Amirkabir University of Technology
(Tehran Polytechnic)

Cloud Computing

Load Balancing in Web Server Clusters

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Scheduling in Web Server Clusters

CS 260

LECTURE 3

From: IBM Technical Report

http://www.cs.ucr.edu/~bhuyan/CS260/index.html

Reference

The State of the Art in Locally Distributed Web-Server Systems

VALERIA CARDELLINI AND EMILIANO CASALICCHIO

University of Roma Tor Vergata

MICHELE COLAJANNI

University of Modena

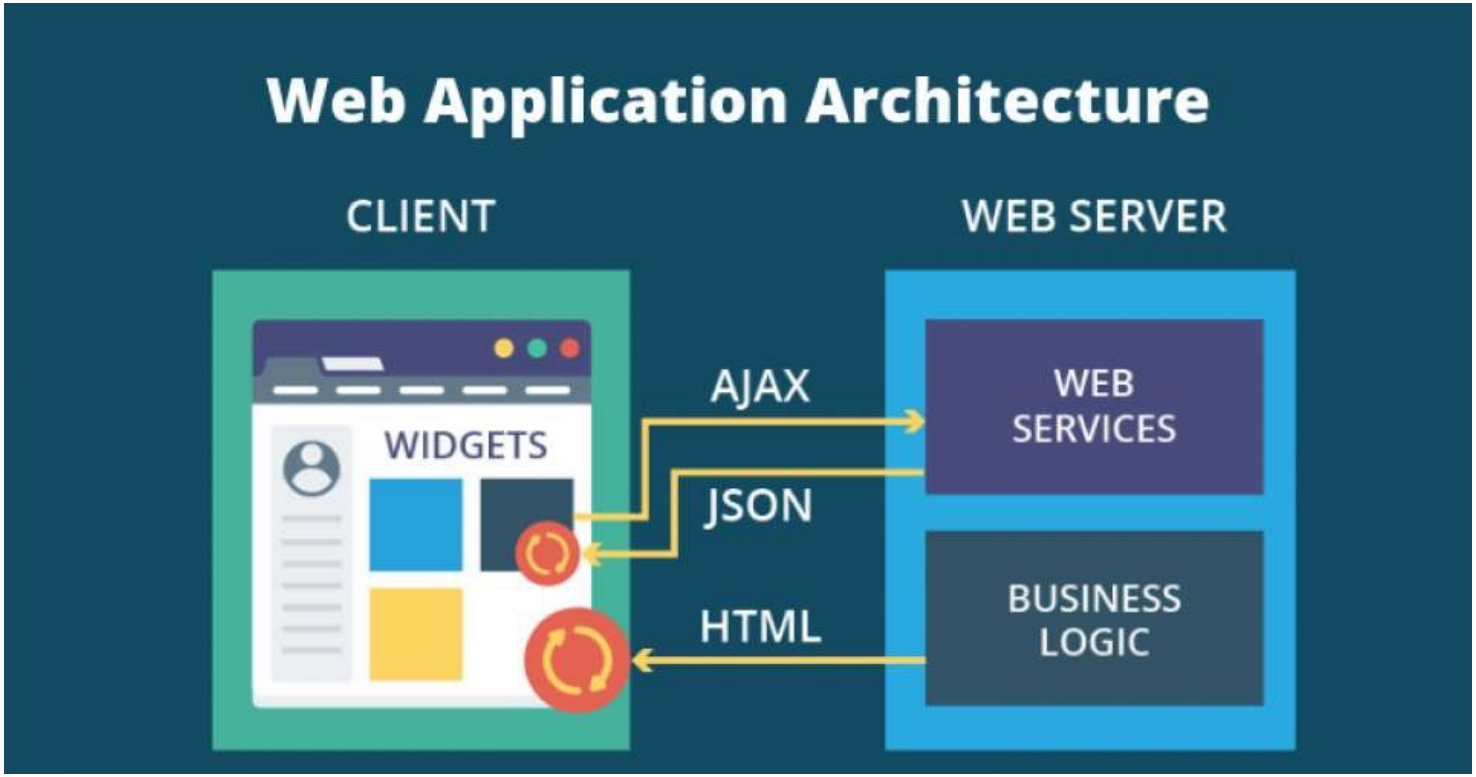
AND

PHILIP S. YU

IBM T. J Watson Research Center

Web Server System

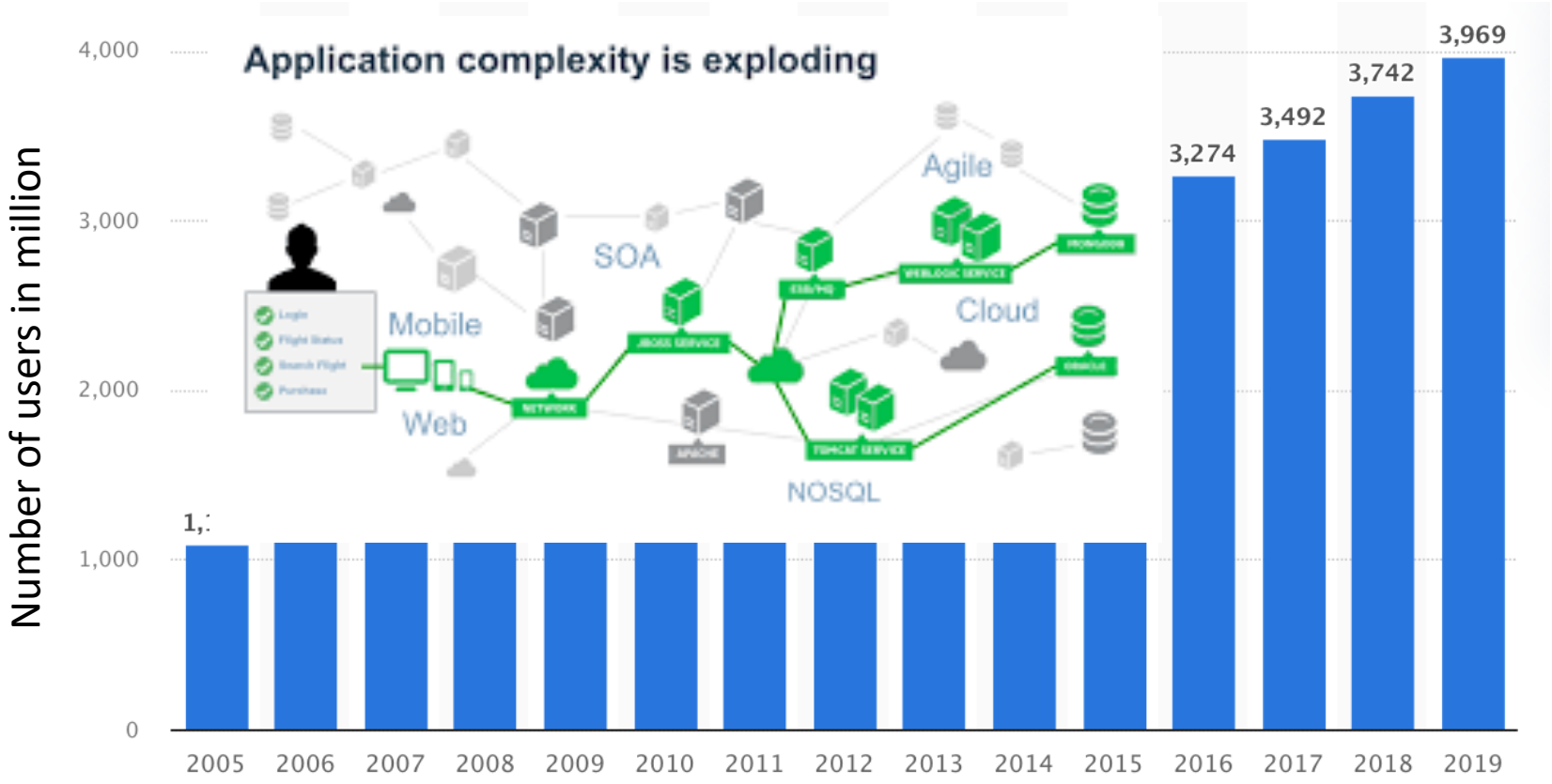
- Providing web service



https://hackr.io/blog/web-application-architecture-definition-models-types-and-more

