A Survey on Cloud-Based Video Streaming-Services

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Cloud Computing for Video Streaming (كاظم)

- Overview:
- Video stream providers have become extensively reliant on cloud services for most or all of their computing demands. For instance, Netflix has outsourced the entirety of its computational demands to Amazon cloud.
- In spite of numerous advantages, deploying cloud services has presented new challenges to video stream providers. In particular, as cloud providers charge their users in a pay-as-you- go manner for their services, the challenge for stream providers is to minimize their cloud expenditure. Therefore, numerous research works have been conducted to overcome the challenges of video streaming using cloud services.

Structure of a Video Stream (كاظم)

- As shown in Figure 1.1, a video stream consists of a sequence of multiple smaller *segments*. Each segment contains several *Group Of Pictures (GOP) with a segment* header at the beginning of each GOP. The segment header includes information such as the number of GOPs in that segment and the type of the GOPs. A GOP is composed of a sequence of *frames*. The first frame is an I (intra) frame, followed by several P (predicted) and B (bi-directional predicted) frames. A frame in a GOP is divided into multiple *slices* and each slice consists of several *macroblocks (MB).*

Structure of a Video Stream (کاظم)

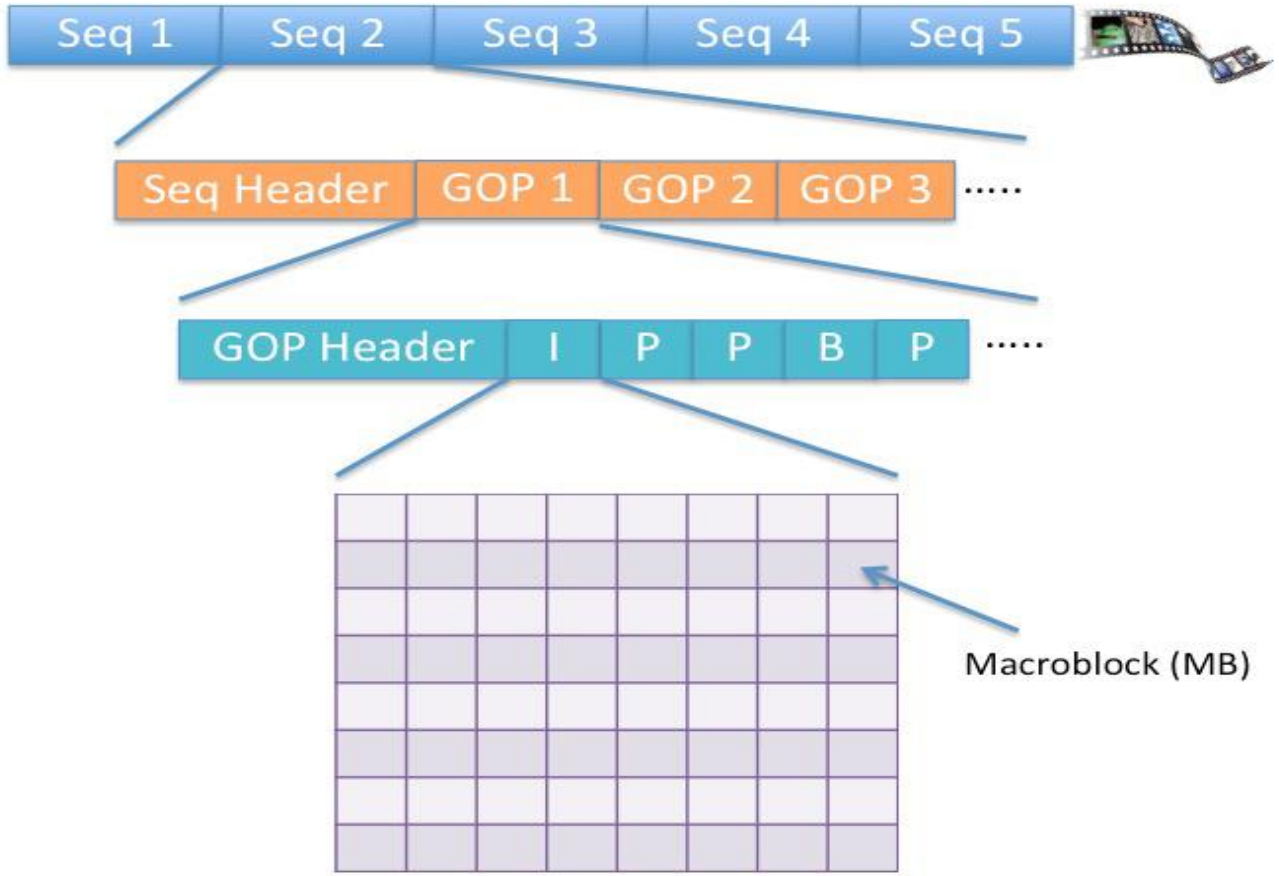


FIGURE 1.1 The structural overview of a video stream.

Video Streaming Types (كاظم)

The taxonomy shown in Figure 1.2 expresses possible ways a video streaming service can be provided to viewers. More Specifically, video streaming service can be offered in three main fashions: *Video On Demand (VOD) streaming ,live streaming, and live-to-VOD streaming.*

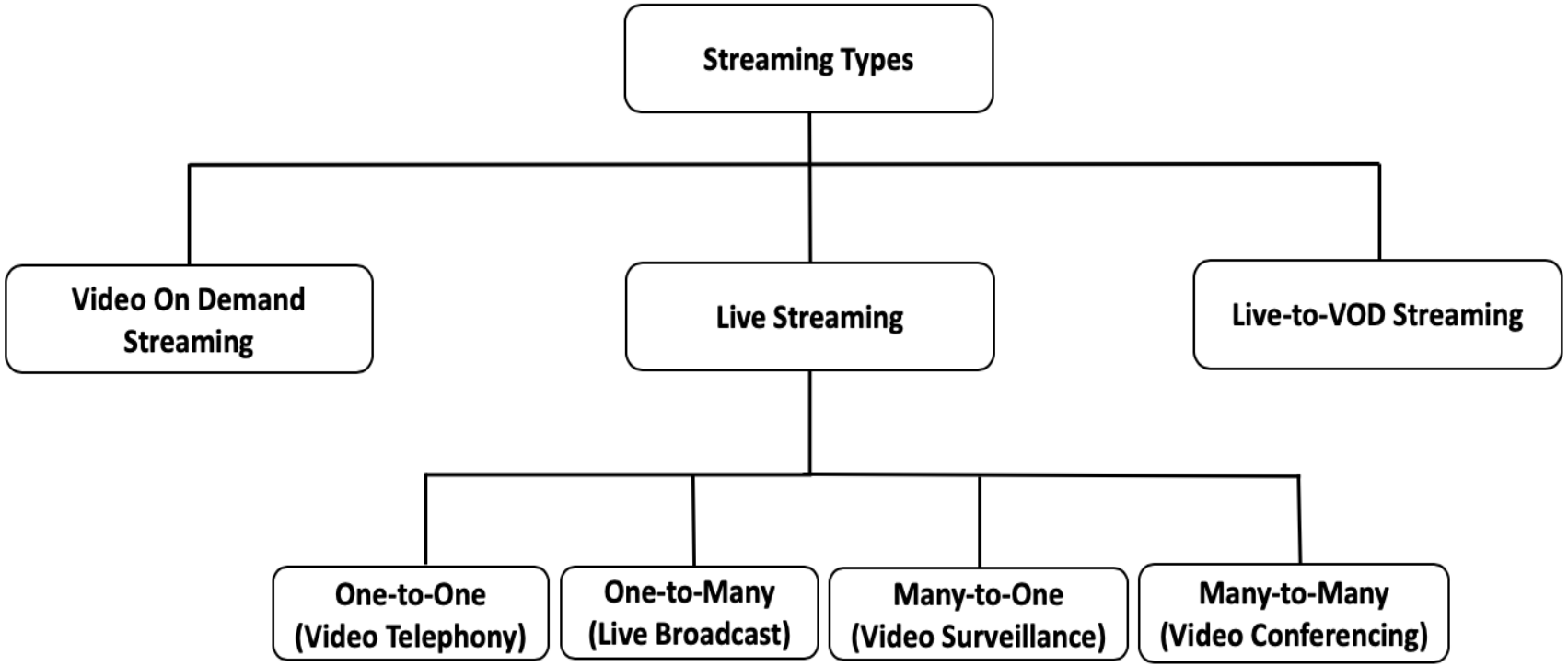


FIGURE 1.2 Taxonomy of different types of video streaming.

