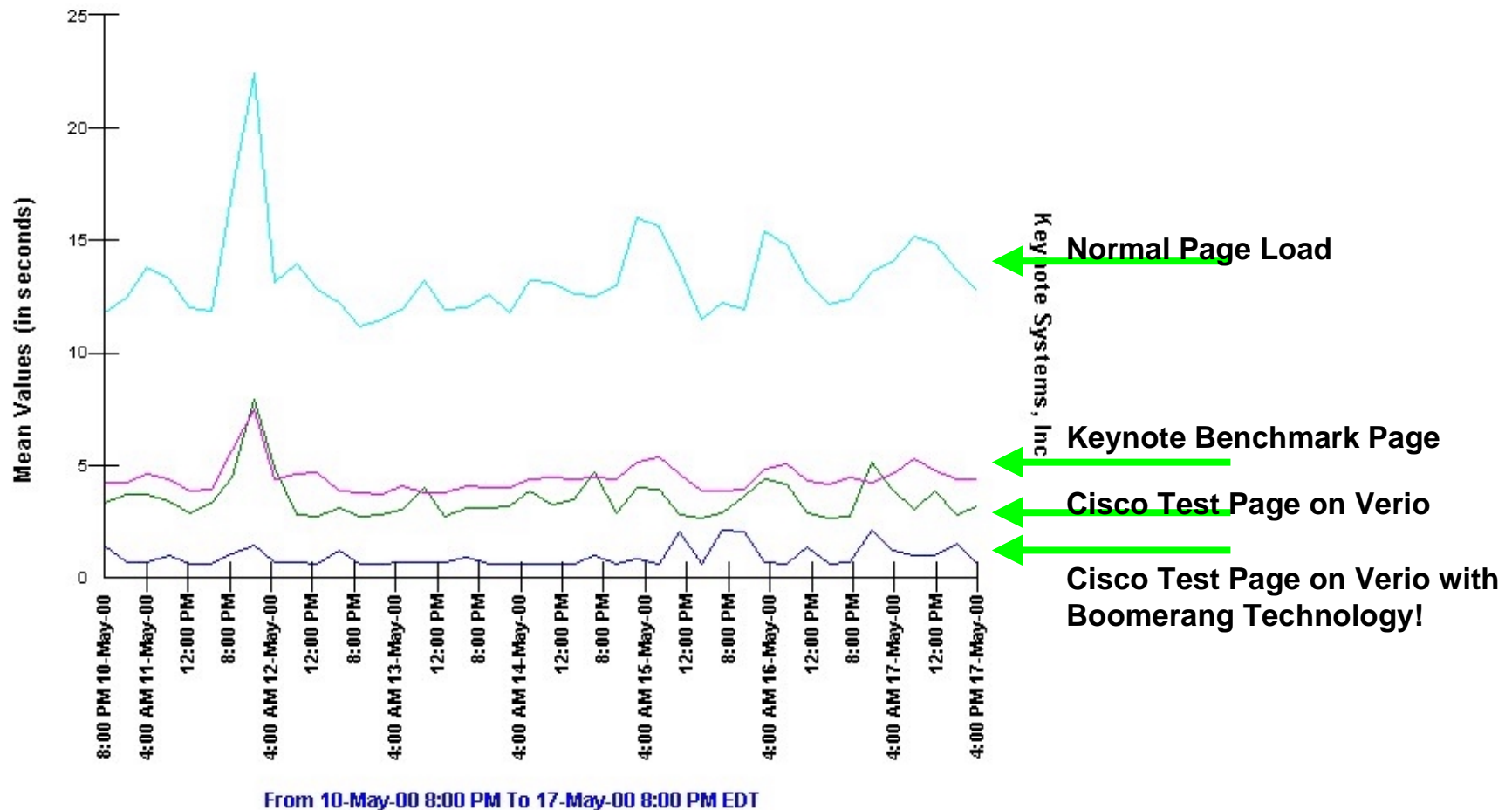
# Boomerang Technology Testing



- Cisco Needed to Prove the Boomerang Technology in a “real-world” environment
- Cisco chose Verio in six collocation facilities
- Solid network, geographic dispersion.
- Cisco Powered Network

