Middleware and Web Services

Lecture 8: High Availability and Performance

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Good Performance

- What influences good performance?
  - *Number of users and concurrent connections*
  - *Number of messages and messages' sizes*
  - *Number of services*
  - *Infrastructure – capacity, availability, configuration, ...*
- How can we achieve good performance?
  - *Infrastructure*
    → *Scalability, failover, cluster architectures*
  - *Performance tuning*
    → *Application Server, JVM memory, OS-level tuning, Work managers configuration*
  - *Service configuration*
    → *Parallel processing, process optimization*

Overview

- Infrastructure
  - *Load Balancers*
  - *Cluster Architecture*
- Performance Tuning

Definitions

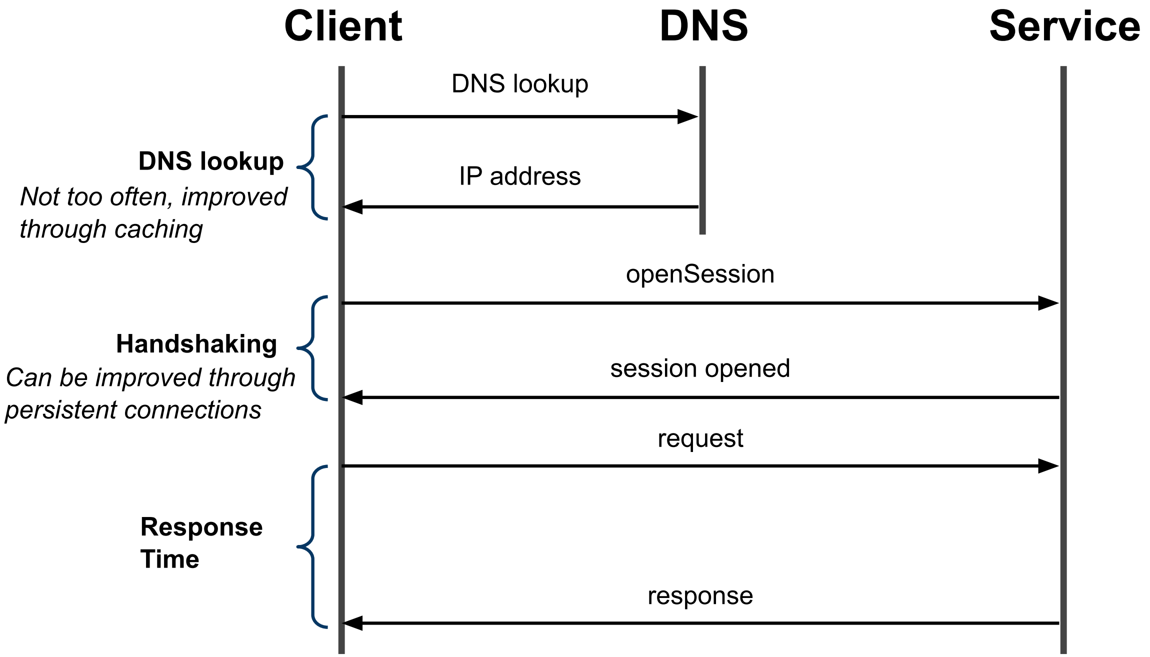
- Scalability
  - *server scalability*
    - → *ability of a system to scale – when input load changes*
    - → *users should not feel a difference when more users access the same application at the same time*
    - → ***horizontal scaling***
      - → *adding new instances of applications/servers*
    - → ***vertical scaling***
      - → *adding new resources (CPU, memory) to a server instance*
  - *network traffic*
    - → *bandwidth capacity influences performance too*
    - → *service should limit the network traffic through caching*
- Availability
  - *probability that a service is operational at a particular time*
    - → *e.g., 99.9987% availability – downtime ~44 seconds/year*

Definitions (Cont.)

- High Availability
  - *When a server instance fails, operation of the application can continue*
  - *Failures should affect application availability and performance as little as possible*
- Application Failover
  - *When an application component performing a job becomes unavailable, a copy of the failed object finishes the job.*
  - *Issues*
    - → *A copy of the failed object must be available*
    - → *A location and operational status of available objects must be available*
    - → *A processing state must be replicated*
- Load Balancing
  - *Distribution of incoming requests across server instances*

Performance Metrics

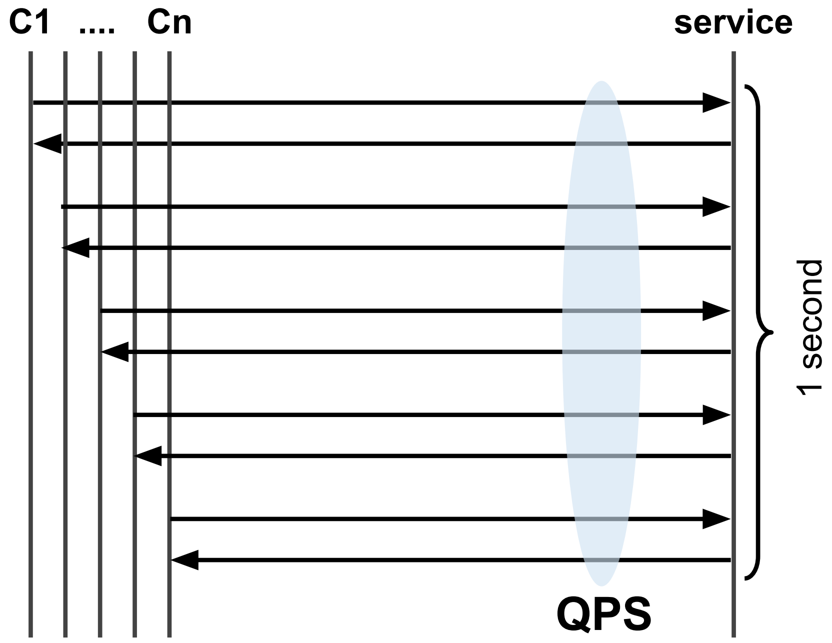
- Response Time
  - *A client-side metric*



