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Using z/OS to Access a Public Cloud - Beyond the Hand-Waving

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Dovetailed Technologies

We provide z/OS customers world wide with innovative solutions that enhance and transform traditional mainframe workloads:

- Co:Z Co-Processing Toolkit for z/OS
  - z/OS Enabled SFTP, z/OS Hybrid Batch, z/OS Unix Batch integration
  - uses IBM Ported Tools for z/OS - OpenSSH
- JZOS
  - acquired by IBM in and now part of the z/OS Java SDK

Agenda

- Introduce z/OS Hybrid Batch Processing
- Hello World Example
- Security Considerations
- z/OS Hybrid Batch and public cloud services
  - Example: generate and publish PDF documents using input from z/OS data sets.
    - Run and managed as a z/OS hybrid batch job
    - 1 million PDFs (60 GB) generated and published on a public cloud Hadoop cluster in an hour for < $25
    - All example code, JCL, and tools available free
- Summary
- References

Acknowledgements

Mike Cox of IBM's Advanced Technical Support first conceived and prototyped this example using z/OS and Co:Z to drive a zBX (power) Hadoop cluster.

Redpaper: "Hadoop and System z" by Vic Leith and John Thomas, IBM. Demonstrates how to use Co:Z Hybrid batch with the IBM public Cloud service.

Hybrid Computing Models

Well Known:

- Linux or Windows as user-facing edge, web and application servers (zBX, zLinux, or on a non-z platform)
  - z/OS provides back-end databases and transaction processing
- zBX as special purpose appliances or optimizers
  - DB2 Analytics Accelerator
  - DataPower

Another Model: **z/OS Hybrid Batch**

- zBX/zLinux/Linux/Unix/Windows integrated with z/OS batch

z/OS Hybrid Batch Processing

1. The ability to execute a program or script on a virtual server from a z/OS batch job step
2. The target program may already exist and should require little or no modification
3. The target program's input and output are redirected from/to z/OS spool files or datasets
4. The target program may easily access other z/OS resources: DDs, data sets, POSIX files and programs
5. The target program's exit code is adopted as the z/OS job step condition code

Network Security provided by OpenSSH.

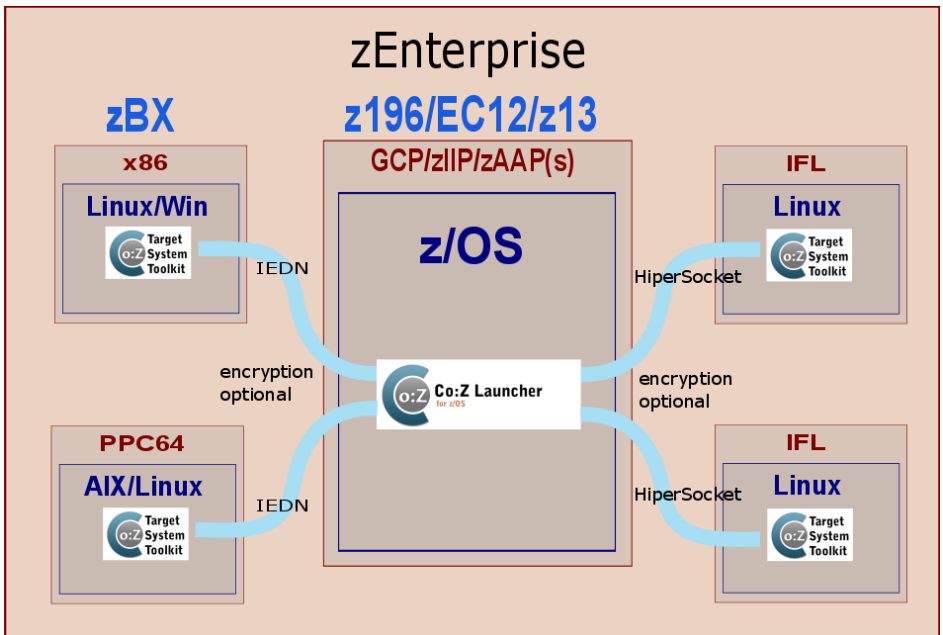
Data security governed by SAF (RACF/ACF2/TSS)

Requires new enablement software…

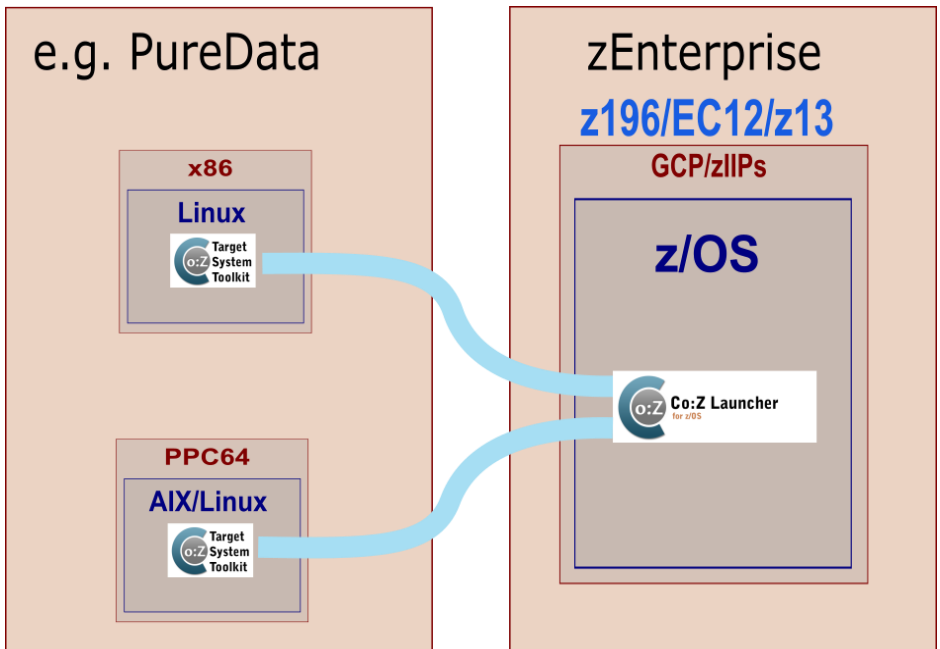
Co:Z Co-Processing Toolkit

- Implements z/OS Hybrid Batch model
- Co:Z Launcher starts a program on a target server and automatically redirects the standard streams back to jobstep DDs
- The target program can use Co:Z DatasetPipes commands to reach back into the active jobstep and access z/OS resources:
  - **`fromdsn/todsn`** – read/write a z/OS DD or data set
  - **`fromfile/tofile`** – read/write a z/OS Unix file
  - **`cozclient`** – run z/OS Unix command
- Free (commercial support licenses are also available)
- Visit http://dovetail.com for details

