Designing High Availability Database Systems using AlwaysOn Availability Groups

IT/Dev CONNECTIONS

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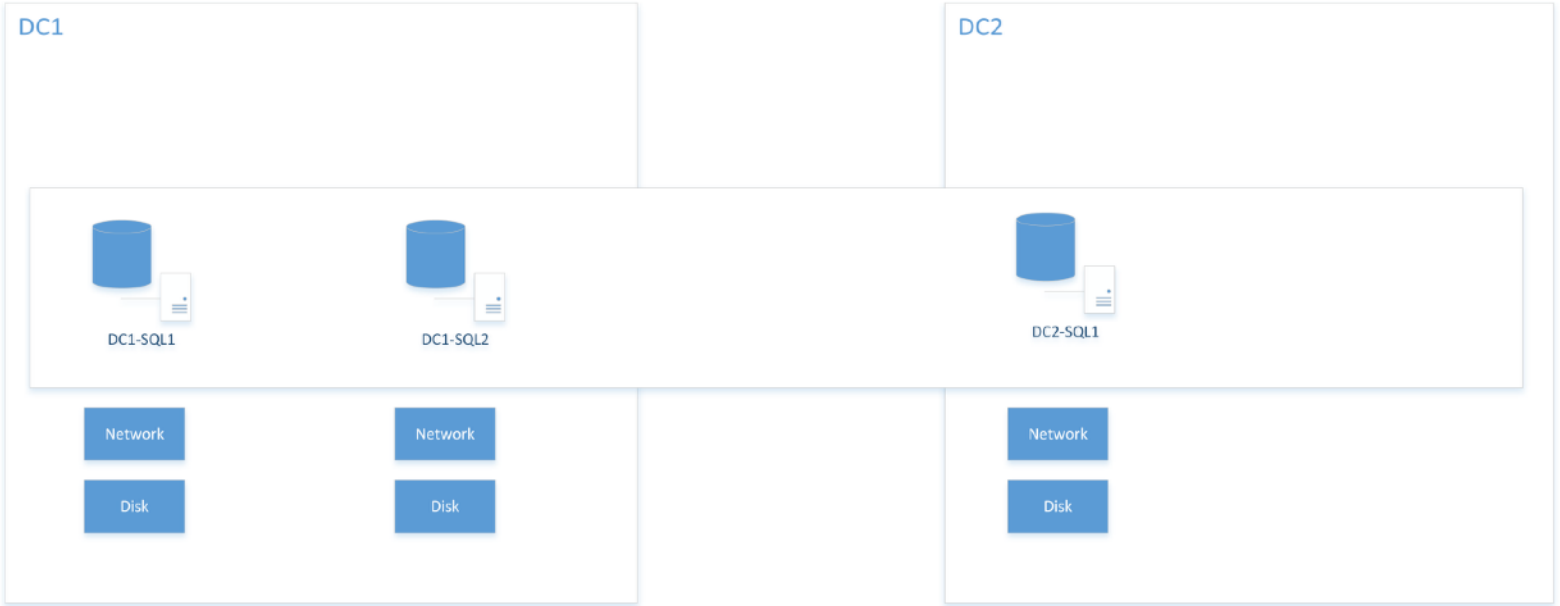
Overview

- Discovery
- **Design**
  - **Topology**
  - **Operations**
- HA/DR Validation
- Application Migration

What is an Availability Group?



Is it hard?

- YES!
- Impact performance
- Spinning plates
  - It's a system, you need to be able to manage the whole thing
- Collaboration is key!

Who needs to participate?

- Networking Team
- Active Directory Team
- Server Team
- DBA Team
- Storage Team

Why Is This Important?

- Recovery Objectives
  - Recovery Point Objective - RPO
  - Recovery Time Objective - RTO
- Availability
  - How much data can we lose?
  - How fast will the system fail over?
- Performance SLA
  - Do queries have to complete in a specified amount of time?
- **Get it on paper!**

Design Objective

- For each application establish
  - RPO
  - RTO
  - Performance SLA

Application	Database	RPO	RTO	SLA
CRM	CRM_DB1	1 minute	5 minutes	10 ms
	CRM_DB2			
	CRM_DB3			
DOC MGMT	DM_DB1	1 minute	5 minutes	10 ms
	DM_DB2			

Does It Really Need AGs?

- Once this phase is complete we find **MANY** databases **don't need AGs**!
  - Good operational practices
  - Backup/Restore
  - Point in time recovery

Availability Group Design

- Group databases into Availability Groups
  - The AG is the unit of failover
- Design considerations
  - Availability requirements - HA and DR?
  - Application or database dependencies
  - Performance
  - Number of databases - soft limit of around 50
  - Worker Threads - http://bit.ly/2ddeyZf

Design Objective

- Group databases into AGs

Application	Availability Goup	Database	RPO	RTO	SLA
CRM	AG1	CRM_DB1	1 minute	5 minutes	10 ms
	AG1	CRM_DB2			
	AG1	CRM_DB3			
DOC MGMT	AG2	DM_DB1	1 minute	5 minutes	10 ms
	AG2	DM_DB2			

