Design Document

Prepared for:

Danamon

EDB PGD IMPLEMENTATION FOR DBANK PRO

011/DD-ITGI/VII/24

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Version 1.1

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INDONESIA

This document serves as an agreement between IT Group Indonesia and Customer that the design workshop conducted was successful.

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Revision History

This section provides all revisions on this document that define the revision date, version, who did the revision and the summary.

Version	Date	Author	Version Summary
1.0	16th July 2024	Prabowo Satria	Initial version
1.1	25th July 2024	Prabowo Satria	Added feedback from Danamon Team (Section 2.1.1 & 2.1.2)

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1. Introduction

1.1. Document Purpose

This document describes the architectural design of EDB PDG for PT. Bank Danamon Indonesia (Persero) Tbk. This document contains introduction, solution design, in scope, out of scope, assumptions, and approval. This document is used by both parties between PT. IT Group Indonesia with PT. Bank Danamon Indonesia (Persero) Tbk during the project.

1.2. Definition of Terminologies

No.	Terminology	Description
1	TPA (Trusted Postgres Architect)	A tool that uses Ansible to deploy and maintain Distributed Postgres EDB.Trusted Postgres Architect is a tool that uses Ansible to deploy and maintain Distributed Postgres EDB.
2	EDB PGD (EDB Postgres Distributed)	Provides multi-master replication and data distribution with advanced conflict management, data-loss protection, and throughput up to 5X faster than native logical replication.
3	PGD Proxy	A process that acts as an abstraction layer between the client application and Postgres. It interfaces with the PGD consensus mechanism to get the identity of the current write leader node and redirects traffic to that node.
4	EPAS (EDB Postgres Advanced Server)	EPAS combines all the features of PostgreSQL with additional enterprise-class functionality to enhance enterprise database performance and security.
5	PEM (Postgres Enterprise Manager)	A tool designed to help database administrators, system architects, and performance analysts in managing, monitoring, and tuning PostgreSQL and EPAS database servers.
6	BARMAN (Backup and Recovery Tool)	A tool used for centralized backup management for EPAS with simplified backup and recovery management. It allows performing remote backups of multiple servers.

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1.3. Related Document

No.	Nomor Dokumen	Sumber	Nama Dokumen	Deskripsi
1	004/DWS-ITGI/VII/24	PT. IT Group Indonesia	[Danamon - EDB PGD] Design Workshop Slide	Presentation slides used in design workshop session with PT. Bank Danamon Indonesia.

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2.Solution Design

The purpose of this section is to describe the scope of the design.

