Data Replication Options in AWS

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November 15, 2013
Thomas Jefferson first acquired the letter-copying device he called "the finest invention of the present age" in March of 1804.

http://www.monticello.org/site/house-and-gardens/polygraph
Agenda

• Data replication design options in AWS
• Replication design factors and challenges
• Use cases
  – Do-it-yourself options
  – Managed and built-in AWS options
• Demos
Data Replication Capabilities

- AWS Data Replication Capabilities
  - Deployment & Administration
  - Application Services
  - Compute
  - Storage
  - Database
  - Networking
  - AWS Global Infrastructure

- Partner Data Replication Capabilities
Data Replication Solution Architecture

AWS Capabilities
- Multiple Availability Zones
- Multiple regions
- AMI
- Amazon EBS and DB snapshots
- AMI copy
- Amazon EBS and DB snapshot copy
- Multi-AZ DBs
- Read replica DBs
- Provisioned IOPS
- Offline backups and achieves
- Data lifecycle policies
- Highly durable storage

Solutions Architecture

Evaluate Options

Measure Metrics

Business Drivers
- Business continuity
- Disaster recovery
- Customer experience
- Productivity
- Mismatched SLA
- Compliance
- Reducing cost
- Information security risks
- Global expansion
- Performance/availability
Focus of Our Discussion Today

Data Preservation

Databases

Business Drivers

Replication Options

Design Factors

Data Type

Design Options

Performance

Storage/Content (Files and Objects)
Focus of Our Discussion Today

Data Type
- Databases
- Storage/Content (Files and Objects)

Business Drivers
- Data Preservation
- Performance

Replication Options
Design Factors
Design Options
Design Options in AWS

- Single AZ
- Multi-AZ
- Cross Region
- Hybrid IT

Databases

Files and Objects
Focus of Our Discussion Today

Data Preservation

- Databases
- Replication Options
- Design Factors
- Design Options
- Performance

Data Type

- Storage/Content (Files and Objects)

Business Drivers
Physical vs. Logical
Synchronous vs. Asynchronous

RPO
4 Hours

RTO
5 Hours

2:00am
Last Backup

6:00am
Event

11:00am
Data Restored

Time
Data Replication Options in AWS

- Single AZ
- Multi-AZ
- Cross Region
- Hybrid IT

Databases

Files and Objects

Preservation
Focus of Our Discussion Today

- Business Drivers
- Data Preservation
- Performance

Data Type
- Databases
- Storage/Content (Files and Objects)

Data Type
- Replication Options
- Design Factors
- Design Options

- Performance
Performance Metric – Total Time

Daily and Weekly Updates

Source DB

Estimated DB Size
~35 TB

ETL

Target DB

600M Records and 320 GB in Size

Estimated DB Size
~48 TB

Can we do this in 10 hours?
Performance Metric – Total Time

Source DB

Estimated DB Size
~70 TB

ETL

Estimated DB Size
~48 TB

Target DB

Can we STILL do this in 10 hours?
Data Replication Options in AWS

- Single AZ
- Multi-AZ
- Cross Region
- Hybrid IT

Databases

Files and Objects

Preservation

Performance
Focus of Our Discussion Today

- **Databases**
- **Storage/Content (Files and Objects)**

**Data Type**

**Replication Options**

**Design Factors**

**Design Options**

**Business Drivers**

**Data preservation**

**Performance**
Factors Affecting Replication Designs

1. Size of Data
2. Read/Write
3. Data Change Rate
4. Throughput, Bandwidth, Latency
5. Read/Write
6. Consistency
Challenges in Replication

- Availability & Performance
- Data Size
- Consistency
- Change Rate

Compute, Storage, Network, Database

Infrastructure Capabilities
Challenges in Replication

- Data Size
- Availability & Performance
- Change Rate
- Compute
- Network
- Database
- Storage
- Consistency
- Infrastructure
- Capabilities
Replication Design Options in AWS

The right tool for the right job
Common Data Replication Scenarios

- Hybrid IT
- Database migration
- HA databases
- Increase throughput
- Cross regions
- Data warehousing
Please Meet Bob

- DBA for a large enterprise company
- 10 years of IT experience
- What is AWS?
Disaster Recovery

Sue, DBA

I can’t find archlog_002 file!!!!!
We Need a Better Way....