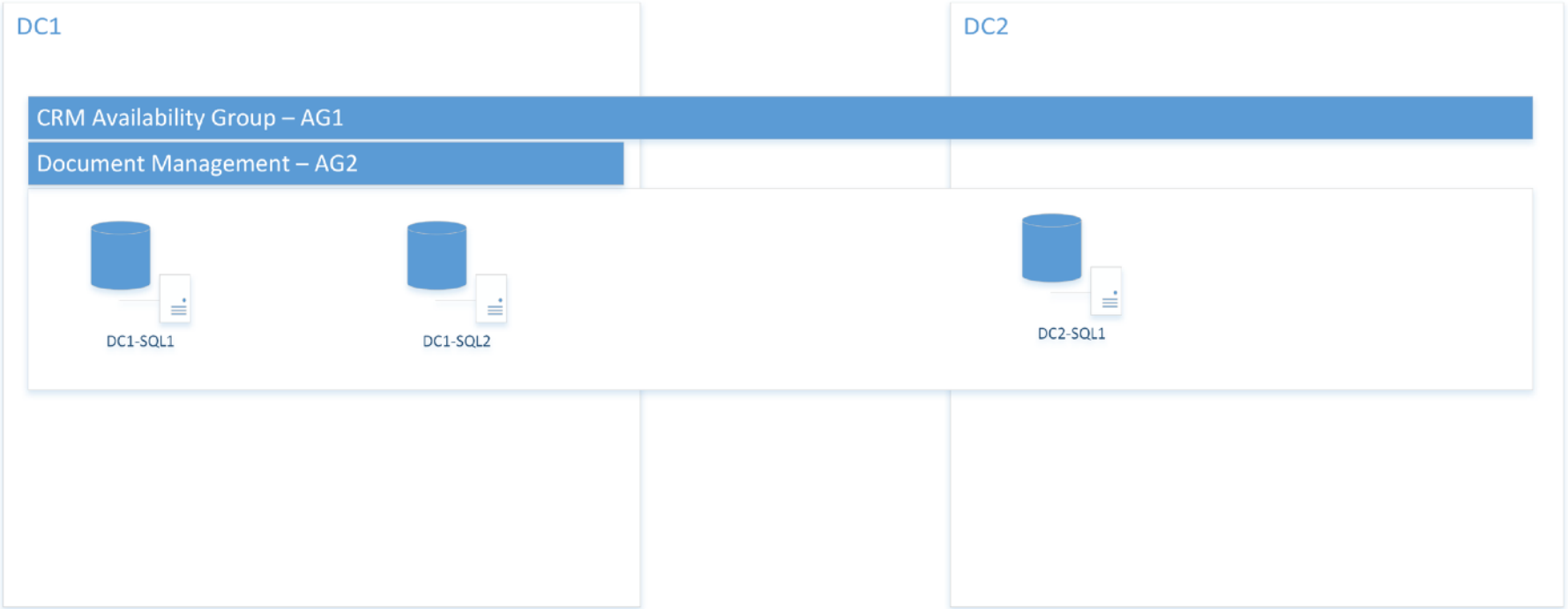
Replica Placement

- Choose the location of the replicas
  - High Availability and Disaster Recovery
  - Multiple data centers?
- Number of replicas
  - Which replicas will run out of which data center?
  - Distributed active workload?
  - Read only routing? - more later

Design Objective

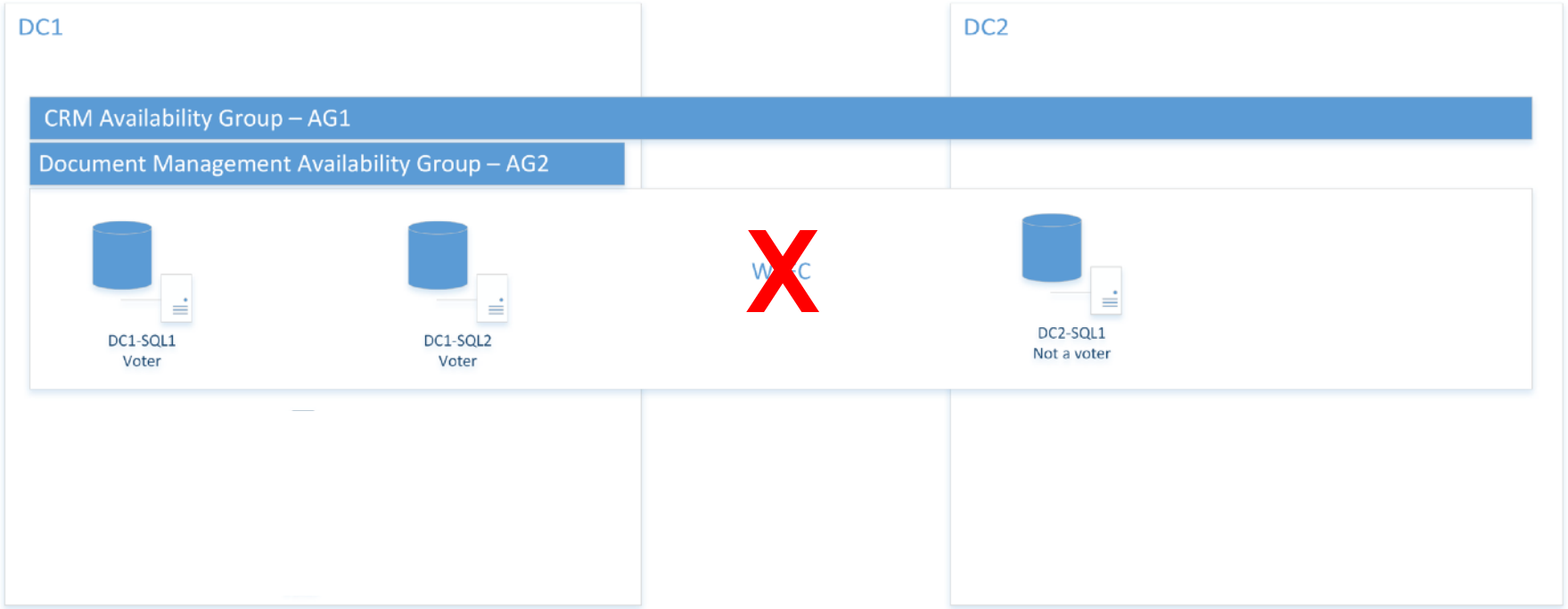
- AG Replica Placement

Application	Availability Goup	Data Center	Replica
CRM	AG1	DC1	DC1-SQL1
	AG1	DC1	DC1-SQL2
	AG1	DC2	DC2-SQL1
DOC MGMT	AG2	DC1	DC1-SQL1
	AG2	DC1	DC1-SQL2


DC1
DC2
CRM Availability Group – AG1
Document Management – AG2
DC1-SQL1
DC1-SQL2
DC2-SQL1

Establish Quorum Model

- AGs still use Windows Failover Clustering
  - 2012 R2 > 2008 R2
    - Dynamic quorum - periodically recalculates based on online voters
- Given the agreed upon replica placement, define a quorum model
  - Network topology
  - Multiple sites?
  - Where is the workload going to run?
- Node majority - useful if there are odd number of nodes
- File share witness - useful if there are an even number of nodes (Microsoft Rec'd)
  - Required for multi-site, choose a third location for file share

