Analyzing WARC on Serverless Computing

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Web Archiving Conference 2021
15 - 16 Jun 2021

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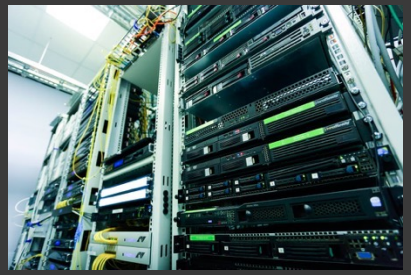
Agenda

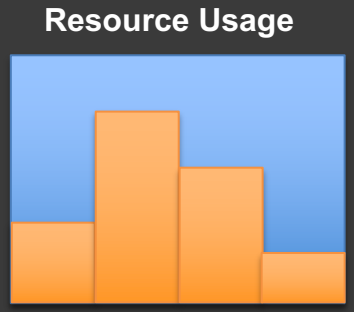
- Challenges
- Serverless
- Architecture design
- Experiment setup
- Results
- Conclusion
- Future work

Challenges

- Limited in-house resource to maintain a cluster 24/7
  - Configure servers, monitor tools, logs, etc.
  - Software version upgrade, security patches, etc.
  - Hardware replacement
- Scalability is limited by the compute resource
- Time to process a set of datasets is fixed
- Moving the entire setup to the cloud would be expensive