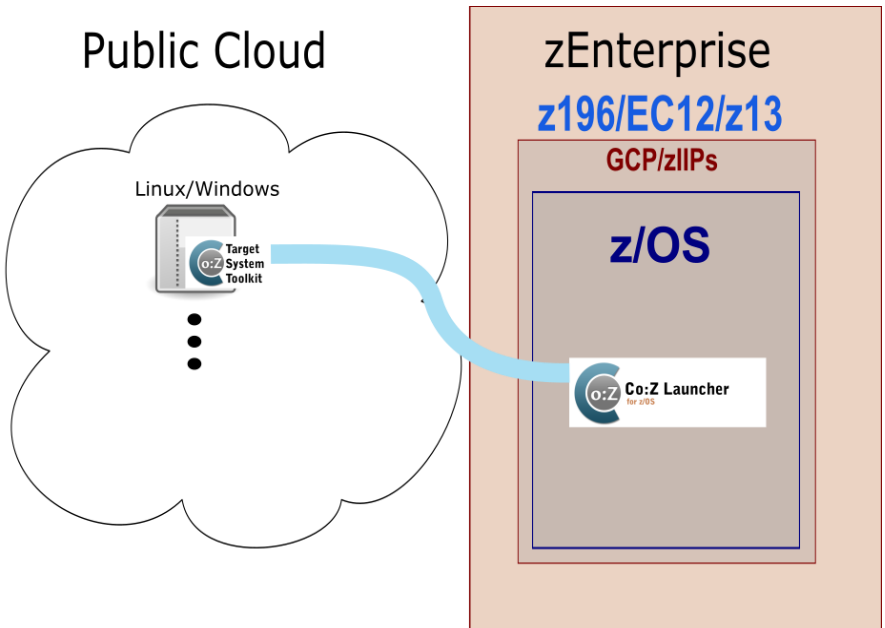
zEnterprise Hybrid Batch Processing



Private Cloud Hybrid Batch Processing

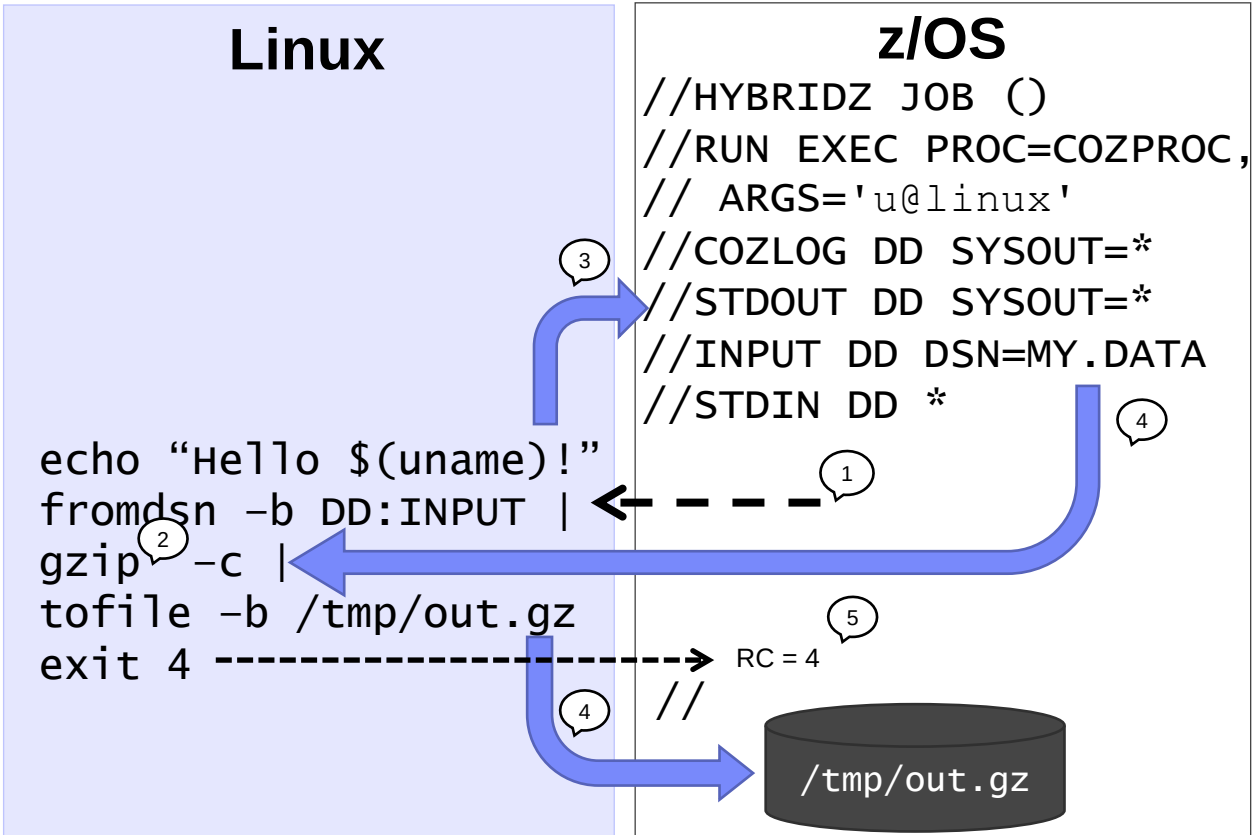


Public Cloud Hybrid Batch Processing



Hybrid Batch – Hello World

- Simple example illustrating the principles of Hybrid Batch Processing
- Launch a process on a remote Linux server
  - Write a message to stdout
  - In a pipeline:
    - Read the contents of a dataset from a jobstep DD
    - Compress the contents using the Linux gzip command
    - Write the compressed data to the z/OS Unix file system
  - Exit with a return code that sets the jobstep CC



Hello World: Hybrid Batch

1. A script is executed on a virtual server from a z/OS batch job step
2. The script uses a program that already exists -- **`gzip`**
3. Script output is redirected to z/OS spool
4. z/OS resources are easily accessed using **`fromdsn`**, **`tofile`**, etc…
5. The script exit code is adopted as the z/OS job step CC

Hello World – DD:STDOUT

```
Hello Linux!
```

Hello World – DD:COZLOG

```
CoZLauncher[N]: version: 3.0.0 2014-11-12
cozagent[N]: version: 1.1.2 2013-03-19
fromdsn(DD:STDIN)[N]: 5 records/400 bytes read…
fromdsn(DD:INPUT)[N]: 78 records/6240 bytes read…
tofile(/tmp/out.gz)[N]: … 1419 bytes written
todsn(DD:STDOUT)[N]: … 13 bytes written
todsn(DD:STDERR)[N]: … 0 bytes written
CoZLauncher[E]: u@linux target … ended with RC=4
```

