

VIRTUOSE

(Virtualized video services)



D1.1 Use Cases Definition

Abstract

This document introduces the selected use cases and sub-use cases, in which VIRTUOSE efforts are focused. This document includes use cases identification, their technical challenges and selection criteria.

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1. Deliverable Record

Owner	ALU (Jose Javier Garcia Aranda)
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Table 1 Deliverable record

2. Executive summary

This document introduces the selected use cases and sub-use cases, in which VIRTUOSE efforts are focused. This document includes use cases identification, their technical challenges and selection criteria.

This document defines the target use cases and their technical challenges as well as criteria to select a subset to work them in the context of VIRTUOSE project. **All use cases are described homogeneously**, including a record and technical challenges, which are the starting point to identify current market products, chain value and opportunities, which are the scope of D1.2.

After analysis of pros and cons, the most feasible use cases in VIRTUOSE are *cloud gaming*, *video analytics*, *video transcoding/distribution* and *multiparty videoconf*. A brief introduction of each use case is following:

- **Cloud gaming** is a service, in which games are rendered remotely and the video is streamed directly to a consumer's computers over the internet. Technology readiness and wrong commercial approaches have hindered some past initiatives. However, the learnt lessons help to identify key problems to tackle.
- **Video transcoding and distribution** use case brings virtualized applications and components available for video service providers in order to start new services rapidly, scale services up or down, or move them to another computing platform
- **Video analysis** uses information coming from video cameras to process and derive new information (usually metadata that describe certain detected events). The generated information is eventually consumed by the user in different areas like parking management, security in public transport, video surveillance, traffic supervision or industrial image processing.
- **Video conferencing** systems have evolved rapidly during the past few years, from being very expensive proprietary equipment software and network requirements to a standards based technology that is readily available to the general public at a reasonable cost.

The main conclusions are:

- The most **suitable set of use cases** for the VIRTUOSE project are cloud gaming, video analytics, video transcoding/distribution and multiparty videoconf.
- **Different use cases are complementary** ways to tackle the same video services problems.
- Video services **share common identified problems**, with different degree of effects depending of use case.
- **Same schema solutions are applicable to different use cases**. For example, the split in functional components and the deployment of these components into cloud or client is a common strategy for both cloud gaming and video analytics.
- **Scalability and business feasibility** are a common point to tackle from all use cases.

3. Motivation and targets

This section answers questions such as:

- What use cases?
- Why these use cases? Why these sub-use cases?
- What are our targets working in each use case to improve it?
- What kind of opportunities are relevant in each use case?

First we identify the potential use cases, describing them briefly and the potential problems that will face video services. Then we set some criteria for selection to work on some of the identified use cases, and finally we evaluate the identified use cases according to the criteria.

3.1. *Potential Use case/ sub case*

3.1.1. Case 1: Single user cloud gaming

"Cloud gaming", also in some cases called "gaming on demand", is a type of online gaming that allows direct and on-demand video streaming of games onto computers, consoles and mobile devices, like video on demand, using a thin client. The actual game is stored, executed, and rendered on the remote operator's or game company's server and the video results are streamed directly to a consumer's computers over the internet. This allows access to games without the need of a console and largely makes the capability of the user's computer unimportant, as the server is the system that is running the processing needs. The controls and button presses from the user are transmitted directly to the server, where they are recorded, and the server then sends back the game's response to the input controls. Companies that use this type of cloud gaming include NVIDIA (GeForce NOW), Playkey, PlayGiga, CiiNOW, Ubitus, Playcast Media Systems, Gaikai and OnLive.

Gaming on demand is a game service which takes advantage of a broadband connection, large server clusters, encryption and compression to stream game content to a subscriber's device. Users can play games without downloading or installing the actual game. Game content is not stored on the user's hard drive and game code execution occurs primarily at the server cluster, so the subscriber can use a less powerful computer to play the game than the game would normally require, since the server does all performance-intensive operations usually done by the end user's computer [17][18]. Most cloud gaming platforms are closed and proprietary; the first open-source cloud gaming platform was only released in April, 2013.

3.1.2. Case 2: Multiuser cloud gaming

Multiuser cloud gaming is a kind of cloud gaming in which several players join the same game and the system must face with latency divergences, as well as common cloud gaming technical problems. There are not production systems available.

3.1.3. Case 3: Multiparty video communications

Video Conferencing is a conduct of video conference by a set of telecommunication technologies which allows two or more locations to communicate by simultaneous two way video and audio transmissions. It differs from the usual video phone calls and is designed to serve for a conference i.e. a multiple locations rather than individuals. It has made significant inroads in the business education and medical field because of the relatively low cost and high capacity broadband telecommunication services and the powerful computing processors and compressing techniques.

Traditional video conferencing systems suffer bandwidth issues, accessibility problems (accessing from different networks, outside of the organization, etc.), expensive hardware requirements for MCUs and interoperability issues. End users may experience different QoE on different network conditions where the need for adaptive streaming techniques increases. As the availability of fiber connections and 4G systems have been spreading day by day, the available end to end bandwidth has been highly increased. Additionally, upcoming 5G technology will boost the available bandwidth. These developments will make the use of video technologies reachable from bigger populations. Although these developments on bandwidth side are quite promising and will introduce even more efficient ways for video delivery when they are supported by new compression algorithms, there are still some accessibility issues and expensive hardware requirements with scalability issues. Virtualization and cloud computing will have great

contributions on development of more scalable and cost efficient multiparty video communication solutions.

3.1.4. Case 4: Computer Supported Cooperative Work (CSCW)

Set of tools oriented to collaborative working, including or not video streaming capabilities.

From techopedia:

The concept of computer-supported cooperative work was introduced by Irene Greif and Paul M. Cashman in 1984. It combines the cooperative work of individuals through networking, hardware, software, etc. The purpose is to provide identical improvements for multiple individuals working on the same or different production processes. CSCW adopts either a technology-centric or work-centric viewpoint. A technology-centric viewpoint emphasizes designing computer technology to support groups working together. A work-centric viewpoint emphasizes designing computer systems to support group work. There are 10 main dimensions inherent in CSCW:

1. Time
2. Space
3. Interaction style
4. Group size
5. Infrastructure
6. Context
7. Privacy
8. Collaborator mobility
9. Extensibility
10. Participant selection

These dimensions provide a rich design space through which the developers of a CSCW navigate. A face-to-face intervention includes digital white boards, electronic meeting systems, room ware and shared tables. A remote interaction includes videoconferencing, real-time groupware and electronic meeting systems.

3.1.5. Case 5: Collaborative applications with interactive video

This use Case is proposed based in the combination of HbbTV and Interactive Video.

Hybrid Broadcast Broadband TV (HbbTV) is an industry standard (ETSI) and a commercial initiative to harmonize the broadcast via hybrid digital TV, IPTV, and broadband delivery of entertainment to the end consumer through connected TVs (smart TVs) and set-top boxes.

Some of the Virtuoso Partners (Sofia Digital, Beia) have a wide experience in the development of the HbbTV standards and have contributed significantly participating in various projects around these standards, set-top boxes and applications for Smart TV solutions. In particular Beia has been involved in the Project Friendly Application for Interactive Receiver (FAIR).

This use case proposes an Interactive Video scenario where data services are added to traditional television technology. In some cases these have included interactive and on-demand delivery of content, online shopping and banking. Interactive TV is an example of vertical integration of information technology.

Other Partners are proposing the use of special codecs like LHE making interactive video applications feasible (Nokia, Innovati).

One of the Project Virtuoso tasks will be involved in the Integration & demonstration of virtualized MPEG-DASH based video services in interactive television utilizing HbbTV 2.0 compatible receivers. Using some of the Partner's experience that develops the required HbbTV applications and provides webTV and HbbTV platform for running the demonstrators.

Open standard for interactive platforms, such as IPTV, HbbTV and digital signage are available. Signage could be one key aspect of the User Case with the presentation of content (as advertisement) in public places via special public platforms with the digital content displayed on the signage presented in different formats: Video clips, Text, Images. This includes the possibility of interactive interfaces with touch screen and various sensors with context-aware capabilities updated according to the audience profile, weather or other external factors.

3.1.6. Case 6: Video transcoding and distribution

Video transcoding and distribution use case brings virtualized applications and components to available for video service providers in order to start new services rapidly, scale services up or down, or move them to another computing platform. The use case is based on sub cases: Cloud based public transport platform, Rapid development of MPEG-DASH video centric HbbTV application and CDN as a Service. The use case is defined based on these sub cases added with functionalities and components in order to cover all involved partners contribution. This use case is the common use case for all partners who participate the video transcoding and distribution use case.

Video service provider companies want to setup their video services efficiently to end users. They want to use virtualized components deployed dynamically into a hybrid cloud environment, encompassing private and public cloud resources. The new services are constructed and launched using the service portal. The service broker maintains a list of virtualized components (i.e. CDNaaS, encoder/transcoder, rapid HbbTV app development). The service providers can select appropriate components for setting up new services. Resource manager allocates resources based on different QoS and cloud provisioning cost information. The resource manager has processing resources available in the hybrid cloud. The client (service provider) can add provide resource to the private cloud which the resource manager can allocate to this client. The service providers have different requirements for deploying their services. For example live video and VoD content are needed to distribute to end users, who are using various devices when content needs to be adapted to the different devices and network capabilities. Private computing resources like smart cameras and gateways must be added to resource pool. Security and privacy must be guaranteed when medical video consultation services are build using the system. After the service provider has setup the new service the service is up and running and scales to varying resource needs and traffic peaks. The end users can access and use the services smoothly. The service provider can update the service by adding or removing components or resources. Finally the service provider can switch off or delete the service when it is no longer needed.

3.1.7. Case 7: Virtualized video analytics solutions

Solutions for virtualized video analytics have the generic characteristic that visual sensor data (usually coming from a video camera) is received as input and further processed (usually using means of image/video analytics) to derive new information (usually metadata that describe certain: events that are detected), and the generated information is eventually consumed by the user (e.g., a human user that triggers further actions or a system that further processes, relays, or stores the information).

The use case is based on five sub cases:

- parking management
- security in public transportation
- video surveillance
- traffic supervision
- industrial image processing

The **parking management** sub case pursue two different aims.

The first one is to provide location coordinates of the moving vehicles in a multi-storey car park. The camera based location data are necessary for autonomous driving vehicles as GPS supplement in indoor car parks. In addition the cloud analytics monitors other vehicles and obstacles in the car park and detects critical situations and creates automatically appropriate warnings which are transmitted via Car2x communication to the vehicle.

The other aim of the parking management sub case is to monitor the occupancy status of the parking lots. This will be shown in the car park as well as on parking lots located along the road side. A special challenge in the on-street parking case is the influence of different weather and lighting conditions on the cloud based object recognition.

In **video-based security in public transportation** the equipment of vehicles with onboard CCTV systems becomes more and more standard. Up to now, most onboard CCTV systems are mainly used for recording purposes in order to document relevant scenes while vehicle operation. In the last years public transport (PT) operators (PTO) used increasingly video systems which provide

real-time data transmission of video streams for detection of critical situations and allow near time intervention. It can be assumed that this trend will continue in the future.

In these days after in most cases a real-time intervention is not possible due to missing structures, smart onboard devices as well as powerful detection and tracking algorithm. The event-related post analysis of video recordings from onboard systems after an incident is associated with a high level of expenditure for personnel and technical solutions. Such an analysis is very time intensive since the material which has to be evaluated comprises huge video footage material over many days of operation as well as a large number of cameras in a specific vehicle. The complexity increases if the video material comes from several vehicles or when video material from vehicles and stationary objects (e.g. footage of several cameras located in train stations) is the base for data analysis.