2.1. Design Overview

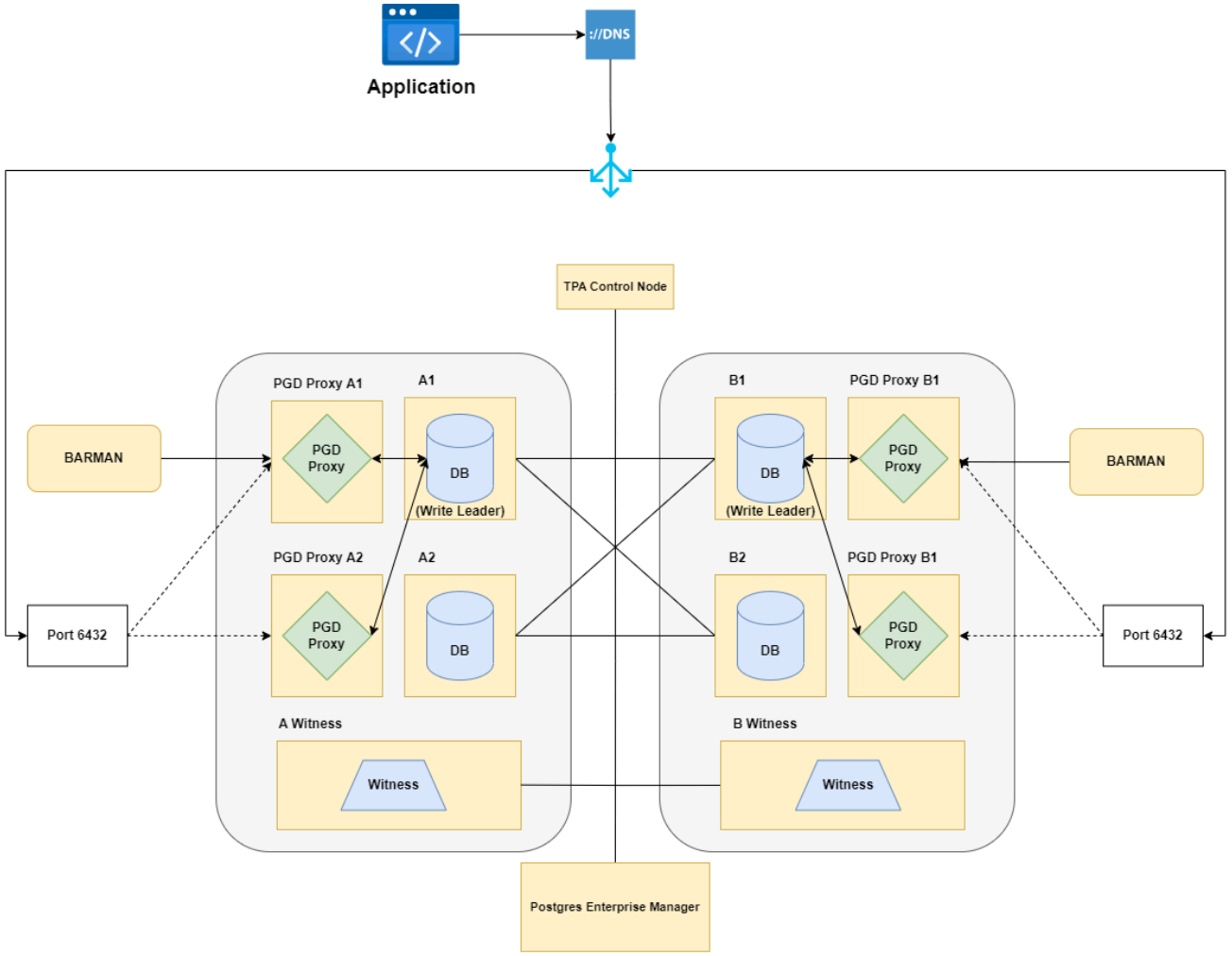

Figure 1. Best Practice Design

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Caption:

PGD Proxy	High Availability Routing for Postgres directs all application traffic from a central or regional location to a single PGD node at any given time in a semi-exclusive manner. This node is designated as the lead master and serves as the primary write target to minimize potential data conflicts.
Witness Server	In a cluster with an even number of nodes, it may be advantageous to create additional nodes as witness servers to facilitate automatic failover.
Barman Server	Barman serves as a backup method, while PGD is designed as a distributed and highly available system. In the event of the loss of one or more nodes in the cluster, Barman can be utilized for point-in-time recovery.
PEM Server	The server is utilized as a central tool for monitoring and managing Postgres
TPA control node	The server serves as the central configuration center for PGD.
Shadow master	The database replication server is configured as read-only
Write leader	The primary database server operates in a master-master configuration. The role of the primary master can be identified using the Harp Manager, and promotion as lead master can be controlled with the harp manager.

2.1.1. Performance Optimization

To achieve optimal performance in transactions, configuration adjustments should be made both at the database and operating system levels. At the database level, this involves tuning parameters related to CPU, memory, and storage. At the operating system level, adjustments to kernel parameters are also necessary.

- Tuning the System
  When it comes to PostgreSQL performance, tuning the operating system gives you extra opportunities for better performance.

- Optimizing the filesystem
  Another tuning point is disks. PostgreSQL does not rely on atime (the timestamp at which the file was last accessed) for the data files, so disabling them will save cpu cycles.

- Huge pages
  By default, the page size on Linux is 4kB. A typical PostgreSQL instance may allocate many GBs of memory, which will end up with potential performance problems with such a small page size. Also, given that these pages will be fragmented, using them for large data sets will end up with extra time for mapping them.
  Enabling huge pages on Linux will give a performance boost to PostgreSQL as it will allocate large blocks (huge pages) of memory all together.