Video Transcoding (كاظم)

- Video contents are originally encoded with one *specific spatial resolution*, *bit rate*, *frame rate*, and compression standard. In order to play the videos on different devices, streaming service providers usually have to adjust the original videos in terms of the viewer's device and network bandwidth. The process of this adjustment is called *video transcoding*.

Video Packaging (کاظم)

- Transmitting an encoded / transcoded video file from server to viewer involves multiple layers of network protocols, namely physical layer, data link layer, network layer, transport layer, session layer, presentation layer, and application layer. The protocols of these layers dictate video packaging details, such as stream file header syntax, payload data, authorization, and error handling.

Video Streaming Delivery Networks (كاظم)

- *Content Delivery Networks (CDN)*
- The goal of CDN technology is to reduce the network latency of accessing web contents. CDNs replicate the contents to geographically distributed servers that are close to viewers.
- *Peer to Peer (P2P) Networks*
- P2P networks enable direct sharing of computing resources for example, *storage* and *content* among peer nodes in a network. P2P networks are designed for both clients and servers to act as peers.

Cloud-Based Video Streaming Services (سلیمان)

Challenges:

1. Cloud Platform
2. Computing Platforms for Cloud-based Video Streaming
3. Cloud-based Video Transcoding
4. Cloud-based Video Packaging
5. Video Streaming Latency and Cloud-based Delivery Networks
6. Cloud Storage for Video Streaming

(1) Cloud Platform (سلیمان)

"The cloud" refers to servers that are accessed over the Internet, and the software and databases that run on those servers. Cloud servers are located in data centers all over the world. By using cloud computing, users and companies do not have to manage physical servers themselves or run software applications on their own machines.

The most common cloud deployments are:

- Private cloud: A private cloud is a server, data center, or distributed network wholly dedicated to one organization.
- Public cloud: A public cloud is a service run by an external vendor that may include servers in one or multiple data centers.
- Hybrid cloud: hybrid cloud deployments combine public and private clouds, and may even include on-premises legacy servers.
- Multi-cloud: multi-cloud is a type of cloud deployment that involves using multiple public clouds. In other words, an organization with a multi-cloud deployment rents virtual servers and services from several external vendors.

Like virtual machines, containers are a cloud virtualization technology. They are part of the PaaS (Platform-as-a-Service) cloud model. Each virtual machine has its own operating system kernel, but containers on the same machine share the same kernel. The main service models of cloud computing are Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), Infrastructure-as-a-Service (IaaS) and Function-as-a-Service (FaaS).

(2) Computing Platforms for Cloud-based Video Streaming (سليمان)

Overview The requested video stream is fetched from the cloud storage servers and the workflow of actions explained previously are performed on them, before streaming them to the viewers. These processes are commonly implemented in form of independent services, known as micro-services, and are generally deployed in a loosely coupled manner on independent servers in cloud datacenters. Services like web server, video ingestion, encoding, transcoding, and packaging are examples of micro-services deployed in datacenters for video streaming

