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SERVICE MODELS FOR CLOUD COMPUTING: VIDEO SURVEILLANCE AS A SERVICE (VSaaS)

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Abstract: *Technical development of cloud computing technology enabled the integration of powerful and scalable platform for storing, processing and distribution of sensory data. Video Surveillance as a Service (VSaaS) is a cloud computing service which provides remote security features. The service offers highly advanced features with elements of intelligent processing and data representation. In this paper we will describe the processes which envelops this cloud service as well examine existing framework solutions.*

Key words: *Cloud Computing (CC), service models, Video Surveillance as a Service (VSaaS), Intelligent Video Surveillance (IVS), Intelligent Video Surveillance as a Service (IVSaaS).*

1. Introduction

Surveillance systems have been in use for several decades now since the invention of CCTV cameras and tape recorders. Over time these systems advanced to using computer system and IP cameras to capture, store and reproduce recordings which quickly reached limits in size, power requirements, processing, analysing and especially storage. Main obstacles are that they are all *on site* based solutions. Cloud computing introduced a novel approach to how data is being managed which reflected to video surveillance as well. This brought to the idea, utilizing cloud computing enormous network, storage and processing capabilities, of constructing a frameworks [1-4] of Video Surveillance as a Service (VSaaS). It is possible to architect a VSaaS using cloud technologies such as Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) cloud services [5]. Author of [6] proposed a model flexible video surveillance, in paper [7] is given a distributed service architecture and architecture based on P2P architecture in paper by authors of [8, 9].

In paper by [10] cloud computing service applies the three layer approach, which are IaaS, PaaS and SaaS as shown on Fig 1.

IaaS provides network device resources, computing resources and storage resources. PaaS is the software platform for the confederation network applications. User could develop application module to communicate with the platform. Authors developed an Internet of Things (IoT) integration module by this approach in their research. SaaS supplies software

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service to users. There are two main ways of SaaS: Vertical SaaS (software which answers the needs of a specific industry) and Horizontal SaaS (products which focus on a software category).

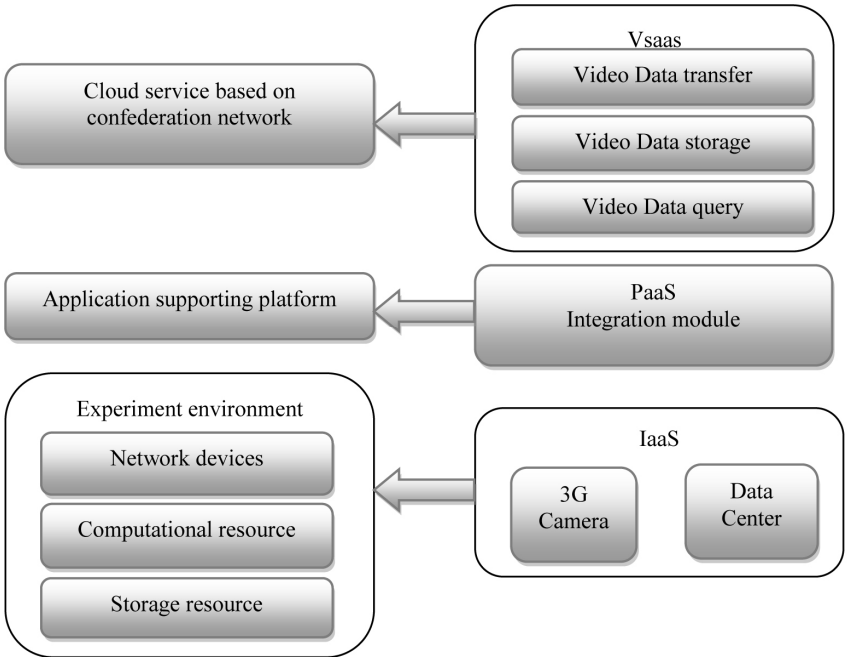

Fig. 1. Composition of VSaaS using PaaS, IaaS and SaaS services [10]

2. Video Surveillance as a Service (VSaaS)

Video Surveillance as a Service (VSaaS) is intended to provide ubiquitous and on-demand network access to a shared pool of recorded multimedia resources that can be rapidly obtained and released with minimal management effort or service provider interaction. Process of cloud based video surveillance is fairly simple for the end user: an on-site camera records the audio/video material, sends it using the internet connection to the cloud and the Video Management Software (VMS) delivers the footage on-demand to the client. However, from a detailed point of view the process consists from several important steps as represented on Figure 2 which is a detailed view of the VSaaS framework which was proposed by author of [1]. There are several derived services such as: Intelligent Video Surveillance)-as-a-Service (IVSaaS), Managed Video Surveillance-as-a-Service (MVSaaS or MVaaS), Cloud Video Surveillance (CVS) and Online Video Surveillance as a Service (OVSaaS).

VSaaS cloud deployment architecture can be public, private or hybrid (a mix of two). Public architecture implies to using a cloud service provider with an already set-up platform for video surveillance management [11]. This is the most common usage scenario for VSaaS. Private architecture refers to internally hosted cloud service by a company or enterprise which used the platform for video surveillance purpose. This is rarely the case as it is harder to finance and maintain

such a system.