- vm.swappiness
  Kernel parameter that can affect the performance of the database. This parameter is used to control the swappiness (swapping pages to and from swap memory into RAM) behavior on a Linux system. The value ranges from 0 to 100. It controls how much memory will be swapped or paged out. Zero means disable swap and 100 means aggressive swapping.

- vm.overcommit_ratio
  The percentage of RAM that is available for overcommitment. A value of 50% on a system with 2 GB of RAM may commit up to 3 GB of RAM.

- vm.dirty_background_ratio
  The percentage of memory filled with dirty pages that need to be flushed to disk. Flushing is done in the background. The value of this parameter ranges from 0 to 100; however, a value lower than 5 may not be effective and some kernels do not internally support it. The default value is 10 on most Linux systems. You can gain performance for write-intensive operations with a lower ratio, which means that Linux flushes dirty pages in the background. The value of **vm.dirty_background_bytes** depending on the disk speed.

- vm.dirty_background_ratio/dirty_backgrounds_bytes
  The flushing is done in the foreground, blocking the application. So **vm.dirty_ratio** should be higher than vm.dirty_background_ratio. This will ensure that background processes kick in before the foreground processes to avoid blocking the application, as much as possible. You can tune the difference between the two ratios depending on your disk IO load.

Parameter Name	Recommendation Values	Need Restart	Description
max_connections	1000 (Depend on Needs)	TRUE	The optimal number for max_connections is roughly 4 times the number of CPU cores. This formula often gives a very small number which doesn't leave much room for error. The recommended number is the GREATEST(4 x CPU cores, 100). Beyond this number, a connection pooler such as pgbouncer should be used.
shared_buffers	16GB	TRUE	This parameter has the most variance of all. Some workloads work best with very small values (such as 1GB or 2GB) even with very large database volumes. Other workloads require large values. A reasonable starting point is the LEAST(RAM/2, 10GB).
effective_cache_size	48GB	FALSE	This should be the sum of shared_buffers and the Linux buffer cache (as seen in the buff/ cache column of the free command).
maintenance_work_mem	3GB	FALSE	This determines the maximum amount of memory used for maintenance operations like VACUUM, CREATE INDEX, ALTER TABLE ADD FOREIGN KEY, and data-loading operations. These may increase the I/O on the database servers while performing such activities, so allocating more memory to them may lead to these operations finishing more quickly. The calculated value of 15% x (Total RAM - shared_buffers) / autovacuum_max_ workers upto 1GB is a good start.
checkpoint_completion_target	0.9	FALSE	This determines the amount of time in which PostgreSQL aims to complete a checkpoint. This means a checkpoint need not result in an I/O spike and instead aims to spread the writes over a certain period of time. The recommended value is 0.9.
wal_buffers	16MB	TRUE	This controls the amount of memory space available for back ends to place WAL data prior to sync. WAL segments are 16MB each by default, so buffering a segment is very inexpensive memory-wise. And larger buffer sizes have been observed to have a potentially very positive effect on performance in testing. Set this parameter to 64MB.
default_statistics_target	500	FALSE	Larger values increase the time needed to do ANALYZE, but might improve the quality of the planner's estimates. The default is 100. For more information on the use of statistics by the PostgreSQL query planner, refer to planner-stats.
random_page_cost	1.1	FALSE	If using SSD disks, the recommended value is 1.1.
effective_io_concurrency	200	FALSE	This parameter is used for read-ahead during certain operations and should be set to the number of disks used to store the data. However, improvements have been observed