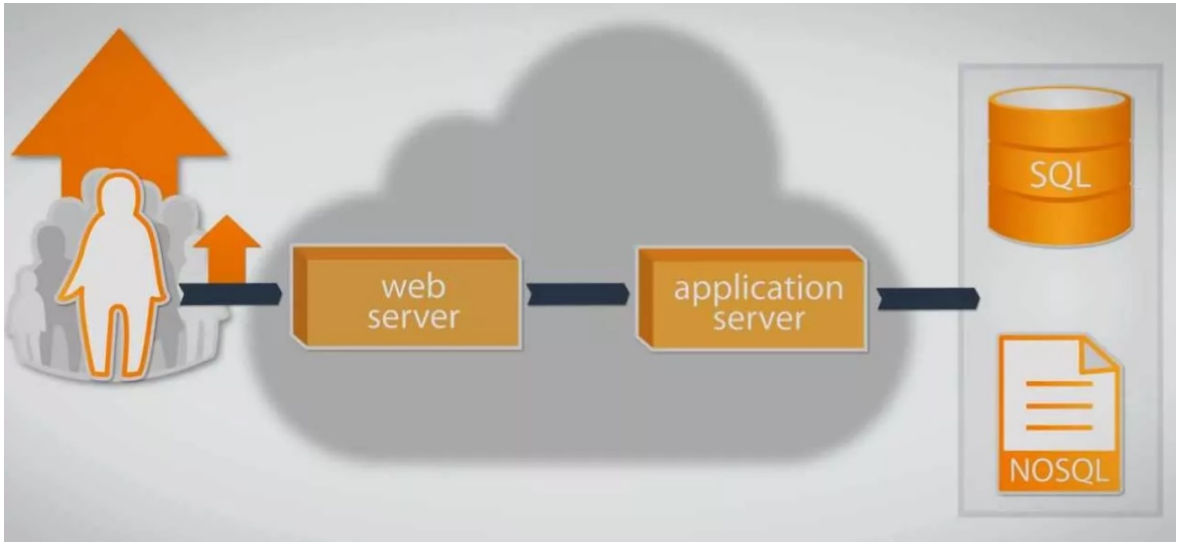
Trend

- Increasing number of clients
- Growing complexity of web applications



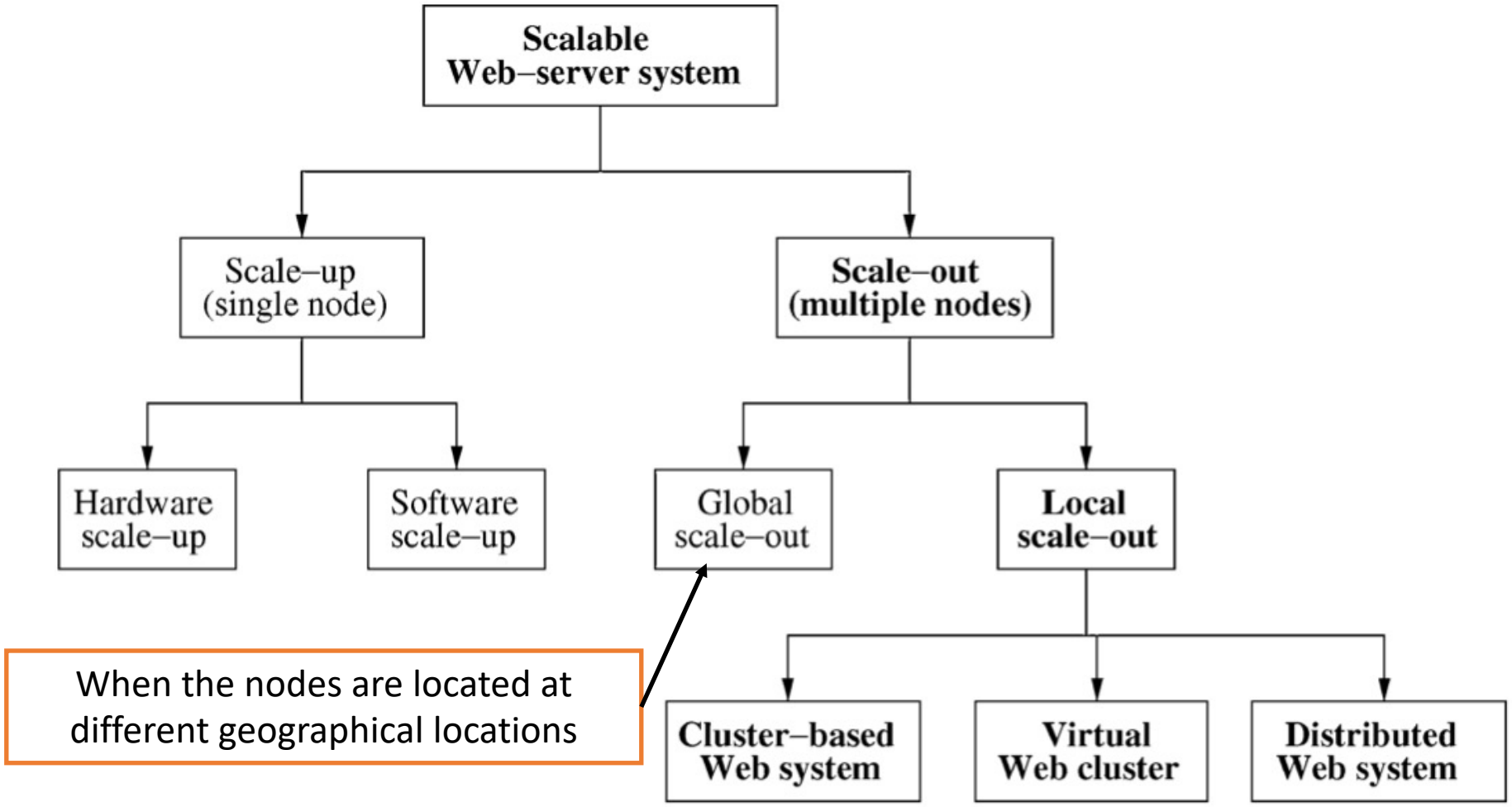
Scalable web server systems

The ability to support large numbers of accesses and resources while still providing adequate performance.

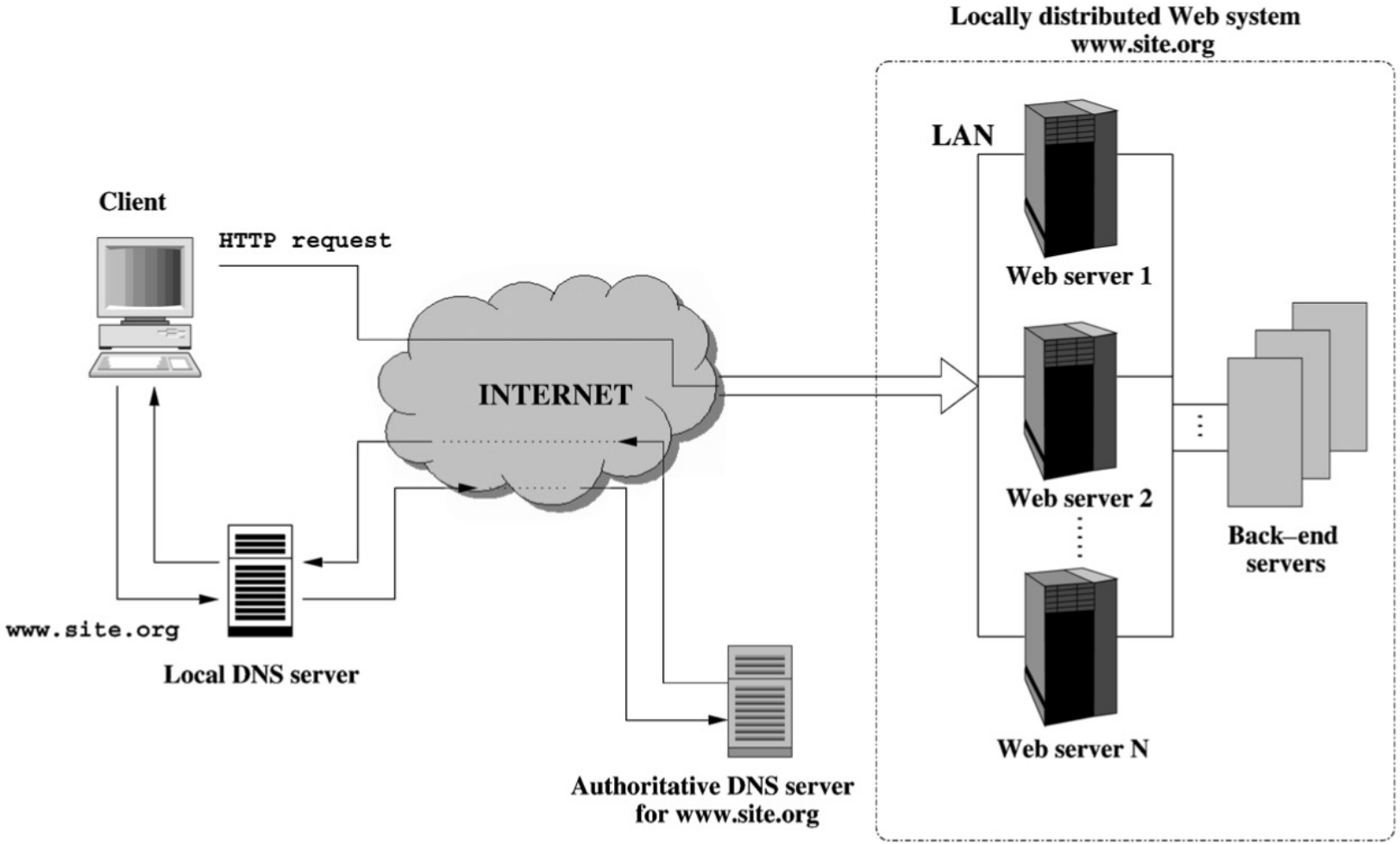


https://www.devteam.space/blog/how-to-build-a-scalable-web-application/

Architecture solutions for scalable Web-server systems.