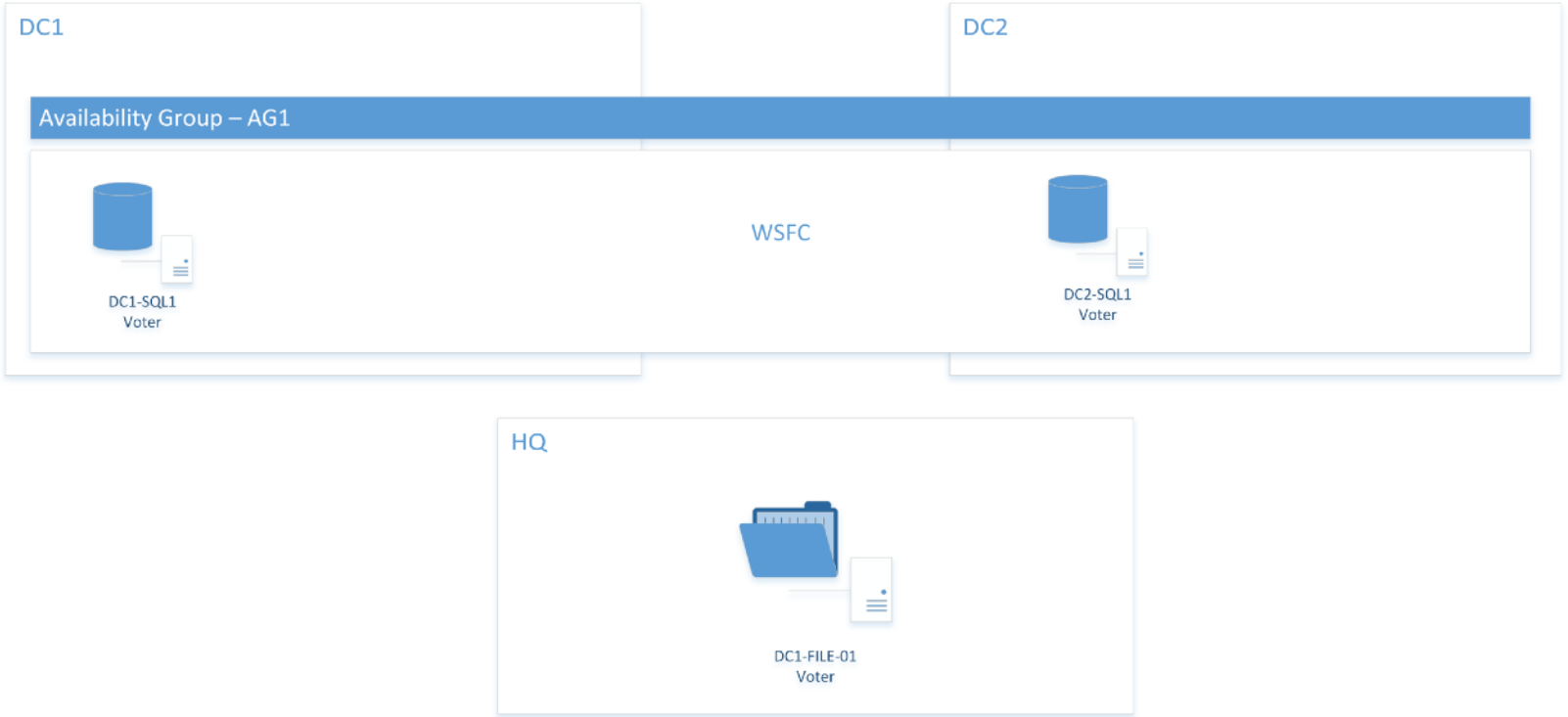


Node Majority + Witness

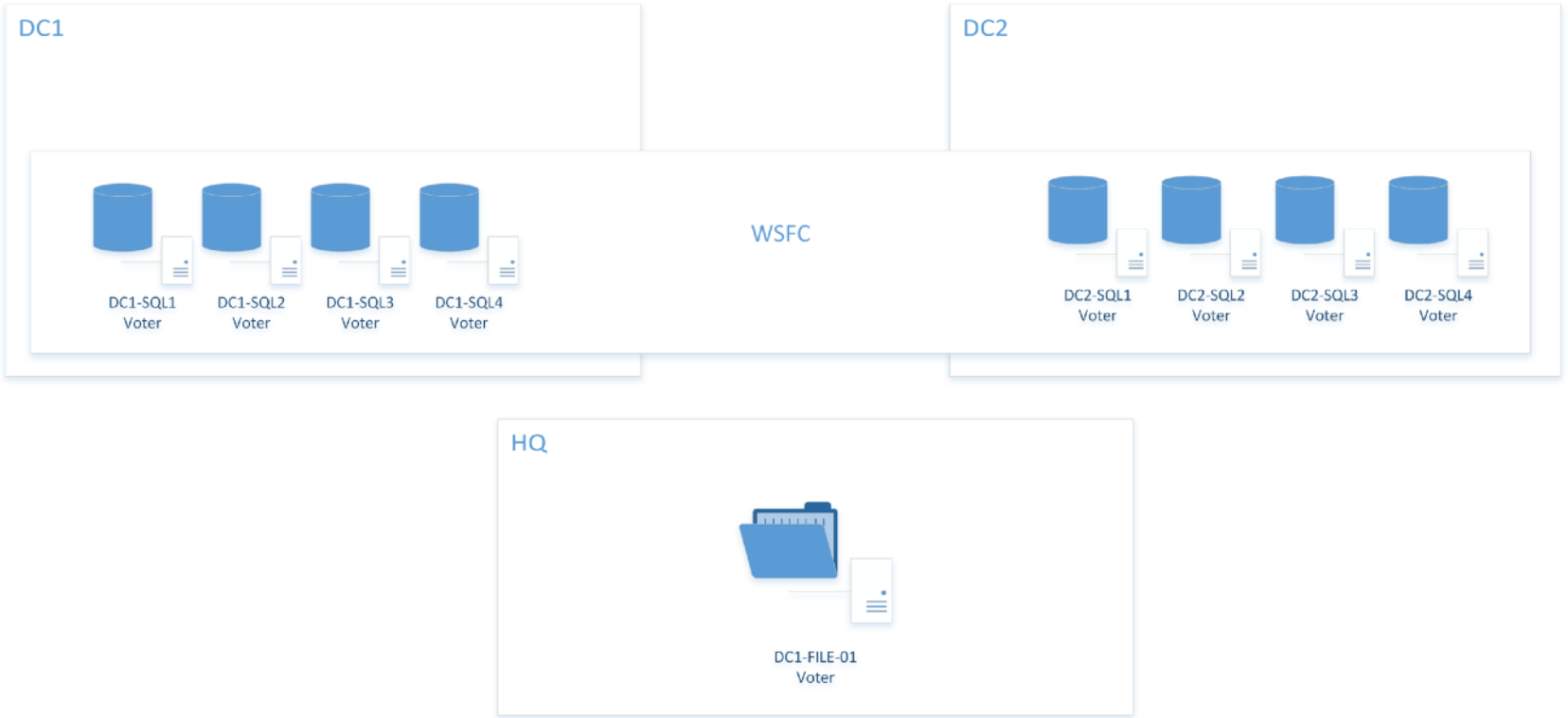
Design Objective

- Establish Quorum Model and Voters

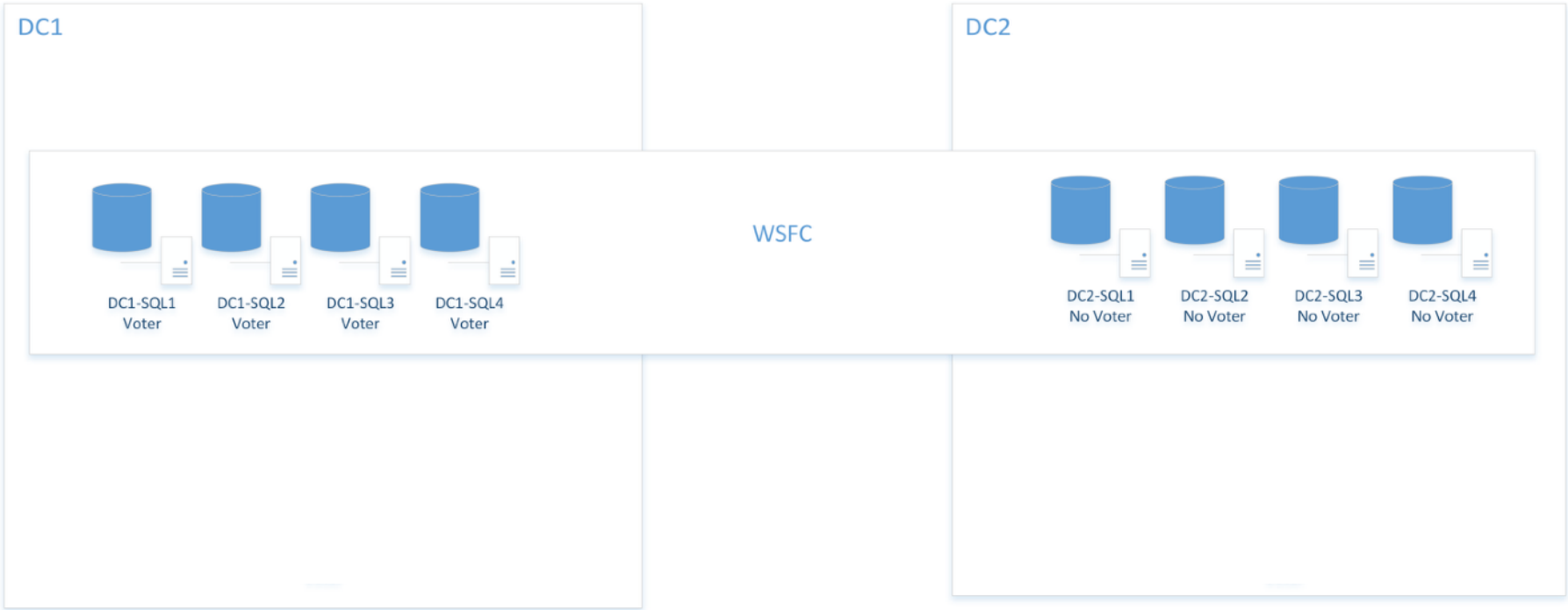
Servers	Quorum	Voter
DC1-SQL1	Node Majority + File Share	Yes
DC1-SQL2	Node Majority + File Share	Yes
DC2-SQL1	Node Majority + File Share	No
DC1-FILE1	Node Majority + File Share	Yes



Node Majority + Witness



Node Majority + Witness



Node Majority + Witness

Failover Model

- The Availability Group is the unit of failover
  - For each Availability Group and for each **replica**
  - Establish a failover policy
    - Automatic
    - Manual

Design Objective

- Establish Failover Model

Application	Availability Goup	Replica	Failover	RPO	RTO	SLA
CRM	AG1	DC1-SQL1	Automatic	1 minute	5 minutes	10 ms
	AG1	DC1-SQL2	Automatic			
	AG1	DC2-SQL1	Manual			
DOC MGMT	AG2	DC1-SQL1	Automatic	1 minute	5 minutes	10 ms
	AG2	DC1-SQL2	Automatic			

