Video on Demand on AWS

AWS Implementation Guide

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About This Guide

This implementation guide discusses architectural considerations and configuration steps for deploying Video on Demand on the Amazon Web Services (AWS). It includes links to AWS CloudFormation templates that launch and configure the AWS services required to deploy this solution using AWS best practices for security and availability.

The guide is intended for IT infrastructure architects, administrators, and DevOps professionals who have practical experience with video-on-demand workflows and architecting on the AWS Cloud.

Overview

Amazon Web Services (AWS) enables broadcasters and content owners to automate media supply chains, streamline content distribution, and deliver media content to a global audience. With the AWS Cloud, you can seamlessly scale your infrastructure to meet demand, and pay only for what you use, helping you build highly available and cost-effective solutions for video-on-demand workflows.

AWS offers its customers several methods to cost-effectively deliver video content to a global audience on the AWS Cloud. These methods enable you to dynamically scale any combination of video processing, delivery, and storage services. AWS Elemental MediaConvert transcodes media files from their source format into versions that will playback on devices like smartphones, tablets, and PCs; and Amazon CloudFront accelerates delivery of your video content to end users. Customers can leverage these AWS services to build a highly available, resilient architectures that ingest, store, process, and deliver video content on demand.

Video on Demand on AWS is a reference implementation that automatically provisions the AWS services necessary to build a scalable, distributed video-on-demand workflow. The video-on-demand solution combines AWS Elemental MediaConvert and CloudFront with AWS Step Functions, a service that allows you to build applications from individual components that each perform a discrete function, AWS Lambda, a service that allows you to run code without provisioning or managing servers, and Amazon Simple Storage Service...
(Amazon S3), a highly-scalable, reliable, and low-latency object store. The solution also leverages Amazon DynamoDB to track source and destination file metadata and progress through the workflow, Amazon CloudWatch to track encoding jobs, and Amazon Simple Notification Service (Amazon SNS) to send publishing, encoding, and error notifications.

The video-on-demand solution ingests metadata files and source videos, processes the videos for playback on a wide range of devices, stores the transcoded media files, and delivers the videos to end users through CloudFront. This reference implementation provides an example architecture to build a global consumer video workflow on AWS. You can customize the architecture to meet your specific needs. For more information, see Customization.

**Cost**

You are responsible for the cost of the AWS services used while running this reference deployment. As of the date of publication, the cost for running this solution with default settings in the US East (N. Virginia) Region is approximately $7 per hour of HD video. This does not include the cost of Amazon CloudFront, which will vary depending on the number of requests for content, or Amazon S3 storage. Prices are subject to change. For full details, see the pricing webpage for each AWS service you will be using in this solution.

**Architecture Overview**

Deploying this solution builds the following environment in the AWS Cloud.

![Figure 1: Video on Demand architecture with AWS Elemental MediaConvert](image)
The AWS CloudFormation template deploys a workflow that ingests source videos, or source videos and metadata files. When you upload a source video only, encoding options are defined in the AWS CloudFormation template at launch, and are applied to every video the solution encodes. When you upload a source video and metadata file, encoding parameters for each source video are defined in the metadata file, allowing customers to apply encoding options on a video-by-video basis.

The template deploys a workflow that includes AWS Elemental MediaConvert and AWS Step Functions, which creates ingest, processing, and publishing step functions. The template also launches AWS Lambda functions that perform the work of each step, and process error messages, Amazon S3 buckets for source and destination media files, Amazon CloudWatch for logging, Amazon CloudWatch Events rules for AWS Elemental MediaConvert notifications and an Amazon CloudFront distribution. An Amazon DynamoDB table stores data captured through the workflow, and Amazon SNS topics send encoding, publishing, and error notifications.

Solution Components

**Encoding Options**
The video-on-demand solution leverages AWS Elemental MediaConvert job templates to define the solution’s encoding options. By default, the solution creates three custom templates that produce UHD, HD, and SD output. Each template creates H.265 MP4; HTTP Live Streaming (HLS); and Dynamic Adaptive Streaming over HTTP (DASH). Additionally, the solution supports Microsoft Smooth Streaming (MSS) and Common Media Application Format (CMAF).

