Performance Monitoring AlwaysOn Availability Groups

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Overview

- Motivation
- How availability groups move data
- Impact of replication latency on availability
- Monitoring techniques
- Demo
- Dealing with replication latency

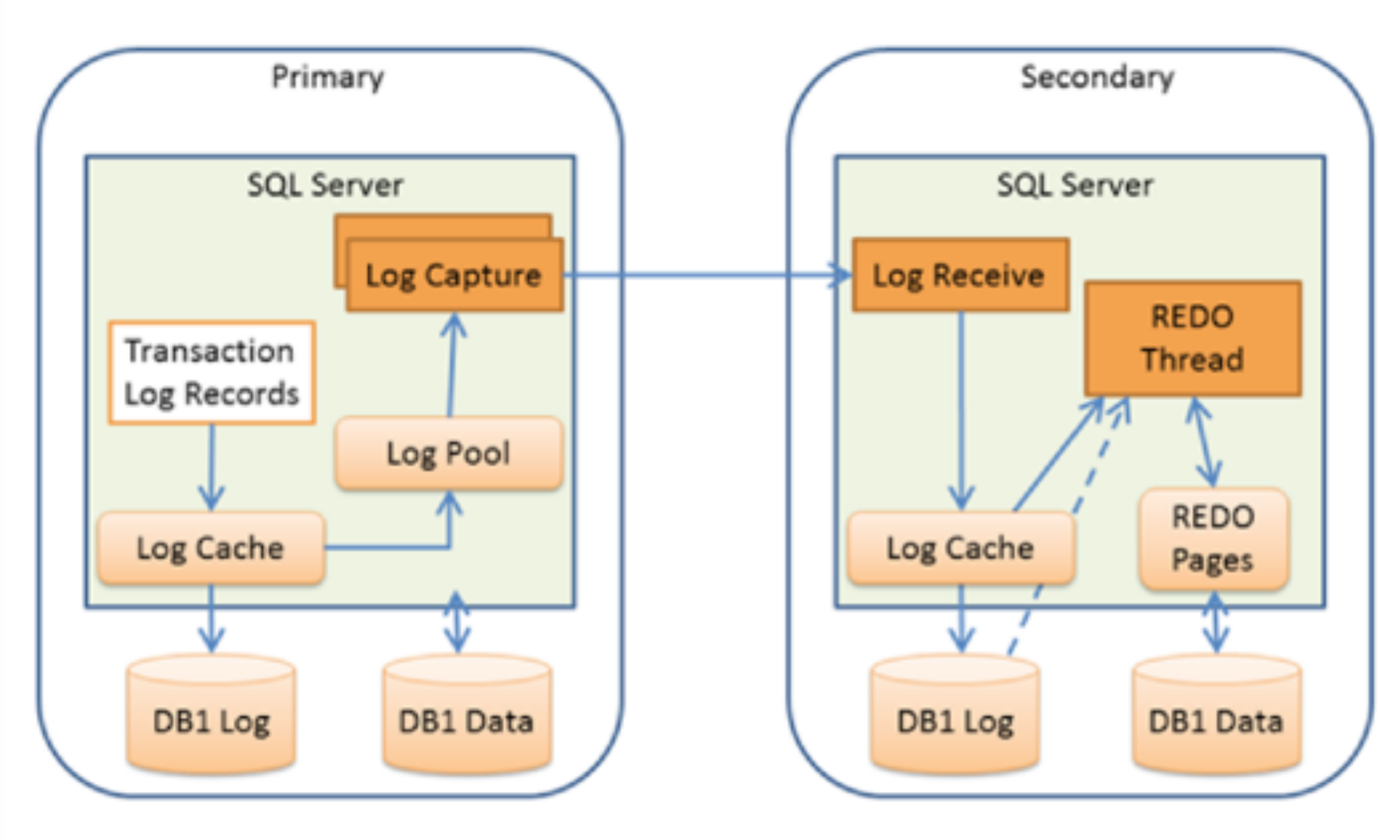
Why is this important?