  - *CPU intensive service or a bad configuration of a service*
    → consider asynchronous processing when CPU intensive
  - *Writing to a data store*

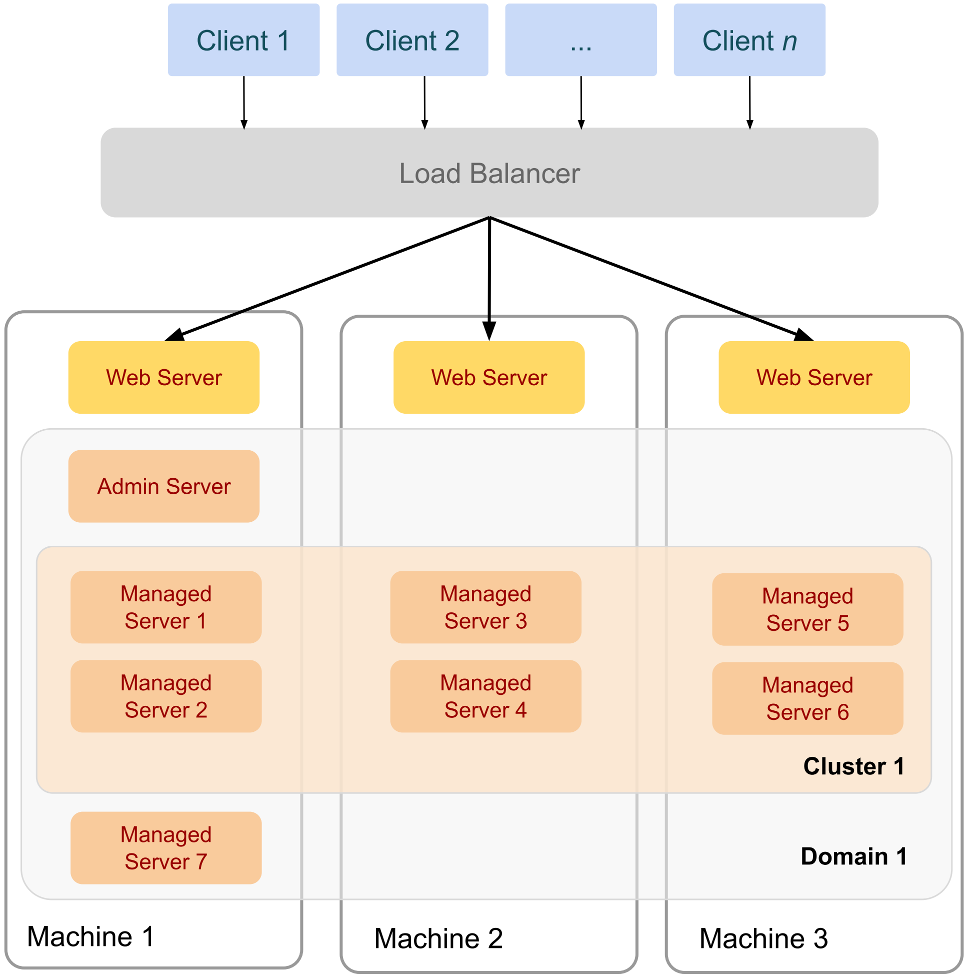
Performance Metrics

- Queries/Requests per Second (QPS)
  - *A server-side metric*



  - *Caching may improve performance*
    → *even if data changes often, with high QPS caching improves a lot*

Infrastructure Example – Weblogic



Clients
Clients access objects or applications running on application server.

Load Balancer
External to application server. Distributes incoming requests to servers running on multiple machines.

Web Tier
Provides access to servers running in a domain on machines.

Domain
Collection of clusters and servers. Each domain contains one Admin Server.

Cluster
Collection of managed servers. Each managed server contains the same copy of objects.

Best Configuration Practices

- Domain configuration
  - *A server is an admin server or a managed server*
  - *Each server is running on a separated JVM*
  - *A physical machine may run one or more servers*
  - *There should be at least two managed servers running on one machine*
    - → *This provides a better performance (as opposed to one server running on one machine)*
  - *A domain can have clustered or unclustered servers*
- Load balancers (LB)
  - *Load Balancers are not part of the domain*
    - → *They are external to Weblogic server*
    - → *There is usually one HW LB and several SW LBs*
    - → *Software LB*
      - → *Realized by the Web Tier (Apache HTTP server)*
      - → *Redirects requests too all managed servers in a domain (across multiple machines)*