The workflow selects one of the three templates, based on the resolution of the source video. You can also customize the solution to work with any valid MediaConvert template. For more information, see Appendix F.

**Frame Capture**
This solution can also create a set of thumbnails from your source videos. If this feature is enabled, the solution will create a set of thumbnails for each selected output. The thumbnails are stored in the Amazon S3 bucket with your video output.

**Error Handling**
The ingest, processing, and publishing workflow AWS Lambda functions, and Amazon CloudWatch Events are configured to invoke an error handler Lambda function that updates
the Amazon DynamoDB table with error message details, and sends an Amazon Simple Notification Service (Amazon SNS) notification to a subscribed email address.

![Video on Demand error handling diagram](image)

**Figure 2: Video on Demand error handling**

**Ingest Step Functions**

**Video-Only Workflow**

When a new MP4, MPG, M4V, M2TS, or MOV video is added to the source Amazon S3 bucket, a Lambda function triggers the ingest workflow. During ingestion, source video details are added to Amazon DynamoDB, the content is validated using MediaInfo, open-source software that displays technical information about media files, and details are stored in DynamoDB.

**Important:** Source video file extensions (.mp4, .mpg, .m4v, .m2ts, or .mov) must be lowercase and file names cannot contain spaces.

**Metadata and Video Workflow**

When a new metadata file is added to the source Amazon S3 bucket, a Lambda function triggers the ingest workflow. During ingestion, the metadata file, source video, and encoding configuration details are added to Amazon DynamoDB, the source video is validated using MediaInfo and details are stored in DynamoDB.
Important: You must upload the source video file to the Amazon S3 bucket before you upload the metadata file. Note that the upload must complete before you upload the metadata file.

Processing Step Functions
The solution uses the height and width of the source video to determine which job template to use to submit encoding jobs to AWS Elemental MediaConvert. If you enable frame capture, the frame capture parameters are added to the job template. Then, the encoding job is created in MediaConvert and the details are stored in DynamoDB.

Publishing Step Functions
After the video is encoded, AWS Elemental MediaConvert sends a notification to Amazon CloudWatch. An Amazon CloudWatch Events rule invokes the publishing AWS Step Functions step function, which validates the outputs, and updates the DynamoDB table with the new content details.

When the workflow is finished, Amazon SNS sends a publish notification. If you choose to archive your source content, the source files are tagged to allow the Amazon S3 lifecycle policy to move files to Amazon Glacier.

Design Considerations
Customization
This solution leverages AWS Step Functions, which breaks the workflow into individual steps, making it easier to customize or extend the architecture for your specific video-on-demand needs. For example, you can modify or replace the encoding steps to produce different content sets. You can also add steps to extend support for more complex workflows, including image processing for poster artwork or additional custom data to the metadata file that will then be stored in Amazon DynamoDB. The solution originates MediaConvert output content directly from Amazon Simple Storage Service (Amazon S3) through Amazon CloudFront. You can, however, customize the solution to leverage a dedicated origin server such as AWS Elemental MediaPackage.

Each time the workflow is initiated, the solution creates a unique identifier. The unique identifier is used as the primary key in Amazon DynamoDB and the execution ID in AWS Step Functions. The unique identifier is passed to each step in the workflow, allowing information to be stored and retrieved in DynamoDB. This makes it easier to add and remove steps from the workflow.
Regional Deployments
This solution uses AWS Step Functions and AWS Elemental MediaConvert which are available in specific AWS Regions only. Therefore, you must deploy this solution in a region that supports these services. For the most current service availability by region, see AWS service offerings by region.

AWS CloudFormation Template
This solution uses AWS CloudFormation to automate the deployment of the video-on-demand solution on the AWS Cloud. It includes the following AWS CloudFormation template, which you can download before deployment:

**video-on-demand-on-aws.template**: Use this template to launch the video-on-demand solution and all associated components. The default configuration deploys AWS Lambda functions, Amazon Simple Storage Service (Amazon S3) buckets, AWS Step Functions, AWS Elemental MediaConvert, an Amazon DynamoDB table, Amazon CloudWatch Logs, Amazon CloudWatch Event rules, Amazon Simple Notification Service (Amazon SNS) topics, and an Amazon CloudFront distribution. You can also customize the template based on your specific needs.