- Recovery Objectives
  - Recovery Point Objective - RPO
  - Recovery Time Objective - RTO
- Availability
  - How much data can we lose?
  - How fast will the system fail over?
- Monitoring and Trending
  - Establish a baseline for analysis - are we meeting those objectives?
  - Impact on resources
- Ownership
  - All of the components are monitored by the DBA

Data Movement In Availability Groups

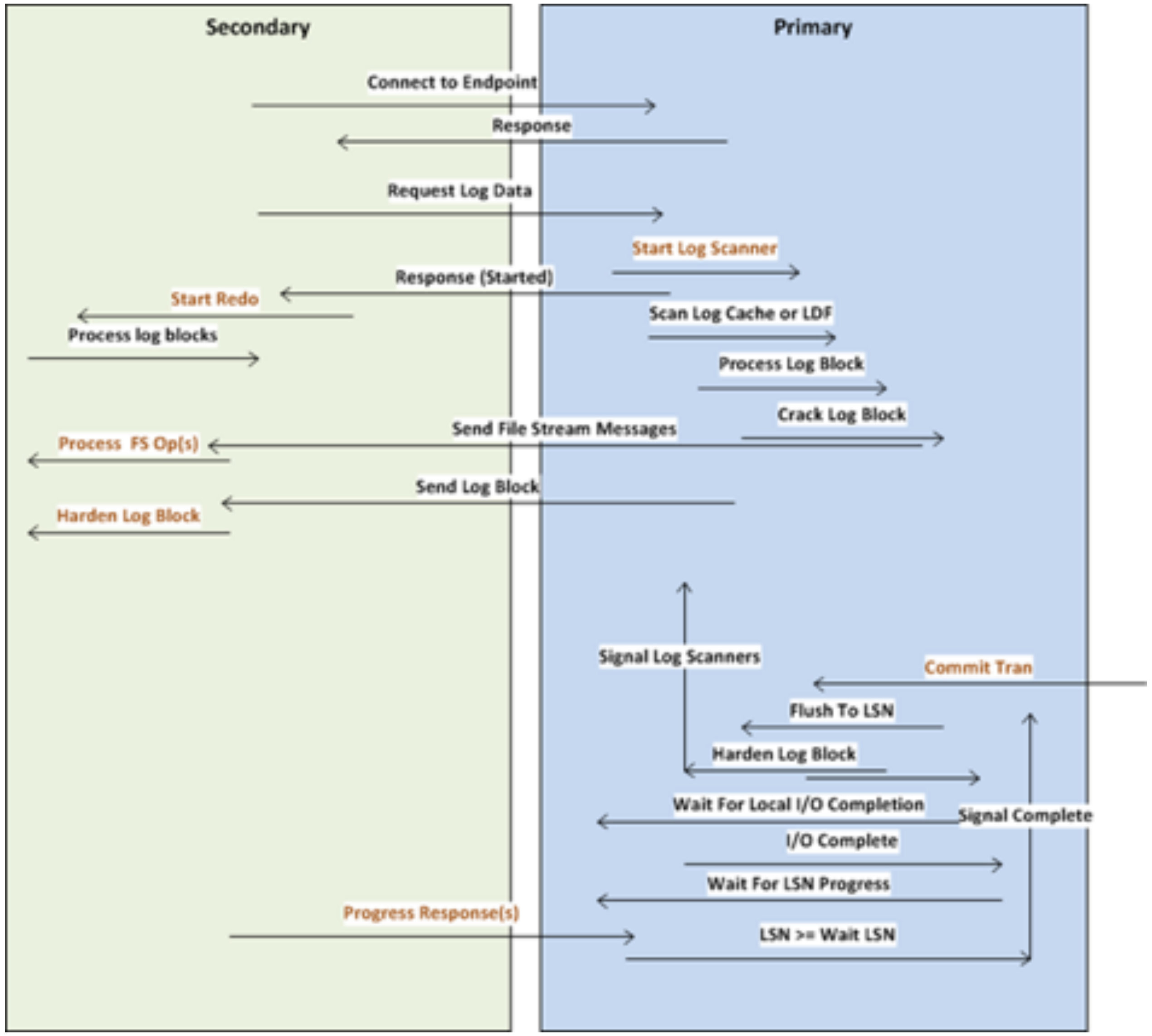
- Transaction log blocks are replicated to secondaries
- Replication mode
    - Synchronous
    - Asynchronous
- Database mirroring endpoint

Data Movement in Availability Groups



From: SQLCAT's Guide to High Availability Disaster Recovery - http://bit.ly/1U0vsss

Synchronous Commit



From: CSS SQL Engineers Blog - http://bit.ly/1P8SzNc

Network Based Replication

- Strong working relationship with network team
    - Maintenance - patching, network outages, database
- Network conditions can impact your AG’s availability
    - Latency - how **long** it takes for a packet of data to traverse the network from source to destination.
    - Bandwidth - how **much** data can be moved in a time interval