Overview

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Load Balancing

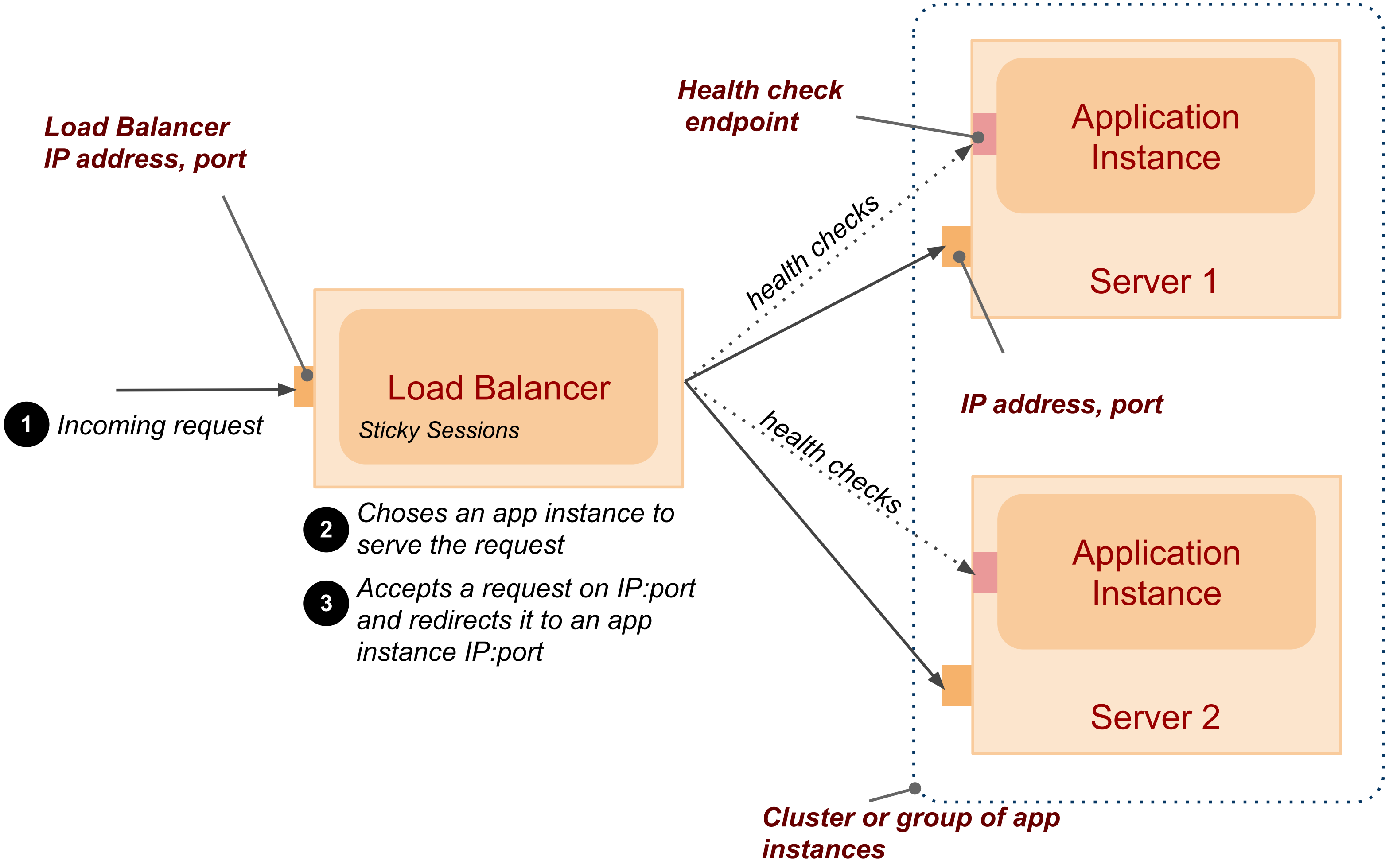
- Distributes a load to multiple app/object instances
  - *App instances run on different machines*
  - *Load sharing: equal or with preferences*
  - *Health checks*
- Types
  - *DNS-based load balancer*
    - → *DNS Round Robin*
  - *NAT-based load balancer (Layer-4)*
  - ***Reverse-proxy load balancer** (Layer-7)*
    - → *application layer*
    - → *Sticky sessions*
      - → *JSession, JSession-aware load balancer*
  - *Client-side load balancer*
    - → *LB run by a client*
    - → *a client uses a replica-aware stub of the object from the server*

DNS-based Load Balancer

- DNS Round Robin
  - *A DNS record has multiple assigned IP addresses*
  - *DNS system delivers different IP addresses from the list*
  - *Example DNS A Record:*

    ```
    company.com A 147.32.100.71 147.32.100.72 147.32.100.73
    ```
- Advantages
  - *Very simple, easy to implement*
- Disadvantages
  - *IP address in cache, could take hours to re-assign*
  - *No information about servers' loads and health*

Reverse Proxy Load Balancer

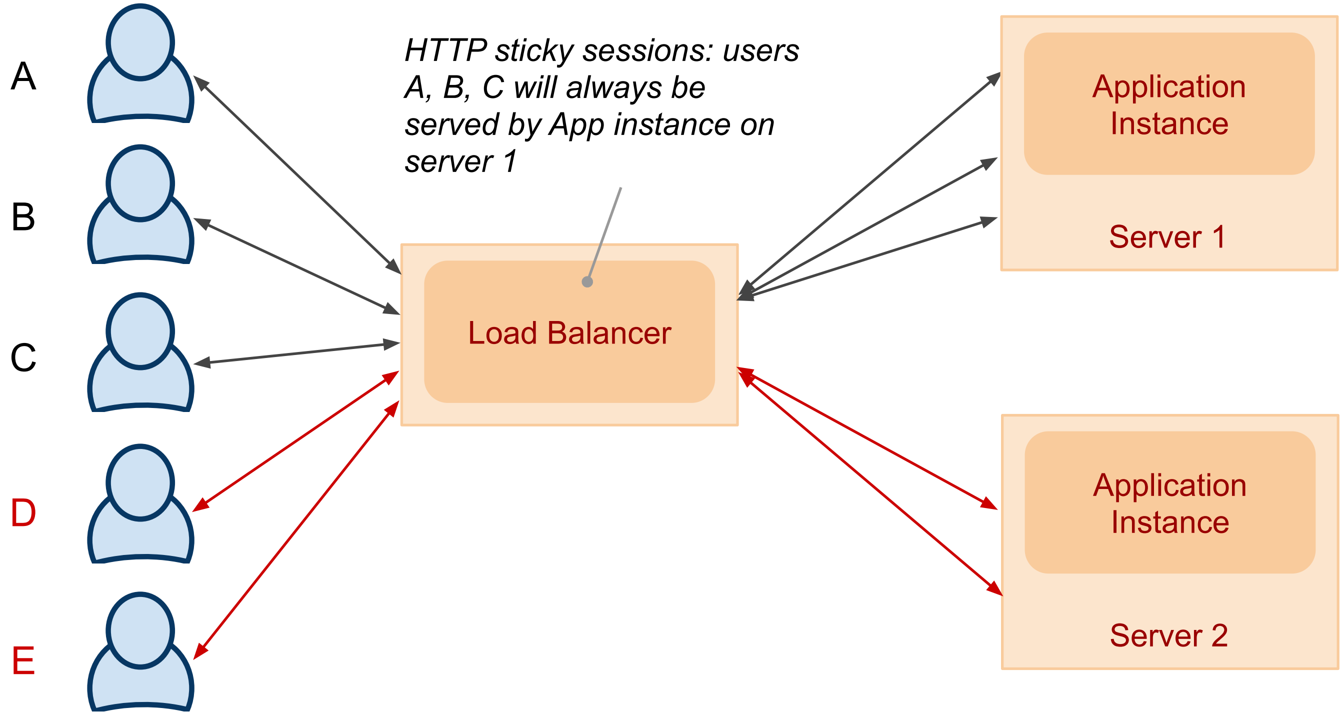


1 *Incoming request*

2 *Choses an app instance to serve the request*

3 *Accepts a request on IP:port and redirects it to an app instance IP:port*

HTTP Sticky Sessions Example


A
B
C
D
E
HTTP sticky sessions: users A, B, C will always be served by App instance on server 1
Load Balancer
Application Instance
Server 1
Application Instance
Server 2