# Keynote Testing of Cisco Technology on Verio Network

Web Site Performance by Time History - Trimmed







# Addendum

## *Case Studies*

# Trans-Oceanic Internet Backbones

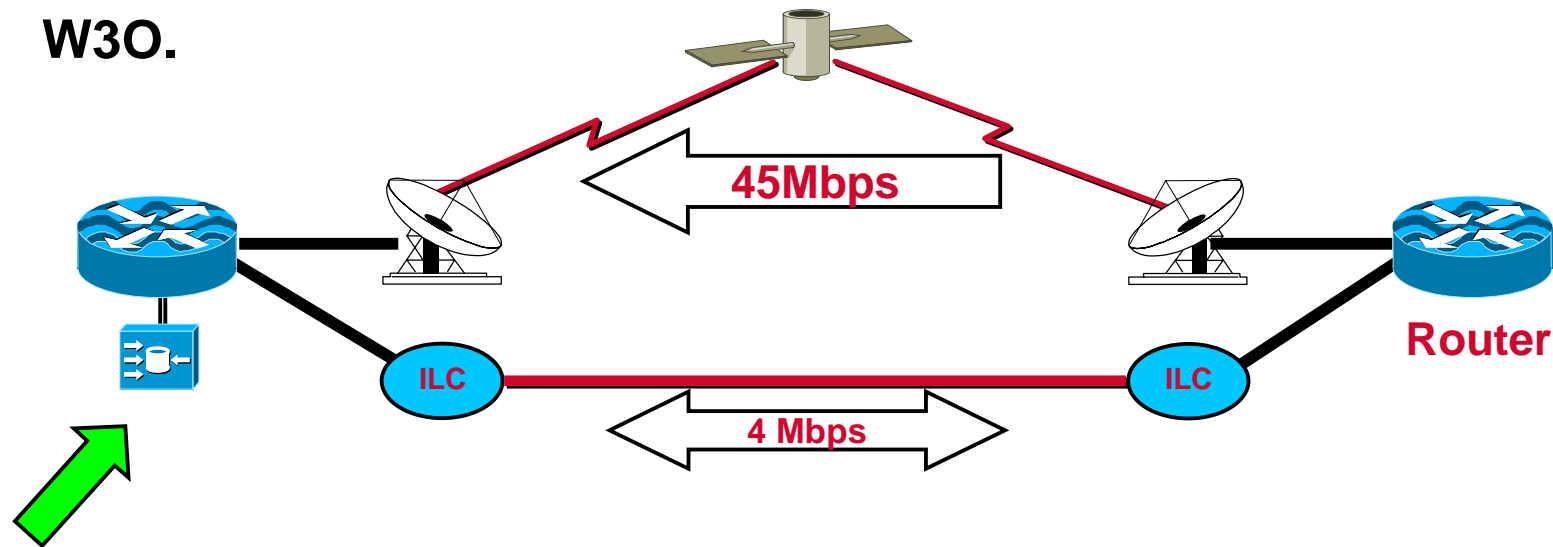
## Asymmetrical Satellite Links

- **WWW Caching adds an additional “buffer” to the higher latency.**

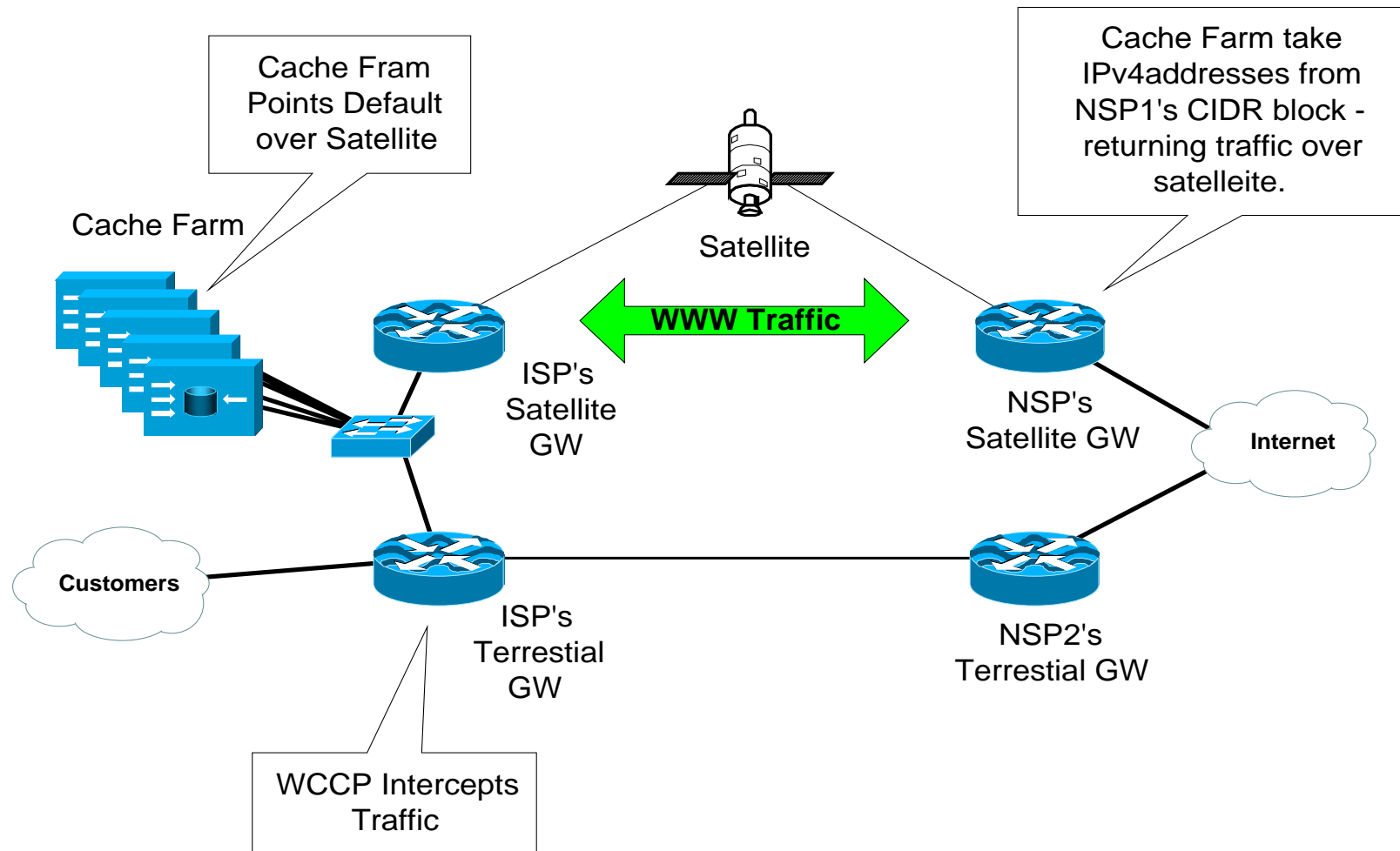
**Caches content as it comes over the link.**

