CSx55: Distributed Systems
[Distributed Servers]

The premise of distributed servers
A hoard of servers hums in the back
A switch out at the forefront
    funneling requests one at a time
    balancing the load

Powered by TCP handoffs
the responses return as if
they spring from the switch
and not the hidden crowd of servers

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Frequently asked questions from the previous class survey

- Can syntactic sugar obscure concurrency issues?
- How is throughput typically calculated?
- Will performance always be capped by the serial element?
- When to use a barrier vs. a latch?
- Where there a multiple queues of differing priorities, could we have more threads to service the highest-priority queue?

Topics covered in this lecture

- Thread architectures on the server-side
- State in Servers
- Distributed Servers
- TCP Handoffs
- Route optimizations using MIPv6

Thread-per-request architecture

- Worker thread is spawned for **each** incoming request
  - Worker thread *destroys itself* after processing request
- Advantages:
  - Threads do not contend for the shared work-queue
  - Throughput is potentially maximized
- Disadvantage
  - Overhead for thread creation and destruction operations

Thread-per-connection architecture

- Associates a thread per connection
- New worker thread created when a client makes a connection
  - Destroyed when client closes the connection
- Client may make many requests over the connection

Thread-per-object architecture

- Associate a thread with each remote object
- A separate thread receives requests and queues them
  - But there is a queue per-object

Thread-per-connection & Thread-per-object

- Advantages
  - Server benefits from lower thread management overheads compared to thread-per-request
- Disadvantages
  - Clients may be delayed when a worker thread has several outstanding requests, but another thread has no work to perform

Server Design Issues

Server Design Issues

- **Iterative** Servers
  - Handles request
  - Returns response to requesting client
- **Concurrent** Servers
  - Pass request to a separate thread/process
    - **Multithreaded server**
  - Await new incoming request

The **endpoint** issue

- Clients send their requests to an endpoint
  - **Port** to which a server listens to
- But how do clients know about a port?
  - Globally assign endpoints for well-known ports
    - Internet Assigned Numbers Authority (IANA)
    - FTP {TCP, 21}, HTTP {TCP, 80}

Implementing each service with a separate server could waste resources

- Instead of having multiple servers awaiting client requests
  - Have a single **super-server**
- INETD daemon on Unix
  - Listens to **several ports** for Internet services
    - Pop3 {110}, FTP {21}, Telnet {23}
  - When request comes in:
    1. **Fork** process to handle it
    2. Process **exit**s once done

Designing Servers: Support interruption

- Terminate client session
  - Server will eventually detect connection loss (TCP)
- Send **out-of-band** data
  - Data to be processed before any other client data
- But how can we send this out-of-band data?
  1. Send to a different port
  2. Reuse same connection
     - TCP **urgent data** e.g., `socket.sendUrgentData(int data)`

Some folks like to get away
Take a holiday from the neighborhood
Hop a flight to Miami Beach or to Hollywood
But I'm taking a Greyhound
On the Hudson River line
I'm in a New York state of mind

New York State of Mind; Turnstiles; Bill Joel

STATE

Tracking State in Servers

- Stateless servers
- Stateful servers

Stateless servers

- No state information about clients
  - E.g., Web Servers
- Usually, some state is maintained
  - Log of documents accessed by client
  - But if this is lost, there should be **no disruption** of service
- **Soft state**: track state for a limited time
  - When timer elapses, revert to default behavior

Stateful servers

- Maintain **persistent** information on clients
- Use this to improve **performance**
  - Real and perceived
- Special measures needed to recover from failures

Stateful servers: A file server example

- Allows client to maintain **local copy** of file
  - Even for updates to the file
  - Maintain {client,file} tuples to track file state
- Identify who has most recent version of file
- If server crashes it must recover the {client,file} entries

