White-paper on Workload Management available for download:
http://www.pythian.com/library/papers_and_books/rac_workload/

Demystifying Oracle RAC Workload Management

North California Oracle User Group
20-May-2010
Alex Gorbachev

Pythian
love your data

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ORACLE RACSIG

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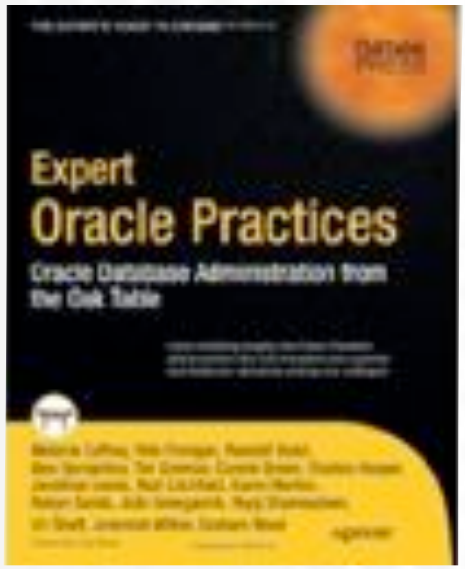
- Blogger
- OakTable Network member
- Oracle ACE Director
- BattleAgainstAnyGuess.com
- Vice-president, Oracle RAC SIG

Sydney ORACLE Meetup



Oracle ACE

OakTable.net

Why Companies Trust Pythian

- Recognized Leader:
  - Global industry-leader in remote database administration services and consulting for Oracle, Oracle Applications, MySQL and SQL Server
  - Work with over 150 multinational companies such as Forbes.com, Fox Interactive media, and MDS Inc. to help manage their complex IT deployments
- Expertise:
  - One of the world's largest concentrations of dedicated, full-time DBA expertise.
- Global Reach & Scalability:
  - 24/7/365 global remote support for DBA and consulting, systems administration, special projects or emergency response

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FOX SPORTS

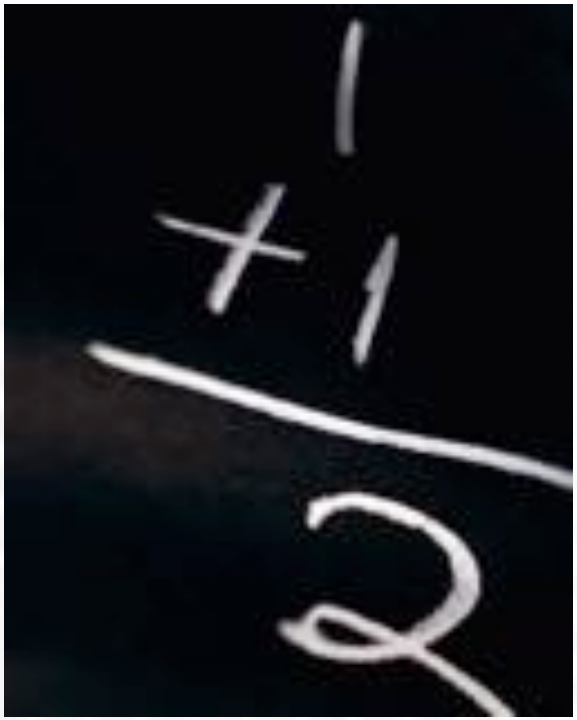
MySQL Enterprise Authorized Platinum REMOTE DBA SERVICES PARTNER

Where we are...

➡Client-side basics

- Oracle Cluster Services
- Server-side CLB
- FAN - HA & LBA events
- Thin JDBC RLB
- ONS Subscriber
- Your own LBA!

Simple example



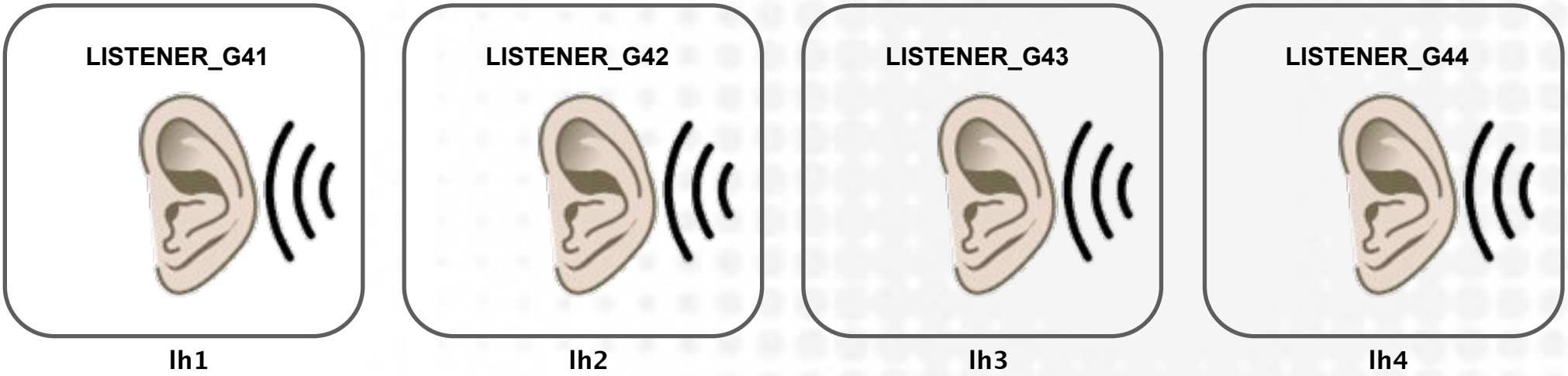
- Establishing one connection
- Dedicated server
- Several RAC nodes

Client-side CLB

```
(DESCRIPTION=
  (ADDRESS_LIST=
    (LOAD_BALANCE=ON)  (FAILOVER=ON)
    (ADDRESS=(PROTOCOL=TCP)(HOST=lh1-vip)(PORT=1521))
    (ADDRESS=(PROTOCOL=TCP)(HOST=lh2-vip)(PORT=1521))
    (ADDRESS=(PROTOCOL=TCP)(HOST=lh3-vip)(PORT=1521))
    (ADDRESS=(PROTOCOL=TCP)(HOST=lh4-vip)(PORT=1521))
   )
     (CONNECT_DATA=(SERVICE_NAME=service10g))
   )
```

Client-side connection balancing and connection-time failover

```
lh1-vip
lh2-vip
lh3-vip
lh4-vip
```



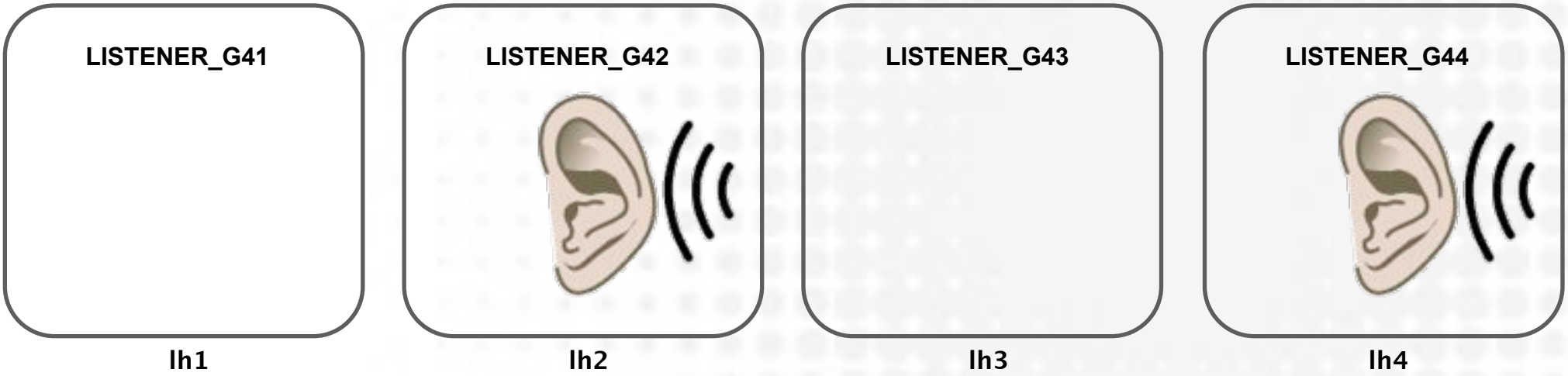
Client-side connection balancing and connection-time failover

```
lh1-vip
lh2-vip
lh3-vip
lh4-vip
```

Client-side connection balancing and connection-time failover

```
LOAD_BALANCE=OFF
FAILOVER=OFF
```

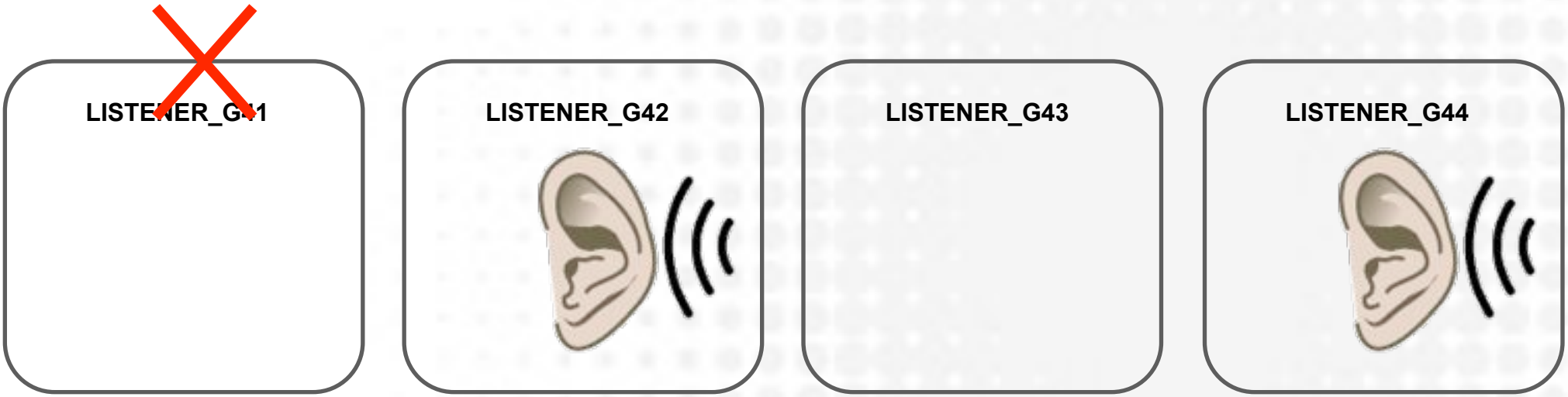
```
lh1-vip
lh2-vip
lh3-vip
lh4-vip
```



Client-side connection balancing and connection-time failover

```
LOAD_BALANCE=OFF
FAILOVER=OFF
```

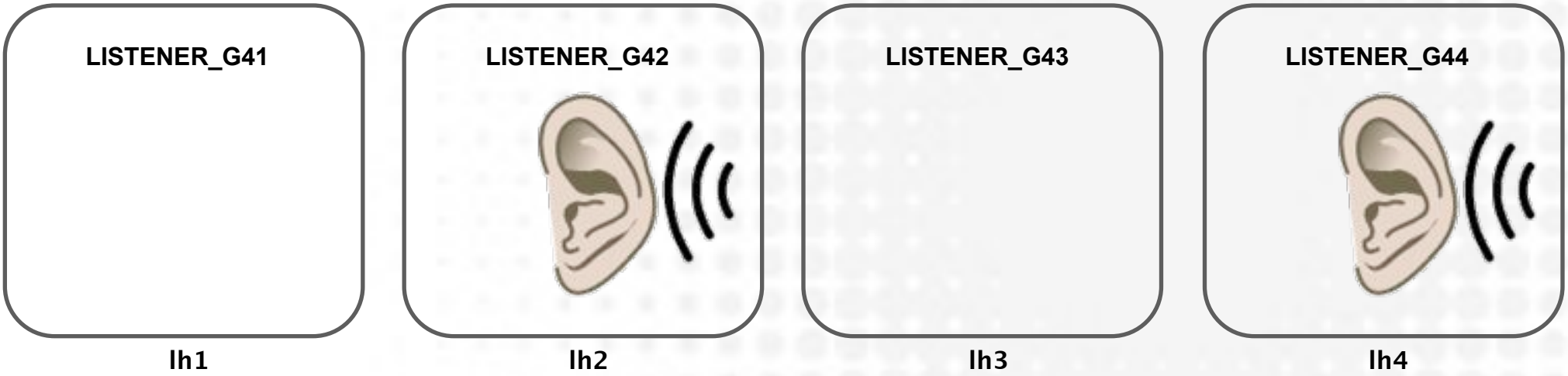
```
lh1-vip
lh2-vip
lh3-vip
lh4-vip
```



Client-side connection balancing and connection-time failover

```
LOAD_BALANCE=OFF
FAILOVER=ON
```

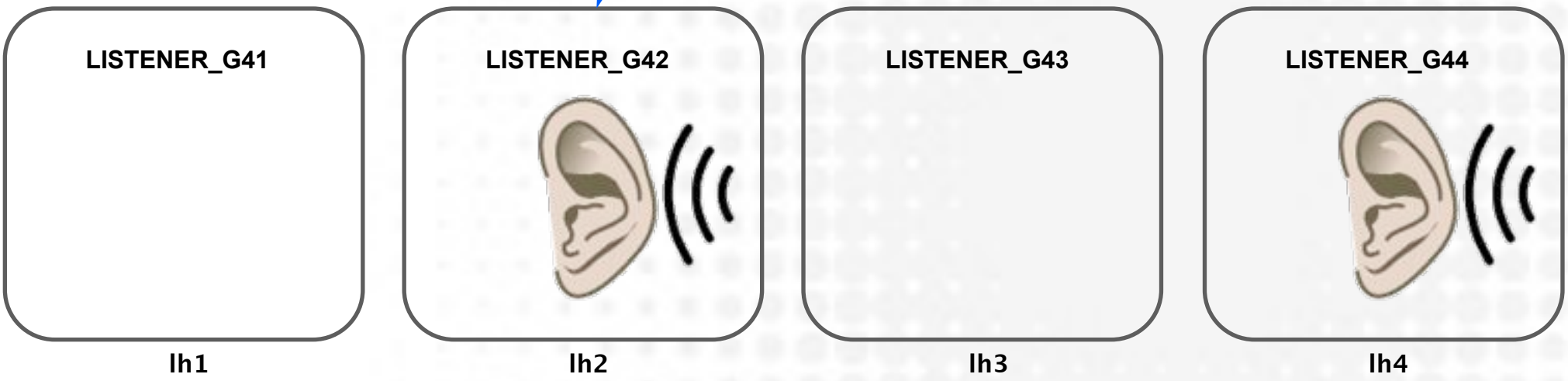
```
lh1-vip
lh2-vip
lh3-vip
lh4-vip
```



Client-side connection balancing and connection-time failover

```
lh1-vip
lh2-vip
lh3-vip
lh4-vip
```

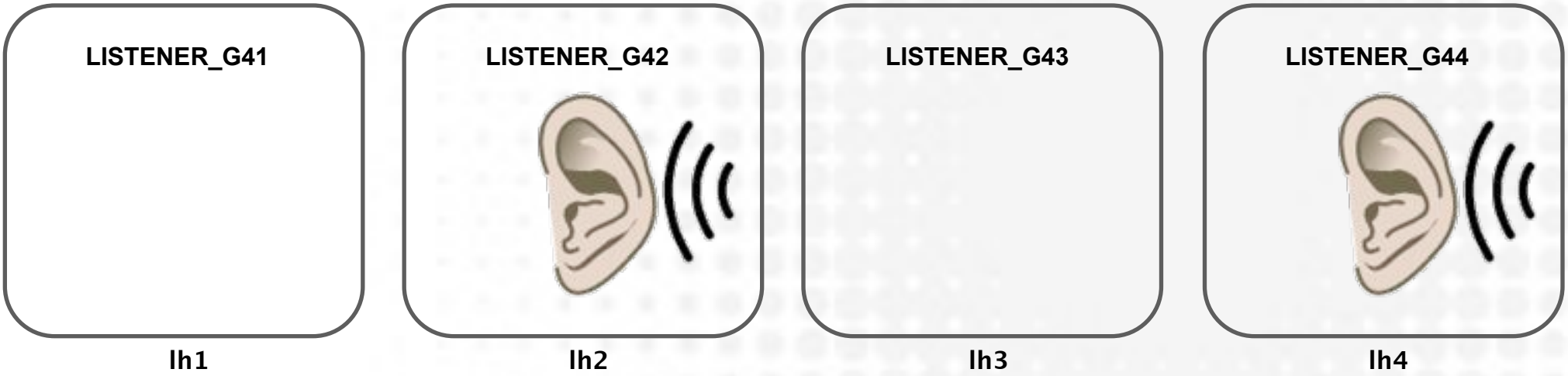
```
LOAD_BALANCE=OFF
FAILOVER=ON
```



Client-side connection balancing and connection-time failover

```
lh1-vip
lh2-vip
lh3-vip
lh4-vip
```

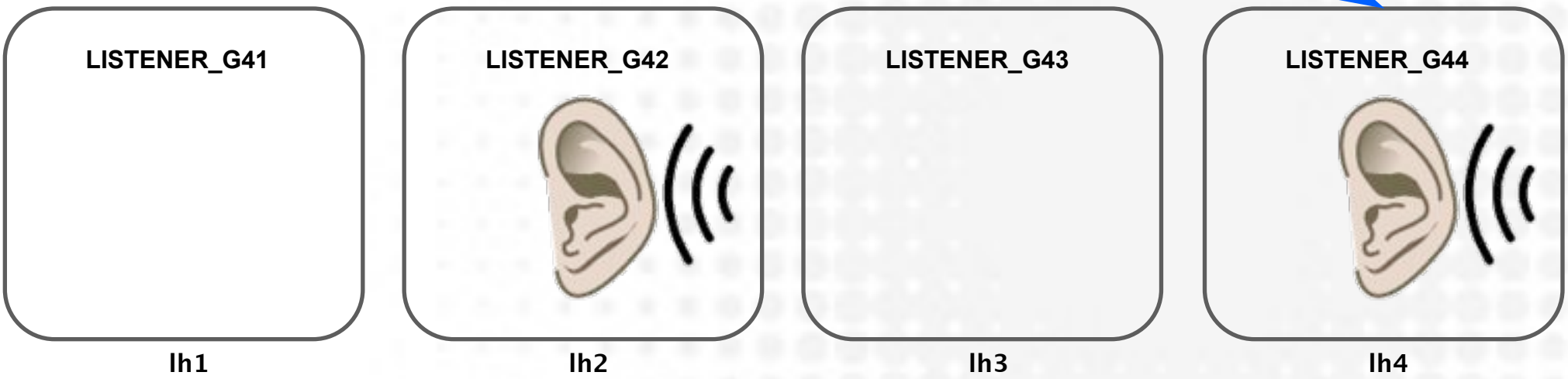
```
LOAD_BALANCE=ON
FAILOVER=ON
```



Client-side connection balancing and connection-time failover

```
lh1-vip
lh2-vip
lh3-vip
lh4-vip
```

```
LOAD_BALANCE=ON
FAILOVER=ON
```



Summary – client-side business

- Client chooses between several addresses
- Why
  - Failure tolerance
  - Distribution across several listeners
- How
  - Several connection points in connection descriptor
  - LOAD_BALANCE=ON
  - FAILOVER=ON

Listener – where to direct request?

lsnrctl status

……

```
Service "service10g" has 2 instance(s).
  Instance "g41", status READY, has 1 handler(s) for this service...
  Instance "g42", status READY, has 1 handler(s) for this service...
```

……

Where we are...

✓Client-side basics

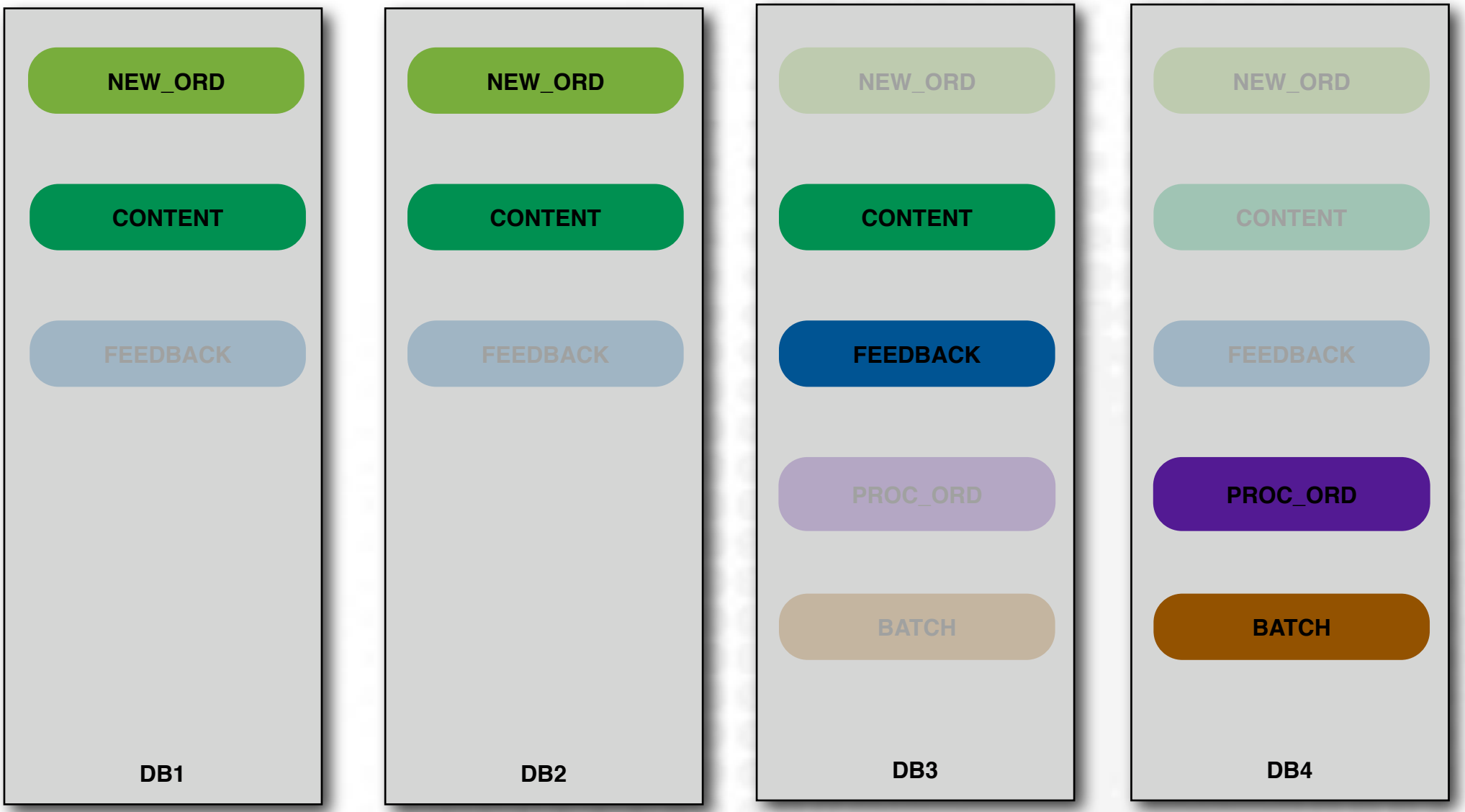
➡Oracle Cluster Services

- Server-side CLB
- FAN - HA & LBA events
- Thin JDBC RLB
- ONS Subscriber
- Your own LBA!