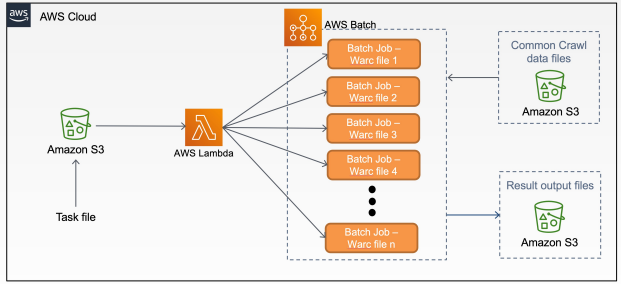
Before

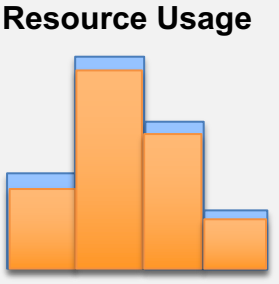




- Cluster 24/7
- Handle scalability under a fixed resource
- Maintenance burden

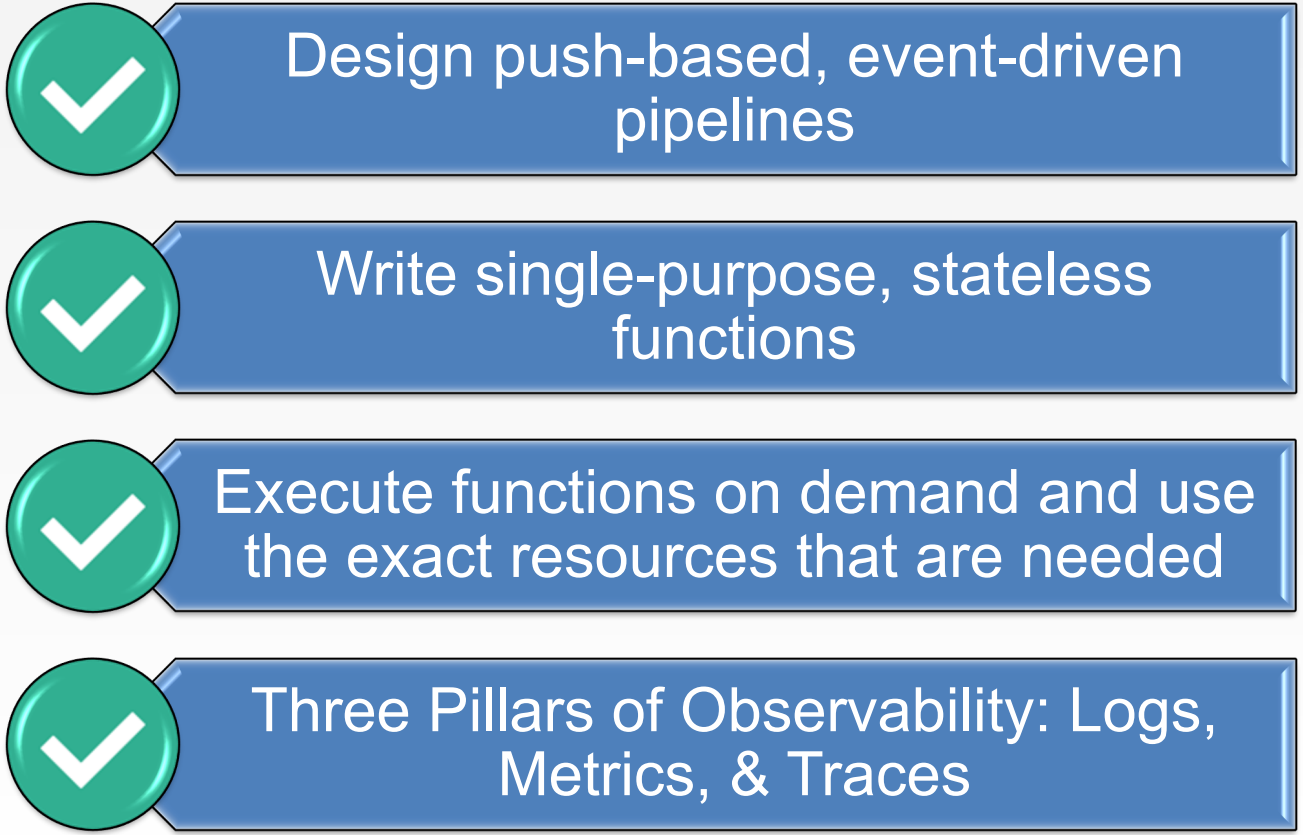
Now





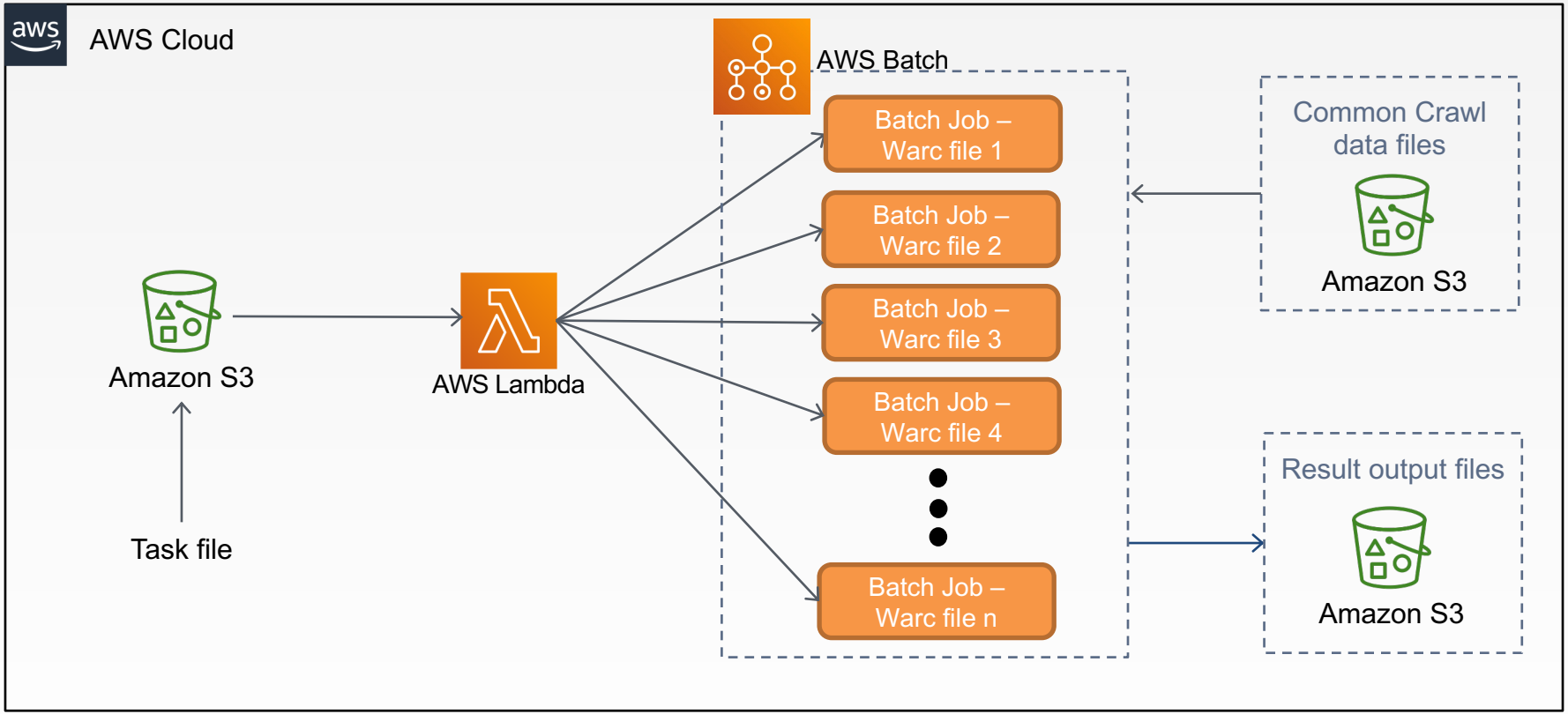
- Ready to receive requests 24/7
- Handle scalability automatically with more flexible resources
- Use the servers, no need to maintain them
- Resource usage is closer to actual usage

Principles of Serverless Design



Event-driven Pipeline Workflow

- Task files upload to a S3 bucket
  - S3 URL location of Common Crawl data
- Trigger a Lambda function
- Lambda function reads content in a task file and submits a batch job
- Each batch job runs a container and processes the program workflow
- Results upload to a S3 bucket

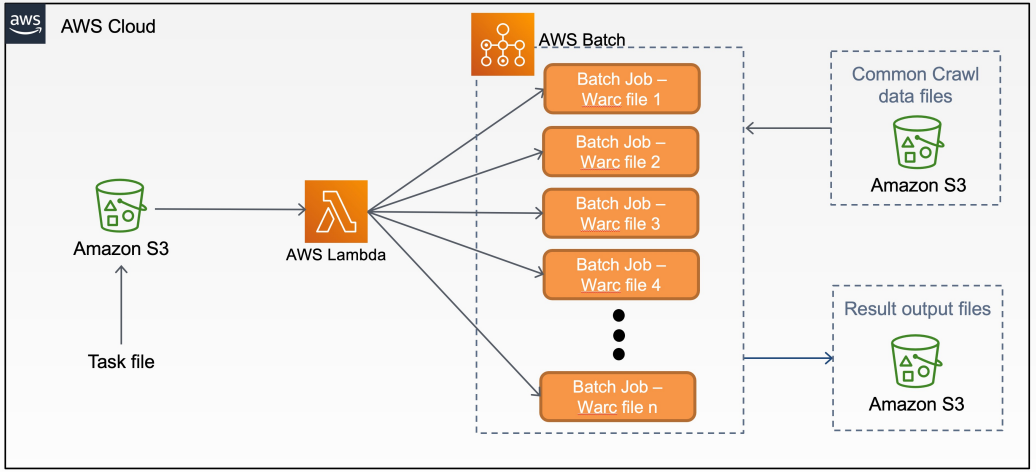

AWS Cloud
AWS Batch
Batch Job – Warc file 1
Batch Job – Warc file 2
Batch Job – Warc file 3
Batch Job – Warc file 4
Batch Job – Warc file n
Common Crawl data files
Amazon S3
Amazon S3
AWS Lambda
Amazon S3
Task file
Result output files
Amazon S3

Program Workflow

- Get a file from Common Crawl
- Load a file into ArchiveSpark
- Create CDX
- Extract page with links
- Save all the derivative data
- Record execution times
- Upload results to a S3 bucket

Infrastructure as Code (DevOps)

```
ComputeEnvironment:
  Type: AWS::Batch::ComputeEnvironment
  Properties:
    Type: MANAGED
    ComputeResources:
      Type: SPOT
      MinvCpus: 0
      DesiredvCpus: 0
      MaxvCpus: 256
      InstanceTypes:
      - optimal
      Subnets:
      - Ref: Subnet
      SecurityGroupIds:
      - Ref: SecurityGroup
      ImageId: ami-00487452f317c9be1
      InstanceRole:
        Ref: IamInstanceProfile
      BidPercentage: 40
      SpotIamFleetRole:
        Ref: SpotIamFleetRole
      Tags: {"name" : "IIPCSpot"}
    ServiceRole:
      Ref: BatchServiceRole
BatchProcessS3Bucket:
  Type: AWS::S3::Bucket
  DependsOn: BatchProcessBucketPermission
  Properties:
    BucketName:
      !Sub '${S3BucketName}-${AWS::AccountId}'
    NotificationConfiguration:
      LambdaConfigurations:
      - Event: 's3:ObjectCreated:*'
```