Network Latency

- Often measured in milliseconds, sometimes microseconds
- Directly impacts network throughput
    - TCP sliding window
- `ping` isn't your best measure of latency, by default it doesn't include any load…measure **your** workload
- It's often up to us to **PROVE** to the network team there is an issue
    - **`Pinging 192.168.2.1 with 32 bytes of data:`**
    - **`Reply from 192.168.2.1: bytes=32 time=1001ms TTL=128`**

Availability Group Flow Control

- Used in response to network and system conditions
- Log blocks exchange sequence numbers
- The AG will enter flow control mode IF:
  - The **primary** detects too many unacknowledged messages, the primary stops sending messages
  - The **secondary** needs to tell the primary to back off, likely due to resource constraints, it will send a flow control message to the primary to back off
- Primary polls every 1000ms for a change in flow control state
  - Secondary will message primary to leave flow control mode

From: SQL Server PFE Blog - http://bit.ly/1ZpGylL

Database Synchronization States

- Not synchronizing
- Synchronized
- Synchronizing
- Reverting
- Initializing

https://msdn.microsoft.com/en-us/library/ff877972.aspx

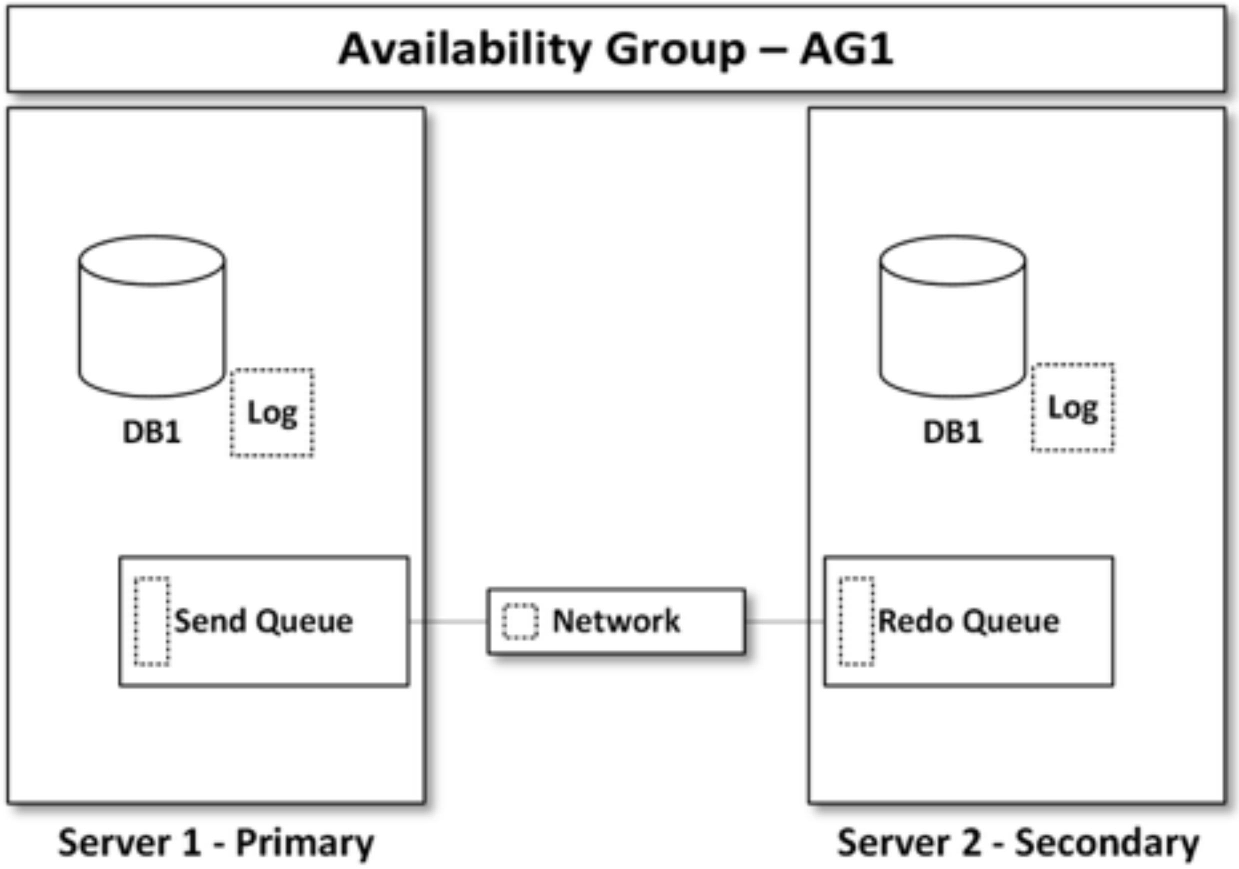
Failover Modes

- Automatic
  - Synchronous mode only
  - Commonly used within a data center
  - Synchronization state must by synchronized
- Manual
  - Synchronous or Asynchronous
  - Commonly used between data centers