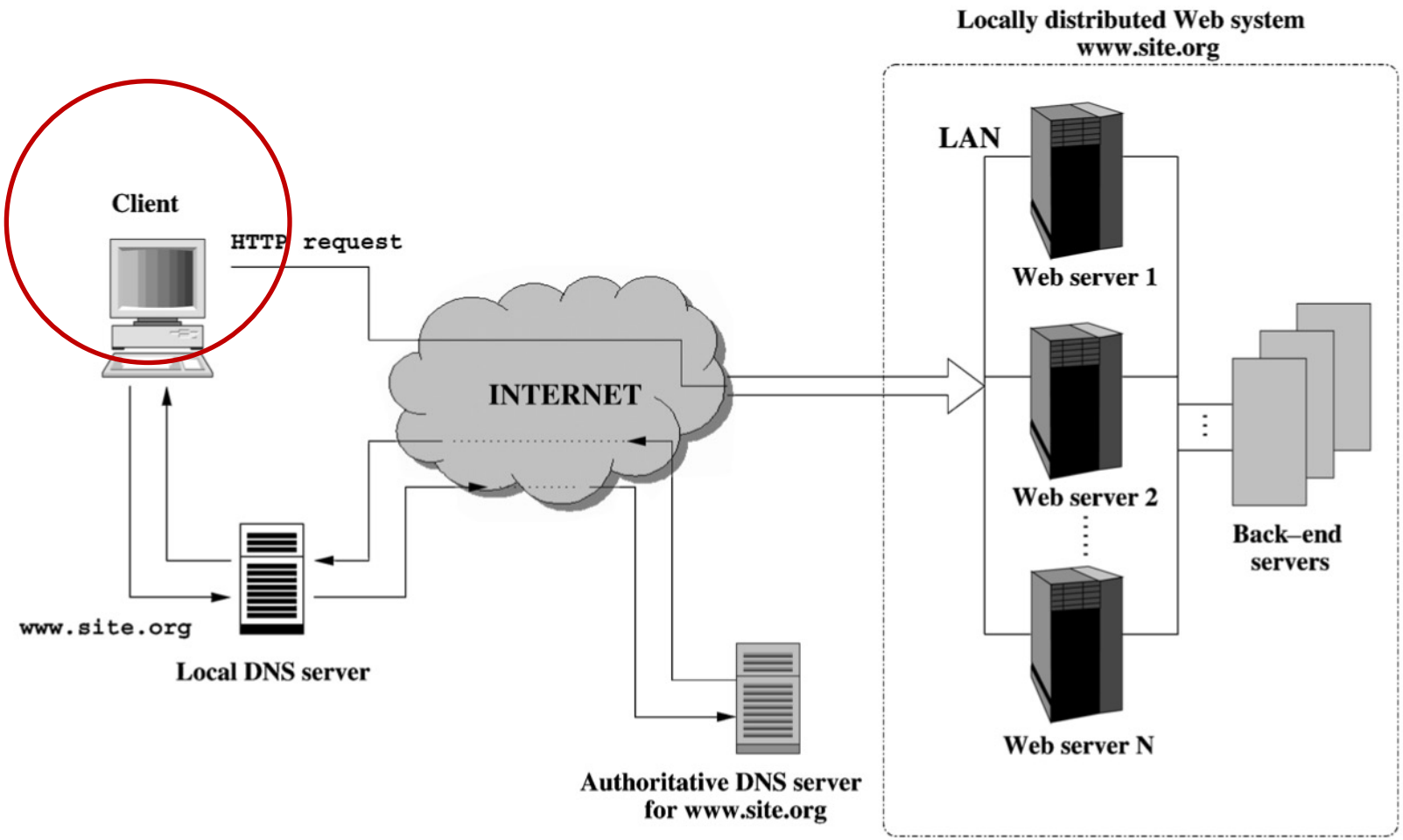


Model architecture for a locally distributed Web system.



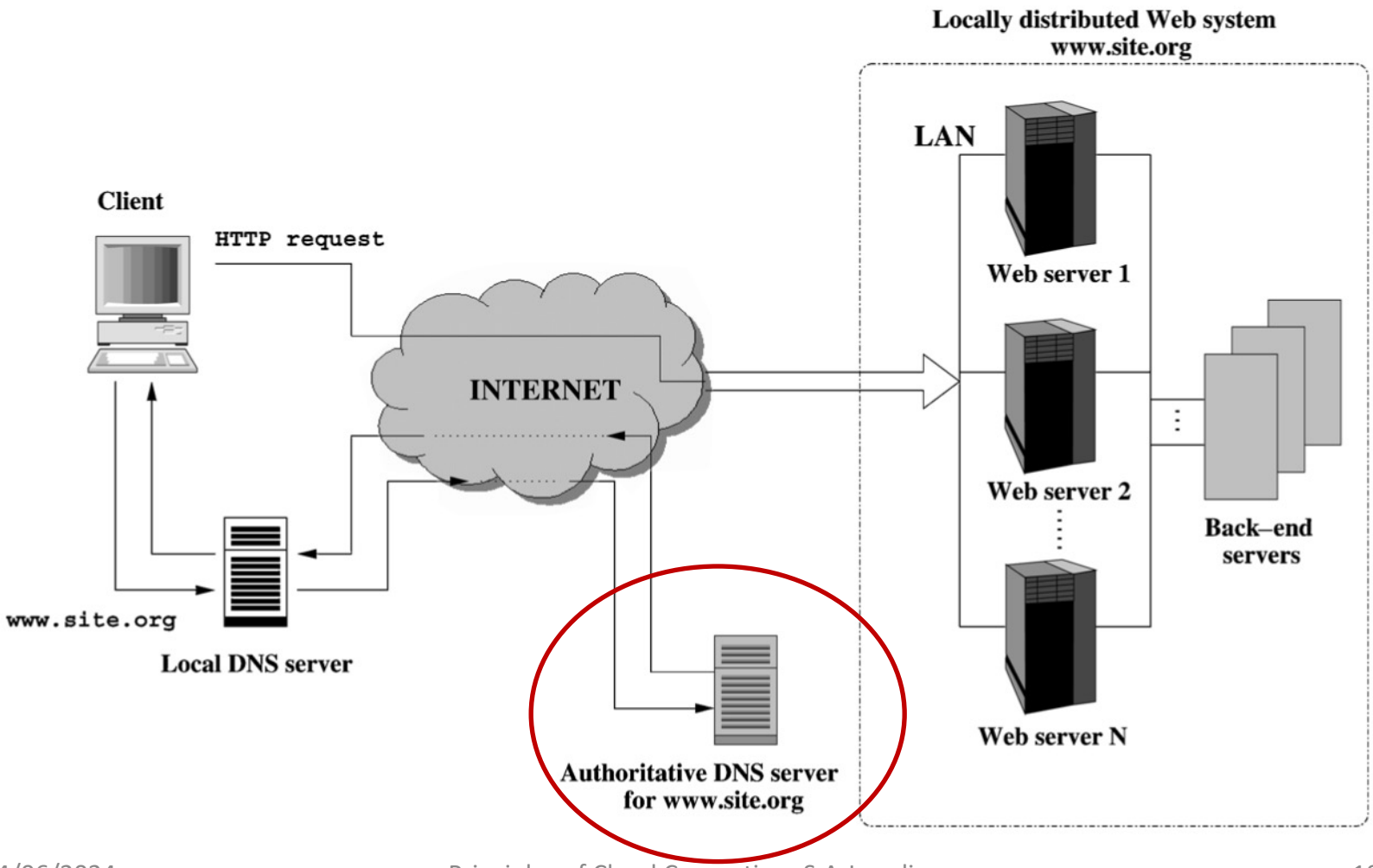
Four possible levels for deciding how to route a client request

1) At the web client level where a request is originated



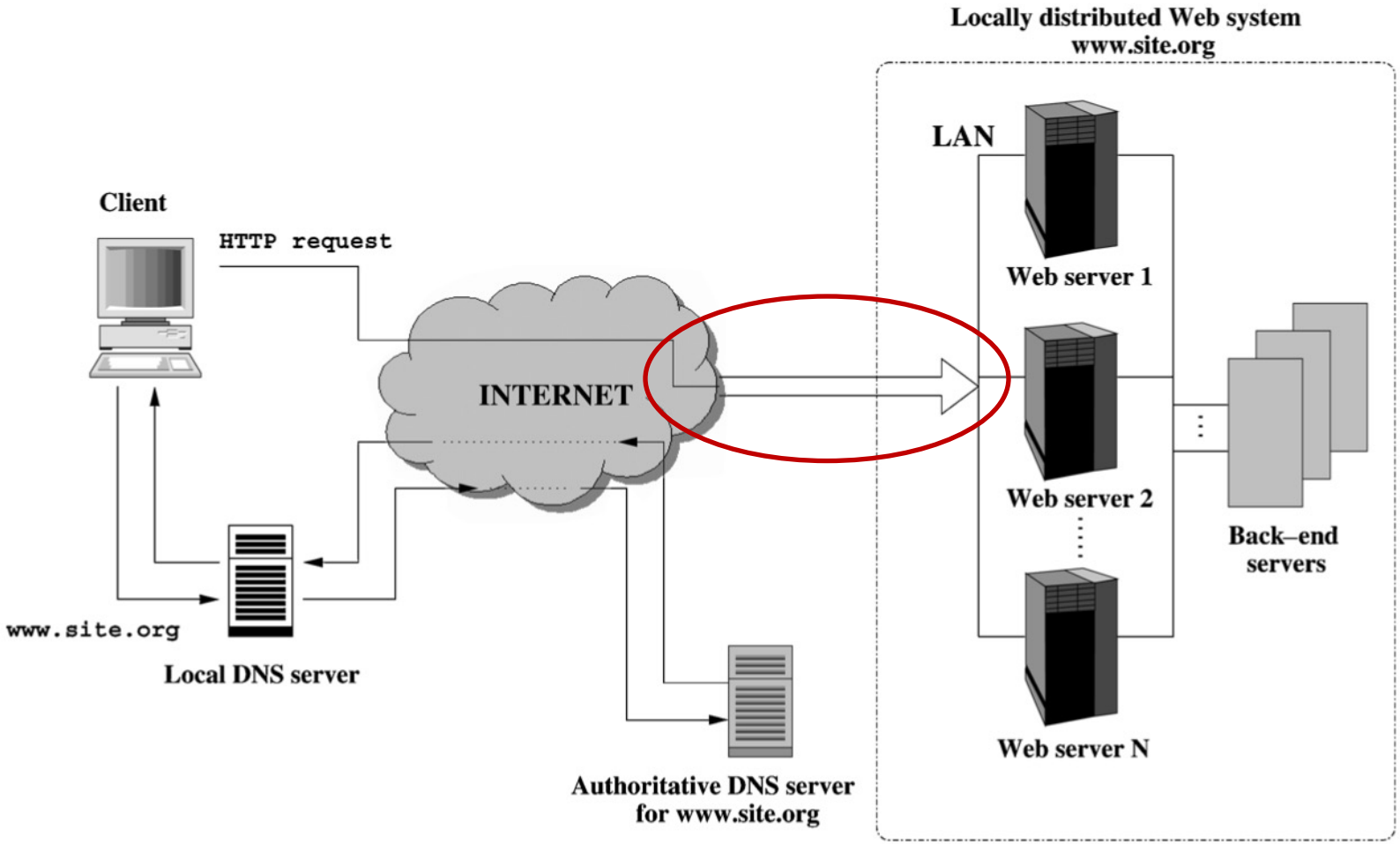
Four possible levels for deciding how to route a client request