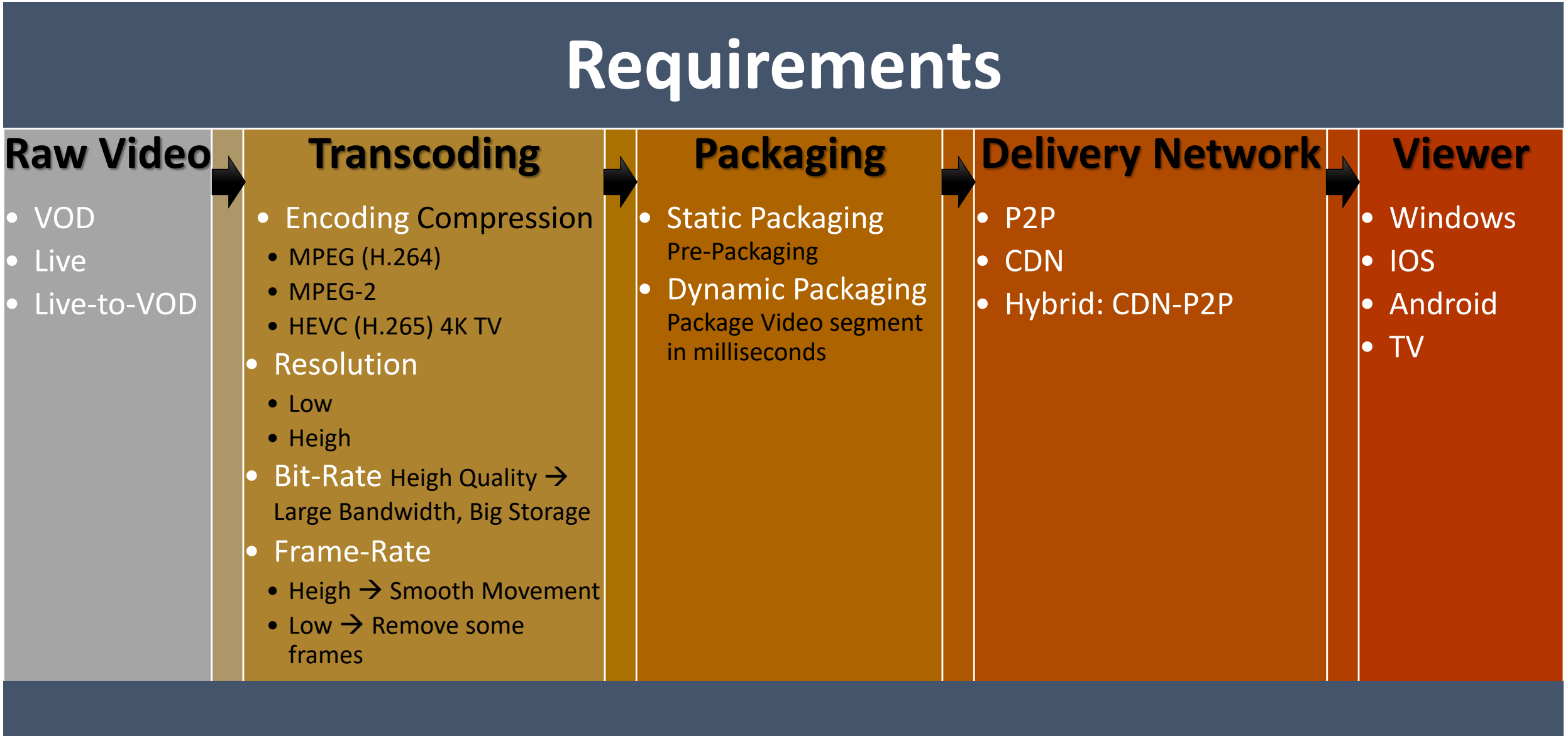
Technologies:

1. Virtual Machines (VM-Based)
2. Containers (Container-Based) : Dockers (Amazon Web Servers – AWS)

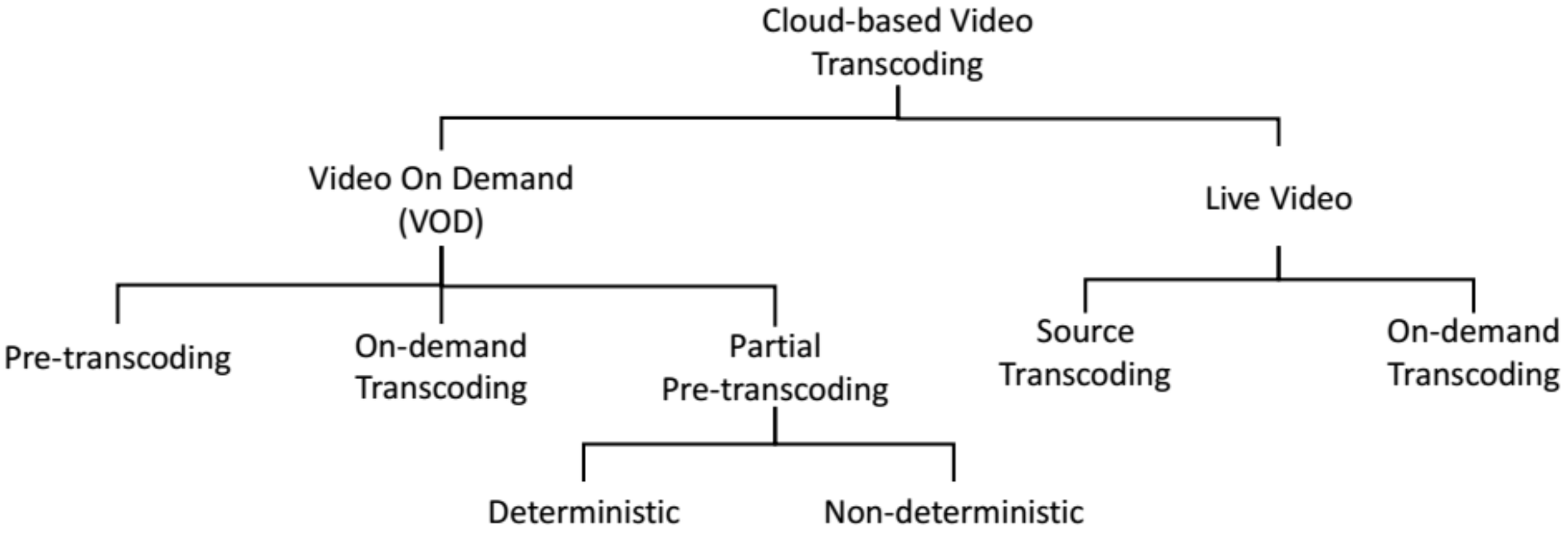
Machines Types:

1. CPU-Based
2. GPU-Based
3. Memory-Based

(1) Computing Platforms for Cloud-based Video Streaming (سلیمان)



(3) Cloud-based Video Transcoding (سلیمان)



Cloud-based Approaches

(3) Cloud-based Video Transcoding (سليمان)

VOD:

1. **Pre-Transcoding:** create several versions of the original video before packaging then store it (Whole video transcoded)
2. **On-Demand Transcoding:** upon viewer's request, transcode the requested part of the original video
3. **Partial Transcoding:** only part of the video (important Group Of Pictures - GOP)
   - **Deterministic:** number of GOP from the beginning of the video are pre-transcoded ans the rest in an demand manner
   - **Non-deterministic:** not limited to the beginning but any popular GOP, this type is more efficient

Live Video:

1. **Source Transcoding:** device transcoding, high latency and inefficient transcoding
2. **On-Demand Transcoding:** upon viewer's request, transcode the requested part of the live stream at run time (if live stream support pre-transcoding)