https://msdn.microsoft.com/en-us/library/hh213151.aspx

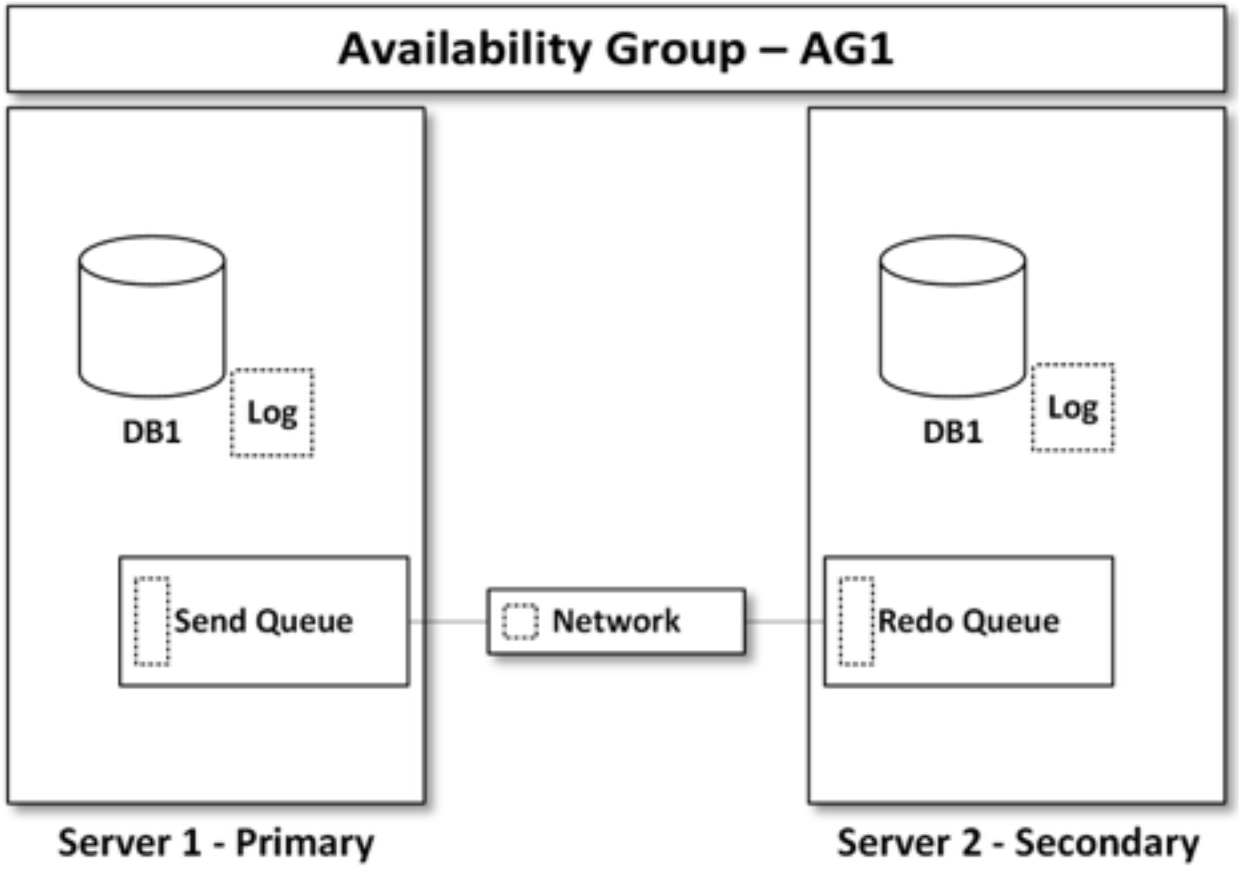
Send Queue

- 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



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



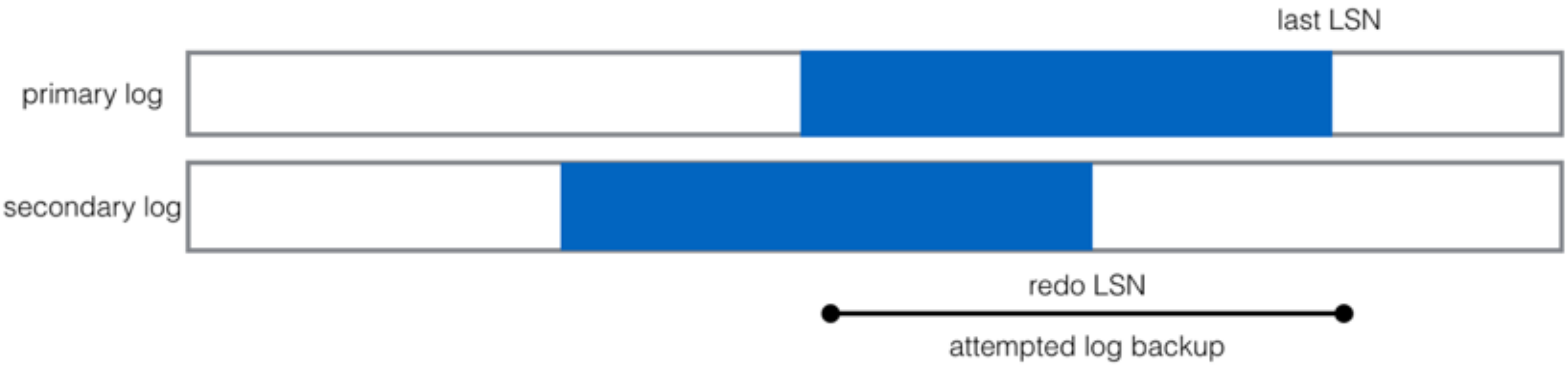
Send Queue Impact on Availability

- When log generation on primary exceeds the rate they can be sent to the secondaries…
  - No automatic failover
  - Data loss
  - Stale data for reporting from secondaries
  - Stale data for off-loaded backups on secondaries
  - Off-loaded log backups can fail
  - Transaction delay
  - Fill up transaction logs
- **Even in synchronous mode!**

Redo Queue Impact on Availability

- When log blocks received on the secondary exceed the rate they can be processed by the redo thread…
  - Delayed failover
    - Detect failure
    - Process Redo Queue
    - Crash recover database
  - Stale data for reporting from secondaries
  - Stale data for off-loaded backups on secondaries
  - Off-loaded log backups can fail
  - Transaction delay

Log Backups


last LSN
primary log
secondary log
redo LSN
attempted log backup

Disconnected Replica

- When a synchronous secondary exceeds it's session time-out, it changes to asynchronous commit mode
- When the secondary comes back online, it will attempt to re-sync, and resume synchronous mode
- WRITELOG - while replica is down
- HADR_SYNCHRONIZING_THROTTLE - time to go from SYNCHRONIZING to SYNCHRONIZED

Transaction Delay