Methods of capturing sensory data include: *send only* which is the case where camera continuously send data to the cloud, *receive only* where the cloud system obtains the data on-demand basis, *hybrid (send/receive)* is the case where the system is pre-configured to perform desired action based on clients preference and event-driven data acquisition such as motion detection, sound activation and alarm system activation.

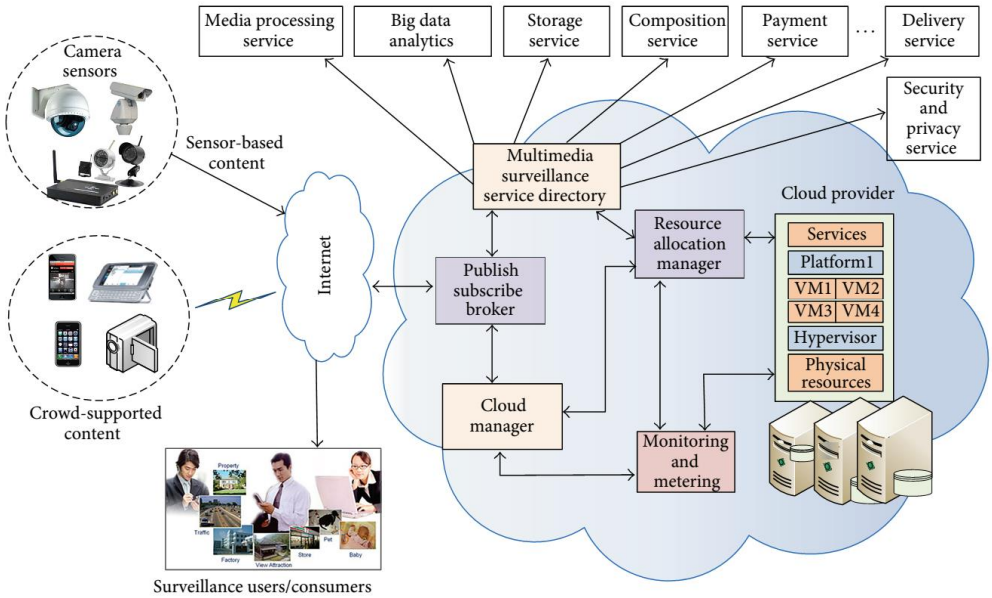

Fig. 2. Detailed view VSaaS architecture [1].

Next step is the data storage which can be stored locally, Network Attached Storage (NAS) and Storage Area Network (SAN) [12], and then sent to the cloud or direct data streaming to the cloud. Local storage can be in a form of an intermediary device which performs temporary storage and conversion of raw video to some compressed format and then sends it to the cloud or a camera with a built-in memory which behaves as a cash storage and sends the data in specified intervals. These approaches have higher usability values as they decrease bandwidth consumption [13-15] and can provide better resolution video due to compression capabilities. Downfall of using this approach is the inevitable delay in event detection. Direct data streaming is a less popular method due to high network demands for sending video and increased costs of cloud storage [16,17], however can be solved with shorter storage times. This method offers real-time viewing and detection of unwanted events.

Once the data is stored it needs to be processed. Clear advantage of cloud based surveillance is that it offers incomparable computing power over traditional systems for video compression, intelligent analysis [18] and streaming. Some of the advanced processing features [19] include: such as face detection, face recognition [20], motion detection, people motion tracking, crowd density estimation, pattern recognition, image sharpening, tamper detection, licence plate recognition, smart searching and big data analytics, using Video Analytics Service (VAS).

Resource allocation is an important

aspect of VSaaS design and determines total cloud-based system performance [21,22]. The amount of computing power required for performing these operations is larger than any traditional system can handle. The advantage of VSaaS is that the required power can be demanded as needed. The scalability capability of service can greatly contribute to sustaining the work load of high resolution video.

On Fig 3 is given a graphical view of VSaaS implementation process

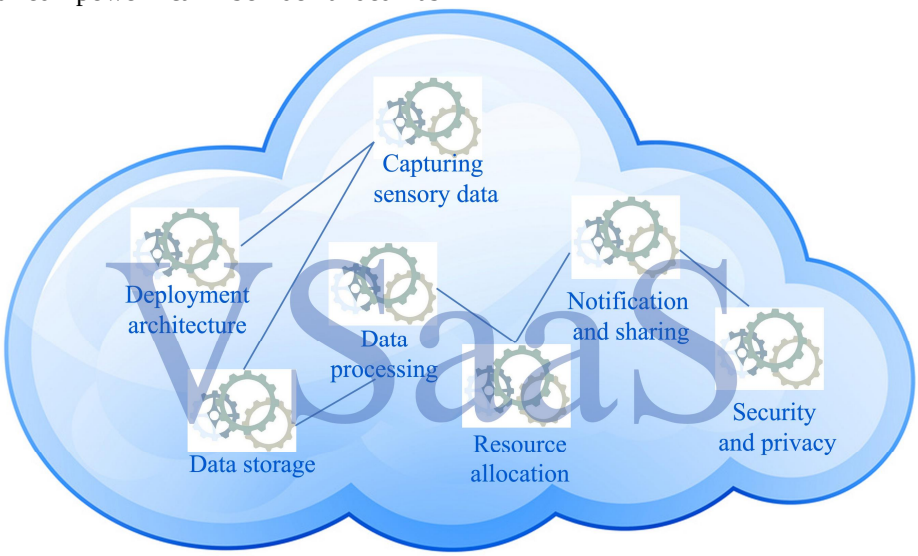

Fig. 3. Steps of VSaaS implementation process.