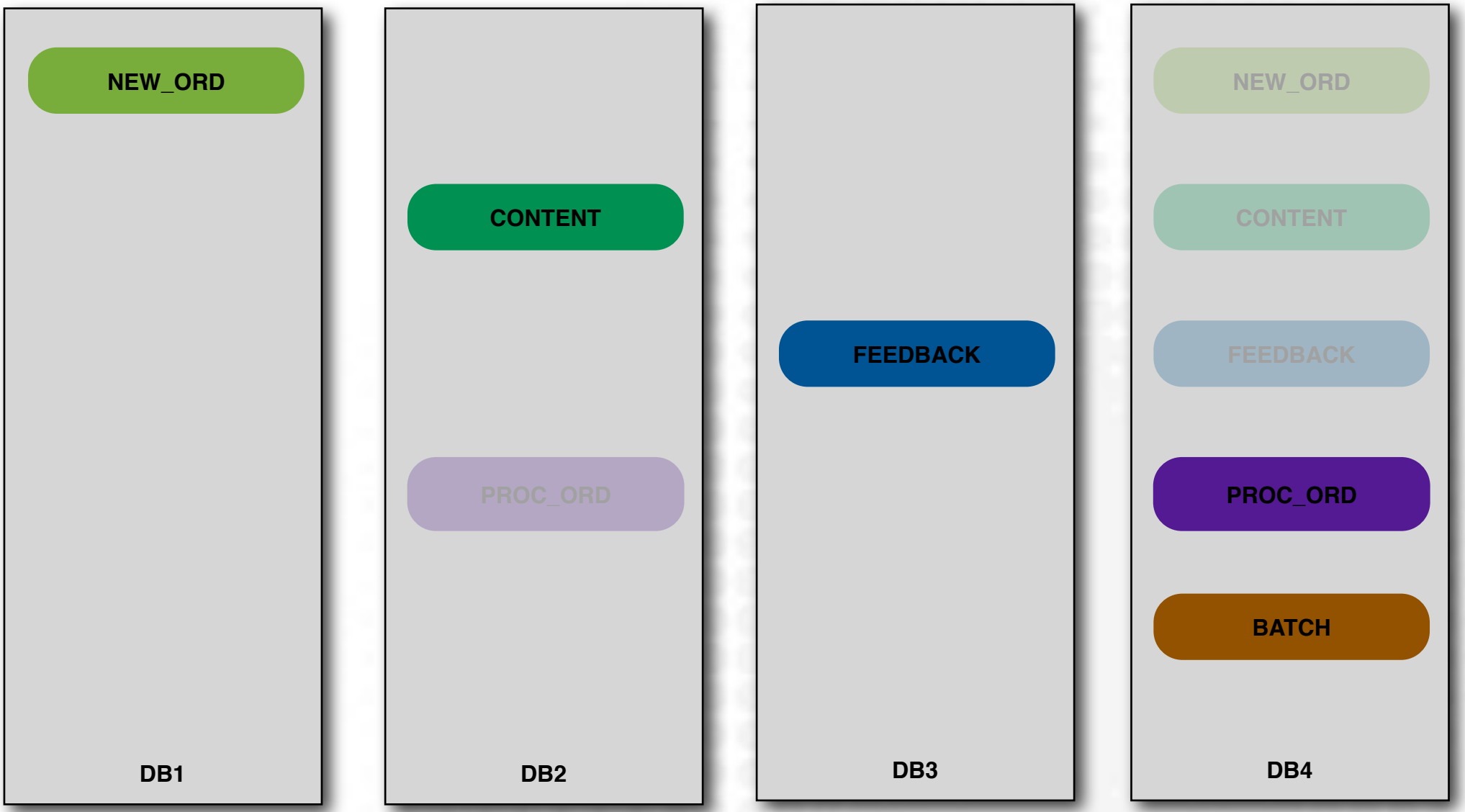
Orders processing example

- Business areas
  - Customers' order (web)
  - Content display (web cached on app-tier)
  - Feedback (web)
  - Orders fulfillment (back-office)
  - Data extraction batches

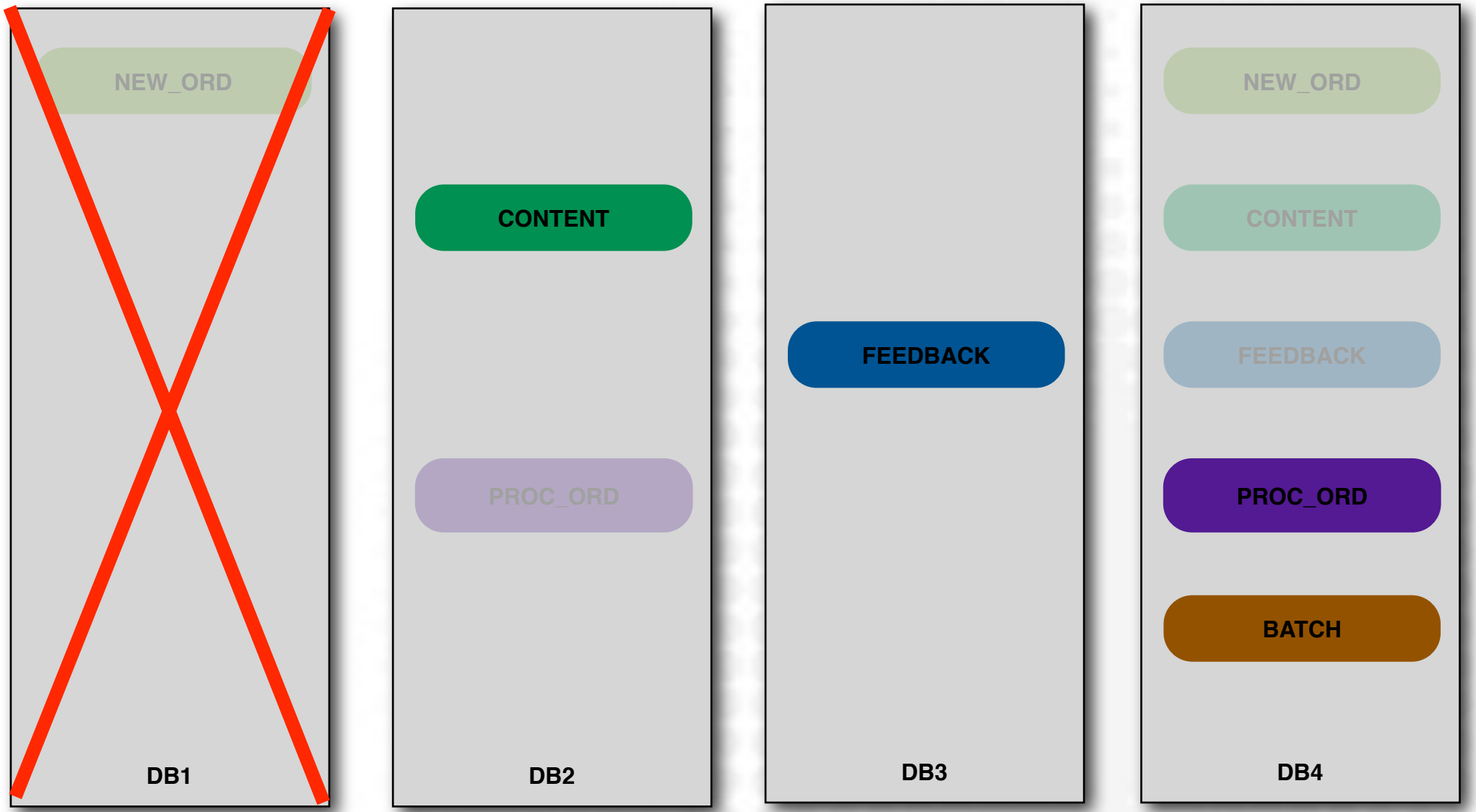
Services: preferred & available



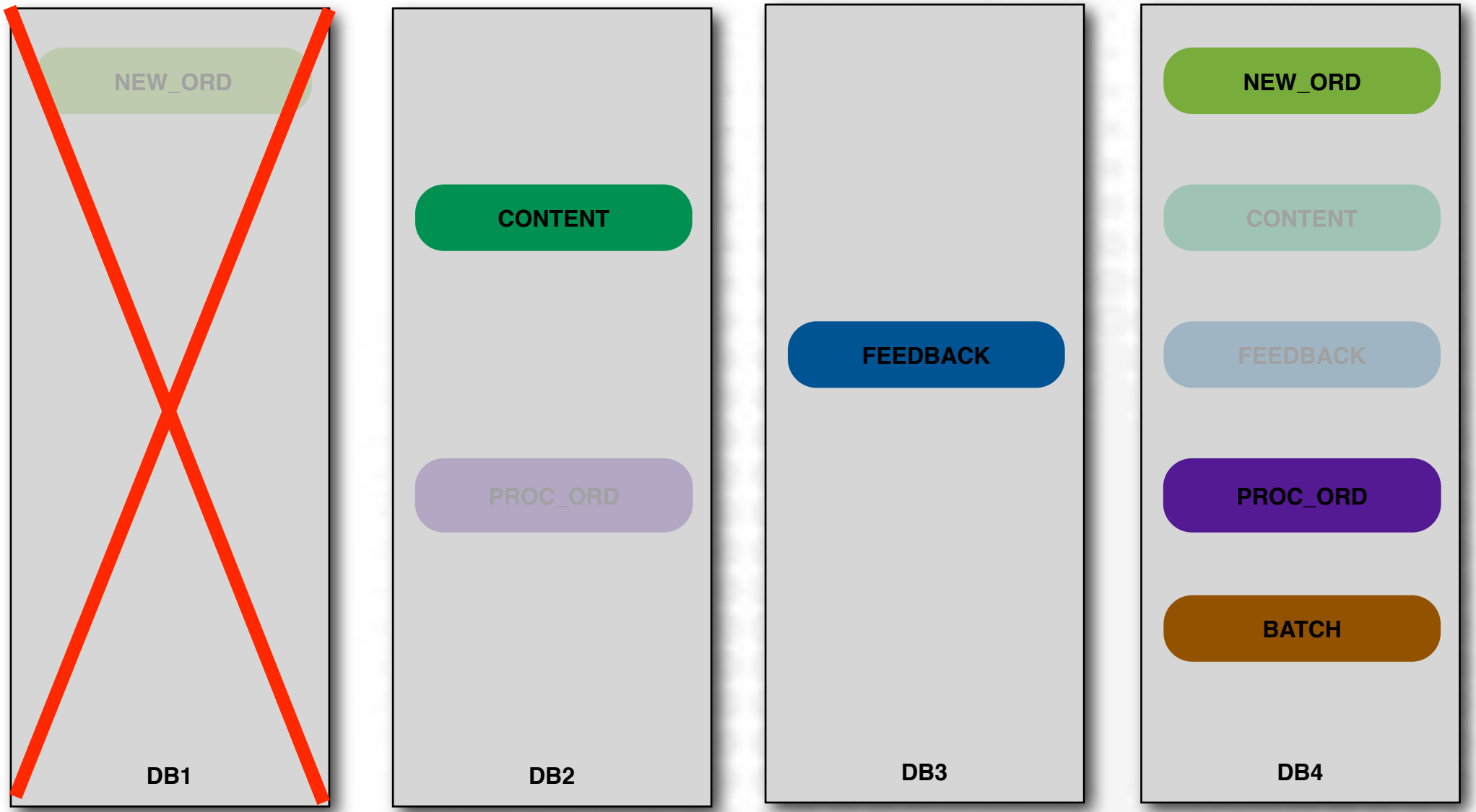
Node affinity



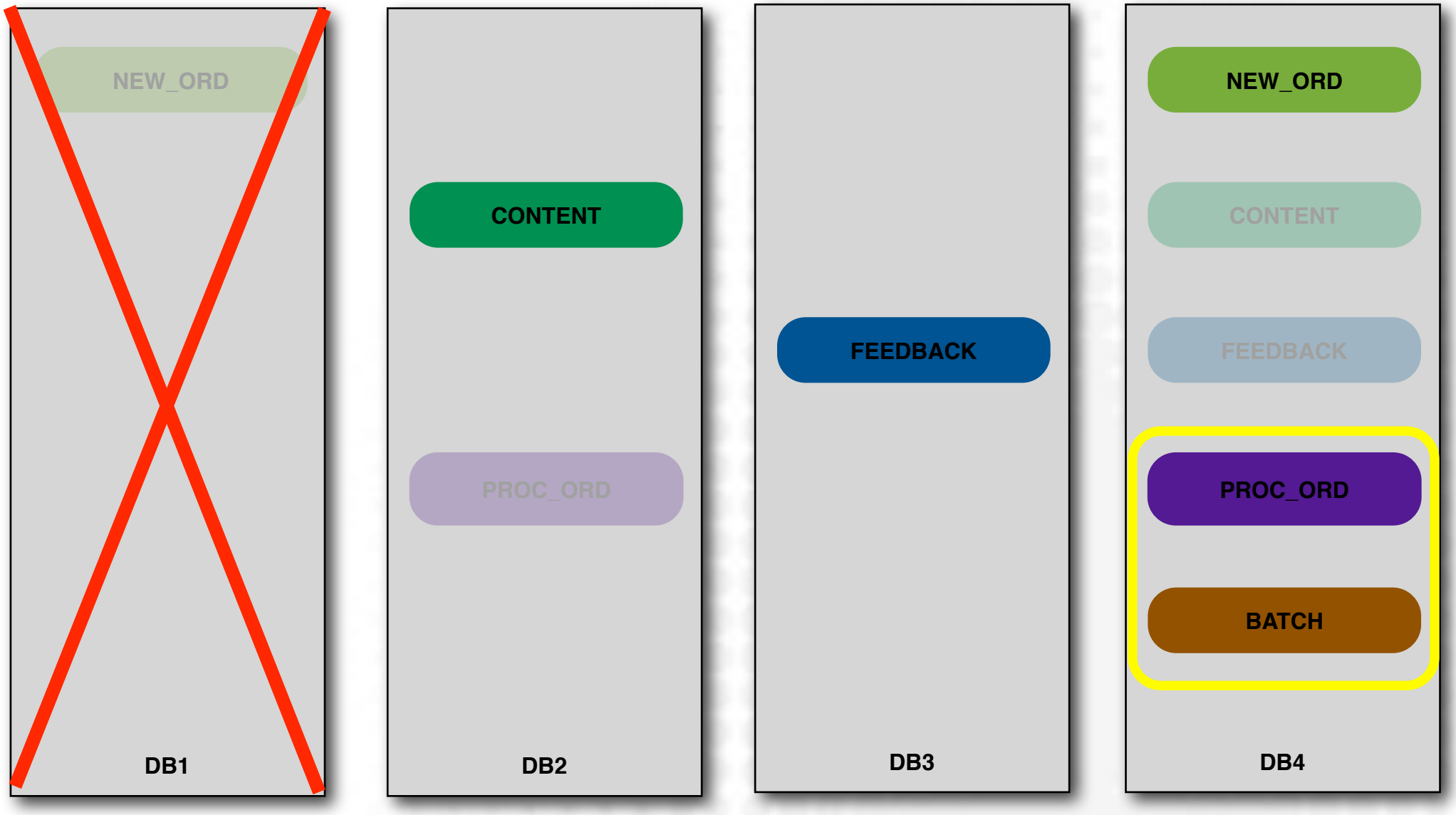
Service failover



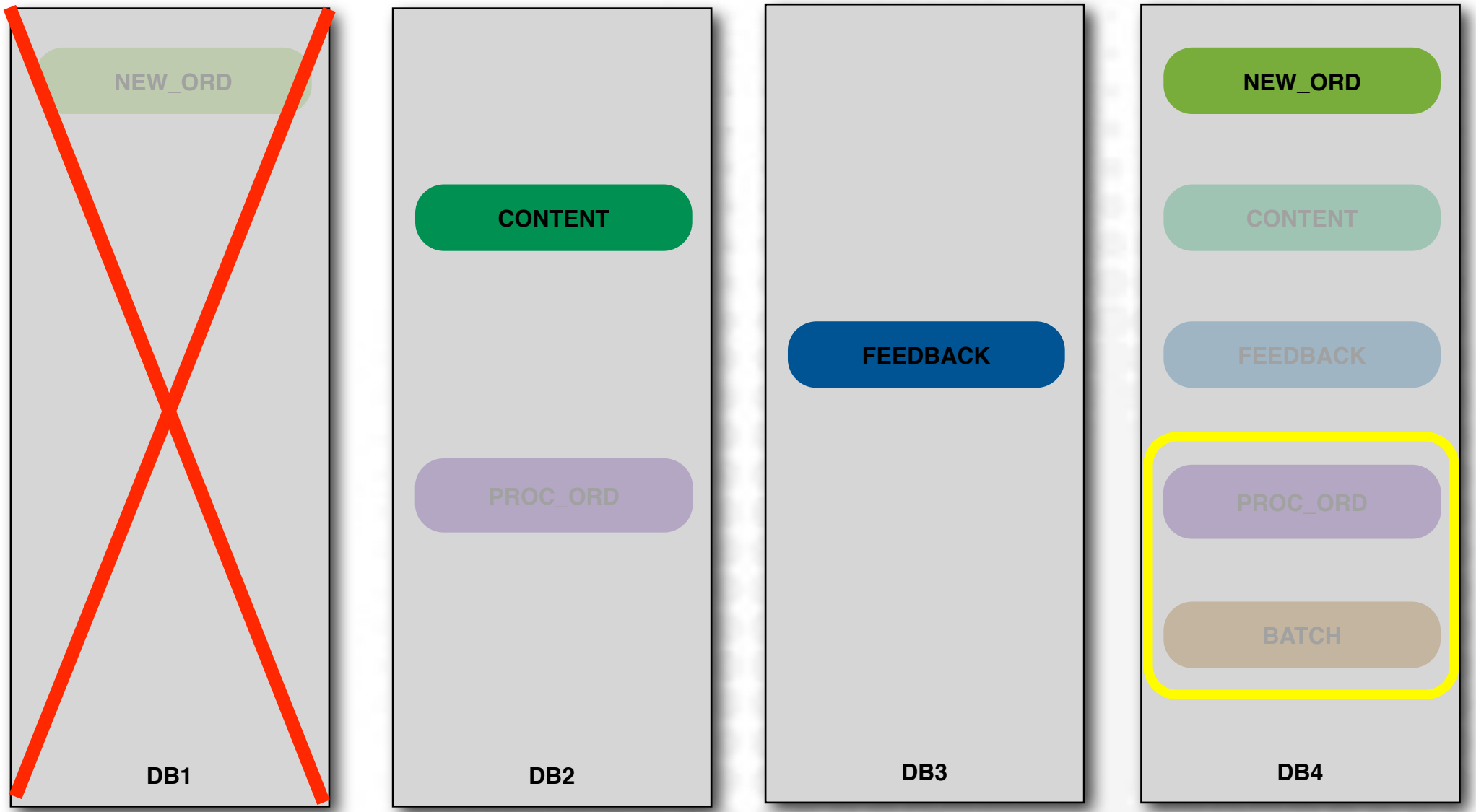
Service failover



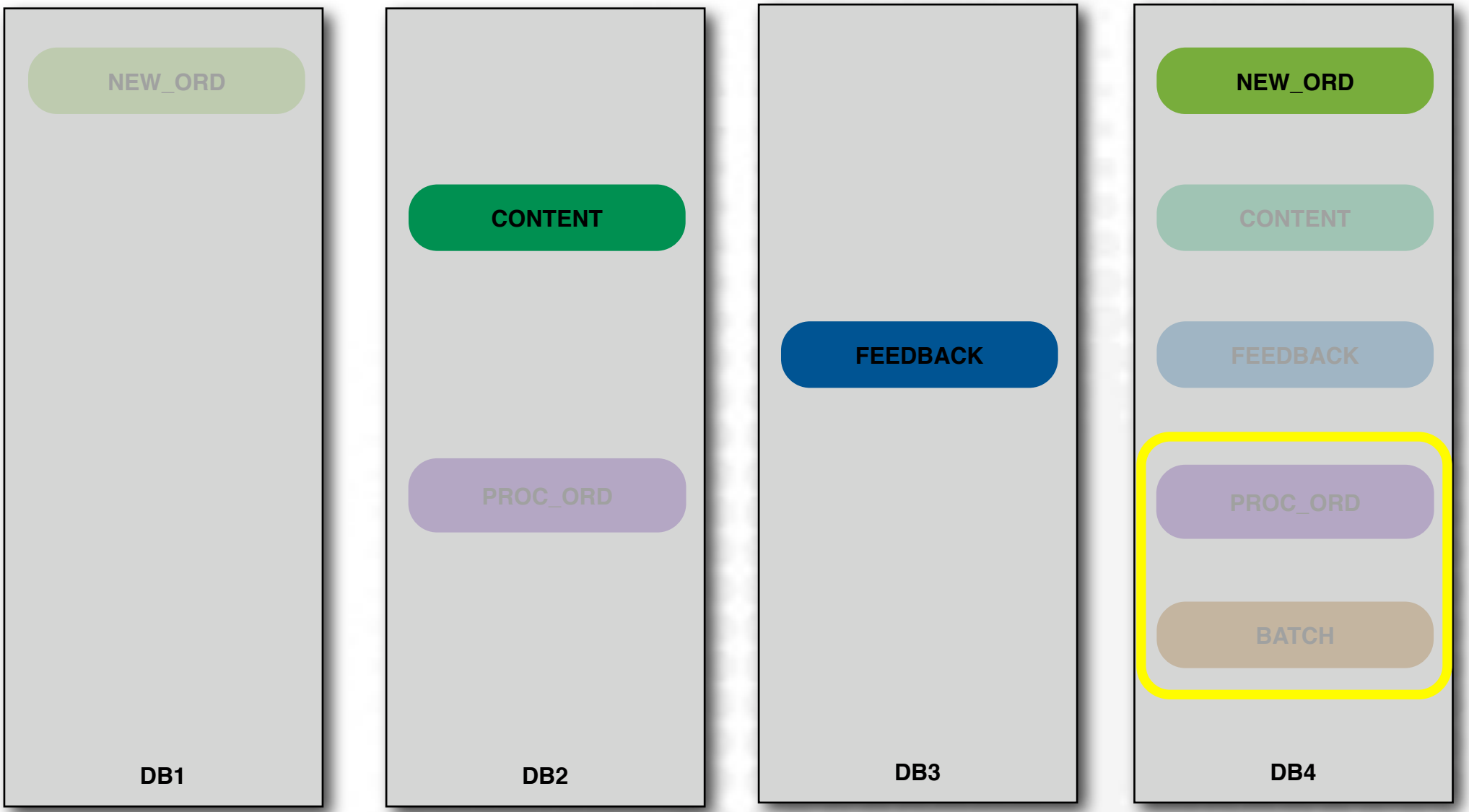
Service failover



Service failover



Service failover



Demo 1 - Services Automation

- HA events introduction
- Logging example
- Using server-side FAN HA events callout

Server-side FAN HA events

- Server-side callout can be used for:
  - Relocating services back to preferred nodes
  - Smart services handling
  - Notify and move sessions after service Down
  - Rebalance sessions on service up
  - Accommodate workload re-balancing for ***legacy applications***

Services & Resource Manager

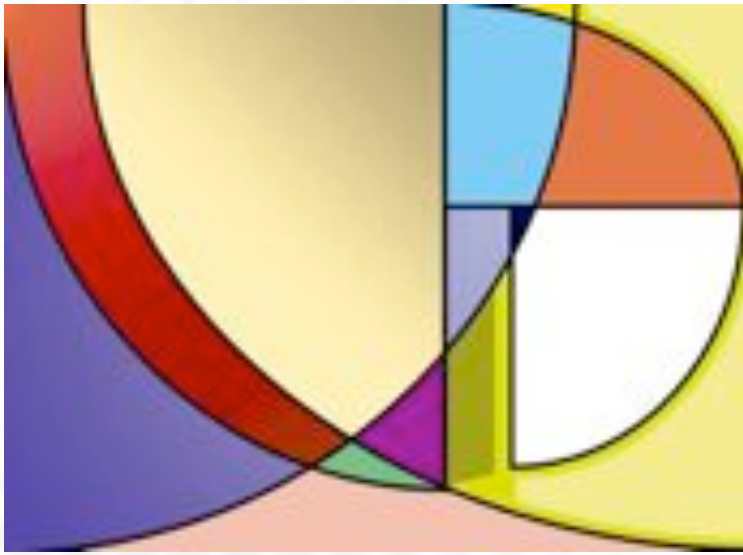
```
DBMS_RESOURCE_MANAGER.SET_CONSUMER_GROUP_MAPPING
    (DBMS_RESOURCE_MANAGER.SERVICE_NAME,
     'NEW_ORD', 'NEW_ORD_GROUP');

DBMS_RESOURCE_MANAGER.SET_CONSUMER_GROUP_MAPPING
    (DBMS_RESOURCE_MANAGER.SERVICE_NAME,
     'CONTENT', 'CONTENT_GROUP');

...
```

- Works on instance level – not RAC-aware
- Doesn't account for >1 instances per node

Services abstraction for apps



- Applications don’t need to know current services configuration!
- Listeners know services status
  - Listeners control which instance gets a new connection

Where we are...

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✓Oracle Cluster Services

➡Server-side CLB

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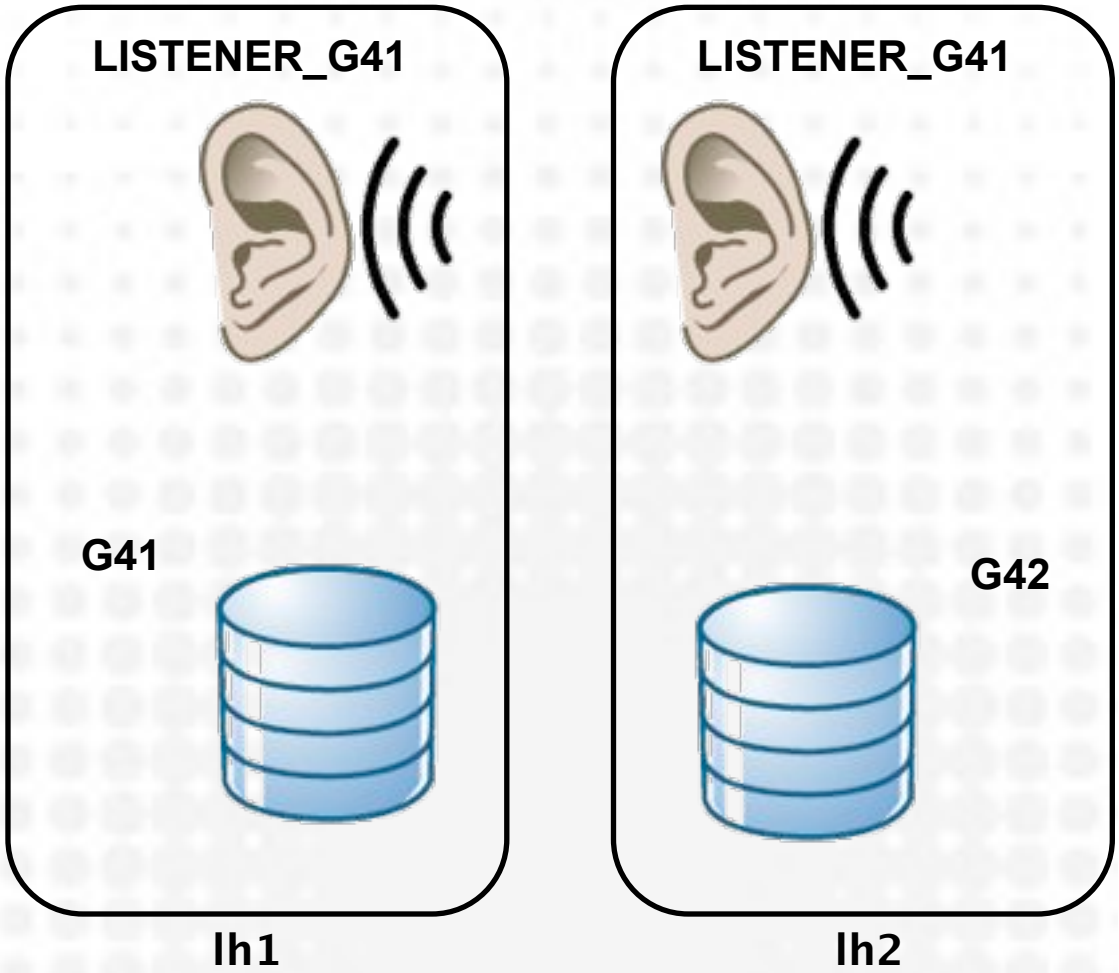
- Your own LBA!