- In synchronous mode, when secondaries are behind, queries on the primary can be delayed
- HADR_SYNC_COMMIT
- HADR_SYNCHRONIZING_THROTTLE - replica back online

Wait stats - sync vs. async

Synchronous - HADR_SYNC_COMMIT

```
sqldk.dll!XeSosPkg::wait_info::Publish+0x138
sqldk.dll!SOS_Scheduler::UpdateWaitTimeStats+0x2bc
sqldk.dll!SOS_Task::PostWait+0x9e
sqlmin.dll!EventInternal<SuspendQueueSLock>::Wait+0x1fb
sqlmin.dll!SequencedObject<LogBlockId,SequencedWaitInfo<LogBlockId>0>::WaitUntilSequenceAdvances+0x160
sqlmin.dll!HaDrCommitMgr::HardenNotifyInternal+0x1af
sqlmin.dll!HaDrCommitMgr::HardenNotify+0xac
sqlmin.dll!RecoveryUnit::NotifyHardenParticipants+0x1e2
sqlmin.dll!RecoveryUnit::HardenLog+0x217
sqlmin.dll!XdesRMFull::CommitInternal+0x6b8
sqlmin.dll!XactRM::SinglePhaseCommit+0x1a1
sqlmin.dll!XactRM::CommitInternal+0x472
…
```

Asynchronous - WRITELOG

```
sqldk.dll!XeSosPkg::wait_info::Publish+0x138
sqldk.dll!SOS_Scheduler::UpdateWaitTimeStats+0x2bc
sqldk.dll!SOS_Task::PostWait+0x9e
sqlmin.dll!SQLServerLogMgr::WaitLCFlush+0x219
sqlmin.dll!SQLServerLogMgr::LogFlush+0x29e
sqlmin.dll!SQLServerLogMgr::WaitLogWritten+0x17
sqlmin.dll!RecoveryUnit::HardenLog+0x25e
sqlmin.dll!XdesRMFull::CommitInternal+0x6b8
sqlmin.dll!XactRM::SinglePhaseCommit+0x1a1
sqlmin.dll!XactRM::CommitInternal+0x472
…
```

Maintenance Events That Can Impact Availability

- Bulk data modifications
- Database maintenance
- Network or server maintenance
- Unplanned outages

- Carefully plan maintenance
- Collaborate with other teams!