2) At the DNS level during address resolution



Four possible levels for deciding how to route a client request

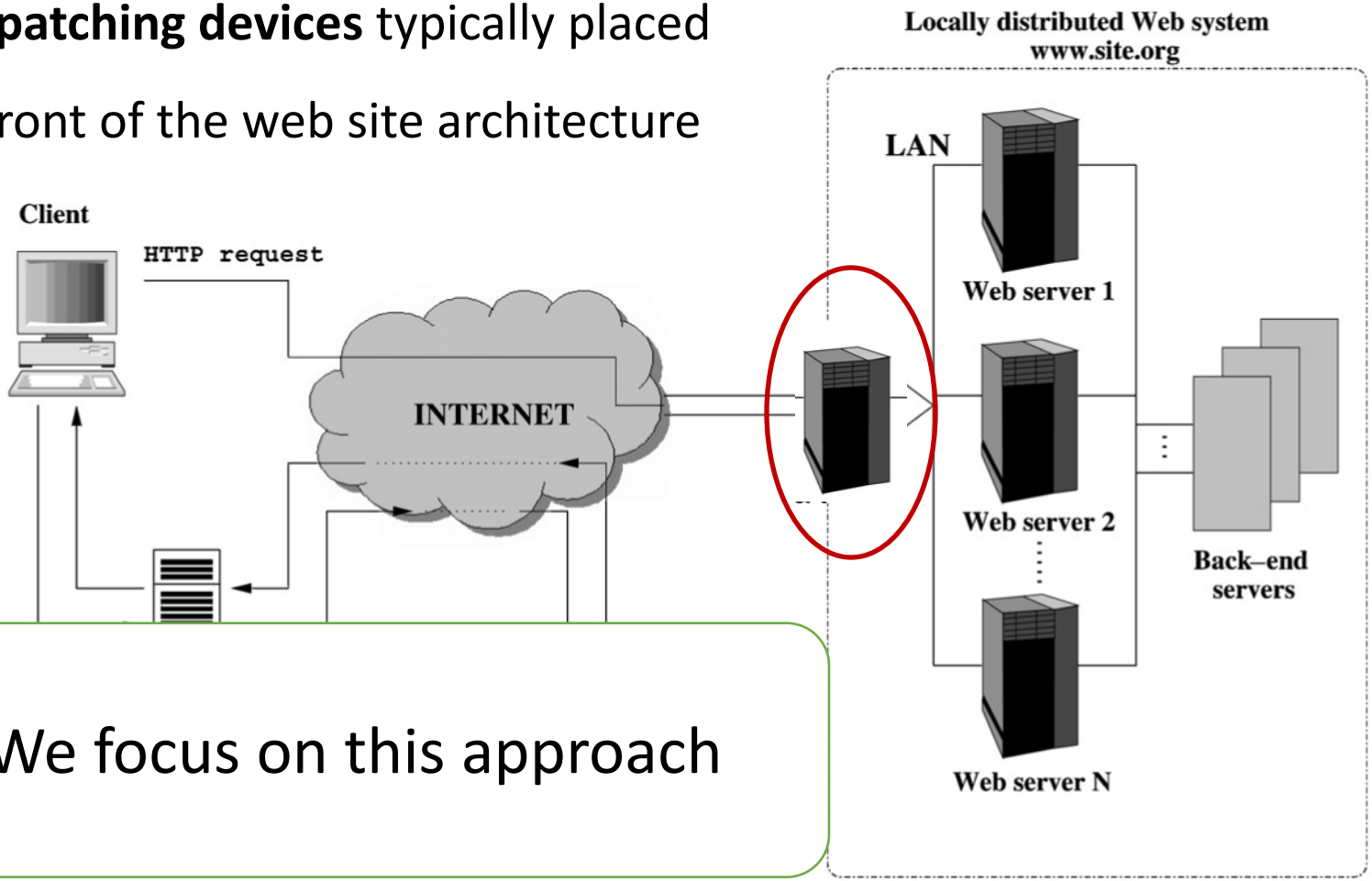
3) At the network level using router devices



Four possible levels for deciding how to route a client request

4) At the web system level

- **Dispatching devices** typically placed in front of the web site architecture



We focus on this approach

Locally Distributed Web System

- Cluster Based Web System

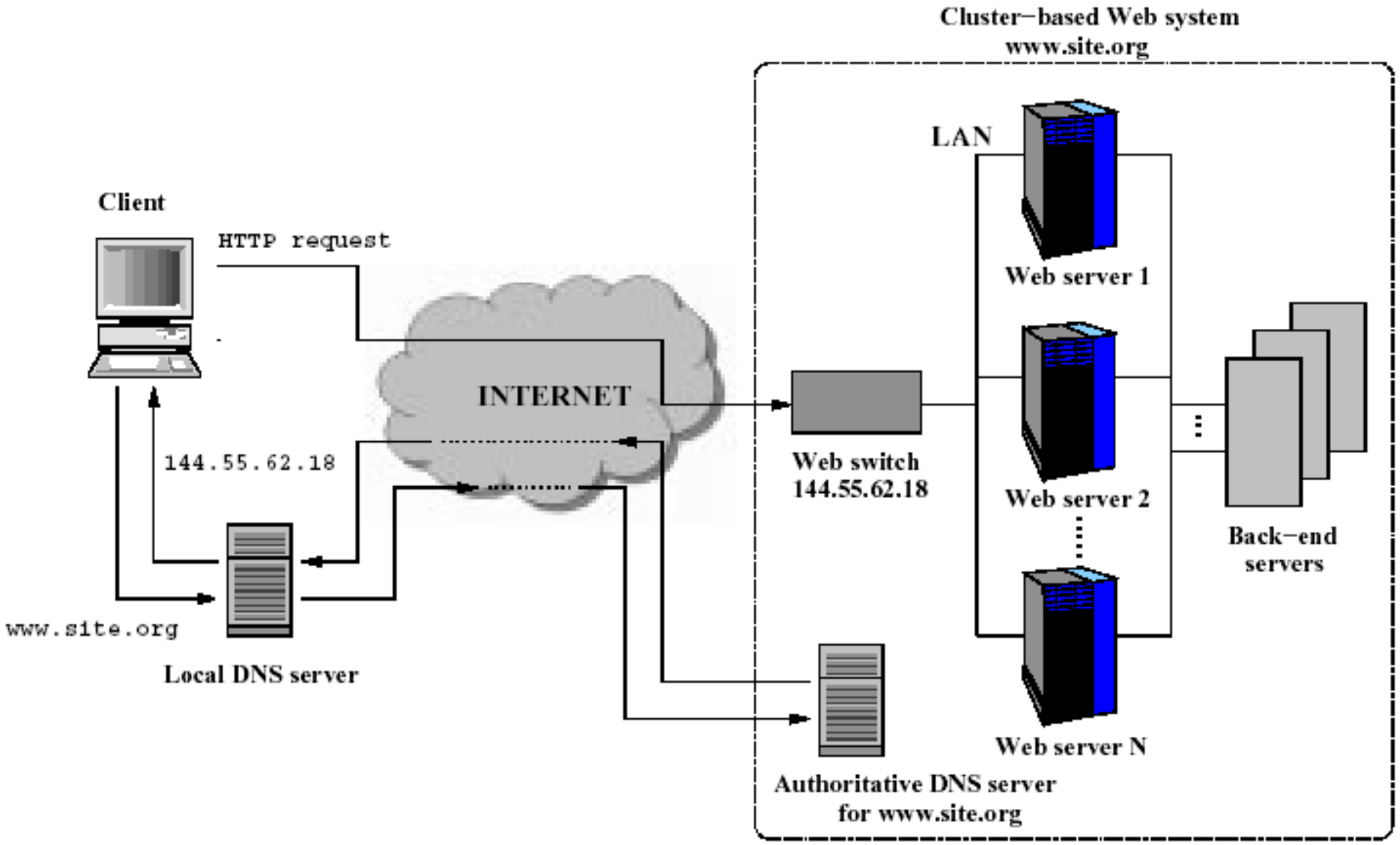
- Distributed Web System

Cluster Based Web System

- The server nodes mask their IP addresses to clients, using a Virtual IP address corresponding to one device (web switch) in front of the set of the servers.

- Web switch receives all packets and then sends them to server nodes.

Cluster based Architecture (cont.)