A hybrid approach: Have the client send its state to the server

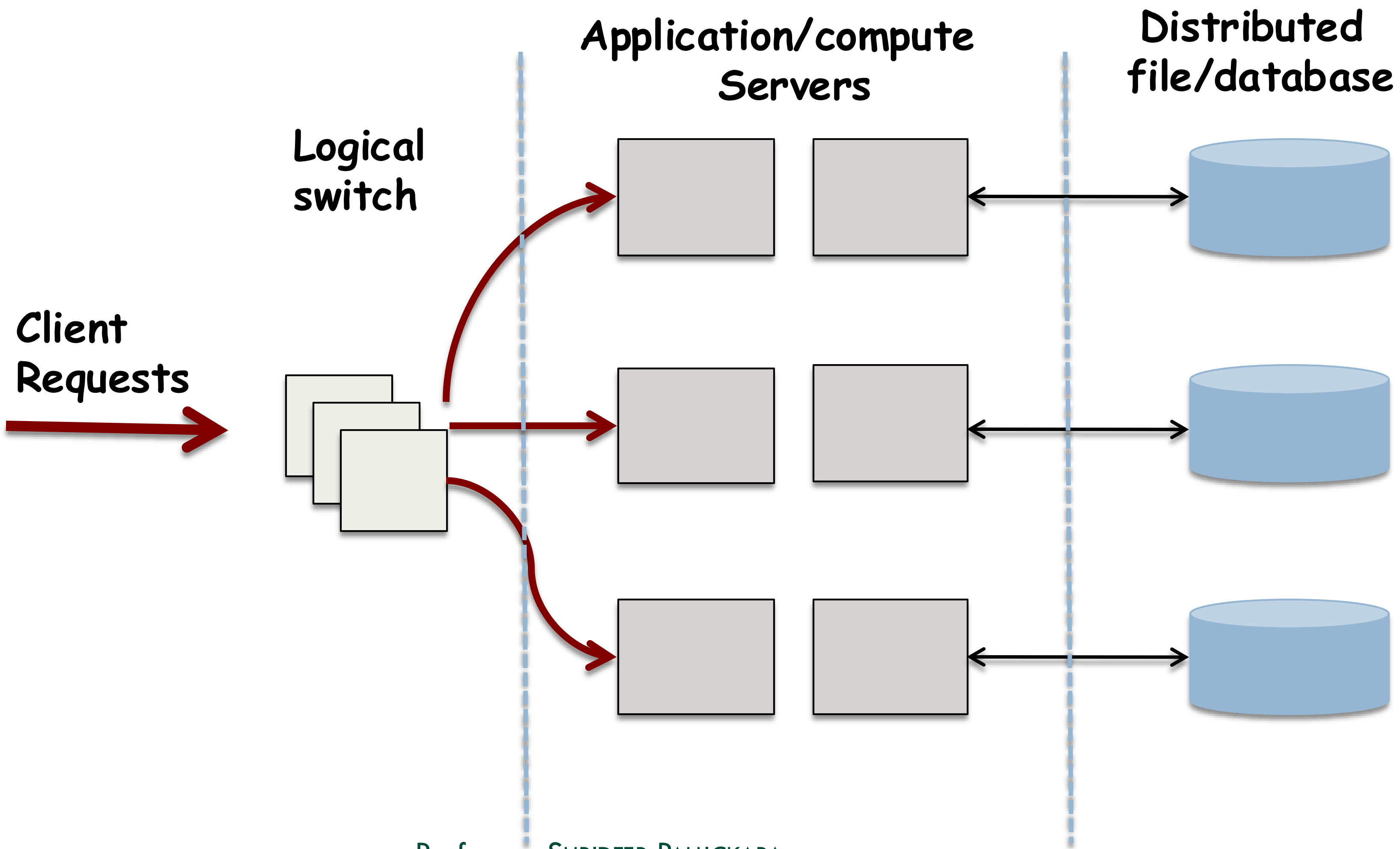
- **Cookies** serve this purpose for Web pages
- Tells a site about the pages accessed by a user
  - Use this to decide how to manage client
  - Sent back to browser every time state info changes
- Cookies don't stay where they are baked!

Distributed Servers

Mean time for failures and the premise for **distributed servers**

- Group several machines together
- Don't rely on the availability of any single machine
- Together, achieve better stability than each component individually
  - The sum is greater than the parts

Server Clusters



Server Clusters

- Switch is also responsible for **load balancing** requests
  - Simplest way to do this is using round-robin

- If there are different services offered within the cluster?
  - Switch needs to dispatch requests appropriately