Launch Stack

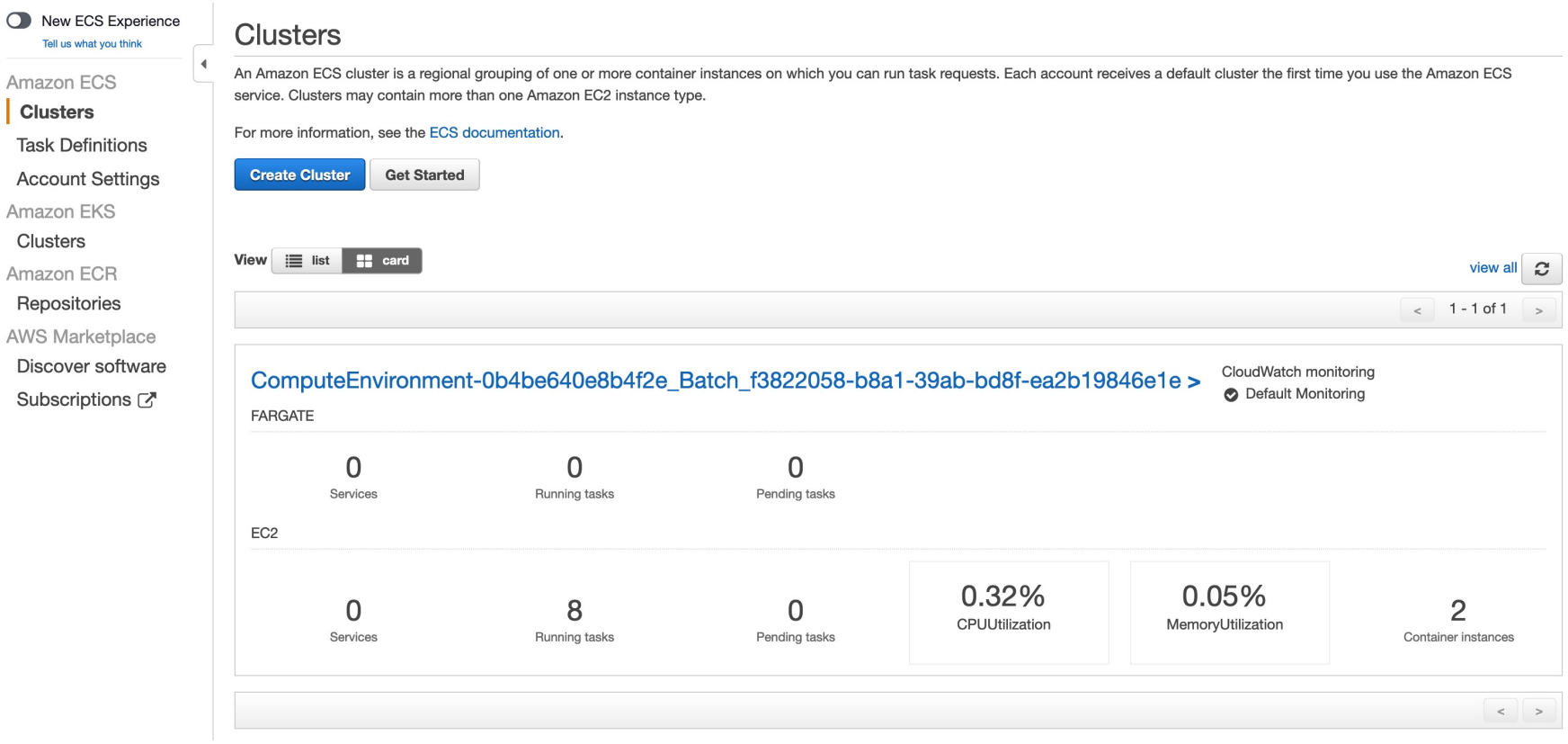
One click deploy

```
CloudFormation stack changeset
Operation                LogicalResourceId          ResourceType
* Modify                 ConvertFileFunction        AWS::Lambda::Function
* Modify                 UploadBucket               AWS::S3::Bucket

Changeset created successfully. arn:aws:cloudformation:us-east-1:909117335741:changeSet/samcli-deploy1614752401/f3165ad7-122e-4644-bd52-f4b4c8b1c8b1

2021-03-03 01:20:17 - Waiting for stack create/update to complete
CloudFormation events from changeset
ResourceStatus                ResourceType                LogicalResourceId
UPDATE_IN_PROGRESS            AWS::Lambda::Function       ConvertFileFunction
UPDATE_COMPLETE               AWS::Lambda::Function       ConvertFileFunction
^[UPDATE_COMPLETE_CLEANUP_IN_PROGRESS  AWS::CloudFormation::Stack  testhello
UPDATE_COMPLETE               AWS::CloudFormation::Stack  testhello
```

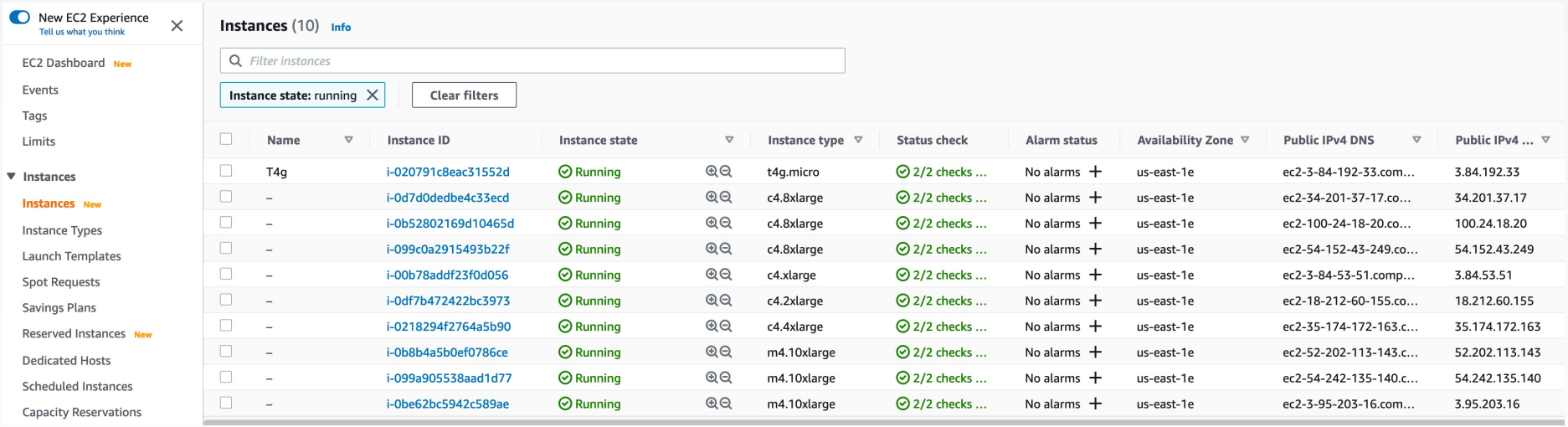
Experiment Setup

- Run 10, 20, 40, 80, 100, 1000 # of tasks
- Each task processes one Common Crawl file
- Run tasks using
  - On-demand instance
  - Spot instance (up to 40% off the on-demand instance price)
- Record execution time, logs, and cost