Remote listener registration



Remote listener registration

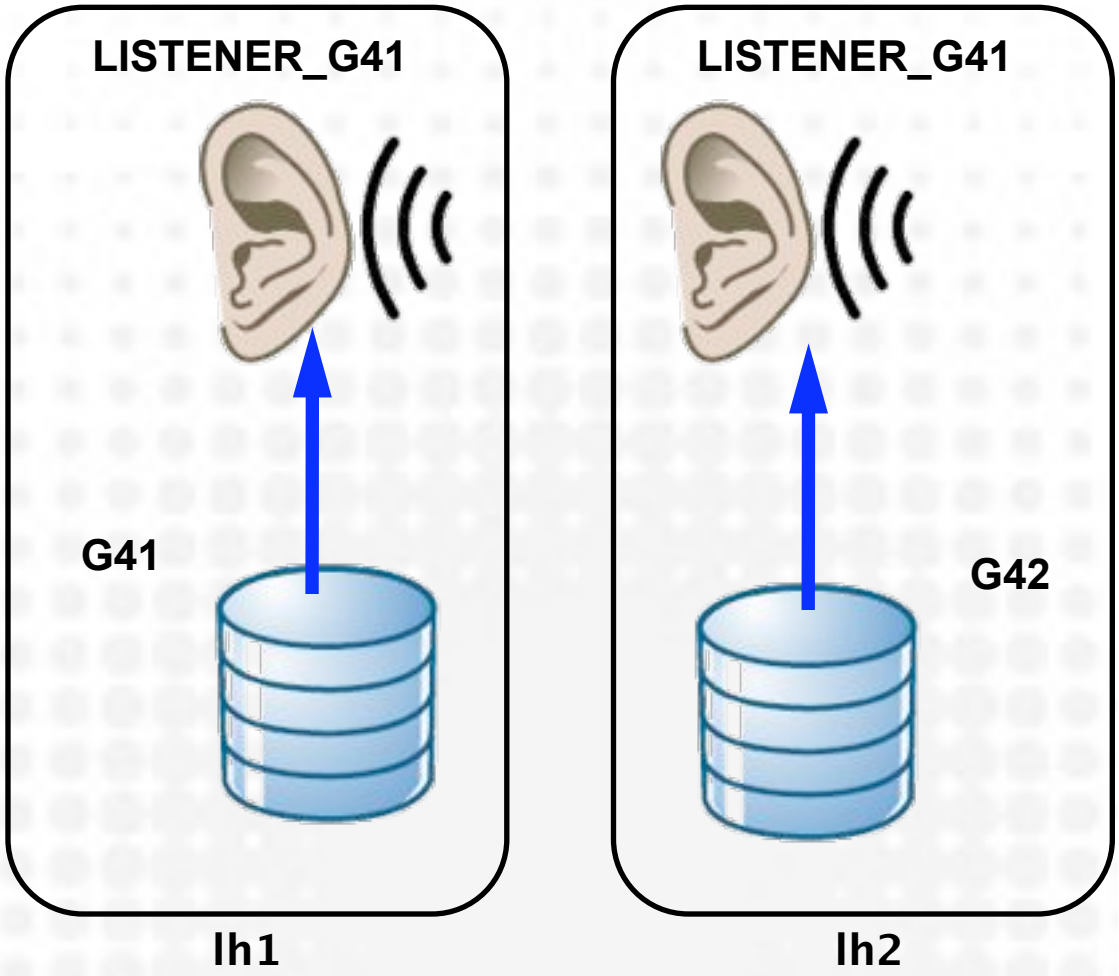
Local registration

```
G41.local_listener=LISTENER_G41

G42.local_listener=LISTENER_G42

G43.local_listener=LISTENER_G43

G44.local_listener=LISTENER_G44
```



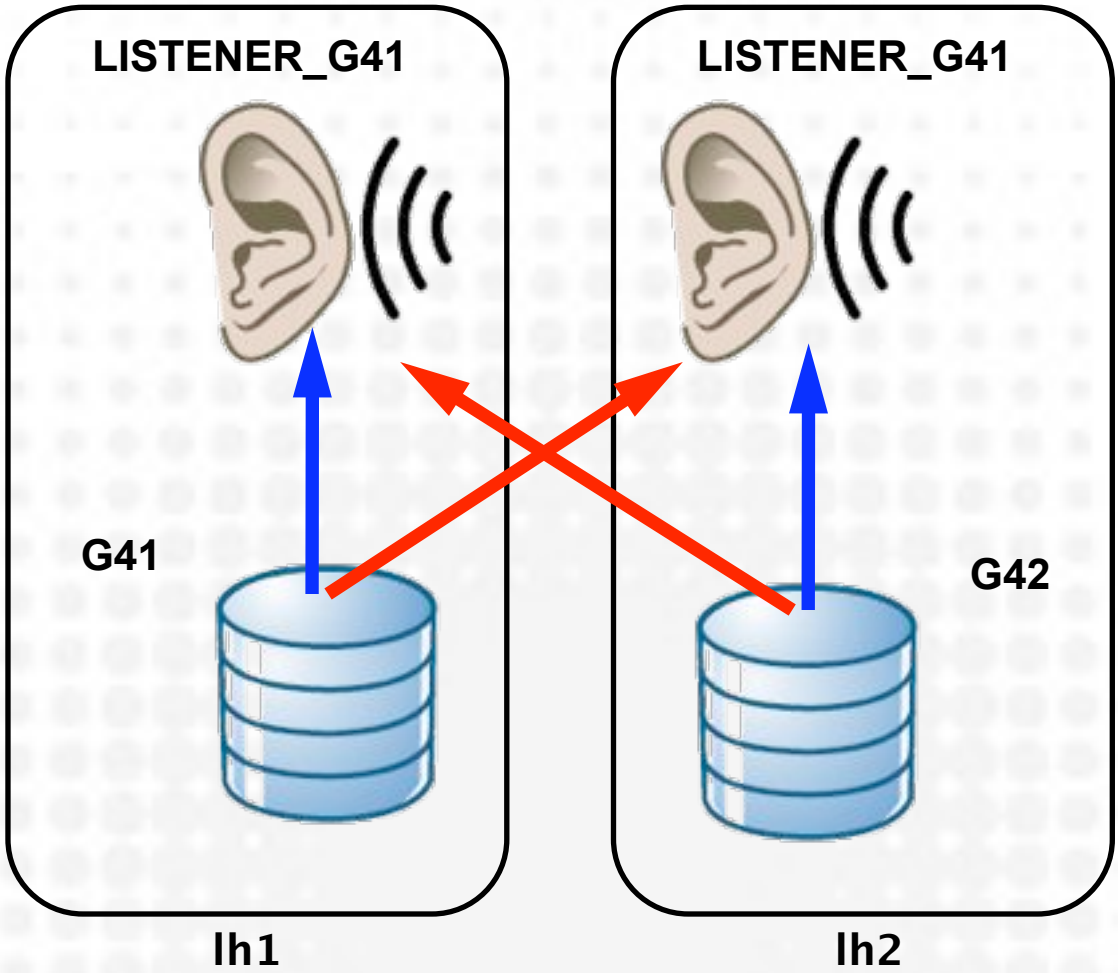
Remote listener registration

Local registration

```
G41.local_listener=LISTENER_G41
G42.local_listener=LISTENER_G42
G43.local_listener=LISTENER_G43
G44.local_listener=LISTENER_G44
```

Remote registration

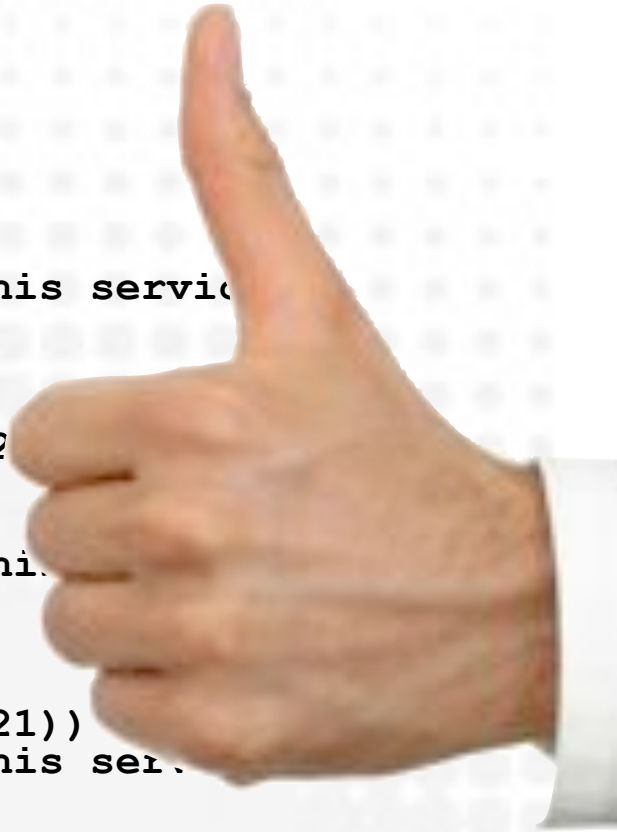
```
*.remote_listener=LISTENERS_G4
```



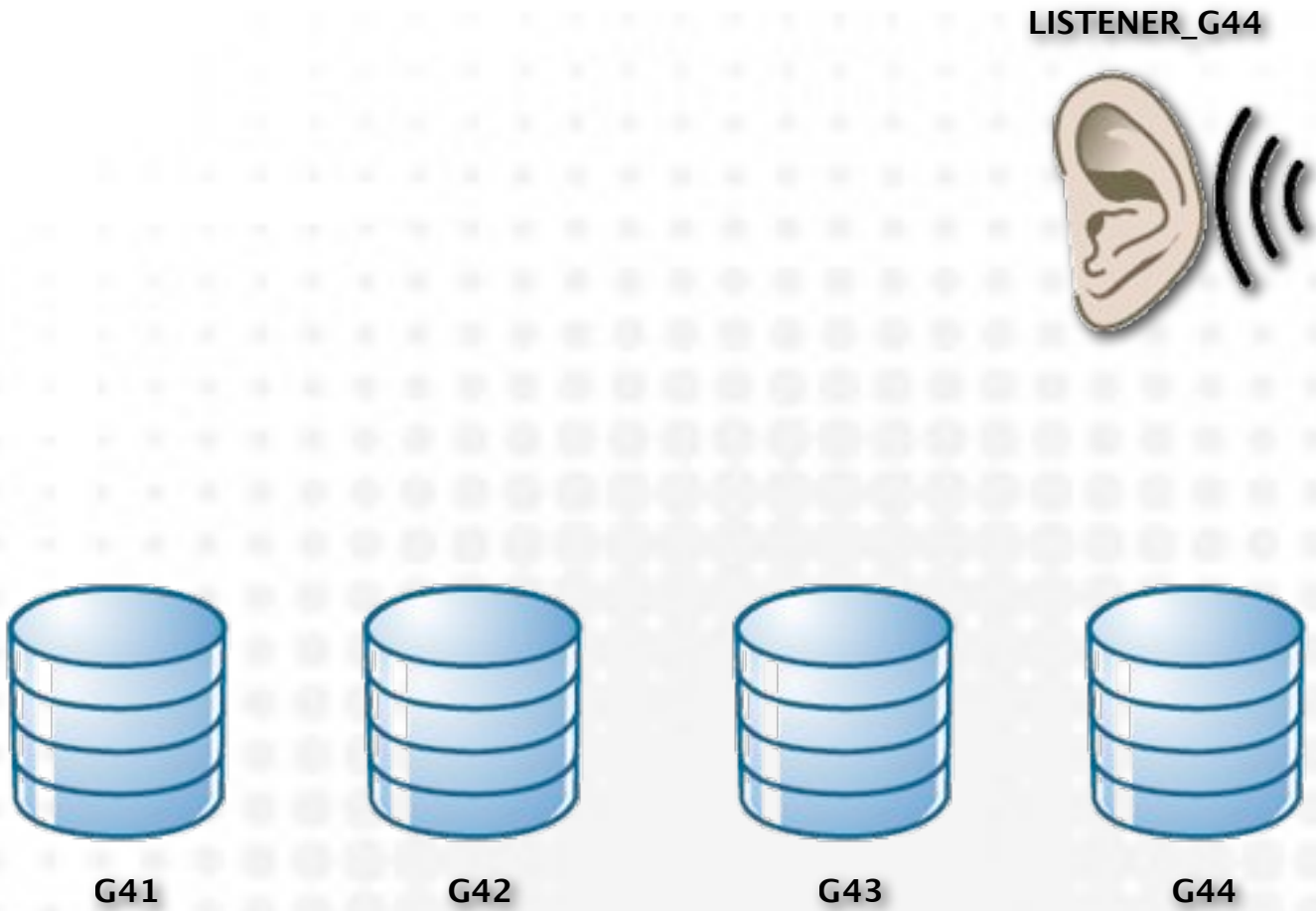
Correct listener configuration
(google for Pythian video VIP)

lsnrctl service

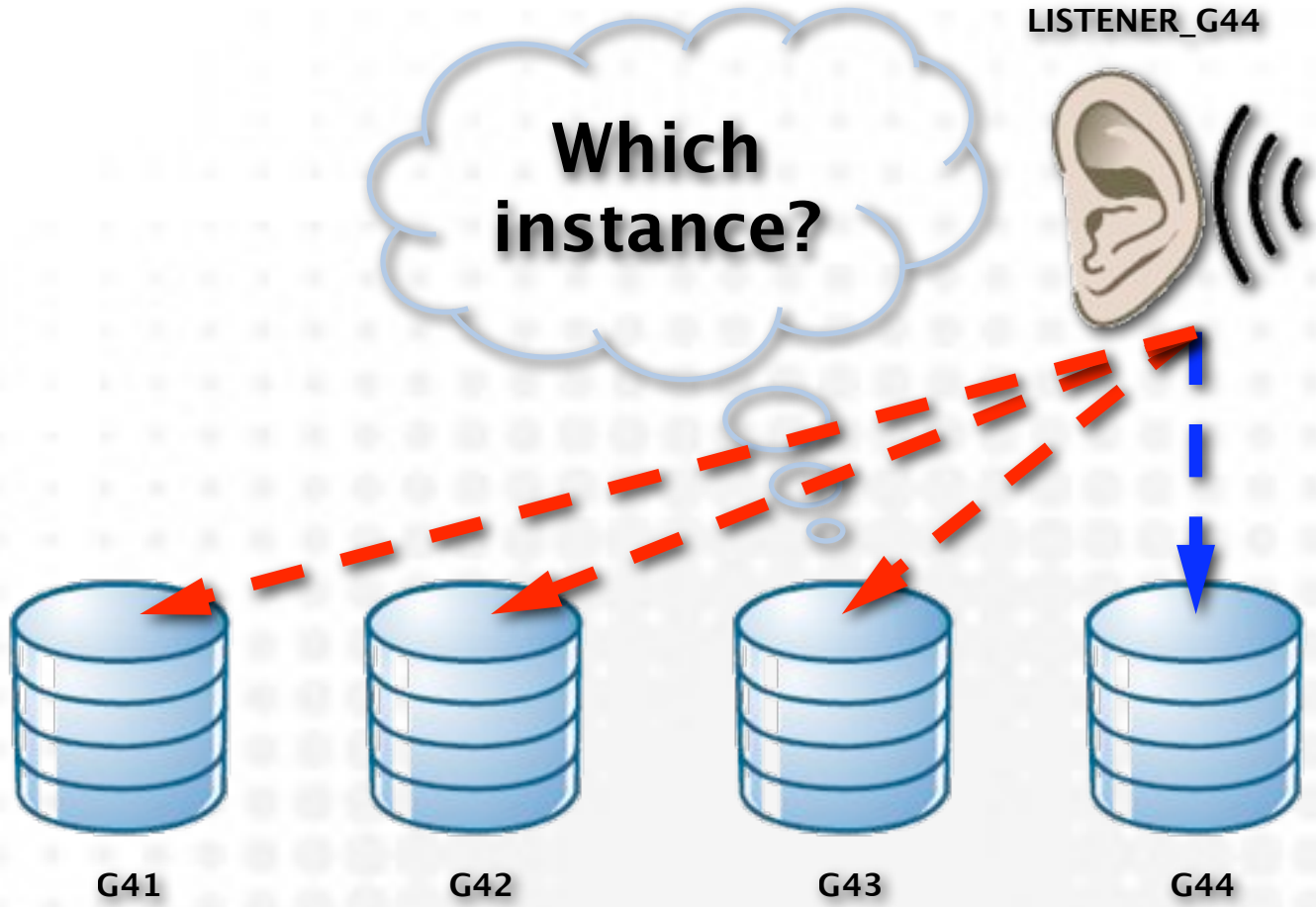
```
Service "service10g.oracloid.com" has 2 instance(s).
  Instance "g41", status READY, has 1 handler(s) for this servic
    Handler(s):
     "DEDICATED" established:0 refused:0 state:ready
         REMOTE SERVER
         (ADDRESS=(PROTOCOL=TCP)(HOST=lh1-vip)(PORT=152
      "DEDICATED" established:0 refused:0 state:ready
         LOCAL SERVER
  Instance "g42", status READY, has 1 handler(s) for thi
    Handler(s):
      "DEDICATED" established:0 refused:0 state:ready
         REMOTE SERVER
         (ADDRESS=(PROTOCOL=TCP)(HOST=lh2-vip)(PORT=1521))
  Instance "g43", status READY, has 1 handler(s) for this ser
    Handler(s):
      "DEDICATED" established:0 refused:0 state:ready
         REMOTE SERVER
         (ADDRESS=(PROTOCOL=TCP)(HOST=lh3-vip)(PORT=1521))
  Instance "g44", status READY, has 1 handler(s) for this
...
```



Server-side CLB

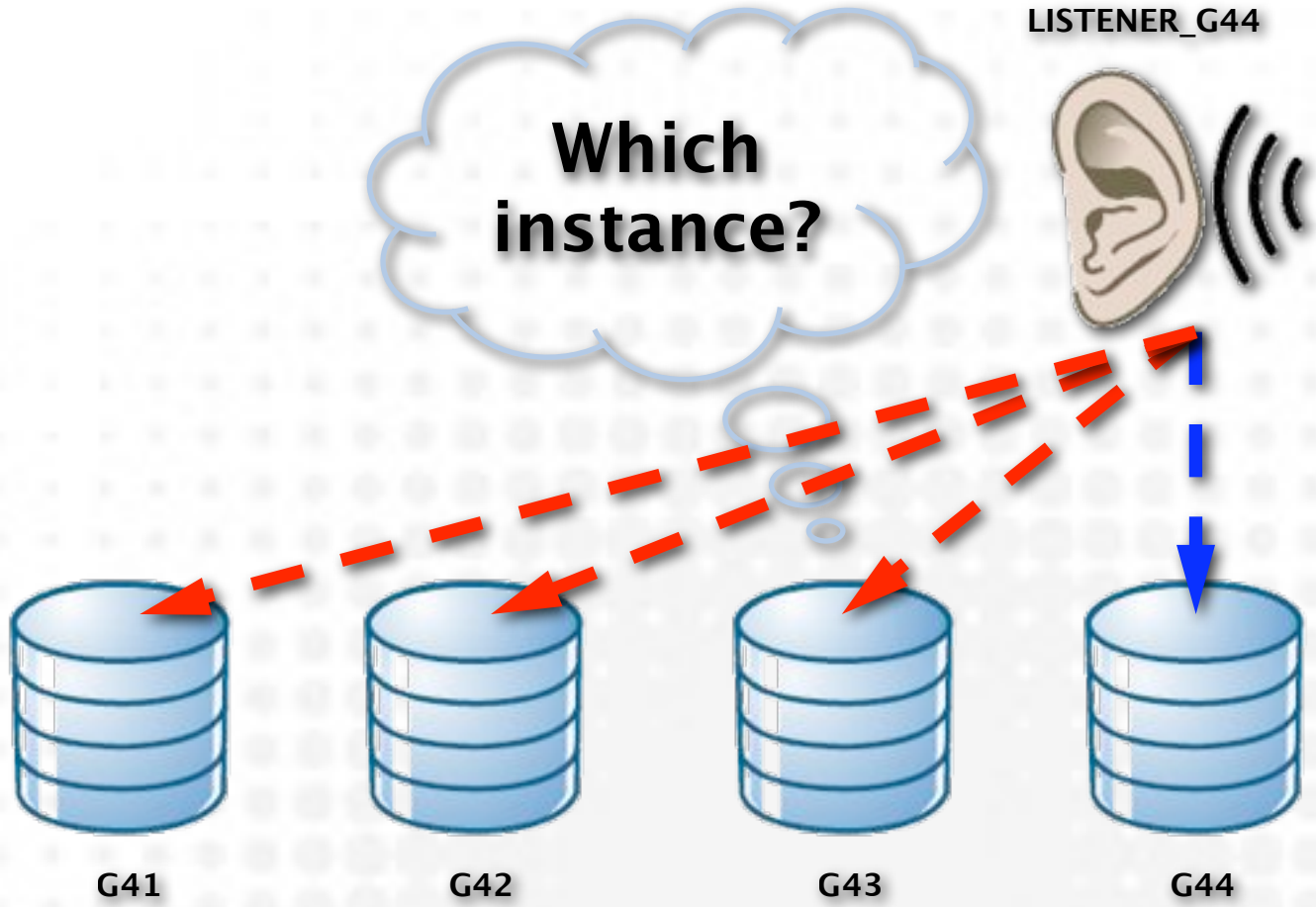


Server-side CLB



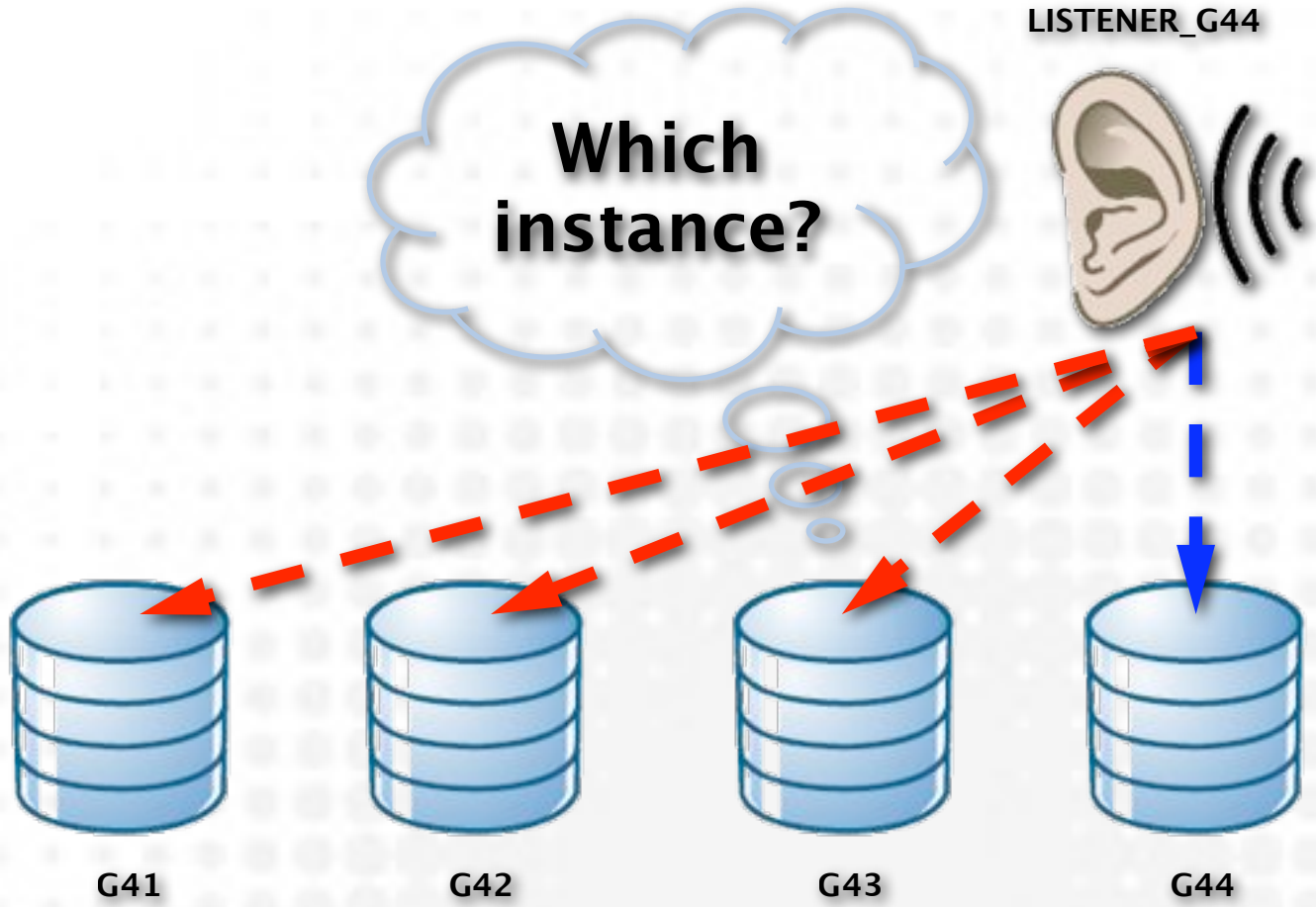
Server-side CLB

- <= 10gR1
  - Instance load
  - Node load



Server-side CLB

- <= 10gR1
  - Instance load
  - Node load
- 10gR2
  - Service Metrics
  - AWR



Demo helper
Tracing listener

lsnrctl trace **user**

```
nsglgrDoRegister: inst loads: ld1:145 mld1:5120 ld2:5 mld2:170
nsglgrDoRegister: inst loads: ld1:58 mld1:5120 ld2:4 mld2:170
```

- **No notion of instance name in trace ☹**

- **ld1 – Load Data 1, mld1 – Max Load Data 1**
- **ld2 – Load Data 2, mld2 – Max Load Data 2**
- **Load data is instance load and node load**

Demo helper

PREFER_LEAST_LOADED_NODE

- listener.ora parameter
  - PREFER_LEAST_LOADED_NODE_%
- ON (default)
  - ld1 => node, ld2 = > instance
- OFF
  - ld1 => instance, ld1 => node

Demo helper
Instance and node loads

- Instance load
  - Number of user sessions
  - TYPE<>BACKGROUND
- Max instance load
  - Max number of sessions
  - SESSIONS init.ora
- Node load
  - Index based probably on load average
- Max node load
  - Max CPU capacity
  - cpu_count*5K

Demo helper
Uneven connection distribution

- PREFER_LEAST_LOADED_NODE_...=ON
  - Default
- Listener uses CPU load to balance connections to the machine with more CPU capacity left
- Can work fine with differently sized nodes
- But what if connections are “permanent”?

Demo helper
"Even" connection distribution

```
PREFER_LEAST_LOADED_NODE_LISTENER_G41=OFF

PREFER_LEAST_LOADED_NODE_LISTENER_G42=OFF
```

- Load based on number of sessions left until maximum is reaches
  - init.ora parameter SESSIONS
- Can configure SESSIONS differently for every node and influence distribution

Demo 3 - 9i style CLB

- listener trace
- PREFER_LEAST_LOADED_NODE
  - instance load
  - node load
- PMON trace 10257 event

9i and 10gR1 CLB summary

- PMON reports to listener
  - instance load
  - node load
- PREFER_LEAST_LOADED_NODE
  - ON - node load (*default*)
  - OFF - instance load
- *lsnrctl trace user*
- PMON: *10257 trace name context forever, level 16*

DB_DOMAIN and bug 5593693

- db_domain init.ora parameter is set
- service_name is not FQDN
  - that's what srvctl does
- Listener appends default domain
- Service metrics updates are lost
  - on the way from PMON => listener
- Result: fallback to instance / node load
- Fixed - 10.2.0.4 & 11.1.0.6

10gR2 and 11g server-side CLB

- Service metrics for each service
- GOODNESS
  - Attractiveness of the instance for this service
  - Higher is worse (should be BADNESS)
- DELTA
  - Estimate of “badness” increase for additional session
- FLAGS (bit map)
  - 0 – all good
  - 1 – blocked
  - 2 – crossed threshold
  - 4 – goodness unknown (usually when no sessions connected)

Connection life-time

- Short living sessions
- Persistent / Oracle Forms / long connections
- Connection pool
  - Oracle standard connection pool
  - Custom connection pool
  - Application server connection pool

Connection classification & CLB

- Long connections
  - idle most of the time (!)
    - persistent connections (non-pooled)
    - over-allocated connection pools
- Short connections
  - active most of the time
  - dynamic connection pools
- Batch-like connection
  - long but always active
  - under-allocated connection pools (!)