Data Movement In Availability Groups

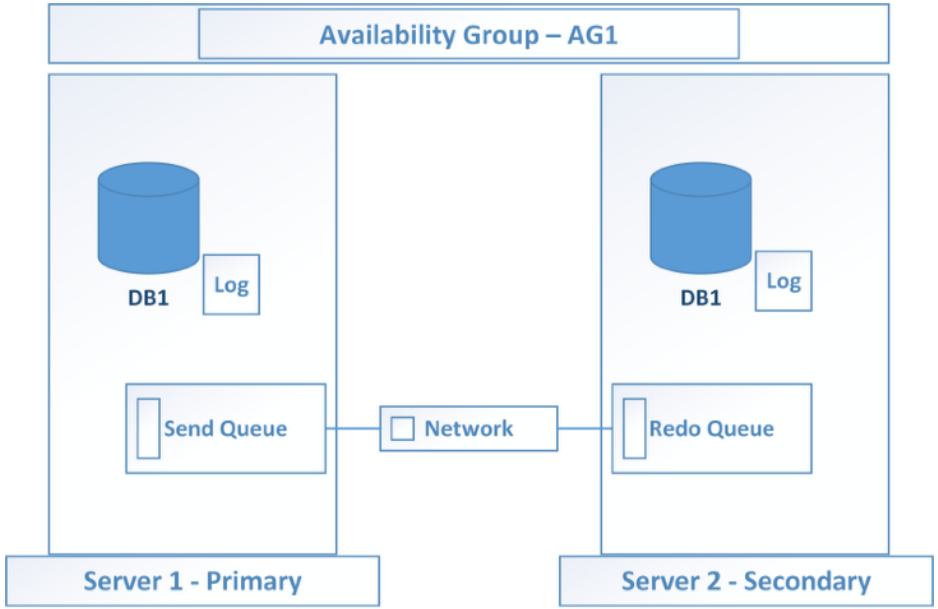
- Transaction log blocks are replicated to secondaries
- Replication mode
  - Synchronous
    - Required for automatic failover
    - Acknowledgements are sent from secondary to primary
    - Monitor replication latency carefully
  - Asynchronous
- Database mirroring endpoint
- Deep dive - http://bit.ly/2cZnCof and http://bit.ly/1nixv0N

Data Movement In Availability Groups

- You can experience data loss in both **synchronous** and **asynchronous** modes
  - Due to replication latency!

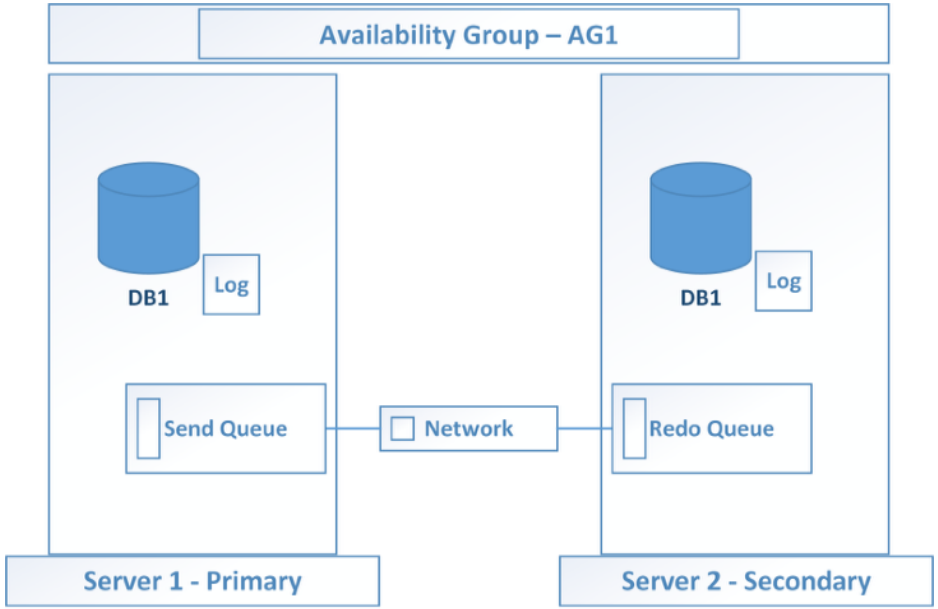
Data Movement - Send Queue

- Queues log blocks to be sent to the secondaries
- Each replica maintains it's own view of the send queue
- Queued data is as risk to data loss in the event of a primary failure
- The send queue can grow due to an unreachable secondary, network outage, network latency and large amount of data change



