



Live more,
Bank less

A wide-angle photograph of the Singapore skyline, featuring several prominent skyscrapers with glass facades. The buildings are reflected in a body of water in the foreground. The sky is blue with light, wispy clouds. A large, semi-transparent white circle is overlaid on the right side of the image, containing the main text.

Engineer **More**, Work **Less**

DBS Journey in Autonomous Database

Neighbours first, bankers second



DBS

**Whatever your
personal goals
and
family priorities are,
they are ours too**



Today – DBS, A Leading Financial Services Group in Asia

Headquartered in Singapore, with a growing presence in Greater China, Southeast Asia & South Asia

Best Digital Bank

in the World

Best Bank

in the World

Safest Bank

in Asia, "AA-" Rating

\$S\$16.5 billion

In Income

33,000 Start-Up

Future-Ready Workforce

Most Innovative

in Digital Banking

15% ROE

Profitable Performance

\$S\$743 billion

In Assets



**Over 280 branches
across 19 markets**



*Financials as of 2021

Powering the Best Bank for a Better World

DBS Journey

Before 2016

10-20%

Own

80-90%

Outsourced



Now

80-90%

Own

10-20%

Outsourced

~ 40,000 Staff
~ 10,000 Technologists

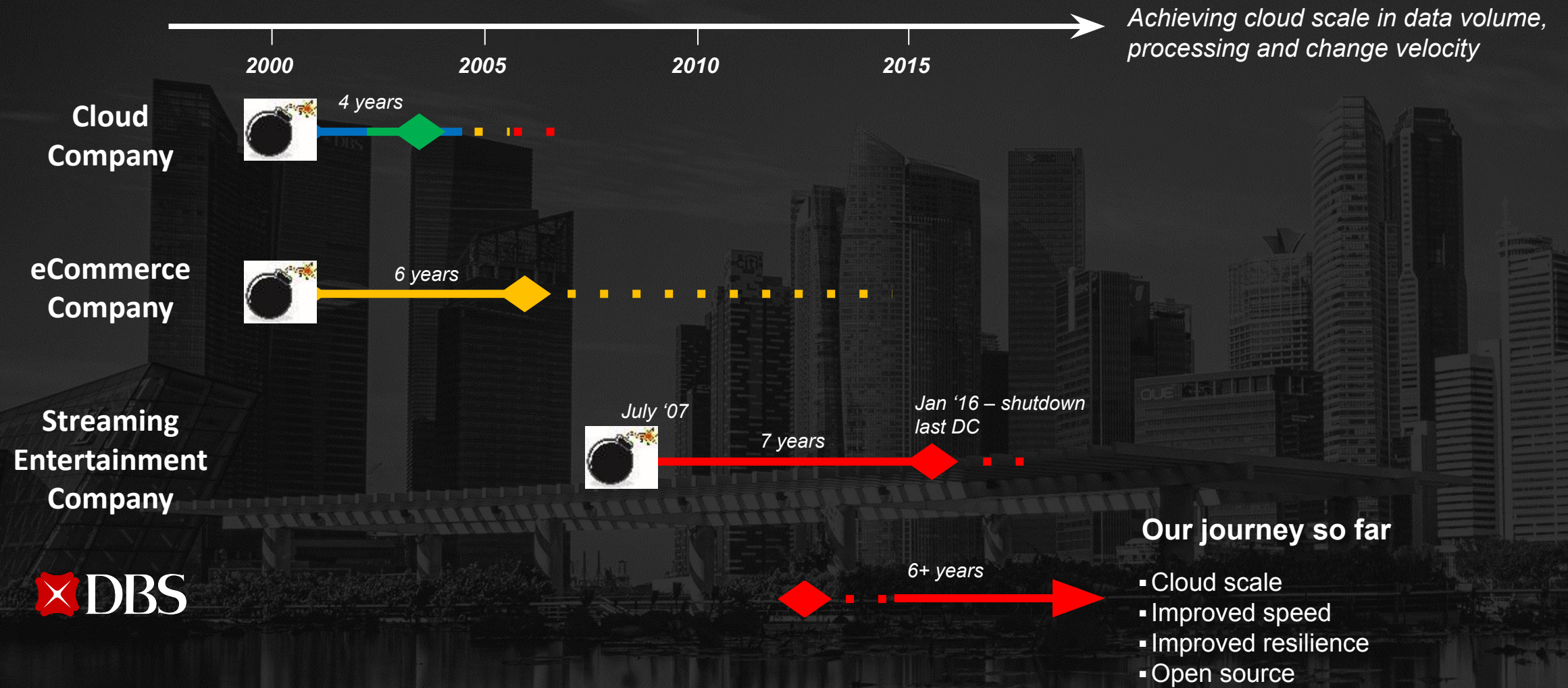


- Bank to Technology Centric
- Embedding ourselves in the customer journey
- Thinking and acting like a startup

