Middleware and Web Services Lecture 5: 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
 - \rightarrow 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
 - \rightarrow 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
 - \rightarrow 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

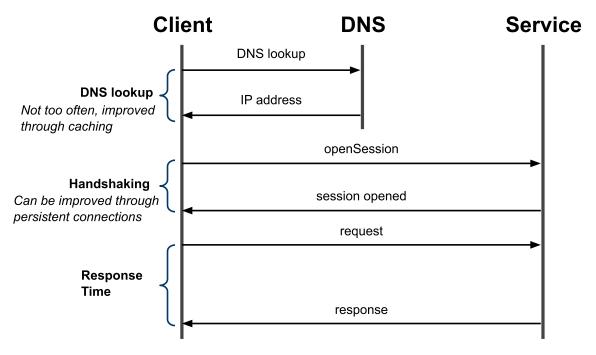
- When an application component performing a job becomes unavailable, a copy of the failed object finishes the job.
- Issues
 - \rightarrow A copy of the failed object must be available
 - \rightarrow A location and operational status of available objects must be available
 - \rightarrow A processing state must be replicated

Load Balancing

- Distribution of incoming requests across server instances

Performance Metrics

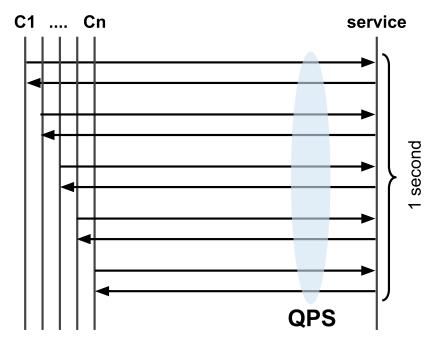
- Response Time
 - A client-side metric



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

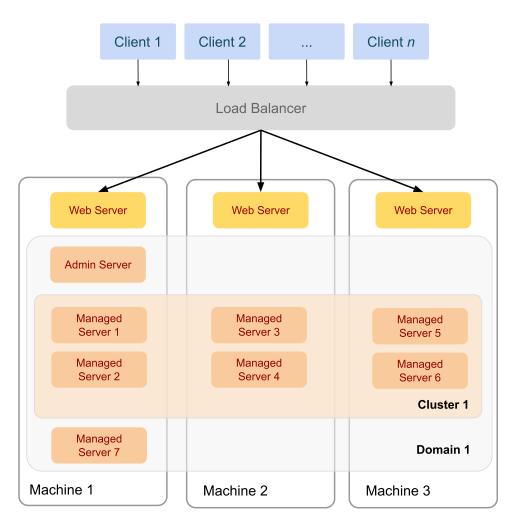
Performance Metrics

- 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
 - \rightarrow Software LB
 - → Realized by the Web Tier (Apache HTTP server)
 - → Redirects requests too all managed servers in a domain (across multiple machines)

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Load Balancing

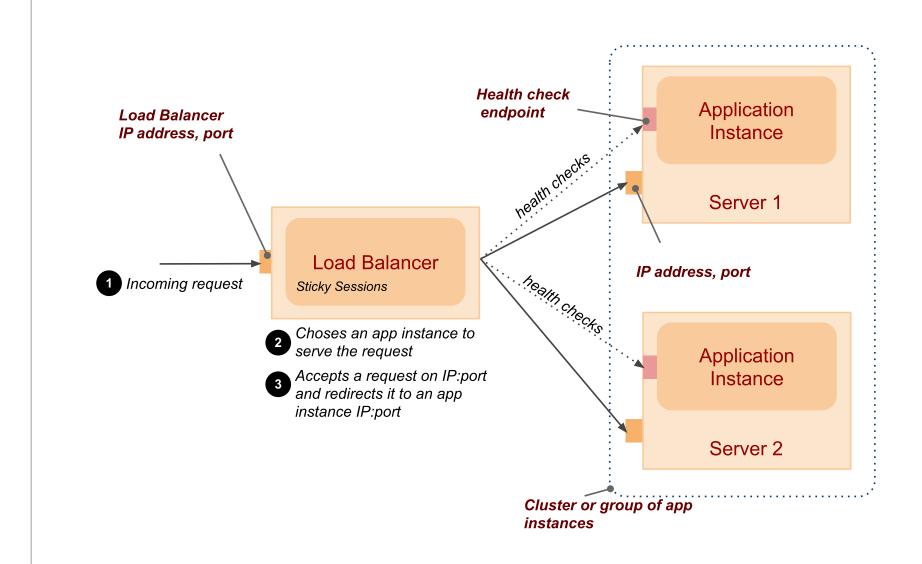
- Distributes a load to multiple app/object instances
 - App instances run on different machines
 - Load sharing: equal or with preferences
 - Health checks
- Types
 - DNS-based load balancer
 - → DNS Round Robin
 - NAT-based load balancer (Layer-4)
 - Reverse-proxy load balancer (Layer-7)
 - \rightarrow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