Automated Deployment
Before you launch the automated deployment, please review the architecture and other considerations discussed in this guide. Follow the step-by-step instructions in this section to configure and deploy the video-on-demand solution into your account.

**Time to deploy**: Approximately 20 minutes

Launch the Stack
Use this AWS CloudFormation template to deploy the video-on-demand solution.

**Note**: You are responsible for the cost of the AWS services used while running this solution. See the Costs section for more details. For full details, see the pricing webpage for each AWS service you will be using in this solution.

1. Sign in to the AWS Management Console and click the button to the right to launch the video-on-demand-on-aws AWS CloudFormation template.
You can also download the template as a starting point for your own implementation.

2. The template is launched in the US East (N. Virginia) Region by default. To launch the solution in a different AWS Region, use the region selector in the console navigation bar.

   **Note:** This solution uses AWS Step Functions and AWS Elemental MediaConvert, which are available in specific AWS Regions only. Therefore, you must deploy this solution in a region that supports these services. For the most current service availability by region, see AWS service offerings by region.

3. On the **Select Template** page, verify that you selected the correct template and choose **Next**.

4. Under **Parameters**, review the parameters for the template and modify them as necessary. This solution uses the following default values.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admin Email</td>
<td>&lt;Requires input&gt;</td>
<td>A valid email address to receive Amazon SNS notifications</td>
</tr>
<tr>
<td>Workflow Trigger</td>
<td>&lt;Requires input&gt;</td>
<td>Choose VideoFile to ingest source videos only; choose MetadataFile to ingest metadata files and source videos</td>
</tr>
<tr>
<td>Archive Source Content</td>
<td>false</td>
<td>Choose true to enable an Amazon S3 lifecycle policy on the source bucket to move applicable files to Amazon Glacier after seven days</td>
</tr>
<tr>
<td>Enable Frame Capture</td>
<td>false</td>
<td>Choose true to create thumbnails for each AWS Elemental MediaConvert output</td>
</tr>
</tbody>
</table>

5. Choose **Next**.

6. On the **Options** page, choose **Next**.

7. On the **Review** page, review and confirm the settings. Be sure to check the box acknowledging that the template will create AWS Identity and Access Management (IAM) resources.

8. Choose **Create** to deploy the stack.

   You can view the status of the stack in the AWS CloudFormation Console in the **Status** column. You should see a status of **CREATE_COMPLETE** in approximately 20 minutes.

   After the stack is created, Amazon SNS sends three subscription notifications to the admin email address with links to enable encoding, publishing, and error notifications.

9. In the subscription notification emails, select each link to enable SNS notifications.
Note: In addition to the AWS Lambda functions that create solution resources and manage the ingest and publishing processes, this solution includes the metrics-helper Lambda function, which runs only during initial configuration or when resources are updated or deleted.

When running this solution, the metrics-helper function is inactive. However, do not delete the function as it is necessary to manage associated resources.

Security

When you build systems on AWS infrastructure, security responsibilities are shared between you and AWS. This shared model can reduce your operational burden as AWS operates, manages, and controls the components from the host operating system and virtualization layer down to the physical security of the facilities in which the services operate. For more information about security on AWS, visit the AWS Security Center.

Amazon S3 Bucket Policy
The Amazon Simple Storage Service (Amazon S3) buckets for AWS Elemental MediaConvert output includes a policy that allows access from Amazon CloudFront. Because the Amazon CloudFront endpoints are publicly accessible, the MediaConvert output bucket is also publicly accessible. For information on how to secure Amazon CloudFront, see Serving Private Content through CloudFront in the Amazon CloudFront Developer Guide.

IAM Roles
AWS Identity and Access Management (IAM) roles enable customers to assign granular access policies and permissions to services and users on the AWS Cloud. Video on Demand on AWS creates several IAM roles, including a role that grants AWS Elemental MediaConvert access to Amazon API Gateway and Amazon Simple Storage Service. This role is necessary to allow the services to operate in your account.