Data Movement - Redo Queue

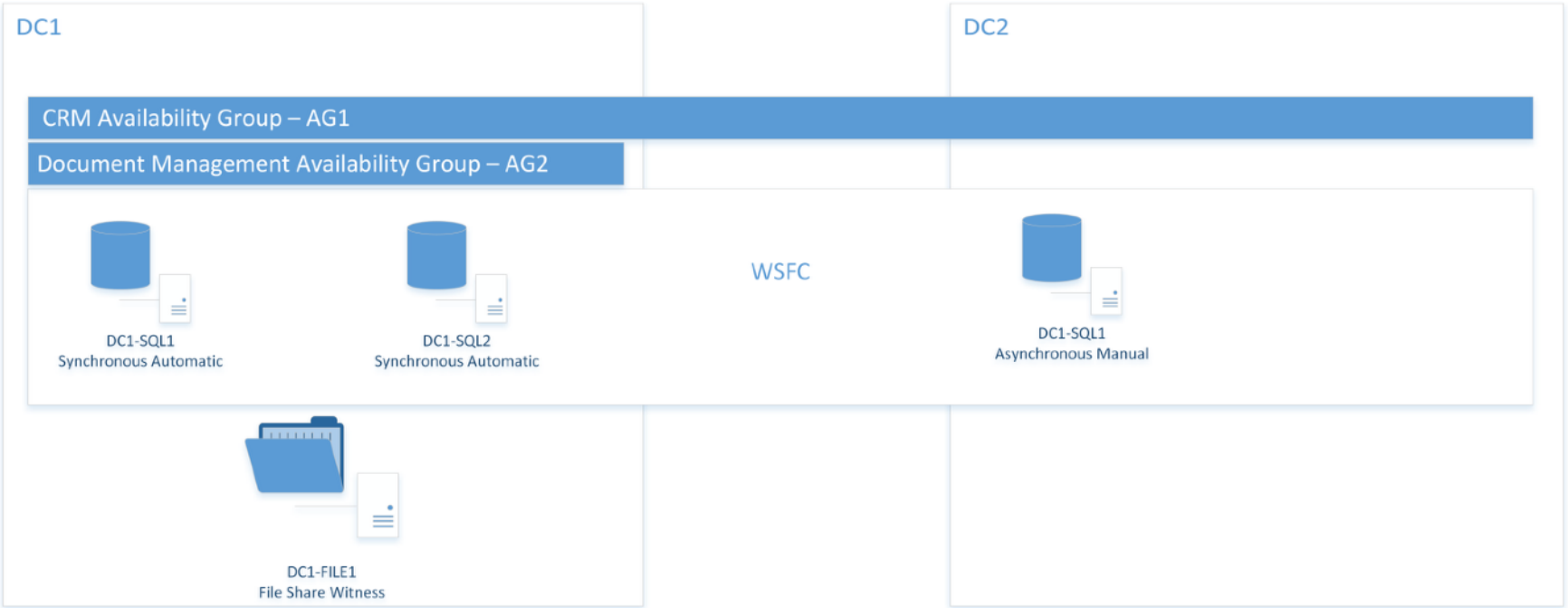
- Queues log blocks received on the secondary
- Each replica has it's own redo queue
- On failover, the redo queue must be completely processed
- The redo queue can grow due to a slow disk subsystem or resource contention or sustained outage and subsequent reconnection of a secondary



Design Objective

- Establish Availability Mode

Application	Availability Goup	Replica	Failover	Availability Mode
CRM	AG1	DC1-SQL1	Automatic	Sync
	AG1	DC1-SQL2	Automatic	Sync
	AG1	DC2-SQL1	Manual	Async
DOC MGMT	AG2	DC1-SQL1	Automatic	Sync
	AG2	DC1-SQL2	Automatic	Sync



Availability Mode

Transaction Log Throughput

- **For each database**
  - What is the amount of transaction log generated?
  - Include days when maintenance or large batch transactions run
  - Add that up for each DB in each AG, this will be your network bandwidth requirements

- **Good** - We can use compressed log backup size as an approximation of log throughput.
  - 2016 uncompressed to sync, compressed to async
- **Better** - If there's a monitoring package, review data or baseline a representative workload
  - Analyze Log Bytes Flushed/sec and Log Flushes/sec
- **Best** - replay of a representative workload into an AG
  - Primary - Log Bytes Flushed/sec, Bytes Sent to Replica/sec (c), Network Interface
  - Secondaries - Bytes from Replica/sec (c), Log Bytes Received/Sec, Redone Bytes/sec, Network Interface

Networking

- Bandwidth analysis for both local and remote replication
  - Log blocks are what's replicated
    - 2012/2014 - compressed
    - 2016 - uncompressed to sync, compressed to async
  - Replication to each replica
  - LAN - shared/dedicated
  - WAN
- Redundant network interfaces and uplinks for each server
- What type of network interconnects?