MySQL

SQL Server

Oracle

RTO is 8 hours
RPO is 1 hour

5 - 6 hours

Daily

Bob, DBA
Demo – AWS S3 Upload

Corporate Data Center

AWS

Generic Database

DB
Full Backup

Amazon S3 Bucket
Think Parallel

Foreach($file in $files) {Write-S3Object -BucketName mybucket -Key $file.filename}
Think Parallel

120,000 Files

Nearly 3 Days
Think Parallel

Multiple Machines, Multiple Threads, Multiple Parts

120,000 files @ 15,000 TPS = 0.8 seconds
Demo – AWS S3 Multipart Upload

Generic Database

DB Full Backup

Amazon S3 Bucket

Corporate Data center
Think Parallel

- Use multipart upload (API/SDK or command line tools) – min part size is 5 MB
- Use multiple threads
  - GNU parallels: parallel -j0 -N2 --progress /usr/bin/s3cmd put {1} {2}
  - Python multiprocessing, .Net parallel extensions, etc.
- Use multiple machines
  - Limited by host CPU / memory / network / IO
Database Replication Options

How are you going to replicate databases?

Tom, Sys Admin
Bob, DBA
Database Replication Options in AWS

Bob's Office

MySQL

SQL Server

Oracle

AWS

Replication

Amazon RDS

MySQL

M
Non-RDS to RDS Database Replication

1. Configure to Be a Master

MySQL

2. mysqldump

mysqldump

3. AWS S3 CP

Dump

Corporate Data Center

Bob's Office

AWS

4. Initialize

mysqldump

Amazon RDS

MySQL

Availability Zone A

Amazon S3 Bucket

AWS re:Invent
Non-RDS to RDS Database Replication

Bob's Office

Corporate Data Center

Amazon RDS

Availability Zone A

Run mysql.rds_set_external_master

MySQL

Run mysql.rds_set_external_master

MySQL
Non-RDS to RDS Database Replication

Bob's Office

MySQL

Corporate Data Center

AWS

Amazon RDS

MySQL

Availability Zone A

Run mysql.rds_start_replication

New
Database Replication Options

- MySQL
- SQL Server
- Oracle
- Amazon S3
- Amazon RDS
- Log Shipping
- Restore

Bob's Office

AWS

MySQL

SQL Server

Amazon RDS

MySQL

Amazon S3 Bucket

SQL Server
Database Replication Options

Bob's Office

MySQL

OSB Cloud Module

Amazon S3 Bucket

AWS

Amazon RDS

MySQL

OSB

SQL Server

Oracle

OSB Cloud Module

RMAN restore

Oracle

Amazon RDS

MySQL

SQL Server

OSB Cloud Module

Bob's Office

MySQL

OSB Cloud Module

Amazon S3 Bucket

AWS

Amazon RDS

MySQL

OSB

SQL Server

Oracle

OSB Cloud Module

RMAN restore

Oracle

Amazon RDS

MySQL

SQL Server

OSB Cloud Module

Bob's Office

MySQL

OSB Cloud Module

Amazon S3 Bucket

AWS

Amazon RDS

MySQL

OSB

SQL Server

Oracle

OSB Cloud Module

RMAN restore

Oracle

Amazon RDS

MySQL

SQL Server

OSB Cloud Module
Database Replication Options

- Amazon RDS MySQL
  - Replication

- SQL Server and Oracle on EC2
  - SQL server log shipping, always on, mirroring, etc.
  - Oracle RMAN/OSB, Active Data Guard, etc.
We need a highly available solution.
HA DB Replication Options

Amazon RDS DB Instance Standby (Multi-AZ)

Oracle Standby

Oracle

SQL Server

SQL Server

Availability Zone A

Availability Zone B

Data Guard Configuration

Prepare primary database
1. Enable logging
2. Add standby redo logs
3. Add data guard parameters to init.ora/spfile
4. Update tnsnames.ora and listener.ora

Prepare standby database environment
1. Install or clone the Oracle home
2. Copy password file (orapwdSID) from primary database
3. Add data guard parameters to init.ora/spfile
4. Update tnsnames.ora and listener.ora

Create standby database using RMAN
1. Duplicate target database for standby

Configure Data Guard broker
1. Setup database parameters on primary and standby database init.ora/spfile
2. Create Data Guard configuration for primary and standby using dgmgrl
3. Setup StaticConnectIdentifier for primary and standby
4. Enable Data Guard configuration
5. Show configuration – should return success
HA DB Replication Options

- Physical Synchronous Replication
- Amazon RDS MySQL Multi-AZ
- Amazon RDS Oracle Multi-AZ

Availability Zone A
- SQL Server
- Oracle

Availability Zone B
- Amazon RDS DB Instance Standby (Multi-AZ)
Increase Throughput

Bob, DBA Manager

Hannah, Finance

The order system is running slowly.

Disk I/O?
Increase Throughput Options

- Amazon EC2 instance type
  - Amazon RDS MySQL
- PIOPS
  - Amazon RDS MySQL
- Read replicas
  - Amazon RDS MySQL

Bob, DBA Manager
Amazon RDS Performance Options

Amazon RDS DB Instance Read Replica

Provision IOPS

Asynchronous

Availability Zone A
m1.small

m2.4xlarge

Availability Zone B

Create Read Replica DB Instance

Modify DB Instance: mydbinstance

Provisioned IOPS: 1000

AWS re:Invent
Increase Throughput Options

- Amazon CloudFront
  - Large objects
Increase Throughput Options

- Amazon DynamoDB
  - Sessions, orders
Cross-region Replication Options

We are opening a new development site in....