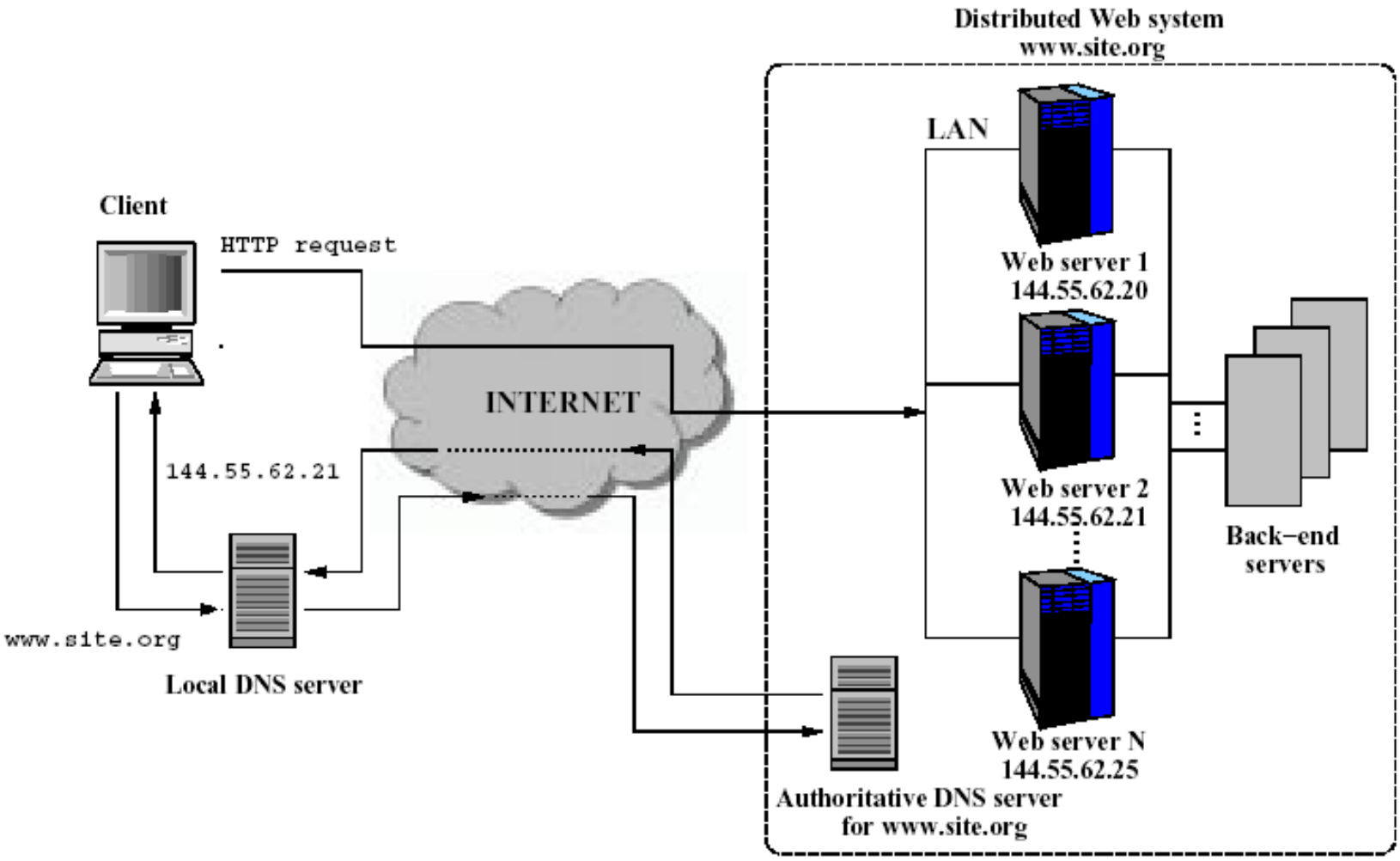


Distributed Web System

- The IP addresses of the web server nodes are visible to clients.

- No web switch, just a layer 3 router ***may be employed*** to route the requests.

Distributed Architecture



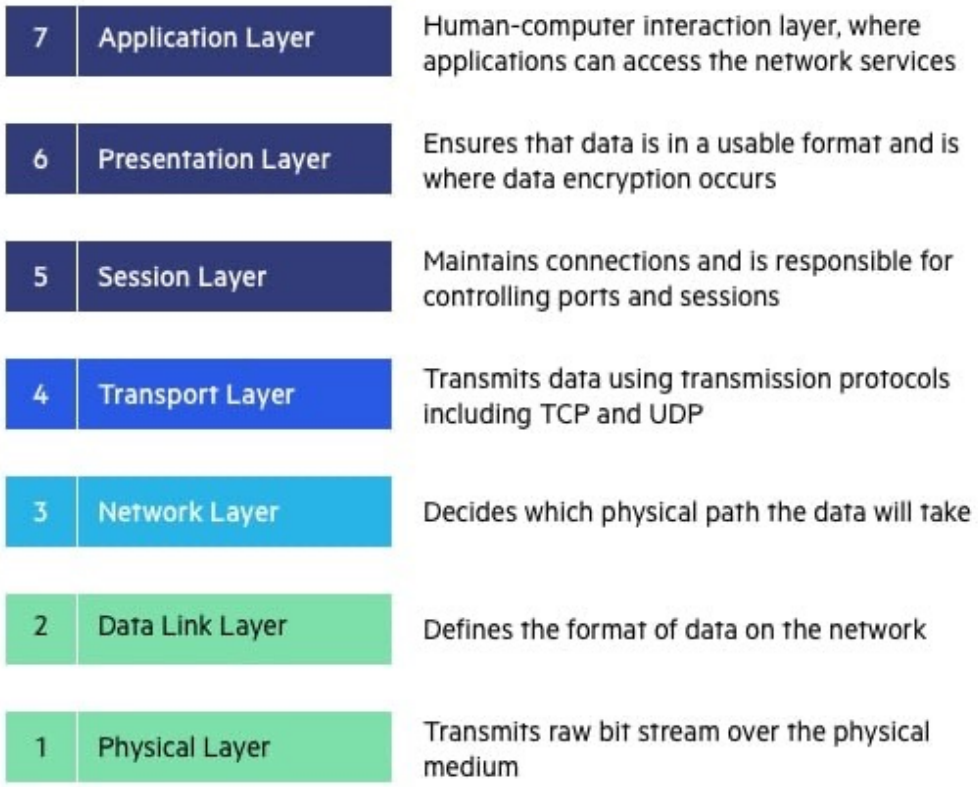
Cluster-based Architecture

Two Approaches

Depends on which OSI protocol layer,

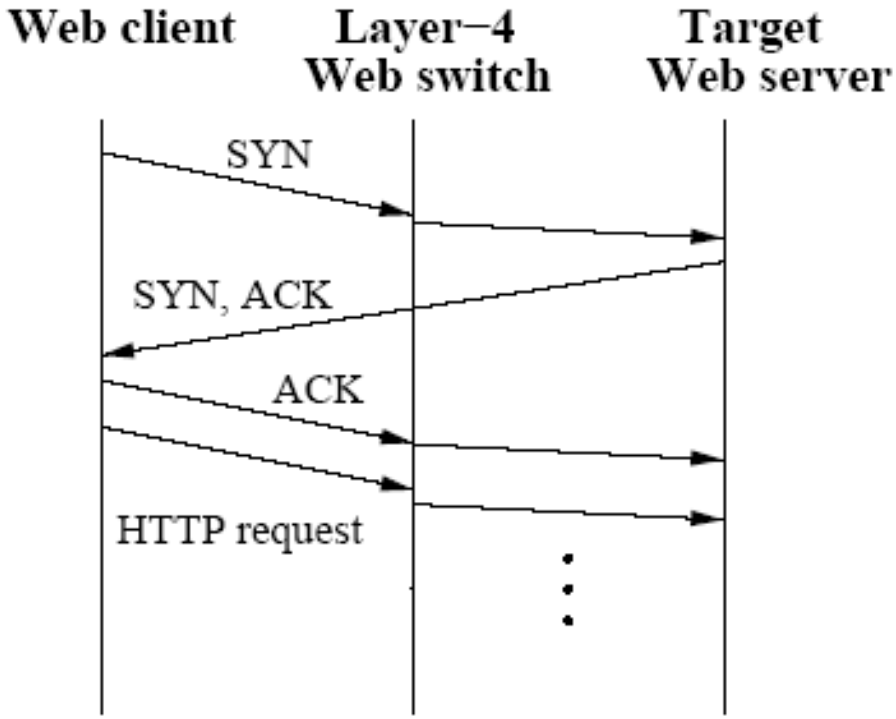
the web switch routes inbound packets

- layer-4 switch
- layer-7 switch



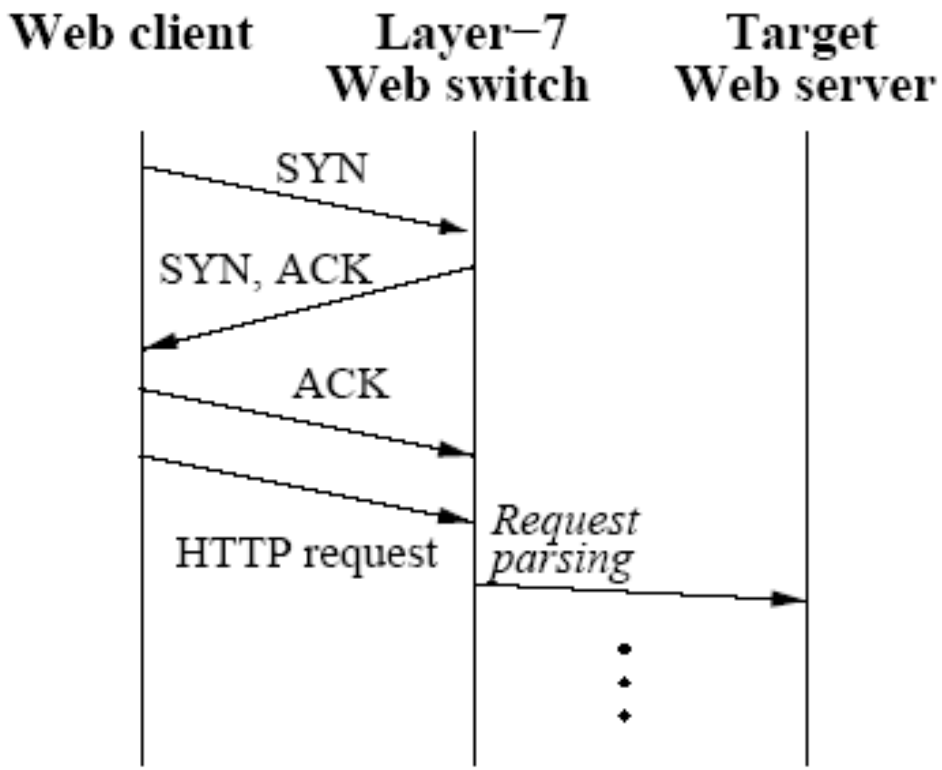
Layer-4 switch

- Determines the target server when TCP SYN packet is received.
- Also called ***content-blind routing*** because the server selection policy is not based on http contents at the application level.