Parameter Name	Recommendation Values	Need Restart	Description
			by using a multiple of that number. For SSD based disk, it is recommended to set this value to 200.
work_mem	32MB	FALSE	The recommended starting point for work_mem is ((Total RAM - shared_buffers)/ (16 x CPU cores)).
min_wal_size	1GB	FALSE	This can be used to ensure that enough WAL space is reserved to handle spikes in WAL usage, for example when running large batch jobs.
max_wal_size	32GB	FALSE	keep the ratio of timed to requested checkpoints as high as possible, whilst ensuring that we do not use more disk space for the WAL than we can afford. In an ideal situation there will be enough disk space available that we can set max_wal_size to a very large number to almost completely eliminate requested checkpoints. On high throughput systems this number might be in the tens or hundreds of gigabytes range.
max_worker_processes	16	TRUE	Sets the maximum number of background processes that the system can support following the number of CPU core. This parameter can only be set at server start. The default is 8.
max_parallel_workers_per_gather	4	FALSE	Sets the maximum number of workers that can be started by a single Gather or Gather Merge node. Parallel workers are taken from the pool of processes established by max_worker_processes, limited by max_parallel_workers. Note that the requested number of workers may not actually be available at run time. If this occurs, the plan will run with fewer workers than expected, which may be inefficient. The default value is 2. Setting this value to 0 disables parallel query execution.
max_parallel_workers	16	FALSE	Sets the maximum number of background processes that the system can support following the number of CPU core. This parameter can only be set at server start. The default is 8.
max_parallel_maintenance_workers	4	FALSE	Sets the maximum number of background processes that the system can support
autovacuum_max_workers	5	TRUE	This is the number of workers that autovacuum has. Default value 3 and requires a DB restart to be updated. Please note that each table can have only one worker working on it. So increasing workers only helps in parallel and more frequent vacuuming across tables.
checkpoint_timeout	900000	FALSE	Longer timeouts reduce overall WAL volume but make crash recovery take longer. The recommended value is a minimum of 15 minutes.

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Parameter Name	Recommendation Values	Need Restart	Description
cpu_tuple_cost	0.03	FALSE	Specifies the relative cost of processing each row during a query. It is currently set to 0.01, but this is likely to be lower than optimal and should be increased to 0.03 for a more realistic costing.
log_min_duration_statement	600000	FALSE	To log all the slow running query that happen during the process based on the threshold we set
log_autovacuum_min_duration	0	FALSE	log_autovacuum_min_duration Monitoring autovacuum activity will help in tuning it. Suggested value: 0.
log_temp_files	0	FALSE	Set to 0. This will log all temporary files created, suggesting that work_mem is incorrectly tuned.
wal_log_hints	on	TRUE	This parameter is required in order to use pg_ rewind Set it to 'on'.

The following are the initial tuning recommendations for clusters:

Pre-prod tuning

max_connections = 200
shared_buffers = 2GB
effective_cache_size = 6GB
maintenance_work_mem = 512MB
checkpoint_completion_target = 0.9
wal_buffers = 16MB
default_statistics_target = 100
random_page_cost = 1.1
effective_io_concurrency = 200
work_mem = 5242kB
huge_pages = off
min_wal_size = 1GB
max_wal_size = 4GB
max_worker_processes = 4
max_parallel_workers_per_gather = 2
max_parallel_workers = 4
max_parallel_maintenance_workers = 2

Prod tuning (Data Node)

max_connections = 300
shared_buffers = 32GB
effective_cache_size = 96GB
maintenance_work_mem = 2GB
checkpoint_completion_target = 0.9
wal_buffers = 16MB
default_statistics_target = 100
random_page_cost = 1.1
effective_io_concurrency = 200
work_mem = 27962kB
huge_pages = try
min_wal_size = 2GB
max_wal_size = 8GB
max_worker_processes = 24
max_parallel_workers_per_gather = 4
max_parallel_workers = 24
max_parallel_maintenance_workers = 4

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Prod tuning (Witness Node)

```
max_connections = 300
shared_buffers = 4GB
effective_cache_size = 12GB
maintenance_work_mem = 1GB
checkpoint_completion_target = 0.9
wal_buffers = 16MB
default_statistics_target = 100
random_page_cost = 1.1
effective_io_concurrency = 200
work_mem = 3495kB
huge_pages = off
min_wal_size = 2GB
max_wal_size = 8GB
max_worker_processes = 8
max_parallel_workers_per_gather = 4
max_parallel_workers = 8
max_parallel_maintenance_workers = 4
```

For further references, please access the following link:

- https://www.enterprisedb.com/postgres-tutorials/introduction-postgresql-performance-tuning-and-optimization
- https://www.percona.com/blog/tune-linux-kernel-parameters-for-postgresql-optimization/

2.1.2. Offload Read

To direct read-only queries to non-write leader data nodes, configure PGD-proxy routing appropriately. By setting up the `read_listen_port` parameter, connections to the specified port will be routed to non-write leader data nodes. When the application performs read queries using the `read_listen_port`, it ensures that these queries are not executed by the write leader.