Monitor Cluster Status



Managed Compute Environment Automatically



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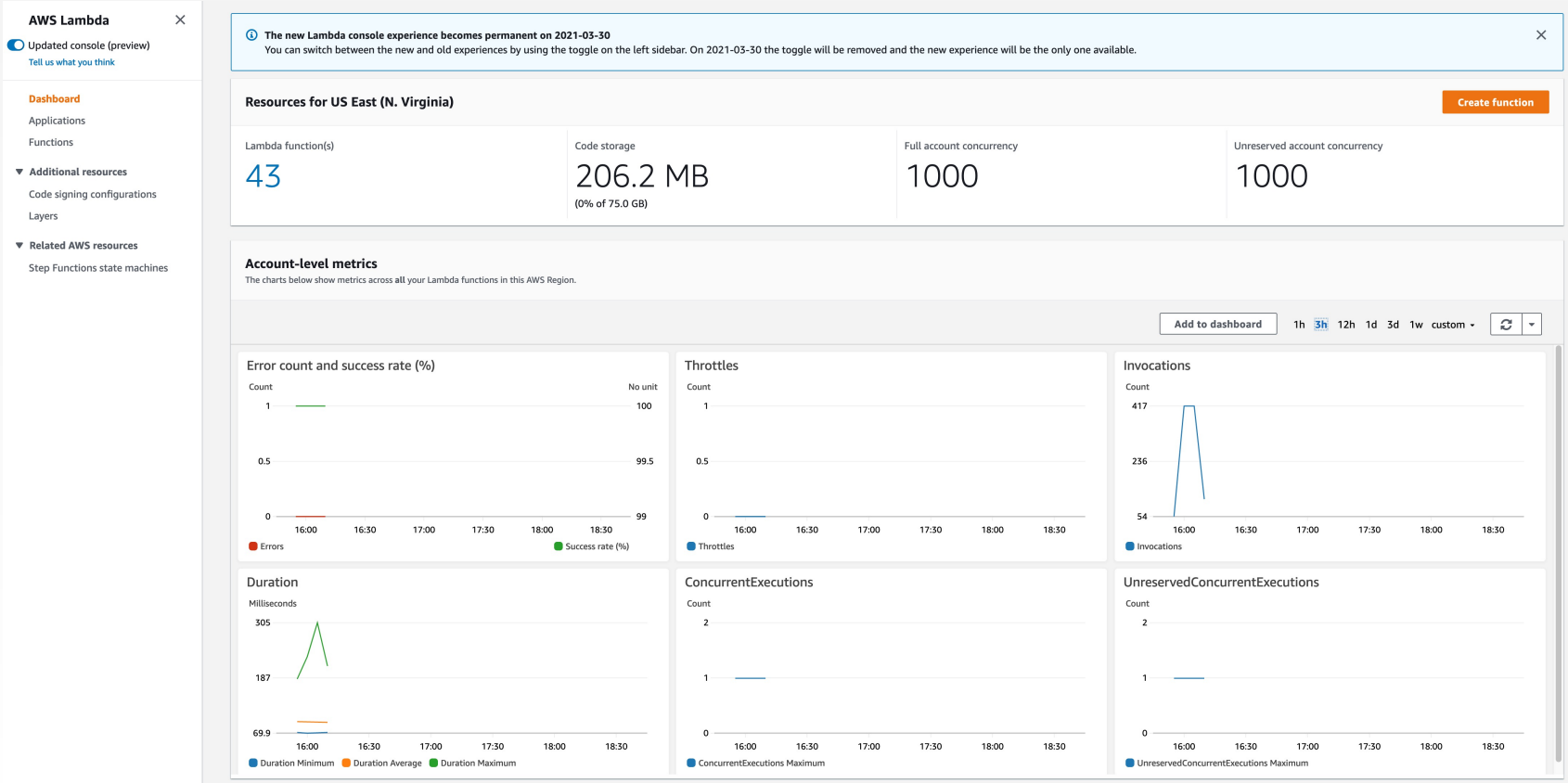
Monitor Lambda Status



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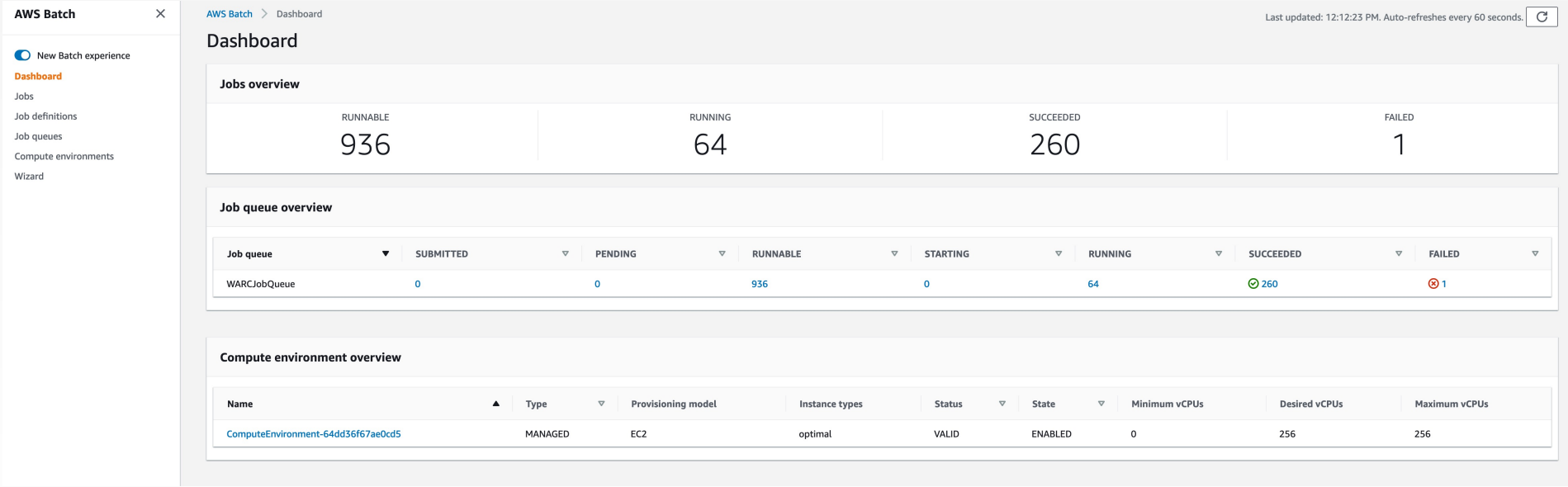
Monitor Job Progress