**Minimizes the download of the same content over and over again.**

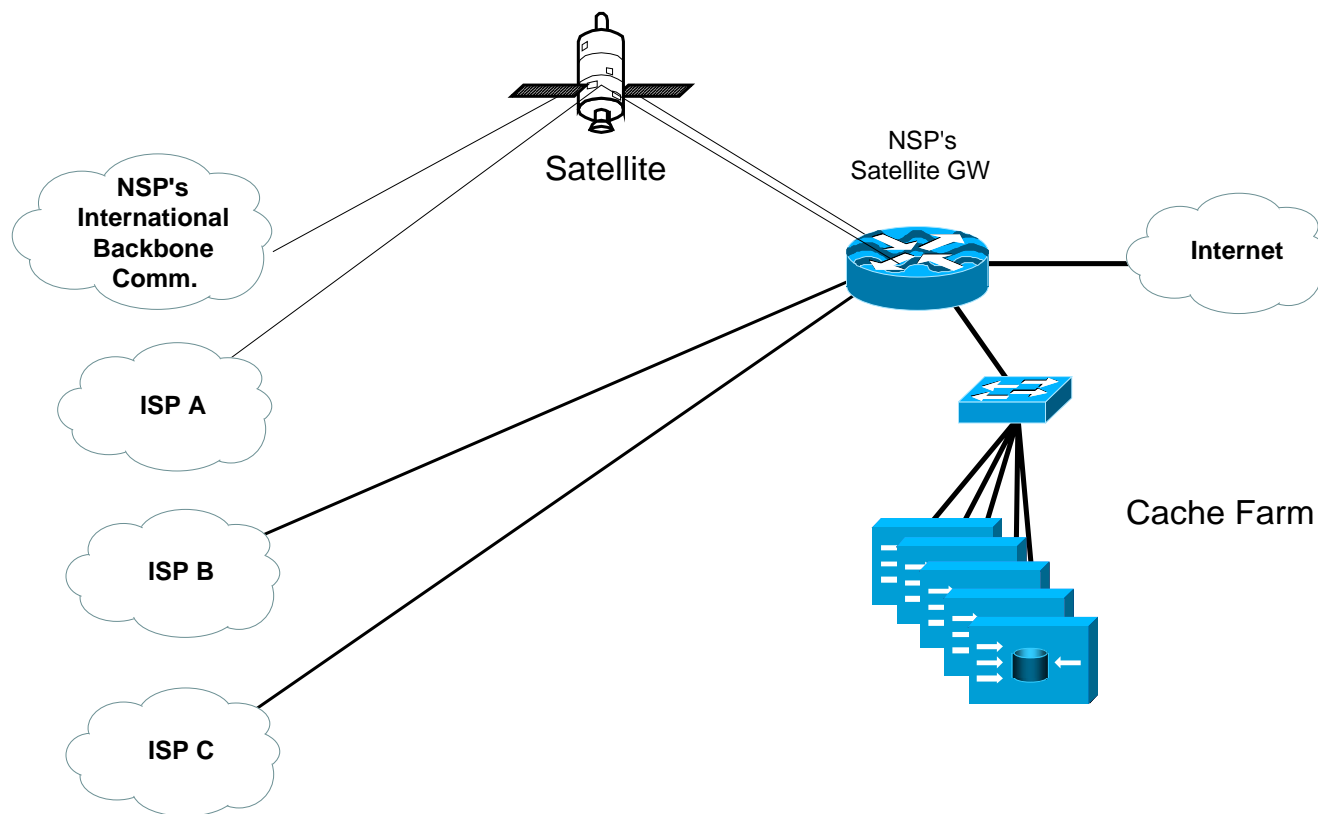
**WWW Caching is a main stream Internet technology - all issues with it's use have been resolved via technical means via IETF and W3O.**