- How to identify a server that hosts the session state
  - *Passive cookie persistence – LB uses a cookie from the server*
  - *Active cookie persistence – LB adds its own cookie*

Types of Load Balancers

- Software
  - *Apache* `mod_proxy_balancer`

    → *HTTP Session persistence – sticky sessions*
  - *WebLogic proxy plug-in*

```
<Location /soa-infra>
    SetHandler weblogic-handler
    WebLogicCluster czfmwapp03-vf:8001,czfmwapp04-vf:8001,czfmwapp05-vf:8001
</Location>

```

`/soa-infra` *is a first part of an URL path that rules in this* `Location` *will be applied (this is a standard Apache configuration mechanism)* `czfmwapp{N}` *is a hostname that corresponds to a virtual IP to which the managed server JVM processes is bounded (using the tcp port* `8001`*).*

`WebLogicCluster` *specifies the list of servers for load balancing*

- Hardware
  - *Cisco, Avaya, Barracude*

Round-Robin Algorithm

- Uses

  `request` – *client request with or without a cookie information*

  `server_list` – *a list of servers that can process the request*

  `rbinx` – *round robin index*

  `sticky_sessions` – *associative array of pairs* `<session_id,server>`

  `unhealthy_treshhold` – *a number of negative consecutive health checks before moving the server to the "unhealthy" state.*

- Round Robin Algorithm
  - *if* `session_id` *exist in the* `request` *and in* `sticky_sessions`

    → *send the* `request` *to the server* `sticky_sessions[session_id]`
  - *otherwise*

    → *send the* `request` *to the* `rbinx` *server in the* `server_list`

    → *extract* `session_id` *from the response from the server*

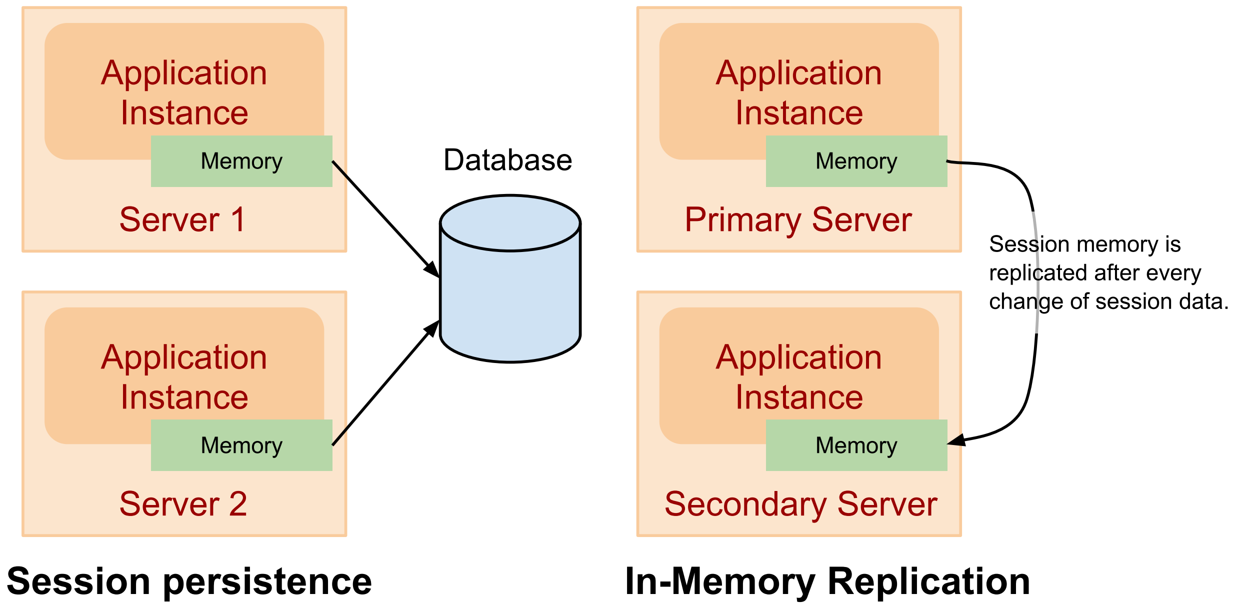
    → *if the* `session_id` *exist, add a pair* `<session_id;server_list[rbinx]>` *to* `sticky_sessions`

    → *increase* `rbinx` *by one or reset it to* `0` *if it exceeds the length of* `server_list`

Health Check

- Health Check
  - *For each server in the* `server_list`
    - → *call the server's heatlhcheck endpoint*
    - → *if a number of failed health checks for the server exceeds the* `unhealthy_threshold`
      - → *remove the server from the* `server_list`
    - → *if the server was unhealthy and a there was a successful healthcheck*
      - → *add the server back to the* `server_list`

Session State Persistence and Replication



Session memory is replicated after every change of session data.