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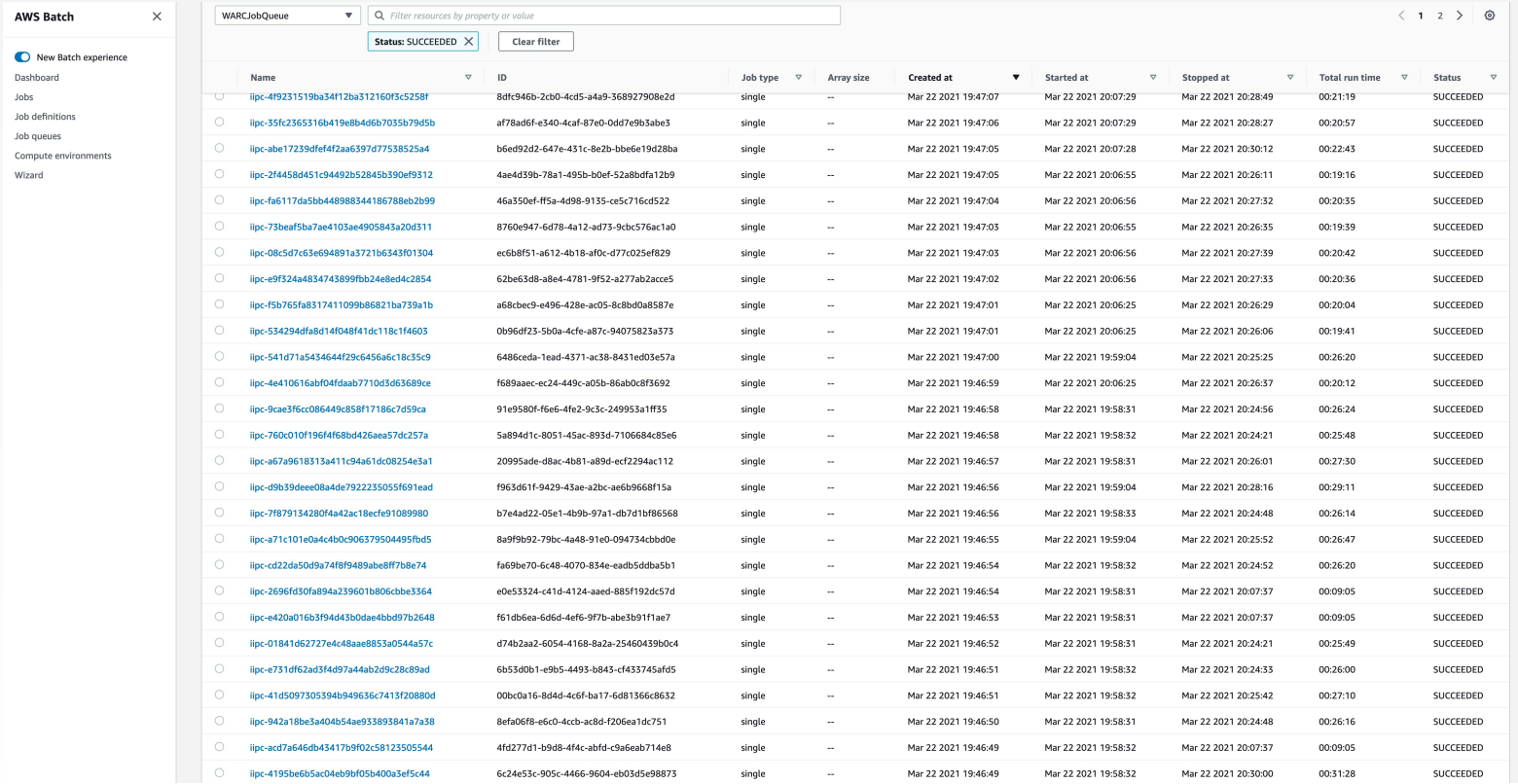
Batch Job Logs