This sophisticated process could be optimized by automated and centralized analysis methods which allow an efficient detection and tracking of objects of interest (OOI) in real time. Such methods can be provided as cloud-based solutions (platform as a service, PaaS). Such a solution could allow a real-time identification/recognition of critical situation (defined as “incident”) including OOI detection and tracking until an appropriate intervention by security staff and/or authorities. Therefore, the cloud service receives video streams from vehicles and rail stations in real time. A smart algorithm processes the video data in the cloud and tracks the object until a specified receiver can coordinate and conduct appropriate actions/operations (e.g. police/security personnel coordinates operations to stop a criminal offense in a vehicle).

The following graphic gives an overview on this scenario:

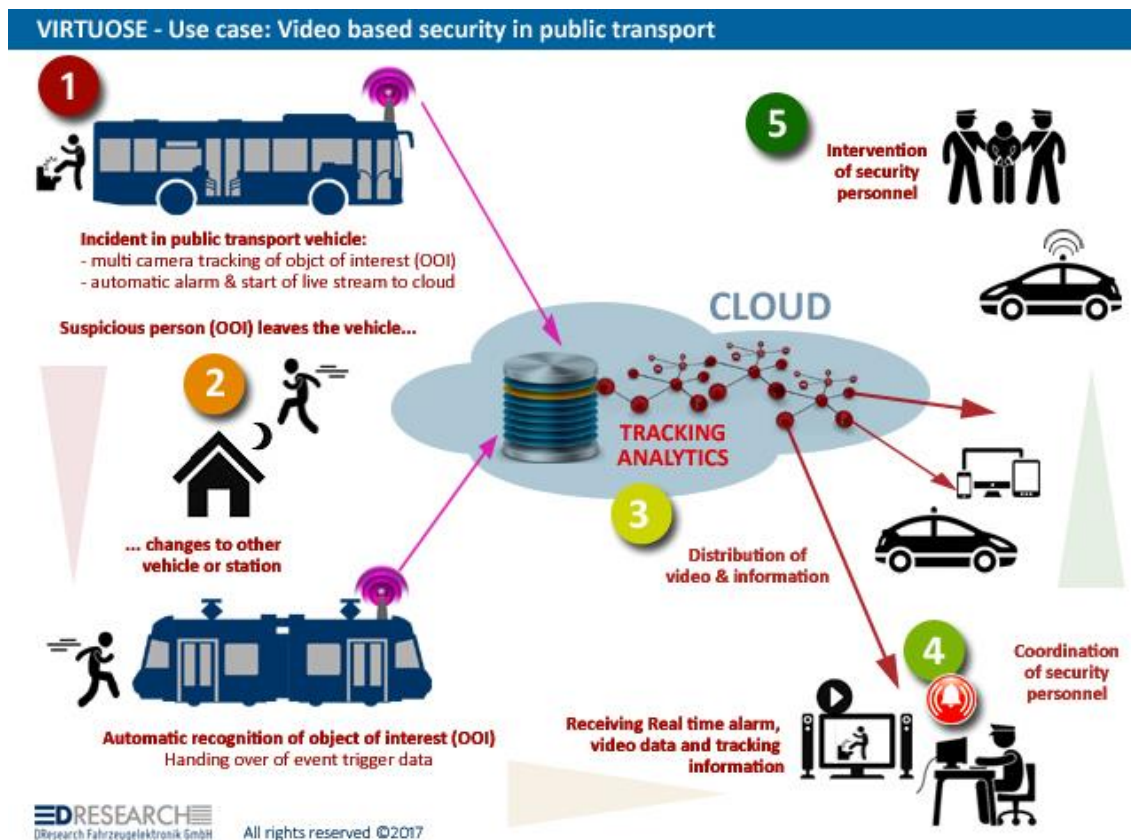


Figure 1 Scenario for video based security in public transport

In **video surveillance**, a main driver of cloud-based deployment and more automated analytics is the sole number of video feeds that are received and need to be analyzed. Different loads on the system (e.g., during day/night) can be efficiently handled using cloud-based processing resources. Further, new business models like Video Surveillance as a Service (VSaaS) can be addressed since the video surveillance components (except camera and IP network) need not be installed at the local site but can be centrally deployed and maintained in the cloud.

For traffic supervision, similar arguments apply since this sub case is conceptually and technically similar to the video surveillance sub case. Especially the convenience of a centrally managed system and the scalability for the usage of cloud processing resources are the main drivers for a cloud-based architecture.

In industrial image processing, image and video data acquired from scanners (e.g., ultrasound, computed tomography) is further processed (e.g., 3D reconstruction, volume rendering). Since the processing of the data is not continuous, elastic resources that can be used on demand offer cost advantages. Furthermore, since the image data is centrally available, additional scenarios like the consultation of a remote expert through remote (interactive) visualization can be realized compared to local applications. For this sub case, the similarity to the other sub cases within virtualized video analytics is mostly on the platform aspects, i.e., distributed architecture, cloud processing and storage as well as on interactive visualization. Thus, the focus within the VIRTUOSE project will therefore be on these aspects and not on specific technology needs of the sub case.

3.2. Use case selection criteria

The following criteria will be used to assess the usefulness of a Use Case for the Virtuose Project taking into account the general goals. The general goals are to define a flexible approach to implement virtualized video services utilizing container and other virtualization techniques. The proposed criteria for use case selection are:

One point per fulfilled criterion:

1. **Can be deployed easily to different computing platforms: this makes it easier to work on it**
2. **Feasibility for the partners of VIRTUOSE, to contribute to the advance on the state of the art in the context of the VIRTUOSE project**
3. **Provide a potential Business platform for the Partners to exploit**
4. **Market/society interest and private companies' interest (belonging to the consortium)**
5. **Implementability in a trial, taking into account the project resources and timing**

3.2.1. Evaluation of criteria for single-user cloud gaming

#1 Deploy	#2 Feasibility	#3 Business	#4 Interest	#5 Trial
Yes, 1 point	Yes, 1 point (LHE coding tech is a valuable contribution)	Yes, 1 point	Yes, 1 point	Yes, 1 point (through Gaming Anywhere or other cloud gaming platforms)

Table 2 Evaluation of criteria for single-user cloud gaming

3.2.2. Evaluation of criteria for multi-user cloud gaming

#1 Deploy	#2 Feasibility	#3 Business	#4 Interest	#5 Trial
Yes, 1 point	Yes, 1 point (LHE coding tech is a valuable contribution)	Yes, 1 point	Yes, 1 point	Yes, 1 point (through Gaming Anywhere or other cloud gaming platforms)

Table 3 Evaluation of criteria for multi-user cloud gaming

3.2.3. Evaluation of criteria for CSCW

#1 Deploy	#2 Feasibility	#3 Business	#4 Interest	#5 Trial
Yes, 1 point. (any commercial cloud provider)	No, (no expertise)	No, (it is not in the Spanish partners scope)	No	Not clear

Table 4 Evaluation of criteria for CSCW

3.2.4. Evaluation of criteria for Collaborative Applications with Interactive video

#1 Deploy	<p>This criteria is fulfilled as some partners have a wide experience and platforms running in this field. It should be possible to implement the use Case Scenario proposed and demonstrators developing open source Smart TV applications in an Interactive environment.</p> <ul style="list-style-type: none"> • Beia FAIR Platform. • Sofia Digital (Set-Top boxes). • Nokia (IPTV platform). • Innovati (DHTV platform).
#2 Feasibility	<p>Hence there is no expertise in this area, it is quite difficult to contribute in the advance of this use case.</p> <ul style="list-style-type: none"> • LHE involved Partners (Nokia, Innovati) will prefer to focus its R&D efforts in the Online Gaming and Security Analysis areas. • IPTV R&D. Nokia will not support a new implementation of another IPTV Platform for Virtuose. • DHCTV Platform (Smart TV based) will not be supported in this Project.
#3 Business	<p>Weak: There is potential but strong competition, because legacy collaborative applications may potentially become multimedia-interactive such as list of collaborative applications:</p> <ul style="list-style-type: none"> • https://en.wikipedia.org/wiki/List_of_collaborative_software • http://www.capterra.com/collaboration-software/ <p>Some existing interactive media-collaborative applications</p> <ul style="list-style-type: none"> • Google docs: collaborative edition. • MashmeTV: collaborative browsing, video multiconference, etc. • Skype • Scribblar, • Mindmeister, • Etc. <p>This market saturation reduce the potential for growing, and makes difficult to create something new.</p>
#4 Interest	<p>Weak: Although many Virtuose partners have an interesting Business on the Collaborative Applications and on Interactive video some of the opportunities of Virtuose will be focused on other</p> <ul style="list-style-type: none"> • LHE involved Partners (Nokia, Innovati) will prefer to focus its business development efforts in the Online Gaming and Security Analysis areas. • IPTV business. Nokia's Business will not support a new implementation of another Imagenio Platform (now Movistar TV) outside its commitments for Virtuose.

	<ul style="list-style-type: none"> Innovati DHCTV Platform (Smart TV) will not be supported in this Project.
#5 Trial	

Table 5 Evaluation of criteria for Collaborative Applications with Interactive video

3.2.5. Evaluation of criteria for video transcoding and distribution:

#1 Deploy	#2 Feasibility	#3 Business	#4 Interest	#5 Trial
Yes, 1 point	Yes, 1 point	Yes, 1 point	Yes, 1 point	Yes, 1 point

Table 6 Evaluation of criteria for video transcoding and distribution

3.2.6. Evaluation of criteria for video analytics

#1 Deploy	#2 Feasibility	#3 Business	#4 Interest	#5 Trial
Yes, 1 point	Yes, 1 point	Yes, 1 point (For example, in the sub-case parking management, the information on available parking space could be made available through a platform or service.)	Yes, 1 point	Yes, 1 point (It is planned to implement two sub cases, i.e., parking management and video-based security in public transportation.)

Table 7 Evaluation of criteria for video analytics

3.2.7. Evaluation of criteria for multiparty video communications

#1 Deploy	#2 Feasibility	#3 Business	#4 Interest	#5 Trial
Yes, 1 point	Yes, 1 point	Yes, 1 point	Yes, 1 point	Yes, 1 point

Table 8 Evaluation of criteria for multiparty video communications

3.3. Use case selection summary

The following table summarizes the evaluation results of the above use cases, and proposes which use cases to select for the project.

Use case	Evaluation based on criteria	Criteria filter[YES/NO]
Cloud gaming single user	5 points	YES
Multiuser cloud gaming	5 points	NO
Computer Supported Cooperative Work (CSCW)	1 points	NO
Collaborative Applications with Interactive video	1 points	NO
Video transcoding and distribution	5 points	YES
Video analytics	5 points	YES
Multiparty video communication	5 points	YES

Table 9 Use case selection summary

4. Global problem description

This section addresses general issues that affect the use cases, how the issues can be solved and how the solutions benefit several use cases.

4.1. Problems that affect the different video services

Problem	Description
A) Coding/transcoding latency	Composite latency= RTT + coding + decoding + game logic or processing
B) Network latency & jitter	RTT affects video and commands
C) packet-loss	1% is not tolerable at gaming
D) Distribution costs vs business	More PoPs (point of presence) implies more quality but also more costs, compromising the business
E) Distribution of intelligence/processing between local component and cloud platform	A good split depends on the available resources (local processing resources, network resources for transmission of the data, ...)
F) High-quality analytics	The detection rate of the analytics algorithm needs to be sufficient for (semi-) automated processing in order to realize scalability of the solution (i.e., more and more video streams to be processed).
G) Virtualization	Virtualization of the video service components allowing the use of off-the-shelf hardware and cloud platforms.
H) Service setup and scalability	Start new services rapidly and scale them based on the current needs.

Table 10 Summary of problems that affect video services

Summary of problems with respect to the use cases is given in the Table below.