- Session persistence
  - *Session information is maintained in the database*
  - *Does not require sticky sessions*
  - *Implements* `HttpSession` *interface that writes data to the DB*
- In-memory replication
  - *A* ***primary server*** *holds a session state, the* ***secondary server*** *holds its replica.*
  - *Information about primary and secondary servers are part of JSession*

In-Memory Replication

- Session format
  - *It's a cookie*
  - `JSESSIONID=SESSION_ID!PRIM_SERVER_ID!SEC_SERVER_ID!CREATION_TIME`

    `SESSION_ID` – *session id, generated by the server to identify memory associated with the session on the server*

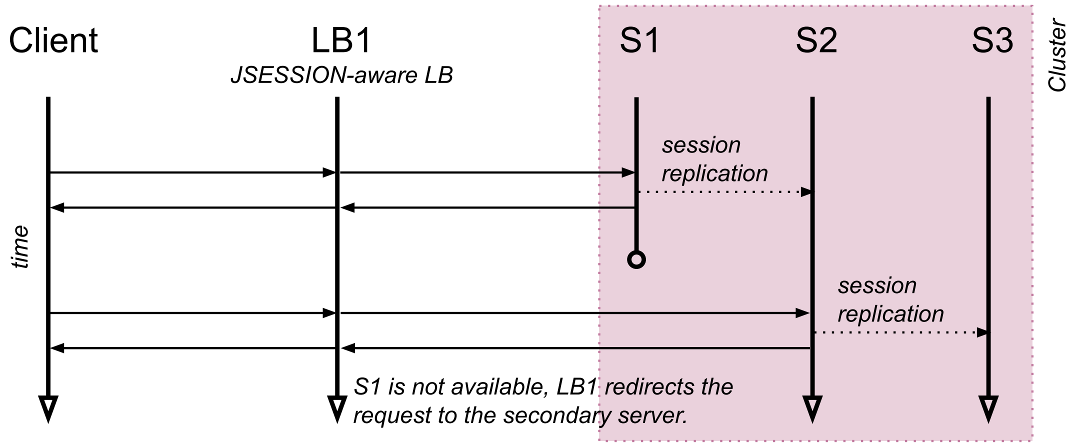
    `PRIM_SERVER_ID` – *ID of the managed server holding the session data*

    `SEC_SERVER_ID` – *ID of the managed server holding the session replica*

    `CREATION_TIME` – *time the session data was created/updated*
- How LB uses this information
  - *LB has information whether the server is running or not (via healthchecks)*
  - *if the primary server is running, it redirects the request there*
  - *if the primary server is not running, it redirects the request to the secondary server directly*
  - *if primary and secondary servers are not running, it redirect the request to any other server it has in the list – this may cause side effects!*

In-Memory Replication Scenarios

Scenario A: JSession-aware load balancer

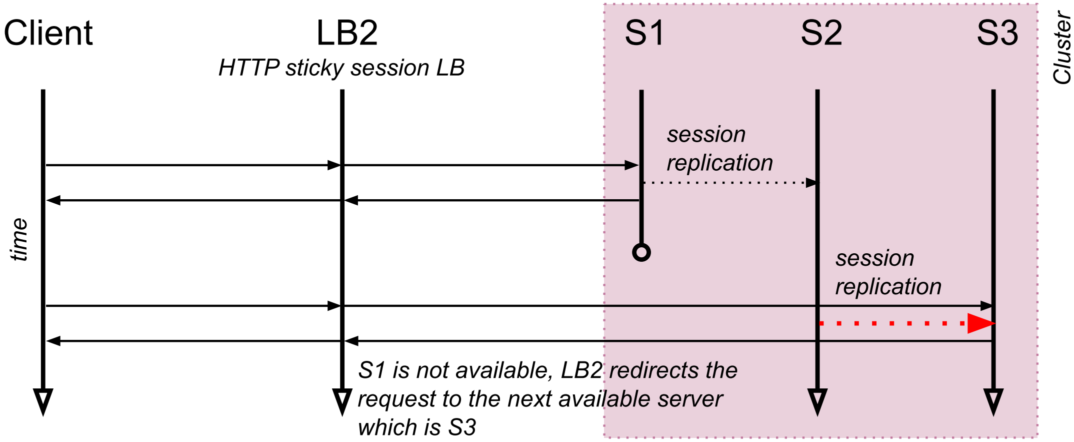


S1 is not available, LB1 redirects the request to the secondary server.

S1 is primary, S2 is secondary; S1 replicates the session to S2

S1 fails, S2 becomes primary, S3 becomes secondary; LB1 directly redirects the request to S2 as it knows the secondary server from the first request.

Scenario B: HTTP sticky session load balancer



S1 is not available, LB2 redirects the request to the next available server which is S3

S1 is primary, S2 is secondary; S1 replicates the session to S2

S1 fails, S3 discovers that S2 has a session and gets the session data from it. S3 becomes primary and S2 becomes secondary.

Overview

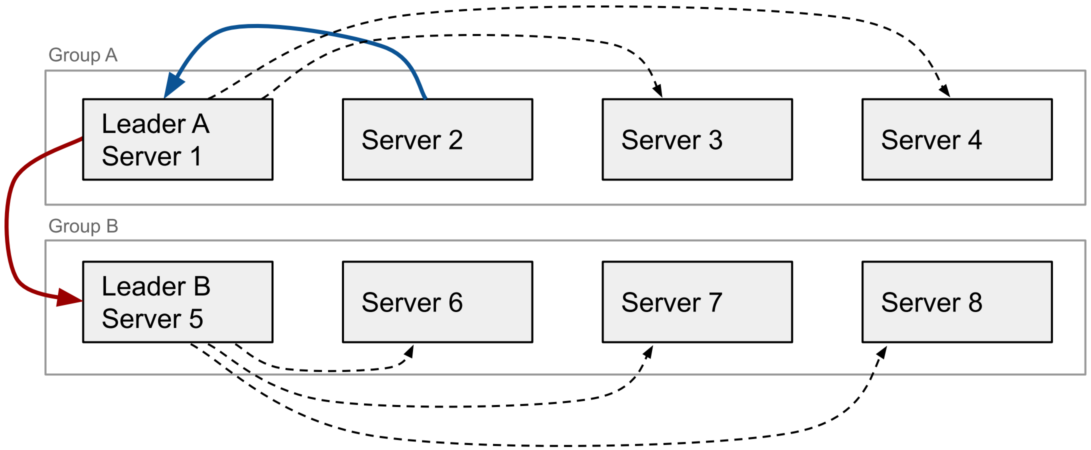
- Infrastructure
  - *Load Balancers*
  - *Cluster Architecture*
- Performance Tuning