Name	ID	Job type	Array size	Created at	Started at	Stopped at	Total run time	Status
iipc-4f9231519ba34f12ba312160f3c5258f	8dfc946b-2cb0-4cd5-a4a9-368927908e2d	single	--	Mar 22 2021 19:47:07	Mar 22 2021 20:07:29	Mar 22 2021 20:28:49	00:21:19	SUCCEEDED
iipc-35fc2365316b419e8b4d6b7035b79d5b	af78ad6f-e340-4caf-87e0-0dd7e9b3abe3	single	--	Mar 22 2021 19:47:06	Mar 22 2021 20:07:29	Mar 22 2021 20:28:27	00:20:57	SUCCEEDED
iipc-abe17239dfef4f2aa6397d77538525a4	b6ed92d2-647e-431c-8e2b-bbe6e19d28ba	single	--	Mar 22 2021 19:47:05	Mar 22 2021 20:07:28	Mar 22 2021 20:30:12	00:22:43	SUCCEEDED
iipc-2f4458d451c94492b52845b390ef9312	4ae4d39b-78a1-495b-b0ef-52a8bdfa12b9	single	--	Mar 22 2021 19:47:05	Mar 22 2021 20:06:55	Mar 22 2021 20:26:11	00:19:16	SUCCEEDED
iipc-fa6117da5bb448988344186788eb2b99	46a350ef-ff5a-4d98-9135-ce5c716cd522	single	--	Mar 22 2021 19:47:04	Mar 22 2021 20:06:56	Mar 22 2021 20:27:32	00:20:35	SUCCEEDED
iipc-73beaf5ba7ae4103ae4905843a20d311	8760e947-6d78-4a12-ad73-9cbc576ac1a0	single	--	Mar 22 2021 19:47:03	Mar 22 2021 20:06:55	Mar 22 2021 20:26:35	00:19:39	SUCCEEDED
iipc-08c5d7c63e694891a3721b6343f01304	ec6b8f51-a612-4b18-af0c-d77c025ef829	single	--	Mar 22 2021 19:47:03	Mar 22 2021 20:06:56	Mar 22 2021 20:27:39	00:20:42	SUCCEEDED
iipc-e9f324a48347438 99fbb24e8ed4c2854	62be63d8-a8e4-4781-9f52-a277ab2acce5	single	--	Mar 22 2021 19:47:02	Mar 22 2021 20:06:56	Mar 22 2021 20:27:33	00:20:36	SUCCEEDED
iipc-f5b765fa8317411099b86821ba739a1b	a68cbec9-e496-428e-ac05-8c8bd0a8587e	single	--	Mar 22 2021 19:47:01	Mar 22 2021 20:06:25	Mar 22 2021 20:26:29	00:20:04	SUCCEEDED
iipc-534294dfa8d14f048f41dc118c1f4603	0b96df23-5b0a-4cfe-a87c-94075823a373	single	--	Mar 22 2021 19:47:01	Mar 22 2021 20:06:25	Mar 22 2021 20:26:06	00:19:41	SUCCEEDED
iipc-541d71a5434644f29c6456a6c18c35c9	6486ceda-1ead-4371-ac38-8431ed03e57a	single	--	Mar 22 2021 19:47:00	Mar 22 2021 19:59:04	Mar 22 2021 20:25:25	00:26:20	SUCCEEDED
iipc-4e410616abf04fdaab7710d3d63689ce	f689aaec-ec24-449c-a05b-86ab0c8f3692	single	--	Mar 22 2021 19:46:59	Mar 22 2021 20:06:25	Mar 22 2021 20:26:37	00:20:12	SUCCEEDED
iipc-9cae3f6cc086449c858f17186c7d59ca	91e9580f-f6e6-4fe2-9c3c-249953a1ff35	single	--	Mar 22 2021 19:46:58	Mar 22 2021 19:58:31	Mar 22 2021 20:24:56	00:26:24	SUCCEEDED
iipc-760c010f196f4f68bd426aea57dc257a	5a894d1c-8051-45ac-893d-7106684c85e6	single	--	Mar 22 2021 19:46:58	Mar 22 2021 19:58:32	Mar 22 2021 20:24:21	00:25:48	SUCCEEDED
iipc-a67a9618313a411c94a61dc08254e3a1	20995ade-d8ac-4b81-a89d-ecf2294ac112	single	--	Mar 22 2021 19:46:57	Mar 22 2021 19:58:31	Mar 22 2021 20:26:01	00:27:30	SUCCEEDED
iipc-d9b39deee08a4de7922235055f691ead	f963d61f-9429-43ae-a2bc-ae6b9668f15a	single	--	Mar 22 2021 19:46:56	Mar 22 2021 19:59:04	Mar 22 2021 20:28:16	00:29:11	SUCCEEDED
iipc-7f879134280f4a42ac18ecfe91089980	b7e4ad22-05e1-4b9b-97a1-db7d1bf86568	single	--	Mar 22 2021 19:46:56	Mar 22 2021 19:58:33	Mar 22 2021 20:24:48	00:26:14	SUCCEEDED
iipc-a71c101e0a4c4b0c906379504495fbd5	8a9f9b92-79bc-4a48-91e0-094734cbbd0e	single	--	Mar 22 2021 19:46:55	Mar 22 2021 19:59:04	Mar 22 2021 20:25:52	00:26:47	SUCCEEDED
iipc-cd22da50d9a74f8f9489abe8ff7b8e74	fa69be70-6c48-4070-834e-eadb5ddba5b1	single	--	Mar 22 2021 19:46:54	Mar 22 2021 19:58:32	Mar 22 2021 20:24:52	00:26:20	SUCCEEDED
iipc-2696fd30fa894a239601b806cbbe3364	e0e53324-c41d-4124-aaed-885f192dc57d	single	--	Mar 22 2021 19:46:54	Mar 22 2021 19:58:31	Mar 22 2021 20:07:37	00:09:05	SUCCEEDED
iipc-e420a016b3f94d43b0dae4bbd97b2648	f61db6ea-6d6d-4ef6-9f7b-abe3b91f1ae7	single	--	Mar 22 2021 19:46:53	Mar 22 2021 19:58:31	Mar 22 2021 20:07:37	00:09:05	SUCCEEDED
iipc-01841d62727e4c48aae8853a0544a57c	d74b2aa2-6054-4168-8a2a-25460439b0c4	single	--	Mar 22 2021 19:46:52	Mar 22 2021 19:58:31	Mar 22 2021 20:24:21	00:25:49	SUCCEEDED
iipc-e731df62ad3f4d97a44ab2d9c28c89ad	6b53d0b1-e9b5-4493-b843-cf433745afd5	single	--	Mar 22 2021 19:46:51	Mar 22 2021 19:58:32	Mar 22 2021 20:24:33	00:26:00	SUCCEEDED
iipc-41d5097305394b949636c7413f20880d	00bc0a16-8d4d-4c6f-ba17-6d81366c8632	single	--	Mar 22 2021 19:46:51	Mar 22 2021 19:58:32	Mar 22 2021 20:25:42	00:27:10	SUCCEEDED
iipc-942a18be3a404b54ae933893841a7a38	8efa06f8-e6c0-4ccb-ac8d-f206ea1dc751	single	--	Mar 22 2021 19:46:50	Mar 22 2021 19:58:31	Mar 22 2021 20:24:48	00:26:16	SUCCEEDED
iipc-acd7a646db43417b9f02c58123505544	4fd277d1-b9d8-4f4c-abfd-c9a6eab714e8	single	--	Mar 22 2021 19:46:49	Mar 22 2021 19:58:32	Mar 22 2021 20:07:37	00:09:05	SUCCEEDED
iipc-4195be6b5ac04eb9bf05b400a3ef5c44	6c24e53c-905c-4466-9604-eb03d5e98873	single	--	Mar 22 2021 19:46:49	Mar 22 2021 19:58:32	Mar 22 2021 20:30:00	00:31:28	SUCCEEDED

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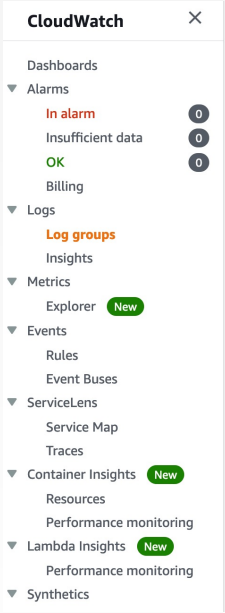
Batch Job Logs