CLB goal

- CLB_GOAL_LONG
  - equal distributions of sessions
- CLB_GOAL_SHORT
  - based on Service Metrics and LBA goal (!)
  - GOAL_NONE
  - GOAL_SERVICE_TIME
  - GOAL_THROUGHPUT

Demo 4 - Service Metrics & CLB

- CLB_GOAL_LONG
- CLB_GOAL_SHORT
- listener trace
- PMON trace
- V$SERVICEMETRIC

10g services load balancing

- For each service defined:
  - Connection load balancing goal
    - CLB_GOAL_SHORT
    - CLB_GOAL_LONG
  - Load Balancing Advisory - LBA
    - GOAL_SERVICE_TIME
    - GOAL_THROUGHPUT

V$SERVICEMETRIC

- For each service and instance contains
  - Short interval (5 seconds)
  - Long interval (60 seconds)
  - INTSIZE_CSEC
  - CPUPERCALL
  - DBTIMEPERCALL
  - CPUPERSEC
  - DBTIMEPERSEC

V$SERVICEMETRIC (cont'd)

- GOODNESS
  - Attractiveness of the instance for this service
  - Higher is worse (should be BADNESS)
- DELTA
  - Estimate of "badness" increase for additional session
- FLAGS (bit map)
  - 0 – all good
  - 1 – blocked
  - 2 – crossed threshold
  - 4 – goodness unknown (usually when no sessions connected)

GOODNESS and CLB_GOAL

- LONG
  - GOODNESS=number of connected sessions
  - DELTA=1
- SHORT
  - Calculated based on
    - GOAL_SERVICE_TIME
    - GOAL_THROUGHPUT
    - GOAL_NONE

GOODNESS and CLB_GOAL_SHORT

- According to my observations
- GOAL_SERVICE_TIME
  - "per call" metrics used
    - CPUPERCALL
    - DBTIMEPERCALL
- GOAL_THROUGHPUT
  - "per second" metrics used
  - CPUPERSEC
  - DBTIMEPERSEC

Listener trace... again

- We can see goodness and delta when instance/service started

```
nsglgrDoRegister: Creating new service: service10g

nsglgrDoRegister: service:service10g
                                  flag:2 goodness:0 delta:0
```

- During service updates

```
nsglgrDoRegister: service:service10g what:4 value:1
nsglgrDoRegister: service:service10g what:2 value:47
```

  - what: 2 = goodness
  - what: 4 = delta

How does listener know about it?

- MMON is the “calculator”
  - V$SERVICEMETRIC
- PMON is the “messenger”
  - `10257 trace name context forever, level 16`

PMON trace example

- 11g trace

```
*** 2007-09-19 05:52:24.797
kmmlrl: update for session drop delta:
                    111 106 10 10 82
kmmlrl: service11g.oracloid.com goodness 8
kmmlrl: update for service goodness
kmmlrl: 55 processes
kmmlrl: node load 358
kmmlrl: instance load 19
kmmlrl: nsgr update returned 0
```

Service Metrics & CLB

- CLB_LONG

  Target - equal number of sessions per instance

  GOODNESS=number of session, DELTA=1

- CLB_SHORT + GOAL_NONE

  Target - equalize CPU utilization

  GOODNESS and DELTA => based on run-queue / load average

- CLB_SHORT + GOAL_SERVICE_TIME

  Target - minimize response time

  GOODNESS + DELTA <= LBA _PER_CALL (?)

- CLB_SHORT + GOAL_THROUGHPUT

  Target - maximize throughput

  GOODNESS + DELTA <= LBA _PER_SEC (?)

Nodes with different capacity

- Works with instance load
  - use different SESSIONS in init.ora
- Works with node load
  - based on CPU_COUNT
- Service Metrics?
  - bug 6613950
  - CLB_GOAL_SHORT is slower than node load *(my observations)*
  - CLB faster than RLB

Where we are...

- ✓Client-side basics
- ✓Oracle Cluster Services
- ✓Server-side CLB
- ➡FAN - HA & LBA events
- Thin JDBC RLB
- ONS Subscriber
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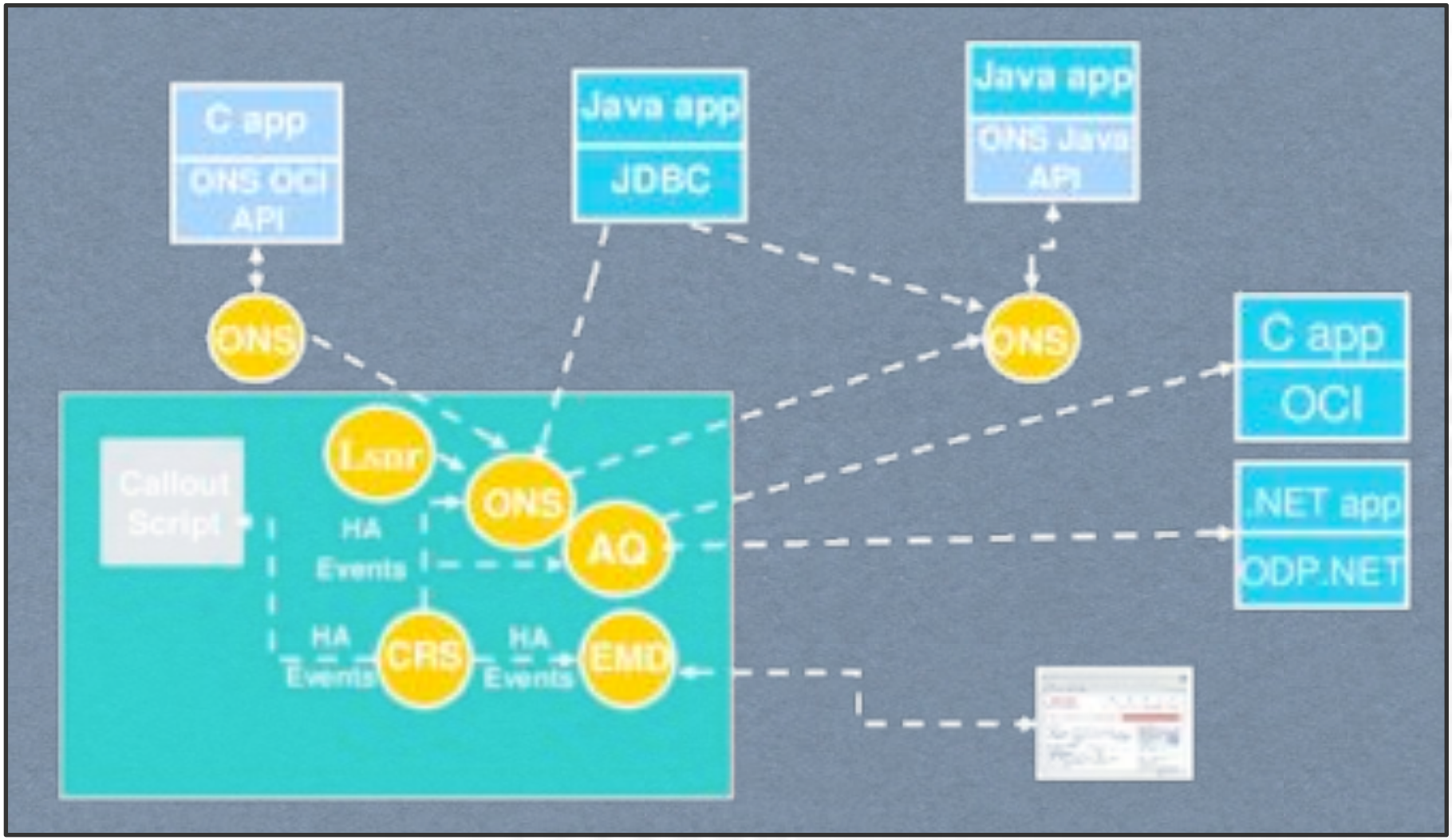
Clusterware processes



ONS Configuration

- $ORA_CRS_HOME/opmn/conf/ons.config

```
localport=6101
#10g
#remoteport=6201
loglevel=9
useocr=on
```

- $ORA_CRS_HOME/bin/onsctl start/stop/ping
- $ORA_CRS_HOME/bin/racgons add_config/remove_config

Demo 6 - LBA events

- ONS log

```
eventType: database/event/servicemetrics/ser
VERSION=1.0 database=g4 {
  {instance=g42 percent=34 flag=GOOD}
  {instance=g43 percent=33 flag=GOOD}
  {instance=g41 percent=33 flag=GOOD}
  } timestamp=2008-02-11 03:24:18
```

- SYS.SYS$SERVICE_METRICS_TAB

Using FAN events on app-tier

- ONC – Oracle Notification Client
- Java ONS API
- C ONS API
- Can be used to manage non-pooled connections or home-grown pools
- Can be standalone ONC – no JDBC/OCI
- – – – local ONS is required (at least with 10g)

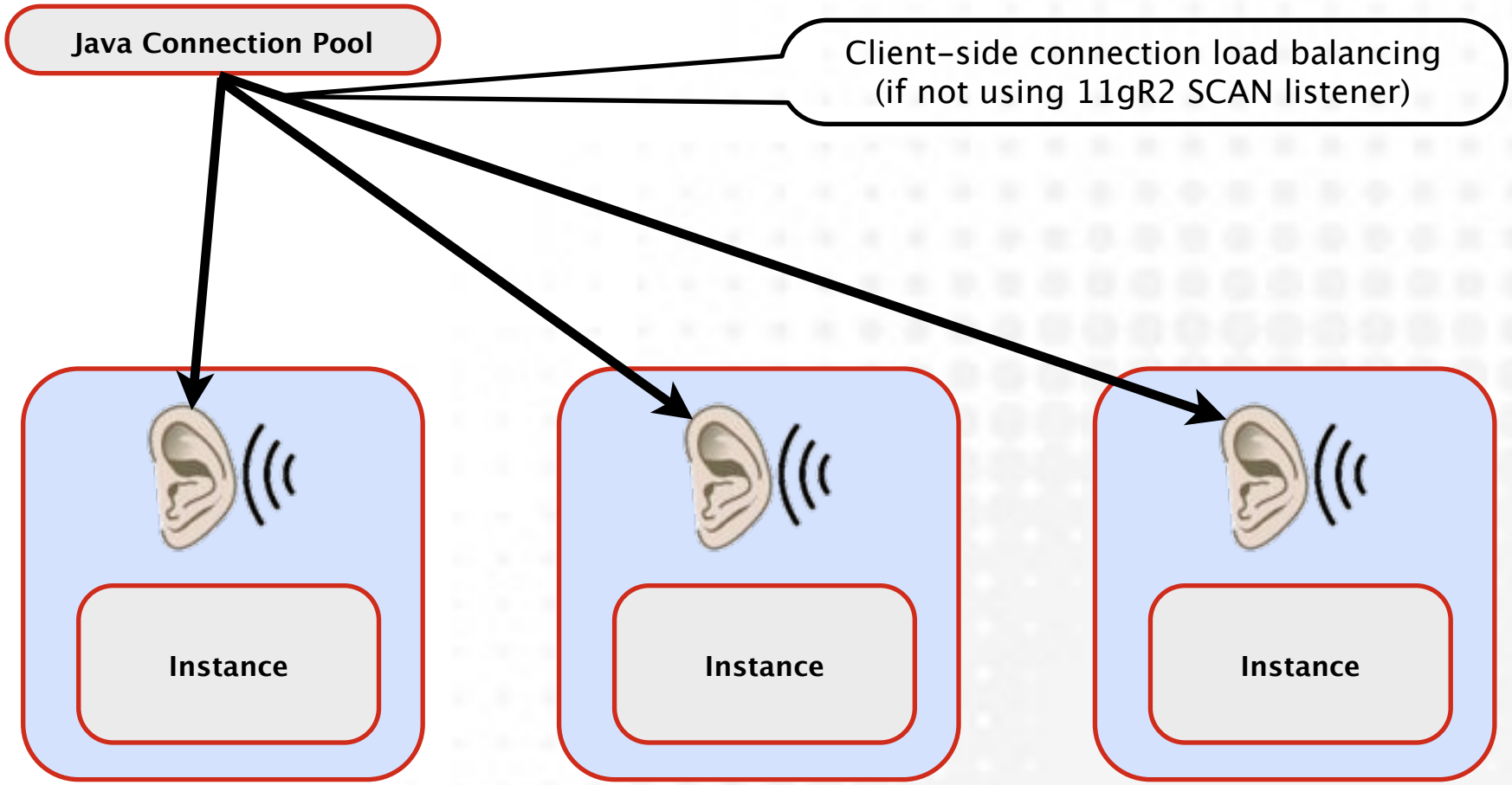
Where we are...

- ✓Client-side basics
- ✓Oracle Cluster Services
- ✓Server-side CLB
- ✓FAN - HA & LBA events
- ➡Thin JDBC RLB
- ONS Subscriber
- Your own LBA!