Bella, VP

Bob, Architect
• Replicate AMIs and Amazon EBS snapshots
• Replicate Amazon DynamoDB tables
• Replicate Amazon RDS snapshots
• Replicate Amazon S3 buckets
Demo Cross-region Replication Options

Amazon DynamoDB

EC2
Create
AMI

Amazon EBS
Snapshot

Amazon EBS
Snapshot

Amazon RDS Snapshot
Snapshot

Amazon RDS Snapshot

Amazon DynamoDB
us-east-1

AWS Data Pipeline

Amazon EBS

Amazon EBS Snapshot

Amazon EBS Snapshot

Amazon EBS

Amazon EBS

RDS Snapshot

RDS Snapshot

Amazon DynamoDB
ap-northeast-1

Copy

Copy

Copy

Copy

Restore

restore

Create

AMl

EC2

Restore

Restore

Restore

Restore

Create
Replicate Amazon S3 Bucket

Source Bucket with Objects

Destination Bucket
Amazon S3 Copy

List bucket (S) → Controller → List bucket (D)

Copy Queue List(S-D)

Source Bucket with Objects

Task Queue

Destination Bucket

Dequeue Task Agent(s) → S3 Copy API
Hive Script to Compare Amazon S3 Buckets

Create external table sourcekeys (key string)
   location 's3://mybucket/sourcebucketlist';

Create external table destinationkeys (key string)
   location 's3://mybucket/destinationbucketlist';

Create table differencelist
   location 's3://mybucket/differencelist'
   as

Insert overwrite table differencelist
Select sourcekeys.key
From sourcekeys
Left outer join destinationkeys
On (sourcekeys.key = destinationkeys.key)
Where destinationkeys.key is null;
We need to understand impact of price changes.
Data Warehouse Replication

- Amazon Redshift
- Amazon DynamoDB
- Bucket with Objects
- Oracle
- BI Reports
Attunity CloudBeam for Amazon Redshift – Incremental Load (CDC)

1. Generate change files
2. Beam files to S3
3. Validate file content upon arrival
4. Execute ‘copy’ command to load data tables from S3
5. ‘Copy’ data to CDC table in customer’s S3 account
6. Execute SQL commands ‘merge’ change into data tables

Source Database: Oracle DB

Amazon Redshift

AWS region

Replication Server

Change Files (CDC)

Net Changes file
Business Intelligence
Bob, Chief Architect
Key Takeaways

• Consider design factors and make trade offs, if possible
• Think parallel
• Pick the right tool for the right job
Please give us your feedback on this presentation

ARC302

As a thank you, we will select prize winners daily for completed surveys!
Amazon DynamoDB Built-in Replication

Region A
- Amazon DynamoDB
- AWS Data Pipeline
- Amazon S3 Bucket

Region B
- Provisioned Throughput
- Automatic 3-way Replication
- Amazon DynamoDB
- Availability Zone A
- Availability Zone B
- Availability Zone C

Region A
- Amazon DynamoDB
- Table

Region B
- Amazon DynamoDB
- Table
WAN Acceleration Test

Instance
AP-southeast-1

Instance
US-East-1

Instance
EU-West-1
Tsunami-UDP here’s how

Install Tsunami

```
yum -y install cvs gcc autoconf automake
cvs -z3 -d:pserver:anonymous@tsunami-udp.cvs.sourceforge.net:/cvsroot/tsunami-udp co -P tsunami-udp
cd tsunami-udp; ./recompile.sh; make install
```

Origin Server

```
$ cd /path/to/files
$ tsunamid *
```

Destination Server

```
$ cd /path/to/receive/files
$ tsunami
tsunami> connect ec2-XX-XX-XX-83.compute-1.amazonaws.com
tsunami> get *
```

*** Note firewall ports need opening between servers
BBCP here’s how

Install BBCP

$ sudo wget http://www.slac.stanford.edu/~abh/bbcp/bin/amd64_linux26/bbcp
$ sudo cp bbcp /usr/bin/

Transmitting with 64 parallel streams

$ bbcp -P 2 -V -w 8m -s 64 /local/files/* ec2-your-instance.ap-southeast-1.compute.amazonaws.com:/mnt/

Notes:

• SSH key pairs are used to authenticate between systems
• TCP port 5031 needs to be open between machines
• Does NOT encrypt data in transit
• Instance Type matters the better the instance type the better the performance
• Many dials and options to tweak to improve performance and friendly features like retries and restarts