# Trans-Oceanic Links

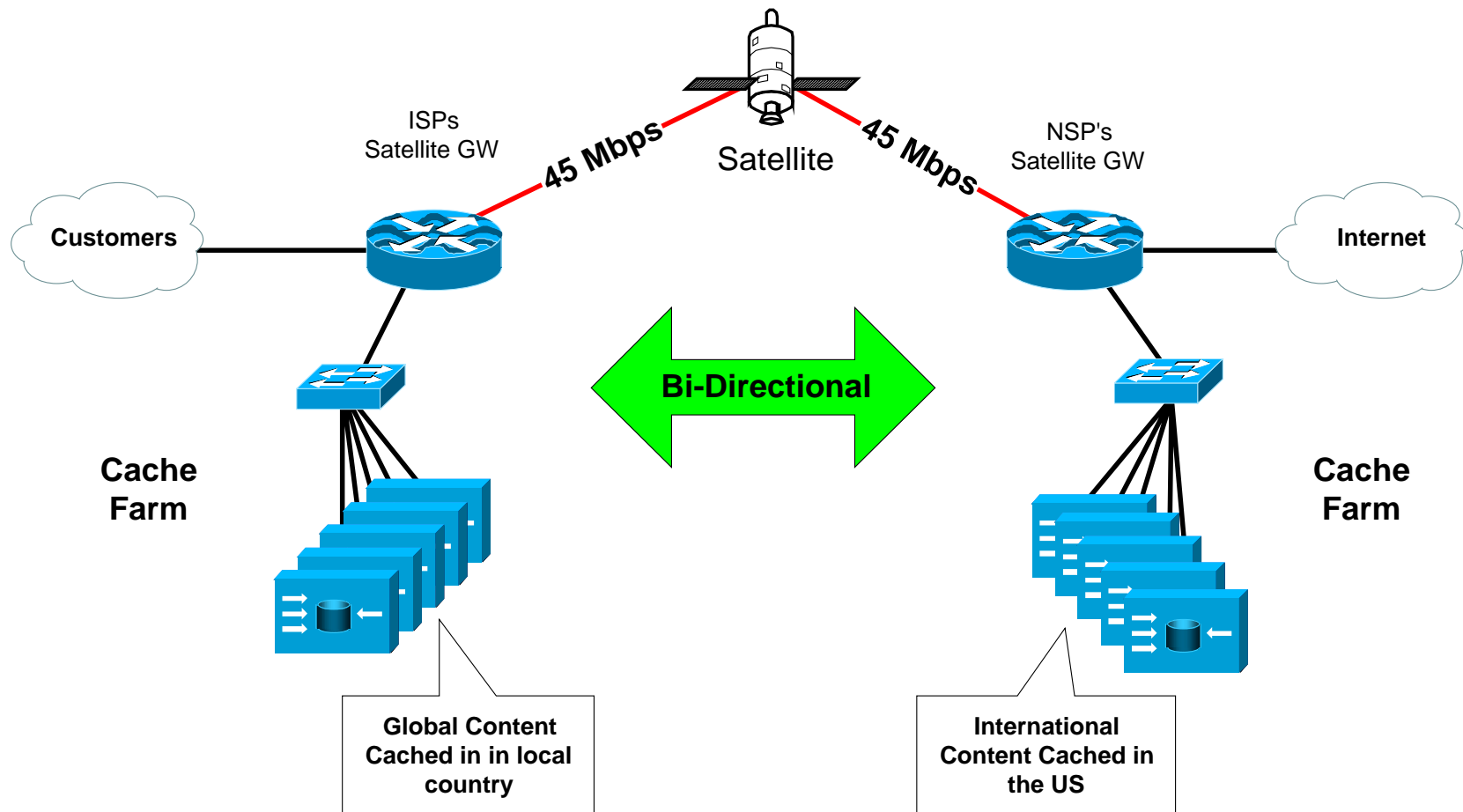


# Trans-Oceanic Links



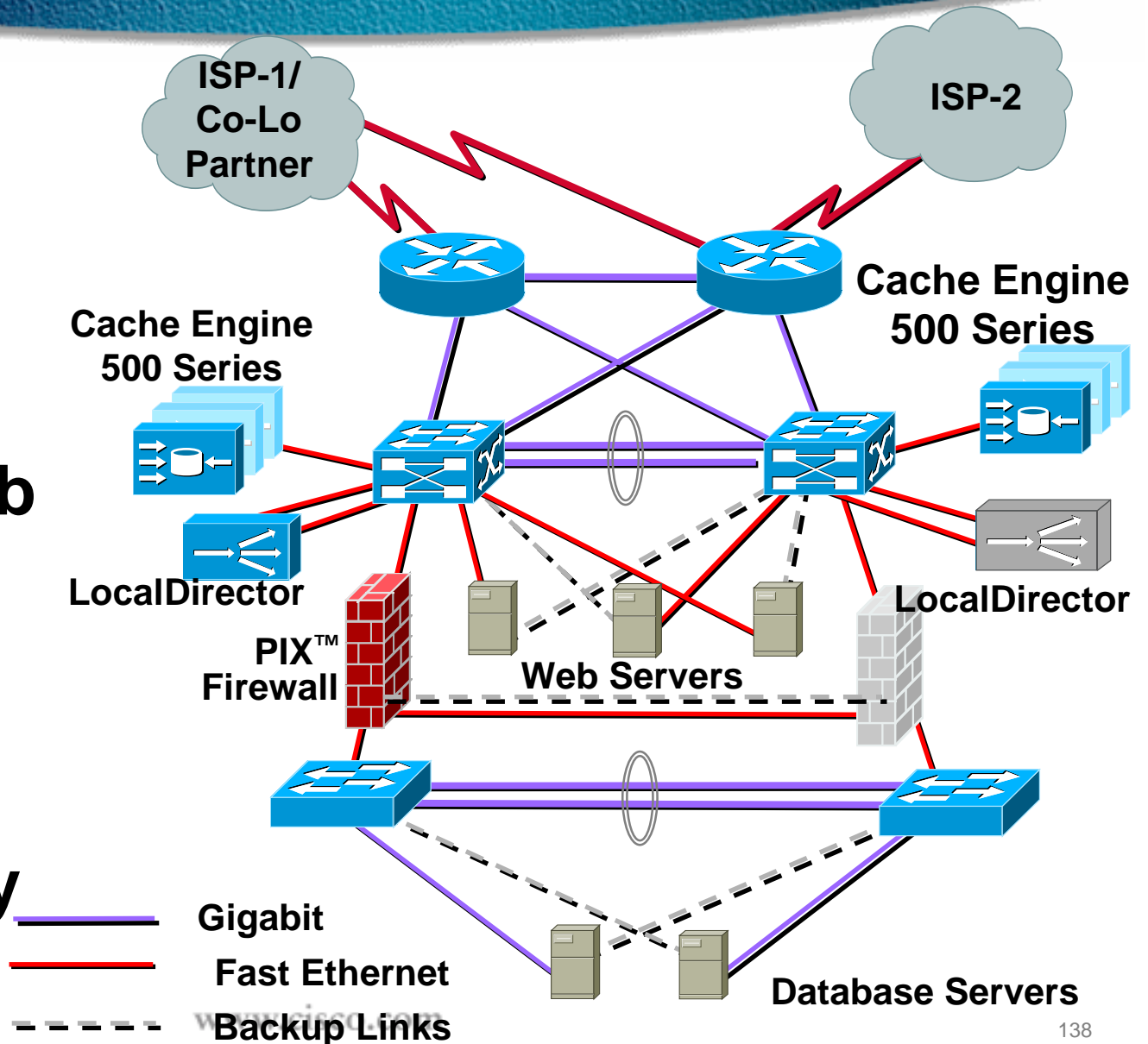


# Trans-Oceanic Links



# Architecture of CCO

- Accelerate content-rich services
- Increased web site capacity
- Higher availability / security / manageability