Establishing a Connection

Java Connection Pool

Establishing a Connection



Establishing a Connection

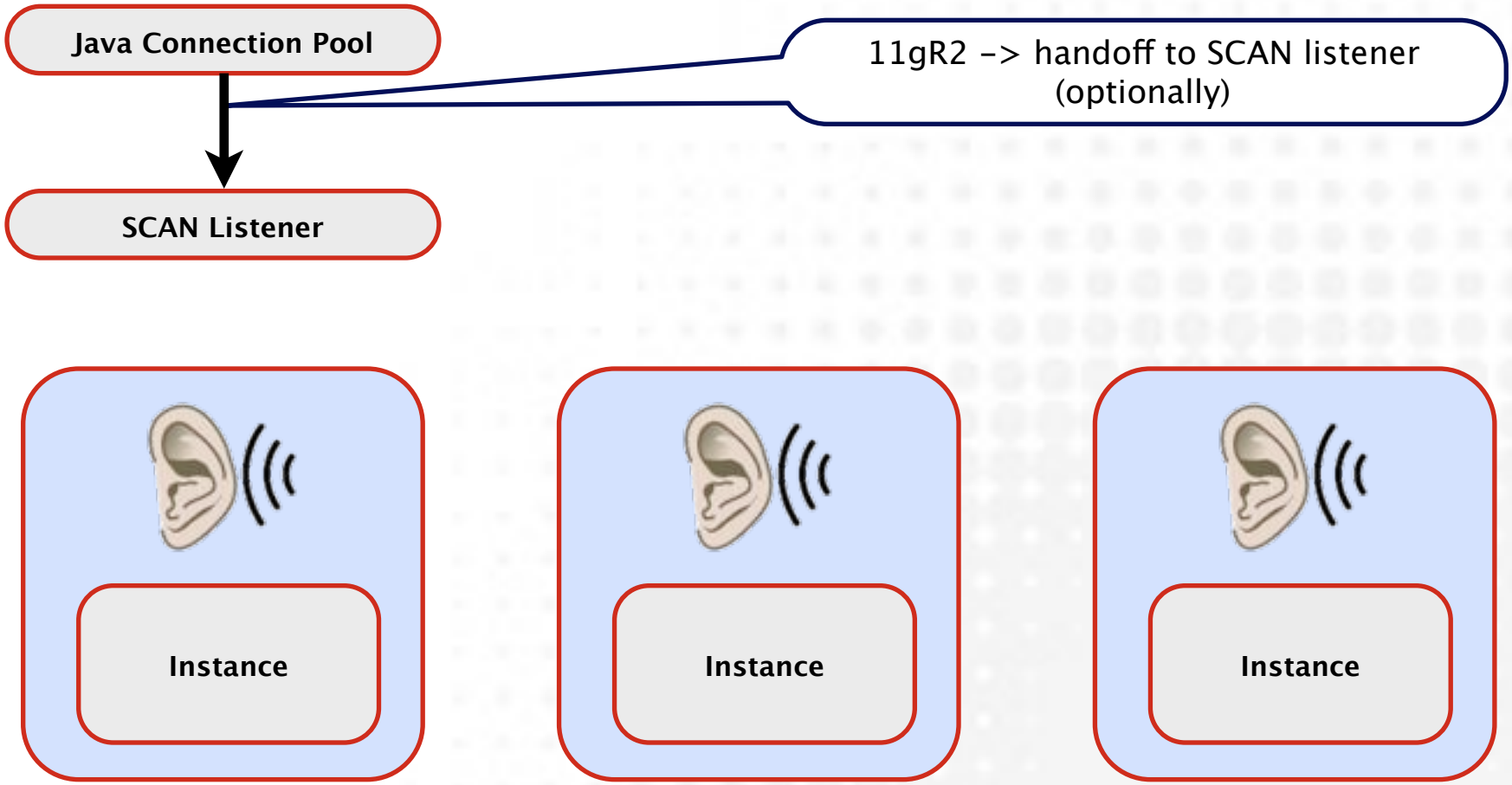
Java Connection Pool

Establishing a Connection

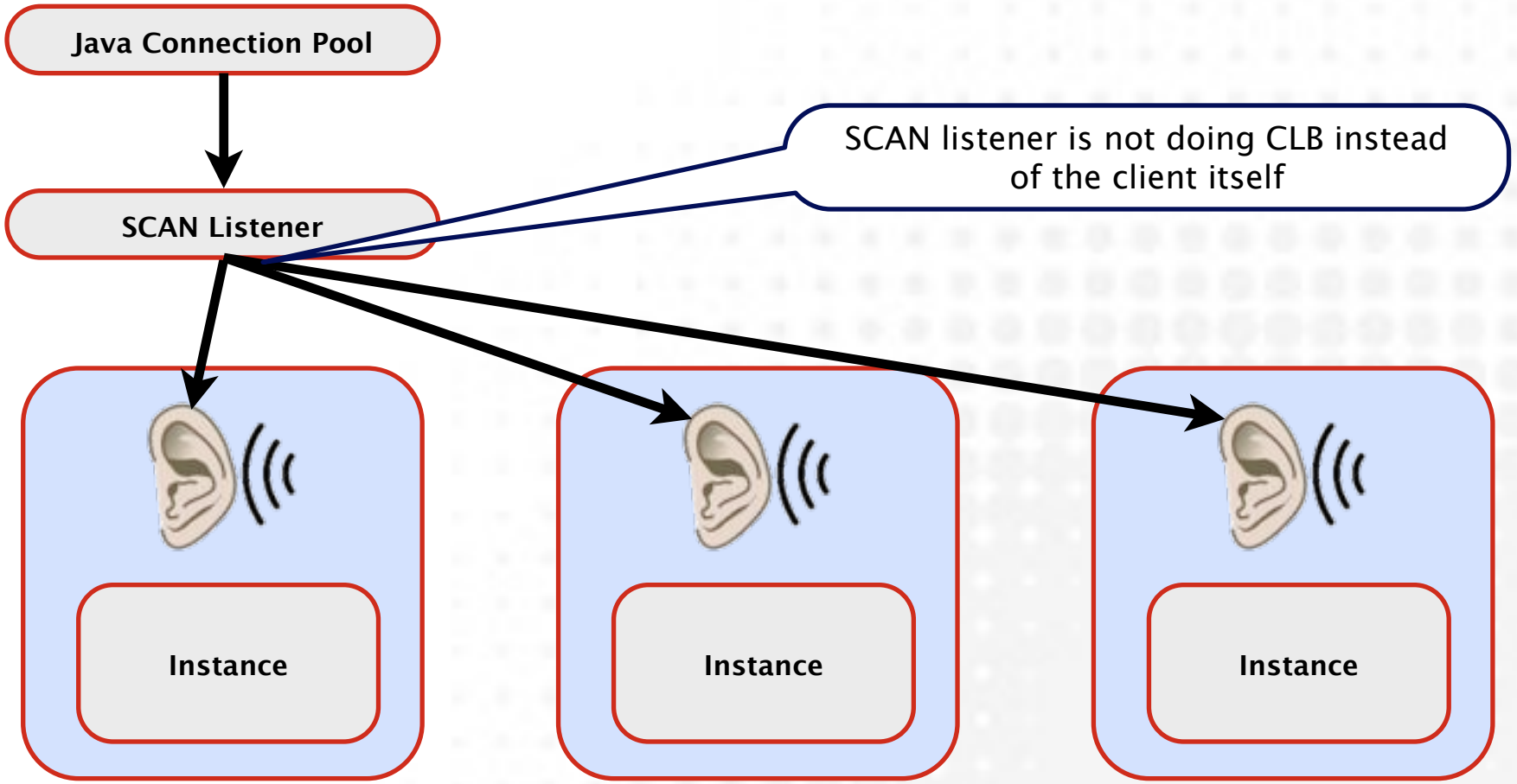
Java Connection Pool

SCAN Listener

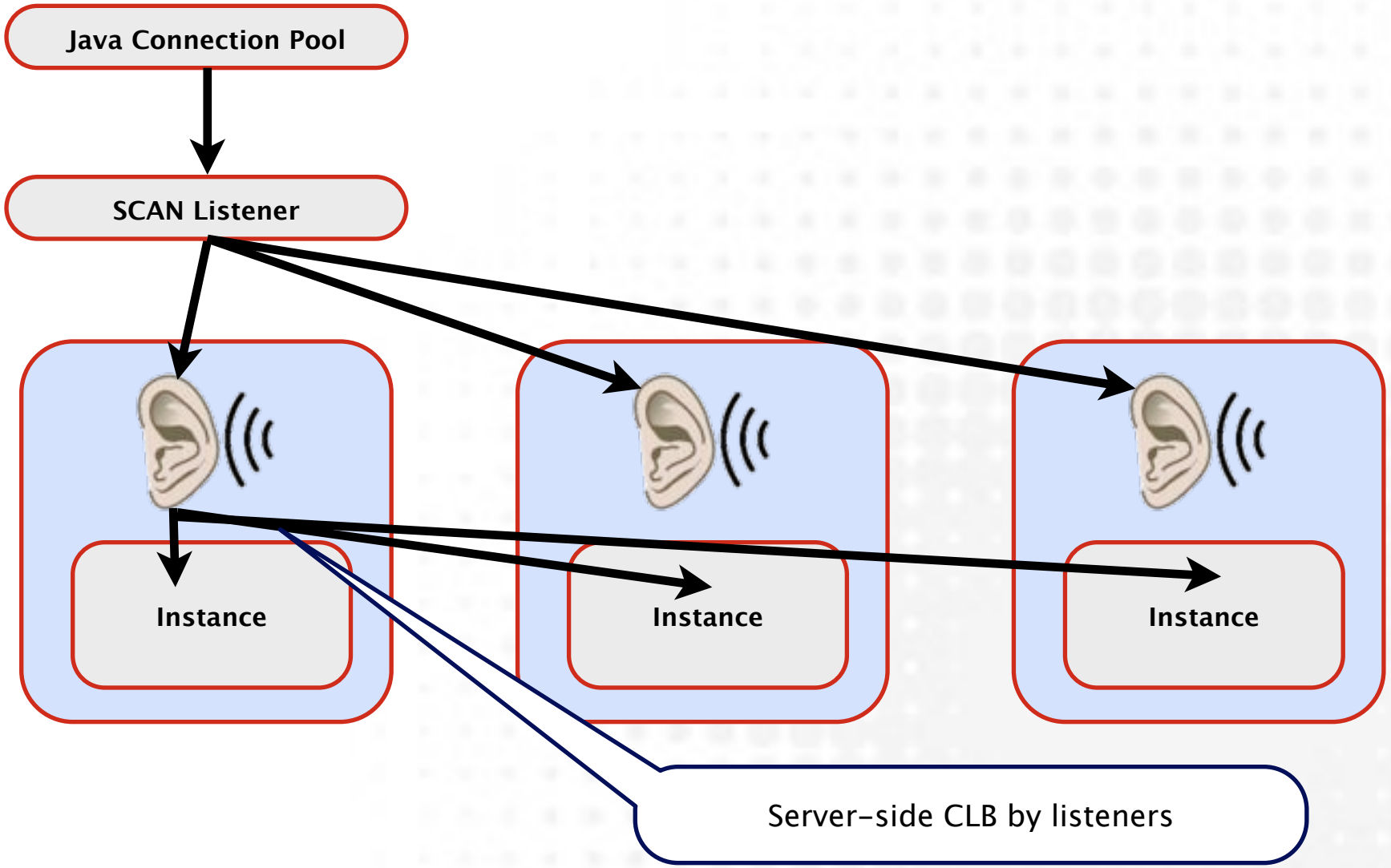
Establishing a Connection



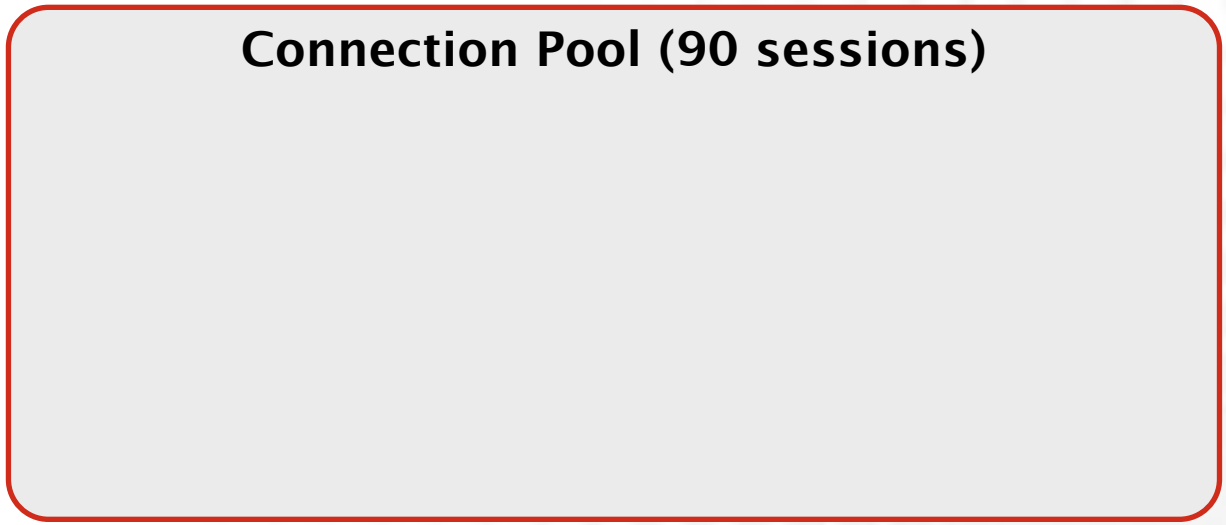
Establishing a Connection



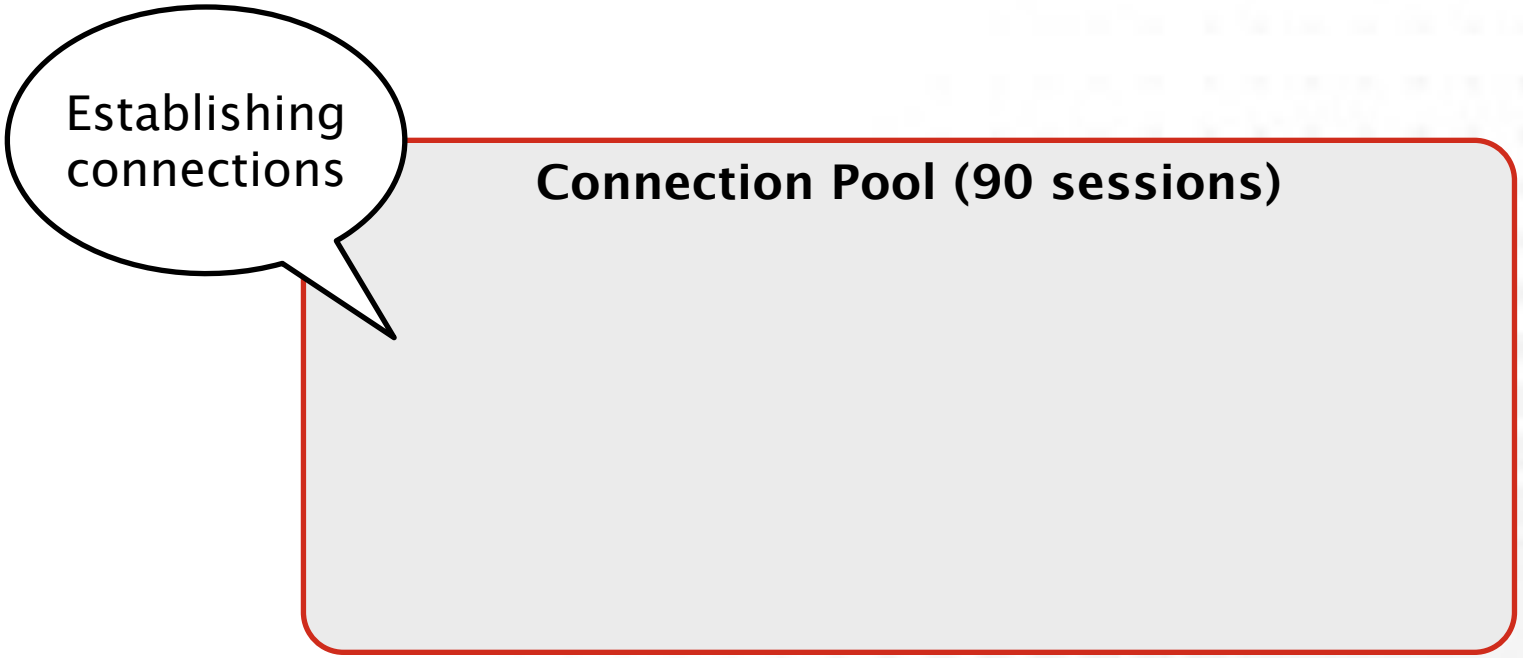
Establishing a Connection



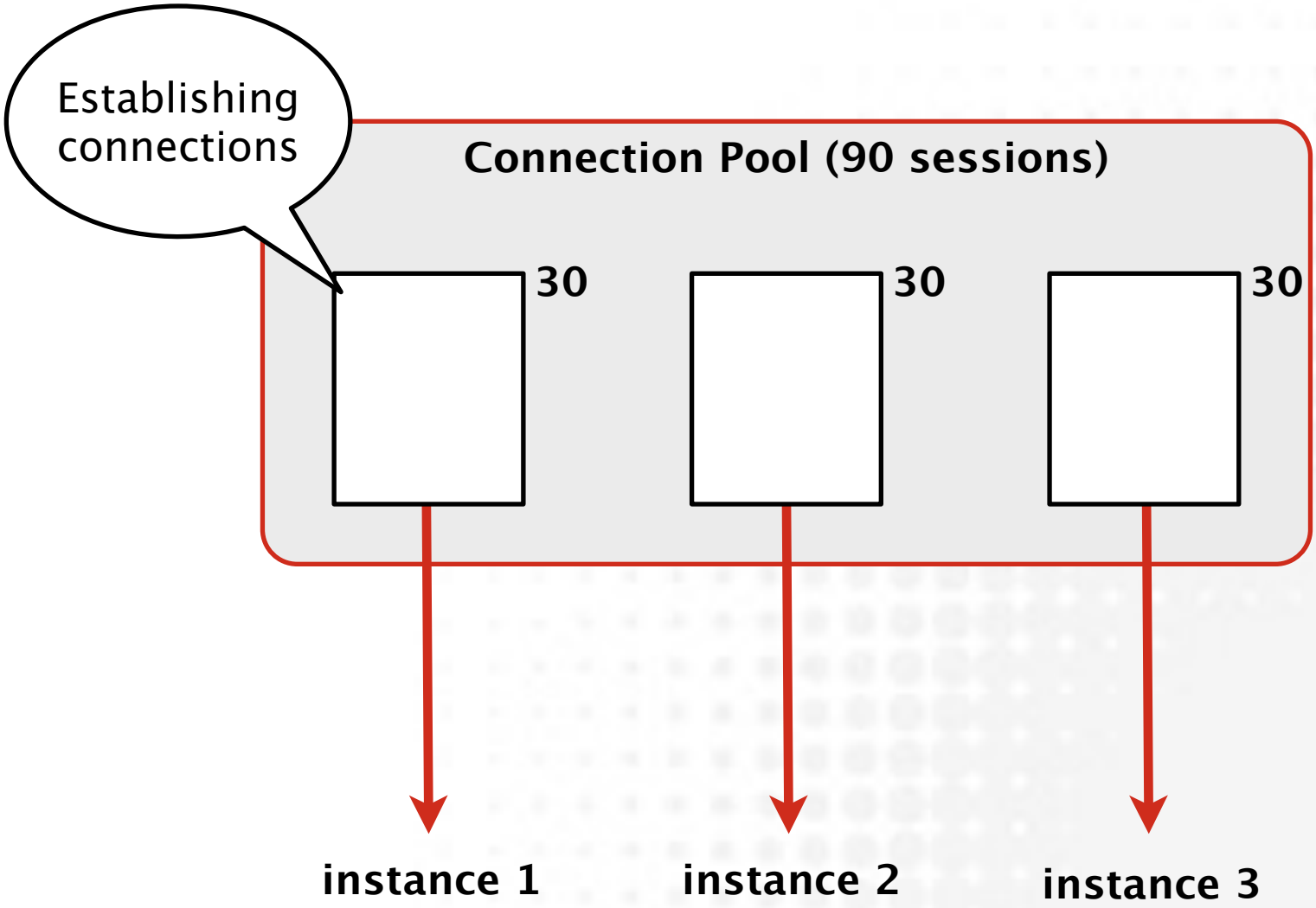
RLB - connection gravitation



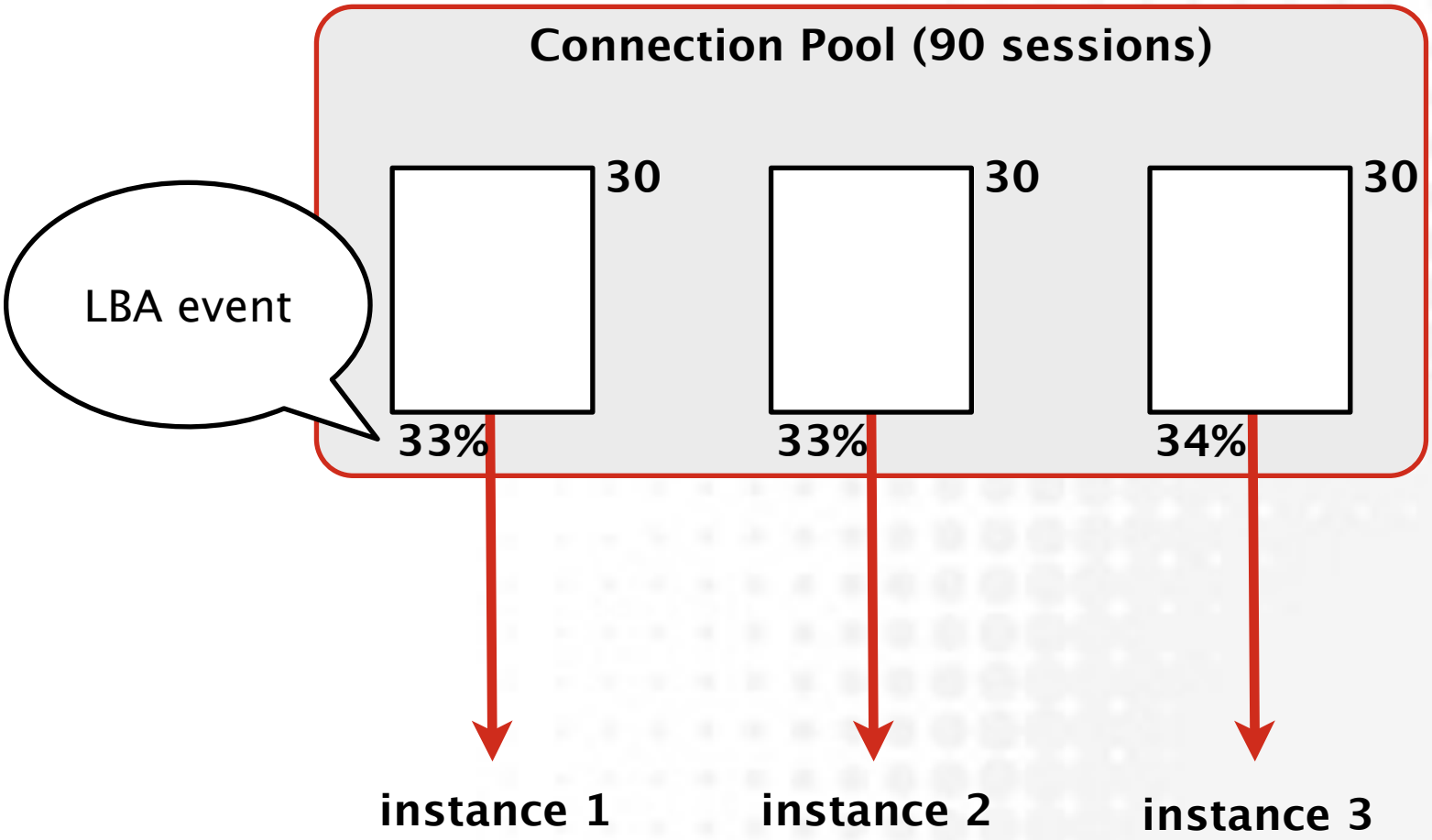
RLB - connection gravitation



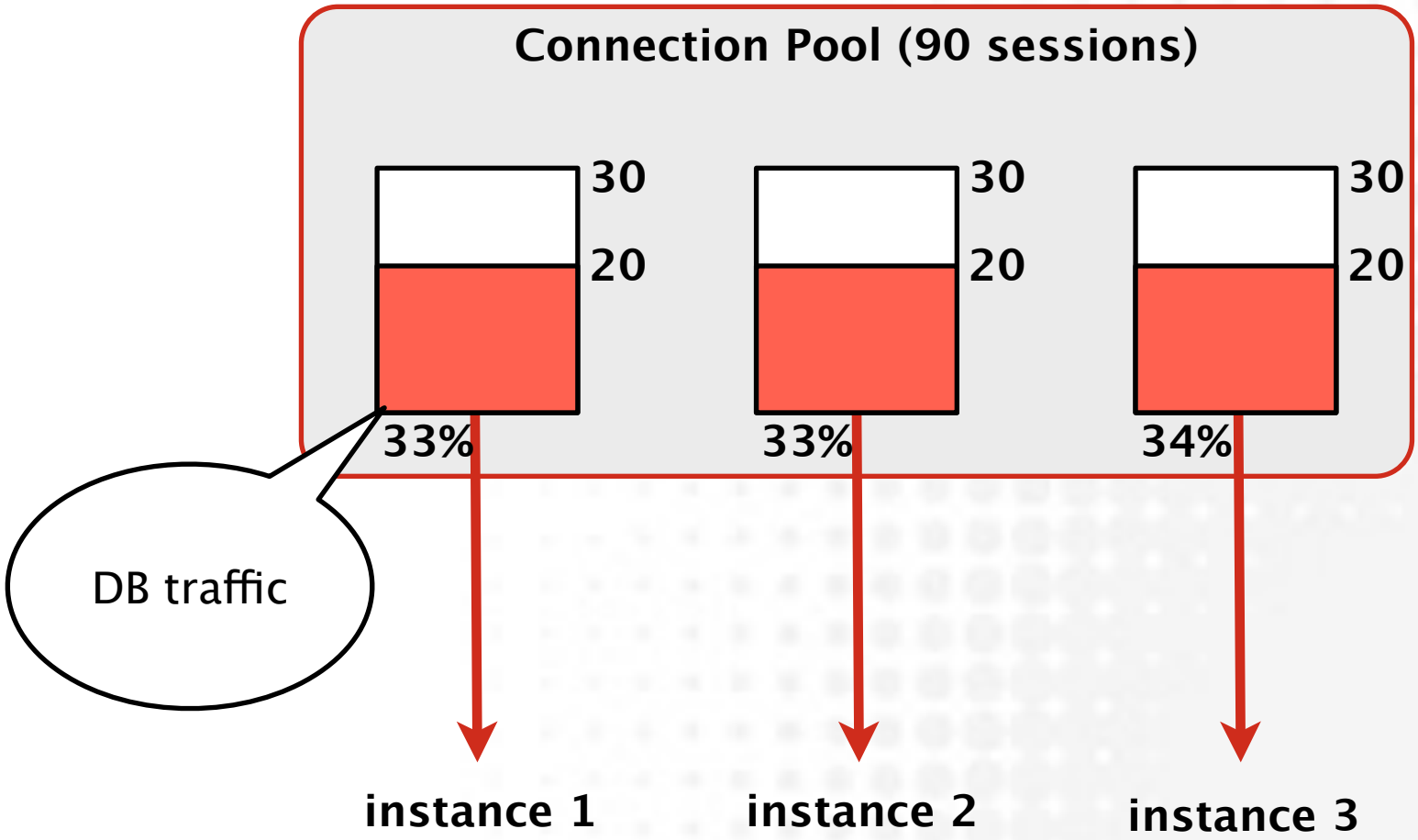
RLB - connection gravitation



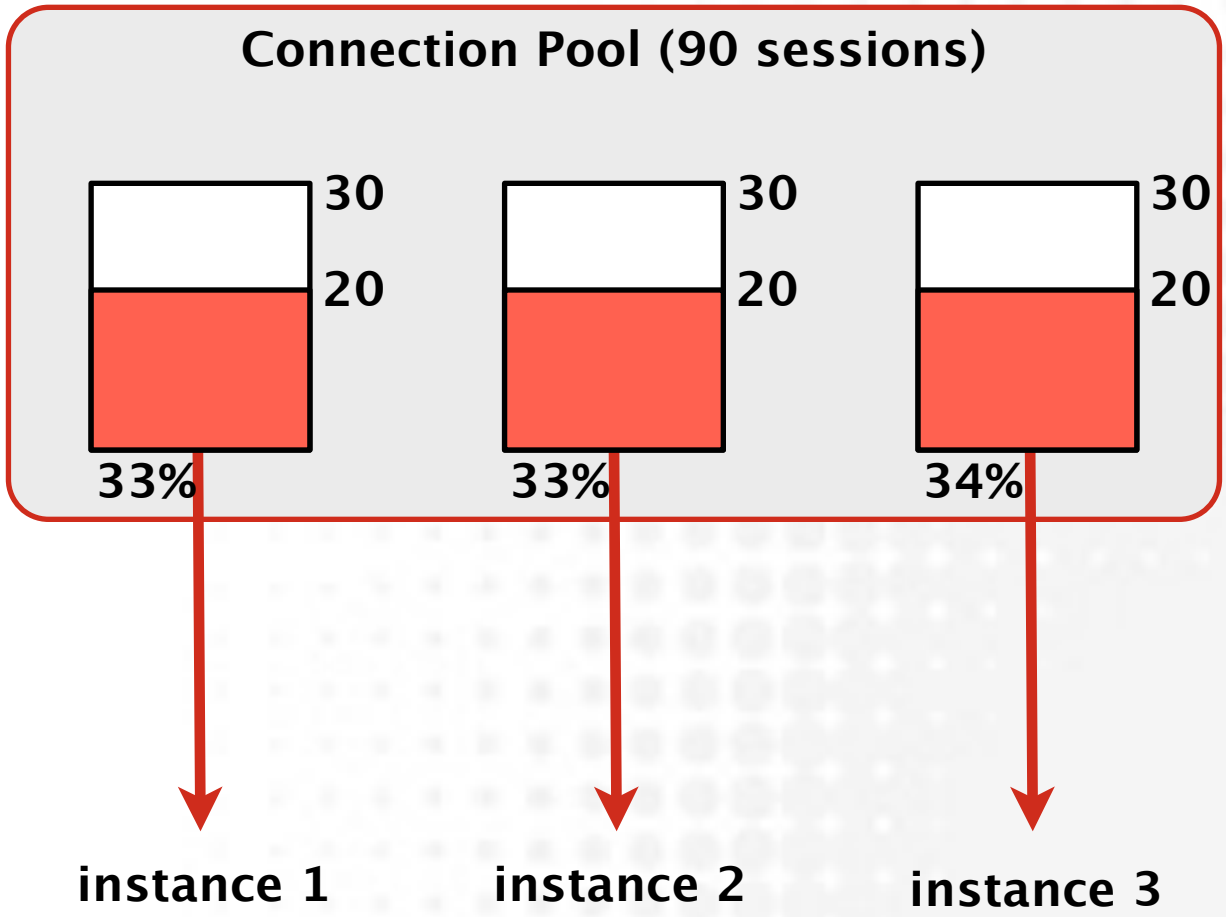
RLB - connection gravitation



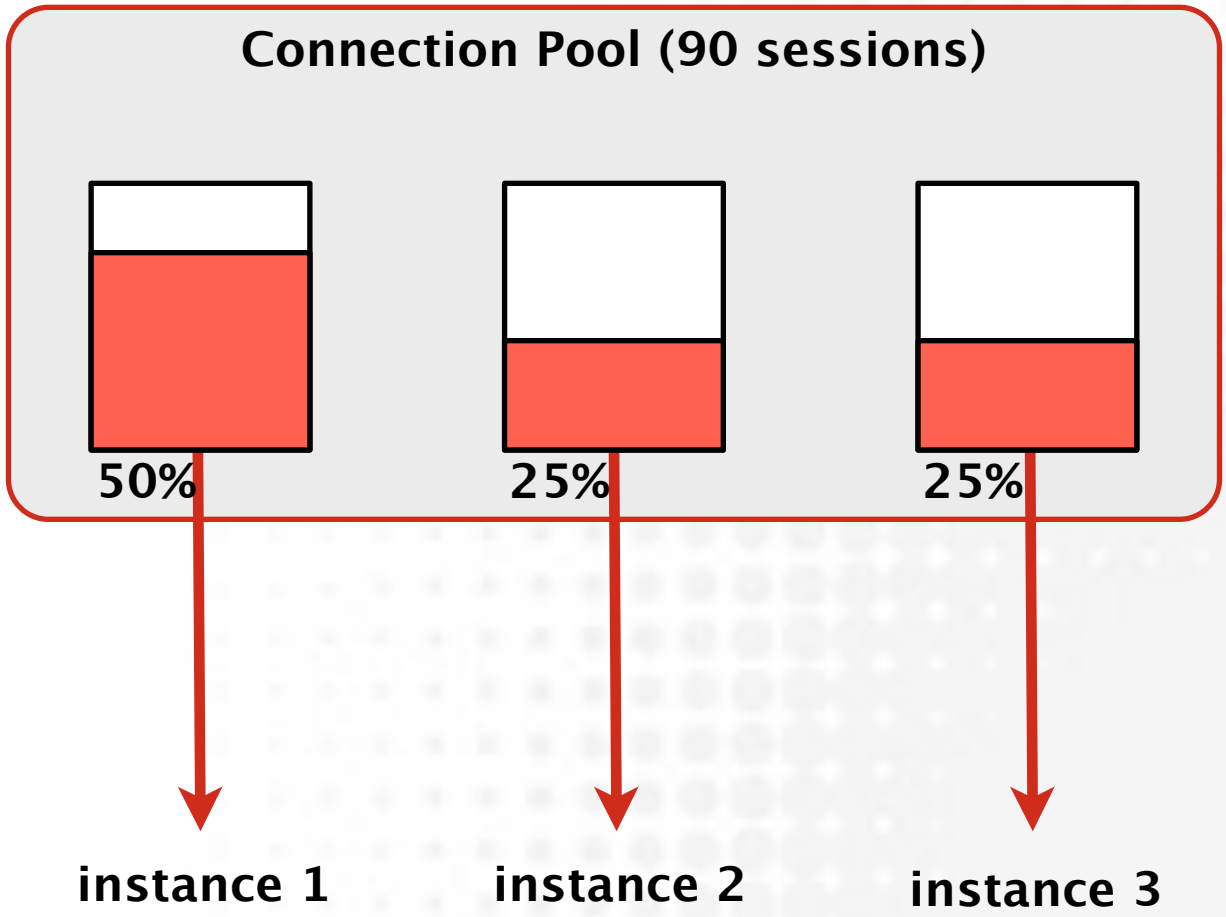
RLB - connection gravitation



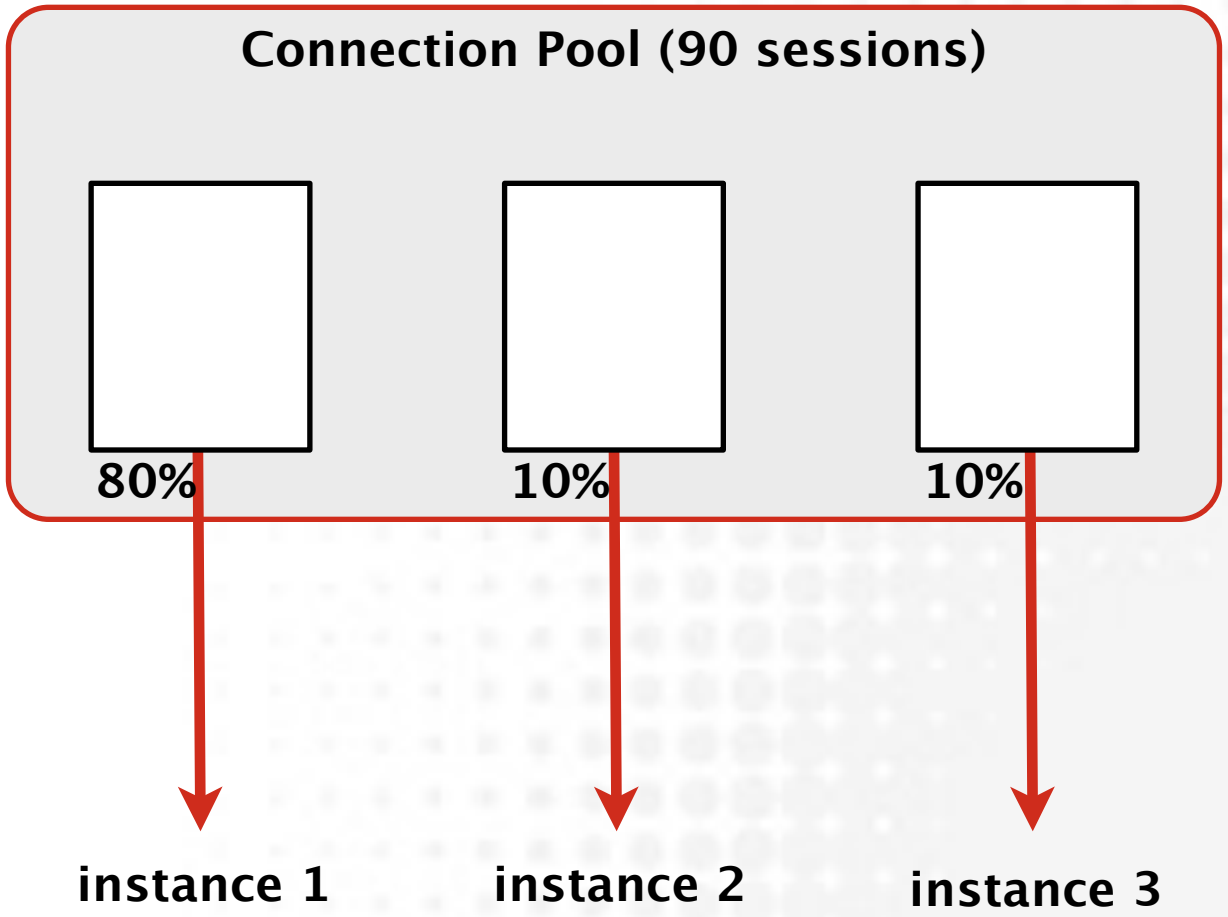
RLB - connection gravitation



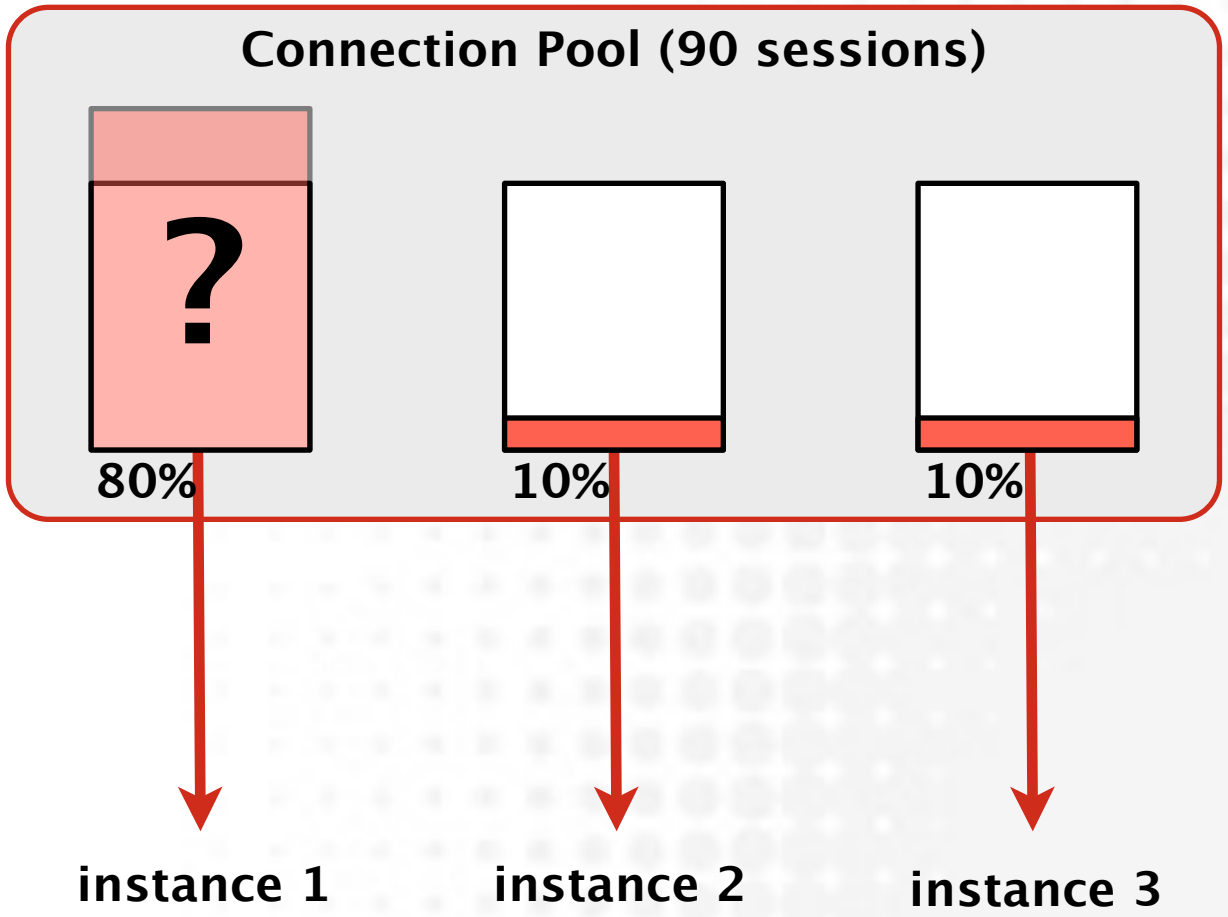
RLB - connection gravitation



RLB - connection gravitation



RLB - connection gravitation



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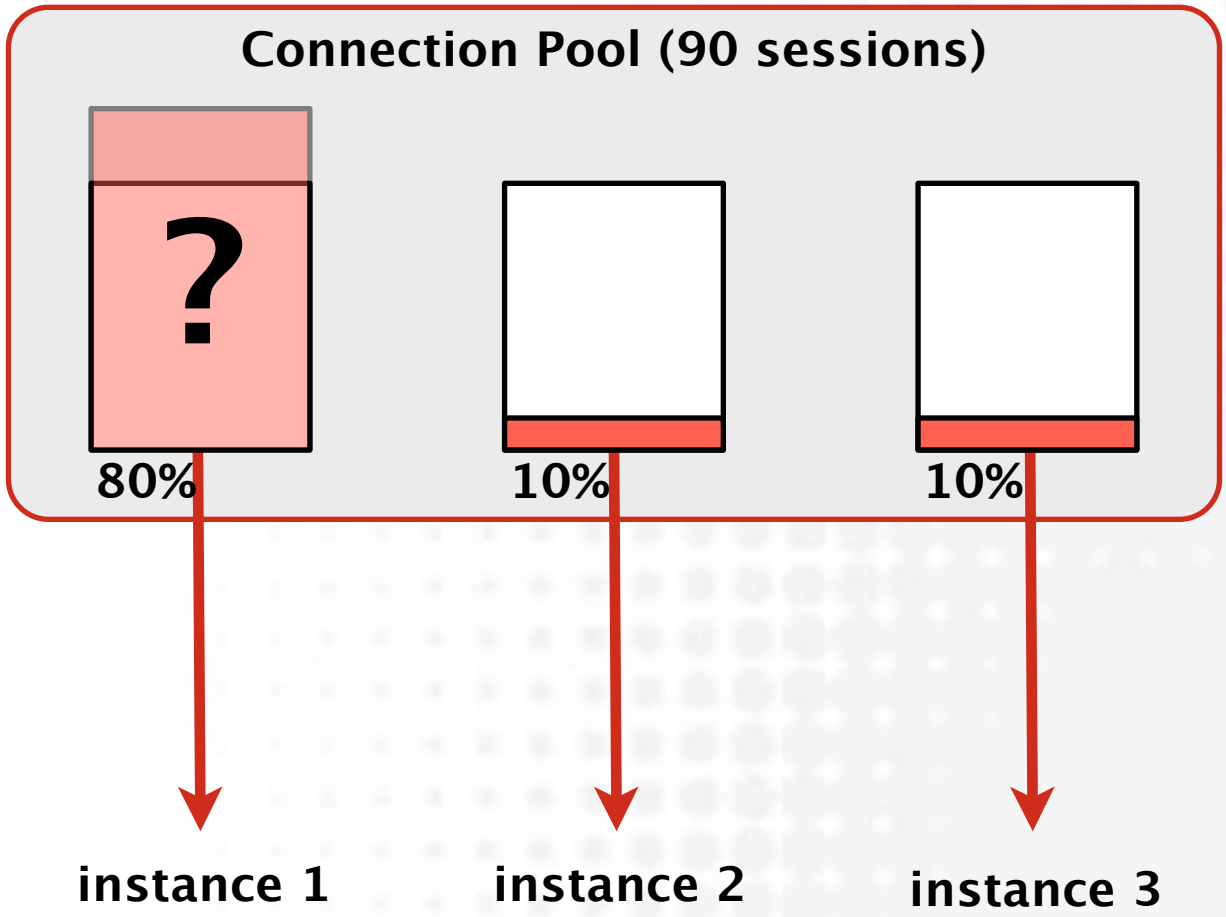
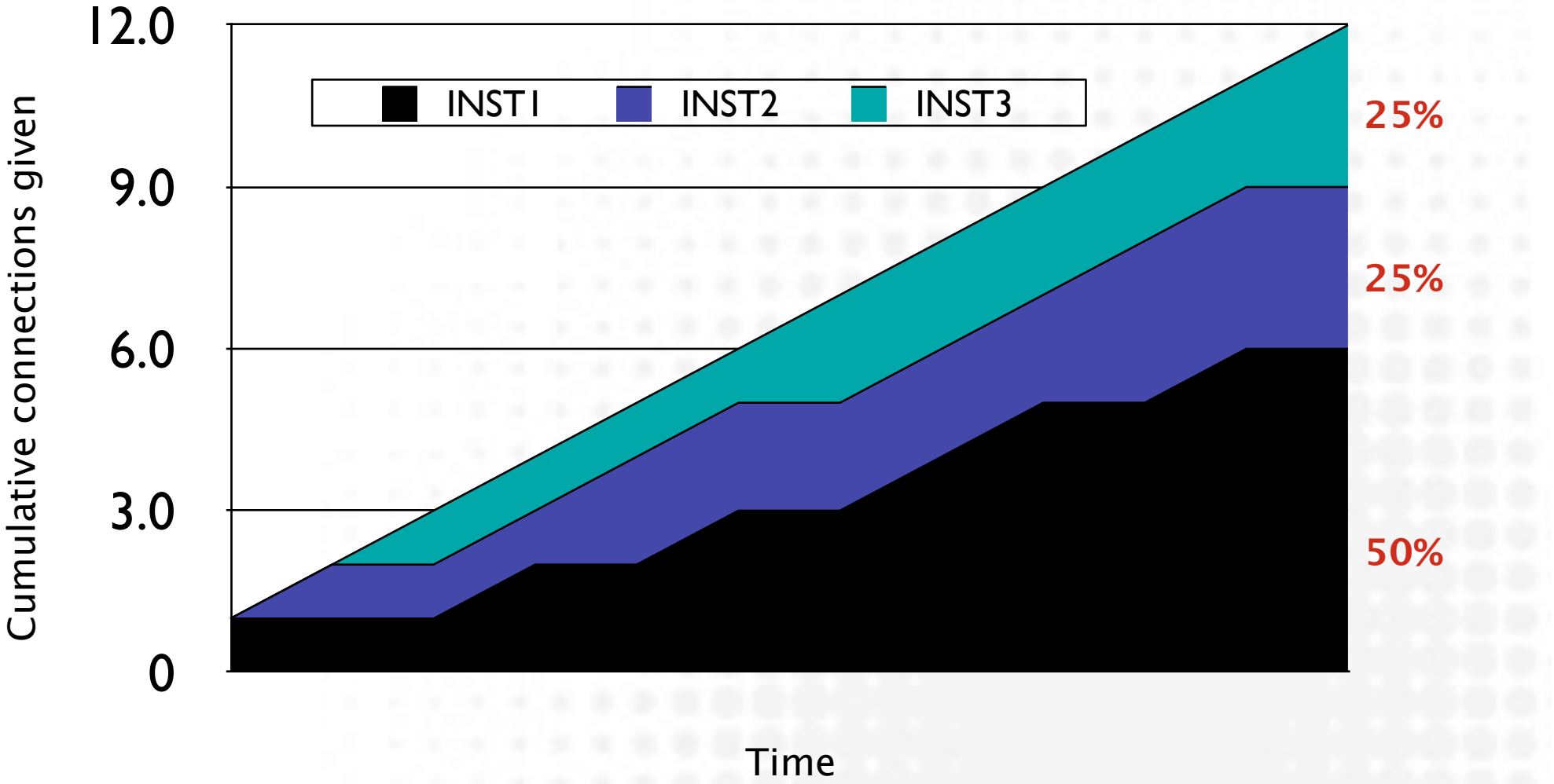


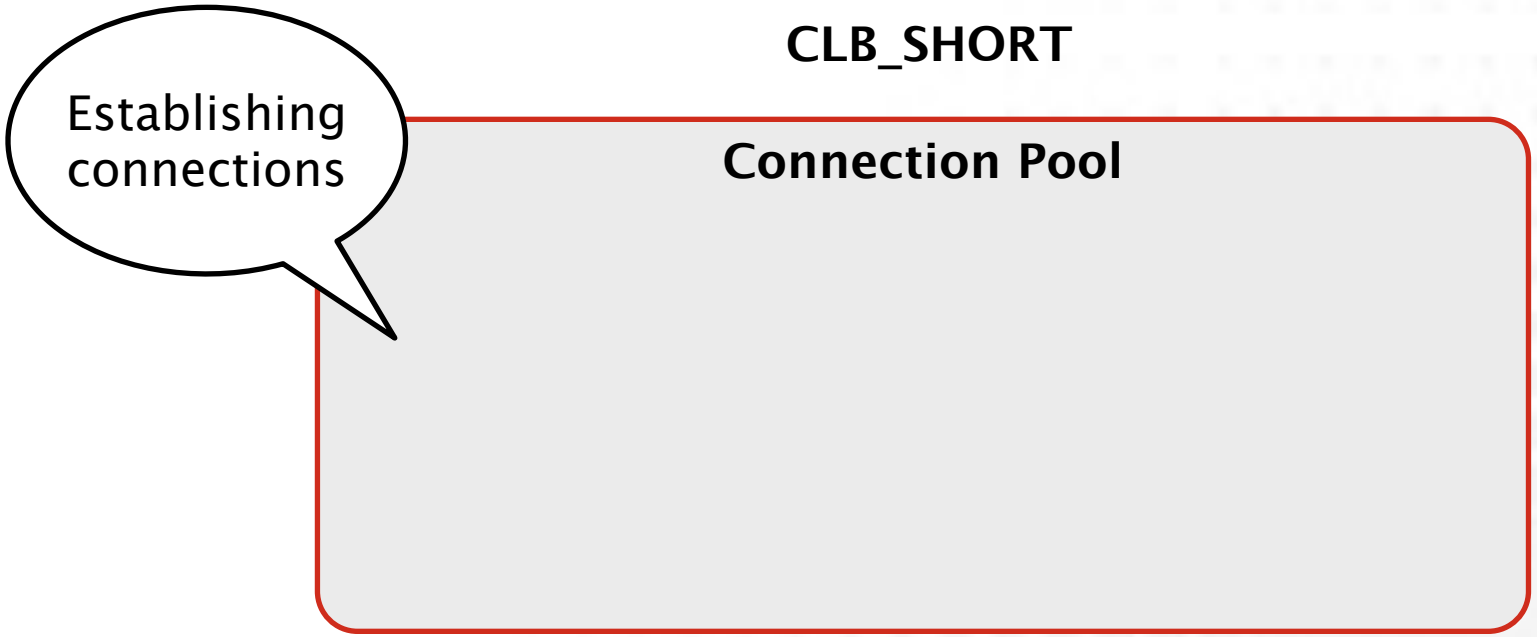
Connection pool must be over-allocated!

RLB - how is workload gravitated?

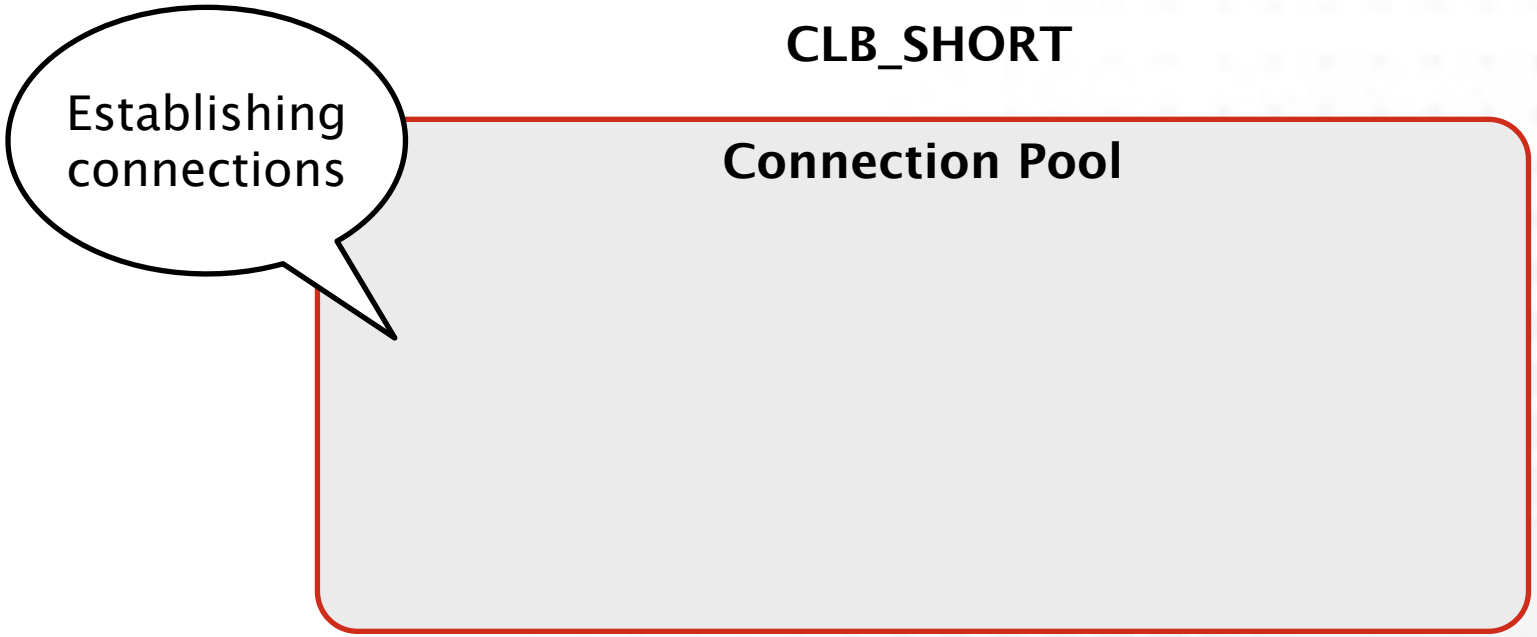


CLB options for RLB

CLB options for RLB

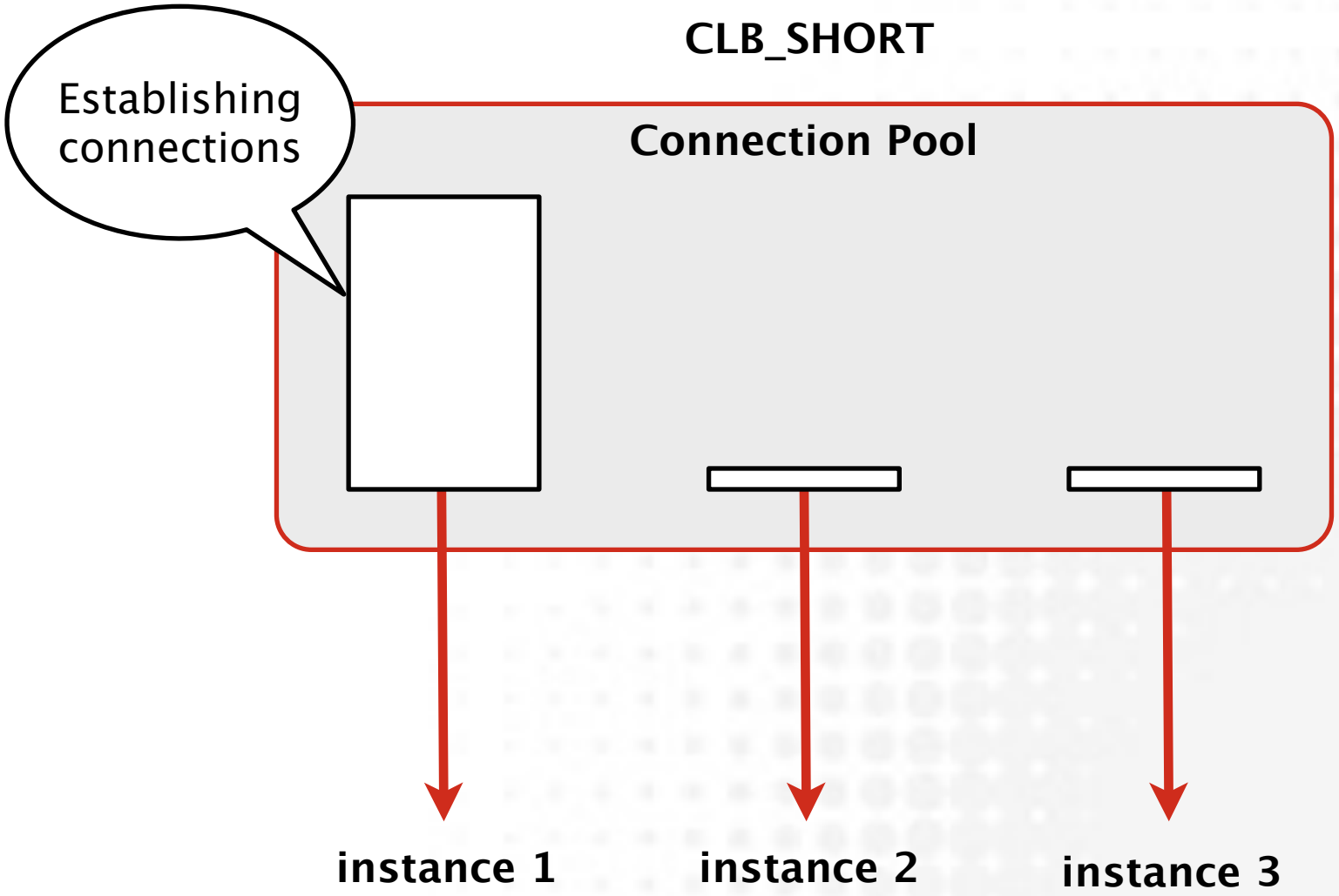


CLB options for RLB



Connections requests burst – most go to the node with the lowest goodness

CLB options for RLB



Connections requests burst – most go to the node with the lowest goodness

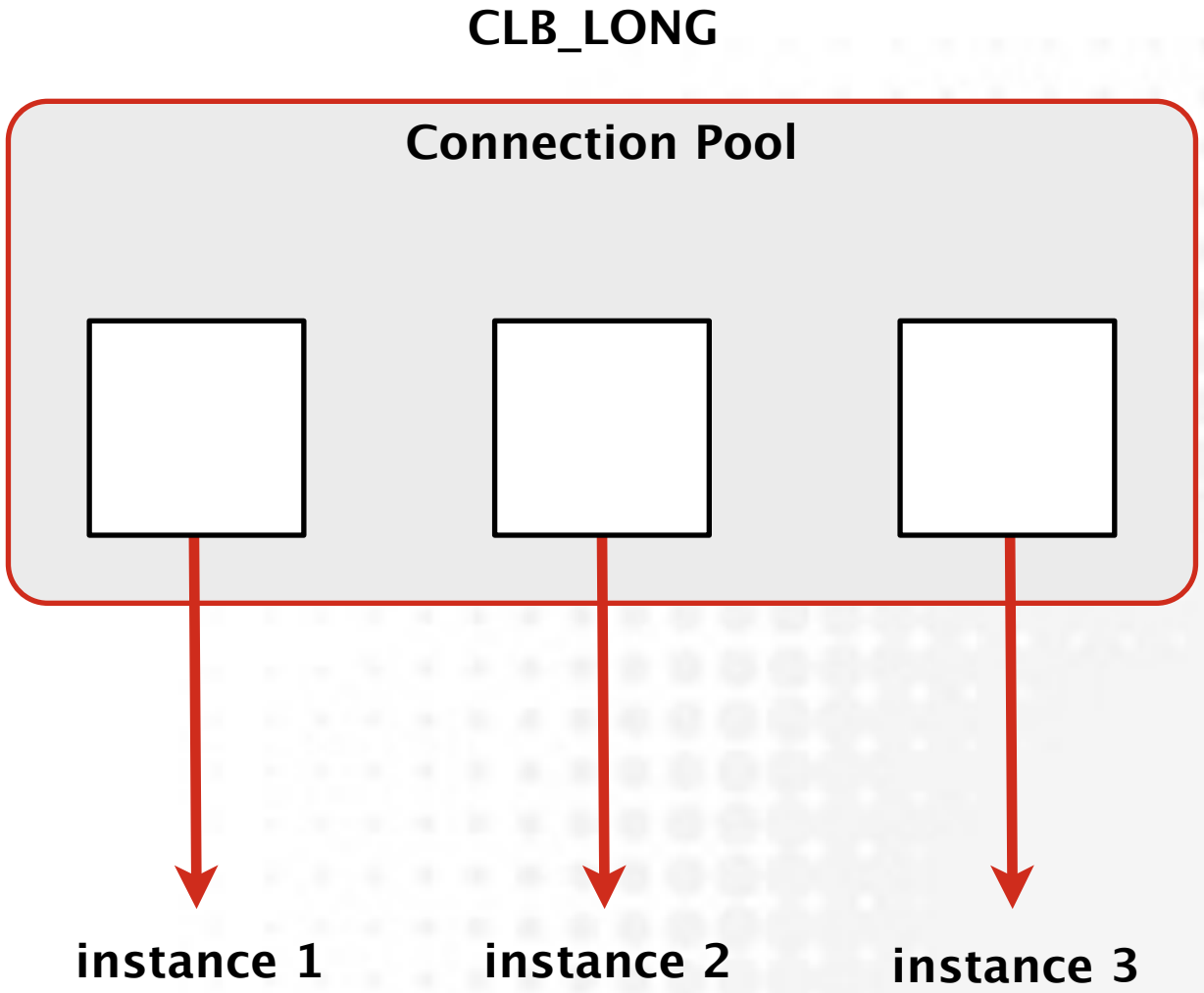
CLB options for RLB

CLB_LONG

instance 1 **instance 2** **instance 3**

Connections requests distributed equally across all instances running a service