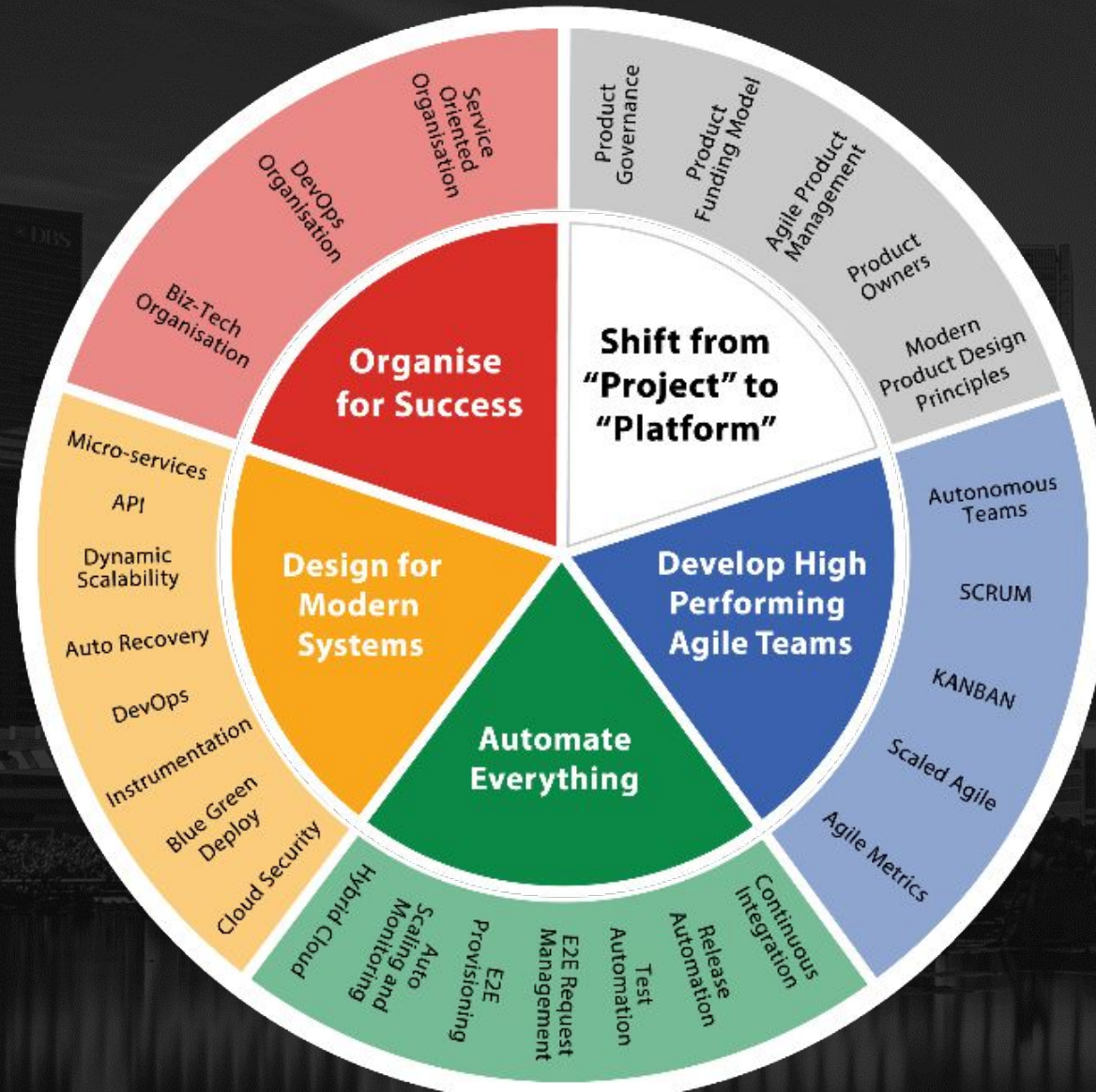
Being the D in



Tech transformation: History of Big Tech



We embarked on a strategy focused on 5 key elements to drive change throughout the organization



Everyone has a cloud strategy, but not all are the same

**CLOUD
LIPSTICK?**



Typical banks

**OR CLOUD TO
THE CORE?**



DBS

Reliability \neq Resiliency

Production



Disaster Recovery



99.999%
(1 out of 100,000)

Reliability ≠ Resiliency



> 100,000 flights per day

Commodity Hardware

- *4x to 5x cheaper than enterprise resilient hardware* ▲
- *2.8x more power efficient* ▲
- *Equal or higher processing capacity* ▲

Challenges

	Traditional	Cloud
HW Failure	< 1% failure	5-7% failure
Scale	3,000 OS 0 MariaDB	40,000 OS 6000 MariaDB/Maxscale Build/Change/Operate
Skillset	Oracle DBA MSSQL DBA DB2 DBA	MariaDB DBA (??)
Resiliency	Greenzone = Downtime	Greenzone ≠ Downtime