2021-03-30T19:48:08.462-04:00	duration: Double = 753.365644969
2021-03-30T19:48:08.548-04:00	summary: String = CDX:106.264873529|PagesWithLinks:753.365644969
2021-03-30T19:48:08.639-04:00	pw: java.io.PrintWriter = java.io.PrintWriter@4d5a6b60
2021-03-30T19:48:08.853-04:00	21/03/30 23:48:08 [WARN] o.a.t.k.p.v.s.KernelOutputStream - Suppressing empty output: ''
2021-03-30T19:48:08.877-04:00	Unauthorized system.exit detected!
2021-03-30T19:48:08.877-04:00	21/03/30 23:48:08 [INFO] o.a.t.Main$$anon$1 - Shutting down kernel
2021-03-30T19:48:08.877-04:00	21/03/30 23:48:08 [INFO] o.a.t.Main$$anon$1 - Shutting down interpreters
2021-03-30T19:48:08.878-04:00	21/03/30 23:48:08 [INFO] o.a.t.k.i.s.ScalaInterpreter - Shutting down interpreter
2021-03-30T19:48:08.880-04:00	21/03/30 23:48:08 [INFO] o.a.t.Main$$anon$1 - Shutting down actor system
2021-03-30T19:48:08.930-04:00	21/03/30 23:48:08 [INFO] o.a.t.Main$$anon$1 - Shutting down interpreters
2021-03-30T19:48:08.930-04:00	21/03/30 23:48:08 [INFO] o.a.t.k.i.s.ScalaInterpreter - Shutting down interpreter
2021-03-30T19:48:08.930-04:00	21/03/30 23:48:08 [INFO] o.a.t.Main$$anon$1 - Shutting down actor system
2021-03-30T19:48:09.091-04:00	[NbConvertApp] Writing 1823 bytes to CC-MAIN-20200524210325-20200525000325-00020_output.ipynb
2021-03-30T19:48:09.510-04:00	Completed 1.8 KiB/134.6 MiB (54.1 KiB/s) with 10 file(s) remainingupload: ../results/CC-MAIN-20200524210325-20200525000325-00020/CC-MAIN-20200524210325-20200525000325-00020_output…
2021-03-30T19:48:09.530-04:00	Completed 1.8 KiB/134.6 MiB (54.1 KiB/s) with 9 file(s) remainingCompleted 1.8 KiB/134.6 MiB (34.8 KiB/s) with 9 file(s) remainingupload: ../results/CC-MAIN-20200524210325-2020052…
2021-03-30T19:48:09.536-04:00	Completed 1.8 KiB/134.6 MiB (34.8 KiB/s) with 8 file(s) remainingupload: ../results/CC-MAIN-20200524210325-20200525000325-00020/cdx.gz/_complete to s3://warcresults/CC-MAIN-202005…
2021-03-30T19:48:09.538-04:00	Completed 1.8 KiB/134.6 MiB (34.8 KiB/s) with 7 file(s) remainingCompleted 1.8 KiB/134.6 MiB (30.4 KiB/s) with 7 file(s) remainingupload: ../results/CC-MAIN-20200524210325-2020052…
2021-03-30T19:48:09.540-04:00	Completed 1.8 KiB/134.6 MiB (30.4 KiB/s) with 6 file(s) remainingCompleted 1.8 KiB/134.6 MiB (29.5 KiB/s) with 6 file(s) remainingupload: ../results/CC-MAIN-20200524210325-2020052…
2021-03-30T19:48:09.541-04:00	Completed 1.8 KiB/134.6 MiB (29.5 KiB/s) with 5 file(s) remainingupload: ../results/CC-MAIN-20200524210325-20200525000325-00020/pages-with-links.gz/_complete to s3://warcresults/C…
2021-03-30T19:48:09.572-04:00	Completed 1.8 KiB/134.6 MiB (29.5 KiB/s) with 4 file(s) remainingCompleted 257.8 KiB/134.6 MiB (3.5 MiB/s) with 4 file(s) remainingCompleted 513.8 KiB/134.6 MiB (6.5 MiB/s) with 4…
2021-03-30T19:48:09.630-04:00	Completed 1.0 MiB/134.6 MiB (11.0 MiB/s) with 3 file(s) remainingCompleted 1.3 MiB/134.6 MiB (9.7 MiB/s) with 3 file(s) remaining Completed 1.5 MiB/134.6 MiB (11.5 MiB/s) with 3 f…
2021-03-30T19:48:09.979-04:00	Completed 3.5 MiB/134.6 MiB (23.4 MiB/s) with 2 file(s) remainingCompleted 3.8 MiB/134.6 MiB (24.6 MiB/s) with 2 file(s) remainingCompleted 4.0 MiB/134.6 MiB (25.7 MiB/s) with 2 f…
2021-03-30T19:48:14.224-04:00	Completed 49.4 MiB/134.6 MiB (98.7 MiB/s) with 1 file(s) remainingCompleted 49.7 MiB/134.6 MiB (98.3 MiB/s) with 1 file(s) remainingCompleted 49.9 MiB/134.6 MiB (98.7 MiB/s) with …
2021-03-30T19:48:14.279-04:00	Done.
2021-03-30T19:48:14.279-04:00	Task Done.

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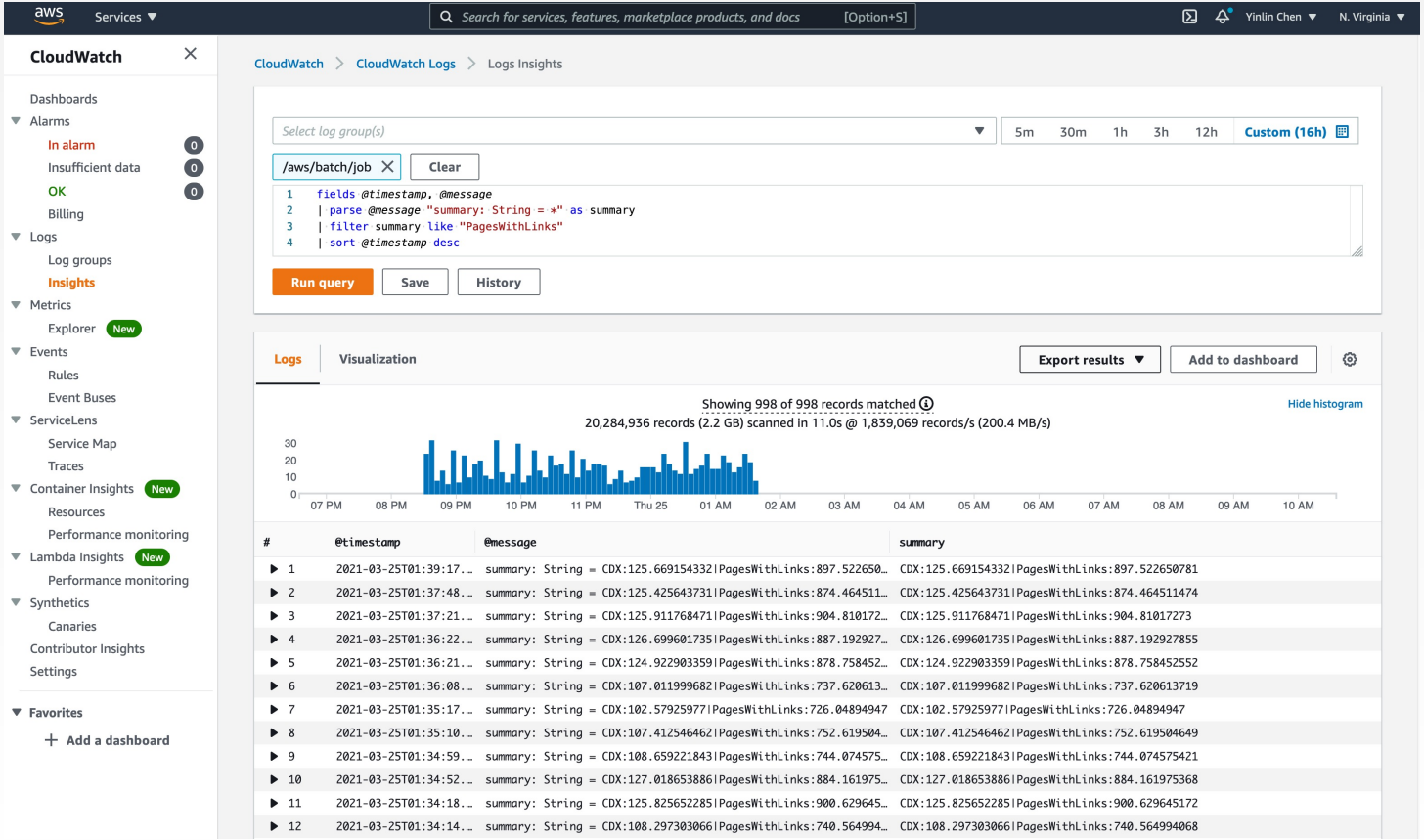
Query Log Results