# CCO cache statistics

```
cco-cache-1#sh stat http s
```

	Statistics - Savings Requests	Bytes
Total:	11364633	108602153913
Hits:	7998850	44203825628
Miss:	3289486	63671295119
Savings:	70.4 %	40.7 %

```
cco-cache-1#sh stat http ims
```

	Statistics - If-Modified-Since Total	Fresh	%
Client to Cache:	11365078		
IMS Received:	2864792		
Served from cache:	2427581	2389596	98.4
Cache Miss:	412656	354745	86.0
Revalidated:	24555	0	0.0
Cache to Server:	4169649		
IMS Issued:	880193		
Due to Client IMS:	24555	24547	100.0
Due to Expiration:	855638	855502	100.0

```
If-None-Match Requests recv : 1711989
ETag Responses recv         : 3211662
INM ETag match               : 1537227
INM ETag mismatch            : 24096
```

# CCO effectiveness

---

**“The reliability of CCO improved considerably. Precisely when we turned on the cache engines, the server loads decreased to less than 20% of previous levels.**

**The webmasters/sysadmins downstairs can now concentrate on improving other aspects of CCO than worrying about [previous P1] scaling issues.”**

---

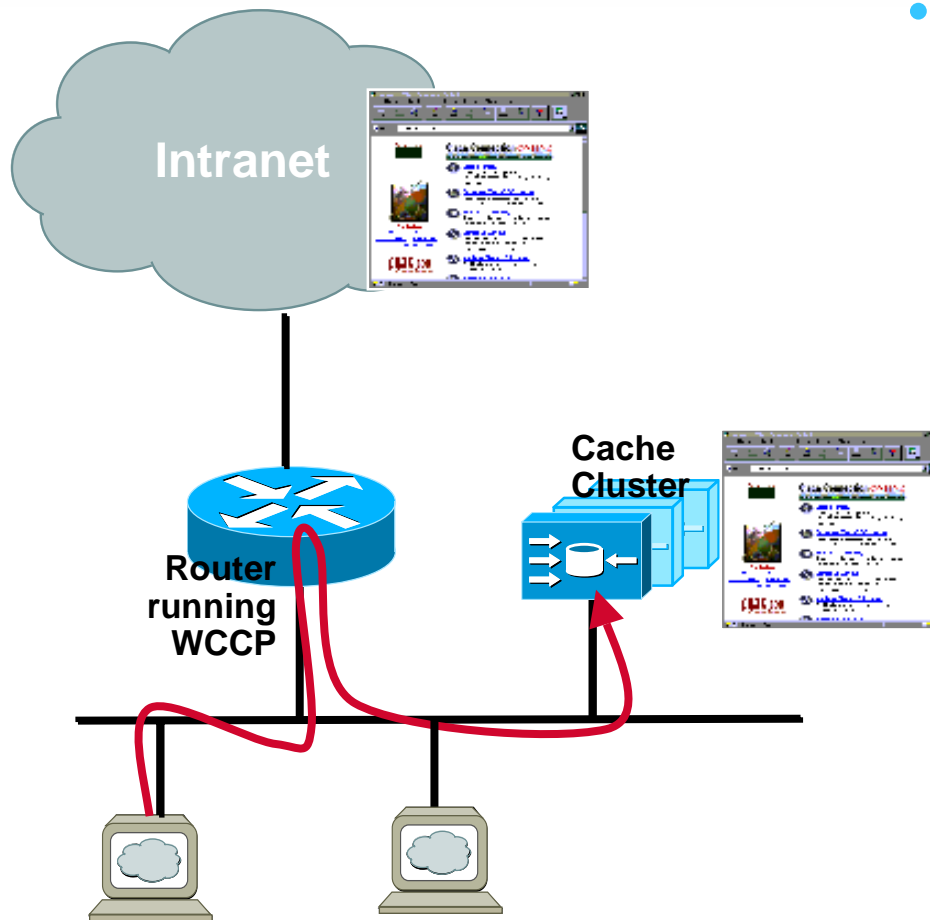


# Cisco branch offices

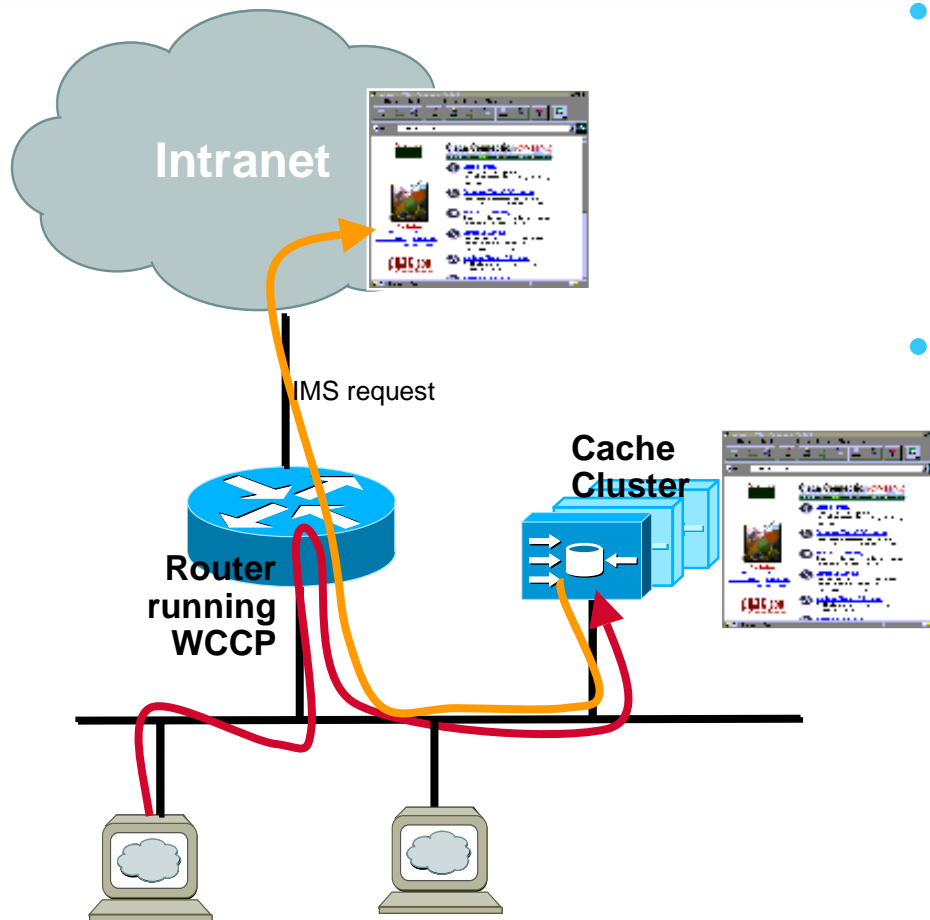
- **Most AsiaPac Cisco offices have 1 x CE550 in them.**
- **All content can be cached - including content requiring authentication**  
**(“http cache-authenticated”)**
- **Cache passes on authentication/authorisation credentials in a check ..**

# Caching of Authenticated Content

- Connection initiated from web-browser for content stored in cache by another user, Router intercepts flow and redirects it to CE

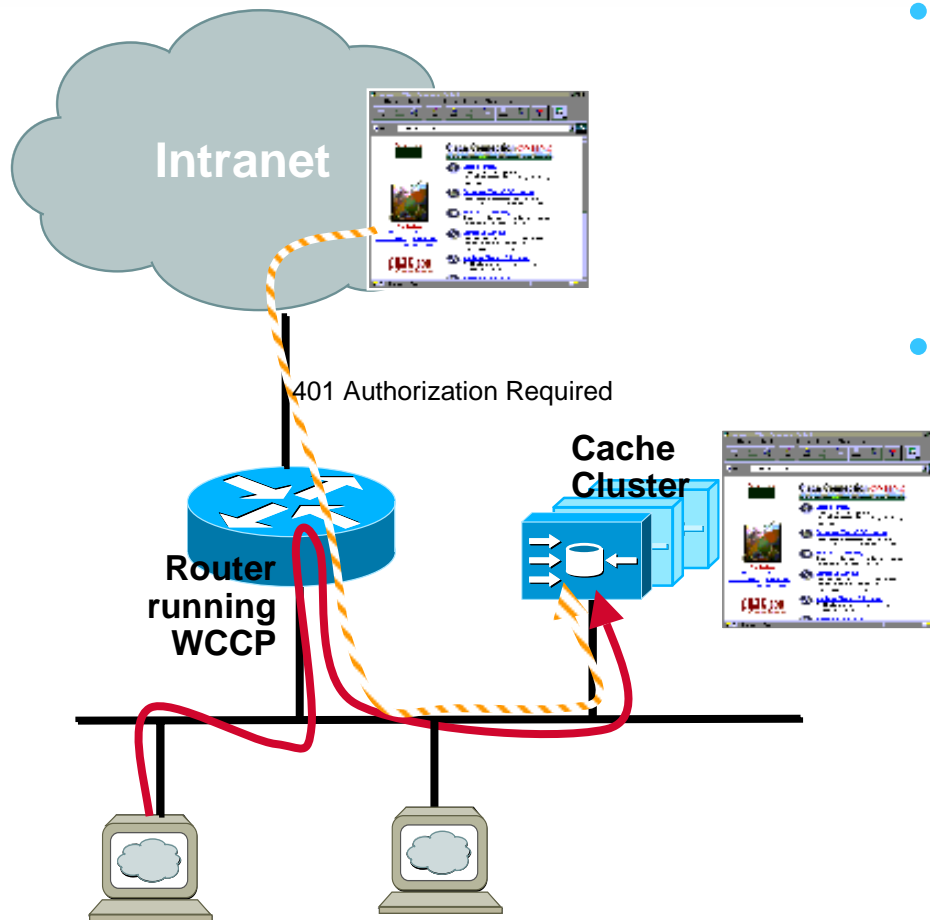


# Caching of Authenticated Content



- Connection initiated from web-browser for content stored in cache by another user, Router intercepts flow and redirects it to CE
- **Cache Hit, but force authentication re-check by sending an IMS request to web-server**