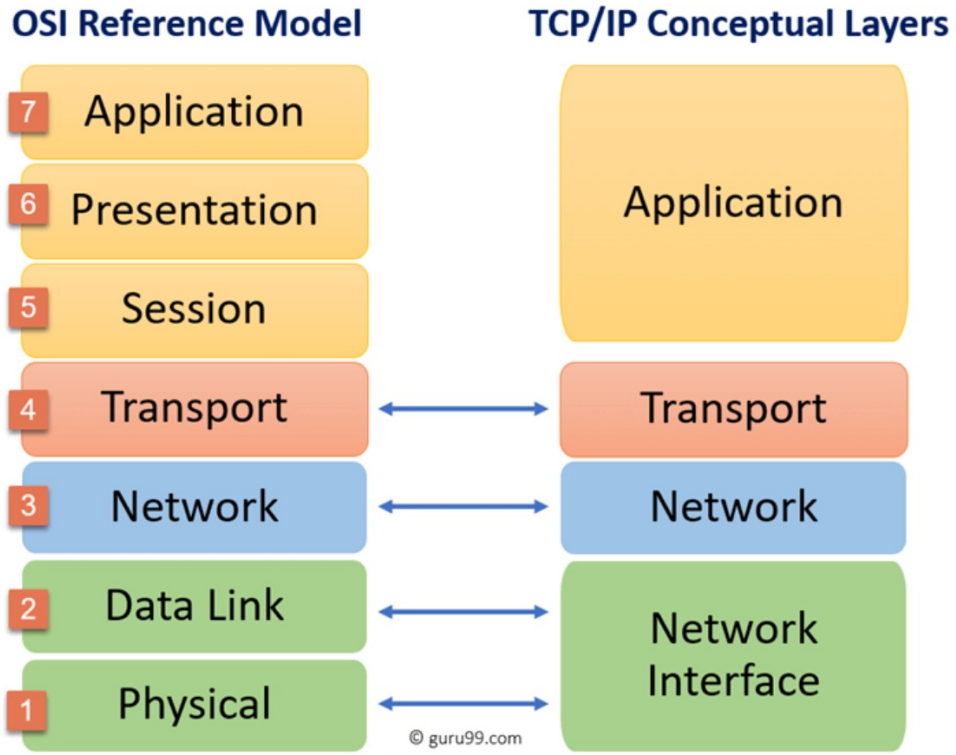
Layer-7 switch

- The switch first establishes a complete TCP connection with the client, examines http request at the application level and then selects a server.



Layer-7 switch (cont.)

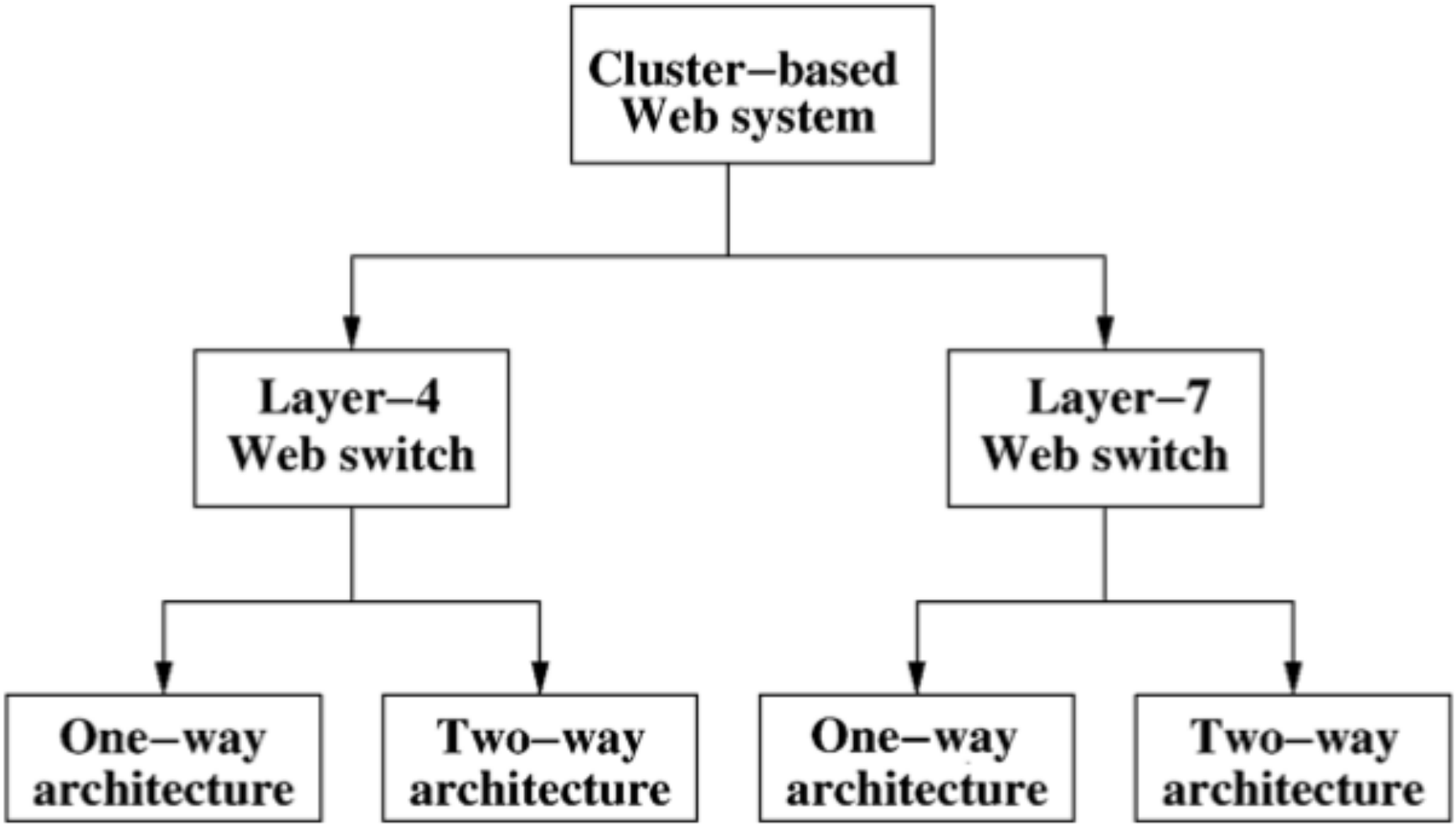
- Can support sophisticated dispatching policies, but large latency for moving to application level.
- Also called ***content-aware switches*** *or Layer **5 (?)** switches* in TCP/IP protocol (application-layer switches).



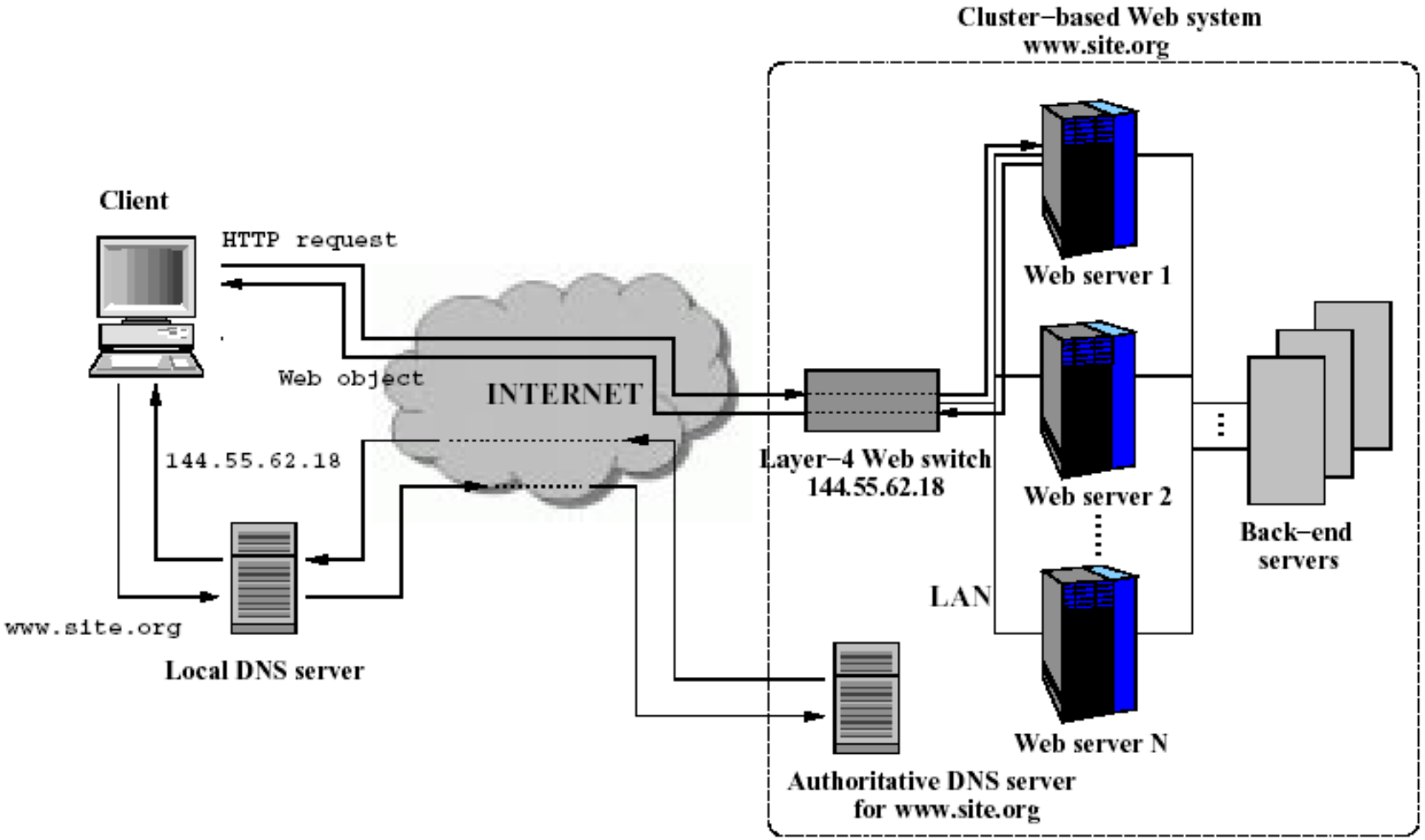
Taxonomy of cluster-based architectures.