Design Objective

- Establish Per Replica Log Throughput

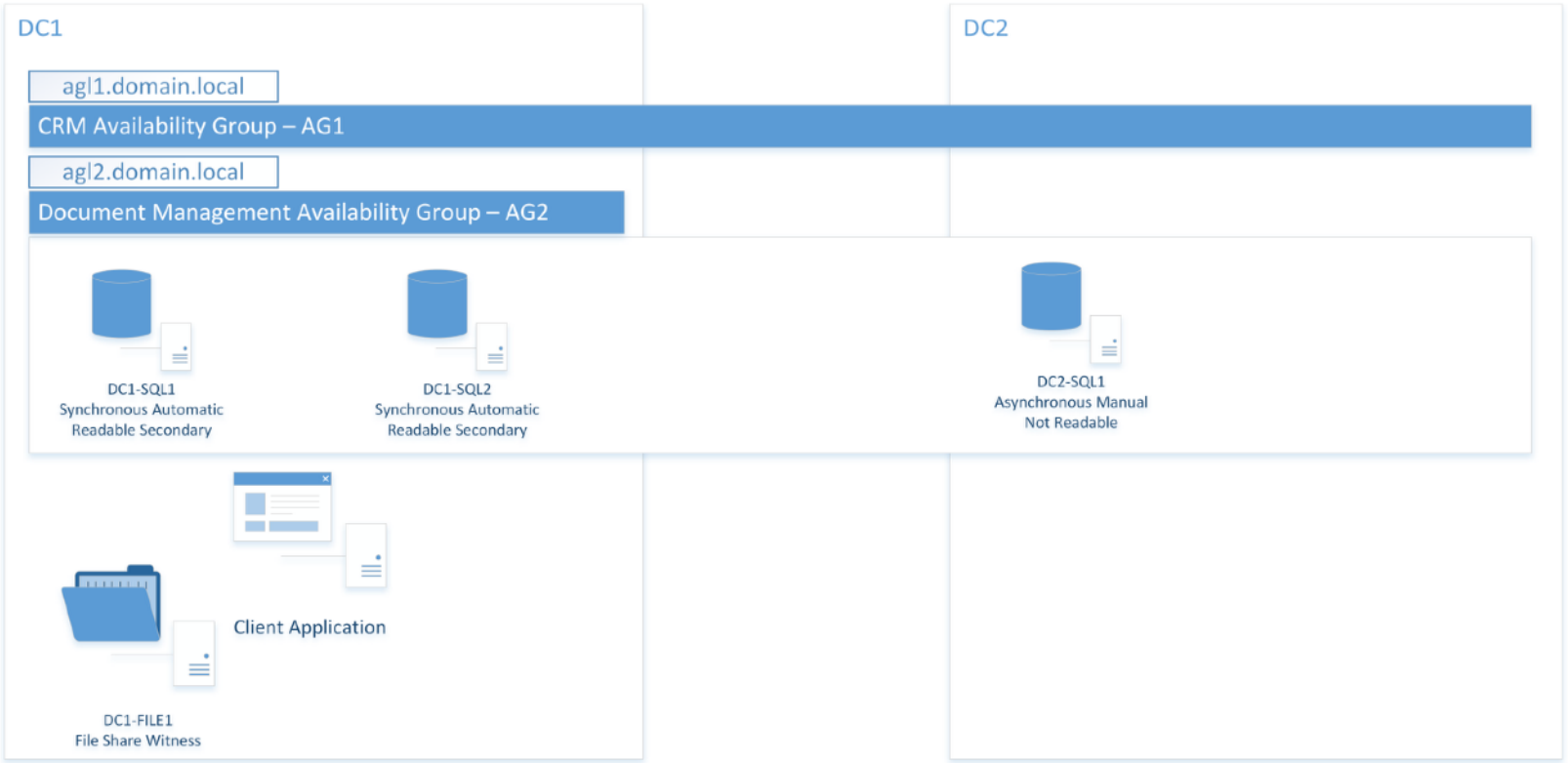
Application	Availability Goup	Database	Replica	Log Throughput
CRM	AG1	CRM_DB1	DC1-SQL1	8Mb/sec
	AG1	CRM_DB1	DC1-SQL2	8Mb/sec
	AG1	CRM_DB1	DC2-SQL1	8Mb/sec
	AG1	CRM_DB2	DC1-SQL1	2Mb/sec
	AG1	CRM_DB2	DC1-SQL2	2Mb/sec
	AG1	CRM_DB2	DC2-SQL1	2Mb/sec
	AG1	CRM_DB3	DC1-SQL1	20Kb/sec
	AG1	CRM_DB3	DC1-SQL2	20Kb/sec
	AG1	CRM_DB3	DC2-SQL1	20Kb/sec
DOC MGMT	AG2	DM_DB1	DC1-SQL1	1Mb/sec
	AG2	DM_DB2	DC1-SQL2	1Mb/sec

IP Addressing Requirements

- Provision static IP address for cluster management
- Provision static IP, Port on each subnet you have replicas for each AG
- DNS name for each AG listener
  - Names alphanumeric including dashes and underscores
  - DNS Aliases

Application Connectivity

- Applications connect to the Availability Group Listener
- How do applications connect to the databases
  - .NET data provider, SQL Native Client, ODBC, JDBC


DC1
ag1.domain.local
CRM Availability Group – AG1
ag2.domain.local
Document Management Availability Group – AG2
DC1-SQL1
Synchronous Automatic
Readable Secondary
DC1-SQL2
Synchronous Automatic
Readable Secondary
DC2
DC2-SQL1
Asynchronous Manual
Not Readable
Client Application
DC1-FILE1
File Share Witness

Application Connectivity

- Multi-subnet failover
  - .NET 4+ and JDBC - http://bit.ly/2d4wjZv
  - `MultiSubnetFailover=True`
  - `RegisterAllProviderIP`
- Non .NET or < .NET4
  - Adjust TTL on DNS record (A or CNAME)

Readable Secondaries

- Will there be readable secondaries?
  - Where?
- Load balancing
  - 2012/2014 - sequential list (hardware load balancer)
  - 2016 - Round robin
- Establish a routing policy - http://bit.ly/2bdFfi9
  - Restricting workload to the "active" site
- `ApplicationIntent=ReadOnly`

Readable Secondaries (con't)

- Requires row versioning on secondary, uses RCSI
  - Monitor usage and disk pressure of TempDB on secondary
  - Additional 14 bytes on the row for versioning info
- Create supporting indexes on the primary
- Blocking of REDO on secondary can occur during schema changes
  - sch-m, sch-s

Readable Secondaries (con't)

- A configured listener
- At least one replica is configure for read-only access
- Each secondary is configured with a URL
- Each replica has a configured routing list
- The replica being routed to must be synchronized or synchronizing