- **Pros and Cons of Traditional method vs Cloud way**
- **Mitigating the challenges into easy operation and maintenance**
- **Automations**

MariaDB - Autonomous Database in DBS

Spent More Time Innovating/Automating & Less Time Managing



Key Considerations for MariaDB deployment in DBS

1 Auto deployment for all regions and all zones

2 Zero downtime for security patches and minor bug fix patches

3 Zero downtime upgrade for major version upgrades

4 Ability to handle ESX reboots or failures

5 Split read queries and write queries for load balancing

6 Seamless deployment in adding more slaves during runtime

7 Ability to handle accidental data changes

8 Ability to handle up to 2 level failures

Day 0 (Deployment Pattern 1) : Standalone DB

For less critical or internal applications

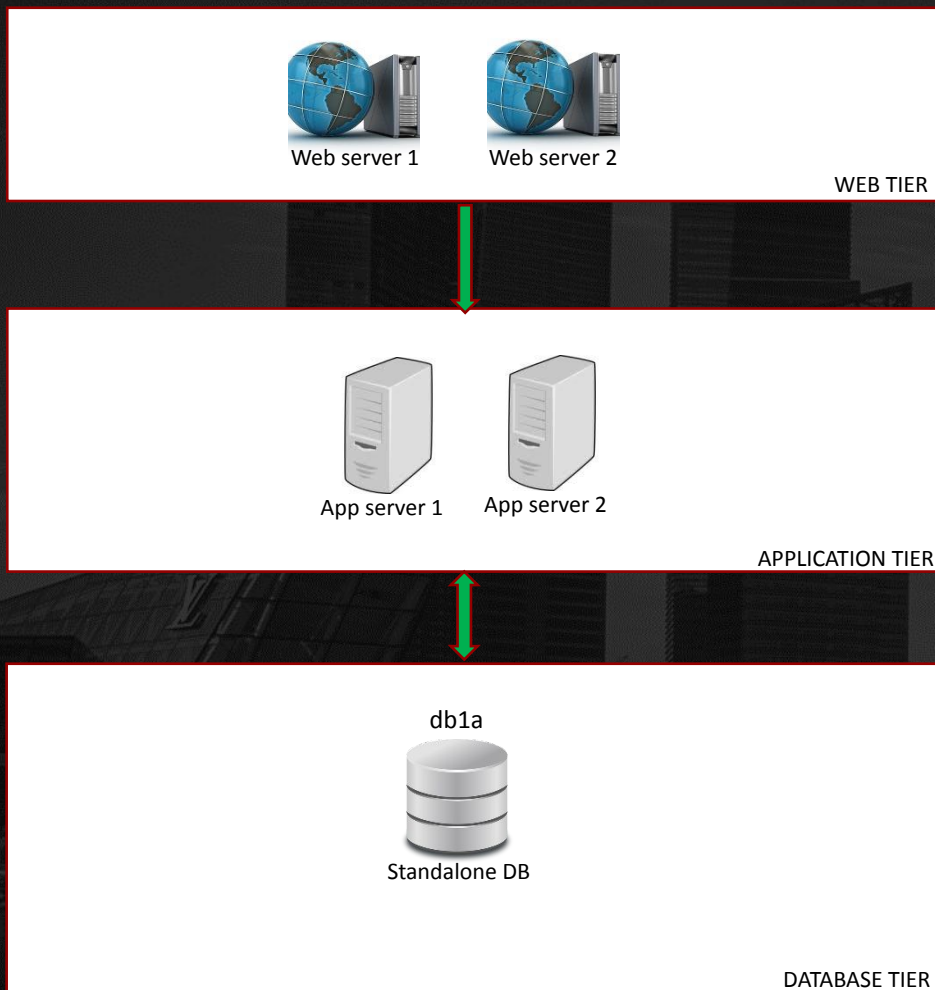
Resiliency = **Good**

Standalone DB

+ **VPC** redundancy (5-10mins)
+ **Backup** redundancy (~4-12hrs)

Constraints: app need to auto rebind to DB connection

1. Leverages on default VPC resiliency. VM reboot within 5-10mins.
2. Application must rebind upon MariaDB VM reboot, else recovery will take longer
3. Application service will be down during 5-10min of VM reboot
4. Standalone deployment is concentrated across less critical systems