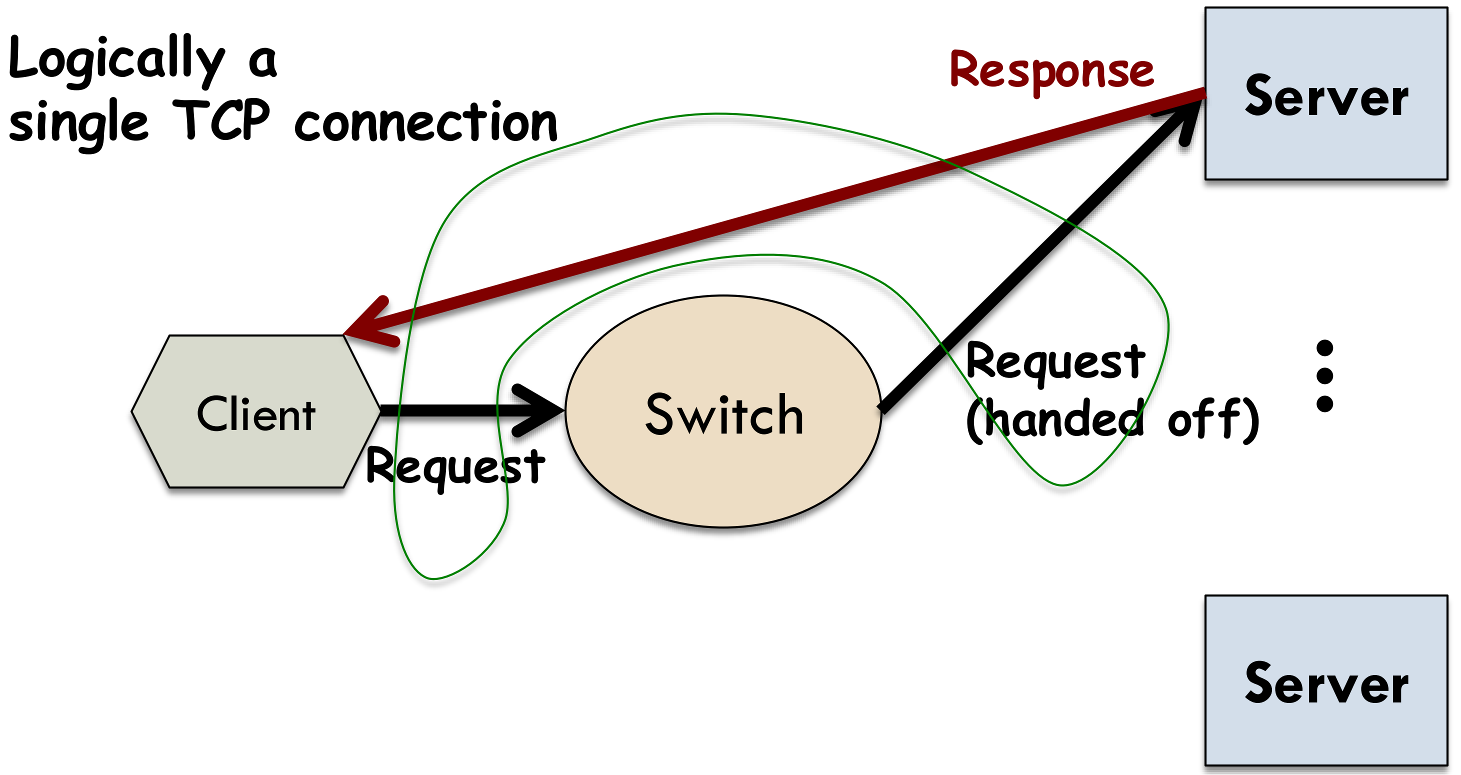
But what about transparency?

- An important consideration is that the server cluster is **transparent**
- Clients typically set up network connections over which requests are sent

But TCP expects an answer from the switch not some arbitrary node

- When server responds to client
  - Inserts **switch's IP address** in source field of the IP packet
- Requires **OS-level modifications**
- Also used in content-aware request distribution

The principle of TCP handoffs



When a cluster offers a single point …

- When there is a failure at that access point?
  - The entire cluster becomes unavailable

- Several access points are typically provided
  - DNS can return **several addresses** all mapped to the same host name
  - Client makes several attempts if there are failures
  - Still requires static access points

Pulls and trade-offs

- Stability
  - Long lived access point
- Flexibility
  - Ability to configure a server cluster including the switch

What would be really nice

- Distributed server with a **dynamically changing** set of machines
- And also varying access points

Mobile IPv6

Mobile IPv6 at a glace

- IPv6 provides the foundation
  - Provides addressing and packet routing
  - Defines the structure of communication on the Internet
- The problem of mobility
  - Devices move across Wi-Fi, cellular, or other networks
  - Without support, each move would **break connections** or **force a new IP address**
- Mobile IPv6 as the solution
  - Extends IPv6 with mobility support
  - Lets a device keep a **stable home address** while roaming
- Manages handoffs so applications stay connected, uninterrupted
- Crux: Separate ***where*** you are (current point of attachment) from ***who*** you are (your permanent IP identity)

Mobility support in IP version 6 (MIPv6)

- A **mobile node** has a **home-network**
- This node has a **home-address**
- The node has a **home agent**
  - Takes care of traffic to the mobile node while it is away

Mobility support in IP version 6 (MIPv6)

- When a mobile node attaches to a **foreign network**
  - Gets a temporary **care-of address**
- Care-of address reported to the home-agent
  - **Forward** all traffic to the mobile node

Apps communicating with mobile node only see the home address and not the care-of-address

- Offers a stable address for a distributed server
  - A single, unique contact address is initially assigned
- Contact address is server's **lifetime** address