# Caching of Authenticated Content

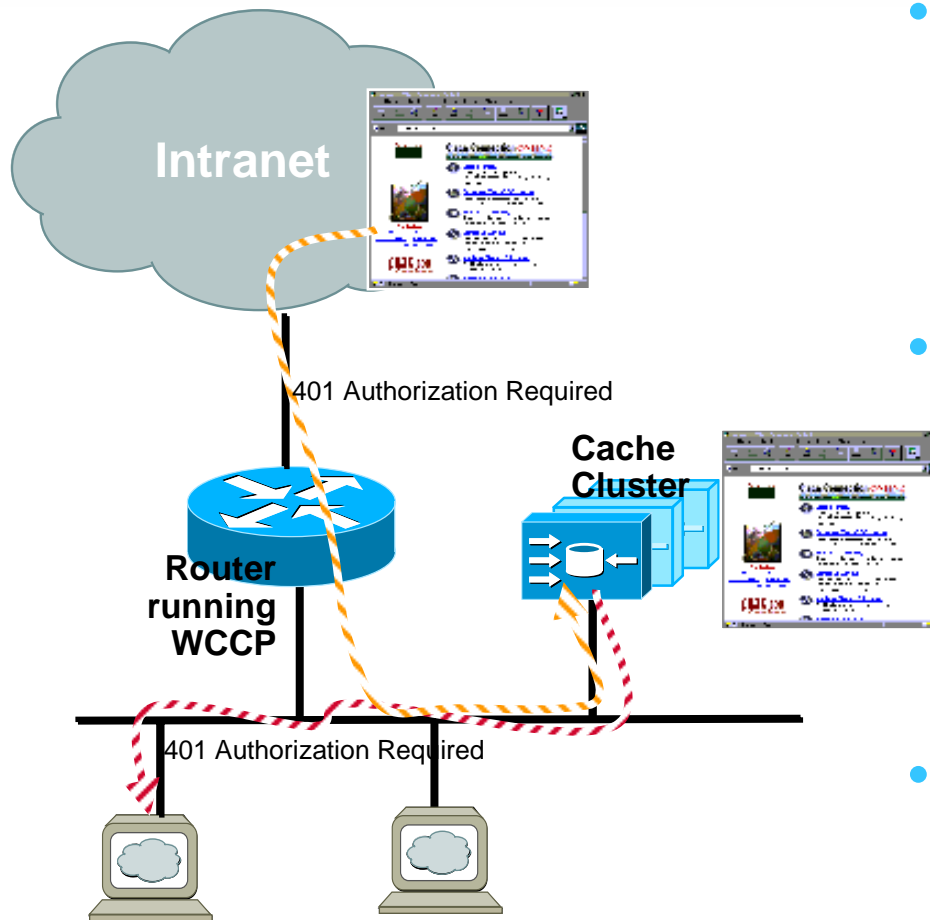


- Connection initiated from web-browser for content stored in cache by another user, Router intercepts flow and redirects it to CE
- Cache Hit, but force authentication re-check by sending an IMS request to web-server