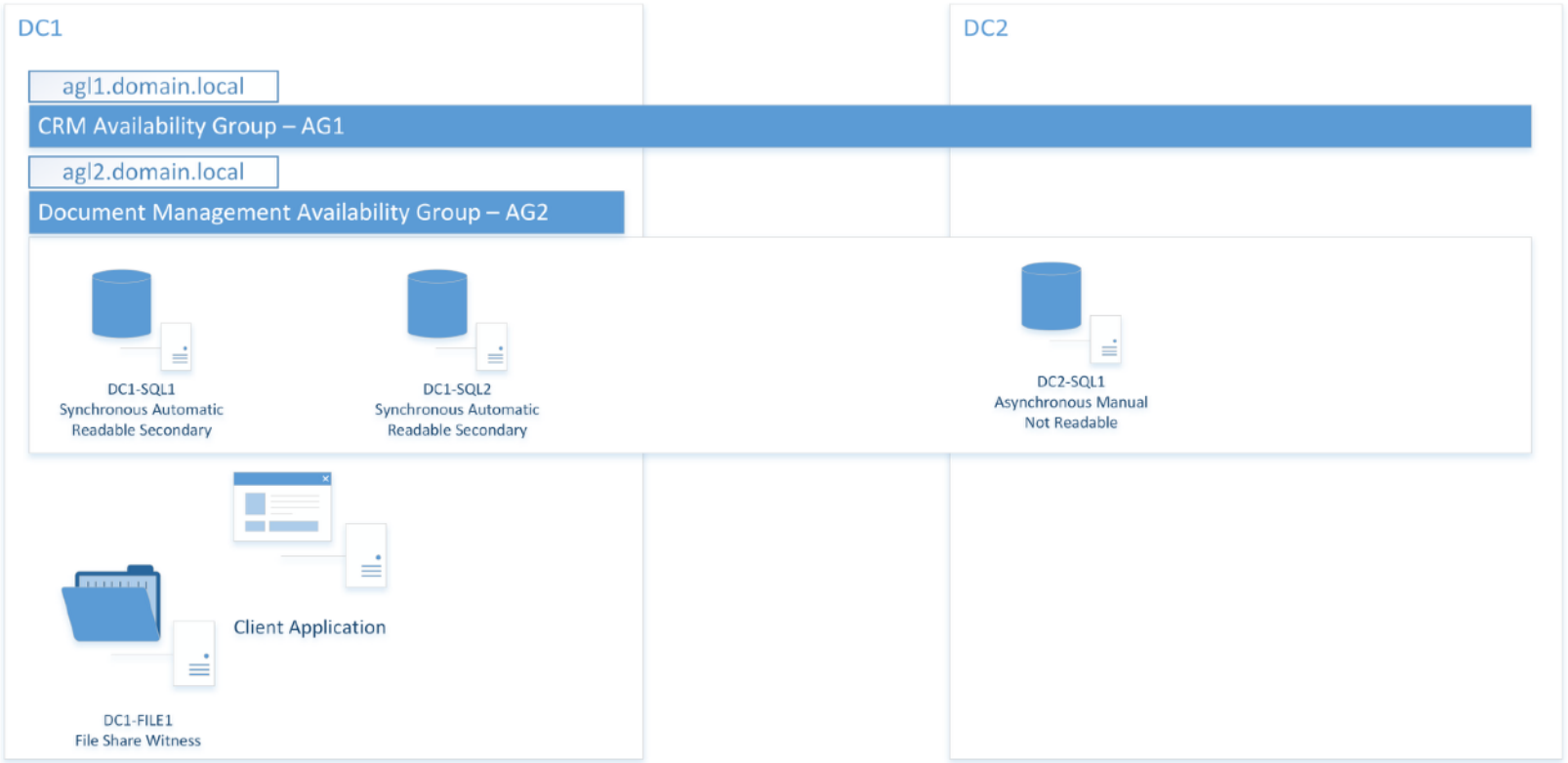
```
ALTER AVAILABILITY GROUP [AG1]
MODIFY REPLICA ON N'SQL14-A'
WITH (PRIMARY_ROLE(READ_ONLY_ROUTING_LIST=(N'SQL14-B',N'SQL14-A')))

ALTER AVAILABILITY GROUP [AG1]
MODIFY REPLICA ON N'SQL14-B'
WITH (PRIMARY_ROLE(READ_ONLY_ROUTING_LIST=(N'SQL14-A',N'SQL14-B')))
```

Design Objective

- For each replica establish Readable Secondaries

Application	Availability Goup	Replica	Readable	RPO	RTO	SLA
CRM	AG1	DC1-SQL1	Yes	1 minute	5 minutes	10 ms
	AG1	DC1-SQL2	Yes			
	AG1	DC2-SQL1	No			
DOC MGMT	AG2	DC1-SQL1	Yes	1 minute	5 minutes	10 ms
	AG2	DC1-SQL2	Yes			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Readable Secondary
DC1-SQL2
Synchronous Automatic
Readable Secondary
DC2
DC2-SQL1
Asynchronous Manual
Not Readable
Client Application
DC1-FILE1
File Share Witness

Backups!

- Required FULL recovery model
- Availability Groups are only part of the HA/DR plan
- Review the current database backup scheme
    - Current backup software (this can get hairy!)
    - Current backup routine
- Review the current enterprise backup scheme
    - Replication and archiving of backups
- Offloaded backups
    - Awesome, but look out! - http://bit.ly/1N2LZN3
    - If availability and recovery are important to you, backup on the primary!

VLDBs

- Large Tables
- Poor Indexing Strategies
- Special backup considerations
  - Differentials
- Special networking considerations
  - Dedicated networking for replication
  - QOS between sites

Application Compatibility

- Does your vendor support AGs?
- Are you using?
  - Cross Database Transactions - No!
  - Distributed Transaction Coordinator
    - 2012/2014 - No - http://bit.ly/2cSPATn
    - 2016 - Yes! - http://bit.ly/2d6Kd10
  - Transparent Data Encryption - Painful

Database Objects

- Synchronization is up to you!
- SQL Agent Jobs
  - Use a SQL Agent Multi-server Management (MSX) - http://bit.ly/2czyved
  - You'll need to build AG aware jobs
- Database logins (ensure the SIDs are the same)
- Linked servers

Operations

- Database maintenance
  - Index maintenance
  - Smart indexing
  - May need to increase the fragmentation thresholds
  - Minimize log generation
  - Can we reindex more frequently?
  - Fill factor
- Statistics maintenance
- CHECKDB
  - All replicas if possible - easiest
  - Where you take backups or any replica that could become a primary

Operations (con't)

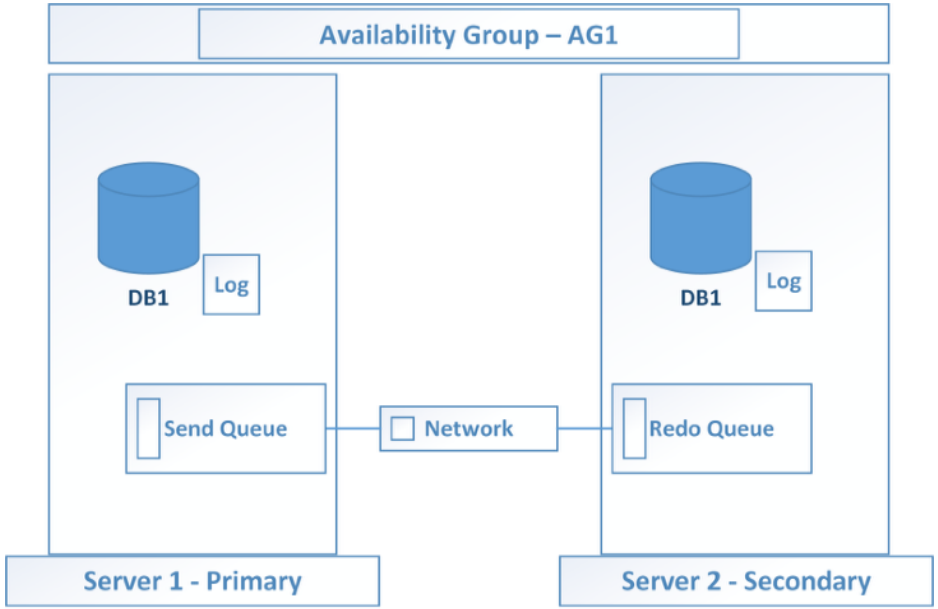
- Non-Production testing
  - Need to have at least one production-like environment for testing
- Patching
  - Manual failover targets, active failover targets, then primary
- Scheduled downtime
  - Anything that makes a secondary unreachable
    - Network maintenance
    - Server maintenance
  - Agree on a schedule with operations team
- Reseeding a replica

Monitoring

- Monitoring and Trending
  - Establish a baseline for analysis
    - Are we meeting recovery and performance objectives?
    - Measure impact on resources
- What do we want to do for monitoring?
  - Roll your own
  - Third party package
  - SSMS AlwaysOn Dashboard

Monitoring (con't)

- Network throughput
- Page splits
- Log Bytes Flushed/sec and Log Flushes/sec
- Send and redo queue size
- Send and redo throughput
- Send and redo latency
- Transaction Delay
- Failover
- Listener online