As PGD Proxy operates at Layer 4 of the TCP/IP model, it does not inspect or alter the traffic passing through it. Consequently, it cannot distinguish between read and write commands transmitted through the `read_listen_port` connection. This means that write operations could potentially occur on a port designated for read-only traffic, as the proxy cannot differentiate between SELECT and INSERT commands.

Because PGD operates in an active-active configuration, every write command will be executed and replicated, which may require conflict resolution. It is therefore the responsibility of the application to ensure that the only `read_listen_port` are used for read-only traffic to avoid potential conflicts and ensure proper command handling.

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The SQL Proxy creation function in PGD includes an optional parameter called `proxy_mode`. This parameter can be configured with one of the following values:

Default	This parameter represents the default value and allows for handling traffic directed to the write leader on port 6432.
read-only	This parameter directs non-write leader traffic to handle only read-only traffic on port 6433
any	This parameter enables the proxy to handle read-only and write-leader-following traffic on separate ports: 6432 for write-leader traffic and 6433 for read-only traffic

The following is the configuration process for read-only PGD proxy routing:

```
# Using SQL To create a new read-only proxy, use the bdr.create_proxy function.
SELECT bdr.create_proxy('proxy-ro1','group-a','read-only');

# Using PGD CLI
pgd create-proxy --proxy-name proxy-ro1 --node-group group-a --proxy-mode read-only
```

For further references, please access the following link:
https://www.enterprisedb.com/postgres-tutorials/introduction-postgresql-performance-tuning-and-optimization

2.2. In Scope

This section describes the scope of the design that will be implemented:

1. Discussion on verifying infrastructure requirements, integrating with existing systems, and assessing storage and network devices, including EDB assessment, and providing recommendations for best practices.
2. Database optimization and tuning.
3. Providing report detailing the current state and proposed changes.
4. Implementation of EnterpriseDB, including standard installation and tuning, for up to two nodes.
5. Installation and configuration of PEM and BARMAN.
6. Conducting testing and documentation.
7. Data migration.
8. Knowledge transfer, including monitoring procedures, optimization and tuning of the database, and methods for addressing similar issues.
9. Project management.

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2.3. Out of Scope

The purpose of this section is to describe the exclusions of this project:

1. Physical installation or mounting of other systems.
2. Handling all types of database and data issues (damage or loss, whether partial or complete).
3. Cable installation or electrical work.
4. Installation/modification of hardware.
5. Installation/modification of other software not mentioned in this document.
6. Configuration of external storage or external network.
7. Installation or configuration of software not supported by EDB Postgres.
8. Code changes or SQL tuning for applications.
9. Tasks related to integrating applications with the EnterpriseDB database.
10. Tasks related to IT security and antivirus.
11. Support for other databases.

2.4. Assumptions

This section outlines the assumptions underlying the project to ensure its effective execution:

1. Installation in the form of Virtual Machine or Bare Metal.
2. Hardware/Virtual Machine, Storage, Network, and Operating System (EDB Compatible) must be provided by the Client.
3. Supported or maintained databases include EDB Postgres with an active subscription.
4. Databases requiring ATSM service/Technical Annual Support and Maintenance must have an active subscription license.
5. At the start of the work, the EDB Postgres Database must be installed and functioning properly.
6. One (1) instance should have a number of databases consistent with the information provided to ITG.
7. One engineer will be assigned for support, and may be replaced by another engineer with the same skill set.
8. If there are multiple tickets/issues, the client must prioritize each ticket/issue accordingly.
9. Supported instances are those installed or configured by ITG.
10. Additional instances and/or those not installed or configured by ITG are not included in this implementation scope.
11. Support work will be performed either on-site or remotely.
12. ITG will provide access to the Knowledge Base Library.