Meaning of the table: problems that will be addressed in each use case

Use case	A	B	C	D	E	F	G	H
Cloud gaming	x		x	x			x	
Video transcoding and distribution				x	x		x	x
Video analytics		(x)		(x)	x	x	x	x
Multiparty video communication			x	x	x	x		

Table 11 Problems that affect each use case

4.2. Partial solutions

Use case	Brief description about what and how it partially solves the identified problems
Cloud gaming	Cloud gaming use case solves partially the problem A) coding latency, speeding up the encoding process using LHE and therefore giving more margin for network latency. In addition, its adaptability to network resources minimizes gameplay degradation
Video analytics	Video analytics will predominantly address the point E and F. For E, an optimal split between local and cloud processing will be investigated. This will likely depend on the concrete requirements and settings of the individual sub cases. For F, improvements beyond the state of the art in video analytics are envisioned, e.g., by employing deep learning approaches.
Video transcoding and distribution	Video transcoding and distribution use case solves partially problems D, E, G and H. The use case shows a software-based approach to video services using a virtualization to enable usage of cloud platforms. Using virtualized components and advanced resource management new services can be setup quickly and scale up or down, or move them to another cloud platform
Multiparty video communication	Multiparty video communication use case solves partially problems C, D, E and F. The use case shows that the interactive multi party HD video experiences. It is easy to use and deploy. It increases room system utilization. It is superior management and analytics.

Table 12 Partial solutions given for each use case

4.3. Complementarity analysis between cases

Cloud gaming use case solves partially the composite latency problem, using a new approach for fast encoding. This is complementary to the **videoconferencing** use case because it may help to increase the user QoE. In addition LHE encoding provides a new set of tools for achieving **video analytics** with reduced computational resources which may help to solve certain heavy processing.

The **video analytics** use case investigates techniques for distributing the processing tasks between the local components/clients and the cloud. The general approach for this aspect also applies for other use cases like **video conferencing**. Vice versa, solutions on networking aspects (e.g., low-delay transmission required for a real-time system) can well be used also for video analytics.

The **video transcoding and distribution** use case considers how virtualized applications and components can be exploited in order to start new services rapidly and scale services up or down using private, hybrid or public clouds. The same approach can be used to set up and manage

other services (use cases) like **cloud gaming**, **video conferencing** and **video analytics** if the components and/or applications are virtualized.

5. Use case: Cloud gaming and multiparty video communication

5.1. Sub case: Cloud gaming (single user)

5.1.1. Record and description

The meaning of each record field is detailed at the appendix I

Title	Cloud gaming, also called "Game as a service" (GaaS)
Author/company	NOKIA
Partners involved	SPAIN: (NOKIA, INNOVATI, UPM, i2CAT)
Primary Actors	<ul style="list-style-type: none"> • Tech provider (such as ubitus, G-cluster, ciinow, etc.) • GaaS provider/operator (such as SFR, NTT, ...) <p>Sometimes the same company assumes all roles (service provider and tech provider)</p>
Stakeholders	<p>There is no stakeholders in this use case, because most pioneers have crashed (onlive, shinra, etc):</p> <ul style="list-style-type: none"> • Service Provider: Game Publisher + GaaS operator <ul style="list-style-type: none"> ◦ Game publisher: N involved but cases like PSnow (by SONY) in which only one. ◦ GaaS Operator (sometimes Network operator). Some relevant examples : SFR, NTT, Orange • Tech provider: Clouds (infrastructure) + cloud gaming platform (software and hardware). Some relevant examples: Otoy, Onlive, Shinra, ubitus <p>Sometimes the same company assumes all roles (service provider and tech provider)</p>
Scope	<p>The main R&D issues are</p> <ul style="list-style-type: none"> • Composite latency • Divergence of latencies at multiuser • Burst effects <p>The main R&D topics are</p> <ul style="list-style-type: none"> • Application based QoS: faster coding, speculative execution, real-time quality measurement (Q4S and similar protocols) • Network Based QoS: prioritization, parallel private networks (IPTV),
Trigger	<p>Main trigger of this use case is the business volume potential. In 2015 there were 1900 Millions of game players and 91.000 M\$ in revenues (source AEVI: Spanish videogames association). This is not cloud gaming but reflects a growing interest and huge potential market.</p> <p>Online Gaming service provider needs technologies to improve the use of the delivery network to compete with specialized (physical)</p>

	<p>platforms. These new technologies must cover different domains but at least partial solutions can be proposed</p> <p>Domains:</p> <ul style="list-style-type: none"> • Coding: faster coding, adapted game engines to codecs... • Network: Diffserv models, dynamic prioritization... • Gameplay optimization strategies (partitioning, speculative execution...)
Preconditions	<p>Composite latency less than 120ms but depending on game type this latency must be less than 90ms. Composite latency is the summation of all latencies in order to perceive the reaction of the game to user interaction</p> <p>Reaction time = RTT+coding+decoding</p> <p>The network latency is the most important problem. However Coding/decoding is part of the problem and has not network infrastructure dependencies, which makes it affordable for algorithmic improvements.</p>
Step-wise Description	<p>Steps are:</p> <ul style="list-style-type: none"> • Validate current tech for use case: failed, tried by some crashed companies such as onlive. The current tech imposes last mille deployments increasing costs, making business impossible to fly • Develop new coding tech to solve current problems • Deploy new network strategies to solve current problems • Validate new approaches in demo labs at potential GaaS operators.
Post (success) Conditions	<ul style="list-style-type: none"> • Solve scaling potential problems • Reduce costs to gain market share versus physical games.
Failed End Condition	<p>Considering the service is NOT offered from last mille, the failed condition is :</p> <p>Insufficient On line Game Quality, in terms of gaming QoE (gameplay), which is a composite measurement including reaction time, video quality (resolution, fps...), network adaptability, etc.</p>
Associated User Requirements	<p>User compares Quality with specialized physical platform</p> <p>User compares price with specialized physical platform</p> <p>The mix (quality- price) must be acceptable by hard gamers. Hard gamers are the real customers of the service, not casual gamers.</p>
Extensions & Variations	<p>The two main problems defines 3 domains of research.</p> <ul style="list-style-type: none"> • Coding • Networking • Gameplay optimization strategies <p>A different combination of improvements on the three domains can setup a different initial valid approach.</p>
Open Issues	<p>The main R&D issues and research domains are:</p> <ul style="list-style-type: none"> • Composite latency (coding and RTT) <ul style="list-style-type: none"> ◦ Coding: faster codec, hot reconfigurability to dynamic network conditions adaptation... ◦ Networking: prioritization, private IP networks

	<ul style="list-style-type: none"> ○ Gameplay optimizations (partitioning, speculative execution) • Divergence of latencies at multiuser <ul style="list-style-type: none"> ○ Real-time measurement protocols (Q4S) ○ Gameplay optimizations (speed control) • Jitter & Burst effects <ul style="list-style-type: none"> ○ Real-time measurement protocols (Q4S) ○ Gameplay optimizations (speed control)
Required Technologies and Protocols	Research: LHE Tools : ffmpeg, GamingAnywhere Protocols: Q4S
Related processes today	<p>Experience of cloud Gaming Companies (with different roles): G-cluster, ubitus, streammygame, gaikai, otoy, SFR, Onlive, NTT, SONY (psnow = gaikai), nvidia, bigfish, coreonline, ciinow, gamenow, GamingAnywhere, googleTV, microsoft-delorean, orange, shinra</p> <p>Most Tech companies crashed. Current solution for provide a quality service is the deployment in last mille, increasing costs and limiting business potential.</p> <p>Market demands different domain solutions in coding, networking and gameplay</p>

Table 13 Record and description of sub use case single-user cloud gaming

5.1.2. Technical challenges

What distinguishes interactive video systems from other video systems is the fact that they are highly delay sensitive, and this sensitivity is a major challenge for operating them in the cloud. While buffering and interruptions of even a few seconds are tolerated in presentational video applications, conversational video applications require a much tighter end-to-end delay (input-to-display delay), usually in the range of 90 to 120 milliseconds, beyond which the application will “fail” since it is not responding to user interactions fast enough.

Despite its advantages, cloud gaming’s Quality of Experience (QoE) is still not good enough for certain video games that are very end-to-end delay sensitive. In fact, user studies have revealed that the e2e latency threshold that makes the gameplay acceptable is up to 120 ms for first person games (FPS or racing games) whereas for third person games (sports, RPG) it increases up to 500 ms [Latency and player actions in video games].

In this manner, new delay reduction methods are being developed in order to satisfy the gaming QoE. The solutions that have been studied till date may be grouped in three categories: game processing and networking and additionally, gameplay optimization strategies.

- i. Game processing techniques: (encoding domain) such as game engine, video rendering and encoding optimizations.
- ii. New networking techniques (network domain).
- iii. Maximization of gaming QoE (gameplay domain)

In addition there is a secondary potential problem: the scalability. But to face this problem, first the main other problems must have a practical and suitable solution.

In this project we will focus on coding techniques. The specific challenges for this domain are:

- Speed
 - New faster algorithms
 - SIMD implementation
 - GPU implementation
- Hot reconfiguration adaptability
 - Fps, resolution, etc.

- Robustness under packet loss

Technical challenges are related with certain technical parameters which have different impact on gameplay. Gameplay is analysed by some authors as a composite equation involving attributes (subjective perceptions) and features (technical aspects)

Technical parameters limited by cloud gaming	Related gameplay attributes	Related gameplay features
Fps	Satisfaction, immersion, effectiveness	Mechanic gameplay
Resolution/bitrate	Immersion, satisfaction, emotion	Artistic gameplay
Composite latency	Interactivity	Interactive gameplay
Scalability (partitioning)	Sociability	Interpersonal gameplay
Speculative execution (called also "client prediction")	Sociability and effectiveness	Intrapersonal/interpersonal gameplay

Table 14 Technical parameters and impact on gameplay

Table of problems and partial solutions on cloud gaming:

Problem	Partial solution
Network quality	QoS, N-QoS, IPTV
Coding latency	LHE, ORBX2 (otoy), game engine integrated with codec
Composite latency	<ul style="list-style-type: none"> • Speculative execution • Partitioning • Speed game limitation • Dynamic network quality on demand
Packet loss	Q4S, A-QoS, dynamic adaptability of coders

Table 15 Problems and partial solutions on cloud gaming

5.2. Sub case: Multiparty video communications

5.2.1. Record and description

The meaning of each record field is detailed at the appendix I

Title	Multiparty video communications
Author/company	BEIA
Partners involved	BEIA, Netas and Videos Visit/FI
Primary Actors	<ul style="list-style-type: none"> • Tech provider (such as Unify, Panasonic, Alcatel-Lucent, Polycom, etc.) • Service provider/operator (such as Circuit, Vodafone, Orange, ...) <p>Sometimes the same company assumes all roles (service provider and tech provider)</p>