Day 0 (Pattern 2) : Master – Slave with Maxscale

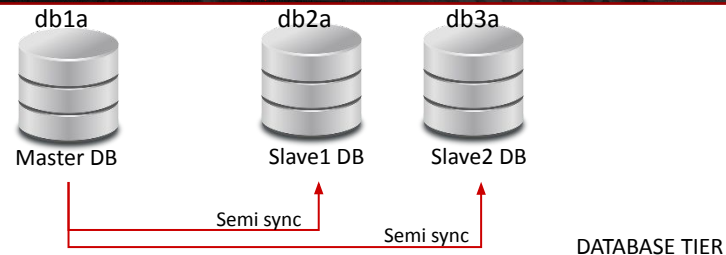
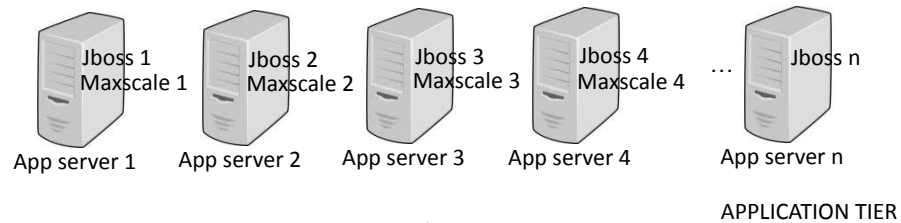
For applications requiring higher level of resiliency and redundancy

Resiliency = **Better**

2/3 Node Master Slave with Maxscale Auto failover



SLB – Load Balancer



**Master – Slave,
Maxscale**

+ **MariaDB** redundancy (30-40s unplanned)
+ **VPC** redundancy (5-10mins)
+ **Backup** redundancy (~4-12hrs)

Constraints: Will not be able to recover quickly from data corruption

1. Maxscale redundancy kick in to connect to Slave MariaDB (and promote Slave to Master) while VPC redundancy will reboot the failed master
2. Maxscale failover is transparent to app and will take < 1 min
3. Failed master will be bought up as slave and once sync up will provide additional redundancy. Cannot support 2 concurrent failure.
4. Read Write load balancing between Master and Slave nodes
5. App service will be down during Maxscale failover of < 1 min

Day 0 (Pattern 3) : Master – Slave with Maxscale & delayed replicas

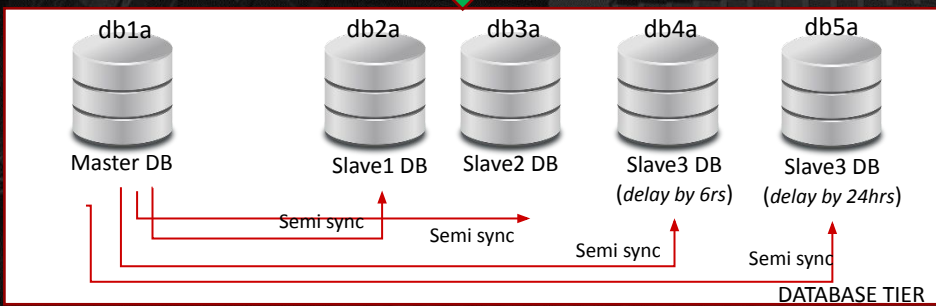
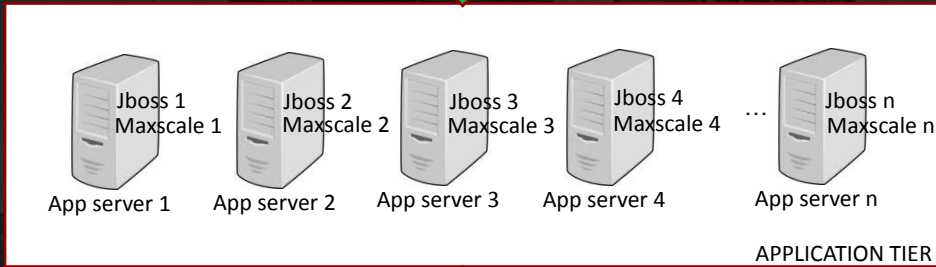
For applications requiring highest level of resiliency, redundancy and faster recovery

Resiliency = **Best**

2/3 Node Master Slave with Maxscale and 2 delayed Slaves (6hrs, 24hrs)



SLB – Load Balancer



Master – Slave,
Maxscale,
Delayed Replica

- + **MariaDB** redundancy (30-40s unplanned)
- + **VPC** redundancy (5-10mins)
- + **Backup** redundancy (~4-12hrs)
- + **Data Replication** redundancy (~1⁺⁺hr)

Constraints: Decision making should be quicker to activate delayed replica. Resync the other servers in the cluster (~4-12hrs).

1. Default Maxscale redundancy as describe in earlier page.
2. Additional Replica / Slave redundancy lagged by 6 or 24 hr. Protect against intentional or unintentional data corruption.
3. Delayed replica copy can be activated instantly but will depend on app design if need to roll to latest record.
4. Transaction roll forward time will depend on actual data change and likely be between 1-2 hrs.

Day 0 (Various Deployment Patterns)

Provisioning database VMs via DBS Technology Marketplace

Home / Build / Virtual Private Cloud (VPC) / MariaDB (PROD)

MariaDB

Database Build

RHEL | MariaDB

Service Provider: JAVIER | Version: 17

Product Enquiry: [MariaDB \(PROD\) Support](#)

4.3 (3 Reviews)

Disclaimer: Software license & maintenance is/are not covered under this provisioning, requestor is to manage this separately with their designated LOBT software coordinator/GPS.