Overview

- Cluster capabilities
  - *A group of servers (aka cluster members) act together to serve clients' requests*
  - *Cluster is transparent to clients*
  - *Servers can run on the same machines or on different machines*
  - *Cluster's capacity can be increased by adding servers to the cluster*
  - *Servers in a cluster may have the same copy of objects and they are aware of each other objects*
    - → *objects: applications, JMS destinations, RMI objects*
    - → *See Cluster-wide JNDI tree in Lecture 4*
- Cluster Messaging Protocols
  - *When servers need to send messages to other members of the cluster*
  - ***Unicast** - one-to-one communication using TCP/IP sockets*
  - ***Multicast** - one-to-many communication*
  - *Cluster services that rely on the cluster messaging protocol*
    - → *Cluster Membership*
    - → *JNDI Replication*
  - *There are services using persistent RMI connections between cluster members*
    - → *such as during in-memory replication of HTTP session information*

Unicast

- Overview
  - *Uses standard TCP/IP sockets to send messages across cluster members*
  - *Uses a **group leader strategy** to limit the number of sockets required to send messages within the cluster*
- Groups in the cluster
  - *Cluster is split into* `M` *groups with* `N` *servers, each group has a leader*
  - *Servers communicate with the group leader, group leaders communicate with servers in the group and other group leaders*
  - *When a group leader dies, the group elects another group leader*
  - *There is up to* `MxN` *network messages for every cluster message*



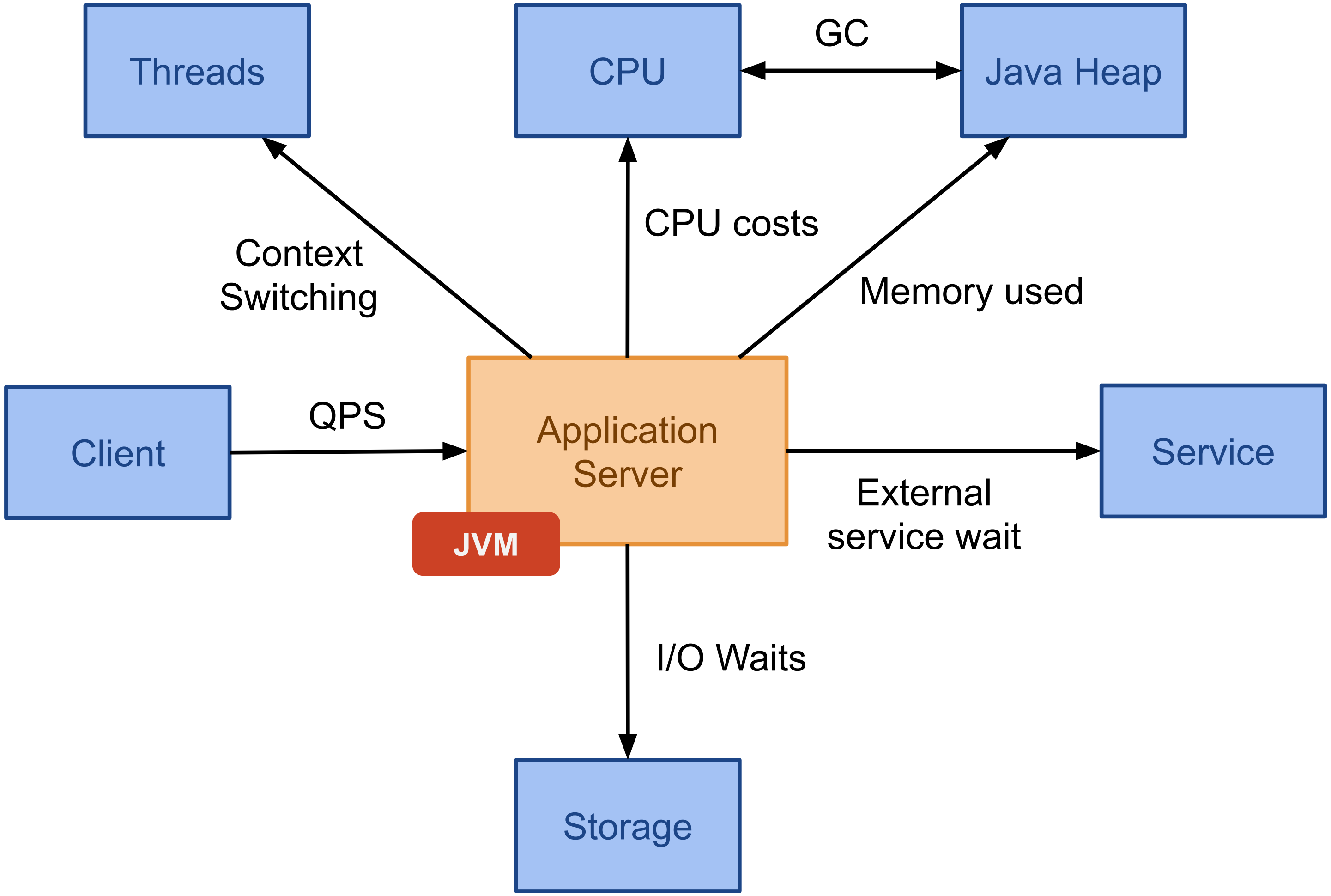
Cluster Services

- Cluster Membership
  - *Cluster members maintain their view on what servers are in the cluster*
  - *Each server sends heartbeat messages to the cluster*
    → *others know it is alive*
  - *Each server receives heartbeat messages*
    → *When a server misses a number of messages from a cluster, it removes the servver from the list until it receives the next heartbeat message.*
- JNDI Replication
  - *Provides each server with a cluster-wide view of the JNDI tree.*
  - *Servers send JNDI update messages to the cluster when an object is bound or removed to their local tree.*
  - *When a server leaves the cluster*
    → *other members remove its JNDI bindings from their three.*
  - *When a server joins the cluster*
    → *The server asks other server for a JNDI state dump.*