Stakeholders	<p>There are several stakeholders in this use case, but adoption rate is low:</p> <ul style="list-style-type: none"> • Service Provider: <ul style="list-style-type: none"> ◦ Providers (tech providers which became providers). Some examples: Circuit (https://www.circuit.com/) ◦ Operator (sometimes Network operator). Some relevant examples : Telekom, Vodafone, Orange • Tech provider: Clouds (infrastructure) + Video communications platform (software and hardware). Some relevant examples: <ol style="list-style-type: none"> 1) Unify (http://www.unify.com/us/products-services/unified-communications/applications/video-conferencing.aspx), 2) Panasonic (http://business.panasonic.sg/office-and-communication/products-and-accessories/hdvc), 3) Alcatel-Lucent (http://enterprise.alcatel-lucent.com/?solution=Collaboration&page=Collaboration-Product-Portfolio), 4) Polycom (http://www.polycom.com/hd-video-conferencing.html) <p>Sometimes the same company assumes all roles (service provider and tech provider).</p>
Scope	<p>The main R&D issues are</p> <ul style="list-style-type: none"> • 3D immersive reality • Transferring complex technology • Adapting processes to local markets <p>The main R&D topics are</p> <ul style="list-style-type: none"> • Application based QoS: Application-based Quality of Service (AQoS) relates to the facilities embedded within an application that preserve the quality of its intended use. • Network Based QoS: Network-based Quality of Service (NQoS) levels are implemented in layer two (Data-Link) and layer three (Network) of the ISO application model.
Trigger	<p>Main trigger of this use case is the business volume potential and savings related to travel. The market of video conferences in the world is around 3.5 billion \$ in 2016. The analysis firm Ovum has reported that the Video Conferencing market's revenue has grown exponentially in the past 4 years, at a compounded annual rate of 5.79.</p> <p>Other triggers:</p> <ul style="list-style-type: none"> • Product or service is robust. • Cross-platform compatible and easy to use. • Discount offers
Preconditions	<p>Composite latency less than 300ms. Composite latency is the summation of all latencies in order to perceive the reaction of the game to user interaction</p> <p>Reaction time = RTT+coding+decoding</p> <p>Network latency is the term used to indicate any kind of delay that happens in data communication over a network. Network connections in which small delays occur are called low-latency</p>

	<p>networks whereas network connections which suffers from long delays are called high-latency networks.</p> <p>High latency creates bottlenecks in any network communication. It prevents the data from taking full advantage of the network pipe and effectively decreases the communication bandwidth. The impact of latency on network bandwidth can be temporary or persistent based on the source of the delays.</p> <p>Jitter should be less than 20ms for high-quality video communication.</p>
Stepwise Description	<p>Steps are:</p> <ul style="list-style-type: none"> • Validate current tech for use case : failed, tried by some • Crashed companies such as onlive. The current tech imposes last mille deployments increasing costs, making business impossible to fly • Develop new coding tech to solve current problems • Deploy new network strategies to solve current problems • Validate new approaches in demo labs at potential operators.
Post (success) Conditions	<ul style="list-style-type: none"> • Solve scaling potential problems • Reduce costs to gain market share versus physical meetings.
Failed End Condition	<p>Considering the service is NOT offered from last mille, the failed condition is :</p> <p>Insufficient On line Video Communications Quality, in terms of QoE (interaction), which is a composite measurement including reaction time, video quality (resolution, fps...), network adaptability, etc.</p>
Associated User Requirements	<p>User compares Quality with physical meetings</p> <p>User compares price with physical meetings</p> <p>The mix (quality- price) must be acceptable by business meetings.</p> <p>Frequent travellers and meeting organizers are the real customers of the service, not casual meeting participants.</p>
Extensions & Variations	<p>The two main problems defines 3 domains of research.</p> <ul style="list-style-type: none"> • Coding • Networking • Video communication interaction strategies <p>A different combination of improvements on the three domains can setup a different initial valid approach.</p>
Open Issues	<p>The main R&D issues and research domains are:</p> <ul style="list-style-type: none"> • Composite latency (coding and RTT) <ul style="list-style-type: none"> ○ Coding: faster codec, hot reconfigurability to dynamic network conditions adaptation... ○ Networking: prioritization, private IP networks ○ 3D Interaction optimizations ○ Divergence of latencies at multiuser ○ Real-time measurement protocols

	<ul style="list-style-type: none"> Interaction optimizations (voice, video and shared documents sync) <p>Jitter & Burst effects</p> <ul style="list-style-type: none"> Real-time measurement protocols Interaction optimizations (sync)
Required Technologies and Protocols	<p>Research: Site Visits, Interviews with key Participants, Facilitating focus groups, Videotaping instructional events.</p> <p>Tools: Skype, ichtat, ooVoo, Adobe Acrobat Connect, Mega meeting.</p> <p>Protocols: TCP , UDP & RTP</p>
Related processes today	<p>Experience of video conference Companies (with different roles): Google Hangouts, Apple, Gotomeeting, Skype, etc.</p> <p>Most Tech companies postponed rollout. Current solution for provide a quality service is the deployment in last mille, increasing costs and limiting business potential.</p> <p>Market demands different domain solutions in coding, networking and interaction.</p>

Table 16 Record and description of sub use case multiparty video communications

5.2.2. Technical challenges

Multiparty video communications helps business to achieve their goal: improve productivity. The benefits of adopting a multiparty video communication solutions are related mainly to the replacement of various types of face-to-face meetings and group meetings with virtual meetings. Multiparty video communications, if well integrated into business processes, provides significant reductions in travel costs, it makes it more effective intra-organizational collaborative work with partners, accelerates decision making through more efficient communication, frequent meetings and information sharing. Also very important is the reduction of the carbon footprint of the company and the overall productivity growth; in fact the less time traveling to employees translates into more time in the office and, also, to an improvement in the quality of work: less time, energy and stress for business trips. The intangible benefits of multiparty video communications also stem from more efficient meetings by exchanging a non-verbal communication that contributes to a stronger sense of community; in fact, to see other participants' reactions makes communication significantly more engaging and rich.

Multiparty video communication also offers the possibility to hold virtual meetings snapshots, particularly useful in the case of decisions that have to be taken urgently and it involves more people who are physically distant. However, the central point is and remains the network: it is essential that the network is capable of handling video traffic appropriately. Video requires more data transfer than packages of voice data; for this reason it is imperative to have a bandwidth of high-quality network and a reliable WAN.

Peer-to-peer (P2P) is a decentralized communications model which was originally used for file sharing, and more recently for real-time communications and media streaming. Due to the utilization of resources, demand of peer to peer network is increasing rapidly and today significant part of the Internet traffic is generated by peer-to-peer (P2P) applications.

Current unsolved Problems:

- 1) **Overlay Efficiency:** the overlay efficiency must be equal to the network and the application representation. For broadcast video, high bandwidth and low latencies are simultaneously required. However, given that applications are real-time but not interactive, a start-up delay of a few seconds can be tolerated.
- 2) **System Considerations:** several important system issues must be addressed in the design of a complete broadcasting system. For example include the choice of transport protocol and the interaction with video players. Further, a key challenge of peer-to-peer

systems involves the presence of large fractions of users behind NATs and firewalls - the connectivity restrictions posed by such peers may severely limit the overlay capacity.

- 3) **Scalability and load balancing:** since the power of any server is finite, a web application must be able to run on multiple servers to accept an ever increasing number of users. This is called scaling. Scalability is not really a problem for intranet applications since the number of users has little chances to increase. However, on internet portals, the load continuously increases with the availability of broadband Internet accesses.
- 4) **Self-organizing:** when the construction of overlay must be done in a distributed style and must be robust to dynamic changes in group membership. Further, the overlay must adapt to long-term variations in Internet path characteristics (such as bandwidth and latency), while being resilient to inaccuracies. The system must be self-improving in that the overlay should incrementally evolve into a better structure as more information becomes available.
- 5) **Honor per-node bandwidth constraints:** as the system is depending on users contributing bandwidth, it is very important to make sure that the total bandwidth a user is required to contribute does not exceed its inherent access bandwidth capacity. Whereas, users also have heterogeneous inbound bandwidth capabilities, and it is desirable to have mechanisms to ensure they can receive different qualities of video, proportional to their abilities.

Approaches for Overlay Construction

An efficient overlay is a crucial component of wireless cooperative live video streaming networks—an emerging wireless streaming solution with ever-increasing storage and computation capabilities, and provides scalability. A large number of proposals have emerged in recent years for peer-to-peer video broadcast. In particular, the proposals can be broadly classified into two categories, namely, **tree-based** and **data-driven randomized** overlay construction, which we discuss below.

1) Tree-Based Approaches:

The vast majority of the proposals to date can be categorized as a tree-based approach. Such approaches are typically push-based, that is, when a node receives a data packet, it also forwards copies of the packet to each of its children. Since all data packets follow this structure, it becomes critical to ensure the structure is optimized to offer good performance to all receivers. Tree-based solutions are perhaps the most natural approach, and do not require sophisticated video coding algorithms. However, one concern with tree-based approaches is that the failure of nodes, particularly those higher in the tree may 4 disrupt delivery of data to a large number of users, and potentially result in poor transient performance.

2) Data-Driven Approaches:

Data-driven overlay designs sharply contrast to tree based designs in that they do not construct and maintain an explicit structure for delivering data. The underlying argument is that, rather than constantly repair a structure in a highly dynamic peer-to-peer environment, we can use the availability of data to guide the data flow. In a typical gossip algorithm, a node sends a newly generated message to a set of randomly selected nodes; these nodes do similarly in the next round, and so do other nodes until the message is spread to all. The data-driven approach at first sight may appear similar to techniques used in file download solutions like BitTorrent. However, the crucial difference here is that the real time constraints imply that segments must be obtained in a timely fashion.

6. Use case: Virtualized video transcoding and distribution

6.1. Sub case: Video transcoding and distribution

6.1.1. Record and description

Title	Video transcoding and distribution
Author/company	VTT
Partners involved	VTT, TUT, Tuxera, Sofia, Teleste, VideoVisit
Primary Actors	<ul style="list-style-type: none"> - Service portal (SP), where services can be constructed and launched - Service broker (SB), which maintains a list of applicable resources, services with related quality information, and accounts for ordered services - Resource manager (RM), which allocates resources based on CPU, memory, bandwidth, video QoS, and cloud provisioning cost information - CDN as a Service (CDNaaS), containing an origin server, edge servers, routing, management, and monitoring - VoD asset library - Live streaming asset metadata - Virtualized encoder/transcoder - Rapid HbbTV app development - 2nd screen app - Smart cameras and home gateways - Application to record and upload videos to cloud - Resources: Clouds, edge clouds and dedicated HW resources
Stakeholders	Video service providers, CDN service provider, network operator, end users, cloud operators, application providers
Scope	Three video service provider companies, VideoHouse Ltd., SecureHouse Ltd., and MessageHouse Ltd., want to setup their video services efficiently to users' home environments. They want to use virtualized components deployed dynamically into a hybrid cloud environment, encompassing private and public cloud resources. The new services are constructed and launched using the service portal.
Trigger	A video service provider wants to setup a new service using the service portal.
Preconditions	The service broker is offering virtualized components (i.e. CDNaaS, encoder/transcoder, rapid HbbTV app development) for the service providers for setting up their services. The resource manager has sufficient processing resources available in the hybrid cloud with storage and processing capacity in different locations (i.e. cloud, edge cloud, smart cameras). The service providers have different requirements for deploying their services. VideoHouse Ltd. has live video and VoD content, which needs to be distributed to end users, who are using various devices (e.g. smart phone, TV). The content needs to be adapted to the different devices and network capabilities in order to ensure the best possible user experience. SecureHouse Ltd. on the other hand has smart cameras and gateways installed in the users' private households. MessageHouse Ltd. wants to setup Medical consultation service where client can use a video application, which records and uploads videos to cloud

	where consulting group or person can watch the video and make the consultation.
Step-wise Description	<ol style="list-style-type: none"> 1. Creation - Live video and VoD service <ol style="list-style-type: none"> 1.1. VideoHouse Ltd. selects the VoD and live transcoder services, which connect to their assets, CDN service and 2nd screen and HbbTV application templates from the service portal (SP). 1.2. SP sends the VoD transcoder creation request with configuration requirements to the service broker (SB) 1.3. SP sends the live transcoder creation request with configuration requirements to the SB 1.4. SP sends a CDN creation request with configuration requirements to the SB 1.5. SP sends a HbbTV app creation request with configuration requirements to the SB 1.6. SP sends a 2nd screen app creation request with configuration requirements to the SB 1.7. SB asks based on the configuration requirements available resources from the resource manager (RM) 1.8. RM allocates cloud resources for the services 1.9. SB creates the selected services and deploys them into the cloud 1.10. SB creates an account for VideoHouse Ltd. services and uses it for maintaining billing information according to the resource usage and cost of the services 2. Creation - Video surveillance service <ol style="list-style-type: none"> 2.1. SecureHouse Ltd. registers the home gateways as private resources using the SP. 2.2. SP sends resource registration request with information to the SB 2.3. SB registers the SecureHouse Ltd.'s private resources to the RM 2.4. SecureHouse Ltd. selects the live transcoder and storage services from the SP. 2.5. SP sends the live transcoder creation request with configuration requirements to the SB 2.6. SP sends the storage creation request with configuration requirements to the SB 2.7. SB asks SecureHouse Ltd.'s private resources from the RM 2.8. The RM allocates resources for the services 2.9. SB creates transcoder service to home gateways, storage to cloud and an account for SecureHouse Ltd. services 2.10. RM monitors the resource usage and cost of the service and SB maintains billing information accordingly 3. Creation - Medical consultation service <ol style="list-style-type: none"> 3.1. MessageHouse Ltd. selects the video application, which records and uploads videos to cloud, the VoD transcoder and cloud storage services from the SP. 3.2. SP sends the VoD transcoder creation request with configuration requirements to the SB