Architecture:

- Standalone - 1
- Cluster(1M-1S) - 1 Master + 1 Slave
- Cluster(1M-2S) - 1 Master + 2 Slave
- Cluster(1M-1S-1D) - 1 Master + 1 Slave + 1 Delayed Replica
- Cluster(1M-1S-2D) - 1 Master + 1 Slave + 2 Delayed Replica
- Cluster(1M-2S-1D) - 1 Master + 2 Slave + 1 Delayed Replica
- Cluster(1M-2S-2D) - 1 Master + 2 Slave + 2 Delayed Replica

Environment:

Server Role (prefix is optional):

Max 2 cha... db

Server Type:

Active

Network Zone:

DC Location:

OS Version:

RHEL8.6

Additional Hard Disk:

MariaDB Version:

I acknowledge that I have read the CES House Rules:

I Acknowledge

Note: All fields are mandatory.

Instance and Pricing

INSTANCE TYPE	SPECIFICATIONS	Estimated Price
C1.S	Online Storage HDS G800 GB(GB)	<p>SGD 124.04*</p> <p>Per Month</p> <p><small>*price may vary based on usage</small></p> <p>SUBSCRIBE</p>
C1.M	Linux)	
C1.L	Managed DB Services(per DB Instance)	
M1.XS	VPC(VCPU)	
M1.S	VPC(VMemory)	

Description

DBS VPC provide an enterprise-class computing environment that gives users the benefits of security and simplicity. VPC auto-provisioning systems ensure that the VM are provisioned with the chosen CPU, memory, disk sizes to install, configure and harden the selected version of RedHat Operating System & MariaDB. Note: Tectia server is not installed by default. For scp file transfer, please request for Tectia server to be installed separately VM hostname with odd naming convention (i.e 1a,3a) will be automatically deployed in PDC site VM hostname with even naming convention (i.e 2a,4a) will be automatically deployed in SDC site Application shall be setup as per VM site affinity as described above. E.g. apps1a, apps3a, db1a, db3a as a active group in PDC where apps2a, apps4a, db2a, db4a as passive (or slave) group in SDC for site resiliency and failover.

Service Detail and Compatibility

Available Country	Singapore Taiwan Hong Kong Indonesia China China SJV India
OS Version	RHEL 8.6 64bit - STIG Hardened
MariaDB Version	v10.6.12 v10.5.19 v10.3.38

SUPPORT

Contact Number: 82014748

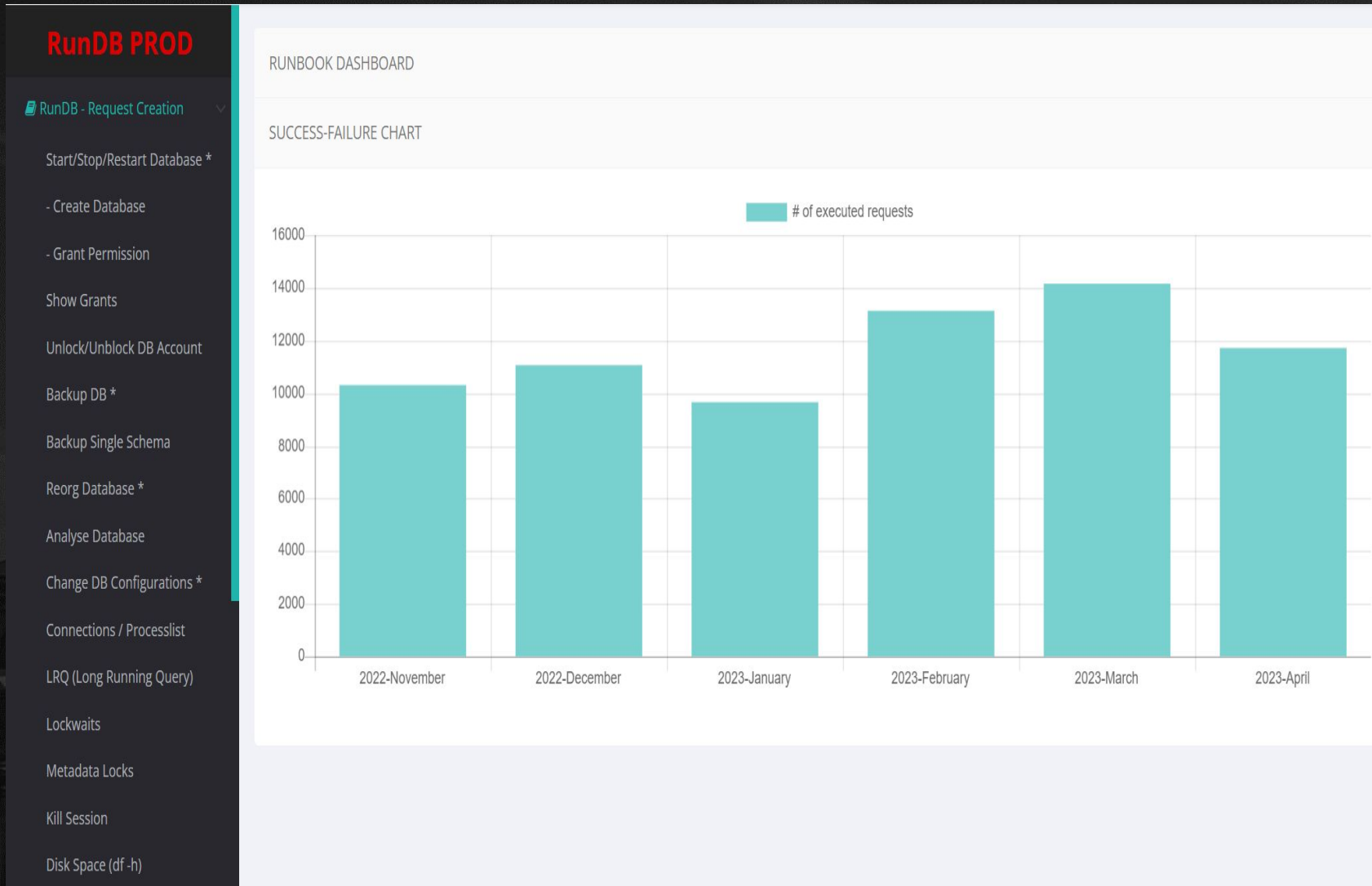
Product Enquiry: [MariaDB \(PROD\) Support](#)