- All client requests necessarily have to flow through the Web switch.
- **One-way architecture**: target server responds directly to the client.
- **Two-way architecture**: target server returns its response to the Web switch, that in turn sends response back to the client .

Taxonomy of cluster-based architectures



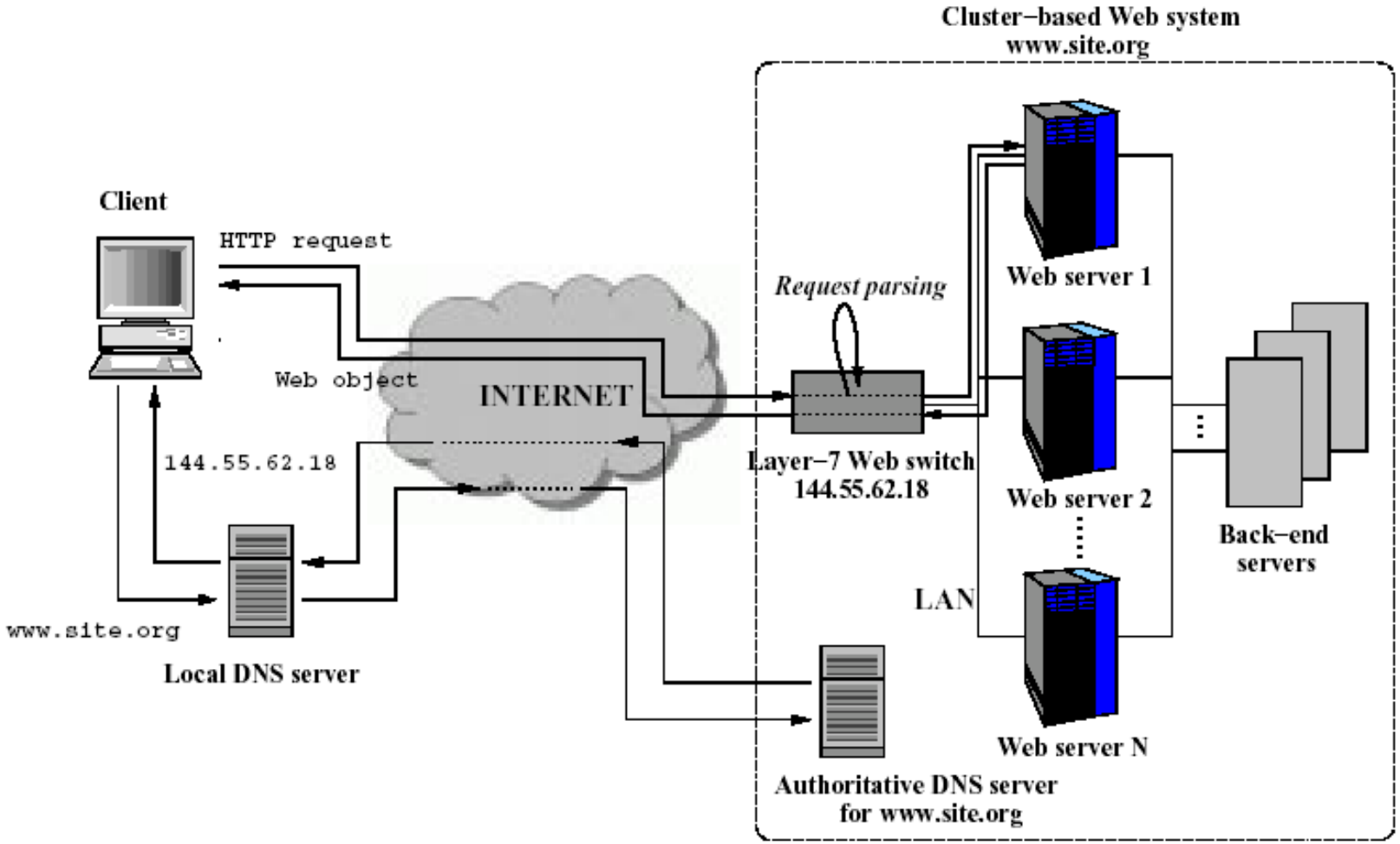
Layer-4 two-way architecture



Layer-4 Products

Two-way	One-way		
Packet double-rewriting	*Packet single-rewriting*	*Packet tunneling*	*Packet forwarding*
Cisco's LocalDirector [33] Magicrouter [4] Linux Virtual Server [68] LSNAT [92] F5 Networks' BIG/ip [48] Foundry Networks' ServerIron [51] Cyber IQ's HyperFlow [39] HydraWEB's Hydra2500 [60] Coyote Point's Equalizer [37]	TCP Router [44]	Linux Virtual Server [68]	IBM Network Dispatcher [59, 61] Linux Virtual Server [68] ONE-IP [41] LSMAC [54] Intel's NetStructure Traffic Director [62] Nortel Networks' Alteon 780 [76] Foundry Networks' ServerIron [51] Radware's WSD Pro [85]

Layer-7 two-way architecture



Layer-7 two-way mechanisms

- TCP gateway

An application level proxy running on the web switch mediates the communication between the client and the server – makes separate TCP connections to client and server.

- TCP splicing

Reduce the overhead in TCP gateway. For outbound packets, packet forwarding occurs at network level by rewriting the client IP address.

Layer 7 products

Two-way		One-way	
TCP gateway	*TCP splicing*	*TCP handoff*	*TCP connection hop*
IBM Network Dispatcher CBR [61]	[34]	ScalaServer [8, 79]	Resonate's Central Dispatch [86]
CAP [27]	Nortel Networks' Web OS SLB [76]		
HACC [101]	Foundry Networks' ServerIron [51]		
	Cisco's CSS [33]		
	F5 Networks' BIG/ip [48]		
	Radware's WSD Pro+ [85]		
	HydraWEB's Hydra2500 [60]		
	Zeus's Load Balancer [100]		
	[98]		

Dispatching Algorithms

- Strategies to select the target server of the web clusters.

- **Static**: Fastest solution to prevent web switch bottleneck, but **do not consider the current state of the servers.**

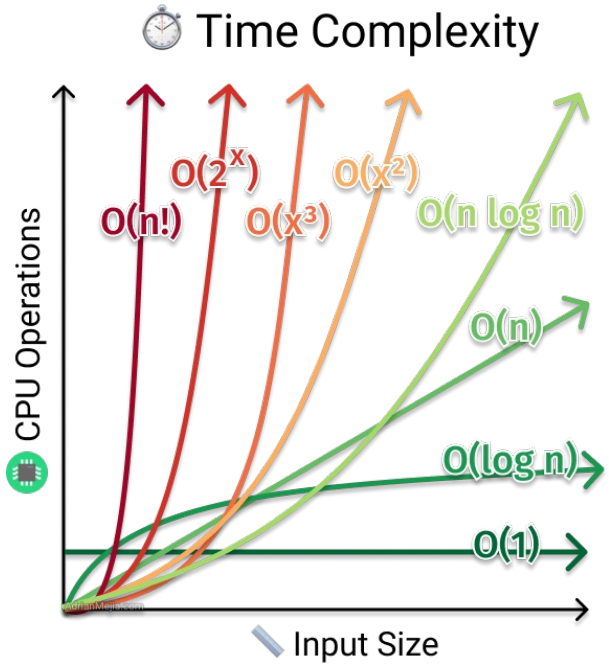
- **Dynamic**: Outperform static **algorithms by using intelligent decisions**, but collecting state information and analyzing them **cause expensive overheads.**

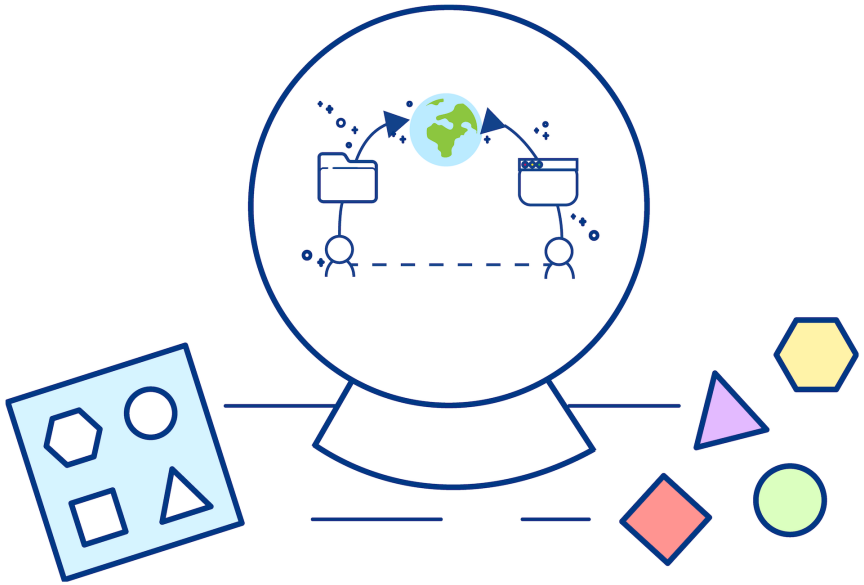
Dispatching Algorithms Requirements

(1) Low computational complexity

(2) Full compatibility with web standards

(3) State information must be readily available without much overhead.





Content blind approach- Static Policies

- Random: distributes the incoming requests uniformly with equal probability of reaching any server.

- Round Robin (RR): use a circular list and a pointer to the last selected server to make the decision.

- Static Weighted RR (For heterogeneous severs): A variation of RR, where each server is assigned a weight Wi depending on its capacity.

Content blind approach-Dynamic policies

- **Client state aware:** Static partitioning the server nodes and to assign group of clients identified through the clients information, such as source IP address.