	<p>3.3. SP sends a video application creation request with configuration requirements to the SB</p> <p>3.4. SP sends the storage creation request with configuration requirements to the SB</p> <p>3.5. SB asks based on the configuration requirements available resources from the RM</p> <p>3.6. The RM allocates resources for the services</p> <p>3.7. SB creates required services and an account for MessageHouse Ltd. services</p> <p>3.8. RM monitors the resource usage and cost of the service and SB maintains billing information accordingly</p> <p>4. Deletion - All</p> <p>4.1. One of the service providers (VideoHouse Ltd., SecureHouse Ltd. or MessageHouse Ltd.) no longer needs to offer its services to users and requests to delete its account for the video services from the SP</p> <p>4.2. SP sends deletion request to SB</p> <p>4.3. SB deletes all instances and request RM to release the allocated resources</p> <p>4.4. RM releases the allocated resources</p> <p>4.5. SB deletes the service provider's account of the services</p> <p>5. Runtime - Live video and VoD service</p> <p>5.1. RM receives monitoring information regarding the performance of the resources, for instance usage of CPU, network traffic and QoS.</p> <p>5.2. If the load increases, the RM adds new nodes to the CDN or new transcoding resources.</p> <p>5.3. If the load decreases, RM releases the resources from the service</p> <p>6. Runtime - Video surveillance service</p> <p>6.1. SecureHouse Ltd. uses its own account from the SP to register a new home gateway to the private resources and to add a live transcoder to it.</p> <p>6.2. SP sends a resource registration request with information to add the live transcoder to the SB</p> <p>6.3. SB register the SecureHouse Ltd.'s new resource to the resource manager (RM)</p> <p>6.4. SB creates the live transcoder service to the new resource.</p>
Post (success) Conditions	The video service is up and running and scales to varying resource needs and traffic peaks. The end users can access and use the services smoothly.
Failed End Condition	The video service or certain nodes are not in operation. The video service does not scale to traffic peaks or resource needs.
Associated User Requirements	The users require cost-effective, secure and rapid video service setup with dynamic resource allocation in hybrid cloud environments.
Extensions & Variations	<p>Alternative sequence 1: Runtime - Live video and VoD service 2-3</p> <p>In the live video case the clients in the network X report QoE values which oscillate between two representations.</p>

	Based on the received monitoring info and RM adds resources for transcoder in the mobile edge cloud in the network X SB creates transcoder to mobile edge cloud to transcode one extra representation between the oscillates representations The clients in the network X select new representation and oscillation between two representations ends
Open Issues	The SB/RM may be need to be integrated with a big data processing pipeline, which handles streaming data collected from cloud instances, and video sessions.
Required Technologies and Protocols	Service broker, Resource manager, CDN, adaptive streaming (MPEG-DASH), Docker, Video transcoder, HEVC encoder, smart cameras, home gateways, cloud resources, (MEC server for Alternative sequence 1)
Related processes today	To setup video service can be used hardware or software transcoders and encoders. The encoding services are available in cloud. For smart cameras and home gateways the encoder/transcoder need to be tailored based on the computing resources. CDN service can be purchased from the CDN provider. The video applications can be purchased from software developer when they can be designed to meet the needs of the service.

Table 17 Record and description of sub use case video transcoding and distribution

6.1.2. Technical challenges

Several technical challenges need to be addressed in the use case when bringing virtualized applications and components to available for video service providers in order to start new services rapidly, scale services up or down, or move them to another computing platform. Following are listed the main technical challenges in the Video transcoding and distribution use case:

- Different cloud platforms: Cloud platforms may be public, private or hybrid solutions, and in some cases those may be inside telco network, for example in the edge computing platforms. The virtualized applications should be deployed easily on different cloud platforms. Cloud resources may be attached to the resource pool.
- Containers: Virtualized components must support different cloud platforms. Components can be used easily on different services. They can be started and stopped remotely.
- Resource management/orchestration: The resource manager needs information about cloud resources and physical location of the cloud nodes. The resource manager must allocate and scale the resources according to the current needs and provide uninterrupted service.
- Security: The use of multiple cloud platforms poses challenges to security especially when information is changed between the cloud platforms.

6.2. Sub case: Cloud based public transport platform

6.2.1. Record and description

Title	Cloud based public transport platform
Author/company	Teleste corporation
Partners involved	Teleste corporation
Primary Actors	Cloud service providers e.g. Amazon S3 Cloud platform components that utilize container architectures e.g. Dockers, different mobile communication systems, and database systems e.g. Cassandra.

Stakeholders	End user, service provider, operator
Scope	Remote management of public transport subsystems
Trigger	End user, operator, automated scripts, alarms, sensors
Preconditions	The public transport system relates to an onboard vehicle, e.g. train or tram, which is equipped with different subsystems that consist of PC units with operating systems, displays and series of different applications related to advertising, passenger information system and CCTV.
Step-wise Description	<p>This step-wise description related to articular video offload application</p> <ol style="list-style-type: none"> 1. The onboard CCTV is recording 24/7 content into the onboard storage system. 2. The onboard CCTV is connected into the cloud based video storage distribution/management system through mobile application. 3. The onboard system offloads video recordings from the onboard system to the cloud storage with wireless link installed onboard. 4. The cloud system monitors distributed onboard video data and updates the status of successfully offloaded data to the onboard system.
Post (success) Conditions	The onboard system and cloud system need to be interconnected for synchronizing the status information. Hence, at least GSM network needs to be available 24/7 to enable minimum communication between the cloud and onboard system.
Failed End Condition	If the connection fails between onboard system and cloud system, use case cannot be executed.
Associated User Requirements	TBD
Extensions & Variations	Any other data apart from video can be transferred from onboard to the ground system and vice versa by using the same cloud based architecture/application.
Open Issues	N/A
Required Technologies and Protocols	Internet protocols, standard video encoding/decoding algorithms, encryption techniques, adaptive streaming techniques.
Related processes today	

Table 18 Record and description of sub use case cloud based public transport platform

6.2.2. Technical challenges

The first challenge is to choose the right technologies to work with and build the cloud platform on. In pursuit of a competitive platform also these targets must be achieved:

- Can be deployed easily to different cloud computing platforms
- Keeps customer video safe end-to-end
- Can be monitored and maintained easily
- Scales up to respond to the growth of the number of users efficiently
- Provide uninterrupted service

6.3. Sub case: Rapid development of MPEG-DASH video centric HbbTV application

6.3.1. Record and description

Title	Rapid development of MPEG-DASH video centric HbbTV application
Author/company	SOF (Sofia Digital Ltd.)
Partners involved	SOF, Finnish partners
Primary Actors	<ul style="list-style-type: none"> • Service portal (SP), where services can be constructed and launched • Rapid HbbTV app development with Sofia Backstage® HbbTV Authoring Tool • Virtualized encoder/transcoder • HbbTV service provider (operator)
Stakeholders	Video service providers, operator, end-user
Scope	Video service provider VideoHouse Ltd. wants to set up their video service efficiently to users' home environments. They want to use virtualized components deployed dynamically into a hybrid cloud environment, encompassing private and public cloud resources. The new HbbTV service is constructed and launched using the service portal.
Trigger	Video service provider wants to build new video centric HbbTV application, which utilizes MPEG-DASH videos and related metadata.
Preconditions	Operator is providing interactive TV services with Sofia Backstage® HbbTV Platform and is willing to add VideoHouse Ltd. new HbbTV service into its service portfolio.
Step-wise Description	<ol style="list-style-type: none"> 1. Plan requirements for the new service keeping in mind the possibilities of HbbTV Authoring Tool ready-made templates. 2. Login to Authoring Tool with "Content creator" user role. 3. Select suitable template from available application templates and open that for editing. 4. Configure parameters, attach desired asset library and edit UI per requirements. 5. Test that application is working as it should be. 6. Publish the application for approval. 7. User with Publisher role logs in to Authoring Tool. 8. Test and verify application. 9. a) Release/approve application to operative HbbTV service. Continue to step 10. or b) Reject application à Application returns back to editing on "Content creator". Continue from step 4 again. 10. Success: New HbbTV service is available for public TV
Post (success) Conditions	New service is developed, tested, accepted and published to operative use.

Failed End Condition	New service deployment fails in some phase of the workflow. Operator continues operations without this new service.
Associated User Requirements	End-user requires fluent and reliable video centric service. There might be need for e.g. some event related HbbTV service like UEFA 2016 application, which presents live/on-demand videos together with rich additional information. Video service provider needs to author these kinds of new services with minimum budget and without any deep technical knowledge of HbbTV application development. Simple-to-use Authoring Tool is required to implement these services.
Extensions & Variations	Depending on type of service there are different templates available in the Authoring Tool. It also might be possible that the desired application cannot be implemented with the Authoring Tool if its requirements/functionality is complex.
Open Issues	Service portal integration might need additional interfaces/integration.
Required Technologies and Protocols	Generic web technologies during authoring process, SFTP in publishing, HbbTV related technologies inside the application, Docker, cloud resources.
Related processes today	Currently similar service development often requires coding skills and takes time and money. Authoring Tool allows to create simple applications with text, images and manually ingested video content. The tool is not yet fully SaaS service, but needs to be installed locally to operator system if seamless authoring – publishing functionality is wanted. Also the better workflow support is still missing to enable trackable authoring – testing – accepting – publishing workflow.

Table 19 Record and description of sub use case rapid development of MPEG-DASH video centric HbbTV application

6.3.2. Technical challenges

Service providers on TV currently lack easy and rapid means of generating HbbTV applications for varying purposes. Often the need for new application e.g. for interactive advertisement comes with a short notice. Development and especially testing of the application on different generations' HbbTV receivers takes time and is not effective.

Ready-made and widely tested application templates combined with easy-to-use authoring tool allows service providers to remarkably shorten the releasing time from application idea to service development and to deployment. Built-in publishing workflow support helps and harmonizes this process and allows every involved party to see what is the current status of each application.