Additional Resources

AWS services
- AWS Step Functions
- AWS Elemental MediaConvert
- Amazon CloudFront
- Amazon CloudWatch
- AWS CloudFormation
- Amazon S3
- AWS Lambda
Other Resources

- MediaInfo

Appendix A: Ingest Workflow

When a new video is added to the source Amazon Simple Storage Service (Amazon S3) bucket, an AWS Lambda function starts the ingest step function. The ingest step function includes:

- **Input Validate** – Parses the input to the workflow, checks for the source video file, and defines the workflow configuration using the AWS Lambda function environment variables. If enabled, this step downloads the metadata file and overwrites the default environment variables with the variable definitions in the metadata file (metadata and video version only). For more information, see Appendix E.

- **MediaInfo** – Generates a signed Amazon S3 URL for the source video and runs MediaInfo to extract metadata about the video.

- **DynamoDB Update** – Takes accumulated data from each step and stores it in Amazon DynamoDB.

- **SNS Notification** – Sends an Amazon Simple Notification Service (Amazon SNS) notification with a summary of the ingest process.

- **Process Execute** – Starts the processing workflow.

Appendix B: Processing Workflow

When the ingest workflow is complete, it starts the processing workflow. The processing workflow includes:
**Figure 4: Processing workflow**

- **Profiler** – Gets the source video’s height and width from the metadata file, defines the settings for frame capture (if enabled), and chooses which template to use for encoding based on the source video’s height. For example, if the source video is greater than or equal to 1080p, the 1080p job template will be used.

- **Encode Job Submit** – Submits the encoding job with the template defined by the profiler to AWS Elemental MediaConvert.

- **Dynamo Update** – Takes accumulated data from each step and stores it in Amazon DynamoDB.
Appendix C: Publishing Workflow

When encoding is complete, Amazon Simple Notification Service (Amazon SNS) sends a notification that triggers an AWS Lambda function that starts the publishing process. The publishing process includes:

- **Output Validate** - Checks the event data for the completed encoding job, gets the GUID from the AWS Elemental MediaConvert notification, gets the asset details from Amazon DynamoDB, and generates the Amazon Simple Storage Service (Amazon S3) and Amazon CloudFront URLs for the MediaConvert outputs.

- **DynamoDB Update** – Updates Amazon DynamoDB table with the event data.

- **Archive Source** – If you configure the solution for archiving, this step tags the source video with a unique identifier and the archive status to trigger the Amazon Glacier lifecycle policy.

- **SNS Notification** – Sends an Amazon SNS notification with a summary of the workflow and the Amazon CloudFront URLs.

![AWS Step Functions publishing workflow](image)

**Figure 5: Publishing workflow**
Appendix D: Workflow Configuration

The Input Validate AWS Lambda function contains the following environment variables that define the workflow configuration.

<table>
<thead>
<tr>
<th>Environment Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archive Source</td>
<td>Choose whether to archive source videos in Amazon Glacier.</td>
</tr>
<tr>
<td>CloudFront</td>
<td>The Amazon CloudFront domain name. This is used to generate the playback URLs for the AWS Elemental MediaConvert outputs.</td>
</tr>
<tr>
<td>Destination</td>
<td>The name of the destination Amazon S3 bucket for all MediaConvert outputs.</td>
</tr>
<tr>
<td>FrameCapture</td>
<td>Choose whether to create thumbnails for each MediaConvert output</td>
</tr>
<tr>
<td>MediaConvert_Template_2160p</td>
<td>The name of the UHD template for MediaConvert</td>
</tr>
<tr>
<td>MediaConvert_Template_1080p</td>
<td>The name of the HD template for MediaConvert</td>
</tr>
<tr>
<td>MediaConvert_Template_720p</td>
<td>The name of the SD template for MediaConvert</td>
</tr>
<tr>
<td>Source</td>
<td>The name of the source Amazon S3 bucket</td>
</tr>
<tr>
<td>WorkflowName</td>
<td>Used to tag MediaConvert encoding jobs. This is defined by the AWS CloudFormation stack name.</td>
</tr>
</tbody>
</table>

These variables are set when you deploy the AWS CloudFormation template and apply to all source videos uploaded to the solution’s Amazon Simple Storage Service (Amazon S3) bucket.

If you set the solution to ingest source videos and metadata files, you can overwrite these files using a metadata file. For more information, see Appendix F.

Appendix E: Metadata File

When you set the solution to ingest source videos and metadata files, the source Amazon Simple Storage Service (Amazon S3) bucket is configured with an event notification that triggers the workflow when you upload a JSON file.