One of the modern features provided by VSaaS environment is the ability to intelligently notify the client about various events which were already mentioned in data processing section [23,24]. Notification can be delivered through E-mail, SMS, MMS and mobile apps [25,26]. Multimedia notification can include snapshots or even video sequence of the detected event.

Compared to traditional systems cloud VMS have significantly less vulnerability issues. There is no need for on-site software, firewalls and open ports. Also, there is no possibility that the storage can be compromised by theft, user malpractice, weather occurrences etc. Surveillance is available at any time from any device which provides even greater level of security. VSaaS providers have dedicated cyber security teams to monitor new vulnerabilities and apply instant security patches via the cloud to the on-premise appliance.

In Table 1 is given a comparison of traditional versus cloud based surveillance systems, which indicates clear advantage of VSaaS over traditional systems in almost all cases [27].

Research company Markets and Markets made several prediction for video surveillance market:

- $25.43 billion by 2016 at a Compound Annual Growth Rate (CAGR) of 19.35% from 2011 to 2016.
- IP video surveillance market estimated from $5.15 billion in 2011 to reach $15.89 billion at an estimated CAGR of 25.31% in 2016.
- $71.28 billion by 2022, at an estimated CAGR of 16.56% [28].

Table 1

Internet-Connected Traditional DVR/NVR/VMS/IP-VS	**Cloud-based VMS / VSaaS**
System installation	
- Time consuming. - Complex configuration.	- Fast on-demand deployment. - Plug-and-play auto-configuration.
System support	
- Manually intensive maintenance process.	- Support is done off-site by the provider.
Payment structure	
- High up-front capital expense. - Unpredictable support expenses. - Costly scaling.	- Extremely low up front capital expense. - Predictable monthly operating cost. - Cheap scalability.
Total cost of ownership	
- High initial cost is high, including high cost hardware/software, and installation. - Many ongoing costs.	- Low initial cost is low, typically a low cost bridge appliance. - Low ongoing monthly subscription cost.
Storage retention flexibility	
- Traditional DVR, NVR or VMS, store the video on-site. - Storage retention is limited. - More expensive storage expansion.	- Flexible combination of on-premise and/or cloud storage. - Instantly increase retention period. - Low cost of storage expansion.
Adding managing cameras	
- Support a broad array of analog IP cameras. - Manually connect configuration of new cameras.	- Support a broad array of analog IP cameras. - Manually connect auto-configuration of new cameras.
Bandwidth management	
- Bandwidth required for remote viewing. - On-site video recording storage requires no bandwidth.	- Bandwidth required for remote viewing. - Majority of storage is streamed, requiring high bandwidth.
Technology longevity, APIs	
- Shorter time to technology obsolescence. - Limited ability for technology updates. - Updates are manual support intensive. - APIs are closed and generally require signing an NDA. API functionality is limited.	- Rapid technology evolution. - Automatic technology updates to on-site appliance. - Continuous evolving for new innovations, has longevity. - Open APIs for analytics, integration applications. Can be used in other systems.
Cyber security	
- Higher chances of cyber-security vulnerabilities. - Configuration of open ports, on-site	- Extremely low chances of cyber-security vulnerabilities. - No open ports, no on-site firewalls, no on-

firewalls, on-premise software and firewall. - End user monitors for attack vulnerabilities.	premise software and no firewall installations. - Dedicated cyber security teams to monitor new vulnerabilities.
Remote access	
- Non-native remote video access, only added on request. - Unpredictable, choppy, low-res quality of video. - Rare encryption existence. -Browser Incompatibilities are common.	Cloud-based systems were architected for remote access [29]. - Hi-res smooth video access streaming. - Built-in advanced encryption. - Universal web browsers and mobile apps support [30].
Redundancy reliability	
- Highly variable redundancy levels. - Redundancies managed by internal it staff. - Cloning servers are often idle, adding to the overhead expense.	- Cloud data centers have double and triple redundancy. - Shared infrastructure results in full server utilization and economies of scale. - Couple of days of on-premise storage as a back-up to protect against the internet going down, along with instant alerts.

3. Conclusion

Video Surveillance as a Service (VSaaS) was among the first cloud technology application because it offers unparalleled benefits in cost, ease of implementation, maintenance, usage, scaling and high security levels. In this paper we presented process of functioning and implementation of VSaaSas well as advantages of adopting cloud based surveillance over traditional systems. VSaaS is a market that is constantly growing and its future of lies in development of new analytics features from software development and lowering ongoing costs with hardware advancement.

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