Content blind approach-Dynamic policies

Server State Aware

- **Least Loaded**
  - The server with the lowest load.
  - Issue: Which is the server load index?
- **Least Connection**
  - The server with fewest active connection first
- **Fastest Response**
  - The server responding fastest
- **Weighted Round Robin**
  - Variation of static RR, associates each server with a dynamically evaluated weight that is proportional to the server load.

Content blind approach-Dynamic policies

➢Client and server state aware

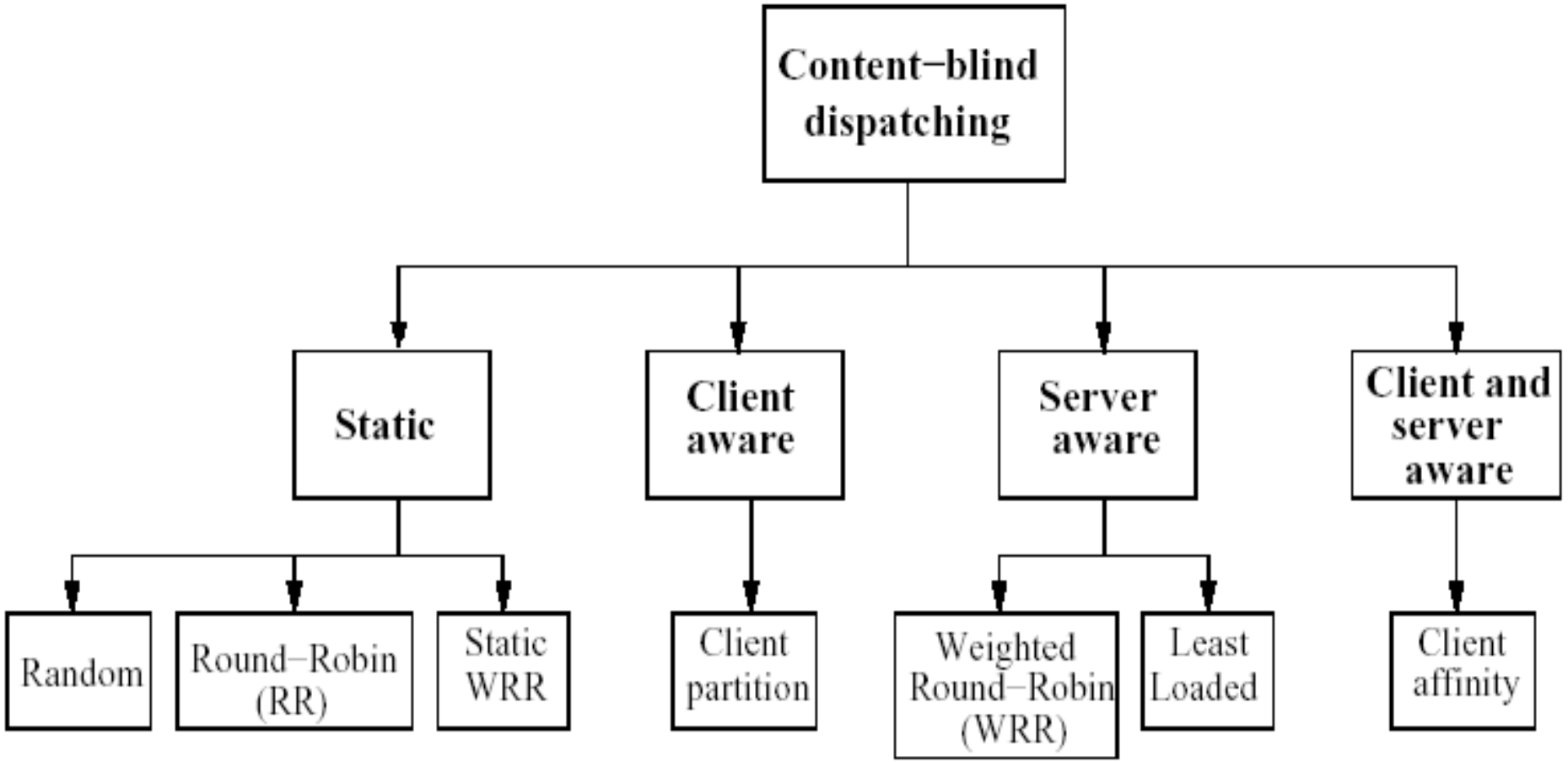
- **Client affinity:** Instead of assigning each new connection to a server only on the basis of the server state regardless of any past assignment, consecutive connections from the same client can be assigned to the same server.

Considerations of content blind

- Static approach is the fastest, easy to implement, but **may make poor assignment decision**.

- Dynamic approach **has the potential to make better decision**, but it needs to **collect and analyze state information, may cause high overhead**.

- Overall, **simple server state aware algorithm is the best choice**, ***least loaded algorithm is commonly used*** in commercial products.


Content−blind dispatching
Static
Client aware
Server aware
Client and server aware
Random
Round−Robin (RR)
Static WRR
Client partition
Weighted Round−Robin (WRR)
Least Loaded
Client affinity

Content aware approach

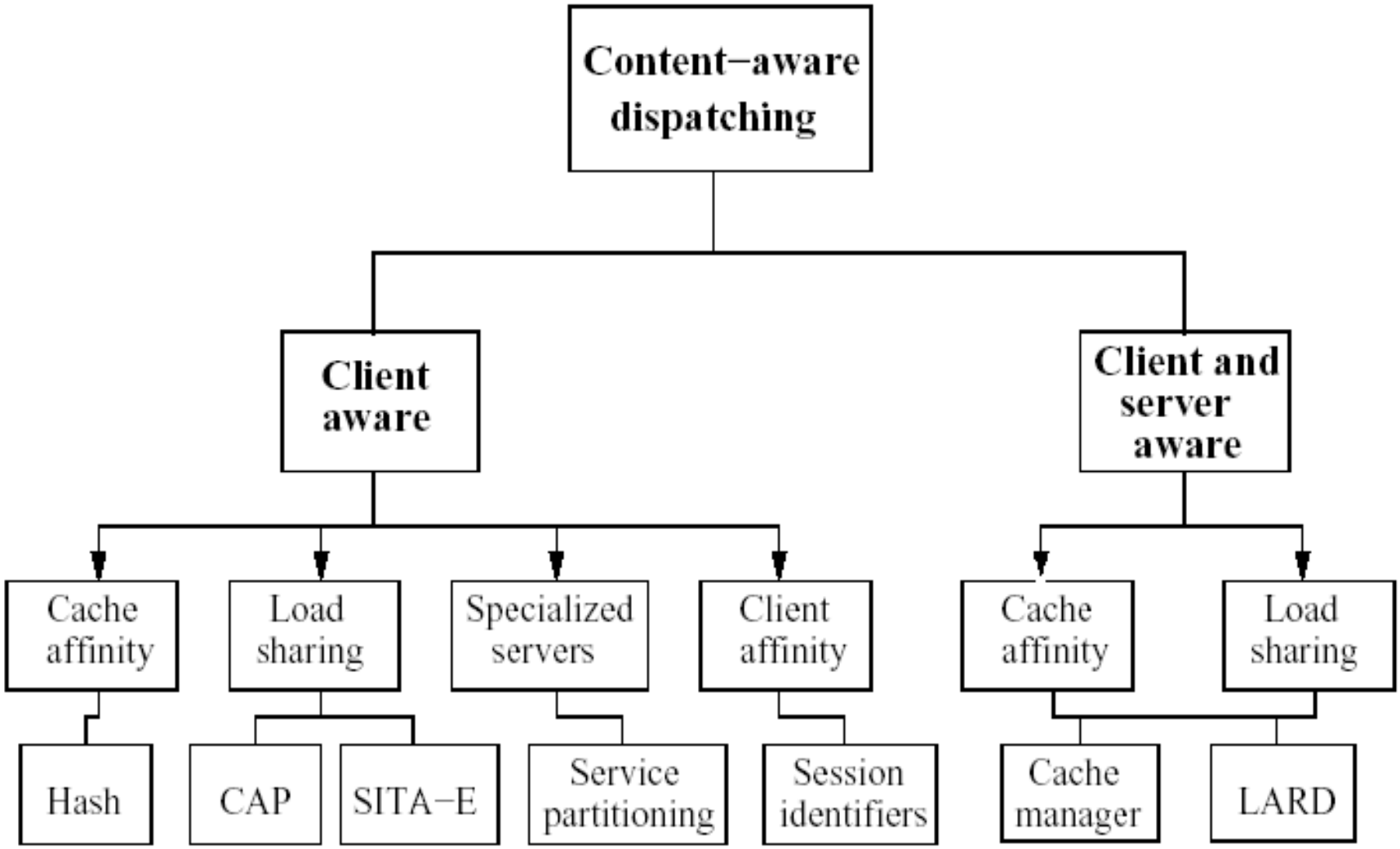
- **Sever state aware**
  - **Cache Affinity**
    - The file space is partitioned among the server nodes.
  - **Load Sharing**
    - **SITEA (Size Interval Task Assignment with Equal Load):** switch determines the size of the requested file and select the target server based on this information.
    - **CAP (Client-Aware Policy):** web requests are classified based on their impact on system resources: such as I/O bound, CPU bound.

Content aware approach (Cont.)

- **Client state aware**
  - **Service Partitioning**
    - Employ specialized servers for certain type of requests.
  - **Client Affinity**
    - Using session identifier to assign all web transactions from the same client to the same server.

Content aware approach (cont.)

- **Client and server state aware**
  - **LARD (Locality aware request distribution)**
    - Direct all requests to the same web object to the same server node as long as its utilization is below a given threshold.
  - **Cache Manager**
    - A cache manager that is aware of the cache content of all web servers.


Content−aware dispatching
Client aware
Client and server aware
Cache affinity
Load sharing
Specialized servers
Client affinity
Cache affinity
Load sharing
Hash
CAP
SITA−E
Service partitioning
Session identifiers
Cache manager
LARD