Hello World – DD:JESMSGLG

```
JOB01515 ---- FRIDAY,  7 SEPT 2014 ----
JOB01515  IRR010I  USERID GOETZE   IS ASSIG…
JOB01515  ICH70001I GOETZE   LAST ACCESS AT…
JOB01515  $HASP373 HYBRIDZ  STARTED – INIT…
JOB01515  -
JOB01515  -STEPNAME PROCSTEP    RC   EXCP…
JOB01515  -RUN      COZLNCH     04   1345…
JOB01515  -HYBRIDZ  ENDED.  NAME-
JOB01515  $HASP395 HYBRIDZ  ENDED
```

Co:Z Hybrid Batch Network Security

- OpenSSH is used to establish secure, authenticated network connections.
  - IBM Ported Tools OpenSSH client on z/OS
  - OpenSSH sshd server on target system
- By default, data transfer is tunneled (encrypted) over the ssh connection
  - Optionally, data can be transferred over raw sockets (option: ssh-tunnel=false)
    - This offers very high performance without encryption costs
    - Ideal for a secure network, such as zEnterprise HiperSockets or IEDN

z/OS Hybrid Batch and a Public Cloud

- Why use a public cloud?
  - Infrastructure, platforms, and services on demand

    (see other sessions for lots of hand-waving on this)
- z/OS is generally not suited as a cloud services *provider.*
  - Operating system, language, software requirements
  - Services like Hadoop are designed to horizontally scale across a cluster of servers
- z/OS Hybrid Batch offers a solution
  - z/OS centric operational control
  - Data and process connectivity
  - Security

Using Co:Z Toolkit with Cloud Services

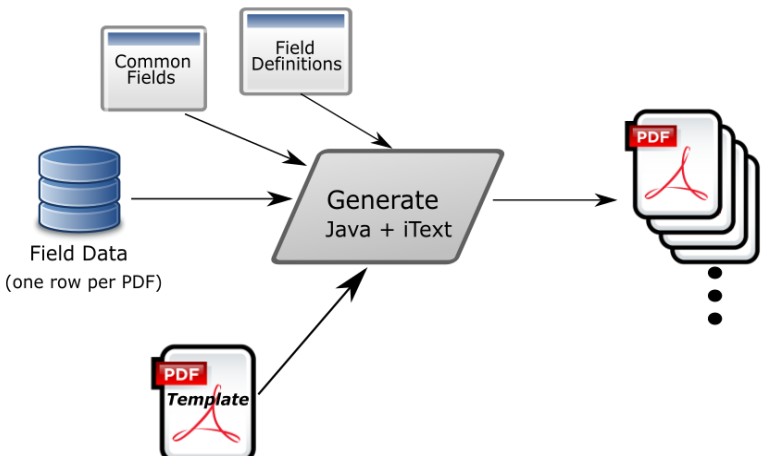
- The Co:Z Launcher and Dataset Pipes utilities facilitate:
  - Redirect input data from z/OS to the cloud
    - Data sets, POSIX files
    - Other sources, DB2, etc
  - Executing compute intensive jobs on cloud servers
    - Source maintained on z/OS
    - Control launch/termination of Hadoop clusters
    - Monitor progress in the job log
  - Redirect results to z/OS
    - Job spool
    - Data sets, POSIX files
    - Other destinations, DB2, etc

Generate, Publish Documents from z/OS data

- Example: generate and publish a million PDF documents using input from z/OS data sets
- Java driven PDF generation can be time consuming and expensive on the zSeries architecture
- z/OS hybrid batch can be used to:
  - Target Java execution to a Hadoop cloud cluster
  - Enable z/OS operations to retain control of scheduling
  - Publish the resulting PDFs in cloud storage
- For example code and JCL see:
  - http://dovetail.com/products/casestudyitext.html

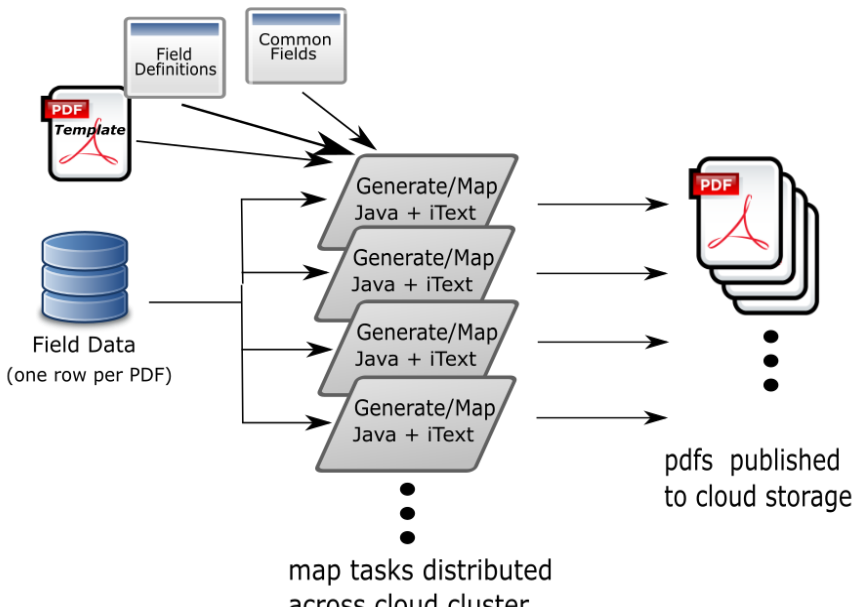
PDF Generation (a.k.a “stamping”)

(a single process implementation)