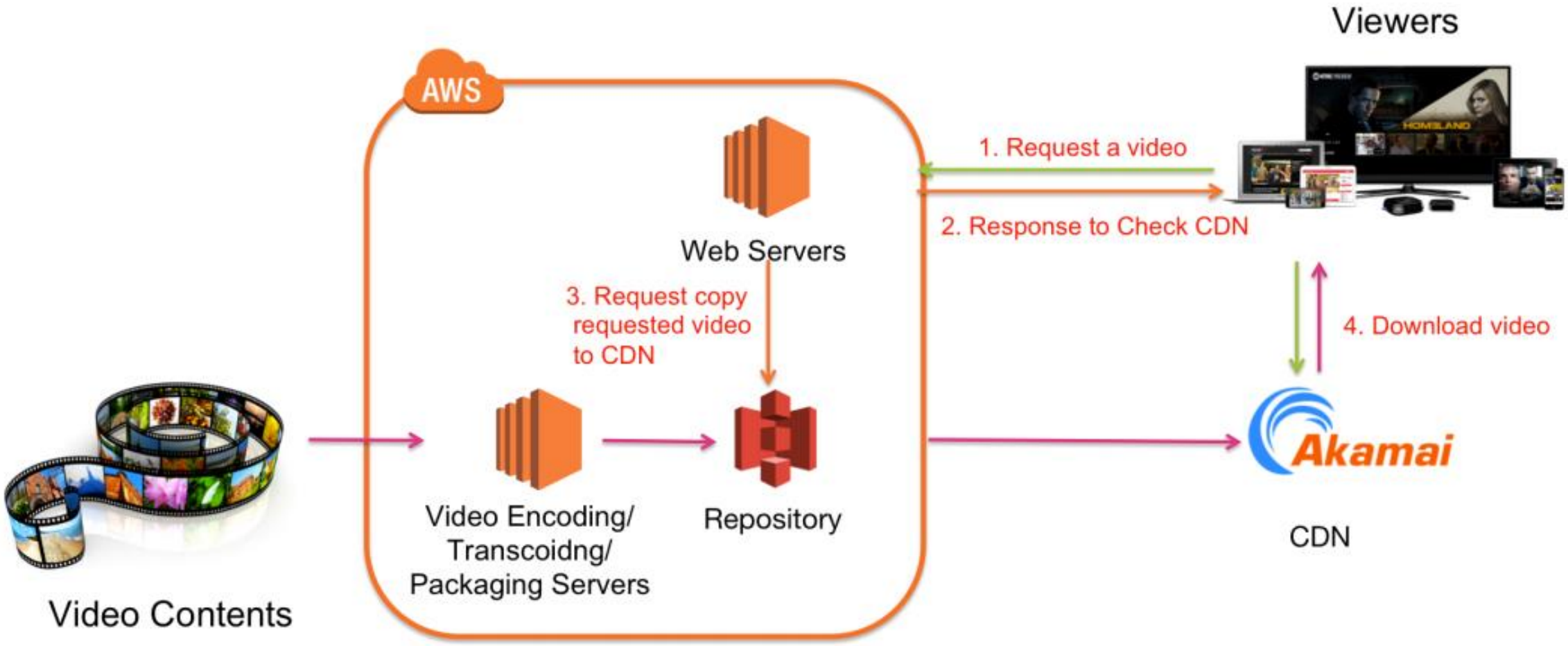
(4) Cloud-based Video Packaging (سليمان)

Static Packaging: Video is transcoded into various formats, therefore, each transcoded format packaged into multi-versions to meet streaming protocol requirements and store it in cloud storage (pre-packaging whole video)

Dynamic Packaging: Packages the video segments (GOPs) based on device supported protocol and viewer request (VOD)

Note: Streaming protocol examples used in cloud-based environments; ***Dynamic Adaptive Streaming over HTTP*** - DASH, ***Apple HTTP Live Streaming*** - HLS, and ***Microsoft Smooth Streaming*** - Smooth.

(4) Video Streaming Latency and Cloud-based Delivery Networks (سلیمان)



Workflow of actions taken place for low latency video streaming

(5) Video Streaming Latency and Cloud-based Delivery Networks (سليمان)

A viewer's request to stream a video, the request is first received by a web server in the cloud datacenter. If the requested video is already cached in the CDN, the web server will send back a manifest file which informs the viewer's computer about the CDN that holds the video files. Then, the viewer sends another request to the CDN and stream the video. However, if the requested video is not cached in the CDN, the web server has to process and send the content from cloud storage to the CDN. Then, the server sends a copy of the file that includes the CDN address to the viewer to start streaming from the CDN .

Content delivery networks (CDNs) that are offered in form of a cloud service are known as cloud CDN. Compared to traditional CDNs, cloud CDNs are cost-effective and offer low latency services to content providers without having their own infrastructure. The users are generally charged based on the bandwidth consumption and storage cost .