Overview

- Infrastructure
- Performance Tuning

Performance Limiting Factors



Monitoring

- Important to understand performance
  - *DevOps monitoring trends*
- What you need
  - *Collect → Filter → Store → View →* ***Tune***
  - *Metrics, dashboards, alerting, log management, reporting, tracing capabilities*
  - *It is necessary to organize metrics well in order to understand what is going on*
  - *Start from a high-level process, detail to technical components*
- Source
  - *Application server*
    - *→ usually management beans with JMX interfaces*
    - *→ log files (access logs, server logs, etc.)*
  - *OS*
    - *→ many utilities available out of the box*
    - *→ open sockets, memory, context switches, I/O performance, CPU usage*
  - *Database*
    - *→ applications may write metrics to the DB*
    - *→ SQL scripts to collect metrics*

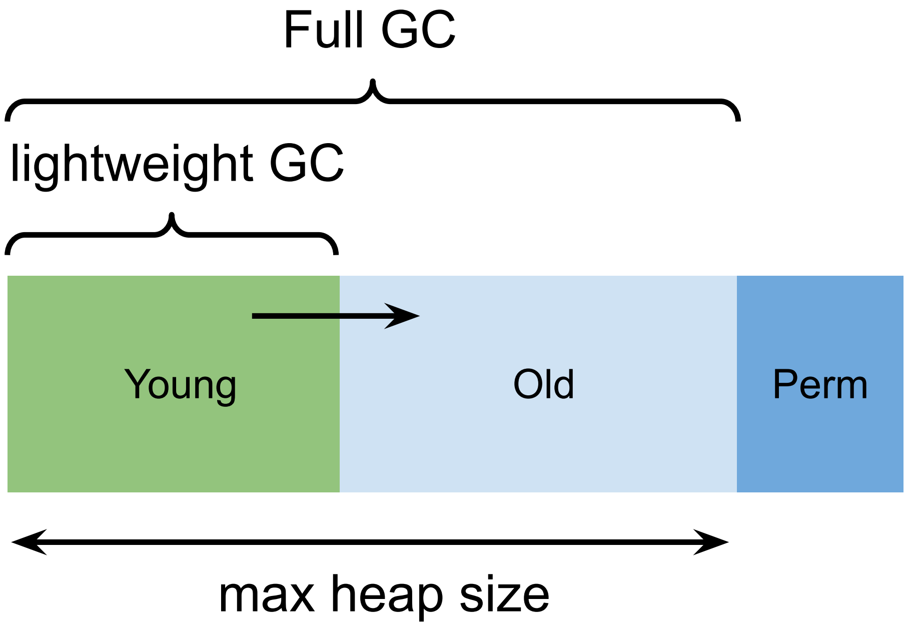
Monitoring Tools

- Commercial Monitoring Solutions
  - *Application server vendor usually offers a monitoring solution*
  - *AppDynamics, Oracle Enterprise Manager, Splunk*
  - *Google stackdriver, Amazon AWS CloudWatch*
- Open source examples
  - *Elasticsearch + LogStash + Kibana*
  - *InfluxDB + Telegraph + DataGraph*

Tuning – A Layered Approach

- Application server can be tuned at multiple layers
  - *Service configuration optimization*
  - *Transport-level tuning*
  - *Application Server Tuning*
  - *JVM Memory Tuning*
  - *OS Tuning*
- Lower levels are cheaper to tune

Memory Allocations



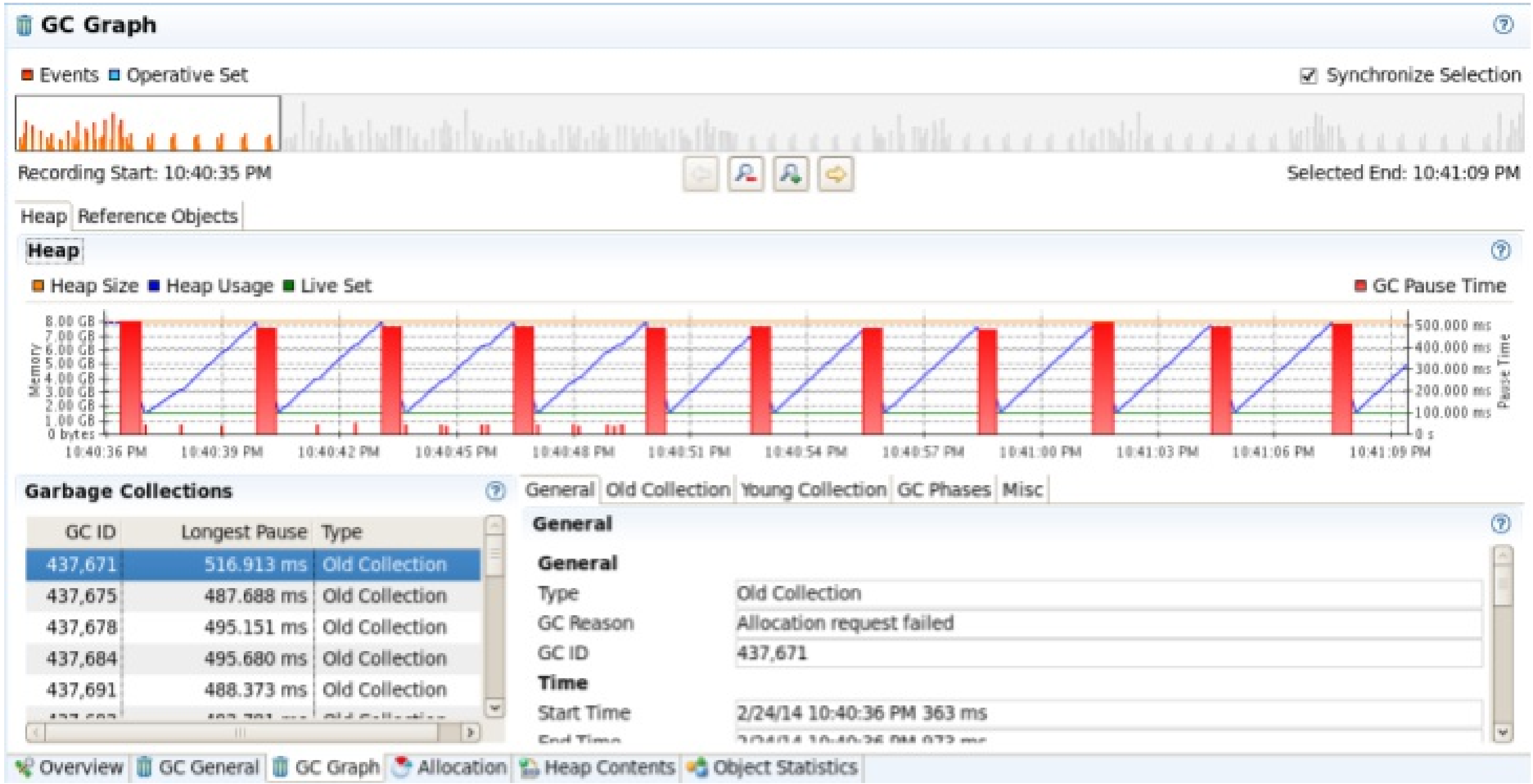
- Generations
  - *Young – objects get allocated in this space initially*
  - *Old – objects get promoted to old from young*
  - *Perm – space for permanent allocations, e.g. objects describing classes and methods*