Hardware

- Physical placement of servers
  - Rack location
  - Power supply
- Servers
  - Can't use last year's hardware for secondaries or DR
  - Physical (CPU/Memory)
  - Virtualization (vCPU/Memory)
- Storage
  - Design for performance on all replica
  - No more using last years SAN or servers at DR

Disk Topology

- Design like any other tier 1 system
  - Establish a performance SLA and design to meet that
- RAID types
- Operating System
- Databases
- Logs
- System databases
- TempDB
  - TempDB configuration

Operating Systems

- Windows 2012 R2 (yes, please)
- Windows 2008 R2 (no, thanks)
    - Special circumstances for quorum
    - Becoming less of an issue
- Review base configuration of operating system
    - Power Management
    - Lock Pages in Memory
    - Instant File Initialization
    - Partition Alignment
    - 64k NTFS Allocation Units

Active Directory

- In 2012 and 2014 Active Directory is required
  - 2016 has domain-less and inter-domain clusters
- The user creating the cluster will need
  - Create computer account on OU servers are in
- Cluster Named Object - (CNO) will need
  - Create computer account on OU servers are in
- SQL Service Accounts
  - Easy - shared domain user per Windows cluster
  - Managed service accounts - not supported but work

HA/DR Testing

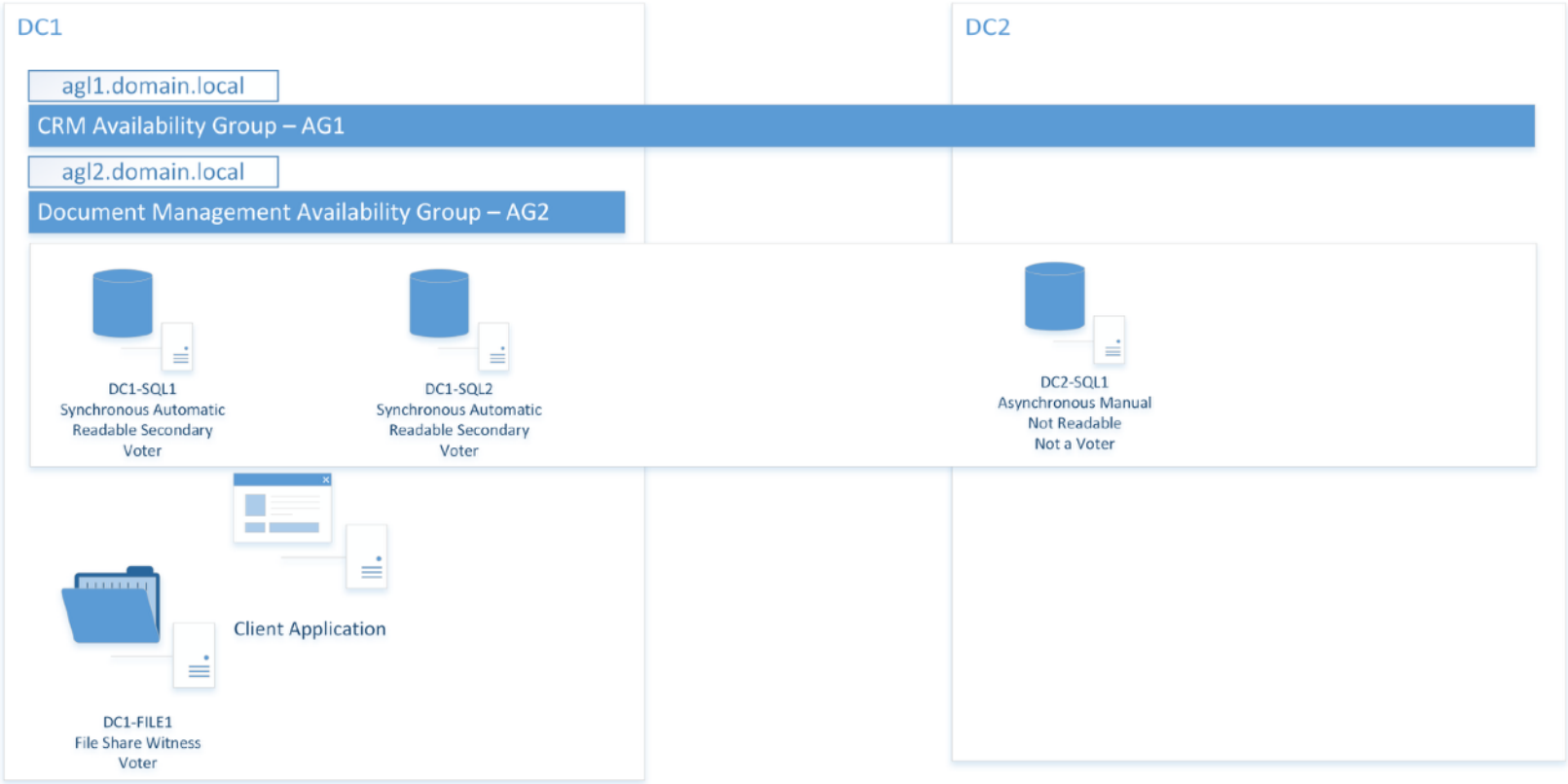
- Planned failover
  - Within a data center
  - Between data centers
- Unplanned failover
  - Within a data center
  - Between data centers
- Did your applications reconnect? In time?

HA/DR Testing

- Planned failover
  - Within a data center
  - Between data centers
    - Change from async to sync then failover
    - Move quorum?
    - Backups - take a full backup
    - Did your applications connect?…in time?

HA/DR Testing (con't)

- Unplanned failover
  - Within a data center
  - Between data centers
    - How much data did we loose?
    - Who decides when to failover?
    - Did your applications connect?…in time?
    - Move quorum?
    - Backups - take a full backup
    - Reseeding replicas



Application Migration

- On-boarding of applications into the new environment
- Construct the new environment
  - Migrate databases onto the new environment
  - Add databases to Availability Groups
  - Use DNS aliases to manage the transition

Licensing

- How many replicas?
- Which secondaries are used for "SQL Workloads"?
    - Basic rule is, if you're connecting to the replica…it needs a license
- Second replica
    - If not used for anything other than failover and on premises (not cloud)
    - For free 2012
    - Free only with SA on 2014+
- Additional replicas
    - Require license
- http://bit.ly/2b5RsSs - Enjoy ;)

SQL Server 2016 Enhancements

- Basic Availability Groups
- Distributed Availability Groups
  - Easier quorum designs
  - Less pressure on inter-AG networks (WAN)
- Parallel redo
- Direct Seeding

Review

- Availability Group topology
- Application connectivity
- Operations
  - Backup
  - Monitoring
  - System and network maintenance
- It's hard!
  - Design
  - Test
- Review the hidden slides in this deck for deeper details and more info!

Thank you

- www.centinosytems.com/blog/talks
- Links to resources
- This presentation
- The design spreadsheet

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Questions?

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