**Web-server challenges credentials**

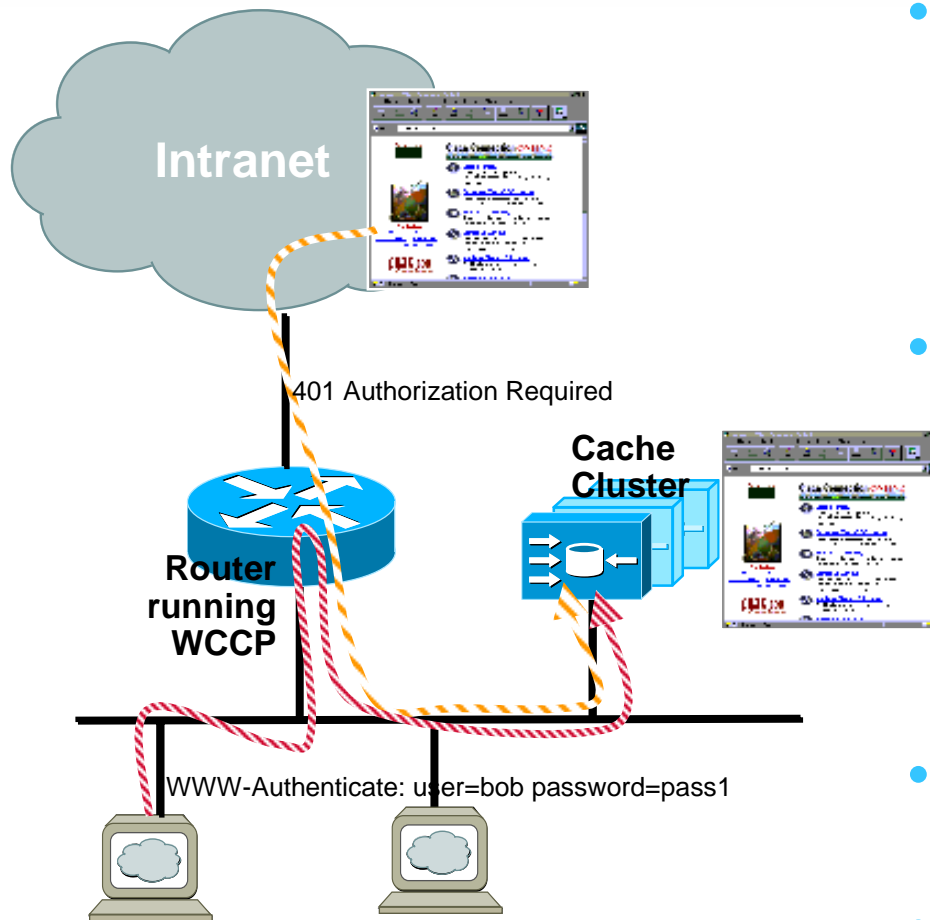


# Caching of Authenticated Content



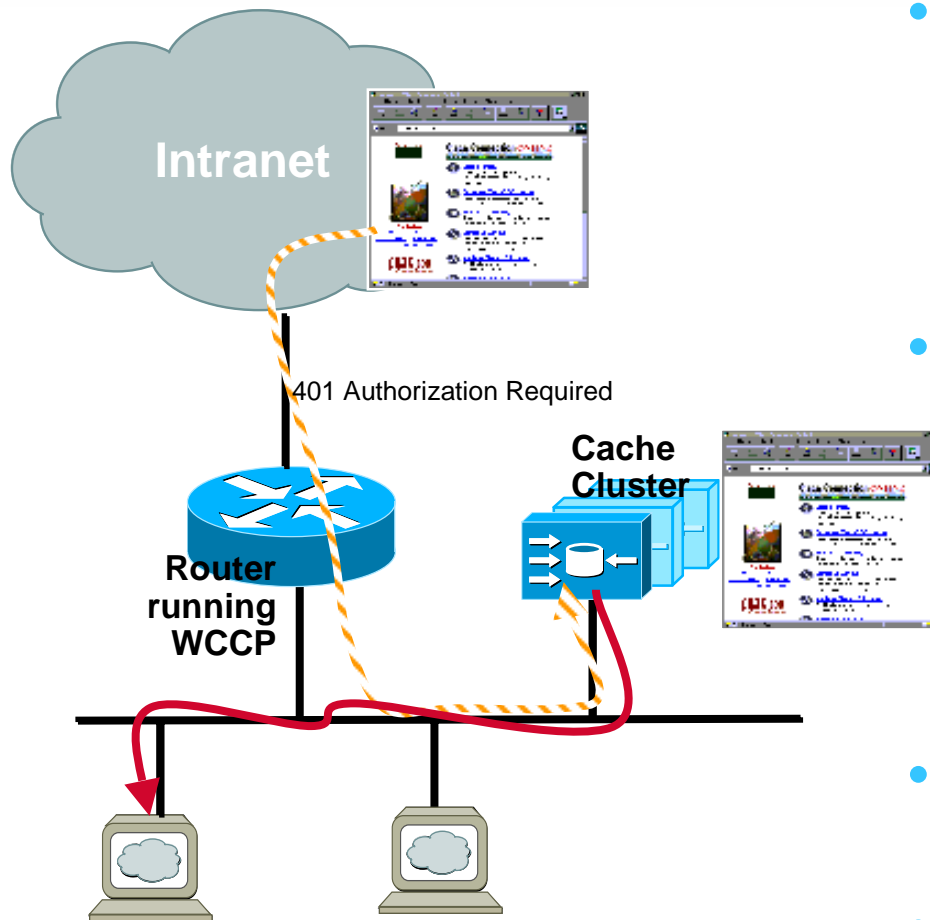
- Connection initiated from web-browser for content stored in cache by another user, Router intercepts flow and redirects it to CE
- Cache Hit, but force authentication re-check by sending an IMS request to web-server  
Web-server challenges credentials
- **Cache passes challenge back to browser**

# Caching of Authenticated Content



- Connection initiated from web-browser for content stored in cache by another user, Router intercepts flow and redirects it to CE
- Cache Hit, but force authentication re-check by sending an IMS request to web-server
- Web-server challenges credentials
- Cache passes challenge back to browser
- **Browser/user respond with credentials**

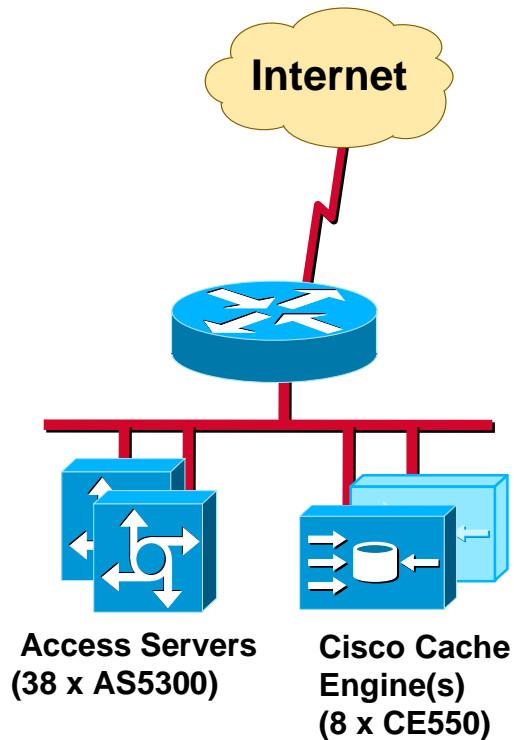
# Caching of Authenticated Content



- Connection initiated from web-browser for content stored in cache by another user, Router intercepts flow and redirects it to CE
- Cache Hit, but force authentication re-check by sending an IMS request to web-server
- Web-server challenges credentials
- Cache passes challenge back to browser
- Browser/user respond with credentials

- **Cache verifies credentials with web-server (with IMS request). If correct, object is served (from cache)**

# iinet example



- 8 x CE550 in 2 WCCP service-groups to cover 38 access-servers
- WCCPv2 on the *access edge* (AS5300's)
- Caches export transaction logs to a host at regular intervals -- volume-based billing
- Traffic to caches is routed via satellite. Caches have the *TCP-over-satellite* TCP stack enhancements enabled for maximum “goodput”