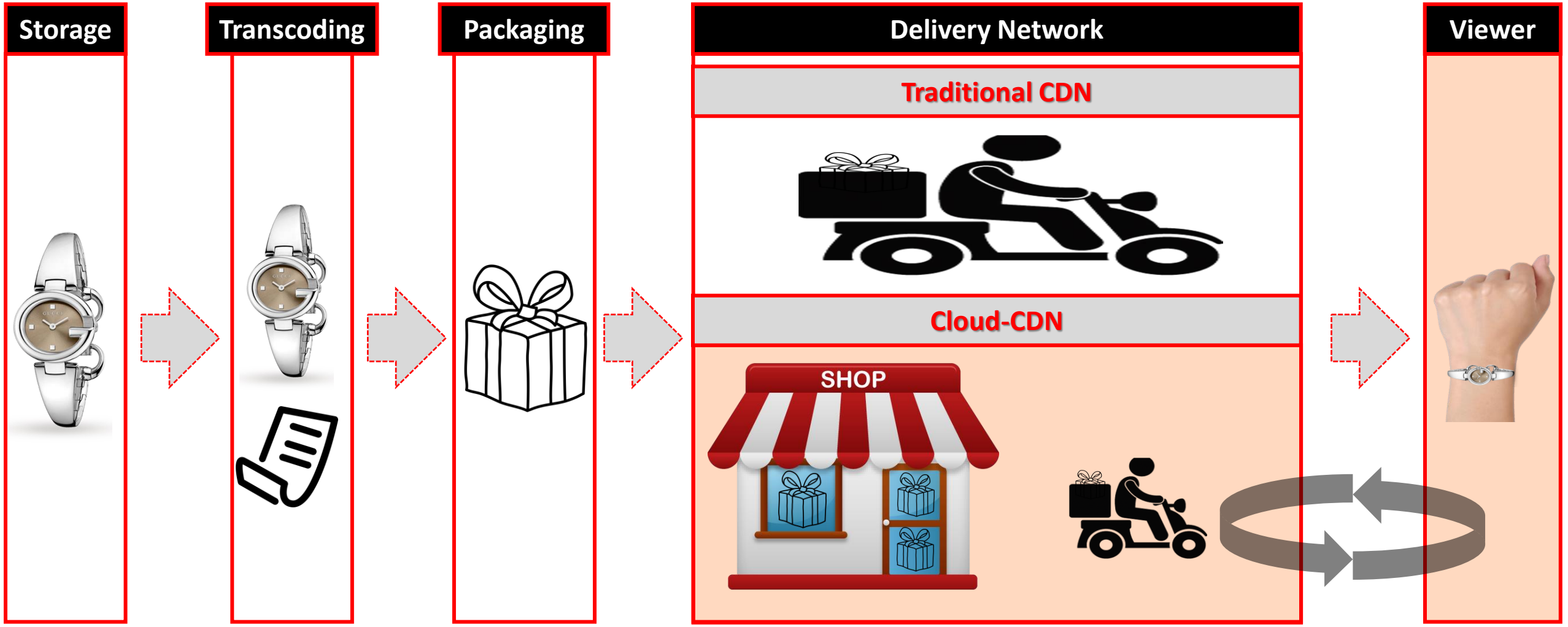
(6) Cloud Storage for Video Streaming (سليمان)

The rapid growth of video streaming usage in various applications, such as e-learning, video surveillance and situational awareness, and on various forms of mobile devices (e.g., smart-phones, tablets, laptops) has created the problem of big video data. The fast growth of video contents on the Internet requires massive storage facilities. However, the current storage servers face scalability and reliability issues, in addition to the high maintenance and administration cost for storage hardware.

Summary (سلیمان)

1. Video streaming is one of the most prominent Internet-based services and is increasingly dominating the Internet traffic .
2. Offering high quality and uninterrupted video streaming service is a complicated process and involves divergent technologies .
3. ways various cloud services can be leveraged to cope with the demands of video streaming services .
4. Cloud computational services via VM, containers, or function (i.e., serverless computing) paradigms. Computational services can be used for processing video transcoding, video packaging, video encryption, and stream analytics .
5. Cloud network services via Cloud-based Content Delivery Networks (CDN) to reduce video streaming latency, regardless of viewers' geographical location .
6. Cloud storage services to store video streaming repositories and enable persisting multiple versions of each video to support a wide range of display devices .

Summary Graph (سلیمان)



A simple example act as video streaming

Thank YOU