*** Note firewall ports need opening between servers
Minutes to Send a 30GB File from US-East-1

To Dublin

To Singapore

- SCP
- BBCP
- Tsunami

*** Note using hs1.xl
# Primary init.ora:
LOG_ARCHIVE_DEST_1='LOCATION=/data/oracle/Prod/db/archive
VALID_FOR=(ALL_LOGFILES,ALL_ROLES) DB_UNIQUE_NAME=Prod'
LOG_ARCHIVE_CONFIG='DG_CONFIG=(prod, stb)'
FAL_CLIENT='prod'
FAL_SERVER='stb'
log_archive_dest_2='SERVICE=prod
VALID_FOR=(ONLINE_LOGFILES, PRIMARY_ROLE) DB_UNIQUE_NAME=prod'
LOG_ARCHIVE_DEST_STATE_1='ENABLE'
log_archive_dest_state_2='DEFER'
LOG_FILE_NAME_CONVERT='prod','prod'
remote_login_passwordfile='EXCLUSIVE'
SERVICE_NAMES='prod'
STANDBY_FILE_MANAGEMENT='AUTO'
db_unique_name=prod
global_names=TRUE
dg_broker_start=True
dg_broker_config_file1="/data/oracle/Prod/db/tech_st/11.1.0/dbs/prod1.dat"
dg_broker_config_file2="/data/oracle/Prod/db/tech_st/11.1.0/dbs/prod2.dat"

# Standby init.ora:
LOG_ARCHIVE_DEST_1='LOCATION=/data/oracle/Prod/db/archive
VALID_FOR=(ALL_LOGFILES,ALL_ROLES) DB_UNIQUE_NAME=stb'
LOG_ARCHIVE_CONFIG='DG_CONFIG=(prod, stb)'
FAL_CLIENT='stb'
FAL_SERVER='prod'
log_archive_dest_2='SERVICE=stb
VALID_FOR=(ONLINE_LOGFILES, PRIMARY_ROLE) DB_UNIQUE_NAME=stb'
LOG_ARCHIVE_DEST_STATE_1='ENABLE'
log_archive_dest_state_2='DEFER'
LOG_FILE_NAME_CONVERT='prod','prod'
remote_login_passwordfile='EXCLUSIVE'
SERVICE_NAMES='stb'
STANDBY_FILE_MANAGEMENT='AUTO'
db_unique_name=stb
global_names=TRUE
dg_broker_start=True
dg_broker_config_file1="/data/oracle/Prod/db/tech_st/11.1.0/dbs/prod1.dat"
dg_broker_config_file2="/data/oracle/Prod/db/tech_st/11.1.0/dbs/prod2.dat"
**Listener.ora**

**Primary DB**

```plaintext
prod = (DESCRIPTION_LIST = (DESCRIPTION = (ADDRESS = (PROTOCOL = TCP)(HOST = primary)(PORT = 1526)) ) )
(SID_LIST = (SID_DESC = (ORACLE_HOME= /data/oracle/prod/db/tech_st/11.1.0) (SID_NAME = prod))
(SID_DESC = (ORACLE_HOME= /data/oracle/prod/db/tech_st/11.1.0) (SID_NAME = prod) (GLOBAL_DBNAME=prod_DGMGRL))
(SID_DESC = (ORACLE_HOME= /data/oracle/prod/db/tech_st/11.1.0) (SID_NAME = prod) (GLOBAL_DBNAME=prod_DGB))
```

**Standby DB**

```plaintext
prod = (DESCRIPTION_LIST = (DESCRIPTION = (ADDRESS = (PROTOCOL = TCP)(HOST = ec2)(PORT = 1526)) ) )
(SID_LIST_prod = (SID_DESC = (ORACLE_HOME= /data/oracle/prod/db/tech_st/11.1.0) (SID_NAME = prod))
(SID_DESC = (ORACLE_HOME= /data/oracle/prod/db/tech_st/11.1.0) (SID_NAME = prod) (GLOBAL_DBNAME=stb_DGMGRL))
(SID_DESC = (ORACLE_HOME= /data/oracle/prod/db/tech_st/11.1.0) (SID_NAME = prod) (GLOBAL_DBNAME=stb_DGB))
```
Primary DB:

```sql
# Primary tnsnames.ora:
STB =
  (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = standby)(PORT = 1526))
   (CONNECT_DATA =
    (SID = prod)
    )
  )
prod =
  (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = primary)(PORT = 1526))
   (CONNECT_DATA =
    (SID = VIS)
    )
  )
```

Standby DB:

```sql
# Standby tnsnames.ora:
STB =
  (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = standby)(PORT = 1526))
   (CONNECT_DATA =
    (SID = prod)
    )
  )
prod =
  (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = primary)(PORT = 1526))
   (CONNECT_DATA =
    (SID = VIS)
    )
  )
```