Currently Authoring tool is a SaaS product supporting mainly simple non-video application templates. During this project the idea is to enhance the authoring tool to:

- Include various video centric application templates
- Add support for managing portfolio of applications (e.g. all interactive services of one TV channel),
- Provide intuitive way of controlling, which applications are currently “live” on TV channel
- Support dynamic setting up and configuration of the Authoring Tool service itself to better suit for virtualized environments
- Provide simple way on how to add new VOD assets or connect to existing VOD libraries or live streaming events
- Collect feedback from existing and new Authoring Tool customers and continuously develop the service to even better fill their needs

6.4. Sub case: CDN as a service

6.4.1. Record and description

Title	CDN as a Service
Author/company	VTT
Partners involved	VTT
Primary Actors	<ul style="list-style-type: none"> - Service: Virtualized CDN (origin server, edge servers, routing, management and monitoring), Content ingest (transcoding, packaging into DASH) - Service broker (SB) maintains a list of applicable resources, services with related quality information and accounts for ordered services. - CDN Service orchestrator (CDN-SO) - Resource manager (RM) allocates resources based on CPU, memory, bandwidth information, video QoS information, cloud provisioning cost information - Resources: Clouds, edge clouds and dedicated HW resources
Stakeholders	Video service provider, CDN service provider, operator, users, cloud operators
Scope	CDN as a service, virtualized services, service brokering, resource management
Trigger	Video service provider need more capacity an existing delivery network or build a new content delivery network
Preconditions	Video service provider has content which need to be distributed to various devices and it need to adapt the network capabilities. Service broker has CDN service available and resource manager has sufficiently processing resources available.
Step-wise Description	<p>Creation</p> <ol style="list-style-type: none"> 1. A video service provider sends a CDN creation request with configuration requirements to the service broker (SB) 2. SB request a CDN Service orchestrator (CDN-SO) instance with configuration requirements for the video service 3. CDN-SO asks based on the configuration requirements available resources from the resource manager (RM) 4. The resource manager allocates resources for the service 5. The CDN-SO creates required CDN instances and informs SB 6. SB create an account for video service providers CDN <p>Deletion</p> <ol style="list-style-type: none"> 1. The video service provider does not need the CDN service anymore and request to delete the account for video service CDN 2. SB sends deletion request to CDN-SO 3. CDN-SO deletes all the CDN instances and request RM to release the allocated resources 4. RM release the allocated resources 5. SB deletes CDN-SO and the account of the video service CDN <p>Runtime</p> <ol style="list-style-type: none"> 1. CDN-SO receive monitoring information about the CDN servers performance, end-user QoS and QoE

	<ol style="list-style-type: none"> 2. If the load in the CDN increases the CDN-SO asks resources from RM, adds new nodes to the CDN. New users are erouted to new nodes 3. If the load in the CDN decreases existing users are rerouted out of the nodes, CDN-SO deletes nodes and informs RM to release the resources from the CDN
Post (success) Conditions	The video service is up and running and scales to varying traffic peaks
Failed End Condition	The video service or certain nodes are not in operation. The video service does not scale to traffic peaks
Associated User Requirements	The end users require video services with higher quality available everywhere, any time and on any device.
Extensions & Variations	<p>Alternative sequence 1: Runtime 2-3</p> <ol style="list-style-type: none"> 2. In the live video case the clients in the network X report QoE values which oscillate between two representations. 3. CDN-SO receive monitoring info and asks resources for transcoder in the mobile edge cloud in the network X from RM 4. CDN-SO creates transcoder to mobile edge cloud to transcode one extra representation between the oscillates representations 5. The clients in the network X select new representation and oscillation between two representations ends
Open Issues	The CDN-SO may be need to be integrated with a big data processing pipeline, which handles streaming data collected from cloud instances, and video sessions.
Required Technologies and Protocols	CDN, adaptive streaming (MPEG-DASH), Docker, Video transcoder, Cloud resources, (MEC server for Alternative sequence 1)
Related processes today	CDN service can be purchased from the CDN provider.

Table 20 Record and description of sub use case CDN as a service

6.4.2. Technical challenges

Several technical challenges need to be addressed when virtualizing the CDN in the hybrid cloud environment. The virtualized components need to run in different cloud platforms (public, hybrid, private). Especially launching and running virtualized components in MEC platform can bring new challenges. The Service orchestrator needs an algorithm for the cache placement and instantiation in the federated cloud networks. The algorithm should consider several objectives e.g. cloud resources and physical location, content popularity and user QoE. Resource manager needs real-time information of the available resources in order to allocate cloud resources to the applications.

7. Use case: Virtualized video analytics solutions

The use case virtualized video analytics is subdivided into five sub cases, i.e., parking management, video-based security in public transportation, video surveillance, traffic supervision, and industrial image processing. The sub cases parking management and video-based security in public transportation are in the focus, i.e., the technology of VIRTUOSE will be developed according to their requirements and two distinct demonstrators will be built up toward the end of the project. The remaining three sub cases (i.e., video surveillance, traffic supervision, industrial image processing) will also be analyzed with respect to their requirements and also here it is the target that the VIRTUOSE technology can fulfill these requirements, but no demonstrator will be built within the scope of the VIRTUOSE project.

7.1. Sub case: Parking management

7.1.1. Record and description

Key information is given in the following table in a structured manner. The meaning of each record field is detailed in Appendix I.

Title	Parking Management
Author/company	DCAITI
Partners involved	FOKUS, HHI, SIEMENS
Primary Actors	<p>Main actors:</p> <ul style="list-style-type: none"> • Personnel of the parking service provider or car park operator • Car driver using the car park <p>Main system components</p> <ul style="list-style-type: none"> • Lane and lot cameras • Automated and autonomous driving cars • Local storage • Cloud analytics • Cloud storage • Orchestration & resource management • Visualization components
Stakeholders	<ul style="list-style-type: none"> • Car park operator • Parking service provider • Technology provider • Cloud provider • Parking Service user
Scope	<p>The main R&D topics/issues considered in the sub case are:</p> <ul style="list-style-type: none"> • Distributed architecture, i.e., combination of local analytics/storage with cloud analytics/storage • Real-time processing/analytics for vehicle and obstacle detection and tracking
Trigger	<ul style="list-style-type: none"> • If the lane cameras detect obstacles or other incidents the system informs other drivers or blocks the concerned lanes or the whole car park and triggers automated alarms. • Car park operator can be notified by the system, if the occupation level dips below or exceeds limit values. • Just in case of the on-street parking scenario the system informs the driver as well as the parking personnel that the booked or paid parking time will be exceeded.
Preconditions	A multi-story car park equipped with lane and lot cameras connected by a sufficient fast network from the local site to the cloud. For the sub-scenario “on-street parking” at least one roadside parking area with monitoring cameras is necessary.
Step-wise Description	<p>The scenario “parking management” comprises the minor sub-scenarios “car park” and “on-street parking”. Both sub-scenarios will be presented separately.</p> <p>The individual steps for the sub-scenario “car park” are:</p> <ol style="list-style-type: none"> 1. A vehicle reaches the barrier or the entrance area of a car par. The system detects the vehicle.

	<ol style="list-style-type: none"> 2. The parking lots will be captured by the lot cameras. The current occupancy rate of the car park will be detected by distributed image recognition jobs in the cloud. 3. If the car park is not fully booked a certain parking lot will be allocated and transmitted via Car2x communication (IEEE 802.11p) to the driver and the barrier is opened by the system. 4. The vehicle drives into the car park and is constantly pursued by a sequence of location coordinates calculated by the local monitoring system. If the vehicle leaves the monitoring area of one camera it will be automatically rediscovered by a neighbouring camera. 5. The cloud analytics monitors other vehicles and obstacles in the car park and detects a critical situation and creates an automatically appropriate warning which are transmitted via Car2x communication to the vehicle. 6. If the vehicle reaches the allocated parking lot the occupancy status of the lot will be changed and monitored in summary parking graphics. <p>The individual steps for the sub-scenario “on-street parking” are:</p> <ol style="list-style-type: none"> 1. The occupancy status of the considered parking area is monitored all the time in an overview graphics. 2. A vehicle takes a free parking space and the overview graphics changes. Since the parking lot along the roadside are unmarked beside the occupancy status also the length of the available parking area has to be detected. 3. The recognition rate will be investigated to study the influence of different weather scenarios and the influence of daylight and darkness.
Post (success) Conditions	<ul style="list-style-type: none"> • Continuous operation during the envisioned time of the event, without service failure. • Moving vehicles will be reliably tracked in the car park and a fail-safe occupancy detection is given for the considered parking areas in the car park and on-street parking areas.
Failed End Condition	We could not find or have no access to an appropriate car park or outdoor on-street parking area as well as to a necessary camera system.
Associated User Requirements	<p>The most relevant stakeholder are the car park operator and parking service provider as well as the system user. Their main requirements related to the service are:</p> <ul style="list-style-type: none"> • Real-time and precise location data of the vehicles and obstacles in the car park. • Reliable occupancy data of the parking lots in the car park and on the roadside. • Visualization of analytics results, also on mobile terminals (e.g., tablet computers)
Extensions & Variations	Currently not defined.
Open Issues	<p>The main challenges and unsolved technical problems related to the solution are:</p> <ul style="list-style-type: none"> • Optimal distribution of intelligence between local site and central cloud • High reliability of the analytics algorithms for object detection/tracking in order to avoid too many false positives

	<ul style="list-style-type: none"> Real-time processing of location data for e.g. autonomous vehicles and the generation of real-time warnings of obstacles
Required Technologies and Protocols	<ul style="list-style-type: none"> Cloud-based real-time processing of video data Real-time object detection Real-time object tracking (possibly over several cameras) <ul style="list-style-type: none"> To achieve real-time performance, compressed domain tracking algorithms, which require lower processing times than pixel domain algorithms, can be employed. Such algorithms use only features from the video bitstream such as motion vectors and block coding modes and thus eliminate the need for full decoding and storage of pixels while still providing fairly high tracking accuracy. Given a set of videos recorded by multiple cameras, multi-camera tracking algorithms place bounding boxes around the targets (e.g. cars) in the videos and partitions the boxes into “trajectories”. A trajectory is set of all boxes belonging to a unique target ordered by time. Finding the trajectories of all targets over multiple cameras yields the solution of the multi-camera tracking problem. The employed algorithms might vary depending on the amount of overlap between the different camera views. Adaptation of the video stream (including “bandwidth” management on transmission link)
Related processes today	Today, mostly fixed camera based monitoring installations are deployed, where processing resources cannot be shared between different locations. A trend towards distributed (i.e., cloud-based) deployment can be seen.