CLB options for RLB



Connections requests distributed equally across all instances running a service

Rule of thumb

use CLB_LONG with connection pools

JDBC Implicit Connection Cache

- Standard JDBC drivers + ons.jar

```
ods.setConnectionCachingEnabled(True);
ods.setFastConnectionFailoverEnabled(True);
ods.setONSConfiguration
      ("nodes=lh1:6201,lh2:6201");
  Properties prop = new Properties();
  prop.setProperty("MinLimit", MIN_CONN);
  prop.setProperty("MaxLimit", MAX_CONN);
  prop.setProperty("InitialLimit", INIT_CONN);
  prop.put
     (oracle.net.ns.SQLnetDef.TCP_CONNTIMEOUT_STR,
     "1000")); // 1 second
  ods.setConnectionCacheProperties(prop);
```

Demo 7 - JDBC RLB

- Implicit Connection Cache
- Enabling FCF
- Subscribe with ONS
- Tracing LBA events in JDBC

ONS JDBC bugs

- Bug 6151350 - RESTRICTION ON SETONSCONFIGURATION

- Bug 6315760 - SETONSCONFIGURATION ONLY REGISTERS A MAXIMUM OF ***THREE*** NODES
  - *-Doracle.ons.maxconnections=5*

Are we there yet?

- ✓Client-side basics
- ✓Oracle Cluster Services
- ✓Server-side CLB
- ✓FAN - HA & LBA events
- ✓Thin JDBC RLB
- ➡ONS Subscriber
- Your own LBA!

Demo 8 - ONC JDBC API

- Local ONS is required on client
- Subscribing to events
  - How to filter only required events
- Parsing events

Are we there YET???

- ✓Client-side basics
- ✓Oracle Cluster Services
- ✓Server-side CLB
- ✓FAN - HA & LBA events
- ✓Thin JDBC RLB
- ✓ONS Subscriber
- ➡Your own LBA!

Demo 9 - your own LBA

- Maximum flexibility of LBA
- ONS Publisher
- Oracle doesn't know how to balance you workload better than you!

- This is not documented anywhere and likely unsupported

Are we there yet?

NO :)

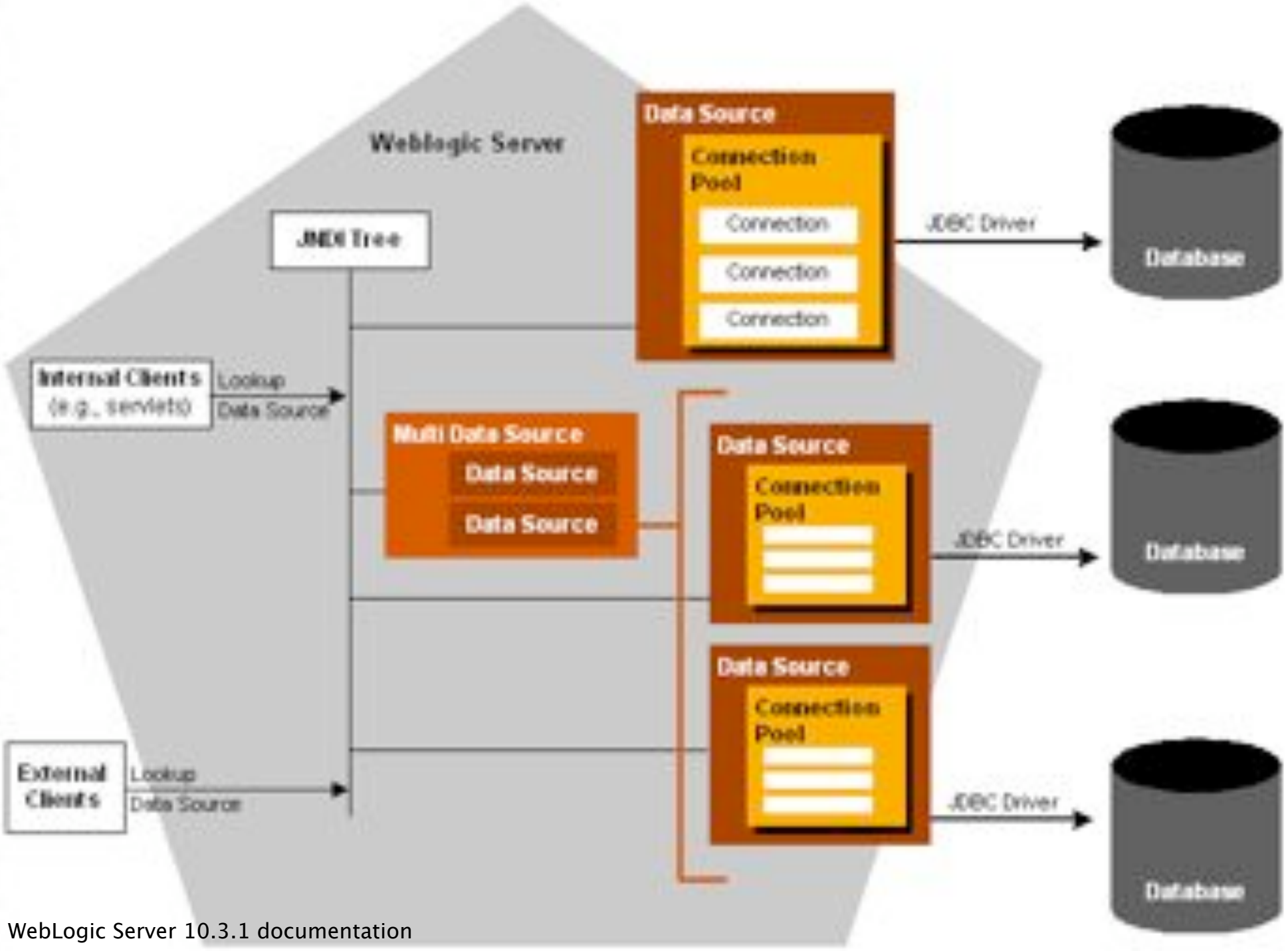
- cle Clu er Ser
- lishi a co ction
- AN A 8 BA e ts
- hin J B
- NS Sub er
- ✓Your own LBA!