General Enquiry: [Technology Marketplace Support](#)

1. Provisioning a database vm is a matter of 5-10 min.
2. Default security hardening is applied.
3. Default maintenance jobs are created and scheduled.
4. Linked with automated portals.
5. Application team can play around anytime they like (provision and decom made easy).

Day 1 - Remaining consideration for application database design – self service portal

To operate MariaDB as a service , self service portal (RunDB) is built.



Self service portal will help on,

1. Users to self perform common DBA oriented tasks.
2. DBAs/L1 support teams to easily perform L1 tasks.
3. Avoid request raising for repetitive tasks.
4. Perform tasks without shell access.
5. Perform tasks to avoid human errors.
6. Rollout changes instantly (with maker/checker) to avoid waiting time.

Day 2 - Remaining consideration for application database design – operation dashboard

To operate MariaDB as a critical infra, an operation dashboard is built.

LOB	App Code	Hostname	DB Status	LRQ	Lock W	File sys	Full Bkp	Incr Bkp	Invalid Vw	Analyze	ISCD	Pri key	Uptime	Version	EOL	Patch	DB Type
CT	GHKLDR	x01gghkldb1a	■	■	■	■	■	■	■	■	■	■	40 Days	10.6.9	■	■	Master
CBGT	H2OO	x01gh2oodb3a	■	■	■	■	■	■	■	■	■	■	41 Days	10.5.16	■	■	Slave
CBGT	SBIE	x01gsbiedb2a	■	■	■	■	■	■	■	■	■	■	55 Days	10.6.11	■	■	Master
CBGT	SBIE	x01gsbiedb4a	■	■	■	■	■	■	■	■	■	■	70 Days	10.6.11	■	■	Standalone
FR	ISIN	x01gisindb3a	■	■	■	■	■	■	■	■	■	■	5 Days	10.5.8	■	■	Slave
ITT	SPE	x01gspedb1a	■	■	■	■	■	■	■	■	■	■	47 Days	10.6.11	■	■	Slave
CT	GHKLDR	x01gghkldb2a	■	■	■	■	■	■	■	■	■	■	40 Days	10.6.9	■	■	Slave
MOT	ALM	x01galmdb1a	■	■	■	■	■	■	■	■	■	■	2 Days	10.5.13	■	■	Standalone
CBGT	SBIE	x01gsbiedb3a	■	■	■	■	■	■	■	■	■	■	55 Days	10.6.11	■	■	Slave
ITT	SPE	x01gspedb2a	■	■	■	■	■	■	■	■	■	■	47 Days	10.6.11	■	■	Master
IBGT	AOS	x01gaoshkdb1a	■	■	■	■	■	■	■	■	■	■	145 Days	10.5.8	■	■	Slave
MOT	RAMM	x01grammdb1a	■	■	■	■	■	■	■	■	■	■	13 Days	10.6.12	■	■	Standalone
FR	IWF	x01giwfadb1a	■	■	■	■	■	■	■	■	■	■	60 Days	10.5.16	■	■	Slave
MOT	LCRS	x01glcrsdb1a	■	■	■	■	■	■	■	■	■	■	2 Days	10.6.12	■	■	Standalone
IBGT	AOS	x01gaoshkdb2a	■	■	■	■	■	■	■	■	■	■	145 Days	10.5.8	■	■	Master
CT	OCCCN	x01gocindb1a	■	■	■	■	■	■	■	■	■	■	6 Days	10.6.11	■	■	Master
CT	OCCCN	x01gocindb2a	■	■	■	■	■	■	■	■	■	■	6 Days	10.6.11	■	■	Slave