#	@timestamp	@message	summary
▶ 1	2021-03-25T01:39:17.…	summary: String = CDX:125.669154332|PagesWithLinks:897.522650…	CDX:125.669154332|PagesWithLinks:897.522650781
▶ 2	2021-03-25T01:37:48.…	summary: String = CDX:125.425643731|PagesWithLinks:874.464511…	CDX:125.425643731|PagesWithLinks:874.464511474
▶ 3	2021-03-25T01:37:21.…	summary: String = CDX:125.911768471|PagesWithLinks:904.810172…	CDX:125.911768471|PagesWithLinks:904.81017273
▶ 4	2021-03-25T01:36:22.…	summary: String = CDX:126.699601735|PagesWithLinks:887.192927…	CDX:126.699601735|PagesWithLinks:887.192927855
▶ 5	2021-03-25T01:36:21.…	summary: String = CDX:124.922903359|PagesWithLinks:878.758452…	CDX:124.922903359|PagesWithLinks:878.758452552
▶ 6	2021-03-25T01:36:08.…	summary: String = CDX:107.011999682|PagesWithLinks:737.620613…	CDX:107.011999682|PagesWithLinks:737.620613719
▶ 7	2021-03-25T01:35:17.…	summary: String = CDX:102.57925977|PagesWithLinks:726.04894947	CDX:102.57925977|PagesWithLinks:726.04894947
▶ 8	2021-03-25T01:35:10.…	summary: String = CDX:107.412546462|PagesWithLinks:752.619504…	CDX:107.412546462|PagesWithLinks:752.619504649
▶ 9	2021-03-25T01:34:59.…	summary: String = CDX:108.659221843|PagesWithLinks:744.074575…	CDX:108.659221843|PagesWithLinks:744.074575421
▶ 10	2021-03-25T01:34:52.…	summary: String = CDX:127.018653886|PagesWithLinks:884.161975…	CDX:127.018653886|PagesWithLinks:884.161975368
▶ 11	2021-03-25T01:34:18.…	summary: String = CDX:125.825652285|PagesWithLinks:900.629645…	CDX:125.825652285|PagesWithLinks:900.629645172
▶ 12	2021-03-25T01:34:14.…	summary: String = CDX:108.297303066|PagesWithLinks:740.564994…	CDX:108.297303066|PagesWithLinks:740.564994068

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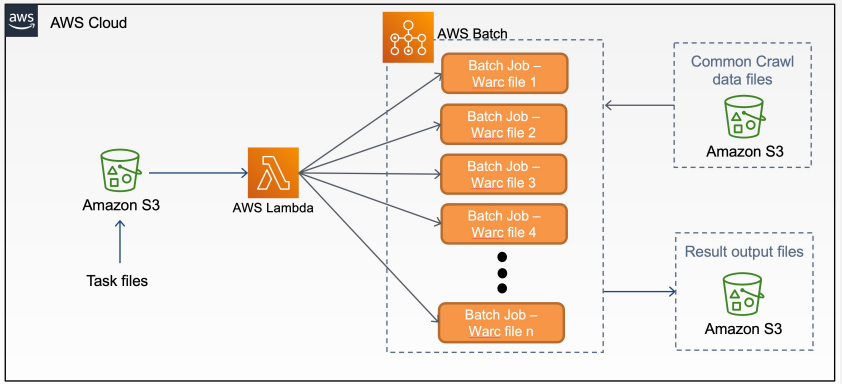
Results

- Avg. execution time for processing a WARC file is 23.3 mins
- Execution times for processing 10, 20, 40, 80, 100 # of WARC files are under 30 mins using on-demand instance
  - 1000 tasks took about 6 hours
- Each job (1G file) cost:
  - On-demand instance: $0.066
  - Spot instance: $0.022
- Success rate:
  - On-demand instance: 99%
  - Spot instance: depends (need to run more experiments)

Cost: Before

- Add one server, plus the cost
- Plan server capacity each year
  - Overestimation
  - Underestimation

Cost: Now



- Pay what we use
  - Use it well and pay less
  - Pay 0 when services are idle
- Some (invisible) costs vanish
  - Server maintenance cost
  - Labor, time, electric, etc.

Conclusion

- This serverless architecture design can process almost any number of tasks
- Use only the resources that are needed
- Eliminate the need to manage underlying servers
- Event-driven pipeline automates the entire workflow
- A suite of services for three pillars of observability: logs, metrics, and traces
- On-demand instance is more stable than spot instance
  - Need more experiments to verify
  - Spot instance cost is cheaper
- GitHub: https://github.com/yinlinchen/warc-analytics-wac2021

Future Work

- Extend WARC processing program for more complex tasks
- Batch resource (compute environment) tuning
  - CPU and Memory
  - Container
- Spot instance usage tuning
- Apply to other use cases using this serverless pipeline

Q & A

Thank You!

This research work was supported by AWS Educate program