Garbage Collection

- Steps to move objects around
  1. *Objects are created in young*
  2. *When young is full, the live objects are copied to old, dead are discarded*
     - ***lightweight GC***
  3. *When young is full and no space in old → the full GC frees the old space*
     - ***Full GC** – nothing is running in JVM, the application stops*
  - ***Too frequent full GC has an impact on performance***
- A memory leak or inadequate heap allocation
  - *Old is out of space → full GC will run often (or continously)*
  - *High CPU utilization, The server will not be able to process/respond to requests*

Heap Size and GC Runs

- Heap Size and GC runs
  - *Wrong heap size allocation – too small or memory leaks*
  - *GC full runs too often, this has a negative impact on performance*



GC ID	Longest Pause	Type
437,671	516.913 ms	Old Collection
437,675	487.688 ms	Old Collection
437,678	495.151 ms	Old Collection
437,684	495.680 ms	Old Collection
437,691	488.373 ms	Old Collection

General

General

Type	Old Collection
GC Reason	Allocation request failed
GC ID	437,671

Time

Start Time	2/24/14 10:40:36 PM 363 ms

JVM Memory Tuning

- JVM Memory Parameters

  `-Xms` – *initial java heap size*

  `-Xmx` – *maximum java heap size*

  `-XX:NewSize` – *the initial size of the heap for young generation*

  `-XX:MaxNewSize` – *the maximum size of the heap for young generation*

- General recommendations

  `-Xms` *and* `-Xmx` *should be set to the same value*
  (do not allow the heap to grow → limit the overhead)

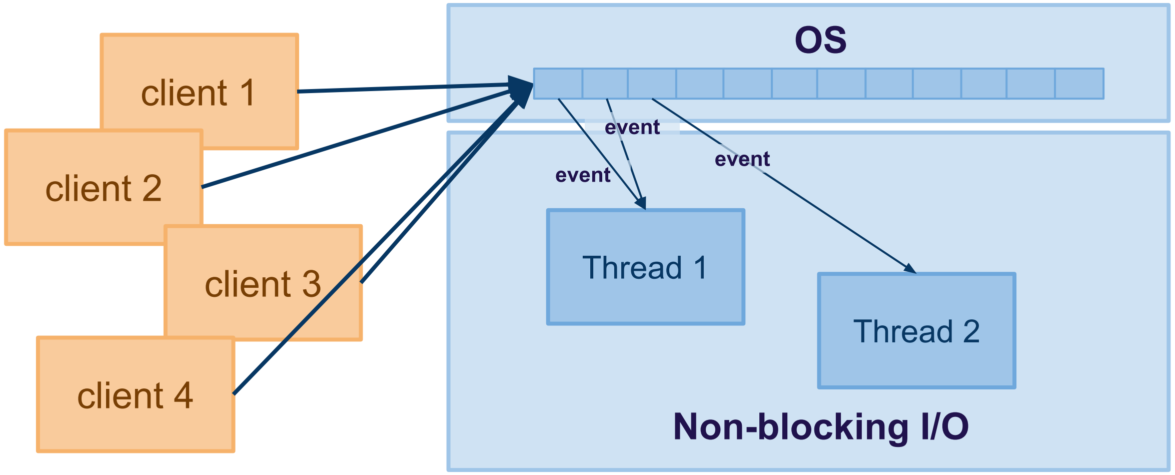
  `-XX:NewSize` *and* `-XX:MaxNewSize` *should be set to the one half of maximum heap*

  – *Example, 1GB heap size*

  ```
  –Xms1024m –Xmx1024m -XX:NewSize=500m -XX:MaxNewSize=500m
  ```

Asynchronous I/O: Recall

- Connections maintained by the OS, not the Web app
  - *The Web app registers events, OS triggers events when occur*



- Characteristics
  - *Event examples: new connection, read, write, closed*
  - *The app may create working threads, but controls the number!*
    → much less number of working threads as opposed to blocking I/O

Work Manager Configuration

- Work Manager
  - *Controls the number of thread allocated to processing of requests*
  - *In WLS is called a dispatch policy*
    - → *Can be assigned to OSB proxy services*
  - *Parameters*
    - → ***maximum threads*** *(*`max`*) – maximum number of working threads*
    - → ***capacity*** *(*`cap`*) – maximum number of connections*
  - *maximum connections waiting to be processed:* `cap - max`
  - *refused connections: when number of connections is* `> cap`
- Inbound throtling
  - *A dispatch policy applied to a single proxy service*
  - *Rejected connections will not be processed*