11g New Features

- SCAN Listener
- Universal Connection Pool
- Connection Affinity in LBA (web sessions, XA)
  - Reduces Cache Fusion overhead
  - Requires UCP
- Data Guard Broker integration with FAN events
- Policy-Based Cluster and Capacity Management

Are we there yet?

Bonus - WebLogic Server Connection Management



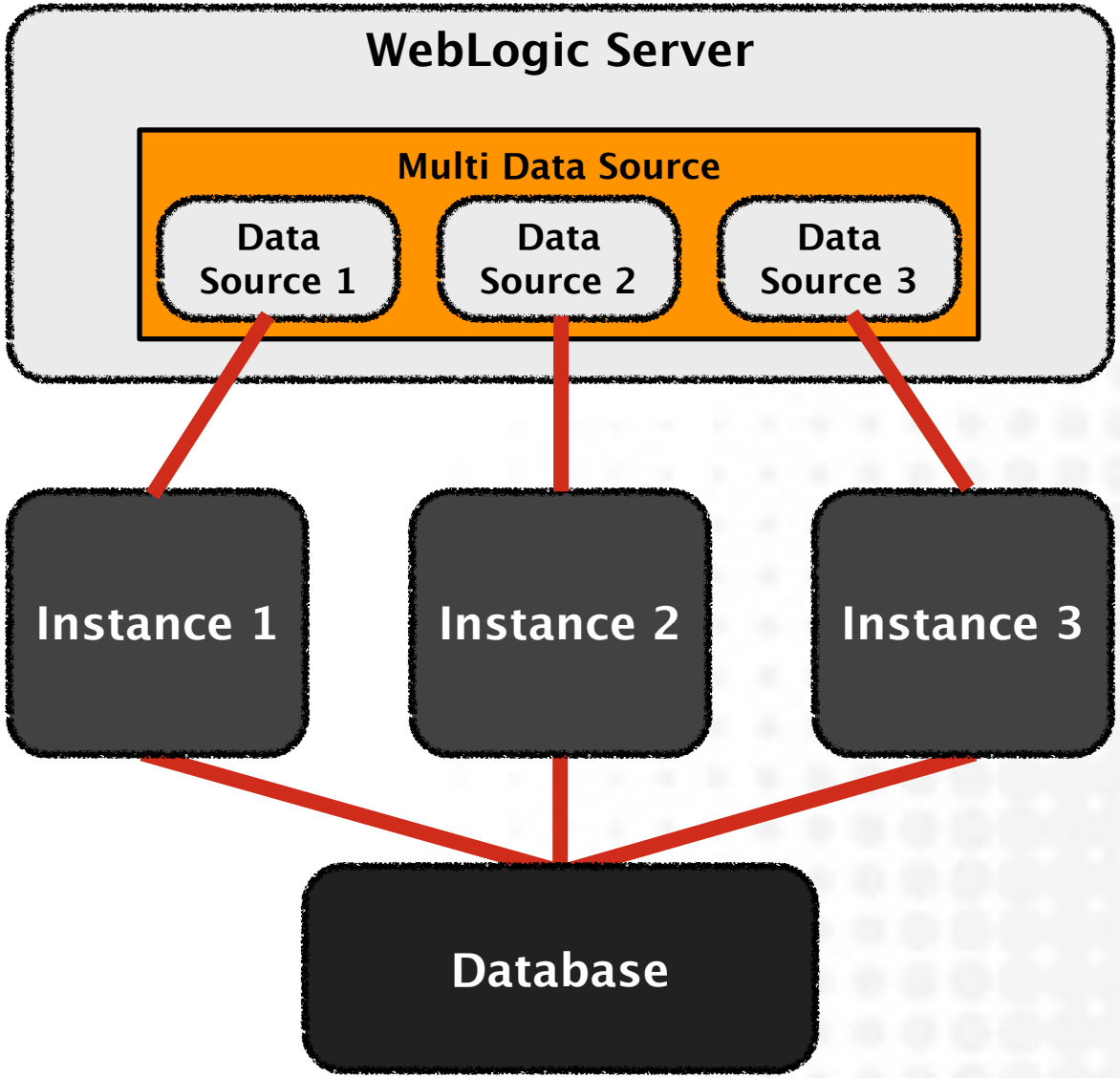
Source – WebLogic Server 10.3.1 documentation

WebLogic Configurations Options for Oracle RAC

- 4 Supported Data Source Configurations

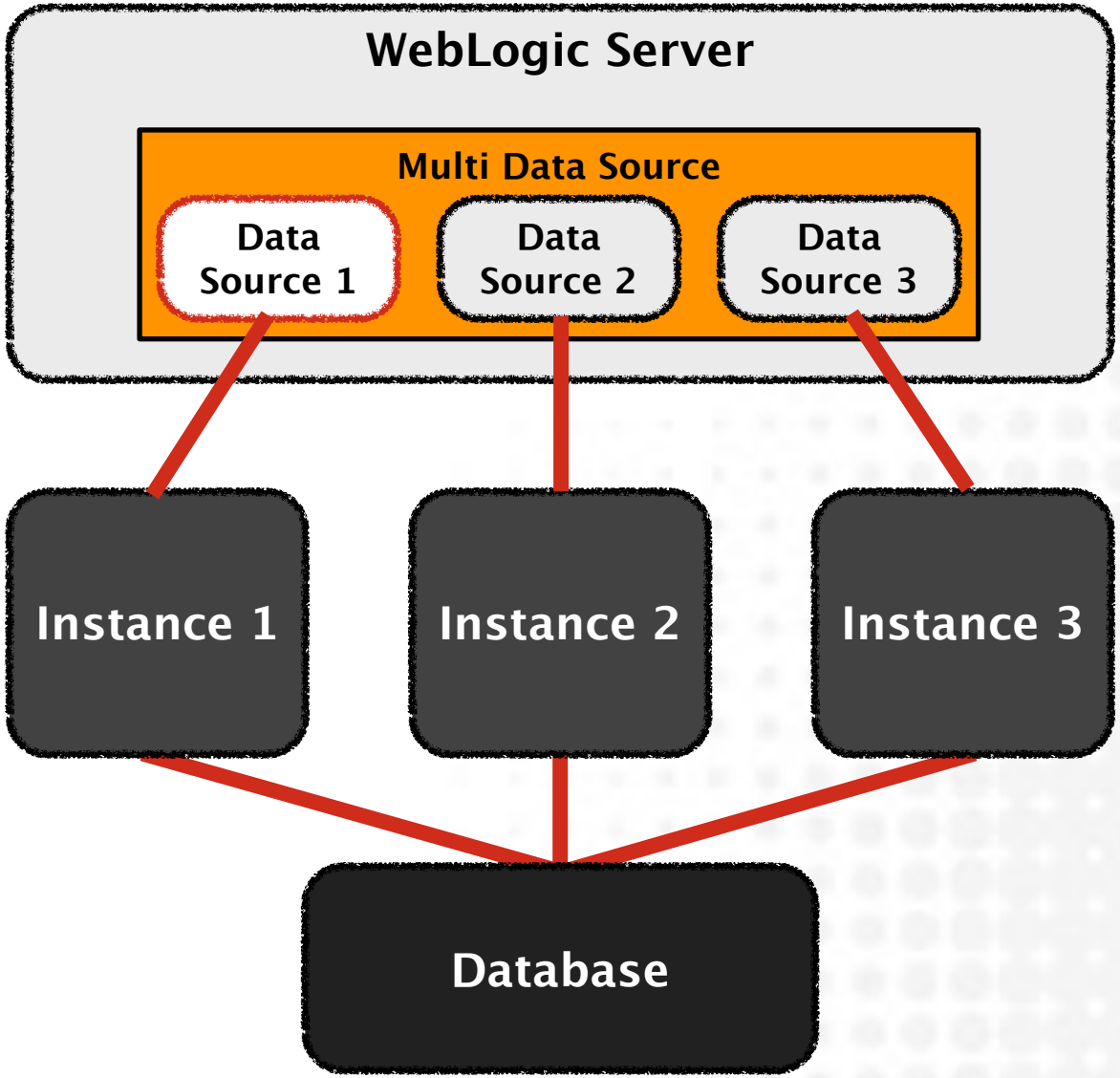
	MDS XA	MDS no-XA	RAC Services	Oracle native
Load balancing	Y	Y	Y	N
Failover	Y	Y	Y	Y
XA support	Y	N	Y	N
JDBC Store	N	Y	Y	Y
RAC Services	N	N	Y	Y

WebLogic Multi Data Source with Oracle RAC



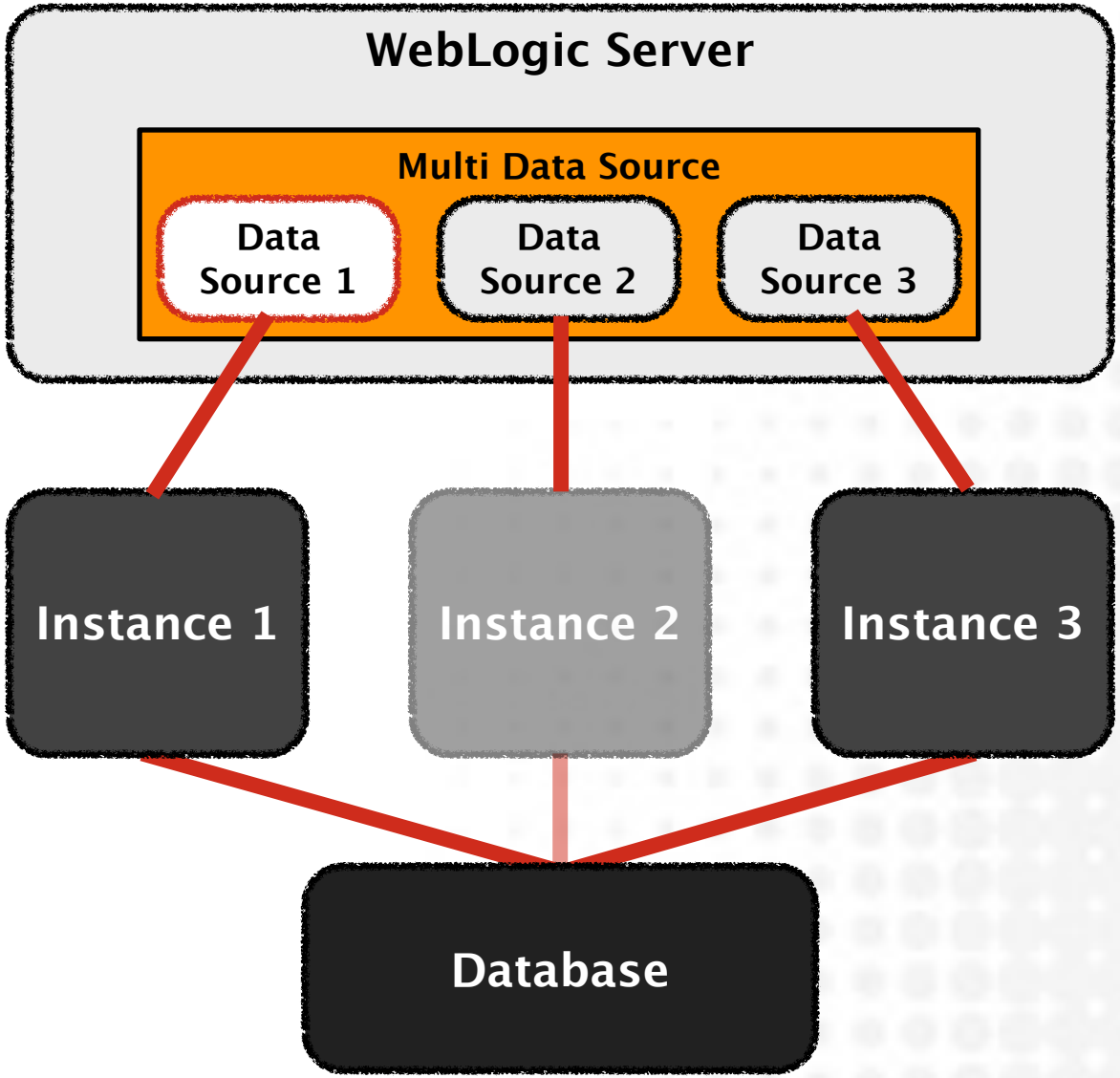
- App uses MDS
- MDS routes connection to one of its DS
  - failover or load balancing
- DS online management
  - Suspend
  - Shutdown
  - Add
  - Remove

WebLogic MDS for Failover with Oracle RAC



- Failover MDS
  - DS health checks
    - failure => DS dead
  - Can manually disable DS
  - Dead DS are re-tested
    - default 120 seconds

WebLogic MDS for Failover with Oracle RAC



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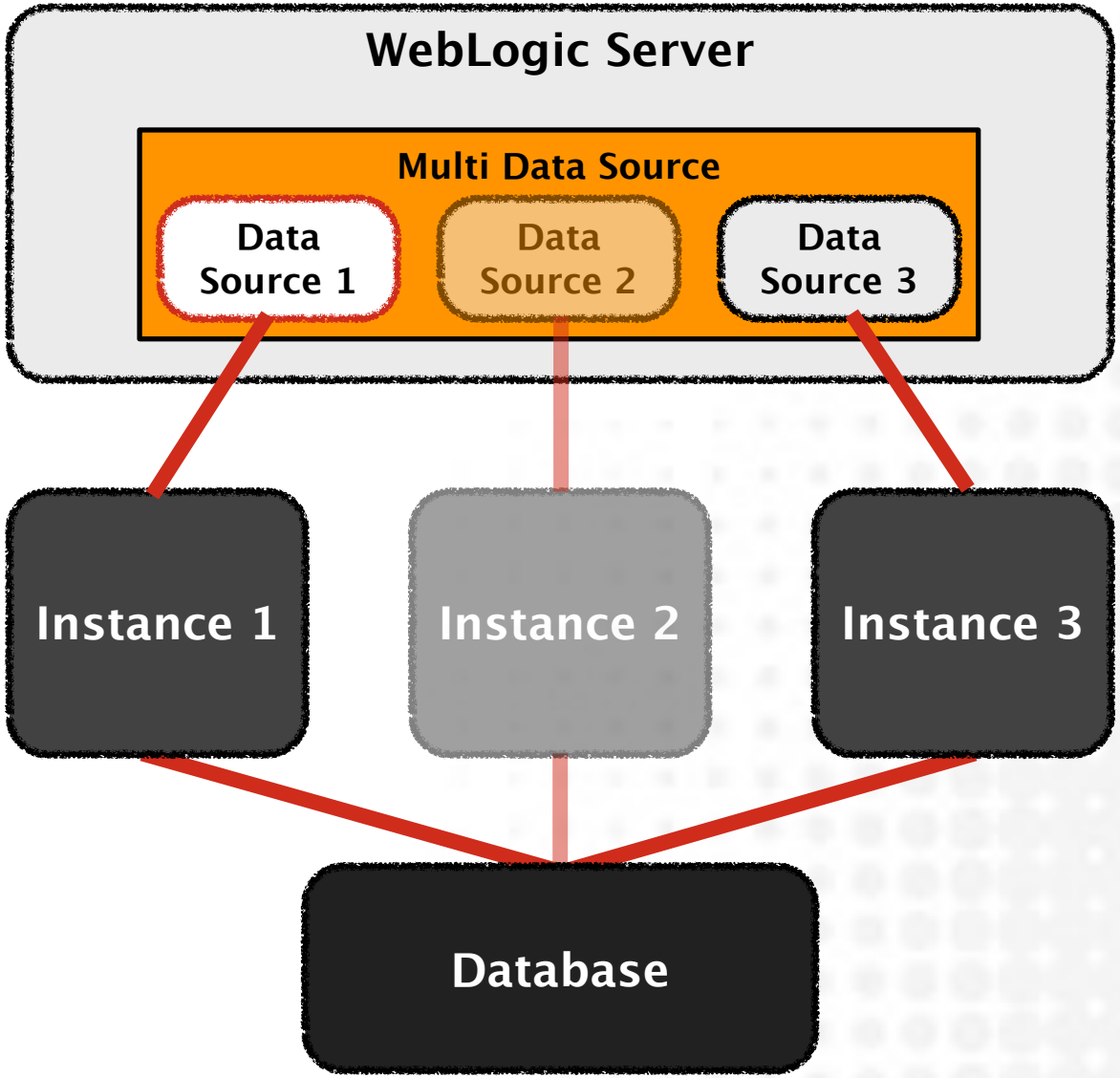

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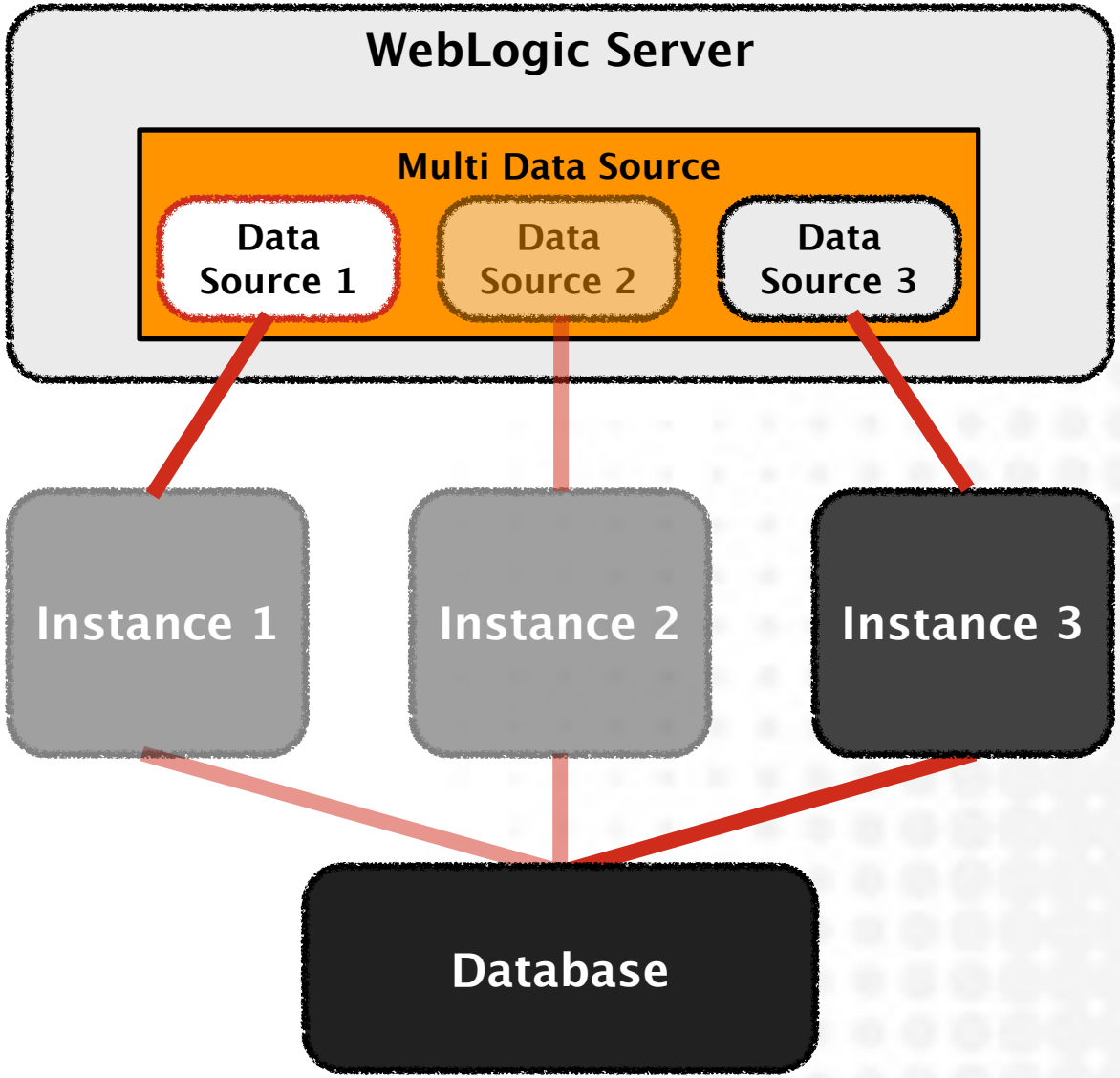

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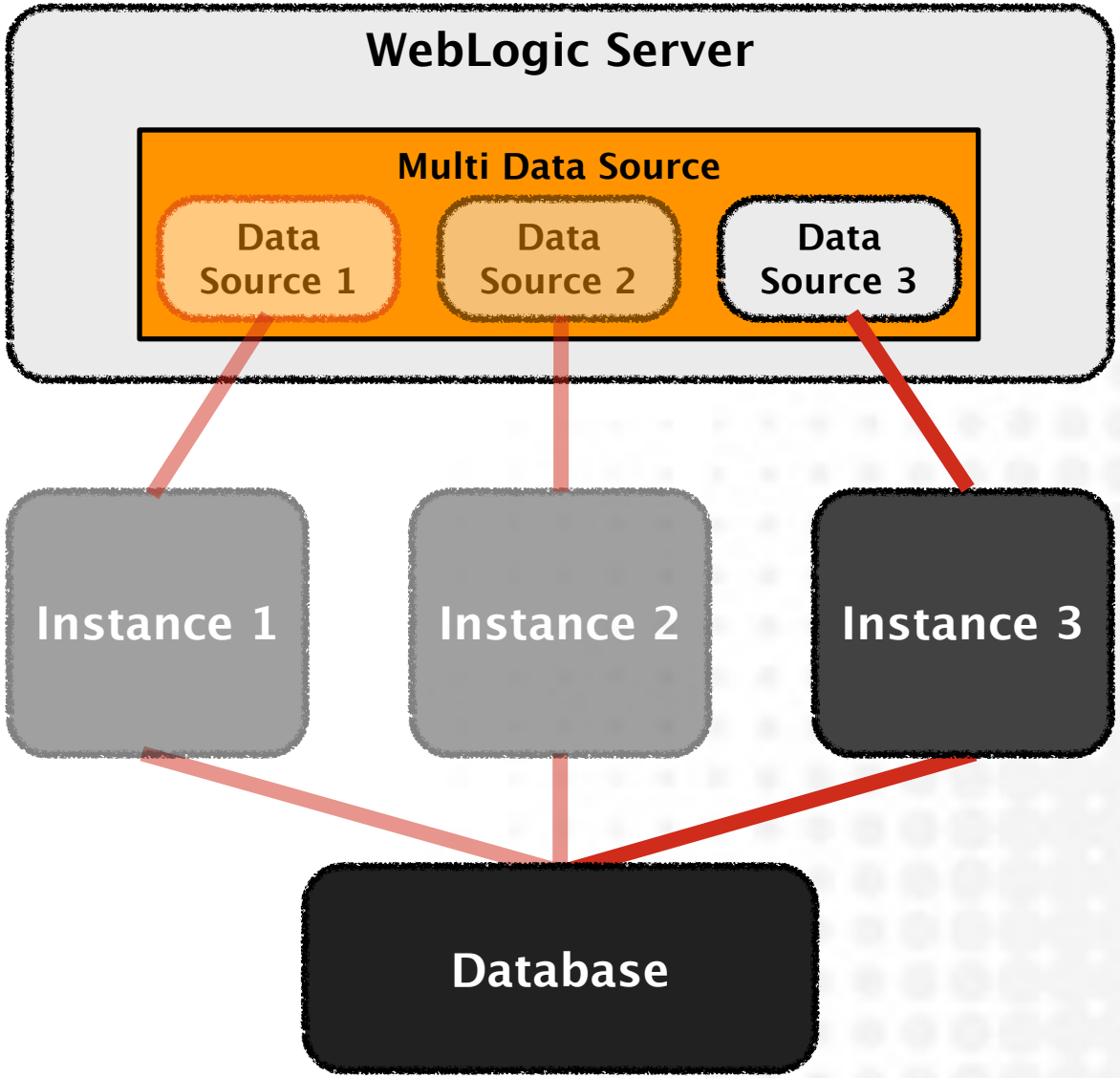