CT	BFRS	x06gbfrsdb1a	■	■	■	■	■	■	■	■	■	■	134 Days	10.5.15	■	■	Standalone
FR	IWF	x01giwfadb2a	■	■	■	■	■	■	■	■	■	■	60 Days	10.5.16	■	■	Master
IBGT	RPBS	x01grbpsmdb1a	■	■	■	■	■	■	■	■	■	■	159 Days	10.6.8	■	■	Master
IBGT	SMEP	x01gi3smdb1a	■	■	■	■	■	■	■	■	■	■	166 Days	10.6.8	■	■	Slave
FR	OFCRMTW	x01gcrtdb3a	■	■	■	■	■	■	■	■	■	■	5 Days	10.5.8	■	■	Slave
FR	PCT-IN	x06gpcindb1a	■	■	■	■	■	■	■	■	■	■	166 Days	10.6.8	■	■	Master
ITT	TRAX-ID	x07tridb1a	■	■	■	■	■	■	■	■	■	■	25 Days	10.6.11	■	■	Master
FR	IWF	x01giwfdb1a	■	■	■	■	■	■	■	■	■	■	60 Days	10.5.8	■	■	Master
IBGT	SMEP	x01gi3smdb2a	■	■	■	■	■	■	■	■	■	■	166 Days	10.6.8	■	■	Master
FR	PCT-IN	x06gpcindb2a	■	■	■	■	■	■	■	■	■	■	166 Days	10.6.8	■	■	Slave
CT	RPS	x01grpsdb1a	■	■	■	■	■	■	■	■	■	■	22 Days	10.6.11	■	■	Standalone
ITT	TRAX-ID	x07tridb2a	■	■	■	■	■	■	■	■	■	■	25 Days	10.6.11	■	■	Slave
CBGT	TDIN	x01glvdb2a	■	■	■	■	■	■	■	■	■	■	25 Days	10.6.11	■	■	Slave
CE	BPCP	x11gbpcpdb1a	■	■	■	■	■	■	■	■	■	■	56 Days	10.3.37	■	■	Standalone
FR	IWF	x01giwfdb2a	■	■	■	■	■	■	■	■	■	■	40 Days	10.5.8	■	■	Slave
IBGT	RPBS	x01grbpsmdb2a	■	■	■	■	■	■	■	■	■	■	32 Days	10.6.8	■	■	Slave
FR	PCT-IN	x06gpcindb3a	■	■	■	■	■	■	■	■	■	■	166 Days	10.6.8	■	■	Slave
FR	IWF	x01giwfdb3a	■	■	■	■	■	■	■	■	■	■	60 Days	10.5.8	■	■	Slave
CT	CNGW	x05cngwdb1a	■	■	■	■	■	■	■	■	■	■	8 Days	10.6.12	■	■	Master

Total : 1470 | Full failed : 1 | Incr failed : 3 | LRQ : 9 | Lockwait : 1 | Uptime : 18 | Pri ky issue : 1067 | File sys issue (Warning) : 39 | Repl lag : 2 | Invalid view : 29 | Analyze fail : 102

Dashboard to detect the following

1. Availability and issue detection
2. Long running queries
3. Lock waits
4. Database backup
5. Security hardening
6. File system capacity utilisation
7. Patch Status
8. EOS/EOL Status

Day 2 - Remaining consideration for application database design – operation dashboard

To operate MariaDB as a critical infra, database patch dashboard is built.

Schedule Patching

DB *
MariaDB

Environment *
PROD

Unit *
CES

App Code *
CLDD

Schedule Date * [View Available Slots](#)
2023-05-10

Slot Time *
00:00 20 02:00 20 04:00 20 08:00 20 10:00 20 12:00 20
14:00 19 16:00 20 18:00 20 20:00 20 22:00 20

Host(s)
Search host...
x01gclddb1a ~ 10.5.19
x01gclddb2a ~ 10.6.11
x01gclddb5a ~ 10.6.11
x18gcldmonyog1a ~ 10.6.11

Selected Host(s) *
Search host...