Monitoring AG Performance

- Dynamic Management Views
  - `sys.dm_hadr_database_replica_states`
- Perfmon Counters
  - SQL Server:Availability Replica
    - Replication data - messages sent, bytes sent, flow control
  - SQL Server:Database Replica
    - Database data - log bytes sent, queue sizes, transaction delay per database

Measuring Replication Latency

- `sys.dm_hadr_database_replica_states`
  - `log_send_queue_size`
  - `log_send_rate`
  - `redo_queue_size`
  - `redo_queue_rate`
- On the primary there's a row for each database on **each** replica
- On the secondaries there's a row for each database on **that** replica
- Pull replication
- Offline
  - log_send_queue_size changes to NULL

log send queue is from primary to secondary

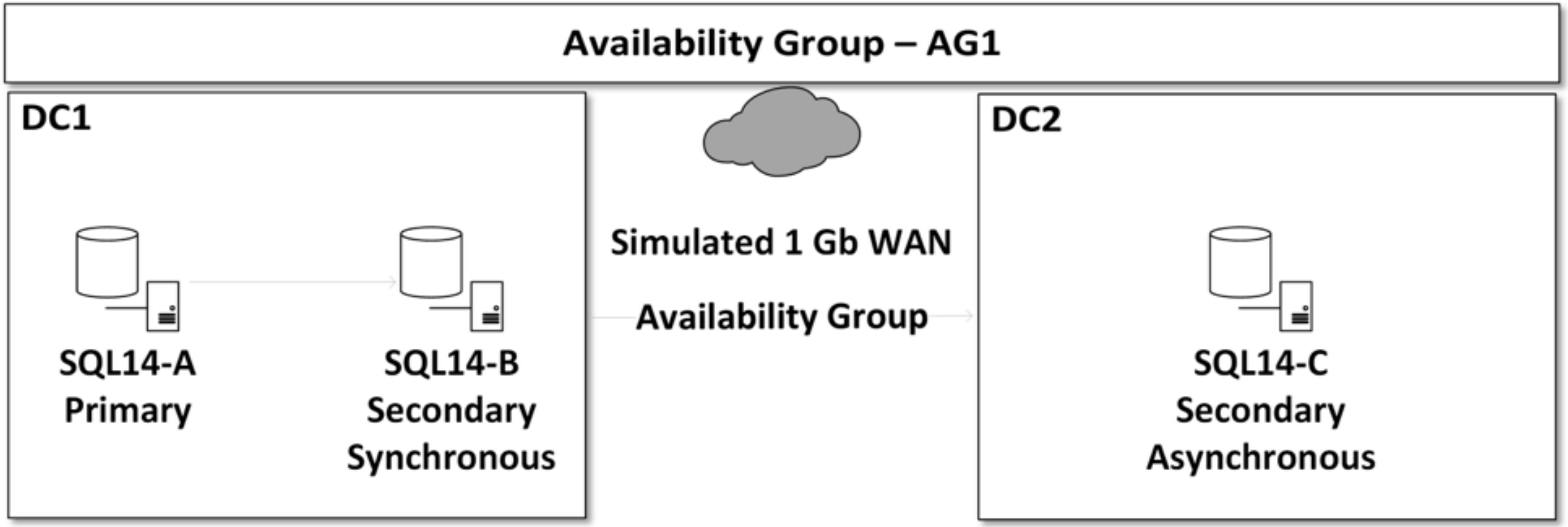
Measuring Replication Latency - **ugh!!!**

- **Well, it looks like `sys.dm_hadr_database_replica_states` doesn't report the correct values for `log_send_rate and redo_queue_rate`**
  - Documented as KB
  - Reported on Connect
    - https://connect.microsoft.com/SQLServer/Feedback/Details/928582
  - Known bug in SQL Server 2012 or 2014
    - https://support.microsoft.com/en-us/kb/3012182
    - Cumulative Update 5 or better
  - Observed in SQL 2016 RC3 - just increases
  - Perfmon!