2.5. Notes & Recommendations

-N/A-

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3. Server & Storage Design

3.1. Server List Option (Pre-Prod)

No	Site	Server	IP Address	#Core	Memory	Disk
1	A	Data node (write leader)	**<TBC>**	**4**	**8**	**<TBC>**
		Data node (shadow master)	**<TBC>**	**4**	**8**	**<TBC>**
		PGD Proxy A1	**<TBC>**	**4**	**8**	**<TBC>**
		PGD Proxy A2	**<TBC>**	**4**	**8**	**<TBC>**
		Barman A	**<TBC>**	**4**	**8**	**<TBC>**
		Witness A	**<TBC>**	**4**	**8**	**<TBC>**
2	B	Data node (write leader)	**<TBC>**	**4**	**8**	**<TBC>**
		Data node (shadow master)	**<TBC>**	**4**	**8**	**<TBC>**
		PGD Proxy B1	**<TBC>**	**4**	**8**	**<TBC>**
		PGD Proxy B2	**<TBC>**	**4**	**8**	**<TBC>**
		Barman B	**<TBC>**	**4**	**8**	**<TBC>**
		Witness B	**<TBC>**	**4**	**8**	**<TBC>**
3	-	TPA control	**<TBC>**	**4**	**8**	**<TBC>**

Note:
TBC: To be confirmed.

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3.2. Server List Options (Prod)

No	Site	Server	IP Address	#Core	Memory	Disk GB
1	A	Data node (write leader)	**<TBC>**	**24**	**128**	**1000**
		Data node (shadow master)	**<TBC>**	**24**	**128**	**1000**
		PGD Proxy A1	**<TBC>**	**8**	**16**	**300**
		PGD Proxy A2	**<TBC>**	**8**	**16**	**300**
		Barman A	**<TBC>**	**4**	**8**	**300**
		Witness A	**<TBC>**	**8**	**16**	**500**
2	B	Data node (write leader)	**<TBC>**	**24**	**128**	**1000**
		Data node (shadow master)	**<TBC>**	**24**	**128**	**1000**
		PGD Proxy B1	**<TBC>**	**8**	**16**	**300**
		PGD Proxy B2	**<TBC>**	**8**	**16**	**300**
		Barman B	**<TBC>**	**4**	**8**	**300**
		Witness B	**<TBC>**	**8**	**16**	**500**
3	-	TPA control	**<TBC>**	**4**	**8**	**300**

Note:
TBC: To be confirmed.

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3.3. Storage Design

1. Site A

No.	Hostname	Mount Point Name	Mount Point Function
1	Data node	/PG_DATA	Postgres Data
		/PG_WAL	WAL File
		/PG_LOG	Database Log File

2. Site B

No.	Hostname	Mount Point Name	Mount Point Function
1	Data node	/PG_DATA	Postgres Data
		/PG_WAL	WAL File
		/PG_LOG	Database Log File

3. PEM & BARMAN

No.	Hostname	Mount Point Name	Mount Point Function
1	BARMAN	/DATA_BARMAN	Data for BARMAN
2	PEM	/DATA_PEM	Data for PEM

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3.4. Open Port Allocation

From	Port	Target	Additional Info	Remark
TPA Control Node	22	PGD Data - A1 PGD Data - A2 PGD Proxy - A1 PGD Proxy - A2 PGD Barman - A PGD Witness - A PGD Data - B1 PGD Data - B2 PGD Proxy - B1 PGD Proxy - B2 PGD Barman - B PGD Witness - B PEM	TCP Required by TPA to Configure PGD Nodes	-
PGD Data - A1 PGD Data - A2 PGD Proxy - A1 PGD Proxy - A2 PGD Barman - A PGD Witness - A PGD Data - B1 PGD Data - B2 PGD Proxy - B1 PGD Proxy - B2 PGD Barman - B PGD Witness - B PEM TPA Control Node	53	DNS Server(s)	TCP/UDP	Bidirectional