Table 21 Record and description of sub use case parking management

7.1.2. Technical challenges

The most essential technical challenges are:

- High reliability of detection results of the occupancy figures of the indoor and outdoor parking areas especially the resistance against light and weather impacts
- Real-time processing of location data for e.g. autonomous vehicles and the generation of real-time warnings of obstacles
- Definition and realization of a system architecture allowing for distributed video processing
- Optimal distribution of intelligence between local site and central cloud

7.2. Sub case: Video-based security in public transportation

7.2.1. Record and description

Title	Video-based security in public transportation
Author/company	DResearch Fahrzeugelektronik GmbH
Partners involved	FOKUS, HHI, SIEMENS
Primary Actors	Main actors: <ul style="list-style-type: none"> Security companies & authorities Vehicle drivers (personnel/staff)

	<p>Main components:</p> <ul style="list-style-type: none"> • Intelligent Mobile Digital Video Recording units (MDVR) • Smart cameras (CCTV equipment mobile/local) • Wireless communication equipment (WLAN/3G/4G/5G gateway units)
Stakeholders	<ul style="list-style-type: none"> • Public Transport companies (rail/road) and operators • Fleet management service provider • Public Transport Passengers • Cloud service provider (platform as a service, PaaS) • Technology provider (infrastructure as a service, IaaS) • Government • Service compiles local stations • Authorities
Scope	<ul style="list-style-type: none"> • recognition of incidents/critical events in public transport operation onboard • identification of object of interest (OOI, suspect person(s)) • marking of OOI • video data transmission depending on infrastructure (low bandwidth, network coverage 3G/4G, in future 5G) • gathering of OOI characteristics and information for further data processing in cloud • object tracking onboard by smart mobile cameras in vehicles (extension of scenario)
Trigger	<ul style="list-style-type: none"> • incident/event in vehicles of public transport (medical emergency, crime, vandalism)
Preconditions	<ul style="list-style-type: none"> • Onboard CCTV equipment in the vehicle is required • technical infrastructure to enable the system to start video data transmission to cloud (3G/4G/5G/WLAN/Cloud services) • sufficient coverage of 3G/4G/5G/WLAN mobile/cellular network, sufficient bandwidth for multi streaming of video data from several vehicles to cloud • infrastructure at operator's site (technical equipment, human, resources)
Step-wise Description	<p>This scenario comprises several sub scenarios (SubS) "SubS A - onboard-onboard object tracking" and "SubS B - onboard-offboard object tracking". the procedure can be described as follows:</p> <ul style="list-style-type: none"> • A critical incident occurs in a public transport vehicle (bus, metro, tram etc). This can be a medical emergency, a brawl, handbag theft or similar. • the critical incident will be identified as "situation with critical characteristics" - either automatically by a smart onboard unit with automatic action/scene recognition algorithm or by persons (other passengers, driver etc) • the identification of the critical situation and the start of an emergency call signal is the trigger of the OOI tracking procedure

	<ul style="list-style-type: none"> • Either the onboard system (onboard controller unit) or smart cameras in the vehicle are tracking the OOI during the stay in the vehicle and gathers significant OOI parameters (face recognition, colour of cloths etc.) • The onboard controller unit establishes a connection via wireless communication (3G/4G/5G/WLAN) to the cloud and sends video streams from vehicle including additional OOI information as GNSS position, date/time, line information etc. • If the OOI leaves the vehicle a cloud based algorithm tries to track the way which will be taken by the OOI - this can be either another vehicle (SubS A) or a stationary object (e.g. railway station, SubS B). The algorithm send broadcast data to other vehicles and stations which are near to the last position of the OOI • another controlling unit receives the tracking demand by cloud service and tries to identify the OOI based in the additional information (vehicle, OOI) • if the OOI can be located the cloud service pushes an alarm signal to appropriate institution (security operator, medical emergency agency, police, public transport operator) which will start an intervention in order to define further actions • The intervention institution conducts further actions/operations
Post (success) Conditions	<ul style="list-style-type: none"> • 24/7 operation or, at least during service time of vehicles • availability of video streams and additional vehicle/OOI information • detection and identification of critical situations ("incidents") with minimum error rate/false alarms
Failed End Condition	<ul style="list-style-type: none"> • complete tracking of route of an OOI is not possible due to missing infrastructure • insufficient identification of critical scenes
Associated User Requirements	<p>Most important stakeholders are PT operators which can provide the required infrastructure. Main requirements are:</p> <ul style="list-style-type: none"> • Increase of safety in public transport • Avoiding crimes, protection of passengers safety • Avoiding damages in vehicles (vandalism) • almost real-time notification of critical situations/incidents and real-time intervention
Extensions & Variations	<p>It is planned to start with the approach that a central onboard controller unit will receive the initial trigger signal for recognition of the incident by push button signal which is initiated by the driver and/or emergency buttons in the vehicle.</p> <p>Depending on any available smart algorithms the scenario could be extended by an automatic incident recognition algorithm which is implemented in an onboard controller unit (central approach).</p> <p>Furthermore, in a first approach the onboard tracking algorithm is provided by the central onboard controller unit. Depending on availability of smart cameras (incl. high performance algorithm) for mobile application an additional variation of scenario would be the</p>

	sharing of onboard OOI tracking procedure by several onboard mobile cameras (decentral approach)
Open Issues	<p>Current technical issues are:</p> <ul style="list-style-type: none"> • availability of IT infrastructure and onboard equipment in vehicle fleets of public transport operators • powerful algorithms with minimum false alarm rate are not available as COTS component • Smart Cameras are required which provide the required algorithms • The difficulty consists in a sufficiently secure automatic recognition of safety-relevant situations. The so far unsatisfactory hit rate of automatic methods leads either to the fact that frequently relevant situations are not detected or a flood of false alarms is generated, which leads to an overloading of the safety center. • high performance video codecs which are optimized for current network conditions during day of service/operation
Required Technologies and Protocols	<ul style="list-style-type: none"> • High performance cloud based services for object tracking, detection and identification <ul style="list-style-type: none"> ◦ Real time tracking can be achieved with low-complexity compressed domain tracking algorithms as explained in detail for the use "Parking management" (see Section 7.1.1, "Required technologies and protocols"). It is subject to further investigation whether the provided accuracy by these algorithms are sufficient to enable successful person tracking in an on-board scenario across multiple cameras. • Anomaly detection and (possibly) action recognition algorithms to identify critical incidents such as theft or brawl. • real-time data communication including protocols for real-time streaming • mobile end devices for visualization of video data • identification/markling/tracking of objects in real time onboard <ul style="list-style-type: none"> ◦ Emerging computer vision techniques called "person re-identification" might play an important role in detecting the same person across several cameras. Person re-identification investigates how to correctly match two images of the same person under intensive appearance changes, such as lighting, pose and viewpoint. • High quality camera equipment which can be used for object identification • Smart cameras with OOI detection/tracking algorithms • IT infrastructure (cellular/mobile network, cameras) which covers a complete operation network of a PT operator including all vehicles and stationary objects as well • reliable onboard systems which will provide required vehicle and operation information (line, date/time, GNSS data with high accuracy, higher than GNSS GPS Navstar)

	<ul style="list-style-type: none"> • sufficient bandwidth for transmission of video data streams
Related processes today	<p>In these days most PT operators will not equip all vehicle fleets with high-end equipment. Most operators are still using “old fashioned” analogue camera equipment which provide a resolution of PAL (720x576px). This resolution may not be sufficient enough to ensure a high-quality OOI detection. Today we see the trend to change the analogue technology into IP-based video technology. Today, an automatic object tracking cannot be used due to missing infrastructure at operator’s site as well as missing interfaces between several CCTV systems.</p>

Table 22 Record and description of sub use case video-based security in public transportation

7.2.2. Technical challenges

We identify the following technical challenges:

- Reliable detection of a critical situation automatically based on scene analytics algorithm
- Reliable process of OOI detection and tracking is a huge challenge because this requires available cloud services with powerful algorithms
- Current wireless (mobile/cellular) network availability could be critical due to insufficient coverage and/or bandwidth for transmission of many streams from many vehicles in operation at the same time (e.g. in daily operation of big PT companies as in London, Paris, Moscow etc.)
- In order to vary the scenario in a way that the OOI detection/tracking will be overtaken by several intelligent/smart camera units onboard powerful camera units are required which fulfill the complex requirements for mobile applications.

7.3. Sub case: Video surveillance

7.3.1. Record and description

Title	Video surveillance (i.e., Video Surveillance as a Service – VSaaS)
Author/company	SIEMENS
Partners involved	SIEMENS
Primary Actors	<p>Main actors:</p> <ul style="list-style-type: none"> • Security personnel in the control room <p>Main system components</p> <ul style="list-style-type: none"> • (Smart) cameras • Local analytics • Local storage • Cloud analytics • Cloud storage • Orchestration & resource management • Visualization components
Stakeholders	<ul style="list-style-type: none"> • Technology provider • Cloud provider (i.e., IaaS provider) • Service provider (i.e., PaaS/SaaS provider) • Service user
Scope	<p>The main R&D topics/issues considered in the sub case are:</p> <ul style="list-style-type: none"> • Distributed architecture, i.e., combination of local analytics/storage with cloud analytics/storage

	<ul style="list-style-type: none"> Real-time processing/analytics, .e.g., object/person detection and tracking
Trigger	<ul style="list-style-type: none"> In general continuous operation Automated alarms can be triggered by the system, which need to be verified by the security personnel Security personnel can trigger specific actions, e.g., forensic analytics on previously recorded video material.
Preconditions	The main precondition behind the described system operation is a sufficient network capacity from the local site to the cloud, at least for a part of the video feeds.
Step-wise Description	<p>The scenario “city marathon” is used in the following in order to give an example description of this sub case. Similar scenarios are events like demonstrations/rallies, political summit, etc.</p> <p>The single steps for the scenario “city marathon” are:</p> <ol style="list-style-type: none"> Set-up (part 1): A city marathon is planned. To ensure the security of the participants and the spectators, surveillance cameras are installed at important locations, e.g., start and finish. The cameras are registered with the cloud infrastructure (i.e., imaging platform) and connected through WLAN or 5G. Set-up (part 2, optional): Drones equipped with cameras are brought to the event and the routes for the drones are planned. The cameras on the drones are also registered with the platform and connected through 5G. During the city marathon, the whole event is supervised. The drones follow the runners while the fixed cameras monitor the hot spots. The cloud analytics detects critical situations and creates alarms. The control room personnel verifies the alarms by visual inspection and initiates appropriate countermeasures (e.g., intervention of police, security, or medical staff). The video feeds are recorded using cloud storage. In case of insufficient network capacity, local storage is used. Post inspection of incidences are done, e.g., based on later complaints of an offense. The related video data is retrieved from the cloud storage for the preservation of evidence. The video data is deleted after the mandated time period.
Post (success) Conditions	<ul style="list-style-type: none"> Continuous operation during the envisioned time of the event, without service failure. Detection of all relevant events.
Failed End Condition	<ul style="list-style-type: none"> Relevant events (e.g., persons in forbidden zones) not detected. Video data (or part of it) not recorded
Associated User Requirements	<p>The most relevant stakeholder is the control room personnel. Their main requirements related to the service are:</p> <ul style="list-style-type: none"> Live (i.e., real-time) view of any video feed that is requested. Note that not all video streams need to be available at the same time. Real-time generation of analytics results Visualization of analytics results, also on mobile terminals (e.g., tablet computers)

Extensions & Variations	Currently not defined. (The step of post inspection can be seen as an extension.)
Open Issues	<p>The main challenges and unsolved technical problems related to the solution are:</p> <ul style="list-style-type: none"> • Optimal distribution of intelligence between local site and central cloud • High reliability of the analytics algorithms for object detection/tracking in order to avoid too many false positives • Real-time processing of the analytics algorithm
Required Technologies and Protocols	<ul style="list-style-type: none"> • Cloud-based real-time processing of video data • Real-time object detection • Real-time object tracking (possibly over several cameras) • Adaptation of the video stream (including “bandwidth” management on transmission link) • Cloud storage of video data • Real-time visualization of video streams
Related processes today	Today, mostly fixed surveillance installations are deployed, where processing resources cannot be shared between different locations. A trend towards distributed (i.e., cloud-based) deployment can be seen.

Table 23 Record and description of sub use case video surveillance

7.3.2. Technical challenges

The technical challenges relate mostly to the deployment model of surveillance applications, i.e., cloud-based installations, which allow for hosted /managed video surveillance (e.g., for small premises), temporary installations (e.g., like the city marathon as described in the step-by-step description above), and flexible extension of existing installations (i.e., cost-efficient upgrade with more cameras and advanced video analytics and the option for seamless transition to hosted / managed video surveillance). Furthermore, the single components of such a solution need to be tailored to the needs of such a deployment but also the needs coming from the domain.

Thus, the technical challenges are:

- Definition and realization of a system architecture allowing for distributed video processing and storage
- Real-time video processing (especially real-time video analytics)
- Real-time visualization of remote/cloud content (i.e., video feeds residing in the cloud)
- High reliability of detection results of the video analytics algorithms to allow for automated operation with minimal user supervision

7.4. Sub case: Traffic supervision

7.4.1. Record and description

In spite of coming from a different application domain, this sub case is similar to the sub case “video surveillance” (as described in the previous section) with regard to the setup of an installation, the course of action, and the related requirements.