Monitoring Tools

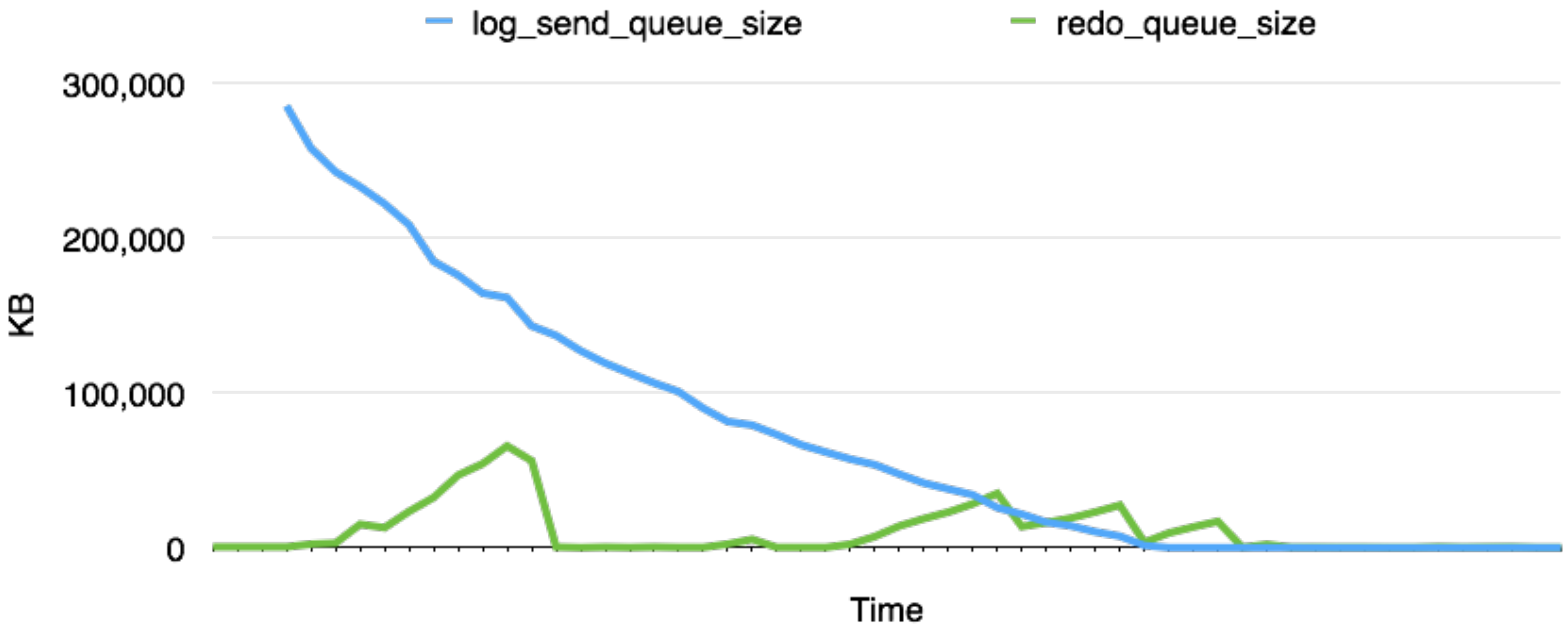
- Build your own
- AlwaysOn Dashboard
- Third Party Tool
  - SQL Sentry Performance Advisor
  - Redgate SQL Monitor