See http://dovetail.com/products/casestudyitext.html

PDF Generation using Hadoop cloud service



PDF Generation Example Overview

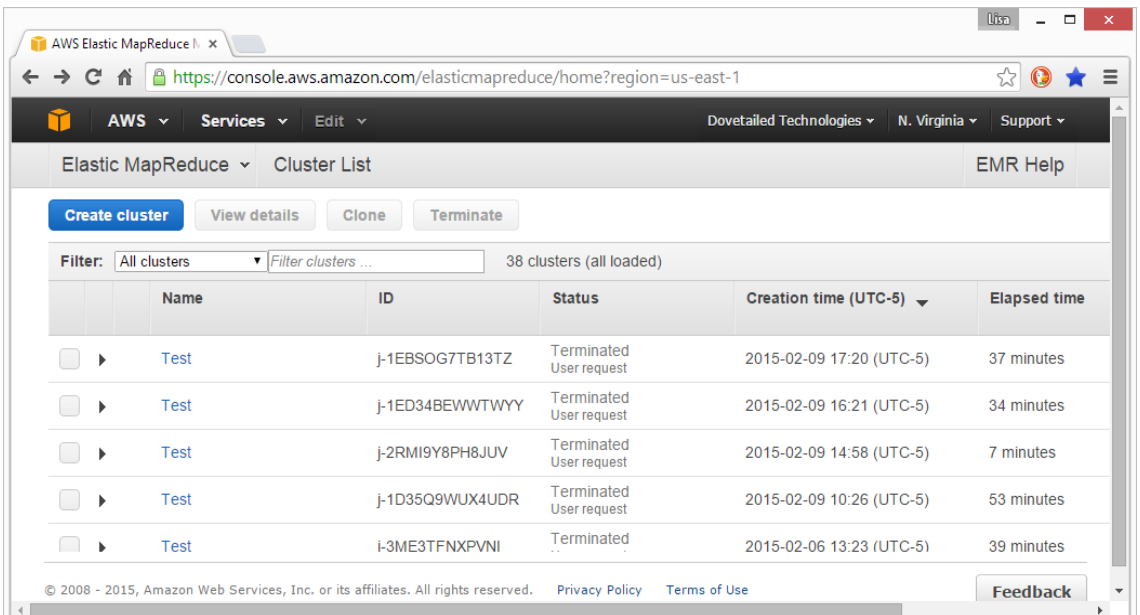
- Write a Java MapReduce application to generate PDFs.
  - See our example code to get started. You can use the free Hortonworks Hadoop sandbox for testing.
- Configure your public cloud Hadoop service
  - for this example we will use Amazon Web Services
- Create and Launch an Amazon Elastic MapReduce (EMR) Cluster
- Run Co:Z Launcher, executing the Java MapReduce on EMR
- Terminate the Amazon EMR Cluster
- View generated PDFs using Amazon S3 URLs

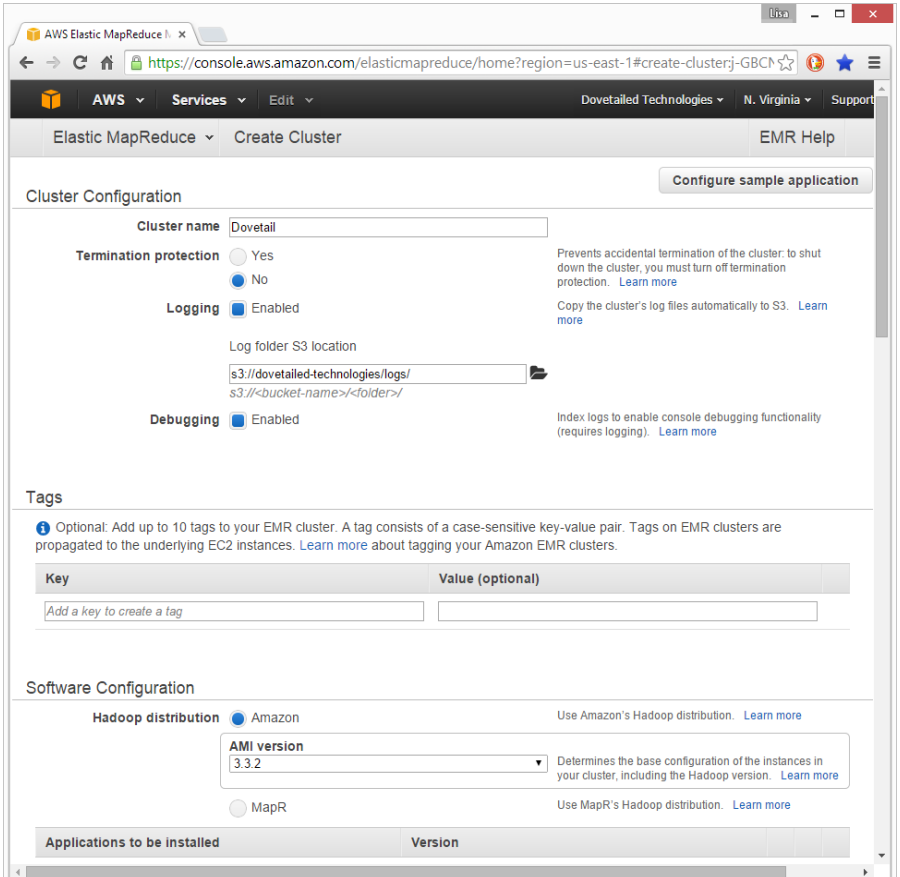
Configure Amazon Web Services

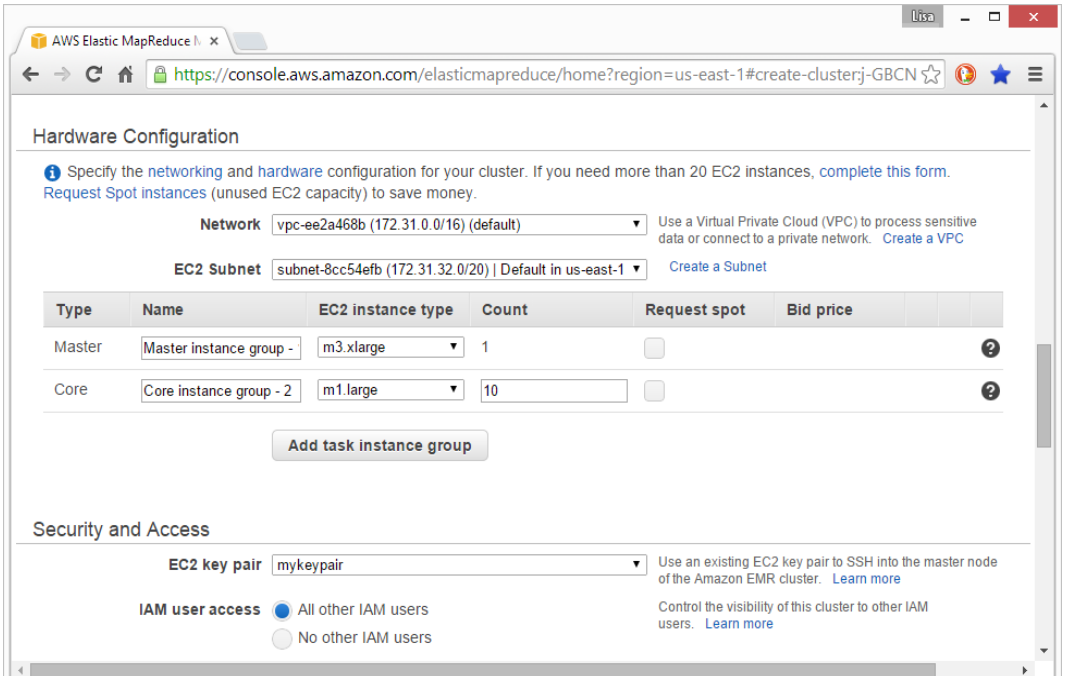
- Create an AWS Account at http://aws.amazon.com
- Create an Amazon S3 bucket
- Create an EC2 access key pair
- Create an Identity and Access Management (IAM) User
- Configure static website hosting
- Enable access to the published PDFs