DNS-based Load Balancer

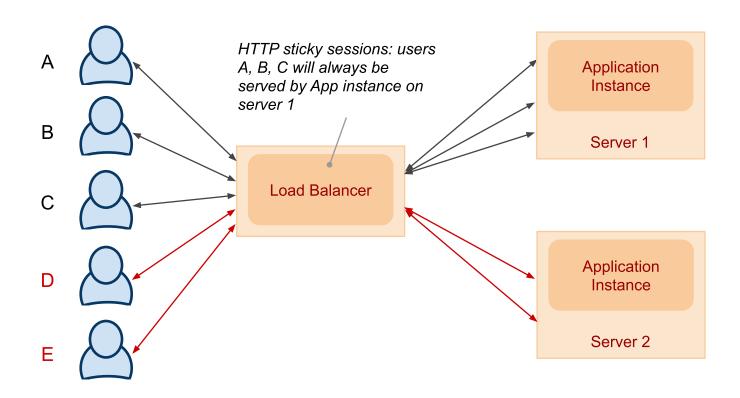
DNS Round Robin

- 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



HTTP Sticky Sessions Example



- 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

/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.
```

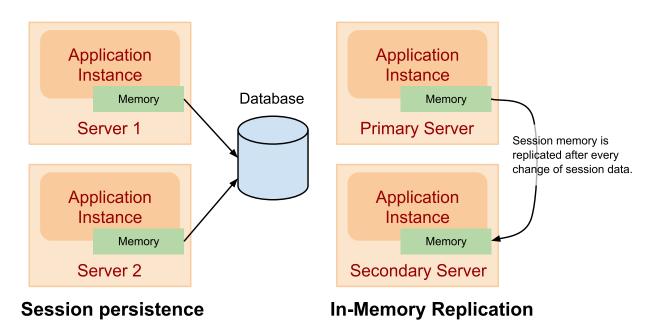
Round Robin Algorithm

- $-\mathit{if}$ 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
 - \rightarrow 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
 - \rightarrow if a number of failed health checks for the server exceeds the unhealthy_threshold
 - → remove the server from the server_list
 - \rightarrow 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 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

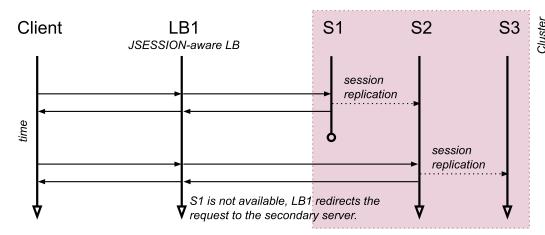
 CREATION_TIME time the session data was created/updated

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

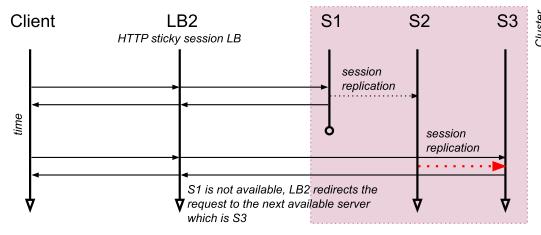
Scenario A: JSession-aware load balancer



S1 is 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 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
 - \rightarrow JNDI Replication
- There are services using persistent RMI connections between cluster members
 - → such as during in-memory replication of HTTP session information

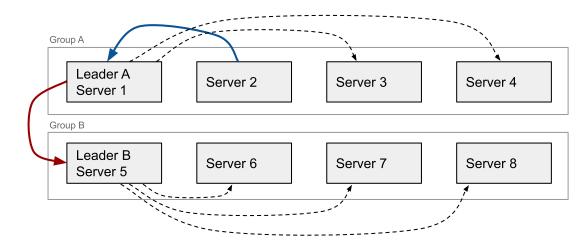
Unicast

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
 - \rightarrow others know it is alive
- Each server receives heartbeat messages
 - → When a server misses a number of messages from a cluster, it removes the server from the list until it receives the next heartbeat message.