Submit

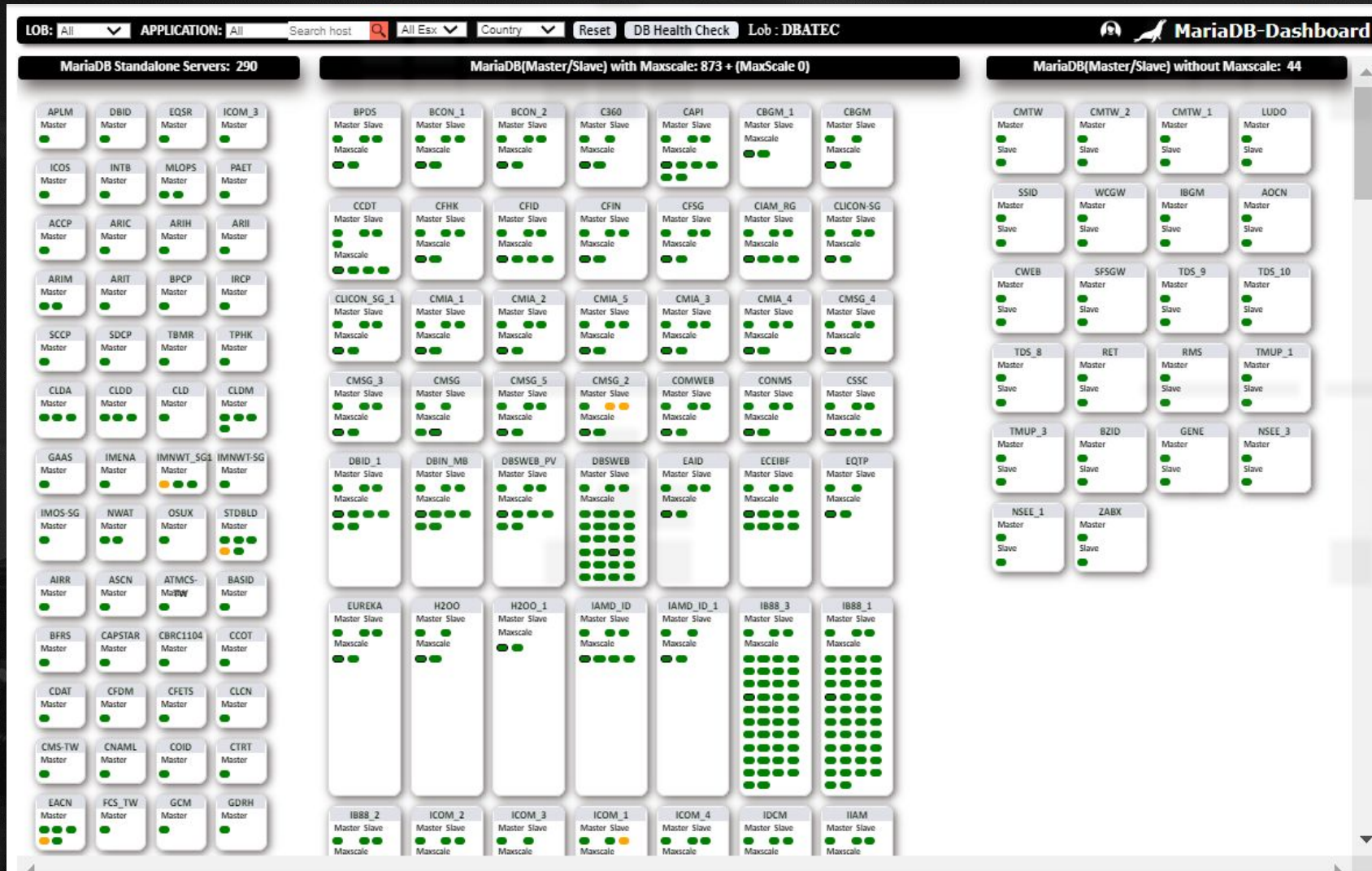
Maximum servers allowed to patch per day : 220
Maximum servers allowed to patch per slot : 20

Dashboard to serve the following

1. Database Patch status
2. Patch Reporting
3. Patch Scheduler
4. Patch Tracker

Day 2 - Remaining consideration for application database design – operation dashboard




To operate MariaDB as a critical infra, an operation dashboard is built.



Dashboard to detect the following

1. Availability and issue detection
2. MariaDB Cluster status
3. MariaDB Replication status
4. Database backup
5. File system capacity utilisation

DBS Virtual Private Cloud is engineered for speed, cost efficiency and resiliency

		Before	Now	Industry Average
Cost Efficiency 	Drive towards cloud <i>(% of workload virtualised)</i>	< 3%	> 99%	50%
	Efficiency of cloud <i>(# of workload on single hardware)</i>	1:5 – 1:8	>1:100	1:20 ⁺
	Data centre footprint <i>(in sqft)</i>	28,000	7,500	67,500
Resiliency & Scalability 	Resiliency of cloud infra <i>(Ability to swing workload to alternate site)</i>	Passive DR	Active-active	Passive DR
	Capacity to scale <i>(buffer in data centre site for future growth)</i>	< 10%	10x	Maybe
Change Cadence 	System provisioning <i>(Provision infra for new applications)</i>	4 months	Minutes	Minutes
	Aggressive automation <i>(System admin to workload ratio)</i>	< 1:50	1:1,200 (OS) 1:650 (DBA)	1:272 (OS) 1:154 (DBA)

What next ?

- 1. MariaDB, Maxscale on Containers/Kubernetes**
 - 2. MariaDB 23.x**
 - 3. Maxscale 23.x**
 - 4. Ransomware protection**
 - 5. Seamless downgrade**
- etc**

Thank You