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From	Port	Target	Additional Info	Remark
PGD Data - A1 PGD Data - A2 PGD Proxy - A1 PGD Proxy - A2 PGD Barman - A PGD Witness - A PGD Data - B1 PGD Data - B2 PGD Proxy - B1 PGD Proxy - B2 PGD Barman - B PGD Witness - B PEM TPA Control Node	123	NTP Server(s)	UDP	Bidirectional
PGD Data - A1 PGD Data - A2 PGD Proxy - B1 PGD Proxy - B2 PGD Witness - A PGD Data - B1 PGD Data - B2 PGD Proxy - B1 PGD Proxy - B2 PGD Witness - B	5444	PGD Data - A1 PGD Data - A2 PGD Witness - A PGD Data - B1 PGD Data - B2 PGD Witness - B	TCP	Bidirectional
PGD Data - A1 PGD Data - A2 PGD Witness - A PGD Data - B1 PGD Data - B2 PGD Witness - B	6432 6433	PGD Proxy - A1 PGD Proxy - A2 PGD Proxy - B1 PGD Proxy - B2	TCP	Bidirectional
PGD Barman - A	22 5444	PGD Data - A1 PGD Data - A2	TCP	Bidirectional
PGD Barman - B	22 5444	PGD Data - B1 PGD Data - B2	TCP	Bidirectional

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From	Port	Target	Additional Info	Remark
PGD Data - A1 PGD Data - A2 PGD Barman - A PGD Witness - A PGD Barman - A PGD Data - B1 PGD Data - B2 PGD Barman - B PGD Witness - B PGD Barman - B	5444/8443	PEM	TCP	Bidirectional
Application Servers	6432 6433	PGD Proxy - A1 PGD Proxy - A2 PGD Proxy - B1 PGD Proxy - B2	If Proxy is not co-located with PGD Data Nodes.	-

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3.5. Prerequisites

This section describes the minimum prerequisites required for this implementation.

- **Minimum prerequisites for Database Node hardware: (OS Redhat 8.x)**
  - 16 CPU cores
  - 32 GB of RAM
  - 256 GB of SSD storage
- **Minimum prerequisites for Witness: (OS Redhat 8.x)**
  - 8 CPU cores
  - 16 GB of RAM
  - 256 GB of SSD storage
- **Minimum prerequisites for PGD-Proxy: (OS Redhat 8.x)**
  - 8 CPU cores
  - 16 GB of RAM
  - 256 GB of SSD storage
- **Minimum prerequisites for PEM Server*: (OS Redhat 8.x)***
  - 8 CPU cores
  - 16 GB of RAM
  - 256 GB of Storage

    Note: For storage, it depends on the number of databases (DB Nodes) that will be monitored.
- **Minimum prerequisites for BARMAN Server: *(OS Redhat 8.x)***
  - 4 CPU cores
  - 8 GB of RAM
  - 512 GB of Storage

    Note: For storage, it depends on the number of databases (DB nodes) to be backed up and the retention policy.
- **Prerequisites for *software*:**
  - Redhat repo. Active subscription manager.
  - Sudoers user to run ansible control and prepare passwordless ssh on all nodes in the PGD cluster.
  - Tpa exec repo.
  - Python repo.
  - PGD repo.
  - EDB repo.
  - EPEL repo.

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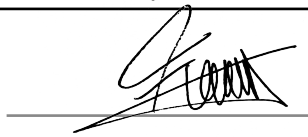
4. Approval

The undersigned acknowledge they have reviewed the **EDB PGD Implementation for DBANK PRO Design Document for PT. Bank Danamon Indonesia (Persero) Tbk** and agree with the approach it presents. Any changes to this requirements definition will be coordinated with and approved by the undersigned or their designated representatives. By signing the Design Document, both parties agree that the work will be done according to the statement of work. Any additional changes may result in changes in the scheduler or professional fees.

PT. IT Group Indonesia		
Reviewed by	**Signature**	**Date**
Azman Agung Nugraha **Subject Matter Expert**		
Febry Ramadhan Sutisna **Project Manager**		
Approved by	**Signature**	**Date**
Henri Adityawan Indrianto **Manager CSS Data & IT Operations**		

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PT. Bank Danamon Indonesia (Persero) Tbk		
Reviewed by	**Signature**	**Date**
Hassan Ridwan **IT Database**		
Ramadoni Ashudi **IT Infrastructure**		
Moh Abdullah Huda Arifin **IT Dev Ops**		
Melisa Amin **Project Manager**		
Approved by	**Signature**	**Date**
Febry Indra Setyawan **IT Mobile & Internet Banking Head**		
Karel Nilandra Thaibsyah **IT Business Partner & Analytics Head**		

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