Title	Traffic supervision (i.e., cloud-based traffic supervision)
Author/company	SIEMENS
Partners involved	SIEMENS
Primary Actors	Main actors:

	<ul style="list-style-type: none"> Supervision personnel in the control room <p>Main system components</p> <ul style="list-style-type: none"> Cameras Local analytics Local storage Cloud analytics Cloud storage Orchestration & resource management Visualization components
Stakeholders	<ul style="list-style-type: none"> Technology provider Cloud provider (i.e., IaaS provider) Service provider (i.e., PaaS/SaaS provider) Service user
Scope	<p>The main R&D topics/issues considered in the sub case are:</p> <ul style="list-style-type: none"> Distributed architecture, i.e., combination of local analytics/storage with cloud analytics/storage Real-time processing/analytics, e.g., object/person detection and tracking
Trigger	<ul style="list-style-type: none"> In general continuous operation Automated alarms can be triggered by the system, which need to be verified by the supervision personnel Supervision personnel can trigger specific actions, e.g. retrieval of previously recorded video material for manual inspection.
Preconditions	<p>The main precondition behind the described system operation is a sufficient network capacity from the local site to the cloud, at least sufficient for a part of the video feeds.</p>
Step-wise Description	<p>The scenario “bus lane” is used in the following in order to give an example description of this sub case. Alternate scenarios are described under “Extensions & Variations”. The step-by-step description of the “bus lane” sub case is the following:</p> <ol style="list-style-type: none"> Setting: The city street / motorway is equipped with traffic surveillance cameras. The cameras are connected through a wired connection (i.e., LAN) to the cloud-based analytics platform hosted by Siemens. A car drives on the bus lane of the city street. The traffic surveillance camera captures the scene and forwards the video feed to the analytics platform. The violation of traffic regulations (i.e., a car drives on the bus lane) is automatically detected by the cloud analytics and an alarm is generated. The alarm is verified by the control room personnel and appropriate countermeasures (e.g., intervention of police, lowering of speed limit and warnings on electronic traffic lights, etc.) are taken.
Post (success) Conditions	<ul style="list-style-type: none"> Continuous operation during the envision time of the event, without service failure. Detection of all relevant incidents.
Failed End Condition	<ul style="list-style-type: none"> Relevant incidents (e.g., car on bus lane) not detected. Video data (or part of it) not recorded
Associated User Requirements	<p>The most relevant stakeholder is the control room personnel. Their main requirements related to the service are:</p>

	<ul style="list-style-type: none"> • Live (i.e., real-time) view of any video feed that is requested. • Real-time generation of analytics results • Visualization of analytics results.
Extensions & Variations	<p>Alternative options for step 2 of the step-wise description of the sub case:</p> <ol style="list-style-type: none"> a) A vehicle stops on the motorway. / A vehicle stops on the city street at a point where it is not allowed. b) A driver turns his car where it is not allowed. c) A car drives in the wrong direction on the motorway.
Open Issues	<p>The main challenges and unsolved technical problems related to the solution are:</p> <ul style="list-style-type: none"> • Optimal distribution of intelligence between local site and central cloud • High reliability of the analytics algorithms for object detection/tracking in order to avoid too many false positives • Real-time processing of the analytics algorithm
Required Technologies and Protocols	<ul style="list-style-type: none"> • Cloud-based real-time processing of video data • Real-time object detection • Real-time object tracking (possibly over several cameras) • Adaptation of the video stream (including “bandwidth” management on transmission link) • Cloud storage of video data • Real-time visualization of video streams
Related processes today	<p>Today, mostly traffic supervision solutions are deployed, where processing resources cannot be shared. Also in this domain, a trend towards distributed (i.e., cloud-based) deployment can be seen.</p>

Table 24 Record and description of sub use case traffic supervision

7.4.2. Technical challenges

The technical challenges relate to the realization of the solution using cloud-based installations, which allow for reduced operational costs due to shared processing resources and due to central maintenance of the system. Furthermore, the single components of such a solution (especially the video analytics) need to be tailored to the needs of such a deployment but also the needs coming from the domain.

Thus, the technical challenges are:

- Definition and realization of a system architecture allowing for cloud-based video processing and storage
- Real-time video processing (especially real-time video analytics)
- Real-time visualization of remote/cloud content (i.e., video feeds residing in the cloud)
- High reliability of detection results of the video analytics algorithms to allow for automated operation with minimal user supervision

7.5. Sub case: Industrial Image Processing

7.5.1. Record and description

Title	Industrial Image Processing (i.e., cloud-based industrial imaging)
Author/company	SIEMENS

Partners involved	SIEMENS
Primary Actors	<p>Main actors:</p> <ul style="list-style-type: none"> • Field NDE technician (NDE – non-destructive evaluation) • Remote expert (for extended use case) <p>Main system components</p> <ul style="list-style-type: none"> • NDE equipment (e.g., ultrasound scanner or computed tomography scanner) • Cloud processing (e.g., 3D reconstruction, image analytics) • Cloud storage • Orchestration & resource management • Visualization components
Stakeholders	<ul style="list-style-type: none"> • Technology provider • Cloud provider (i.e., IaaS provider), if service provider does not use his own hardware • Service provider (i.e., PaaS/SaaS provider) • Service user (i.e., field NDE technician, remote expert)
Scope	<p>The main R&D topics/issues considered in the sub case are:</p> <ul style="list-style-type: none"> • Distributed architecture, i.e., combination of local processing with central/cloud storage • Remote visualization of image data (for extended use case)
Trigger	<ul style="list-style-type: none"> • The field technician triggers the NDE measurement and sends the NDE data to the cloud, where the processing (e.g., 3D reconstruction) is performed. • Extended use case: In case the field technician needs additional support from a remote expert, he triggers a request for this expertise (e.g., decision support)
Preconditions	<p>The main precondition behind the described system operation is a sufficient network capacity from the local site to the cloud. Since this is usually a fixed line network, this precondition should be met although the amount of NDE data to be transmitted is usually high.</p>
Step-wise Description	<p>The single steps for the scenario are:</p> <ol style="list-style-type: none"> 1. Acquisition of a ultrasound sequence or CT projection images from a scanner by the field NDE technician 2. Upload of ultrasound sequence or projection images to the cloud storage 3. Processing of the NDE image data (e.g., 3D reconstruction, volume rendering, ...) 4. Interactive remote visualization of the reconstructed and rendered image data to the field NDE technician (possibly including suitable preview on the data for fast interaction) 5. Submission of assessment by field NDE technician
Post (success) Conditions	<p>The workflow as described above is completed and the assessment is recorded.</p>
Failed End Condition	<ul style="list-style-type: none"> • The NDE image data cannot be uploaded due insufficient upload capacity • The visualization of the reconstructed and rendered image data to the field NDE technician (or in the extended use case additionally to the remote expert) cannot be done due to insufficient network capacity or (for interactive operation) due to high end-to-end delay

Associated User Requirements	<p>The most relevant stakeholder is the field NDE technician (and in the extended use case additionally the remote expert). Their main requirements related to the service are:</p> <ul style="list-style-type: none"> • Retrieval of results similarly fast compared to local processing on a workstation • Fast generation of analytics results • (Interactive) visualization of processing results
Extensions & Variations	<p>The sub case can be extended as follows:</p> <ol style="list-style-type: none"> 6. The Field NDE technician requests a second opinion from a remote expert. 7. Data is visualized to remote expert. 8. Submission of assessment by remote expert
Open Issues	<p>The main challenges and unsolved technical problems related to the solution are:</p> <ul style="list-style-type: none"> • Optimal distribution of processing and storage between local site and central cloud for fast and cost-efficient execution of the use case • Interactive visualization of large sets of image data
Required Technologies and Protocols	<ul style="list-style-type: none"> • Cloud-based processing of image data (high resolution, high bit-depth, ...), likely including GPU acceleration • Cloud storage of image data (high resolution, high bit-depth, ...) • Real-time (i.e., interactive) visualization of image data
Related processes today	<p>Today, the operation is mostly performed on a local workstation. Thus, the limitations are:</p> <ul style="list-style-type: none"> • No sharing of processing resources (higher costs due to multiple local realization of reconstruction/rendering pipelines) • No consultation of a remote expert (travelling might be required)

Table 25 Record and description of sub use case industrial image processing

7.5.2. Technical challenges

The technical challenges relate to the realization of the solution using cloud-based installations, which allow for reduced operational costs due to shared processing resources and due to central maintenance of the system. Furthermore, the single components of such a solution, especially the (interactive) remote visualization, need to be tailored to the needs of such a deployment.

Thus, the technical challenges are:

- Definition and realization of a system architecture allowing for cloud-based NDE image processing and storage
- GPU support for industrial image processing (i.e., industrial imaging for non-destructive evaluation)
- Real-time visualization of remote/cloud content (i.e., NDE image data residing in the cloud)

Note: It is not planned to investigate/realize specific aspects within this scenario, e.g., aspects related to the processing of NDE image data (i.e., 3D reconstruction, volume rendering, etc.) or big data analytics within the scope of the VIRTUOSE project, since different requirements apply for these aspects. In addition, also the modality (i.e., more image data than video data) is not the same. Thus, the focus will be mostly on common technology aspects like distributed architecture, cloud processing and storage, interactive visualization, etc.

Technical challenges regarding LHE video analytics:

There is a common set of basics operations for video analysis which have equivalency in different domains. For example, the convolutional filters in the space domain have equivalency as multiplications at frequency domain. LHE keeps at space domain but transforms signal in hops. Certain operations (linear and nonlinear filters) can be achieved operating hops instead signal values, improving efficiency and speed.

The technical challenge for experimental use of LHE at video analysis is to identify the operations in this new “compressed domain” composed of logarithmical hops, and identify new kind of operations which can take benefit of LHE information, such as perceptual relevance metrics, in several scenarios such as identify patterns and motion compensation.

8. APPENDIX I: description of the use case template

Title	<i>The title of the use case or sub-use case</i>
Author/company	<i>The main author of the use case</i>
Partners involved	<i>The partners and countries contributing to the use case</i>
Primary Actors	<i>The main system components/actors involved in the use case description</i>
Stakeholders	<i>The main stakeholders impacted by the solution</i>
Scope	<i>The main R&D topics/issues considered in the use case</i>
Trigger	<i>The trigger initiating the technical sequence (by an actor or stakeholder)</i>
Preconditions	<i>The main assumptions or preconditions behind or leading to the described system operation</i>
Step-wise Description	<i>Step-wise description (1-2-3-4-...) of the operational sequence of the system after the initial trigger</i>
Post (success) Conditions	<i>The successful end condition(s) when the system and all its optimizations and enhancements work as intended</i>
Failed End Condition	<i>The end condition(s) when something goes wrong or if the optimizations fail</i>
Associated User Requirements	<i>Considering the user or other stakeholders, what is expected by them from the systems' operation and what can be considered as sufficient level of performance or quality? Are there any tradeoffs in the user/stakeholder expectations (e.g. video quality vs. monetary cost) that can be utilized in optimizing the system's operation further?</i>
Extensions & Variations	<i>Any alternative steps or extensions to the technical operational sequence, included in the step-wise description, if some step(s) in the sequence have a different end result depending on the context.</i>
Open Issues	<i>Challenges or unsolved technical problems related to the solution</i>
Required Technologies and Protocols	<i>List of relevant technologies required for the implementation</i>
Related processes today	<i>How are the technical problems addressed by the use case handled today? What is the novelty of the solution?</i>

Table 26 Description of the use case template