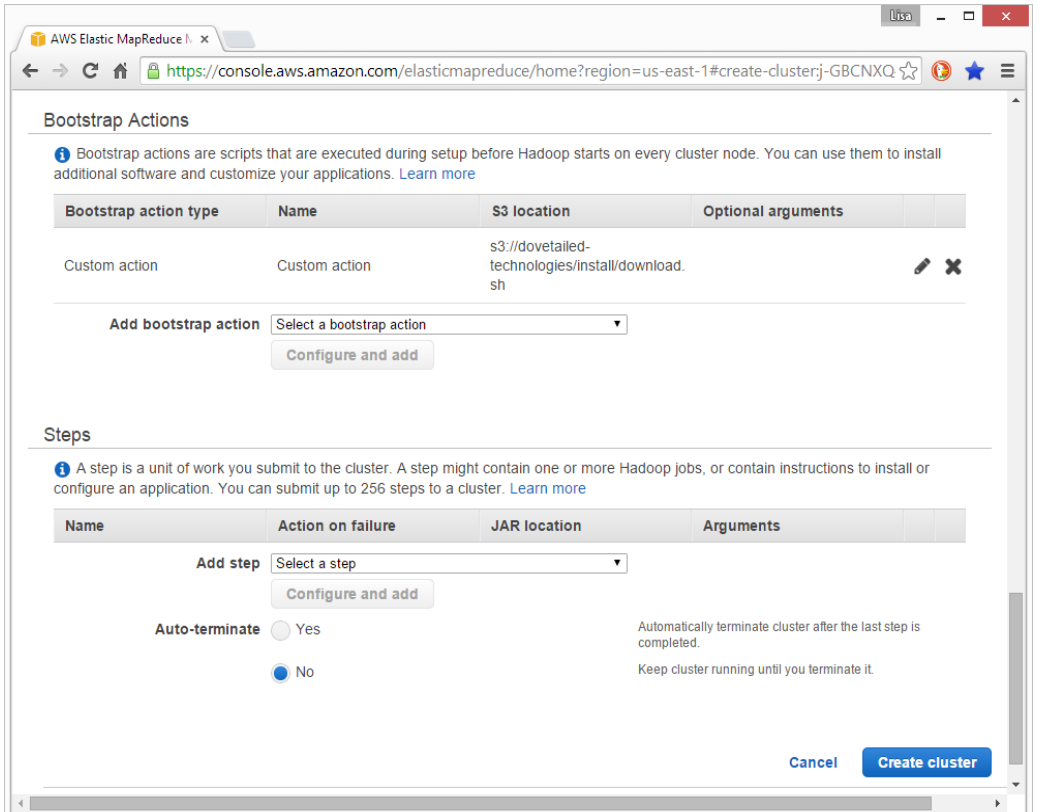
Note: *The README in our downloadable example walks through these steps for proof of concept purposes; however, refer to aws.amazon.com for complete AWS documentation and recommendations for configuration and security.*