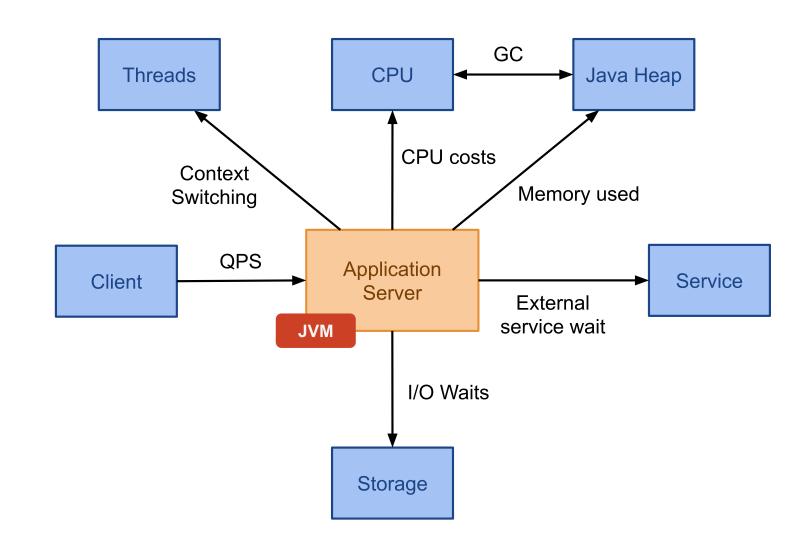
• JNDI Replication

- 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
 - \rightarrow other members remove its JNDI bindings from their three.
- When a server joins the cluster
 - \rightarrow 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
 - $Collect \rightarrow Filter \rightarrow Store \rightarrow View \rightarrow Tune$
 - 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
 - \rightarrow log files (access logs, server logs, etc.)
 - OS
 - \rightarrow many utilities available out of the box
 - → open sockets, memory, context switches, I/O performance, CPU usage
 - Database
 - \rightarrow applications may write metrics to the DB
 - \rightarrow SQL scripts to collect metrics

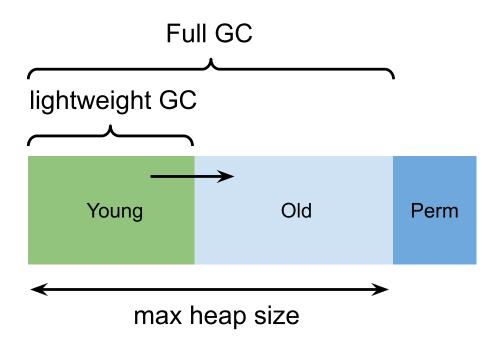
Monitoring Tools

- 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

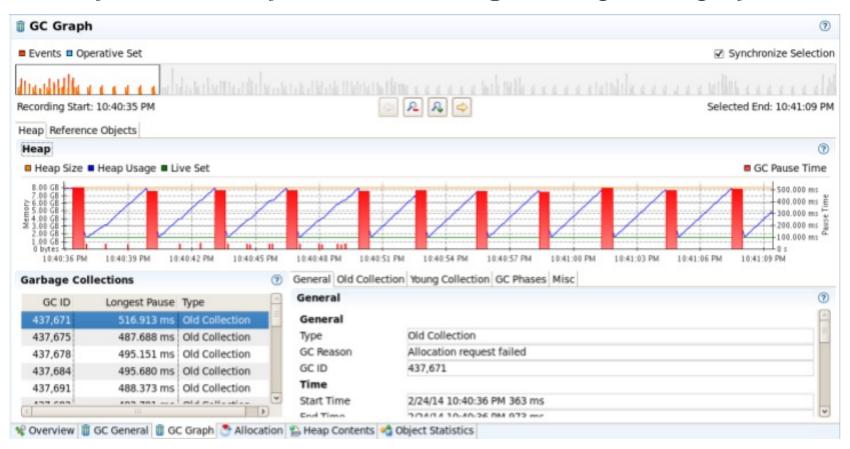
- Young objects get allocated in this space initially
- − Old − objects get promoted to old from young
- Perm space for permanent allocations, e.g. objects describing classes and methods

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 \rightarrow 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 \rightarrow 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

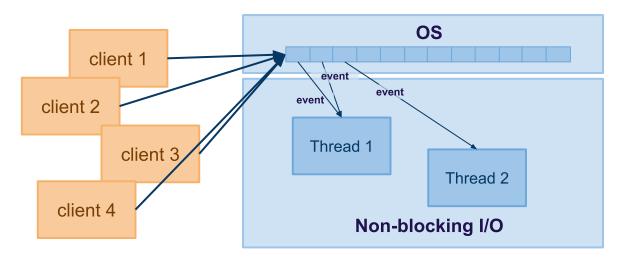


JVM Memory Tuning

- 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 \rightarrow 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*
 - \rightarrow *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