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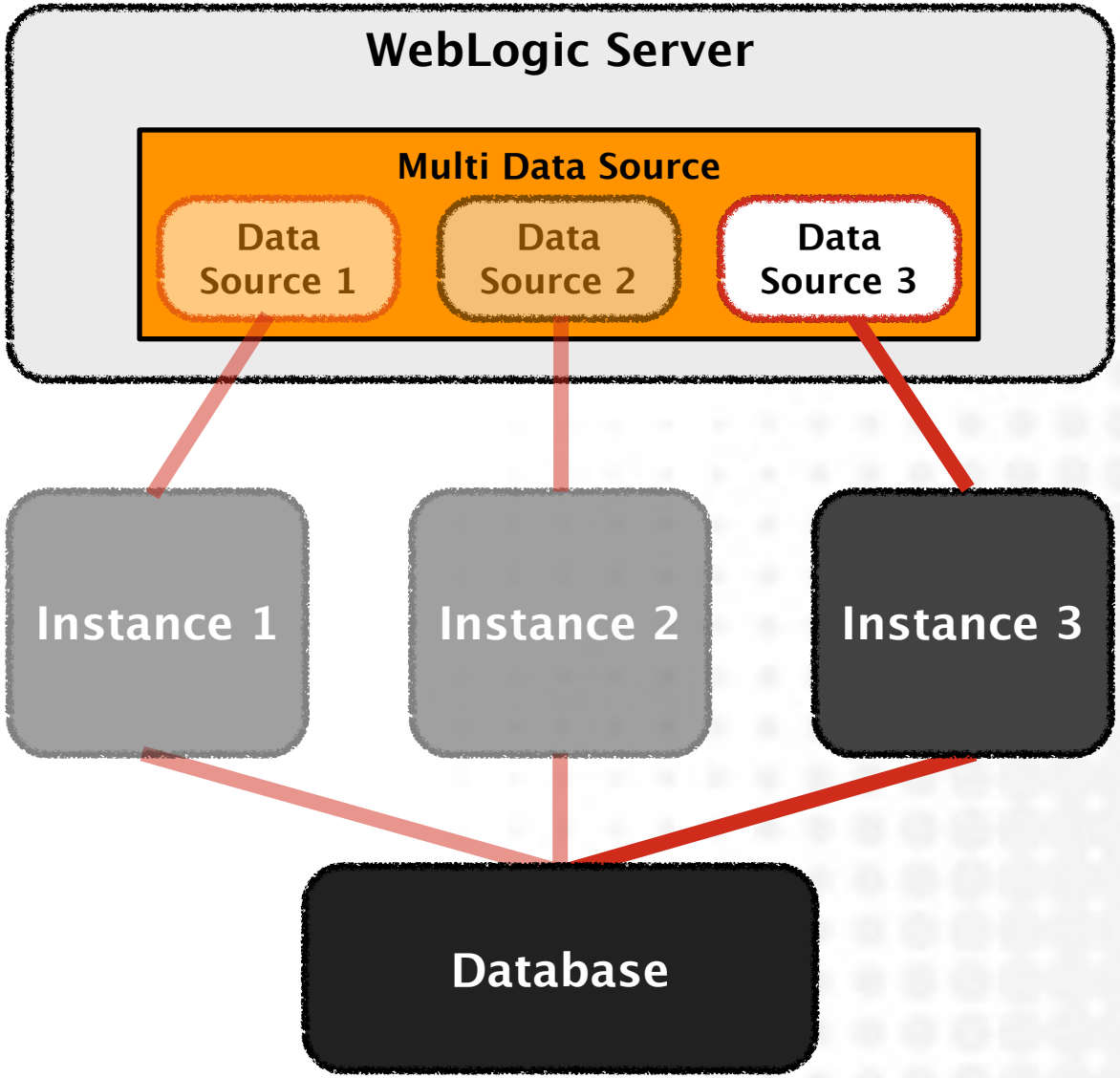

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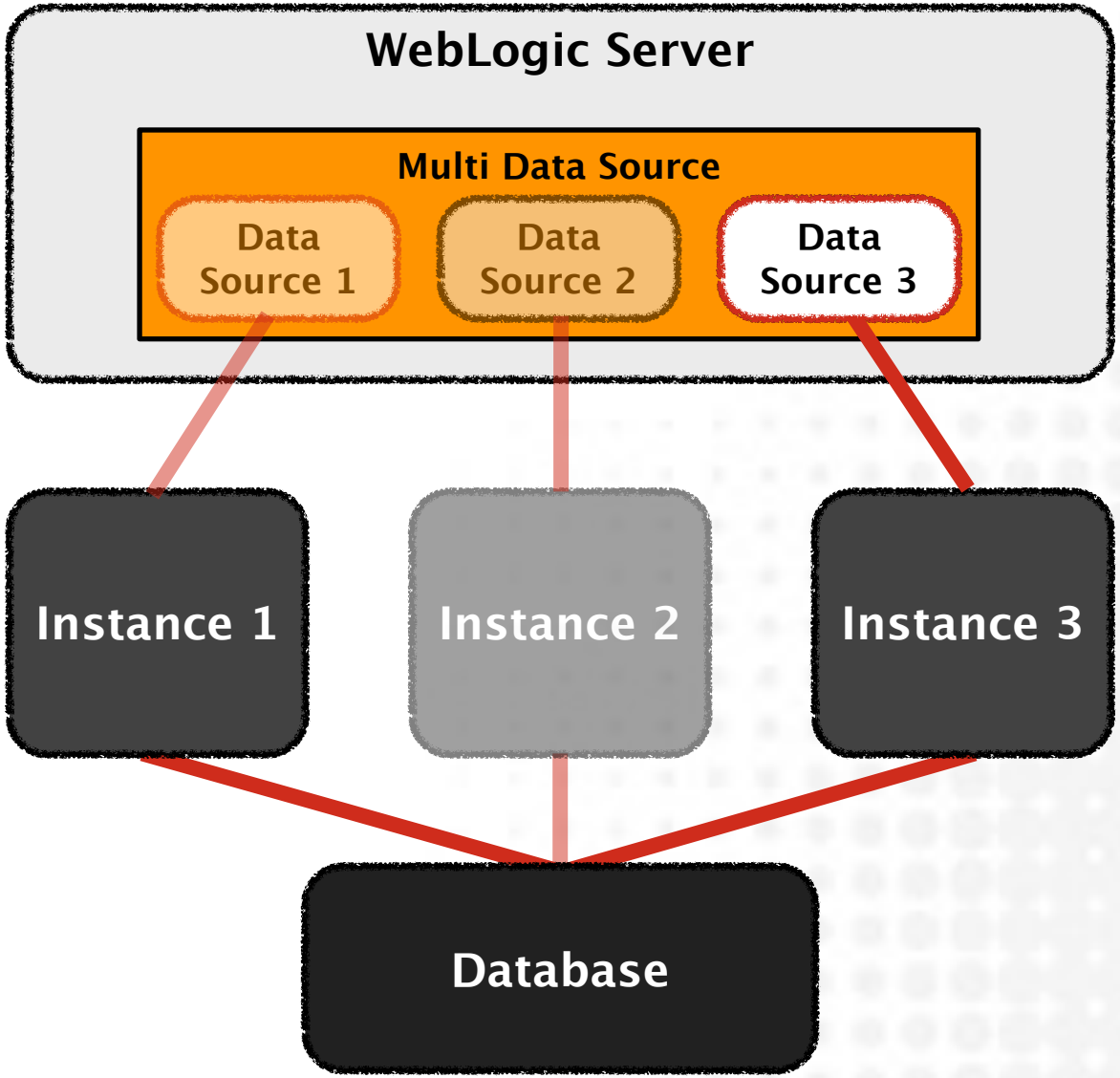
WebLogic MDS for Failover with Oracle RAC



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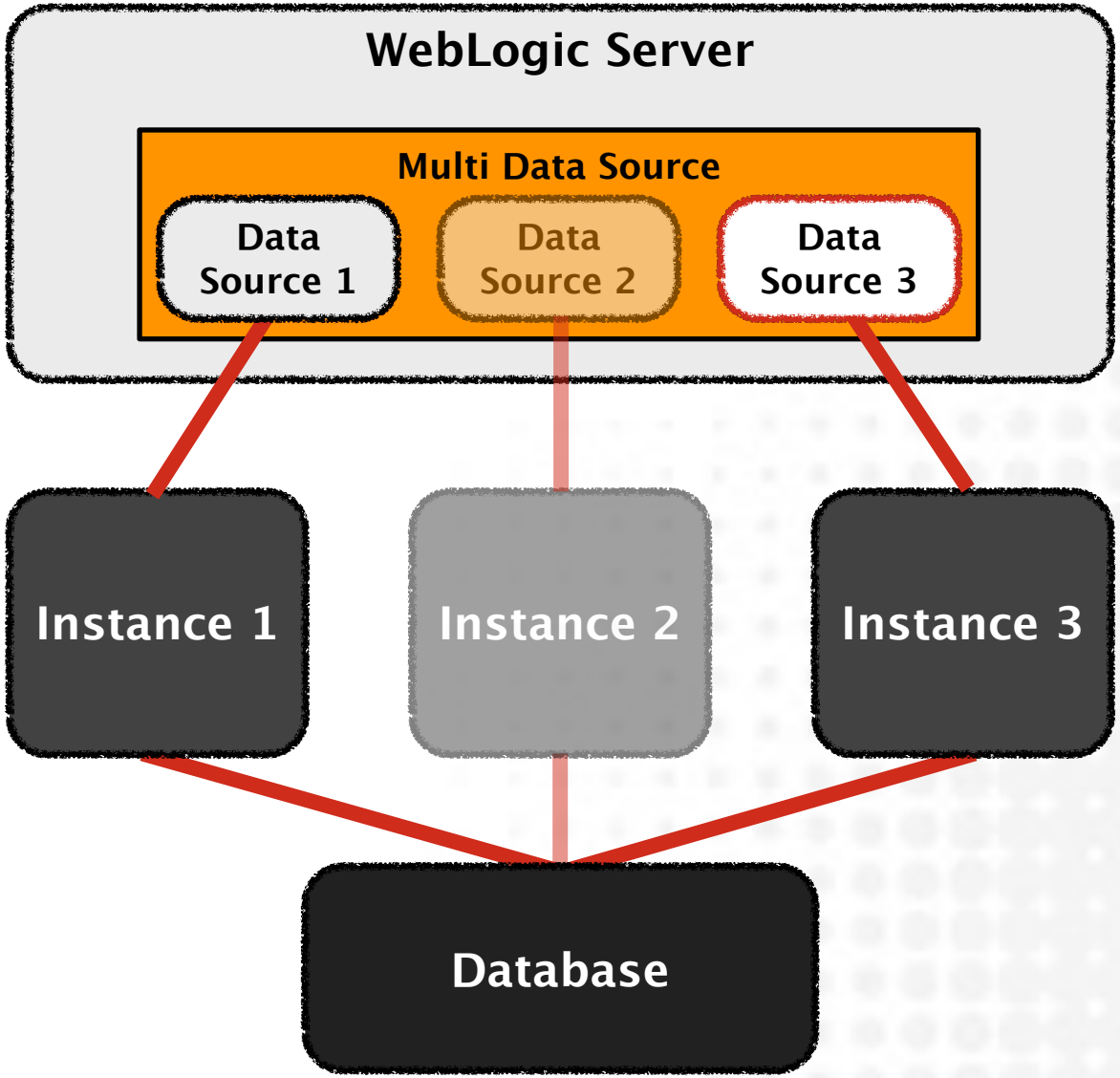
WebLogic MDS for Failover with Oracle RAC



- Failover MDS
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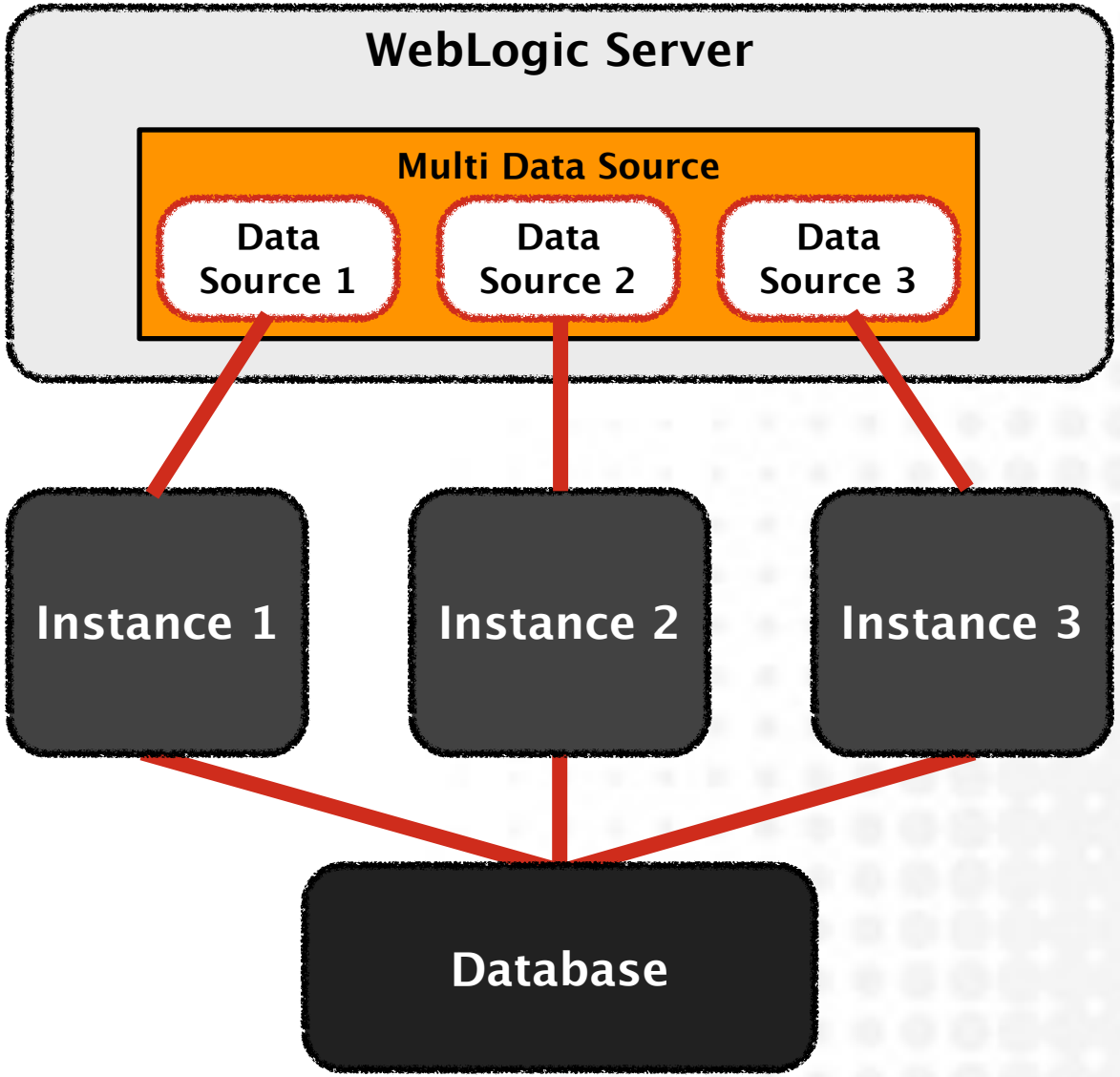
WebLogic Multi Data Source with Oracle RAC

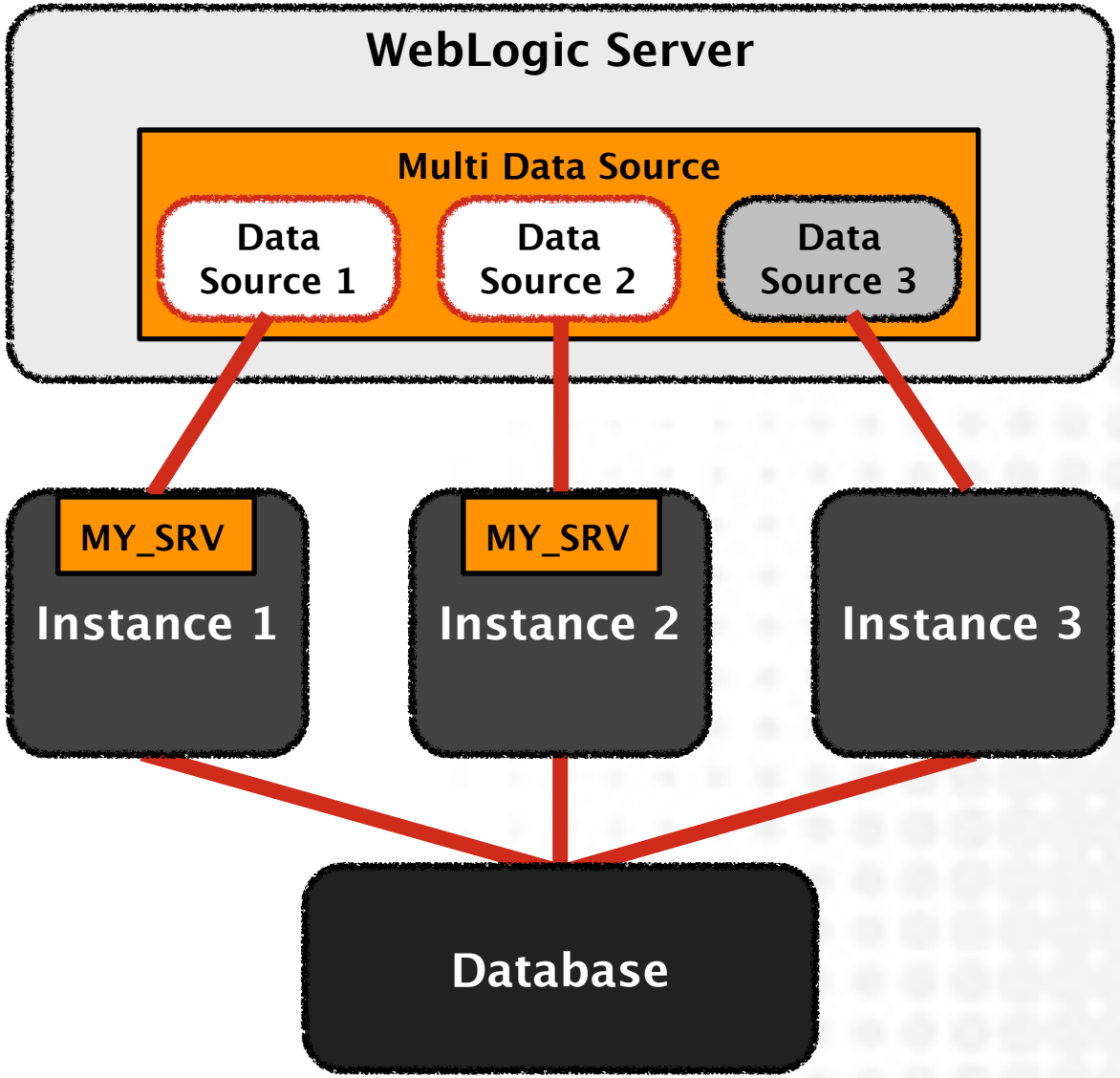


- Load Balancing
- MDS routes connection to all active DS
  - round-robin
  - failover is supported
  - no performance base load balancing like Oracle RLB
  - DS size doesn't affect LB

Oracle RAC: JDBC Pool vs WebLogic Multi DS

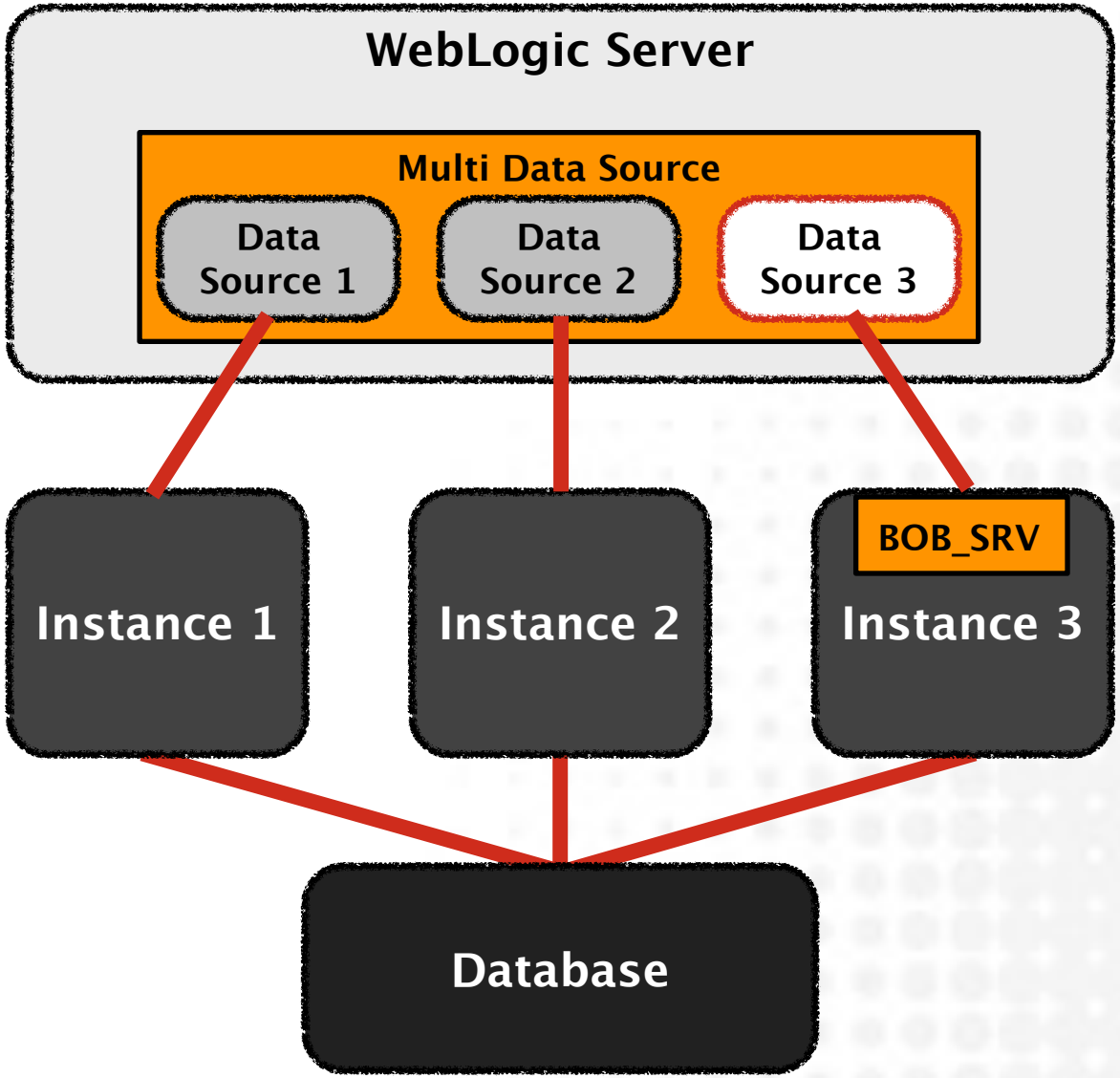
	Oracle JDBC	WLS Multi-DS
Connect failover	connect time failover	MDS failover
Connection load balancing	JDBC CLB	none
Server-side CLB based on service metrics / performance	Listener	none
Control connections layout	RAC Services	MDS config / members
Reconnect on failure	FCF	MDS managed
Run-time load balancing based on service performance	RLB / LBA	MDS LB round-robin
Use new (or recovered) instance	not until reconnect	automated by MDS

WebLogic Connections to RAC Services

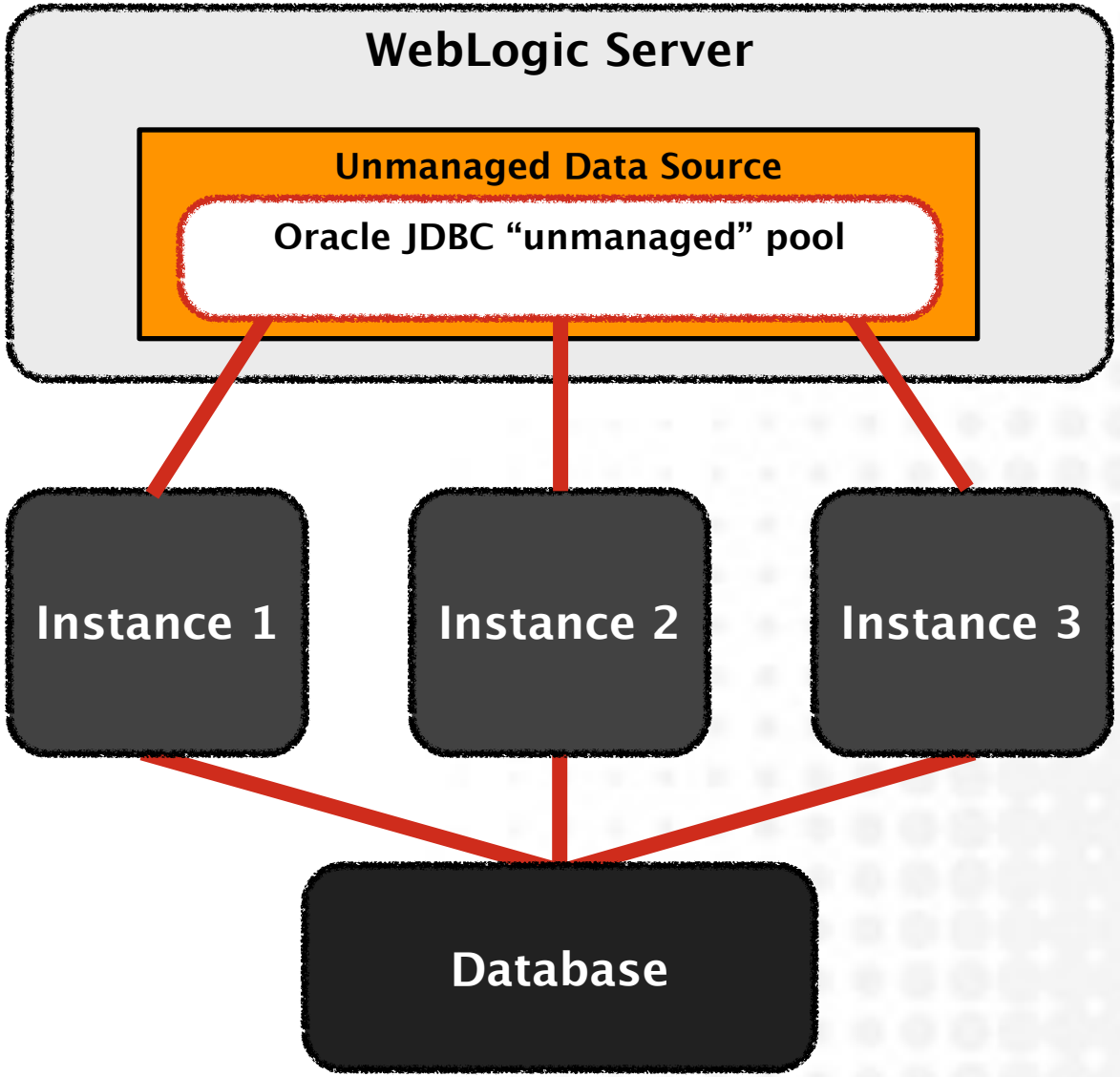


- Initial Capacity = 0
- DS must exist for every node that can run the service
- Services layout change requires WLS reconfiguration
- XA supported
  - branches of the same XA transactions are routed to the same instance
- MDS for load balancing
  - Failover makes little sense

WebLogic Connections to RAC Services



WebLogic Unmanaged DS with Oracle RAC



- JDBC native CLB
- DB Server - CLB_GOAL_LONG
- Failover - FCF
  - Based on HA events
- RLB does not work
- Connection testing not required

What's next?

- Book draw
  - Leave me your business cards

Q & A

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