Create and Launch an Amazon EMR Cluster

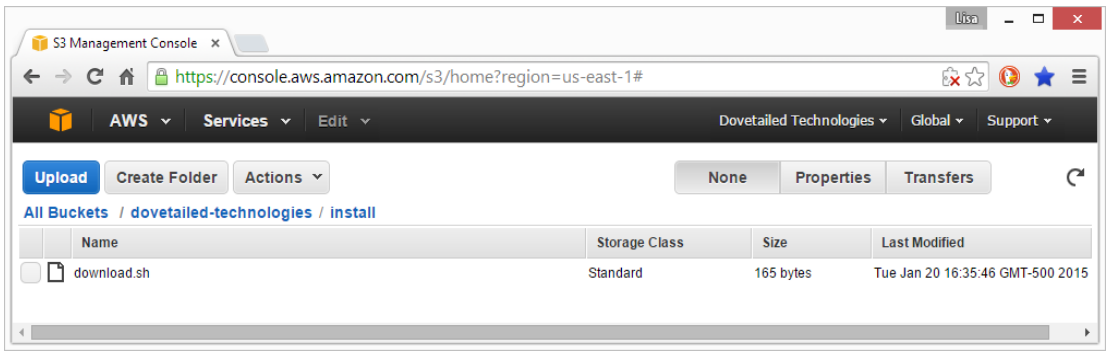






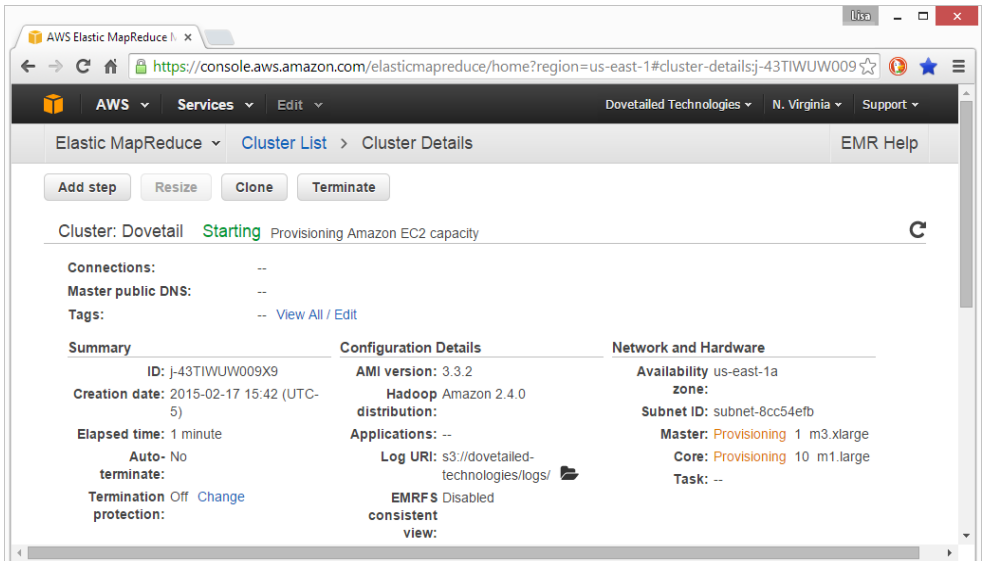


Bootstrap Action

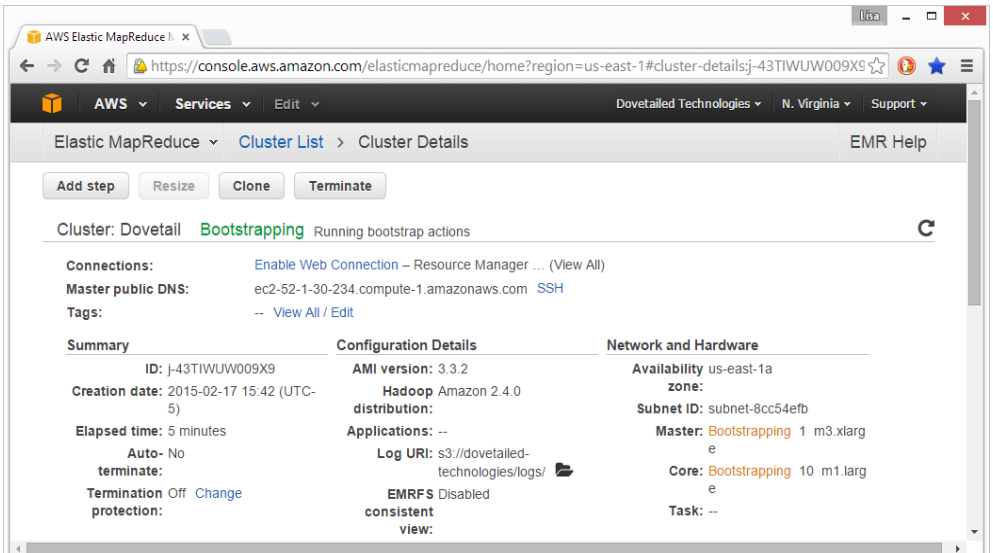



```
#!/bin/bash
wget http://www.dovetail.com/downloads/coz/coz-toolkit-1.1.2-1.x86_64.rpm
sudo rpm -i  coz-toolkit-1.1.2-1.x86_64.rpm
mkdir -p /home/hadoop/tmp
```

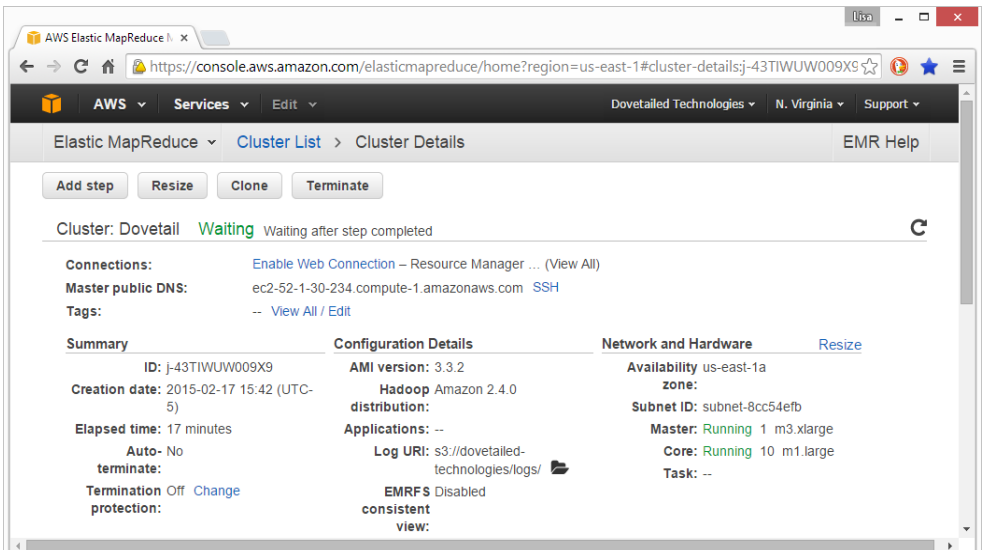
Starting the Cluster



Starting the Cluster …



Cluster is Ready



- Transfer your mykeypair.pem to your z/OS .ssh directory
- Click on the SSH link and follow instructions to connect to the Master public host name from z/OS

z/OS Hybrid Batch JCL

- Defines inputs from z/OS data sets
  - Customer field data (one row per output PDF)
  - Common fields and field descriptions
  - a template PDF with form fields
- Submits the MapReduce job to the cluster
  - Transfers Java jar and submits the job to the hadoop master node
  - Streams input data to the cluster for processing
  - Streams output PDFs to Amazon S3, scalable cloud storage
- Transfers to z/OS the list of Amazon S3 URLs for each generated PDF

Co:Z Launcher: Define z/OS Data Set Inputs

```
//CZUSERR JOB (),'COZ',MSGCLASS=H,NOTIFY=&SYSUID,CLASS=A
//   SET PRFX=CZUSER.COZ.HADOOP.ITEXT
//DELOLD EXEC PGM=IEFBR14
//URLOUT   DD DSN=&PRFX..URLOUT,
//            DISP=(MOD,DELETE,DELETE)
//STEP01  EXEC PROC=COZPROC, ARGS='-LI '
//FLDDATA  DD DISP=SHR,DSN=&PRFX..FLDDATA
//COMDATA  DD DISP=SHR,DSN=&PRFX..CONFIG(COMDATA)
//COMMAP   DD DISP=SHR,DSN=&PRFX..CONFIG(COMMAP)
//FLDMAP   DD DISP=SHR,DSN=&PRFX..CONFIG(FLDMAP)
//TEMPLATE DD DISP=SHR,DSN=&PRFX..TEMPLATE
//URLOUT   DD DSN=&PRFX..URLOUT,
//         DISP=(NEW,CATLG),
//         SPACE=(CYL,(200,100),RLSE),
//         DCB=(RECFM=VB,LRECL=1028,BLKSIZE=6144)
```