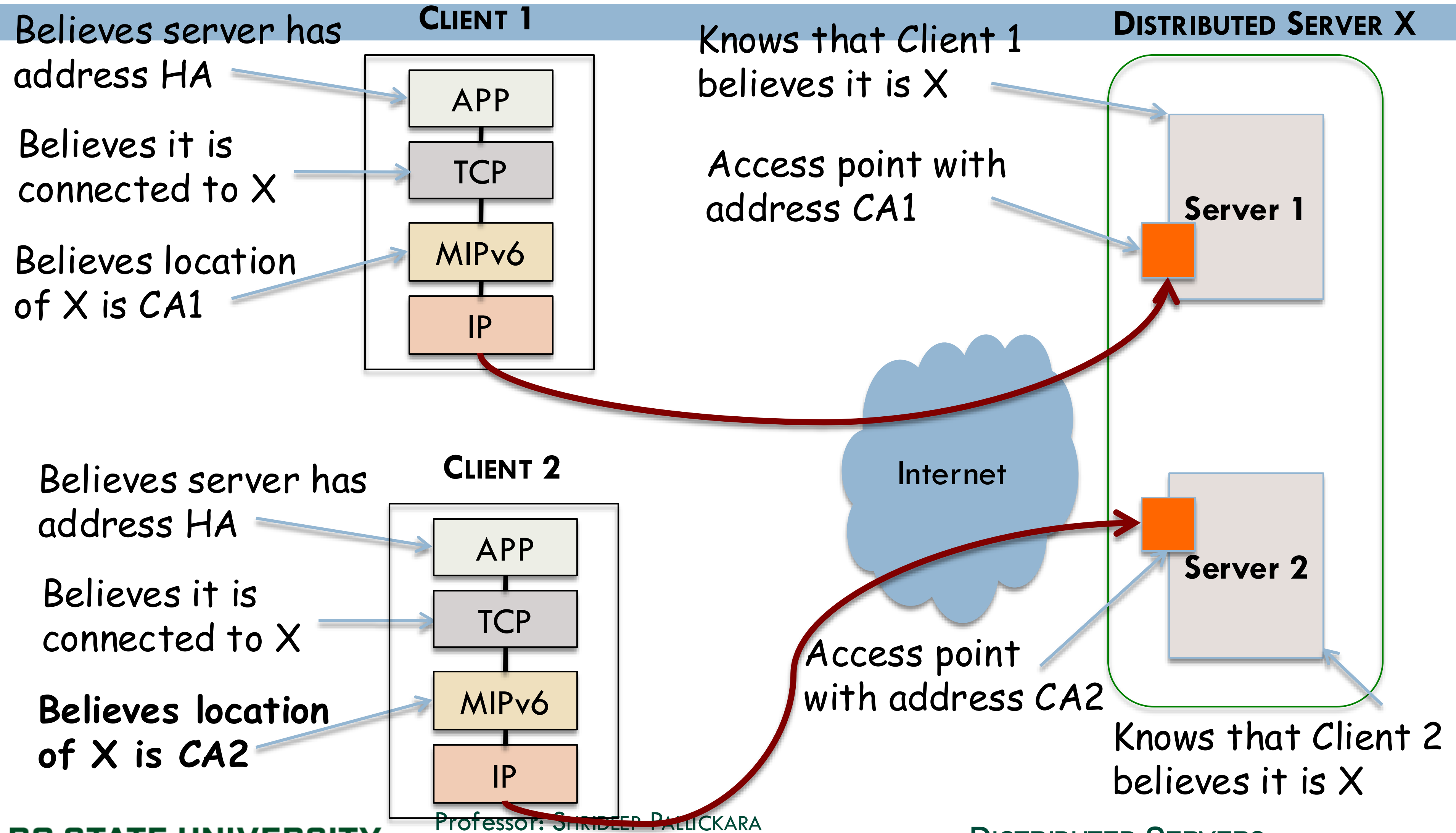
Any node can act operate as the access point

- Record own address as the care-of address
- All traffic will be directed to the access point
- If there's a failure at the access point?
  - Another node takes over
- Potential bottlenecks?
  - Home agent and access point
  - All traffic **must flow** through them

The route optimization feature in MIPv6

- When a mobile node reports its care-of address (CA) to the home-agent (HA)
  - The HA reports the CA to a client
- Client keeps **{HA, CA}**
- Communications will be with the CA
  - Applications can still use the HA
  - MIPv6 protocol stack will translate HA to CA

Depicting Route Optimizations



The contents of this slide-set are based on the following references

- *Distributed Systems: Principles and Paradigms. Andrew S. Tanenbaum and Maarten Van der Steen. 2nd Edition. Prentice Hall. ISBN: 0132392275/978-0132392273.* [Chapter 6, 2]
- *Distributed Systems: Concepts and Design. George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair. 5th Edition. Addison Wesley. ISBN: 978-0132143011.* [Chapter 7, 14]