To trigger the workflow, you must upload a JSON metadata file. If you only upload a source video file, the workflow will not start.

**Important:** You must upload the source video file to the Amazon S3 bucket before you upload the metadata file. Note that the upload must complete before you upload the metadata file.
The definitions in the metadata file overwrite the default settings you specified when you deployed the solution. This enables you to define different workflow configurations for each source video. If you do not specify a definition in the metadata file, the solution will use the default value you set during deployment. Note that the metadata file must include a definition for **srcVideo**.

The following example metadata files shows all available variable definitions.

```json
{
    "srcVideo": "string",
    "ArchiveSource": boolean,
    "FrameCapture": boolean,
    "Source": "string",
    "destination": "string",
    "CloudFront": "string",
    "MediaConvert_Template_2160p": "string",
    "MediaConvert_Template_2160p": "string",
    "MediaConvert_Template_2160p": "string",
    "JobTemplate": "custom-job-template"
}
```

**Figure 6. List of metadata file definitions**

The following sample JSON metadata file will overwrite the default settings for the **Archive Source Content** and **Enable Frame Capture** AWS CloudFormation template parameters for the `example.mpg` file. The file will also set the job template for AWS Elemental MediaConvert to `custom-job-template`.

```json
{
    "srcVideo": "example.mpg",
    "ArchiveSource": true,
    "FrameCapture": false,
    "JobTemplate": "custom-job-template"
}
```

**Figure 7. Sample JSON metadata file**

The video-on-demand solution also supports adding additional metadata, such as title, genre, or any other information, you want to store in Amazon DynamoDB.
Appendix F: MediaConvert Templates

By default, the video-on-demand solution selects the job template for AWS Elemental MediaConvert based on the source video height. The solution includes three default job templates:

- MediaConvert_Template_2160p:
  - 3 mp4 outputs including HEVC and AVC 2160p through 720p
  - 8 HLS outputs AVC 1080p through 270p
  - 8 DASH outputs AVC 1080p through 270p

- MediaConvert_Template_1080p:
  - 2 mp4 outputs AVC 2160p through 720p
  - 8 HLS outputs AVC 1080p through 270p
  - 8 DASH outputs AVC 1080p through 270p

- MediaConvert_Template_720p:
  - 1 mp4 720p AVC output
  - 7 HLS outputs AVC 720p through 270p
  - 7 DASH outputs AVC 720p through 270p

You can also modify the solution to use other system job templates or custom job templates. For more information about working with job templates for MediaConvert, see Working with MediaConvert Job Templates.

If you set the solution to ingest source videos and metadata files, you can specify the template using the JobTemplate field in your metadata file. For more information, see Appendix E. Or, you can replace the default templates in the Input Validate AWS Lambda function by modifying the MediaConvert_Template_<resolution> environment variables.

Appendix G: Collection of Anonymous Data

This solution includes an option to send anonymous usage data to AWS. We use this data to better understand how customers use this solution and related services and products. When enabled, the following information is collected and sent to AWS each time a video is processed:
• **Solution ID:** The AWS solution identifier
• **Unique ID (UUID):** Randomly generated, unique identifier for each Video on Demand on AWS deployment
• **Timestamp:** Data-collection timestamp
• **Use Glacier:** Whether Amazon Glacier is used
• **Workflow Trigger:** The workflow trigger selected
• **Frame Capture:** Whether thumbnails are created for AWS Elemental MediaConvert output

Note that AWS will own the data gathered via this survey. Data collection will be subject to the [AWS Privacy Policy](#). To opt out of this feature, modify the AWS CloudFormation template mapping section as follows:

```yaml
AnonymousData:
  SendAnonymousData:
    Data: Yes
```

to

```yaml
AnonymousData:
  SendAnonymousData:
    Data: No
```

### Source Code

You can visit our [GitHub repository](#) to download the templates and scripts for this solution, and to share your customizations with others.
# Document Revisions

<table>
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<tr>
<th>Date</th>
<th>Change</th>
<th>In sections</th>
</tr>
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<tbody>
<tr>
<td>April 2017</td>
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<td>--</td>
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<tr>
<td>June 2017</td>
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