(Sample input field data)

```
//FLDDATA  DD DISP=SHR,DSN=&PRFX..FLDDATA
10010|Shana V. Crane|(642) 468-1794|non.arcu@ignore.com|915-2786 Cursus Ave|Green Bay|…
10011|Orla A. Peck|(138) 218-6798|convallis.est.vitae@ignore.com|P.O. Box 392, 2726 Ma…
10012|Isadora N. Tyson|(603) 373-1585|pede.malesuada.vel@ignore.com|989-4958 Tempor Ave…
10013|Lesley X. Castro|(892) 940-5463|egestas@ignore.com|Ap #420-7231 Magna. Rd.|Huntin…
10014|Lisandra L. Russo|(625) 271-5861|sed.dolor.Fusce@ignore.com|Ap #802-4828 Eu Street…
10015|Kibo Z. Sykes|(751) 248-2339|Nunc.mauris.sapien@ignore.com|394-3122 Etiam Ave|Hart…
10016|Erin A. Shannon|(773) 202-0622|ac.turpis.egestas@ignore.com|Ap #941-8398 Mauris. R…
10017|Ian V. Mcclure|(561) 633-9148|vel.convallis@ignore.com|P.O. Box 686, 5766 Cras Ave…
10018|Omar F. Grant|(171) 220-6026|nec.diam@ignore.com|207-8265 Cursus. St.|Coatesville|…
10019|Calvin S. Walters|(417) 929-6722|vel.turpis@ignore.com|Ap #353-7720 Sed Rd.|Evansv…
10020|Hedley S. Guy|(623) 456-8704|magna@ignore.com|8223 Aenean St.|Garland|C6G 5W9|NB|A…
10021|Tamekah K. Mccray|(310) 180-5164|nascetur@ignore.com|9983 Libero. Rd.|Culver City|…
10022|Jessica H. Walter|(673) 189-5945|vulputate@ignore.com|Ap #119-768 In St.|Ocean Cit…
10023|Maile P. Holland|(735) 320-8493|dignissim@ignore.com|P.O. Box 732, 7222 Pede Road|…
10024|Alfreda Y. Snider|(398) 791-0593|libero.et.tristique@ignore.com|6816 Nam Avenue|Mo…
…
```

Co:Z Launcher JCL: Setup

```
//COZCFG DD *
target-user=hadoop
target-host=ec2-52-1-30-234.compute-1.amazonaws.com
# Note: StrictHostKeyChecking=no could be added to ssh-options
ssh-options=-oIdentityFile=/home/czuser/.ssh/mykeypair.pem
//STDIN DD *
#
# Define the output directory as a bucket URL
#
awsid=CKIBICAXYBHETULAZKEL
awskey=54TzLHOqqOpZ9XNOTnM8IZwW8PUQaewp5D2qaJfc
bucket=s3://${awsid}:${awskey}@dovetailed-technologies
outdir=${bucket}/output
```

Co:Z Launcher JCL: transfer Java jar

```
# Transfer application jar from z/OS to hadoop master node
source=/home/czuser/coz-itext-hadoop
fromfile -b ${source}/ItextPdfGenerator.jar > ItextPdfGenerator.jar
```

Co:Z Launcher JCL: Submit Job to EMR

```
# ${outdir} is a bucket in Amazon S3
# /user/hadoop is HDFS in the hadoop cluster
# /home/hadoop/tmp is a local file system temp directory
#
hadoop jar ItextPdfGenerator.jar          \
${outdir}                                 \
/user/hadoop                              \
/home/hadoop/tmp                          \
<(fromdsn DD:COMDATA)                     \
<(fromdsn DD:COMMAP)                      \
<(fromdsn DD:FLDDATA)                     \
<(fromdsn DD:FLDMAP)                      \
<(fromdsn -b DD:TEMPLATE)                 \
2500000   # max split size
test $? -ne 0 && exit 8
```

Co:Z Launcher: Transfer URLs to z/OS

```
#
# Copy the URL list from S3 to a dataset,
# one file per mapper task
#       ../output/urls-m-xxxxx
#
hadoop fs -cat ${outdir}/urls* | todsn DD:URLOUT
```

Bash shell: process substitution

- Make a command (or pipeline) appear as a file name argument:
  - <(cmd) – is substituted with name of *readable* pipe file: /dev/fd/nn
  - >(cmd) – is substituted with name of *writable* pipe file: /dev/fd/nn

- for this example:

```
diff <(ls dir1)  <(ls dir2)
```

the bash shell actually does something like:

```
mkfifo /dev/fd/63 /dev/fd/64  # temp named pipe files
ls dir1 > /dev/fd/63 &  # forks a child process
ls dir2 > /dev/fd/64 &  # forks another child process
diff /dev/fd/63 /dev/fd/64
rm /dev/fd/63 /dev/fd/64
```

- Very handy for enabling “data in flight” in hybrid batch processing…

Co:Z Launcher: DD:COZLOG

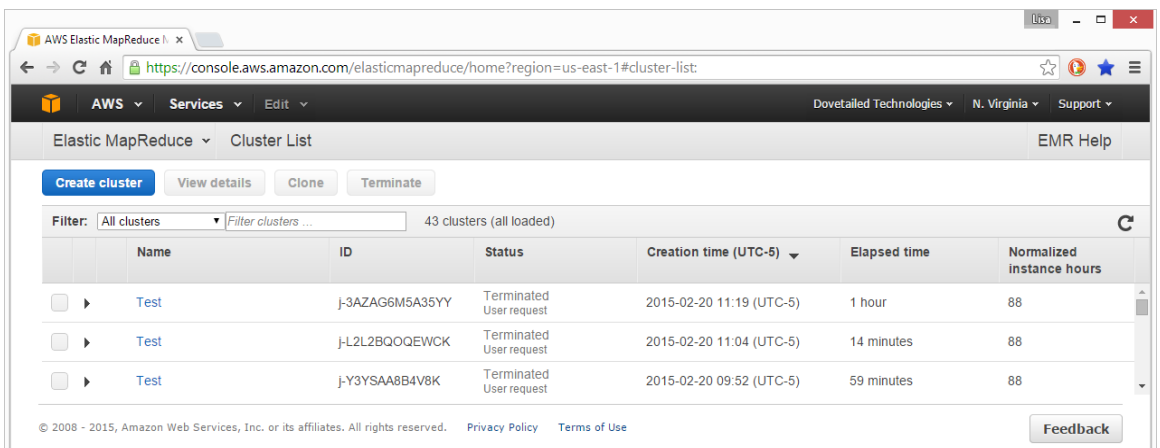
```
CoZLauncher[N]: version: 3.0.0 2014-11-12
cozagent[N]: version: 1.1.2 2013-03-19
fromdsn(DD:STDIN)[N]: 20 records/1600 bytes read…
fromfile(/home/czuser/coz-itext-hadoop/ItextPdfGenerator.jar)[N]: 7095063 bytes read…
fromdsn(DD:COMMAP)[N]: 1 records/26 bytes read…
fromdsn(DD:COMDATA)[N]: 1 records/40 bytes read…
fromdsn(DD:FLDMAP)[N]: 1 records/99 bytes read…
fromdsn(DD:TEMPLATE)[N]: 11 records/62716 bytes read…
fromdsn(DD:FLDDATA)[N]: 1000000 records/122727376 bytes read…
cozagent [22:33] Waiting for completion...
   :
cozagent [22:53] Waiting for completion...
todsn(DD:URLOUT)[N]: … 71888896 bytes written …
todsn(DD:STDERR)[N]: …353 records/32938 bytes written …
todsn(DD:STDOUT)[N]: …0 bytes written …
CoZLauncher[I]: CoZAgent process (33620106) ended with RC=0
CoZLauncher[N]: hadoop@ec2-54-152-154-141.compute-1.amazonaws.com target command '<default
  shell>' ended with RC=0
CoZLauncher[I]: CoZLauncher ended with RC=0
```