Demo

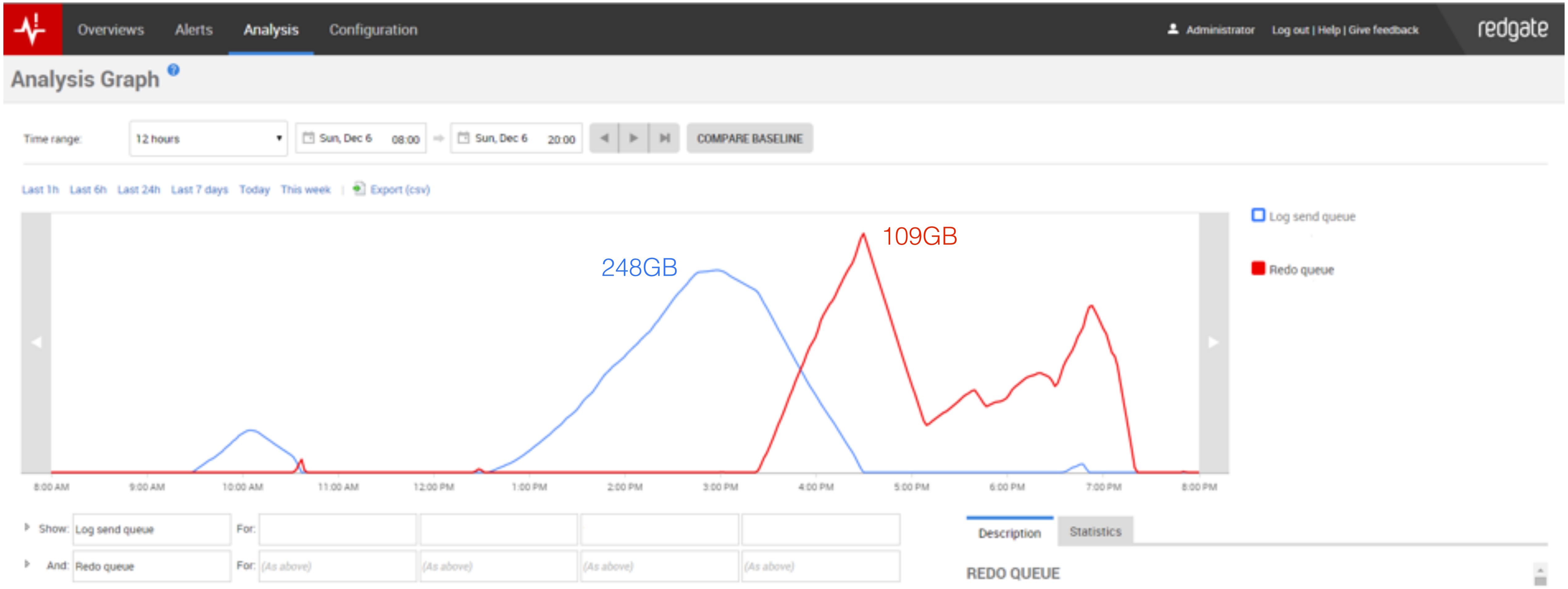

Availability Group – AG1
DC1
SQL14-A
Primary
SQL14-B
Secondary
Synchronous
Simulated 1 Gb WAN
Availability Group
DC2
SQL14-C
Secondary
Asynchronous

Demo

Demo


log_send_queue_size
redo_queue_size
300,000
200,000
100,000
0
KB
Time

Real World Example



Time range: 12 hours | Sun, Dec 6 08:00 → Sun, Dec 6 20:00

Show: Log send queue For:

And: Redo queue For: (As above) (As above) (As above) (As above)

REDO QUEUE

Dealing With Slow Replication Latency

- Identify your bottleneck and mitigate it
  - Minimize log generation
    - Use smart index maintenance
  - More bandwidth
    - Perhaps a dedicated network connection
  - Better hardware
    - Log throughput on secondaries needs to be equal to primary
  - Upgrade SQL Server
    - 2012 single threaded redo - ~45MB/sec
    - 2016 multi-threaded redo - ~600MB/sec

Key Takeaways

- It is imperative to track and trend replication latency in your Availability Groups so you can answer the questions
  - How much data ~~can~~ will I lose?
  - How long it will take to failover?
- Monitor and trend `send_queue` and `redo_queue` in `sys.dm_hadr_database_replica_states` on replicas to measure availability impact
- Understand how much log is generated in your databases
- Understand your system's operations, consider downtime for patching and network maintenance

Key Takeaways

- Plan database maintenance
- Use a smart index maintenance strategy!
- Offloaded backups
  - If availability is most important, backup on primary

Need more data?

http://www.centinosystems.com/blog/talks/

Links to resources
Demos
Presentation

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Thank You!

http://www.sqlsaturday.com/491/sessions/sessionevaluation.aspx

Thanks to the SQLSaturday Pensacola Team!

Questions?

References

- http://www.centinosystems.com/blog/sql/designing-for-offloaded-backups-in-alwayson-availability-groups/
- http://www.centinosystems.com/blog/sql/designing-for-offloaded-log-backups-in-alwayson-availability-groups-monitoring/
- http://www.centinosystems.com/blog/sql/monitoring-availability-groups-with-redgates-sql-monitor
- https://msdn.microsoft.com/en-us/library/ff878537.aspx
- https://msdn.microsoft.com/en-us/library/ff877972.aspx