Co:Z Launcher: DD:STDERR

```
2015-02-20 16:25:55,790 INFO  ItextPdfConfiguration -
  pdf-output-hdfs-directory: s3://<awsid>:<awskey>@dovetailed-technologies/output
  local-hdfs-root:  /user/hadoop
  local-work-directory:  /home/hadoop/tmp
  common-data:  /dev/fd/63 (csv delimted by '|')
  common-map:  /dev/fd/62 (csv delimted by '|')
  field-data:   /dev/fd/61 (csv delimted by '|')
  field-map:   /dev/fd/60 (csv delimted by '|')
  pdf-template:  /dev/fd/59
  max-input-split-size:  2500000
2015-02-20 16:30:58,074 INFO  JobSubmitter - number of splits:50
2015-02-20 16:30:58,617 INFO  Job - The url to track the job: http://172.31.2.91:9046
2015-02-20 16:30:58,618 INFO  Job - Running job: job_....
2015-02-20 16:31:09,819 INFO  Job -  map 0% reduce 0%
…
2015-02-20 16:56:32,575 INFO  Job -  map 100% reduce 0%
2015-02-20 17:16:09,155 INFO  Job - Job job_... completed successfully
2015-02-20 17:16:09,292 INFO  Job - Counters: 36
   File System Counters …
   Job Counters
           Launched map tasks=50 …
```

Terminate the EMR Cluster

- From the Amazon EMR interface, terminate the cluster
- Once terminated, the normalized instance hours provide the approximate number of compute hours.



Automate Cluster Launch and Termination

- A cluster can be created, launched and terminated using the AWS CLI
- Use the Co:Z Launcher properties exit to create and launch a cluster, setting the `target-host` property to the Master public host name

```
//COZCFG DD *
target-user=hadoop
target-host=
ssh-options=
properties-exit=/home/czuser/set-properties.sh
```

- Requires `ssh-options` to be set to the following in set-properties.sh:

```
-oStrictHostKeyChecking=no -oIdentityFile=/home/czuser/.ssh/mykeypair.pem
```

- Add a second step to the JCL that terminates active clusters

```
//STEP02  EXEC PROC=SFTPPROC
//SFTPIN    DD *
/home/czuser/terminate.sh
/*
```

- The set-properties.sh and terminate.sh z/OS shell scripts use ssh to connect to a linux server and run AWS CLI commands.
- Download the example code to review the z/OS and linux sample scripts.

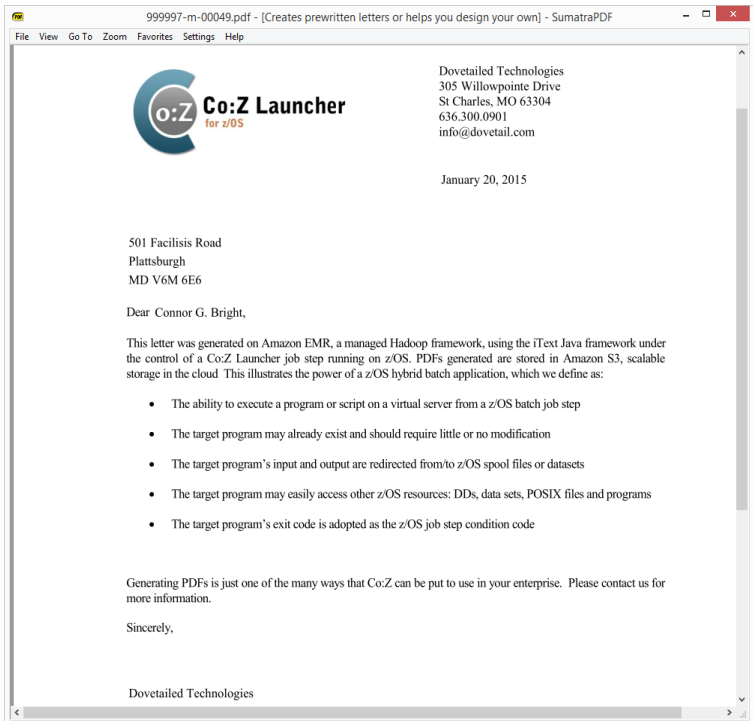
View the generated PDFs

- From ISPF, view the URLOUT data set

```
                    :
                    .
s3.amazonaws.com/dovetailed-technologies/output/3661/111957-m-00009.pdf
s3.amazonaws.com/dovetailed-technologies/output/4239/111958-m-00009.pdf
s3.amazonaws.com/dovetailed-technologies/output/9127/111959-m-00009.pdf
s3.amazonaws.com/dovetailed-technologies/output/2479/111960-m-00009.pdf
s3.amazonaws.com/dovetailed-technologies/output/7964/111961-m-00009.pdf
s3.amazonaws.com/dovetailed-technologies/output/1198/111962-m-00009.pdf
s3.amazonaws.com/dovetailed-technologies/output/2276/111963-m-00009.pdf
                    .
```

- Note the randomized part added to the S3 key
- Use the URL to access the PDF from a browser

A generated PDF



The results

- Using a EMR 10-node (+1 master) “m3.xlarge” cluster
  - 4 vCPUs, 15 GB memory, Intel Xeon E5-2670 v2*

- Generated 1 Million PDFs (~ 60 GB) and transferred them to S3 storage.
  - Cluster startup - 5 minutes
  - Job execution - 58 Minutes (including startup)
  - EMR cost: $3.85
  - S3 storage/transfer cost: $12.00

z/OS: TOTAL TCB CPU TIME= .03 TOTAL ELAPSED TIME= 58.5

References

- Contacts: http://dovetail.com
  info@dovetail.com
- For example code and JCL see:
  http://dovetail.com/products/casestudyitext.html
- Hybrid Batch Information including additional case studies
  http://dovetail.com/solutions.html
- Additional presentations, articles, webinars
  http://dovetail.com/webinars.html
  - Introduction to z/OS Hybrid Batch Processing
  - z/OS Hybrid Batch Processing on the z/Enterprise
  - z/OS Hybrid Batch Processing and Big Data
- “Hadoop and System z” by Vic Leith and John Thomas, IBM
  http://www.redbooks.ibm.com/redpapers/pdfs/redp5142.pdf

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